THE UNITED NATIONS CONFERENCE ON SCIENCE
AND TECHNOLOGY FOR DEVELOPMENT.
CANADA'S NATIONAL PAPER.

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- PREFACE -

1. This national paper attempts to summarize Canadian experience in science policy in the domestic context and as an aspect of our development and aid programs. It is not an inward-looking history of Canadian science and technology - indeed, certain major areas such as nuclear energy which have been dealt with extensively in other U.N. fora are not addressed at all. Nor does the paper treat the subject from the point of view of national achievements. Neither theme would be relevant to an international audience or to UNCSTED. What follows is an outline of some Canadian experiments in applying science and technology (S&T) to problems of development at home and abroad. The emphasis of the paper is on federal government policies, structures, mechanisms and programs and not on science itself.

2. This theme has been chosen because it is in keeping with the basic thrust of UNCSTED. Canada welcomes the opportunity to learn from the UNCSTED process, from the experience of other countries in finding new ways and means of nurturing an indigenous S&T capacity and to use that capacity to the solution of economic and social problems. It has also been chosen because it is germane to the compelling themes of a new international economic order.

3. The paper also reflects as well, Canada's sense of common interest and shared experience in the global problems of development. Although a comparatively wealthy and technologically advanced country, much of Canada's past and contemporary situation makes us acutely aware of the challenges now faced by other developing nations. Our experience of foreign ownership of industry and resources, our global trade in basic commodities and raw materials, and our dependence on foreign markets for our manufactured goods have been fundamental forces in shaping and, to some extent, limiting our national S&T capacity. We have been net importers of capital, technology and skills. Our geographic station beside the world's largest economy has confronted us with chronic difficulties in maintaining an indigenous pool of skilled manpower, a high level of national expertise and training, and a viable component of innovative secondary industry. Successive Canadian governments have tried and are continuing to try to design institutions and mechanisms to enable S&T to be an effective part of the solutions to these crucial national problems.

4. UNCSTED provides both the process and the forum whereby this experience can be compared and discussed at the broadest international level. We believe that this discussion can lead to a better insight into the role of S&T in modern society and to a clearer understanding of how it can more effectively be applied to the global problems of mankind.

SECTION ONE

- THE CANADIAN EXPERIENCE -

Introduction

5. Eighty years ago almost one-third of Canada was unexplored, unmapped and virtually unknown. Twenty years later, towards the end of the First World War, Canadians were still importing 98% of their oil and large amounts of iron ore and coal. The total expenditures of the faculties of applied science in the country were less than the annual budget of the Massachusetts

Institute of Technology in the United States at the time. Canadian scientists had to send their instruments for testing and calibration to the U.S.A., because there were no adequate facilities in their own country. Only two Canadian universities granted doctorates and these had produced less than a dozen Ph.D's in the pure sciences. The government laboratories were spending less than $100,000 annually for research in a country whose land mass was then some nine and a half million square kilometres. The government agency established in 1917 to coordinate industrial research found that there was little or nothing in the country to coordinate.

6. As economic and social development progressed certain problems seemed intractable. The growth of industry in Canada - much of it foreign owned - seemed to be unable to staunch the flow of skills out of Canada. In 1938, one submission to the Federal Government drew attention to the fact that many of our best people were continually being drawn away and thus "we suffer a heavy loss, both in money to pay for imports and culturally in the slowing up of our own progress." In 1967, a government commission concluded that despite the impressive growth in national science and technology (S&T) capacity "Canada not only plays a subordinate role in the technology race, but stands aside as well from the innovative process." And throughout this period of the 1950's and 60's there was the frequent comment that after a century of effort Canada's research was still scattered and uncoordinated.

7. New mechanisms of coordination have been established in the 1970's but there are still deficiencies in our research and development component. The comtemporary challenge is the search for more effective linkages between our S&T capacity and our industrial capacity in an effort to encourage the research and development component of our industries to carry more weight.

8. This Canadian experience in applying S&T to development is especially relevant to a United Nation's conference on the subject in the 1970's: first because, by definition, "history" in Canada is not remote but recent; because it is a response to contemporary economic and social problems of development; and third, because it is largely the story of a nation in search of a national, indigenous competence in a modern world.

The Period 1840 - 1916

9. Settlement, transportation and the exploitation of natural resources were the overriding imperatives in the 19th century as the country strove to become a transcontinental nation. During this period, as the technology of the Industrial Revolution was first being applied to our national development, science was organized to perform two basic functions in government - reconnaissance and research. In 1842 the Geological Survey of Canada was established with the principal task of exploration. Its initial role extended to an analysis of all major resources in the Canadian hinterland including forests, soils, water and biology. In the remaining years of the last century several other federal scientific surveys were founded either as permanent additions to government or as temporary fact-finding commissions. But after the 1850's it gradually became apparent that the discovery and description of resources were not enough to answer the needs of society and government. There was also the concomitant requirement to understand and measure the carrying capacity of land and sea-based resources. The idea of conservation was still in its infancy, especially in a country where

opportunity seemed infinite, but Canadians were learning the need for the long-term point of view especially in the management of renewable resources. The protection of the diminishing fisheries of the Great Lakes and the Atlantic coasts was a formative experience for both the government and industry. Unpopular legislation and the enforcement of conservation required the justification and backing of scientific knowledge and informed opinion. This pattern was increasingly, if somewhat sporadically, applied to the opening up of the "new lands" of western Canada for the protection of scarce timber stands and the vital business of water-shed management and irrigation. Scientific land use became a facet of government planning. Finally, the crucial needs of the farming industry to meet the particular conditions of the Canadian west brought about the first large scale investment by Federal and Provincial governments in research facilities and research scientists. From 1885 onwards a network of government Experimental Farms was established.

10. While our own scientific efforts were being applied to the development of our natural resources, external circumstances led early governments in Canada to look to foreign capital, imported technologies and protective legislation to begin the development of a manufacturing sector. As will be seen, a century later the weakness in industrial R&D which ensued is still a central problem of Canadian science policy.

11. By the First World War Canadian science had passed through its infancy. We had created in the process a set of first-class scientific institutions within government departments for the analysis and enhancement of natural resources. With the benefit of hindsight some broad conclusions can be drawn from this national experience.

: First, there was growing recognition within government that policies and programs had to reflect and take into account scientific knowledge. Science was becoming a necessary adjunct to government.

: Second, where government development programs failed, it was often not due to lack of knowledge but to the failure of the decision-making system to take existing knowledge into account. This flaw in the system was left as a piece of unfinished business, so to speak, and was to become a major theme of science policy later in the century.

: Third, the organization of science and scientific laboratories became the business of government in Canada. And at a relatively early stage in our development much of the scientific research capacity in the country became entrenched within government departments. This pattern was to have long term effects on the growth and nature of science in Canada.

The Period 1916 - 1959

12. By the end of the second decade of the 20th century a formative relationship between government and science in the country had been established. It had been accepted that science was useful and necessary to the process of governing and especially to the development of rational policies for settlement and resource exploitation. From 1916 onwards we can discern, in retrospect, a new element evolving in that relationship. Government was to

become increasingly concerned with the ways and means of creating and nurturing a domestic scientific and technological infrastructure.

13. The immediate cause of this shift in perspective was the severe disruption in the world supply of natural resources and raw materials by the First World War. The history of the Canadian response to this crisis, and indeed the history of science development in the country for the ensuing half century, centres largely around the creation and evolution of one organization - the National Research Council of Canada.

14. The initiative came from industrialists who were anxious to spur government spending for the support of applied research in manufacturing. What was sought was a means to encourage industrial research, through the allocation of funds to university departments, which would be relevant to the immediate wartime problems of industrial products and processes. The government's response led to the creation of a body which evolved into the National Research Council, and which was to become the expression of Canada's scientific capacity. Whatever criticism may be made of the Council's work and mission during its years of growth and expansion, it undoubtedly did more to shape and develop Canadian S&T than any other institution in the country.

15. Its impact and significance can be seen from three perspectives: in terms of its growth and activities; in terms of the evolution of its role and mission; and in the way it came to represent and reflect the strengths and perceived shortcomings of our national scientific capacity.

16. The mandate of the National Research Council was to consult and coordinate in order to bring about a united effort in industrial research work in Canada. To do this the new Council was given a much wider degree of freedom from political and bureaucratic control than any department or other agency which then existed within the Federal Government structure and was thus able to respond to the demands placed upon it with an unusual degree of flexibility.

17. The Council's first undertaking was to prove significant in its subsequent development. In 1918 and in response to its mandate, it surveyed Canada's capabilities, and found that there was little to coordinate. It also was apparent that there was little opportunity for the few science and engineering graduates produced in Canada - a situation which was already beginning to lead to the emigration of this skilled work force.

