DEPARTMENT OF REGIONAL INDUSTRIAL EXPANSION

OFFICE OF INDUSTRIAL INNOVATION

# TECHNOLOGY ASSESSMENT DIRECTORATE

# TECHNOLOGY PORTFOLIOS

October 1984

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## FOREWORD

The purpose of this booklet is to introduce the Technology Assessment Directorate of DRIE's Office of Industrial Innovation, outline its role and objectives, highlight how it has begun to address its task, and seek advice and comments.

The document provides a compendium of the technology portfolios prepared during the first six months of the Office's existence. Each contains a preliminary overview of the technology and the plans each officer has for both gaining a better understanding of it and building consensus on what needs to be done if Canada is to fully exploit the opportunities presented.

Only selected key technologies are covered in this overview. Technologies for which there is already a clear focus within the Department or elsewhere have been omitted from the Directorate's purview.

Given the rapid evolution of the emerging technologies under review, it is intended that the portfolios be updated annually, that all the major achievements for each technology portfolio be highlighted in the subsequent editions, and that the workplans will be modified. From time to time new technologies will be added, and, as those currently under review mature, some will be deleted.

The officers responsible for the technology portfolios contained in the document are:

| | |
|---|---|
| Advanced Industrial Materials | - Jacques Boulakia |
| Advanced Manufacturing Technologies | - Louis Giroux |
| Biotechnology | - Chummer Farina |
| Health Care Technologies | - Louis Giroux |
| New Computing Technologies | - Alain Letendre |
| Sensors and Instruments | - Chummer Farina |
| Photonics | - Chummer Farina |
| Information Technologies | - Alain Letendre |

They can be reached at (613) 995-3741 and look forward to responding to your enquiries, comments and advice.

Anthony M. Stone
Director
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Office of Industrial Innovation

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## 1.0 THE TECHNOLOGY ASSESSMENT DIRECTORATE

The Technology Assessment Directorate is a division of the recently created Office of Industrial Innovation (OII) in the Department of Regional Industrial Expansion. The OII is currently the focal point within the Department for strategic planning of policies and programs in support of technological development, innovation and the diffusion of innovations.

The Technology Assessment Directorate has three specific roles. The Directorate plays a special role in the area of Advanced Manufacturing Technology through, for example, its support for the CAD/CAM Technology Advancement Council and through its co-sponsorship of the Steering Committee of the National Manufacturing Technology Information Centre. The Directorate also performs a role in support of the technology transfer and innovation diffusion activities of the Office of Industrial Innovation through the communications related activities of its Technology Transfer Services Section which provides coordination and liaison services in this area.

The primary role of the Technology Assessment Directorate is the collection of intelligence on technological developments in Canada and abroad and the assessment of the implications of these developments for industrial development in Canada.

Principal sources of domestic technology intelligence for this unit currently consists of the departments' Industry Sector Branches and Regional Offices, other federal departments, agencies and laboratories, provincial governments, provincial research organizations, industry associations, and industry and universities. The Technology Assessment directorate is also engaged developing windows on foreign technological developments, through the participation in, and monitoring of international S&T organizations, the development of a close liaison with External Affairs, the focused use of the science counsellor network and the acquisition of foreign technological information services and sources.

The primary intelligence requirements of the unit are related to current and emerging technological developments, sources of technology, rates of diffusion, potential applications, markets and the ability of Canadian firms to exploit and develop new technologies.

## 2.0 KEY TECHNOLOGIES

Technologies of interest to the Office are of two types. The first, emerging technologies, are of longer-term industrial importance and are horizontal in nature, cutting across the interests of several industrial sectors. For these, a major output of the Office will be a status report which highlights international trends in the technology, its application or government policies and programs for its support.

The second, networking technologies, are of near-term industrial significance and consequently many departments are involved in the field at the present time. The issue to be addressed in these areas is one of providing a focal point within the department for involvement with other departments including interdepartmental committees and working groups.

The key technologies selected for assessment have been identified on the basis of the following criteria:

a) Diversity of Impact

Technologies affecting a large and diverse number of industries are of higher priority.

b) Potential for Canadian Industrial Development

Technologies where Canada has existing capability, or the basis for developing that capability, are of higher priority.

c) Economic Importance of the Sector Affected

Technologies having major impacts on industries who play a major role in the Canadian economy are of a higher priority.

d) Regional Impacts

Technologies affecting a number of regions, or technologies which will assist in addressing regional disparity issues, are of higher priority.

e) Government Policies

Technologies identified in federal policies and program as requiring special attention are of a higher priority.

f) Departmental Mandate

Technologies which affect industries within the purview of the department's mandate are of higher priority. Those technologies in which other departments have the central role to play are of lower priority.

g) Focal Point for Information

Technologies where there is a recognized need within the department for a focal point for information and coordination of activities with other departments are of a higher priority.

h) Consensus

Technologies where there is an emerging consensus among national and international groups that this technology is of long-term importance are of high priority.

## 2.1 Emerging Technologies

Seven areas of emerging technology are monitored by the Technology Assessment Directorate. These are:

a) Advanced Industrial Materials

- to include advanced metallic materials, new ceramics, composites, organic and high polymers and material treatments.

- selected because of its diverse impact, its potential threat to Canadian resource-based industries, international recognition of the importance of the field and the central role of affected industries in departmental activities.

b) Advanced Manufacturing Technologies

- to include CAD/CAM, flexible manufacturing, robotics and advanced material handling and processing.

- selected because of its diverse impact, international recognition of the importance of the field, the need for a focal point for information and coordination of activities, the economic importance of the industries affected and the central role of affected industries in the department's activities.

c) Biotechnology

- to include waste treatment, cellulose utilization, human and animal health care products and, to a more limited extent, nitrogen fixation and mineral leaching.

- selected because of its diverse impact, the economic importance of the sectors affected and stated government policies.

d) Health Technologies

- to include diagnostic equipment and drugs, instruments, and information systems.

- selected because of the economic importance of the sector and the potential for Canadian development.

e) New Computing Technologies

- to include chip design, new computer architecture, artifical intelligence and fifth-generation computers, and applications such as vision systems, natural language processing and expert systems.

- selected because of its diverse impact, the potential for medium term Canadian industrial development and potential for productivity gains throughout all sectors.

f) Photonics

- to include their applications in medical equipment, industrial automation and information systems.

- selected because of its diverse impact, the potential for Canadian development and international recognition of the importance of the field.

g) Sensors and Instruments

- to include microsensors, testing equipment and monitoring devices.

- selected because of its diverse impact, the economic importance of the sectors affected and international recognition of the importance of the field.

2.2 Networking Technologies

The Directorate provides the focal point within DRIE for three areas of technology:

a) Energy Technologies

- to include energy conservation, new energy sources and new liquid fuels.

- selected because of the economic importance of the sector, the potential for Canadian development and the need for a focal point within the department for coordination of our activities with those of other departments.

b) <u>Information Technologies</u>

- to include computers, micro-processors, peripherals such as storage systems, input/output devices, software and applications such as in office environments.
- selected because of its diverse impact, the potential for Canadian industrial development in the field and the need for a focal point within the department for coordination of our activities with those of other departments.

c) <u>Oceans and Arctic Technologies</u>

- to include northern engineering, northern transportation, ocean platforms and advanced vessel design.
- selected because of stated government policies, the potential for Canadian development, and the need for a focal point within the department for coordination of our activities with those of other departments.

## 3.0 APPROACHES TO TECHNOLOGY ASSESSMENT

A rich variety of technology assessment methodologies are currently available with the most appropriate for any given situation being dependent on such factors as objectives, audiences, resources and time frame. The assessments performed by the Technology Assessment Directorate are aimed a enhancing awareness of commercial opportunities in emerging technologies and providing background information for policy development. As such, the approach to assessments places heavy emphasis on process including developing networks of interested individuals, linking potential users of technology with developers and encouraging the development of an environment conducive to the further development of technology. Thus, although a variety of assessment methodologies are used by the Technology Assessment Directorate (including delphi, diffusion, patents and citations), a **participatory approach** is a central element of all assessments.