18. The Council's response was immediate. It began a program of university research support in Canada whose twofold aim was to produce a supply of people trained in scientific disciplines and to assist in the creation of first-class graduate schools in the country.

19. The Council's second response to the perceived shortcomings of national scientific capacity at the time was to create, in 1920, the associate committee structure. These committees were designed to bring together expertise in a given problem area, to review the state of knowledge and to design a program of research. They decided how and where the research needed could be undertaken most effectively and economically.

20. One other theme pervaded the Council's early discussions - the need for government laboratories to provide the testing and calibration facilities which were missing in the country. A major argument advanced at the time was that a university-like complex of research facilities, organized around traditional academic disciplines, would be able to prove their utility by advancing the country's economic growth. This was thought to be the answer to Canada's needs for applied research to promote industrial innovation.

21. It can be argued that the pattern of the Council's growth was the result of the Canadian tendency to create science within and under the umbrella of government. There may have been no other feasible solution given the economic facts of Canadian nationhood at the time, and in particular, the lack of R&D capacity in the industrial sector. But the result has been that the Federal Government became the major shareholder and manager of the country's scientific capability. In retrospect it can be seen that the initiatives by government did not bring about a parallel growth in investment in R&D by the industrial sector at rates comparable to those in other industrialized countries.

22. With the further benefits of hindsight we can see that during its formative era the National Research Council was successful in establishing most, but not all, of the critical elements of a scientific infrastructure. The missing link, as far as manufacturing was concerned, was the one which should have created the closest and most effective relationship between the laboratory and the twin elements of production and marketing. In contrast, agricultural science in government did enjoy considerable success and the speed with which practical application followed upon progress in the laboratory was in large measure due to an efficient provincial agricultural extension system linking the farmers with the results of laboratory research and experimentation.

23. One final observation. The spectacular growth of government financed science in the era up to the 1960's was entirely in the natural and engineering sciences. The social and human sciences were not considered at the time and for all practical purposes were left largely to their own devices.

The Period 1960 - Present

24. The appointment of the Royal Commission on Government Organization by the Federal government in 1960 was a major watershed in the development of science policies in Canada and introduced a period of change and contention which continues to the present time. It brought science, science organization, and science policy into the arena of public and political controversy and debate.

25. The Commission's main observations can be summarized as follows. The Commission found:

: that science policy in Canada was the result, rather than the cause, of the growth which had taken place in government science activities.

: that there was an inadequate level of supervision, planning and direction within government science;

: that the National Research Council had turned aside from its original duty and mandate, and

: that the original intent to stimulate R&D in Canadian industry had bee relegated to a "minor distraction".

26. The changes which followed in the wake of this Commission, (and there were several subsequent studies launched), did not in the final event correspond to any one particular recommendation. There was, however, a clear trend towards a centralization of science policy efforts and to the creation of a mechanism whereby the Federal government could develop such a policy and oversee its implementation.

: In 1964 the government created a Science Secretariat in the Cabinet office to provide information and analysis to support the Cabinet Committee on Scientific and Industrial Research.

: In 1966 the Science Council of Canada was created, an independent agency funded by Parliament to advise the government on long-term objectives for science in Canada.

: A Ministry of State for Science and Technology was officially established in August of 1971 which replaced the Science Secretariat. It was an experiment in coordination, a ministry without budgetary authority over government science expenditures and with no research programs of its own.

27. The Ministry's central purpose was to try to bring about at the level of Cabinet a degree of planning and consultation among science departments and agencies which had not previously existed in the Canadian structure except, perhaps, during the Second World War. In the language of government administration the Ministry is a "coordination model" rather than a "concerted action model", with horizontal, rather than vertical, responsibilities.

28. The decision to circumscribe the Ministry's role and authority reflected a fundamental attitude and approach within the Canadian system to science policy. Science and technology are not perceived as an end in themselves but as a means of solving national problems and achieving national goals. It is the major departments of government which have the responsibility for meeting national objectives and it is they who must decide how to employ their scientific capability to meet those objectives.

29. There is one aspect of the Ministry's role which is fundamental to an understanding of this country's attitude to science. The Senate Special Committee on Science Policy recommended the creation of " a coherent overall science policy" for the country. This was often interpreted that science policy should be a single, visible entity. The Ministry found this concept to be unworkable. What is meant by "science policy" in the present Canadian context is the sum of policies in three distinct areas.

: Policies for the support of science including the support of university research, the provision of national scientific and engineering skills, the maintenance of basic research capacities, and the dissemination of scientific knowledge.

: Policies for the application of science and technology which include the ways and means of using science in government to achieve national objectives.

: Science in Public Policy which refers to the development of systems and strategies to ensure that scientific knowledge is brought to bear on the analysis and development of national economic and social priorities and programs.

30. One example of the type of policy-making now underway in Canada is the government's strategies to support industrial R&D. The specific programs which have been developed reflect three basic perceptions or tenets in the theory and practice of science policy today.

: The first, is that industrial innovation is a key factor in overcoming the major economic problems which Canada now faces: unemployment, inflation and a serious imbalance between exports of raw materials and the importation of manufactured goods.

: The second, is the realization that the transfer of technology from the laboratory to the production line and from there to the market-place, is a complex and costly process. When the laboratories are not organizationally linked with production and marketing units (as has often been the case in Canada where government laboratories have tried to serve private industrial needs), the process is considerably more difficult and diminishes the likelihood of success. Consequently, the present set of incentive policies is aimed at encouraging research by and within the private sector.

: Finally, government programs to support industrial R&D have to be adjusted to, and take into account, the element of commercial risk. This is especially true where international competition is a factor. If competition or risk are keen, government tends to make a direct contribution to the venture by means of grants or contracts for R&D. In other cases, general tax incentives may be sufficient to stimulate the industry to undertake its own innovation.

31. There are two major considerations which underlie and influence the issue of industrial development in Canada. The first is that as that as a country we will continue to be a sustantial importer of technology. Canadian policy thus seeks to identify those critical areas in which to invest our own scientific and technical resources to greatest effect. The second factor is the constraint imposed by the need to protect and maintain environmental quality.

32. It should be stressed here, as well, that the role and experience of governments at the provincial level is especially relevant in the development of policies and programs for resources and for industrial support. Several provinces have extensive experience in creating and maintaining non-profit, research institutes which provide technical support to primary and secondary

industries. These organizations have played a significant role in the transfer of technology from the laboratory to the production unit. In addition, during the last decade, many provinces have established science policy units under the direction of ministers to provide a policy focus for programs of industrial and university research.

33. This brief overview of national experience and experiment would be incomplete without reference to Canadian own vast underdeveloped regions. More than forty percent of our country is arctic tundra or sub-arctic forest. Canada's two northern territories comprise an area of 3.7 million square kilometers but with a population of only 65,000. More than half of these people are descendants of Canada's two original races, the Indian and the Inuit.

34. The basic challenge which the Canadian north presents is not unique in the contemporary world: it is the need to enhance the capacity of the land and oceans to support an expanding human society and enterprise but without causing profound disruption to a way of life or irreparable domage to the environment.

35. In the scientific and technological context there are striking similarities between this situation and other areas of the world. The first is the problem of developing a scientific capacity within the region which is capable of responding to local needs and which is able to add the insights of systematic knowledge to the experience and competence of northern people. The second parallel is the need to adapt technology to the north. In this, remoteness and cost are the crucial factors.

36. The development of an indigenous technology for Canada's arctic and sub-arctic must be based on a close working relationship between scientists and those who will use the technology but it is a process which should recognize and draw upon the experience of other countries. It is hoped that such an exchange and comparison of experience can take place under the auspices of UNCSTED.

SECTION TWO

- CANADA'S SCIENCE AND TECHNOLOGY - SOME ILLUSTRATIVE SECTORS -

37. This National Paper discusses Canadian experience in the application of science and technology under five headings: Food and Fibre, Natural Resources and Energy; Communications and Transportation; Industrial S&T, and Scientific and Technical Information. These have been selected as those sectors of Canadian competence which correspond most closely to the five subject areas designated by the UNCSTED process for the purpose of illustration and discussion. Each of the five sections which follows has been written to illustrate:

1. the way in which science and technology have been applied in Canada to social and economic problems of development, and

2. the way in which that capacity is, and can be, incorporated into development assistance programs.

FOOD AND FIBRE

Introduction

38. Since the earliest days of Canadian history, agriculture, fisheries and forestry have played a dominant role in the country's economy. Taken together, they represent the second largest category of Canada's exports accounting for nearly 30 percent of the total. Pulp and paper has been Canada's leading industry for many years, producing 40 percent of the world's newsprint. Agriculture acccounts for over 3 percent of the gross domestic product and provided well over $1000 million net to our international balance of payments in 1976. The fisheries industry, while now relatively less important than in earlier years, is a mainstay of the economically depressed Atlantic region and a significant source of jobs in the Pacific and fresh-water fisheries as well.

39. All three have felt the impact of new technology in recent years, with the result that they have become much less labor-intensive, much more capital-intensive and more energy-intensive. Concern for the physical environment has brought an awareness that the production of food and fibre depends on a healthy environment, whereas this same production, if conducted improperly, can damage it. For all these reasons, food and fibre production have taken on an almost totally new look during the past three or four decades enabling them to retain their important position in Canadian life despite changing conditions.

Agriculture

40. Unexpected though it may seem, the important role of agriculture in Canada has been achieved despite, not because of, what nature and geography gave us. Of the vast area of Canada, the second largest country in the world, only 4 percent could have been regarded as naturally arable land; today 7 percent is under cultivation as a result of scientific and technical advances and 8 percent seems an achievable target. Large parts of our western prairies are semi-arid, have a short growing season, and suffer from a variable, hostile climate. Without the early and deliberate development of a strain of wheat that could survive these harsh conditions it is unlikely that Canada's prairies could ever have become one of the world's important bread baskets. This is perhaps a classic example of the immense benefits science can bestow on agriculture.

41. The importance of applying science and technology (S&T) to Canadian agriculture was recognized early. Five experimental farms were established nearly a century ago ranging from the Atlantic to the Pacific and the beginning of an associated extension service was in place. Today there is a highly decentralized network of research organizations spread widely across the

country, operated by the Federal government, provincial governments, universities, and to some extent by private industry. About half the work is performed in 47 federal research stations and experimental farms. While the extension services are entirely a provincial function there is close cooperation between the two. This arrangement, involving geographically widespread research stations and greatly diverse R&D, is not accidental, but rather is essential under Canadian conditions: extreme variations in climate, widely differing soils and soil conditions, and the resulting great variety of crops and animals. An incidental advantage of this decentralization, aided by a well-developed extension service, has been the encouragement for researcher and farmer to cooperate closely and directly. On occasion the farmer is able to tell the researcher what technological developments he expects to need some years in the future. A primary lesson learned by Canada, therefore, was the importance of decentralized and diversified agricultural R&D, based on regional needs, and backed by an effective extension system providing two-way communication between scientist and farmer.

42. Recent decades have seen a great refinement in this concept of regional diversity. It has been realized that optimum agricultural practice can differ markedly between neighboring regions that are sometimes as small as a few tens of kilometres in breadth, resulting in the need for different crops or strains, different cropping practices, and even different implements, to suit highly localized conditions. It is no longer possible, for example, to think of the western prairies as a single homogeneous agricultural region. A primary factor in this development has been the collection of information on soil types and conditions on a detailed scale over vast areas of the country, often with the aid of remote sensing by satellite. Of equal importance has been the ability of our plant and animal breeders to produce new strains to meet a variety of needs. Wheat, already mentioned, has been developed in a variety of strains designed for higher yield, improved disease resistance, shorter maturing time, greater protein content, drought resistance, etc. Maize, formerly grown only in a small part of southern Ontario, is now available in strains that thrive from coast to coast. Similar developments have taken place with other cereal grains, vegetables and animals. Where formerly plant and animal breeders concentrated on dealing with unexpected current problems, such as the appearance of new strains of wheat rust, their major effort is now applied to anticipating possible future problems. An important part of this process is the maintenance and expansion of gene pools by collecting specimens from around the world.

43. The availability of new technology and mechanization has made Canadian agriculture highly capital-intensive and energy-intensive, and therefore vulnerable to rising energy costs. Agricultural research and development (R&D) may find the latter problem less tractable than those it has faced in the past, and it remains to be seen how the system will adjust to these new stresses.

44. Despite the obvious differences between agriculture in Canada and in most developing countries, arising from both climatic and operational differences much Canadian experience has nevertheless proved applicable in other

countries. One highly successful example of technology transfer is the All-India Coordinated Research Project on Dryland Agriculture, jointly managed by Indian and Canadian scientists, and aimed at conserving soil and water, increasing yields by 100 percent, and devising contingency plans for abnormal conditions such as droughts or floods. Keys to the success of the project were the development of a comprehensive plan during a two-year pre-project planning period, establishment of 24 research centres, and the training of Indian specialists in both Canada and India. A similar method was adopted in assisting Tanzania to develop a new variety of wheat. "Twinning" arrangements have been developed between individial Canadian research stations and comparable units in developing countries.

Forestry

45. Thirty-five percent of Canada's land area is forest, mostly coniferous, and a large part of it is being commercially exploited. The chief products are lumber, paper, and wood-pulp. Because of this importance, much technical effort has been expended on forest inventories and mapping especially by aerial photography. The expertise thus acquired by private companies, consultants, and government agencies has already been applied in many developing countries. In recent years much use has been made of data from the remote- sensing satellite Landsat, especially for monitoring major changes in land- use or mapping the major classes of forest and vegetation, and to provide base maps upon which details from aerial photography and ground surveys can be entered. Canada has also developed advanced techniques of stereo orthophotography and a very promising system of low-altitude aerial photography which combines the use of 70-mm cameras, a foliage-penetrating radar altimeter, and a gyro device to indicate aircraft attitude at the instant of exposure. This has been tested in several developing countries and can increase the efficiency of any survey of forest resources, agriculture, range lands, or wild-life habitat.

46. Canada has a large and rapidly growing requirement for reforestation, which has proved to be a complicated technical operation requiring a coordinated system from selection of planting sites and collection of seed to the successful establishment of growing stock. Even with recent high-technology developments reforestation tends to be labour intensive, requiring trained and experienced workers. Some of the technological advances include a partly-automated planting machine for seedlings raised in containers and a helicopter-borne aerial cone rake for collection of seeds. Transfer of reforestation technology has proved to be most successful if carried out gradually, not abruptly, and preferably by means of frequent visits to the recipient country by professional and technical experts.

47. Timber harvesting and transportation in Canada has become highly mechanized, evolving from the axe and manual saw for felling, and horses or humans for skidding, through power-operated saws and skidders, to completely mechanized harvesters. Some stages were highly successful while others were costly failures and the lesson once again was that advances should be evolutionary, not revolutionary. For example, a mechanical harvester was

unsuccessful when used under conditions designed for conventional felling and skidding because it introduced a radical new pattern in the system and put unusual demands on the infra-structure and the workers. On the other hand, the Canadian-developed articulated rubber-tired skidder was successfully integrated into the system because it merely replaced horses for skidding. A number of other new devices have been developed, and a new system of cable logging would be of interest to countries with forests in mountainous terrain.

48. Canadian development assistance has been offered in fields ranging from simple forest inventories to multiphasic forestry planning studies. Emphasis has been concentrated mainly on three areas of research: savannah forestry, forest product utilization, and agrisilviculture.

Fisheries

49. During the past 25 years, the Canadian fishing industry has undergone a virtual revolution through the application of modern technology. This is especially true on the Atlantic coast where the industry began two centuries ago based on the artisanal fisherman and where the old practices tended to be firmly embedded. Today there are still many thousands of artisanal fishermen across Canada but using modernized vessels and techniques. Equally important, major sectors of our deep-sea fishing industry are now equal to the most sophisticated and industrialized in the world. These changes were brought about by a deliberate technology-transfer program at the initiative of the Federal government but shared with several provincial governments.

50. In some cases the new technology already existed in Canada but was not universally used. For example, the up-to-date Pacific Coast seining methods were introduced to the Atlantic Coast by bringing a Pacific seiner East to demonstrate the techniques and equipment. In other cases, government experts were pesonally acquainted with the latest methods used in other countries and were able to apply them in Canada.

51. The most interesting cases involved bringing to Canada individual master fishermen or government experts from other countries, sometimes for as long as one or two fishing seasons, to demonstrate their techniques. Typically, a vessel would be chartered on which the foreign adviser would demonstrate and explain his methods in the presence of a government expert as well as the crew of the vessel. On the basis of this experience, the government expert would later offer short courses at a central location for the benefit of groups of fishermen brought in from their local ports. In this way, for example, Scottish fishermen taught seining operations, a German expert helped develop Canadian mid-water trawling, Japanese fishermen assisted in improving cod trapping and Japanese technologists taught Canadians how to process herring roe for the Japanese market. In general, the operation was highly successful, although some adaptation to Canadian conditions was required, some methods proved impractical, and some encountered resistance for various reasons. In many cases the transfer was two-way, as some Canadian techniques proved to be useful to the foreign advisors. In

retrospect it seems likely that the transfer of technology from the government expert would have been better accomplished by the use of extension techniques in the fisherman's own environment rather than by formal centralized courses. Nevertheless, Canada was able to develop its fisheries very rapidly through a planned program of technology transfer from both domestic and foreign sources. Having experienced the process themselves, Canadian experts have already applied it in a number of developing countries. Expertise is available from the Federal and the various provincial governments, universities, fisheries training institutions, the fishing industry, and development assistance organizations. A central register of Canadian experts in fisheries technology is being developed by the Federal government.