Assessments of all technologies will also have a strong international component. Emphasis will be placed on obtaining and assessing information on technological developments and policies in support of technological development in other countries.

## 4.0 OUTPUTS

The outputs of the Technology Assessment Directorate are directed at the policy and program activities of the Office of Industrial Innovation and the Department of Regional Industrial Expansion as well as the S&T related activities of other federal departments and agencies and the Provinces. The unit will also play an important role in promoting greater awareness in Canadian industry with respect to new technological developments and their application.

The major output of this group will be situation reports on the emerging technologies enumerated above. These reports will provide up to date information and analysis related to international and domestic developments in these technology, their applications, market impacts and government programs supporting their development.

Detailed business plans which provide a comprehensive overview of the reports to be developed follow. Guidelines for the development of these business plans are found in Appendix I.

## ADVANCED INDUSTRIAL MATERIALS (AIM) June 1984

### 1.0 OBJECTIVE

To provide a general introduction to the field and to outline a phased work plan for the portfolio.

### 2.0 DESCRIPTION

Advanced industrial materials (AIM) are defined as new or improved materials possessing physical or chemical properties which make them superior technically or economically in one or more respects to conventional industrial materials in a given application. They also include new or improved processes and manufacturing techniques. In some cases, AIM may render practicable applications for which no suitable materials previously existed.

AIM always evolves towards conventional materials, and what might be thought of as an advanced industrial material by one nation may be conventional to another. The Office of Industrial Innovation's (OII) effort on AIM will cover the advanced industrial materials field from a Canadian perspective.

The different areas of AIM are heterogeneous in that they draw from a wide range of scientific and engineering disciplines in their development, and the products derived from their use are utilized in a broad range of applications.

AIM includes:

### 2.1 Advanced Metallic Materials

Modern metallurgical research is directed to the improvement in properties and characteristics of existing metals and alloys and the development of new alloys having improved and more desirable characteristics. Among the major developments in this area, are:

Clean steel, steel low and closely controlled in defect and inclusions with improved mechanical properties, is being developed and will serve markets in construction, Arctic construction and shipbuilding, and beverage container industries.

High-strength alloys of light metals such as aluminium, magnesium and titanium are extensively used in aircraft, aerospace and other applications where weight saving is important. Further development in high-strength light-weight alloys will be important for the aircraft industry if planned reductions in fuel consumption are to be achieved.

Appropriate heat treatement and other processing of alloys further increase some of the desirable properties and creates specialized materials for special applications. Hydrogen alloys, for example, will provide safe and economical storage of hydrogen. They have the property of absorbing hydrogen when their temperature is lowered or pressurized. Conversely, upon increasing the temperature or releasing pressure, the hydrogen is discharged. Shape-memory alloys have the property of regaining their original "memorized shape" at specific temperatures. For example, a car body made of shape memory alloy could regain its original shape by simply pouring hot water on it even when it is crushed out of shape by a collision.

Semiconductors, which are combinations of metals or metallic compounds having special electrical properties, and their associated technologies, have created a revolution in the communications and computer fields. The next generation of microelectronic devices is likely to depend on gallium arsenide which will supplant silicon chips in many applications. They will also play an important role in the production of low cost and high efficiency solar cells.

Superconductors are materials which exhibit extremely low electrical resistance at cryogenic temperatures. They are used in magnetic levitation devices, linear induction motors and DC power transmission devices.

Rapid solidification technology has emerged, in the last five years, as a process capable of producing a revolution in the metallic materials field. It involves rapid cooling of molten alloys, and the materials produced have enhanced corrosion and mechanical properties previously not achievable by conventional melting and metal-working processes. The scope for the applications of materials produced by rapid solidification is broad and include the aerospace, automotive, chemical and electrical sectors.

The present attainable characteristics of many materials are considerably below those indicated by theoretical values and continuing metallurgical research is expected to result in a continuing series of new products.

## 2.2 Ceramic Materials

Ceramic materials represent a new and important area. They have the important attributes of stability, high strength and the ability to withstand extremes of temperature. New ceramic material formulations and methods of manufacture have simplified the adaptation of this material to new applications.

New ceramics are fine chemical products made from highly purified oxides found in clay and alumina or from carbides , nitrides, borides, silicates and phosphates which have been synthesized and refined. These new ceramics are thermally and chemically unique and possess specific properties. The ultimate objective of much ceramics R&D is engines with major components in ceramics, enabling higher running temperatures, perhaps without cooling systems and thus greater efficiencies.

## 2.3 Plastics

Over the last decade or so, developments in plastics have produced a wide range of valuable new materials, many of which have found uses as substitutes for metals, while others have unique properties not previously available and so they have found a new range of applications. For example, there is an increasing use of plastics in motor vehicle bodies and trim applications where lower weight, lower cost, resistance to corrosion, and ease of manufacture are important considerations. Furthermore, the energy-absorbing properties of such plastics reduce the incidence of damage in collision.

The low cost, ease of installation and non-corrosive properties of plastic materials have resulted in their wide adoption in electrical and plumbing applications. Their use has speeded up building construction work and has resulted in a more satisfactory service.

Plastic materials are also becoming important in surgery, where special physical properties and inertness to body tissue and fluids are attributes required of materials to be used in the human body.

The main advantages of plastics - such as light weight, low cost and ease of machining and forming - are attractive in many applications and enable savings to be made.

Technological advances of the last few years suggest that advanced polymer materials are headed for unprecedented growth. This is due, in large part, to the development of new polymers, advances in reinforced thermosets and, perhaps most significant, to several evolving processing technologies such as the reaction injection molding of thermoplastics, the interpenetrating polymer networks and the self-reinforced plastics.

Physical properties of plastics can be improved by incorporating other non-metallic or metallic materials to form composites.

The raw material for plastics is derived from crude oil, but this represents only a very small part of total oil usage and even with growing demand for plastics the constraints on oil supply should not represent major difficulties for the industry. As crude oil represents about 4 to 6% of the value of plastics, the price of oil, even if it increases substantially, will have only a small impact on the price of plastic products. Furthermore, in terms of energy requirements for the production of various basic materials, plastics are among the most efficient users of energy.

## 2.4 Composite Materials

Fibre-reinforced composite materials - that is, plastics or metals incorporating fine monocristalline fibres of other non-metals or metals such as glass, carbon, boron or beryllium - are a relatively new group of materials. One of their attractive qualities is low density combined with strength. Glass-fibre-reinforced resins (commonly known as fibreglass) have been used for some years in vehicle, boat building and in the construction industry. Use for these materials are increasing as the technology adavances.

Fibrous filler materials for plastics present superior strength properties when the fibres are uniformly aligned. A recent process for the manufacture of structural sections for use in applications such as the chemical industry uses this feature. "Poltrusion" is the process of pulling a mixture of glass fibres and resins through a forming die. The process closely aligns the individual glass fibres and results in the formation of a light weight corrosion resistant structural section having about the same strength as structural steel but at a cost about half that of stainless steel, the alternative material for this particular application.

The main impact of composite materials over the next decade and beyond will be in specific applications, where the combination of the fiber and the matrix properties offers advantages unobtainable otherwise.

# 3.0 INTERNATIONAL TRENDS

Both economic and strategic considerations are spuring the development and diffusion of advanced materials and applications.

In the U.S. very large expenditures are funneled via the defence and space programs, to industry for the development of AIM.

A report submitted, last Spring to selected U.S. federal departments and agencies by the National Academy of Sciences stressed the key role that materials science plays in technology development and called for increased efforts in this area as a major responsibility of the government because of the long lead times necessary in bringing the technology of complex new materials to commercial viability. The report stated that materials science provides a most promising route to develop substitutes for strategic materials that exhibit unique properties required by the industry and which are only available from insecure sources. It also mentioned that both large national R&D facilities and small institutional based research in materials are essential, but the balance must be continuously monitored. It called for an evaluation of the cost-effectiveness of large national R&D facilities in relation to the research output and technology development done by smaller institution-based groups.

The U.S. Office of Technology (OTA) is working on a report, due by mid-1984, entitled "Technologies to Reduce U.S. Materials Import Vulnerability", which focus on technological opportunities to reduce the U.S. vulnerability to interruptions in supply of strategic and critical imported materials in the longer term. Strategic materials are defined as those important to the U.S. industrial economy. The study will project anticipated needs over the next 25 years arising from advances in such fields as energy generation and transmission, transportation, electronics and others. It will deal with material substitution, including product and process substitution, material processing and recycling technologies and more efficient design and fabrication.

Under the terms of the U.S. National Materials and Minerals Policy Act the U.S. Department of Commerce was directed to prepare a case study related to materials needs and their effect on industrial production, economic activity and national security. The U.S. aerospace industry, being one of the foremost contributors to the U.S. manufacturing activity and trade balance, was selected as the focus of this study which was published in 1981.

Recommendations contained in a 1981 report on the U.S. DOE Energy Advisory Board led to the National Centre for Advanced Materials (NCAM) at the Lawrence Berkeley Laboratory. NCAM will be funded at $265 million over a six year period, of which $140 million will be for construction costs. It is expected that NCAM will have significant industrial participation in the planning, performing and funding of research that will be explicitly directed toward advanced materials.

On behalf of the U.S. Industry, Battelle-Columbus has begun a study on the 100 most innovative materials commercialized in the U.S., Western Europe and Japan, with forecasts of demand

- in quantities and dollars - for each of the materials during the next five years and estimates of the expected growth in demand through the year 2000. Battelle's researchers will also assess the relative impacts that the 100 innovative materials will have on technology, industry and society.

Little information is presently available on current and projected developments on AIM in Europe. However, research will be undertaken on the subject during the preparation of the various technology situation reports. Also, the U.S. reports and studies aforementioned will be analyzed, if available.

For Japan, for example, the motivation to become a major force in the development of AIM could be attributed to several factors, such as:

- the desire to reduce Japan's dependence on imported raw materials through the development of substitute and domestically produced materials;

- the need for product life cycle extensions via new material attributes; and

- the redeployment of human resources from slow growth to high growth sectors.

In the near term, Japan will continue to rely on traditional materials such as steel, aluminium, other metals, plastics and concrete to meet its manufacturing demands. However, AIM, especially composite materials, fine ceramics and amorphous materials, are steadily increasing in acceptance and will begin to capture traditional market shares.

The Japanese Ministry of International Trade and Industry (MITI) has outlined a ten year plan with objectives and financial support to coordinate current activities in AIM.

The fine ceramics market in Japan stands at $1.5 billion in sales per year. Ceramics are steadily growing into a major industry centering on electronics products applications and machine parts. Rapid growth is likely to occur in ceramics engines and bioceramics. Both of these sectors holds potentially substantial markets, and "spillovers" in innovatiove technologies to other sectors has been described as overwhelming. The greatest focus of development in new ceramics in Japan is for ceramics engines. According to MITI, the market for automobile ceramics could reach $30 billion per annum by the early 1990's.

As an indicator of the trend of materials research, of 157 significant patents on AIM issued in the U.S. in the last two years, 75% were assigned to U.S. companies and 16% to Japanese companies. Other countries represented were Germany, France, England, Switzerland and Sweden. None of these patents were from Canada. To give an indication of today's emphasis on materials research, the breakdown of the patents examined was as follows:

| | |
|---|---|
| - Advanced Metallic Materials | 19% |
| - Ceramics | 14% |
| - Plastics | 43% |
| - Composites | 24% |

## 4.0 CANADIAN ACTIVITIES

### 4.1 General

There is, at present, no complete and readily accessible data base on Canadian capabilities in advanced industrial materials and on the scope and focus of materials related projects in industrial laboratories, government research establishments and universities.

The available data base on advanced materials in the Canadian private sector is incomplete, in part because of the diversified technological capabilities and market interests of individual firms, in part because of the degree of foreign ownership or control, and in part because there is no mechanism for continuous monitoring and updating of this type of information.

In advanced metallic materials, with the exception of semiconductors technology, most of the research is conducted in government laboratories.

Ceramic development in Canada is principally located in government laboratories and universities with little industrial support, guidance or target. Technology is for the most part transferred into Canadian industry from abroad.

In organics and high polymers, Canadian industry has thrived on technology transfer from abroad but has found, under these circumstances, the rate and quality of transfer difficult to control. However, transfer has worked reasonably well in large companies, but small companies generally do not participate in such transfer.

In composites, although Canadian realisations such as the De Havilland Dash-8 commuter plane employs the highest percentage (approximately 10%) of exterior composite structure of any civil aircraft, compared with the U.S. and

Western Europe, Canadian efforts are minimal and at a level only keyed to demand.

## 4.2 Federal Activities

EMR's CANMET is conducting R&D on clean steel and NRC's National Aeronautical Establishment (NAE) is engaged in the development of superalloys.

CANMET, NRC's Division of Chemistry (DOC) and Industrial Materials Research Institute (IMRI), and AECL are active in new ceramics.

NRC's DOC and IMRI are active in organics and high polymers technologies.

NRC's IMRI and NAE, as well as DND's Defence Research Establishments Pacific and Valcartier (DREP and DREV) are active in composite materials technologies.

## 4.3 Provincial Activities

The Ontario Research Foundation (ORF) is producing advanced metallic materials using the rapid solidification process.

ORF and the Centre de Recherches Industrielles du Québec (CRIQ) are active in advanced ceramic materials.

ORF is active in advanced polymer technology.

## 4.4 Industry Activities

Cominco and Noranda supply refined raw materials to domestic (Bell Northern and Mitel) and foreign semiconductor manufacturers.

The companies involved in fine ceramics in Canada are either part of a multinational group such as IBM, Murata and Xerox, or are very small in size such as BM Hitech, Almax and Hamilton Porcelain.

Dupont and Xerox carry out R&D and product development of organics and high polymers in Canada.

Major developers and manufacturers in high performance composites are Boeing, Fleet Industries, de Havilland Aircraft, Canadair, and Canadian Aircraft Products.

## 4.5 University Activities

Post graduate education in superalloy metallurgy is presently available at NAE cooperatively with universities.

Canada has only one ceramic engineering facility which is located at MacMaster. However, Toronto, Queen's, UBC, Laval and the Ecole Polytechnique have some resident expertise in the field.

Waterloo, Toronto and Montreal have resident expertise in organics and high polymers.

The Institute of Aerospace Sudies of the University of Toronto provides the only comprehensive composites technology and design curriculum in Canada for undergraduate to post graduate level. Ottawa, UBC and Concordia have resident expertise in the field.

## 5.0 FEDERAL GOVERNMENT CONSIDERATIONS

The future for materials will be shaped by our responses to forces already well recognized. Some of these forces are long-standing and amount collectively to supply and demand. Others have emerged only recently and are related to national problems that include energy, environment, productivity and innovation. Still others relate to worldwide political and institutional changes and growing global interdependence. Together these forces are creating clear-cut challenges and opportunities in materials science and technologyand the results of the past 35 years of materials research and development have been spectacular.

There is a world-wide recognition of long-term importance of AIM to a broad spectrum of industries. However, developments in the field are risky and take years to provide a decent return on investment. As a result, most governments have recognized the need for concerted support programs in this area.

There is no sense of Canadian national recognition for AIM nor an established networking entity. Therefore, it is necessary for all concerned departments to act in concert in order to provide the needed national focus and build recognition.

There are currently no federal policy priorities nor related strategic guidelines in support of AIM and the development of related material processing technologies throughout the manufacturing industry with the view to contributing to long-term productivity improvements, enhancing international competitiveness, and maximizing economic development opportunities.

Economic pressures to produce innovative products using new or improved materials and the growing demand for higher levels of durability, reliability and safety of industrial and consumer products represent important driving forces underlying innovative technological trends in engineering materials. Such economic pressures interact with concerns in the leading industrialized countries over the continuity and security of supply of certain key materials needed to sustain their future industrial development and, in many instances, their defence capabilities. All this has led to an intensified search for substitutes or alternative material compositions and has impacted on the demand for the more traditional materials.