52. Domestic fisheries have taken on a new importance with the introduction of the 200-mile exclusive economic zone. This will put demands not only on our capability of harvesting the fish resources in this enlarged area but also assessing and managing them. Canada is prepared to continue to offer development assistance in most of these fisheries-related subjects.

- NATURAL RESOURCES AND ENERGY -

Introduction

53. The pattern of the historical development of Canada's natural resources was set by its geographical and demographical structures. A large, wild and sparsely inhabited country favoured the lone prospector and ambitious entrepreneur. As a result many mineral deposits were discovered after only limited scientific investigation or even by chance. It became obvious that a sound topographical and geological survey program was a pre-requisite to a proper assessment and development of the country's resources. This function, with accompanying scientific research, became a prime concern of government at both federal and provincial levels.

54. Today, Canada's energy and mineral resources are of key importance to the socio-economic development of the nation. The development of energy resources is illustrated by the following production figures for 1977: daily production of crude oil 1.4 million barrels and of liquid propane gas 150,000 barrels; annual production of coal 31.6 million short tons; electrical energy 290 million mega-watt hours and natural gas 25.9 billion cubic feet. Mineral resources in crude or semi-manufactured form accounted for one third ($5.7 billion) of Canada's total exports in 1975. These resource industries account, directly or indirectly, for some 12% of the total labour force.

Application of Science and Technology to non-renewable resource development

55. Canadian experience suggests that the following steps are desirable for the orderly development of a nation's mineral and energy resources: The preparation of the resource information base, the determination of the geological, geophysical and geochemical framework, the estimation of resources, and the commercial exploitation of deposits.

The Topographic Information Base

56. Before any comprehensive and orderly program for the development of non-renewable resources can be instituted, the first requirement is for adequate topographic base maps. One major impact of science and technology (S&T) on topographical surveying in Canada has been to improve the speed with which the essential base maps can be made. The production of these maps requires aerial photographic coverage and the establishment of a geodetic ground central network. The efficiency of the latter, which involves expensive field operations, has been improved by using new types of equipment and techniques including a Doppler Satellite Positioning System, inertial survey systems and electronic distance measuring instruments. Further scientific developments include two systems for the automatic drafting of topographic maps from air photographs.

Determination of the Geological, Geophysical and Geochemical Framework

57. There is general agreement that the progressive development of natural resources in any country depends upon an understanding of the geological, geophysical and geochemical environment. Canadian experience suggests that basic programs aimed at obtaining this understanding are best carried out by government institutions.

58. The Canadian Department of Energy, Mines and Resources carries out research into the configuration, evolution, and dynamic processes of the structural framework of the North American continent, and the hazards associated with natural and induced geophysical phenomena. Canadian earth physicists have considerable experience in conducting the gravity and magnetic surveys, deep crustal sounding surveys, and field studies in paleomagnetism, magnetotellurics and geothermics necessary to establish the fundamental structural framework. Geological surveys exist in both the Federal and various provincial governments.

59. The impact of S&T on these basic activities has not been to change their fundamental nature but rather to provide more sophisticated tools which have specific applications. For example, the advent of the air photograph and more recently the satellite image has provided the geologist with the means of recognizing first order structures and terrain features not always visible at ground level. Important work has been done on the development of remote sensing techniques by the Canada Centre for Remote Sensing, a branch of the Department of Energy, Mines and Resources. Many applications of satellite technology have been developed in the fields of agriculture, forestry and natural resources where the cyclic nature of a satellite borne system provides unique advantages at reasonable cost.

60. In the field of geophysics the continuing improvement of instrumentation for airborne magnetic and radiometric surveying has steadily promoted the use of airborne surveys as a means of acquiring geophysical data over large areas in a short time.

61. There has also been a steady increase in the development of regional geochemical surveys with improvements in analytical techniques facilitating the analysis of large numbers of samples. Techniques being developed in the digitization and computer processing of both geophysical and geochemical data now provide a flexible means of presenting graphically the results of these surveys for the evaluation of mineral and element distribution patterns. Computer programming provides a means of analyzing and ordering the explosive increase in numerical data acquisition which is now taking place.

Estimation of Energy and Mineral Resources and the Development of Commercial Deposits

62. In Canada, the estimation of energy and mineral resources is a concern of the government geological surveys at the federal and provincial levels. Such estimates consider not only the traditional economic and technological factors but also possible impacts due to environmental damage in the production of resources. Liaison with private companies is maintained and reports on exploration work are required by government agencies responsible for licensing and granting of concessions.

63. The commercial development of natural resources, on the other hand, is normally seen for the most part as the responsibility of the private sector with government, at federal and provincial levels, playing a supportive role by conducting, through their laboratories, investigations into mining methods, metallurgy and equipment design. Thus, while encouraging on the one hand the entrepreneurial initiatives required for resource development, the involvement of government S&T facilities ensures, by providing the technical knowledge required for the development of government policies, that such initiatives are undertaken within the context of the socio-economic development of the country as a whole.

The Development of Renewable Energy Resources

64. Total estimated expenditures by the Canadian Government on energy - related scientific activities will be $183.5 million in 1978-79, an increase of $23.1 million over 1977-78. Of these funds, some $13.6 million will be devoted to R&D on renewable energy resources.

65. This funding covers a series of programs underway in various government departments in the renewable energy field. One of these programs involves the search for high temperature water reservoirs in areas of young volcanic belts which may be used for the generation of electric power on a relatively small and local basis - a promising area for the application of S&T potential in a number of developing countries.

66. The National Research Council of Canada has its own energy project office with major programs underway in solar energy, conservation of energy in buildings and wind energy. In the field of solar heating the approach has been to establish a number of solar heated homes in various locations across

Canada with the aim of demonstrating the technology to the public and collecting data on the performance of these systems under a variety of different meteorological situations.

67. Finally, a number of small scale demonstration projects for wind driven generators are also currently in progress in Canada. These include both horizontal axis windmills with power outputs in the 1-10 kilowatt range, and a large vertical axis turbine with a 200 kilowatt capacity now being installed on the Magdalen Islands.

International Development Assistance

68. Although active in most aspects of assistance in resource planning and management, the Canadian International Development Agency, (CIDA)* has traditionally concentrated on the energy sector. Activities in this sector represent some 20% of the Agency's bilateral program and account, together with projects funded through the main international banks, for some $180-200 million (Canadian) annually.

69. While assistance has been provided in such areas as resource inventory preparation - including aerial surveys and interpretation - and the provision of master resource plans, a heavy weighting has been given to the electric power sector. Projects have included the establishment of hydro-electric power systems, thermal generating plants (diesel, gas, coal and nuclear), transmission lines and substations.

70. A major lesson learnt from experience in both domestic and international spheres concerns the fundamental importance of the preparation of an overall national energy strategy including consideration of the socio-economic impact of energy sector projects.

71. A wide spectrum of Canadian S&T expertise in Federal government departments, provincial organizations, the universities and the private sector is used by CIDA to assist in the preparation of energy options for the developing country concerned, to assist in subsequent planning to arrive at the most viable development sequence of the sectors chosen, and to build up the indigenous capability of the developing partner to plan, operate and maintain projects as they come on stream.

- COMMUNICATIONS AND TRANSPORTATION -

Introduction

72. Transportation has been the key to Canadian development. Without these man-made elements little else would have been possible in a country whose landmass is almost 10 million square kilometres. The problem of size goes beyond sheer dimension and distance. Ninety-seven percent of Canada has been repeatedly covered by glaciers within the last million years leaving vast tracts of the country eroded down to bare rock where large-scale, per-

* See paragraph 137 *et seq*

manent human settlement has been virtually impossible. Only seven percent of our land area is suitable for agriculture and thus for the traditional patterns of community life which have taken root in other parts of the American continent. The basic Canadian need, therefore, has been to provide not only the internal arteries of commerce and trade but a network of movement and communication to overcome the sense of remoteness and physical isolation which have been endemic in our society. Canadian nationhood has been not only a political and constitutional experiment but a conscious and planned attempt to forge the physical links of a national identity.

73. The modern era in building the national transportation network began about 1850 with the first attempts to apply the imported technology of the industrial revolution to a pioneer system which consisted of the seasonal use of lakes and rivers and the sporadic construction of military roads which were little better than bush trails.

74. In 1850 Canada possessed 106 km of railway track: by 1974 the figure had increased to 96,958 km. At the present time there are some 405,000 km of roads and highways outside municipal jurisdiction and the registration of all types of motorized vehicles is now in excess of 11,000,000. In 1975 there were 12.5 million telephones or approximately one telephone for every two people in the country. The figures for the ownership of radios and television sets have reached almost 100% of Canadian households. Domestic air transportation now carries 15 millions passengers annually and another 5 million on international routes.

75. This complex of transportation and communication has been built up over a century by a combination of private industrial investment and government agencies.

TRANSPORTATION

76. Canada has established an extensive transportation system over the last one hundred years as part of a planned effort to achieve its national economic and social goals. A large element of this network has been financed by governments in Canada and legislation has been enacted to ensure that control remains in Canadian hands.

77. The technology needed for a modern transportation system has been largely borrowed but Canadian industry has had a major task in adapting both vehicles and systems to the Canadian climate and topography.

78. The infrastructure of Canadian transportation can best be described within the three modes of surface, air and marine.

Surface

79. Railways have played a major role in the political integration, settlement and economic development of Canada. They are partners in multimodal transportation systems designed to move specific products and

containers over vast distances with speed, efficiency and economy. Innovations such as welded track, concrete ties, powerful locomotives, unit trains and comfortable high-speed passenger trains ensure for railways an important role in intercity transportation in the future.

80. A number of ideas have recently been developed through research and have proven applicable to railways. These include a communications system in long trains to replace radio communications, which are not completely satisfactory in tunnels, winding terrain, and in proximity to other trains; guided radar for detection of snow and landslides around curves or over hills, using an electromagnetic surface wave-guide such as coaxial cable; and control of multi- locomotive powered trains to reduce the incidence of coupler failure due to high drawbar pull in long trains. Three types of experimental passenger trains - the LRC (light, rapid and comfortable) which uses present technology, the turbine-driven train, and a more futuristic model based on magnetic levitation principles - could provide ground transportation capable of linking city centres of speeds competitive with air travel.

81. The development of containerized shipments, requiring the cooperation of several modes of transportation and the design of smooth efficient interchange facilities, has been one of the most significant developments for rail freight in recent years. In 1975, 166,417 railway freight cars carried 3,558,082 metric tons of containerized freight.

82. Canada, through CIDA, has completed a number of transport-oriented projects including: a railway improvement investigation in Malaysia which made recommendations for improvement of major crossings enabling usage of heavy and faster locomotives; the provision of materials to developing countries such as steel rails, sleepers, etc; engineering technology for new rail lines, renovations to existing lines, improved rail curvature in Malawi; and refurbishing the major railway system in Bangladesh.

Air

83. The contribution of the aircraft to transportation in Canada has increased sharply and dramatically ever since the delivery of the first pure jet in 1960. This new type of aircraft, larger and capable of much greater speed and range, opened a new era not only for the passenger but for cargo as well.

84. Although Canadian air carriers perform many varied services - including such specialty flying as crop dusting, forest fire patrol, pipeline inspection, aerial survey and photography, construction, and flight training - passenger and cargo transport is by far the most important activity.

85. Canadians have provided expertise to developing countries on master planning and ultimate development of airport facilities of various sizes such as; the extension and improvement of the new terminal at St. Vincent, the new apron facilities at Dominica, the new terminal with facilities at Barbados, and the new main arterial hub airport scheduled to commence construction in the near future at St. Kitts and Antigua.

STOL

86. A pioneer in the development of short take-off and landing (STOL) aircraft, Canada has added a further dimension to the use of such aircraft. In July 1974, Airtransit introduced an experimental city-centre to city-centre commuter service, using 11-passenger de Havilland Twin Otter (DHC-6). A larger and much quicker STOL aircraft requiring only 2,000 feet of runway, capable of transporting 48 passengers at a cruise speed of about 275 miles per hour, has been developed by the de Havilland Aircraft Co. This aircraft, the Dash 7, a four-engine turbo prop, made its first flight on March 27, 1975.

Marine

87. The Canadian Coast Guard is responsible for navigational aids and waterways, ship safety and regulations, pilotage, telecommunications and electronics systems, and the Coastguard fleet. The duties of the fleet include ice-breaking and ice escort, search and rescue, fishery patrol and maritime pollution control.

88. Because of Canada's long coastline, the marine mode has, for years, provided the only means of transportation for numerous coastal villages and remains the principal means of transportation in such areas.

89. Work in the hydraulic laboratory facilities has involved research associated with the movement of large vessels in Canadian waterways including the study and development of navigation standards incorporating the physical aspects of the waterways and vessels using them. Certain major research categories involve; fixed and moveable bed model studies, tidal and non-tidal estuary studies, vessel dynamics and performance, and wave generation and wave related model studies.

90. Canada, through CIDA, has provided small vessels/barges and related equipment for use at seaports and river navigation, and engineering technology on design and construction of new port facilities at Karachi, Pakistan.

Air Cushion Technology

91. Canada, over the past 10 years, has been closely involved in various aspects of air cushion technology to meet some of our difficult and peculiar transportation problems. In particular, we see its application in areas of difficult river crossings, expansion and extension of port facilities, and the carrying of cargo and passengers into areas where the terrain does not permit the use of other types of transportation without vast expenditures on supporting facilities such as roads, docks and airfields. The possibility also exists of using the technology for mineral exploration and mining.

THE ROLE OF TELECOMMUNICATIONS IN DEVELOPMENT

92. The first telecommunication service offered to the Canadian public was the telegraph (1846), followed by telephone (1878), radio telecommunications (1923) and, recently, remote access to electronically stored information and to data processing services. By massive expenditures, Canada has developed a vast and complex telecommunication system which includes everything from landline telegram systems and open wire telephone systems, dating from the turn of the century, to 1985 fibre optics, using among other things microwave, coaxial cable, communications satellites, and "intelligent" digital switching.

93. Canada is now in the process of examining the technical, economic and social aspects of this conglomerate. We are focusing our attention on defining how all this telecommunication technology should inter-relate technically, operationally and institutionally.

94. This examination of telecommunications at the domestic level could mean that one of Canada's contributions to the developing world might be to provide consultative know-how, at the policy as well as programme levels, on how to integrate the range of available technologies into the specific socio-economic priorities of particular nation.

95. On the programme side, some of the Canadian developments which are most relevant to the types of problems faced by developing countries, are the following:

Satellite Technology and Applications

96. Canada has been testing specific applications for the delivery of vital community services. In particular, it has been examining the delivery of public services such as tele-medicine, tele-education, community development and administration, to remote areas through the Communications Technology Satellite (Hermes) and the Anik-B Satellite, which is to be launched late in 1978.

Switching Systems

97. Canada has begun examining the integration of advanced digital transmission and switching systems with antecedent analogue and wide line plant. This experience would be useful to developing countries wishing to modernize their systems.

Remote Sensing

98. A major application of telecommunications technology to development is the use of airborne or satellite-borne imaging radar. This technique permits wide-area mapping of geographic areas which, because of such features as forest cover, lack of roads or difficult terrain, are impenetrable or inaccessible using other techniques such as aerial photography or ground surveying. Some of the developing countries have already made arrangements to have their territories extensively surveyed using airborne imaging radar.

Development Assistance

99. In the field of telecommunications, assistance programmes have not, so far, been a main separate sector of concentration. However, there have been substantial allocations in response to individual bilateral requests from developing countries for telecommunications assistance and also multilaterally as a response to project proposals of the International Telecommunications Union, (ITU). Allocations to telecommunications projects have amounted to about $90 million over the last five years and have included both hardware and technical assistance. In addition, CIDA's contribution to telecommunications development through multilateral agencies such as the UNDP amounted to about $17.2 million.

100. The largest project now being implemented by Canada is the design, engineering, supply and installation of about 3,000 kilometres of microwave radio links which will extend, as part of the PANAFTEL network, over five countries - Mali, Senegal, Upper Volta, Niger and Benin.

101. Canada has also provided communication satellite earth stations in India, Pakistan and Bangladesh. These facilities have had a remarkable effect on upgrading the efficiency of international communications for all three countries.

102. Radio and television broadcast equipment have been supplied to several countries, including an educational television project for the Ivory Coast.

103. The provision of training, workshops and specialists have been important parts of Canada's telecommunication assistance programme. About $19 million has been spent on technical assistance over the last five years.

104. In common with other development assistance agencies, CIDA's hesitation to concentrate a large portion of its funds in the telecommunications sector results from a lack of real knowledge about the impact of telecommunications on economic and social development. CIDA is now involved with the Canadian Department of Communications and the ITU in studies which will lead to a better understanding of the quantifiable links between telecommunications and development. If the results prove positive, Canada's telecommunications assistance program may be substantially increased.