## 6.0 DRIE CONSIDERATIONS

In summary, the current situation of AIM as it affects DRIE is as follows:

a) the development of new materials will have, on the medium and long term, a significant impact on traditional Canadian industrial material suppliers;

b) some sectors of the Canadian industry might be rejuvenated by using new materials and associated processes; and

c) new markets could be created for Canadian raw materials required to produce AIM and derived products.

DRIE will need to develop a strategy to ensure the greatest economic return on the investments made in the scientific and technological developments occuring in AIM. This will require cooperation with other departments, most notably NRC, and a clear and detailed understanding of the likely impacts of AIM on Canadian industry.

## 7.0 ROLE OF OII

Within DRIE, industrial suppliers and users of AIM fall within the responsibility of various groups located in different responsibility centres. In cooperation with these groups (e.g. the Metals and Minerals Directorate and the Aerospace Directorate in the specific field of composites), the Office can play a major role in meeting the challenge of AIM for Canadian industry by providing assessments of major longer-term industrial trends and a window on scientific developments in the field. In so doing, the Office would highlight industrial development opportunities. To this end, a series of situation reports on the technologies will be a major component of the work of the Office.

## 8.0 WORK PLAN

Given the complexity of advanced materials and their interdependence with other technological issues a phased work plan is attached to this business plan. It proposes four technology situation reports covering each of the AIM technologies considered.

After consultation with other groups involved with AIM, within DRIE and in other departments, it is proposed that the technology situation reports to be produced by the Technology Assessment Directorate of the OII be undertaken in the following order of priority:

1. Ceramics;
2. Composites;
3. Metallic Materials; and
4. Plastics.

## ADVANCED INDUSTRIAL MATERIALS (AIM)

### WORK PLAN

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE I - General Review of the Field** | | |
| Identify the major actors in the field, both internationally and nationally. | | on-going |
| Review literature to establish a knowledge base in the field and to identify:<br>a) important scientific and technological trends;<br>b) stimuli for and constraints on technological development;<br>c) likely industrial applications and their significance;<br>d) likely rates of diffusion and their significance; and<br>e) domestic and foreign government policies in the area. | | on-going |
| Identify and participate in committees and task forces. | OII becomes a recognized source of information in the field | on-going |
| Establish and maintain files and a library of information on domestic and foreign policy, programs and activities. | | June '84 |
| Establish a network of key players among federal Government departments and agencies. | | April '84 |
| Select a methodology to identify economic factors associated with the adoption of AIM by Canadian industry. | St. Lawrence study | May '84 |
| **PHASE II - In-Depth Review of the Canadian Situation** | | |
| Discuss with federal departments and agencies to gain in-depth knowledge of:<br>a) policies, programs and activities;<br>b) expenditures; and<br>c) major issues which need to be addressed. | | April '84 |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| To establish, in conjunction with ISBs and ROs, a dialogue with both relevant industries and industry associations to determine:<br><br>a) impact of technology on industry;<br>b) markets;<br>c) constraints on, and stimuli for, development;<br>d) likely future impact;<br>e) potential for future development; and<br>f) imports and exports of the technology. | | on-going |
| Analyze the diffusion process of AIM technologies via selected national trade associations. | Dr. Litvak's study | Sept. '84 |
| Discuss with Regional Offices to:<br><br>a) assess regional strengths and weaknesses;<br>b) determine aspirations; and<br>c) identify major regional issues with respect to the technology which need to be addressed. | | June '84 |
| Discuss with various provincial organizations to determine:<br><br>a) policies, programs and activities;<br>b) expenditures; and<br>c) major issues which need to be addressed. | | Oct. '84 |
| Discuss with universities to determine:<br><br>a) likely future trends in the technology; and<br>b) constraints on university research in the area. | | Oct. '84 |
| Create and maintain a data base within OII which will contain key information on industrial involvement in the field. | OII becomes a recognized source of information in the field | Oct. '84 |
| Initiate and organize, in collaboration with other departments and agencies, workshops. | Workshops across Canada | on-going |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE III - Production of Technology Situation Reports** | | |
| Production of 1st report | | |
| Write draft report in the agreed attached format; and | Report | Jan. '85 |
| circulate for comment and revise accordingly. | | |
| Production of 2nd report | | |
| Write draft report in the agreed attached format; and | Report | May '85 |
| circulate for comment and revise accordingly. | | |
| Production of 3rd report | | |
| Write draft report in the agreed attached format; and | Report | Sept. '85 |
| circulate for comment and revise accordingly. | | |
| Production of 4th report | | |
| Write draft report in the agreed attached format; and | Report | Jan. '86 |
| circulate for comment and revise accordingly. | | |
| Respond to enquiries from industry, universities and government on AIM. | | on-going |
| Organize seminars. | | on-going |
| **PHASE IV - National Advanced Industrial Materials Information Centre** | | |
| Facilitate the creation of a centre which will serve as a national focal point for disseminating information to companies, industry association, universities and provincial agencies on the development and utilization of advanced industrial materials technologies. The Centre will | | April '86 |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| also provide facilities for workshops, seminars and cooperative projects to be undertaken by industry to enhance the diffusion of the new technologies into the workplace. | | |
| **PHASE V - Development of a Federal Strategy** | | |
| If appropriate, develop recommendations to assist in further industrial development of AIM and pursue the implementation of these recommendations. | Action | April '86 |

ADVANCED MANUFACTURING TECHNOLOGIES (AMT) May 1984

## 1.0 OBJECTIVE

To provide a general introduction to the field and to outline a phased work plan for the portfolio.

## 2.0 DESCRIPTION

AMT covers a very wide range of scientific and engineering disciplines that are combined to produce systems used in a wide spectrum of applications. The advent of new and more sophisticated materials and technologies, coupled with a need for greater productivity, has created a demand for new products, tools and applications that are generally of a much greater complexity than their predecessors. Indeed, they are often so complex that engineers and scientists would not have the capability of creating or modifying them without the help of computers.

The main areas presently covered by AMT are:

### 2.1 Computer Aided Design Systems (CAD)

This field covers various types of computerized systems being used in the design, planning and optimization of products and production processes. It also includes visual presentation, automatic drafting and mathematical and economic modelling necessary to define a product, a method or a process.

### 2.2 Computer Aided Engineering (CAE)

Computers are also used to analyse designs for basic error-checking, or to optimize manufacturability, performance, and economy (for example, by comparing various possible materials or designs). Information drawn from the CAD/CAD design data base is used to analyze the functional characteristics of a part, product, or system under design, and to simulate its performance under various conditions. In electronic design, CAE enables users to detect and correct potentially costly design flaws. CAE permits the execution of complex circuit loading analyses and simulation during the circuit definition stage. As well, it can be used to determine loads, vibration, noise, and service life early in the design cycle so that components can be optimized to meet those criteria. Finite element modeling is perhaps the most powerful technique presently used in this field.

## 2.3 Computer Aided Manufacturing (CAM)

The use of computer and digital technology to generate manufacturing - oriented data and to control production equipment on the factory floor. Data drawn from a CAD/CAM data base can assist in or control a portion or all of a manufacturing process, including numerically controlled machines, computer-assisted parts programming, computer-assisted process planning, robotics, and programmable logic controllers. CAM applies to the control of discrete manufacturing operations as opposed to continuous processes (such as oil refining, chemical manufacturing and electrical power generation) and can involve: production programming, manufacturing engineering, industrial engineering, facilities engineering, and reliability engineering (quality control). CAM techniques can be used to produce process plans for fabricating a complete assembly; to program robots; and to coordinate plant operation.

## 2.4 Computer Integrated Manufacturing (CIM)

CIM embraces what historically have been classified as "business systems" applications including order entry, bill of material processing, inventory control, and material requirements planning; design automation, including drafting, design and simulation; manufacturing planning, including process planning, routing and rating, tool design, and parts programming; and shop floor applications such as numerical control, assembly automation, testing and process automation.

CIM is the application of computer hardware and software technology to the automation of information flows in a business organization from an entry of an order to the shipment of the finished product. It encompasses the concept of a totally automated factory in which all manufacturing processes are integrated and controlled by a CAD/CAM system. CIM enables production planners and schedulers, shop-floor foremen, and accountants to use the same data base as product designers and engineers.

## 2.5 Robotics

Computer-controlled manipulators or arms are used to automate a variety of manufacturing processes such as welding, material handling, painting and assembly. Industrial robots are reprogrammable machines designed for the performance of a variety of tasks.

## 2.6 Controlled Machine Tools

Manufacturers have more and more recourse to sophisticated machine tools that require less and less human intervention. These machine tools are numerically controlled and can be classified as follows:

- Numerical Control (NC): control information is stored on paper tape, punched cards or magnetic tape.

- Direct Numerical Control (DNC): direct control by the computer without the use of tape.

- Computer Numerical Control (CNC): uses dedicated mini or microcomputer and input takes the form of paper tape, magnetic data tape, cassette or floppy disk.

## 2.7 Flexible Manufacturing System (FMS)

Automated manufacturing equipment is grouped together under direct computer supervision. Variable and random manufacturing processes are integrated with auxiliary equipment to form a complete manufacturing unit.

## 3.0 INTERNATIONAL TRENDS

The need for increased productivity underlined by the recent economic recession and the necessity of maintaining competitivity on domestic and international markets are amongst the factors influencing the appreciation of technological innovation in the field of manufacturing.

Japan, the U.S.A. and many European Countries have recognized years ago the potential offered by advanced manufacturing technologies in terms of flexibility, increased profuctivity and competitiveness. Indeed, Japan and Germany are widely applying these technologies while Britain, France and the U.S.A. are moving fast to catch-up. On the international scene we are looking at an ever increasing utilization of AMT. The following forecasts give an idea of present trends in future demand for industrial robot installation:

## MARKET FOR INDUSTRIAL ROBOTS FORECASTED ANNUAL RATE OF GROWTH

| | | | |
|---|---|---|---|
| Japan | 1980-1985: | 35-40% | (Bache, Halsey Stuart Shields) |
| | | 30% | (JIRA) |
| | | 10-20% | (CREI-Lettre 2000) |
| United States | 1980-1985: | 35% | (Wall Street Brokers) |
| | | 26% | (CREI-Lettre 2000) |
| | 1980-1995: | 36% | (Predicast) |
| Sweden | 1979-1984: | 20% | (Swedish Computers and Electronics Commission) |
| | 1985-1990: | 17-26% | (ibid) |
| | 1981-1986: | 26% | (Creative Strategies International) |
| France | 1980-1985 | 27-35% | (Diebold) |
| | 1985-1990 | 21-24% | (Diebold) |
| | 1981-1986 | 49% | (Creative Strategies International) |
| United Kingdom | 1981-1986 | 58% | (Creative Strategies International) |
| West Germany | 1981-1986 | 46% | (Creative Strategies International) |
| Italy | 1981-1986 | 56% | (Creative Strategies International) |
| Australia | 1982-1990 | 30% | (Australian Science and Technology Council) |

Governments of these countries have recognized the importance of diffusing and applying new technologies. For example, France has a Machine Tool Program of about $670 million (U.S.) with the specific objective of putting in place 16,000 new CNC machines between 1982 and 1985 and a 3-year program (1981 to 1984) of about $400 million, grouping ten research institutes, to work on general robotics, engineering and technology, advanced remote operations and flexible production systems. Japan will invest about $150 million (U.S.) over the next seven years on intelligent robot research. Germany has the largest robotics research program in Western Europe. Notwithstanding these efforts, all of the above countries continue to develop new ways and means to assist companies that want to make use of automation.

In comparison, Canada has been very slow to recognize the importance of AMT and, therefore, is lagging behind the U.S. and other industrialized countries in the application of most manufacturing technologies. This gap varies greatly from one industry to another.

## 4.0 CANADIAN ACTIVITIES

### 4.1 General

Due to a lack of complete and readily available data base on AMT it is practically impossible to accurately determine the level of activities in this field. Nevertheless we know that many activities are presently taking place. Indeed, federal and provincial governments, universities and the private sector are all more or less involved in either the diffusion or application aspect or both of new manufacturing technologies. These numerous, although very often uncoordinated, activities are due to the existence of a widespread consencus that Canadian manufacturers will have to adopt advanced manufacturing technologies as quickly as possible to either remain competitive or regain lost competitiveness on both domestic and international markets, and the recognition that such changes will have an important impact on the Canadian socio-economic structure.

The scope and impact of the new manufacturing technologies are such that there is an urgent need for a nationally concerted and coordinated effort. The Federal Government appears to be the only entity in a position to fulfill this need and provide a national leadership. Therefore, work is being done to determine which ways and means would be best suited to diffuse information on AMT across the country; to assist industry, whenever required, in the application process and to study the opportunities offered to Canadian firms in the areas of import replacement or of new specialized products.

### 4.2 Federal Government

As early as in the mid-70's the Canadian Government had recognized the impact that computerized manufacturing technologies would have on the manufacturing world and their importance for Canadian firms to adopt them as rapidly as possible in order to increase their productivity and remain, or even become competitive on both domestic and international markets. Governmental activity has increased rapidly during the past few years with DRIE (formerly ITC), MOSST and NRC as major actors.

In 1978, the CAD/CAM Technology Advancement Council was established to advise the Government through the Minister of Industry, Trade and Commerce on CAD/CAM Technologies and to diffuse information on them. The Council published a report entitled "Strategy for Survival" in 1980 which was updated by

"Closing the Gap" in 1983, a series of reprints on CAD/CAM Technologies and a directory of companies and organizations providing CAD/CAM products and services in Canada ("CAD/CAM Products and Services in Canada"). Besides these publications the Council distributes a monthly newsletter to about 3000 people across Canada.

On December 20, 1983 based on a paper presented by MOSST, Cabinet agreed on measures that should lead to the adoption of a National Strategy on AMT in a not too distant future. According to the decisions taken then:

- A National Manufacturing Technology Information Centre, co-sponsored by DRIE and NRC, and managed by the private sector is being established and should be in operation by the end of 1984. The Natural Sciences and Engineering Research Council is considering the possibility of placing a high priority and of allocating funds to targeted research programs in manufacturing technologies. Finally, Statistics Canada is developing an implementation plan for the on-going measurement of the diffusion of AMTs in Canada.

- DRIE is examining the suitability and adequacy of existing and planned incentives programs in order to encourage an adequate level of current and future private investment in AMT by both producers and users.

- MOSST, in consultation with relevant departments and the private sector, will undertake a forecast and assessment of the likely longer-term directions in the evolution of the fully computer-integrated factory of the future.

- The CAD/CAM Technology Advancement Council has been given the added role of providing advice on CAD/CAM matters to the Steering Committee mentioned above.

The Government also recognized the need for long-term research programs in order to ensure future productivity and competitiveness and to adopt generic technologies to suit specific needs and to take advantage of our competitive edge in both the resource industries and manufacturing. Therefore, NRC has been mandated to establish a Manufacturing Technology Institute located in Winnipeg.

Besides the above mentioned activities the Federal Government also contributes, through its various assistance programs, to provincial and university activities which will be covered in the following paragraphs. It also encourages and supports employment retraining programs in AMT through its Skills Growth Fund.

## 4.3 Provincial Activities

All provinces have recognized the informance of advanced manufacturing technologies and are pursueing their diffusion and implementation on their territories through the establishment of specialized Centres or Institutes (see attached list). In the majority of the cases some funding is provided by the Federal through its various programs. Many of the existing Centres or Institutes received their funding through the Institutional Assistance Program (IAP) now replaced by IRDP.

It must be pointed out that the majority of these Centres or Institutes are offspring of or closely related to a university.

## 4.4 Canadian Regional and National Organizations

There are many educational and scientific organizations (see attached list) active in the area of manufacturing technologies. They usually recruit their members from industry, educational institutions and government. The majority hold regular meetings and some sponsor either seminars or conferences.