INDUSTRIAL SCIENCE AND TECHNOLOGY

Canada's Industrial Growth

105. For a period of three hundred years following the establishment of a European presence in what is now Canada, the majority of the tools and supplies needed by the populace were imported first from France and then from Britain. In exchange for these imports, the original settlers exported animal furs, fish, timber, etc. Gradually, however, attempts were made to

produce these goods in Canada and by the beginning of the nineteenth century domestic manufacturers were supplying an increasing proportion of the tools and equipment needed by Canadians.

106. In 1879, the Federal government adopted a "National Policy" which called for completion of a railway line from the Pacific Ocean to the Atlantic Ocean, intensive efforts to populate the largely unoccupied lands in Central Canada and tariffs on imported goods. Thus, the policy was designed to increase the size of the domestic market, improve transportation between the major population centres of the country and stimulate domestic manufacture of the goods required by Canadians.

107. During the twentieth century, steady growth in the size of the domestic market and the demands of two major wars resulted in a rapid expansion in Canadian manufacturing capability. This was effected in part by the development of indigenous technology but also to a great extent by the importation of foreign technology and the establishment of manufacturing plants in Canada by foreign companies.

108. An indigenous supply of raw materials and energy, a constant flow of immigrants from the industrially developed parts of Europe, and close proximity to, and trade with, the United States have resulted in Canadian industrialization keeping pace with activities in other developed countries. There are, however, two important aspects of Canada's industrialization history worth emphasizing. First, Canada's secondary manufacturing industry was established to meet the needs of the domestic rather than the export market. Second, the sheer physical size of Canada has demanded a steady stream of major construction projects associated with railroads, highways, waterways, airports, hydroelectric plants, telecommunications, etc. As a result, Canada has developed consulting engineers, construction firms and manufacturers with the competence and experience to undertake major construction projects in any part of the world.

109. The Canadian industrial scene has companies ranging in size from the very small to the very large including a number of multinational corporations, e.g. Bata, Massey-Ferguson, Alcan, INCO, Northern Telecom. The inflow of foreign investment into Canada, however, has resulted in a high proportion of Canada's total manufacturing sector being foreign controlled. Thus, in 1974, 57% of the value of Canadian manufacturing output was produced by foreign controlled companies.

110. Such foreign control sometimes results in Canada's comparative advantages not being optimally exploited and companies not developing a complete range of corporate activities. Thus, foreign-controlled firms in Canada are often not encouraged or permitted by their home office to assume responsibility for the development and world-wide exploitation of specific products. Instead, they are limited to adapting the wide-ranging technology of parent firms for exploitation on the Canadian market only.

111. Nevertheless, attracting foreign investment continues to be a priority for the Canadian government for it has played a large role in developing Canada's manufacturing base and in providing employment. Foreign investment has in addition led to an inflow of technology from foreign parent firms into Canadian subsidiaries. Such subsidiaries receive technology from the parent firm in the form of drawings and plans, or access to advice on a personal basis for which there is no explicit expenditure. Technology transfer is also facilitated by the importation of new production machinery developed by the parent firm. A recent study estimated the value of these invisible inflows of technology in 1976 to be $600 - $700 million.

112. The Canadian government is concerned to ensure that foreign investment continues to provide appropriate benefits to Canada and has established the Foreign Investment Review Agency, (FIRA), to ensure that this occurs. As part of its existing mandate FIRA has been requested to place particular emphasis on assessing the scientific and technological component of a potential foreign investment when determining whether there is significant benefit to Canada.

Industrial R&D

113. Increases in knowledge and technological advances are an important factor in improving productivity and enhancing economic growth. Studies have indicated that, on average, R&D as an investment outperforms other investments in the private sector, not only in terms of return to the investor, but also in terms of benefit to society.

114. It is estimated that for 1977, approximately $1.9 billion was spent on R&D in Canada which represents about 0.9% of GNP. This percentage is low in comparison with figures for other developed countries. With regard to industrial R&D, it is estimated that for 1977, 34.9% (i.e. $670 million) of the Canadian R&D effort will be funded by industry and that 44.2% (i.e. $850 million) will be performed by industry. Although the amount of R&D performed by industry has increased significantly in absolute terms (from $129 million in 1961 and $471 million in 1971), its growth since 1971, measured in constant dollars, has been small. This under-investment in industrial R&D may be partially attributable to the high degree of foreign ownership of Canadian industry.

115. A number of measures have been taken by the Canadian government over the years to encourage R&D in Canadian industry. The laboratories established by the National Research Council have done excellent work in both the scientific and the technological areas and have been of considerable assistance to Canadian manufacturing companies by providing technical advice and resolving difficult technical problems. Provincial Governments have established research organizations to serve the needs of industry in their individual provinces and the larger companies have also established R&D facilities.

116. In a few instances, cooperative research organizations have been established to meet the needs of specific industrial sectors, e.g. pulp and paper, welding, natural gas. Financial assistance was provided by the

Canadian Government to establish these research associations, but their ongoing operation is supported by companies in the specific industrial sectors which wish to avail themselves of the expertise and facilities the research associations offer.

117. Since the 1960's, a number of fiscal measures have been introduced by the Federal Government to encourage R&D in Canadian industry. These are:

First: the discretionary shared-cost programs administered by the Department of Industry, Trade and Commerce and by the National Research Council. Together it is estimated that this group of programs will contribute about $80 million to industrial R&D in the coming year. These Programs tend to help established, medium-sized firms embark on projects that have a clear prospect of commercialization.

Second: government R&D contracts awarded to industry are estimated to reach about $130 million in 1977-78. These contracts reflect the government's Contracting-Out Policy introduced in 1973 for new R&D requirements and recently extended to most science requirements. Contracting-Out does not represent an additional government expenditure, since the government has an R&D requirement which must be paid for whether it is performed in-house by public servants or contracted to industry.

Third: the government has introduced tax incentives to encourage companies to carry out R&D. Thus, when calculating taxable income, a company may deduct from earnings the actual R&D expenditures incurred during the year plus 50% of the amount by which current R&D expenditures exceed the average R&D expenditures incurred in the previous three years. Also, depending on its geographical location in Canada, a company may claim a tax credit of from 5% to 10% of its annual R&D expenditures.

Technology Transfer from Canada to Developing Countries

118. In Canada, as in other Western countries, most of the information on industrial processes, product design and industrial know-how is contained in the private sector. Clearly the private sector has a vital interest in providing information to potential customers in both developed and developing countries. This is done through commercial advertising, trade fairs, sales drives and with the help of the Trade Commissioner Service. There is however, no formal mechanism existing in the private sector directed towards developing countries as a group, although there may be regional offices catering mainly to developing countries, e.g. in Latin America. In the public sector it is the Canadian International Development Agency, (CIDA), which acts as the prime mechanism for assisting in the transfer of technology to developing countries.

119. By means of a program which shares the costs of pre-feasibility and feasibility studies, CIDA supports Canadian firms in their exploration of specific joint venture investment opportunities in developing countries. Joint

ventures are particularly encouraged since they represent a continuing involvement of the Canadian company in the technical, managerial, financial and marketing aspects of the project. The program requires that an applicant company fulfill certain criteria which indicate that an investment would be of social and economic benefit to the host country and be acceptable to the host government. It assists only studies of new entreprises or the expansion of existing enterprises into new fields. The applicant must be an established Canadian firm which has a demonstrated competency in a particular field and which has adequate resources available for investment.

120. CIDA also provides information to Canadian industry and firms interested in investing in developing countries. It has sponsored investment promotion missions in Canada introducing developing country investment mission groups to Canadian industry at meetings in cities across Canada. At such meetings developing country groups are able to investigate Canadian technologies while prospective Canadian partners have the opportunity to learn more about investment climates in the developing countries.

121. Finally, specific requests by developing country firms for Canadian partners are matched through an active roster of Canadian firms which have indicated interest in such partnerships. CIDA is only responsible for initial contact in such requests but successful matches may lead to applications under the feasibility study program.

SCIENTIFIC AND TECHNICAL INFORMATION

Introduction

122. The supplying of scientific and technical information (STI) to users in Canada is made difficult by such factors as a small population distributed over large distances, a pluralistic society with two official languages, multiple levels of government, and the need for an industrialized country to maintain coverage of virtually all fields of S&T while itself producing only some 3 percent of the world's output. No matter what exact definition may be chosen for STI, it is clear that maintenance of an adequate and up-to-date data base must be an important part of Canadian scientific and technological activities. Within the federal government alone, about $100 million was spent on scientific information services in 1977-78 out of a total budget of $1664 million for scientific activities of all kinds. For the most part these STI activities are elements of broader programs, contributing to such activities as training of highly qualified manpower, regulatory functions, resource management, defence, and support of industrial technology, as well as scientific research in general.