## 4.5 Universities

As mentioned earlier many Canadian Universities have very close ties with CAD/CAM Centres or Institutes. However, their main role is to provide formal training and education. In addition to undergraduate and extension courses, several are now offering post-graduate degree courses at the M.Sc and Ph.D level.

## 4.6 Industrial Activities

Canadian manufacturers are recognizing the need to use advanced manufacturing technology to keep abreast with international competition. New technologies are first implemented by the large firms and filtered down to medium and eventually small sized firms, for example computer aided design and industrial robots have barely reached medium-sized companies and have not reached small companies at all.

According to a 1982 survey conducted jointly by the Canadian Manufacturing Association and the CAD/CAM Technology Advancement Council:

- 14% of the respondents were currently using CAD/CAM techniques for engineering design;

- 31% were using numerically controlled machine tools; and

- 3.1% were using industrial robots (used almost exclusively in large-sized companies).

The majority of the equipment used is imported. Very few Canadian companies are developing and marketing CAD/CAM systems of various types. These include Omnitech Graphic Systems Inc. (computer graphics process control, etc.), Oscatech Inc. (display terminals for CAD), TrisKelion International Corp. (CAM), Octant Computers (CAM), Diffracto Ltd. (robotics) and Cymbol Cyternetics Corp. (CAD).

## 5.0 FEDERAL GOVERNMENT CONSIDERATIONS

There is a world-wide recognition of the importance of advanced manufacturing technologies. The U.S.A., Japan and other industrialized countries have all entered the race to the automatic factory. They have recognized that these technologies are becoming key factors affecting manufacturing productivity and competitiveness by lowering design and manufacturing costs and greatly increasing production flexibility. Consequently, they all have adopted incentive programs that take the form of money directly invested in R&D, increased support of technical institutes and universities that work in the automation field, tax breaks for companies that make use of automation and various organizational vehicles for encouraging and accelerating application of state-of-the-art manufacturing technology.

As a consequence of these concerted and intensive efforts, Canada is behind the U.S. and other industrialized countries in the application of most manufacturing technologies. This gap on average varies from two to six years. If nothing is done here, it will continue widening, our productivity will continue to fall relating to our competitors, our competitiveness will disappear and in a not so distant future Canadian firms will be put aside from both domestic and international markets. Furthermore, the situation will most likely deteriorate further more as Canadian industry will have to face lower tariff protection, continuing high rates of inflation and vigorous competition from developed and developing countries.

If Government wants to maintain a healthy and expanding manufacturing industry in Canada, efforts must be made to close the above mentioned gap or, at least stop its widening. Advanced manufacturing technology can contribute to the realization of this. However, the rate of diffusion in industry is slow due to the fact, amongst other things, that there is a lack of awareness, specially at the small and medium sized industry levels, and that risks associated with the application of AMT are high. It is clear that Government must address these problems if a healthy and expanding manufacturing industry is to be maintained in Canada. A national implementation strategy, coupled with adequate financial assistance programs will have to be developed.

## 6.0 DRIE CONSIDERATIONS

DRIE's mission is to increase overall industrial, commercial and tourism activity in all parts of Canada and in the process reduce economic disparity across Canada. This implies enhancing the investment climate and improving competitiveness.

The current situation as it affects DRIE is as follows:

- Canada has been very slow to recognize the importance of AMT and is therefore lagging behind the U.S. and other industrialized country in its application. Canadian manufacturers are falling behind their main trading partners.

- It is recognized that AMT is not a panacea but, nevertheless, has a great potential for improving productivity, product quality, competitiveness and economic growth.

- The overall economic situation plays an important role on capital investments especially with regards to new technologies. If economic conditions are weak and market expectations pessimistic, then potential users of AMT will be reluctant to invest in these technologies.

- Adoption of new technologies and processes requires capital expenditures and affect the firm's cash flow. Technology intensive firms, especially small and medium sized ones, have difficulty raising equity funds and generating sufficient cash flow to capitalize around new technologies.

- The risks associated with the acquisition and production of AMT are considerable. They are highest for the first user of a new system or equipment.

- There is a general lack of awareness amongst the Canadian busines community on the benefits offered by AMT. Even with the advent of the CAD/CAM Centres potential users still do not know enough about the technology to make choices.

- AMT suppliers are concentrating their marketing staff in only a few industrialized areas and poor marketing potential offered by the less developed areas in Canada generally hinders suppliers from travelling about the country or establishing regional offices in these areas. Furthermore, the Canadian market for AMT products and equipment offers a limited potential compared to foreign markets such as the U.S.A. Consequently, suppliers have not identified Canada as a first priority market.

- There are few Canadian suppliers of AMT because the domestic market size is judged too small and the foreign market, dominated by very large Japanese firms, too risky to substantiate high investments.

- There is a lack of adequate Canadian consultant firms with expertise in AMT applications. Canadian universities and colleges are not well equipped to train enough engineers and operators specialized in AMT.

- Senior management do not adequately support implementation of AMT due to a lack of knowledge and its reluctance to change.

- Cabinet decision of December 20, 1983 asked DRIE to examine the suitability and adequacy of existing and planned incentives programs to encourage an adequate level of current and future investment in AMT.

- Many provinces and universities are developing policies and programs in this area and are, or will be looking to DRIE for coordination assistance.

- With its Research Institute in Winnipeg to begin operating in 1986 and its involvement in the National Manufacturing Technology Information Centre that should be in operation by the end of 1984, NRC is in the process of developing considerable expertise in the field.

## 7.0 ROLE OF OII

Within DRIE, suppliers and users of AMT fall principally within the responsibility of Capital and Industrial Goods and Consumer Goods Services and Resource Processing areas. Given the complexity of the advanced manufacturing technologies, their interdependence with other technologies, the diversity of needs and players involved and the potential impact of these technologies on the Canadian economy, there must be a focal point to exercise a coherent leadership and ensure an adequate coordination of all departmental activities in this field. OII can assume this leadership role and provide adequate liaison between the above mentioned branches, DRIE regional offices, other federal departments and organizations such as the CAD/CAM Technology Advancement

Council, the National Manufacturing Technology Information Centre, etc. and outside government users and producers. The office has established an interdepartmental Working Group with the mandate of "developing a strategy to foster a more rapid development of AMT diffusion in Canada and to develop a focal point within DRIE".

In cooperation with these parties the Office can provide assessment of major longer-term industrial trends and a view on scientific developments in this field. The Office would highlight industrial developments in this field and, to this end, a status report on the technologies will be a major component of the work of the Office.

## 8.0 Work Plan

Given the complexity of advanced manufacturing technologies and their interdependence with other technological issues, a three-phase plan is proposed (see attachment).

The major focus of the plan at the present time is the production of an implementation strategy and of a marketing plan for the diffusion and implementation of AMT in Canadian industry as stated in phase II of the plan.

## Centres or Institutes Involved in AMT

The following Centres are presently active in one or more manufacturing techologies:

Alberta Microelectronic Cèntre (funded under I.A.P.)

Industrial Technology Centre in Winnipeg
(Computer Aided Engineering Facility)

The Canadian Institute for Metalworking (funded under I.A.P.)

The Ontario CAD/CAM Centre (funded under BILD)

The Ontario Robotics Centre (funded under BILD)

The Ontario Centre for Microelectronics (funded under I.A.P.)

New Brunswick Manufacturing Technology Centre (funded under I.A.P.)

The Centre for Advanced Technology in CAD/CAM (funded under IRDP)

Concordia University - Science Industrial Research Unit

Computer Aided Design Centre - Technical University of Nova Scotia

SME Computerized Automation & Robotics Information Centre (CARIC).

Centre for Advanced Resource Technologies (B.C.)

This list is not exaustive. CAD/CAM equipment also exists in many Community College across Canada.

The above Centres, Institutes or Community Colleges are funded through either federal or provincial programs or both.

## Canadian Organizations Active in AMT

The CAD/CAM Association

CASA/SME Chapter (Toronto Area)

Canadian Industrial Computer Society (CICS)

National Computer Graphics Association

Ottawa-Carleton CAD/CAM Society

Robotics Program in Ontario (Toronto Area Chapter of RI/SME)

The Western Foundation for Advanced Industrial Technology

Major technical societies active in Canada are:

The Society of Manfacturing Engineers (SME)

The Numerical Control Society

The Canadian Society for Mechanical Engineering (CSME)

The Canadian Society for Civil Engineering

The Canadian Society for Electrical Engineering

## Terms of Reference for the Steering Committee for the Establishment of a National Manufacturing Technology Information Centre

### General

- The Steering Committee will be co-chaired by DRIE and NRC.
- DRIE and NRC will be jointly responsible for the administration of the Steering Committee, the appointment of members.

### Mandate

The Steering Committee will:

- take appropriate action required for the establishment as early as possible of a National Manufacturing Technology Information Centre, to be managed by the private sector;

- be responsible for overseeing the Federal contribution to the new Centre.

### Duties

The Steering Committee will:

- provide a focus for accountability for the Federal contribution to the Centre and ensure appropriate reporting of the Centre's activities;

- provide guidelines for the operations of the Centre;

- provide guidelines for identifying the relationship that should exist between the Centre and the various interested parties engaged in the field of AMT and ensure effective working relationships between the Centre and everyone involved;

- review the Centre's recommendations to Government, regarding initiatives to encourage the use of AMT and to stimulate the design, development, production and marketing in Canada of the related products and services;

- determine performance criteria to assess the performance of the Centre in terms of quality and quantify of services provided and in terms of financial management;

- undertake periodic evaluation of the Centre's operations (based on financial and operational criteria set-up);

- ensure effective linkages between the Centre and the CAD/CAM Technology Advancement Council.

## Membership

The Steering Committee will consist of 5 members selected from DRIE (2), NRC (2) and MOSST (1) and 2 observers selected from NSERC (1) and Statistics Canada (1).

## Meetings

Once the information centre has been established, the Steering Committee will meet at least once a year.

# ADVANCED MANUFACTURING TECHNOLOGIES

## WORK PLAN

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **RECURRENT** | | |
| CAD/CAM Newsletter | Monthly distribution | On-going |
| Activities related to the Council's Secretariat<br>- minutes of meetings<br>- enquiries, etc. | Minutes approximately 4 times a year | |
| Response to enquiries on AMT | | On-going |
| **PHASE I** | | |
| Identify and develop a close working relationship, and consult with:<br>- Industry;<br>- Universities; and<br>- Federal and provincial government departments and agencies. | | On-going |
| Identify and participate in committees and task forces. | | On-going |
| Develop and maintain sources of intelligence abroad (using embassies and scientific counsellors) and within Canada. | | On-going |
| Establish and maintain files and a library of information on domestic and foreign AMT programs. | | On-going |
| **PHASE II** | | |
| Preparation of a strategy for the advancement of AMT in Canada | Strategy paper on the "Advancement of AMT" | end Sept. '84 |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| | - Discussion papers for DRIE Policy Committee | Oct. '84 |
| | - Memo to Cabinet, CCERD Technology | Nov. '84 |
| | - Sub Committee | |
| | - Implementation | Dec. '84 onwards |
| | Marketing plan for the diffusion and implementation of AMT in Canadian industry. | Winter '85 |
| Implementation of Cabinet Decisions of December 20, 1983 on AMT | Revised mandate for the CAD/CAM Council<br>- Participate in DRIE/NRC Steering Committee dealing with the establishment of the National Manufacturing Technology Information Centre<br>- Added role of CAD/CAM Council<br>- Monitoring NSERC activities re preferences to programs related to AMT<br>- Participate in Statistics Canada | End Nov. '84 |
| Revision of the CAD/CAM Reprints | Publication and distribution of CAD/CAM Reprint #3 | Fall '84 |
| Update of the CAD/CAM Directory (This is to be done by a consultant) | Publication and distribution of CAD/CAM Directory | Feb. 85 |
| National Manufacturing Technology Information Centre | | |
| To work, in conjunction with NRC, on the following: | Selection of the private organization that will run the Centre | Fall '84 |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| - Role and mandate of the Centre<br>- Managerial & financial organization<br>- Relationships with federal, provincial departments and/or other organizations, etc. | Recommendation on the organization of the Centre | Spring '84 |
| Consult with: | | |
| - Each DRIE officer involved with AMT;<br>- External Affairs officers responsible for AMT; and<br>- NRC, DND, EMR, DSS, AECL, and MOSST officers looking after AMT. | | On-going |
| Meet with private sector firms involved in AMT | | On-going |
| Review literature related to AMT, such as periodicals, newsletters, reports, etc. | | |
| **PHASE III** | | |
| Implementation of Cabinet Decision on AMT Strategy | | On-going |
| Review the work of the CAD/CAM Technology Advancement Council and of its Secretariat | Possible new Terms of Reference with added role(s) | Spring '84 |
| Establish relationships with the NRC Manufacturing Research Institute in Winnipeg | Contract with the Information Centre for the publication of the CAD/CAM Newsletter | On-going |
| Respond to enquiries from industry, universities and government on AMT | | On-going |
| Review the innovation element of major AMT projects | | On-going |
| Organize seminars | | On-going |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| Create and maintain a data base within the OII which will contain key information on industry (e.g. mailing lists, products, domestic and export sales, regional distribution, etc.) | | Summer '85 |
| Attend conferences and trade shows. | | On-going |
| **PHASE IV** | | |
| Maintain all activities associated to the portfolio. | | On-going |
| Implement elements of the strategy selected. | | Spring '85 |

BIOTECHNOLOGY May 1984

## 1.0 OBJECTIVE

To provide a general introduction to the field and to outline a work plan for the portfolio.

## 2.0 DESCRIPTION

Biotechnology has been defined in a variety of ways but, in general terms, it is the utilization of a biological process to provide goods and services. In one sense, biotechnology has existed for centuries in fermentation, a biological process, which is an essential part of existing food, beverage and waste treatment industries. However, recent advances in cellular and molecular biology, biochemistry, microbial genetics and biochemical engineering have greatly magnified the range of applications to which biological processes can be directed, thereby extending the range of fermentation processes. Major areas of impact of these developments include agriculture, forest products, pharmaceuticals, mining, pest control, waste treatment, energy and chemicals.

The biotechnology industry refers to a diverse set of firms. On the one hand, the industry includes new firms established specifically to develop and/or market products using genetic technology, especially recombinant DNA and cell fusion. Most of these firms are less than four years old. The industry also includes established firms interested in using biotechnology as an alternative to presently used products or processes. Chemical synthesis, extractions from tissues and preparation of new products which may fall into any one of a number of industrial sectors such as pharmaceuticals, chemicals, mining or pollution control are of particular interest. The third group of firms included within the biotechnology industry consists of those which are not applying the novel biological processes themselves but which support firms that are. Forms of support include the preparation and sale of reagents specifically used in genetic engineering such as restriction enzymes, the production of apparatus such as fermentors or DNA synthesizers; and the supplying of information, such as on DNA sequences.

## 3.0 INTERNATIONAL TRENDS

Biotechnology should be seen as an emerging technology, one in which current sales of products and processes are very limited but one in which the predicted commercial impact is exceedingly high. Enormous difficulties exist in measuring this impact but one report has suggested that in 1980 sales totalled $25 million but that by 1988-1990 sales will exceed $25 billion world-wide.

In the near-term, the most likely areas for development are human and animal health care products (i.e. drugs, diagnostics and vaccines). In the long-term, the sectors affected will include agriculture, chemicals, mining, food processing, forest products, energy production and waste treatment and utilization. The conclusion to be drawn from this is that the impact on the Canadian economy is likely to be very large but, given that health products manufacture is not strong in Canada, these impacts are likely to be felt in the longer-term.

Countries with major efforts in biotechnology are the U.S., Japan, France, Germany and the U.K. Of these, the most significant are the U.S. and Japan. The U.S. industry has all three classes of firms - specialty, established and support firms. A major strength of the U.S. effort is that there are over 200 specialty companies in the country. Most of these, if not all, are linked to larger more established firms by contracts, licencing agreements and often ownership.