123. In developing mechanisms for the collection and delivery of STI in Canada, the emphasis is on practical tools and services rather than explicit policies. The importance is recognized of interdependency and cooperation, both domestic and external.

STI Organizations

124. Because Canada is largely dependent on knowledge published elsewhere, we are accustomed to drawing on the world's science literature through libraries and related systems and services. Foremost among these is the Canada Institute for Scientific and Technical Information (CISTI), which holds our largest collection of STI - over one million volumes. CISTI is part of the National Research Council of Canada, which operates the Federal government's largest multi-disciplinary R&D laboratories. It carries primary responsibility for providing national STI services and related support, and is specifically charged with building up a national network of STI services. (General bibliographic matters of national scope are the particular responsibility of the National Library of Canada).

125. The strength of CISTI is in the natural sciences and engineering, complemented by other federal collections of national stature such as those of the National Library in the social sciences and humanities, of the Geological Survey of Canada, and several others. Additional scientific and special libraries have grown up over the years in response to institutional needs, and there is a great degree of cooperation and interdependence in matters such as inter-library loans. To aid this process CISTI maintains a Union List of Scientific and Technical Serials in Canadian Libraries. Specific examples of this type of cooperation include the network of 26 branch libraries of the Canada Department of Agriculture located across the country, at the hub of which is the headquarters library in Ottawa. The network of cooperating university libraries in Ontario and Quebec is an additional example.

126. This type of domestic rationalization and cooperation might commend itself to developing countries. It is equally applicable to more specialized data collections, such as the national index to sources of geoscience data and the provision of a supporting referral service by the Centre for Geoscience Data, part of the Canadian Department of Energy, Mines and Resources, or the Water Resources Document Reference Centre operated by the Department of Fisheries and the Environment.

127. Increasing use is being made of various computerized data-bases that are available commercially, such as INFOMART and QL Systems in Canada, or Lockheed's Dialog, which provide rapid and effective bibliographic search services.

Systems Development

128. CISTI has pioneered the development of a number of innovations in systems and services for bibliographic search and retrieval appropriate to broad national needs. A prime example is CAN/OLE (Canadian On-Line Enquiry), now widely used in Canada and well-known internationally. At present over five million citations from eight data-bases can be accessed, in either French or English, through some 240 communications terminals across the country. It is not only a bibliographic search system but also a location tool and a national directory of subject expertise.

129. Another CISTI Development is CAN/SDI (Selective Dissemination of Information), which has been of particular interest abroad. CAN/SDI enables large bases to be searched regularly and printed citations in very specific subject areas to be printed out for particular individuals. With the aid of CISTI expertise, the system is now operational in nine organizations of seven countries. Technical and educational assistance has been provided to build up national SDI services in Argentina, Indian and Mexico.

Assistance to Industry

130. In 1945 a Technical Information Service (TIS) was formed within the NRC. TIS resembles an agricultural extension service but is oriented to the needs of small and medium manufacturing industry, where there are few or no technical staff or resources. Through a network of field offices, many operated in conjunction with provincial organizations, it provides technical information to help solve their manufacturing problems, improve productivity, identify opportunities resulting from technological development, and promote the use of research results in industry. With its three decades of operating experience, TIS has been a model for similar schemes in a number of other countries. Individuals have come to TIS for training from five developing countries and consultants have been sent to assist in the planning of similar services in several other countries. A particularly interesting example is TECHNONET-Asia, consisting of eleven institutions in nine countries in south-east Asia and nearby. Planning began in 1972, a commitment of more than $3 million over a seven-year period being made by the International Development Research Centre* and with technical advice and assistance being provided by TIS.

External Links

131. Because of Canada's significant dependence on knowledge generated elsewhere, particular attention has to be paid to external channels for the purchase or exchange of STI. For example, to ensure that the National bibliographic data-base is in a form capable of interfacing with foreign services, the National Library has developed standards and tools like Canadian MARC (machine-readable cataloguing) and magnetic tape distribution service, designed with this compatibility in mind. The Canadian MARC offers services in both french and english.

132. It is obvious that there are many foreign STI systems, both private and public, which can meet the needs of our scientific community, but where Canadians have little or no influence over their management, control and pricing. For this reason we are watching with particular interest the development of cooperative international information systems such as INIS, the International Nuclear Information System, where participating countries supply new information from within their territory for merging into a common data-base, which is then supplied to members as magnetic tapes or in printed form. It is hoped that similar success will be achieved by AGRIS, FAO's information system for agricultural S&T. In this area we also rely heavily on a different type of internationally-directed STI system, that of the

* The International Development Research Centre - see para 143 et se

Commonwealth Agricultural Bureaux (CAB), of which Canada has been a member for 50 years. The CAB provides a data-base covering the world literature in agriculture, forestry and nutrition, using its own professional staff but managed by Commonwealth countries.

133. Canada views with particular interest such cooperative international efforts to attain wider accessibility and to develop mutually beneficial STI systems, and believes that they should be encouraged. However, mechanisms are needed to set priorities, coordinate initiatives from various international organizations, eliminate overlap, and ensure compatibility of system design. Canada has welcomed the activities of the UNISIST program of UNESCO and of the International Standards Organization in their efforts to harmonize such developments and ensure that systems can be inter-connected. A mechanism is needed however, to ensure that the initiatives of all agencies are reviewed so as to enable the broad priorities of member states to find expression; possibly the most logical focus is within the committee structure of UNESCO's General Information Programme.

SECTION THREE

- CANADA'S DEVELOPMENT ASSISTANCE PROGRAMS -

134. Before 1960 Canada's development assistance program was administered by the Department of External Affairs and, to a much lesser extent, by the Department of Trade and Commerce through the latter's Economic and Technical Assistance Bureau. In 1960 that Bureau's functions were transferred to External Affairs and an External Aid Office was established which in turn, in 1968, became the Canadian International Development Agency (CIDA).

135. The initial approach to development assistance placed an emphasis upon building up the physical infrastructures of developing countries and providing extensive training and education for their students. By the late 1960's an additional need for further strengthening the indigenous capabilities of the developing countries in the science and technology (S&T) area had been identified as a major concern. In 1970 therefore, the International Development Research Centre was established with the mandate, simply stated, to support research for the developing countries, by the developing countries and, where possible, in the developing countries.

136. In 1975, the last year for which comparative data is available, Canada and Sweden led the OECD countries in the share of gross national expenditure on R&D devoted to the problems of less developed countries with 2% of expenditures going to that purpose. The bulk of this funding is provided through CIDA and IDRC.

Canadian International Development Agency (CIDA)

137. CIDA is the official government channel through which development assistance is offered to developing countries. The Agency's funding has almost tripled since 1970, reaching $1.1 billion in 1977-78. About half of

this was spent through the bilateral channel in 1976-77 ($478 millions) including economic, food, technical and energy assistance to approximately 80 developing countries in Asia, Commonwealth and Francophone Africa, Latin America and the Carribbean. $417 millions was disbursed through the multilateral channel, including contributions to the World Bank, regional development Banks, United Nations agencies, Commonwealth and Francophone programmes, and international food aid channeled through the World Food Program. A further $69 millions was spent on several special programmes, including $38 millions in matching grants to numerous Canadian non-governmental agencies.

138. Almost all of CIDA's programmes contain some element of technology transfer either directly in the various forms of technical assistance provided and research programmes funded, or indirectly through the provision of capital equipment. In terms of technical assistance as an example, about 1,600 Canadian advisors and educators were serving overseas in 1976. Over 1,400 students and trainees were taking courses in Canada and another 648 were studying through Canadian scholarships in "third country" institutions located near their homelands.

139. In terms of support to the scientific and/or technological programs more strictly defined, CIDA estimates its spending as approximately $27.6 millions in 1977-78. Examples of the kinds of projects supported bilaterally include two wheat production pilot projects in Tanzania and Zambia, a rapeseed farming project in Peru projects concerned with the protection of vegetables in Niger, Mali and Upper Volta, and a project aimed at improving farming methods in the drylands of India. Also under its bilateral programme the Agency is encouraging interest in a different approach to the use of energy sources, such as wood and charcoal, and is looking at the benefits of alternate energy forms e.g. biomass, windpower and solar converters.

140. In carrying out these projects CIDA makes extensive use of Canada's domestic S&T capability and in particular the universities, no less than 20 of which having been involved to some degree in the Agency's program over the last decade.

141. CIDA's multilateral programmes contain, as an important element, support for international research centres reflecting the value of potential perceived for these centres as mechanisms for focussing scarce scientific resources on major problems of concern to a number of developing countries. The bulk of this support ($5.15 millions in 1976-77) has been for agricultural research, through the Consultative Group on International Agricultural Research.

142. Since 1976 CIDA has contributed to research programmes of the World Health Organization (WHO), including those on malaria, and other widespread tropical parasitic diseases, and on human reproduction.

International Development Research Centre

143. The International Development Research Centre (IDRC) is a public corporation established in 1970 by the Canadian parliament to promote the use of scientific and technological research as a means of providing solutions to

the social and economic problems of developing countries. As far as is known, it was the world's first aid organization set up specifically to support research projects identified, designed, conducted and managed by developing country researchers in their own countries, in terms of their own priorities.

144. The IDRC is unique among Canadian public agencies in having its policy set by an international and autonomous Board of Governors, whose members include representatives of developing countries.

145. Under the IDRC ACT, the chairman, vice-chairman, and nine other members of the 21-member Board must be Canadian citizens; the other 10 are non-Canadians. The Board is appointed by the Canadian Government, and all funds come from a parliamentary grant (last year's (1977) was $34.5 millions.)

146. The IDRC attempts to respond to a need first formally articulated by the 1963 United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas. One of the themes of that conference was the need for "research specifically designed to produce new applications of special interest to less developed countries".

147. Early studies showed that 98% of all research and development, (R&D), outside the socialist world was performed by the industrialized countries, with only 2% taking place in the LDCs. In terms of GNP, the industrialized countries devoted between 1 and 3% to R&D, the less-developed countries, 0.2%.

148. In addition, much of the R&D conducted in developing countries was either carried out in fields with little relevance to the needs of the majority of their people, or duplicated research engaged in by industrialized countries to meet their own specific problems. In other cases, it was even detrimental to the interests of the LDCs -- as where it dealt with synthetic fibres which would compete with their exports.

149. The need for a greatly expanded effort in R&D for development was obvious if the developing countries were to gain some competence to pursue their own needs and priorities. The IDRC was the Canadian government's answer to this need.

150. The IDRC supports research primarily in areas that directly affect the day-to-day lives of the majority of people in the Third World: the rural poor. These people have also usually been the last to benefit from the advantages of science and technology. The Centre's activities are carried out by five program divisions:

> The Agriculture, Food and Nutrition Sciences Division emphasizes research on crops, farming systems and reafforestation in arid and semi-arid lands. It supports research on various food crops, agroforestry (the combination of trees with food crops), multiple

cropping systems, use of agricultural wastes and by-products, post-harvest systems, fish farming and shell-fish culture.

The Health Sciences Division concentrates on four program areas: basic health services, including care delivery and traditional health workers; biological and environmental control of some major tropical diseases; studies of techniques to improve water supply systems and sanitation in squatter settlements and rural areas; and studies of more effective methods of fertility regulation and family planning.

The Information Sciences Division cooperates with U.N. agencies to establish worldwide information services with the participation of developing countries, and supports projects aimed at improving industrial extension services and creating centres supplying specialized information on subjects of interests to developing countries. It also supports research related to communications problems in developing countries, library services development and map-making, especially from earth satellite images.

The Publications Division disseminates the results of IDRC-supported research through a wide range of scientific and general publications and audiovisual material. It also supplies articles on S&T to the media in developing countries, and research is supported that is aimed at devising media suited to linking scientists with rural people.

The Social Sciences and Human Resources Division is primarily concerned with helping rural people in transition from a traditional to a modern way of life. It focusses on studies that aim at balanced or harmonious development between city and countryside. The Division supports the formation of appropriate S&T policies, investigation of the most effective means of delivering rural primary education, and research into the determinants of population range. Its Human Resources Awards Program aims to broaden the resource base of Canadians and developing country scholars trained in problems of development.

151. In early stages of project formulation, Centre professional staff help developing country institutions (such as government departments, universities, and research centres) to fit their research proposals into this divisional framework. Every project proposal is then reviewed by the Centre's professional staff, and assessed in the light of factors such as:

National priority: Does the proposal fit into a priority expressed by a government or research institute in a developing country?

Regional applicability: Are the research findings likely to have useful application over a region and in countries beyond the one in which research takes place?

Practicality: Will the research help close gaps in living standards in those countries, and lessen the imbalance in development between rural and urban areas?

Local resources: Will it make the fullest possible use of local resources and research workers from the region?

Research training: Will it result in better trained and more experienced researchers, and more effective research institutions?

Research area: Does it fall within the IDRC's areas of concentration?

152. Once projects are approved, each program division channels funds to the institutions involved. In every project, the local institution is expected to pay a portion of local costs. Payments are made according to a contract entered into by the Centre and the developing country institution concerned.

153. While concentrating on projects that develop the research capabilities of the countries proposing them, the Centre has also stressed the coordination of research across national boundaries and between developing regions, through the creation of research networks. For example, teams in 10 countries, from Argentina to Yugoslavia to India, are studying how S&T policies can make the greatest use of local skills and derive the most benefit from imported technology, particularly in large and medium scale industry.

154. The Centre has also provided funding for research in the world-wide network of international research institutes, such as the International Rice Research Institute in the Philippines. Recently, it played a key role in establishing two new international bodies, the International Centre for Agricultural Research in the Dry Areas (ICARDA), and the International Council for Research in Agroforestry (ICRAF). These institutions are aimed at filling vital gaps in the research capabilities of the Third World.

155. The Centre also fosters cooperation between developing country researchers and Canadian and other institutions in developed nations. Last year, for example, Asian scientists, supported by Canadian expertise and using a hormone extract from British Columbia salmon, succeeded for the first time in breeding milkfish in captivity, thus opening up the possibility of greatly increased protein supplies for Asia.

156. Finally, the IDRC contributes funds toward research in specific areas such as tropical diseases and contraceptive technology, which is conducted through other international agencies, such as the World Health Organization, and private foundations, such as the Ford Foundation. These programs make use of the best available scientific talent in the world, furthering basic knowledge in areas of value to developing countries.

157. The validity of the Centre's approach as an agency that grants funds to developing countries for research by their own nationals into problems they themselves identify as important, has been amply confirmed since the IDRC's inception in May, 1970. Not only has the budget grown steadily from an initial grant of $1 million for the first year to the present level of nearly $40 million, reflecting increasing acceptance and requests from developing countries, but the concept has been increasingly regarded by other developed countries as a model to be exemplified.

Voluntary Agencies

158. In 1976, over 253 Canadian non-government organizations, (NGO), were involved with CIDA financial assistance, in more than 968 projects in 98 countries. The value of the projects was over $125.9 millions (Canadian) of which CIDA provided $38.1 millions in the form of grants designed to match the cash raised by these organizations. Further matching contributions totalling $6.65 millions were made by four provincial governments. Canada has found this concept of matched funding to be very effective and the projects conceived by the NGOs to be among some of the most innovative of the whole assistance program.

159. Many of the projects undertaken by NGOs are technological in nature or have research components. Examples include the work on solar energy applications, appropriate technology and food technology undertaken by such organizations as the Canadian Council of Churches, the Brace Institute, the Canadian Hunger Fund and the Mennonite Central Committee.

160. A further substantial - though often not very visible - contribution to international assistance is made by the scientific and engineering associations of Canada, many of which having affiliations to larger international bodies. The Canadian National committee for the International Council of Scientific Unions (ICSU) is a case to point. Operating on a very modest budget this organization is able to secure the voluntary services of outstanding scientists in many countries, including Canada, and amongst other very useful activities provides valuable scientific advice to such bodies as UNESCO, WMO and FAO.

Other Government Programmes

161. In addition to IDRC and CIDA a number of Federal government departments have become involved in international development activities in the S&T sector. For example, the Departments of Energy, Mines and Resources and Agriculture Canada have provided technical experts for CIDA projects in a number of developing countries. In the agricultural field research has been carried out on several major projects, among them agricultural development in Zambia, a soil survey and wheat production project in Tanzania, dryland farming in India and Sri Lanka, training of wheat breeders in Brazil and soil surveys in Malaysia.

Future Possibilities

162. Canada believes that through the various forms of assistance provided, a useful contribution has been made in the S&T area towards strengthening the indigenous capability of the developing countries. We are, nevertheless, conscious of the evolutionary nature of development assistance and therefore welcome the opportunity offered by UNCSTED to examine other initiatives which would further enhance the application of Canada's S&T capabilities to international development cooperation.

163. Among initiatives currently underway are studies aimed at seeking new strategies and mechanisms for enhancing the application of Canada's domestic S&T capabilities to international development assistance including considerations of an enhanced involvement of Canadian universities. A major emphasis in these studies is being placed upon the potential of a cooperative R&D approach to selected problems of mutual concern to both Canada and certain developing countries.

CONFERENCE PREPARATIONS

164. Canada views this national paper as but one early component of the widespread national activities and studies just getting underway - activities which it is hoped will enable us to contribute substantially as the Conference preparations develop.