The U.S. has no explicit policy for biotechnology but is perhaps the most advanced in the areas of regulation and patenting and also has good linkages between sectors.

Unlike the U.S., Japan has no start-up companies that specialize in biotechnological R&D. However a 1982 survey of the Japanese industries most likely to be affected by developments in biotechnology indicated that over 80% of these firms were involved in biotechnological research. According to the survey, the most active research areas, in descending order of intensity, were chemicals, pharmaceuticals, textiles and pulp and paper. Important factors influencing Japanese development in this area include the national concensus of the need for a technologically-oriented society, the private ownership of many of the large industrial giants thereby allowing a longer-term outlook, a high degree of interaction between sectors and the recognition of biotechnology as a major industrial force in the coming years.

## 4.0 CANADIAN ACTIVITIES

### 4.1 General

Several reports have been released on the state of developments of biotechnology in Canada. In general, the conclusions drawn have been:

a) Levels of activity are low and scattered geographically, with few centres of expertise of any size;

b) Despite a general interest in the field (general monitoring of developments), few of the larger firms in Canada have become involved in a significant way (a notable exception is Labatt's);

c) There are a number of small, highly innovative firms in Canada but, at the present time, there are less than six products produced in Canada derived from developments in biotechnology;

d) There is a recognition that, at present, the best work being done in this area is in the universities. Consequently, major concerns are technology transfer and cooperative ventures (university/industry and government/industry);

e) The relatively low levels of activity in Canada coupled with the lack of significant involvement in biotechnology by Canadian industry make information dissemination, both from domestic and foreign sources, of high priority.

## 4.2 Federal Activities

A National Biotechnology Strategy was announced by the Minister of State for Science and Technology in May of 1983. This policy stresses linkages between existing activities in government, industry and the universities through networks which will focus their activities on areas of particular importance to Canadian industrial development. Funds were made available to federal departments to promote the networks. A cost-share program to promote university - PRO - industry interactions was established at the NRC and a National Biotechnology Advisory Council was created to advise the Minister of MOSST on the state of biotechnology in Canada.

At the same time, the NRC was allocated funds to build a major biotechnology research institute in Montreal and to expand the biotechnological capabilities of the Prairie Regional Laboratory. Some $60 million will be spent to build the new institute in Montreal which, when fully staffed, will house some 226 personnel.

The major player at the federal level involved in the field is Agriculture Canada which has ongoing research programs in plant breeding and nitrogen fixation both in Ottawa and in its regional laboratories. Other departments with interests in the field include Environment, Energy, Mines and Resources, Fisheries and Oceans and Health and Welfare.

## 4.3 Provincial Activities

Several provinces have announced major policies or programs, or both in biotechnology. Of particular note are the provinces of Quebec, Ontario and Saskatchewan.

In Quebec, a five-year plan stressing training, technology transfer and communications is being implemented. The Quebec plan has a total budget of $60 million of which $40 million is expected from the federal government. Also in Quebec, SGF has established BioMega as a holding company responsible for SGF's commercial developments in biotechnology. BioMega has in turn acquired and expanded Bioendrocrinologie (BioEndo) as its commercial arm and created BioCel to promote university research.

In Ontario, the government, John Labatt's Ltd., and CDC have jointly established Alleslix Inc. Equity financing by the three partners amounts to $105 million over 10 years. Their $20 million research establishment in Mississauga was opened in October of 1983. The major focus of the company will be agricultural applications of biotechnology.

## 4.4 Industrial Activities

Canadian industrial involvement in biotechnology is relatively limited in scope and can be grouped under four topics; health care products, food and feed, modified plants and organisms and microbial conversions processes.

There are a few specialty firms in Canada including Allelix, BioEndo, VIDO, Connaught Laboratories, and Armand Frappier. At this stage, few of the larger established firms in Canada are involved in the field with the notable exception of Labatt's. It should also be noted that INCO was a major backer of Biogen, a U.S. based biotechnology company. Supply companies include MDS, Biologicals and Forintek.

# 5.0 FEDERAL GOVERNMENT CONSIDERATIONS

There is world-wide recognition of the long-term importance of biotechnology to a broad spectrum of industries. However, developments in the field are very risky and it will be years before they mature. As a result most governments have recognized the need for concerted support programs in the area. In this regard it is interesting to note that biotechnology is one of the few areas of technology in which Canada has an explicit federal policy. This policy was outlined above, but, in summary, remaining concerns are as follows:

a) Although research networks will be created, in all likelihood they will be weak in comparison to the activities of the NRC;

b) The NRC has indicated a willingness to consult industry, but historically the labs have not been very responsive to industrial needs or very good at transferring developments to industry (with a few notable exceptions).

Consequently, most of the resources allocated to biotechnology will go into the development of basic science. Clearly then, a major policy issue which remains to be addressed is how to ensure that the industrial infrastructure is in place to capitalize on the developments arising out of biotechnology.

## 6.0 DRIE CONSIDERATIONS

In summary the current situation in biotechnology as it affects this department is as follows:

a) Immediate impacts of biotechnology on industries of interest to this department are small and tend to be focused in the energy, food and, to a more limited extent, diagnostic and vaccines areas.

b) Through the MOSST Strategy, Cabinet asked DRIE in May to examine its role in the support of biotechnology and was to "consider the creation of a special emphasis for biotechnology within its responsibility for industrial development". This examination is currently underway.

c) As a precursor to the development of this report, DRIE's Policy Committee has asked for a ways and means paper for a Framework for Industrial Development of Biotechnology.

d) Considering the low levels of biotechnological activities in Canada and the low propensity to absorb biotechnological developments in Canadian industry, information collection and dissemination from both domestic and foreign sources is of high priority. The target audience includes both suppliers and users of biotechnological products and processes.

e) A committee to advise Minister Johnston on biotechnology has been established with a secretariat in MOSST. DRIE is represented on this committee.

f) The outside impression is that the department is not interested in the new biotechnology but rather favours older more established biological technologies (i.e. traditional fermentation).

g) The NRC's program is the national thrust in biotechnology. However, the emphasis on basic R&D in this program has led to concern about optimizing industrial benefits from these investments. This represents a major challenge for the department.

h) Many provinces and universities are developing policies and programs in this area and will be looking to the IRDP for support.

In summary, DRIE needs to develop a strategy to ensure the greatest economic return on the investments made in the scientific and technological developments occurring in biotechnology. This will require cooperation with other departments, most notably the NRC, and a clear and detailed understanding of the likely impacts of biotechnology on Canadian industry.

## 7.0 ROLE OF OII

Within DRIE, all industrial suppliers and users of biotechnology fall with the responsibility of the Consumer Goods, Services and Resource Processing area and, within this area, the majority of the industrial activity lies within the purview of the Food and Consumer Products Industries Branch. In cooperation with this Branch, the office can play a major role in meeting the challenge of biotechnology for Canadian industry by providing assessments of major longer-term industrial trends and a window on scientific developments in the field. In so doing, the Office would highlight industrial development opportunities. To this end, a status report on the technology will be a major component of the work of the Office.

The status report will act as a major input into the development of the ways and means paper and ultimately to the report to Cabinet. It will address questions of industrial development opportunities, the need for an effective information collection and dissemination program and the need for effective technology transfer process especially as they relate to the NRC's program in the field.

## BIOTECHNOLOGY

## WORK PLAN

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE I - General Review of the Field** | | |
| Identification of major actors in the field both internationally and nationally. | | on-going |
| Review of literature to establish a knowledge base in the field and to identify:<br>a) important scientific and technological trends;<br>b) stimuli for and constraints on technological development;<br>c) likely industrial applications and their significance;<br>d) likely rates of diffusion and their significance;<br>e) domestic and foreign government policies in the area. | | on-going |
| Identify and participate in committees and task forces. | | on-going |
| Establish and maintain files and a library of information on domestic and foreign policy, programs and activities. | recognized source of information in the field | Feb. '84 |
| **PHASE II - In-Depth Review of the Canadian Situation** | | |
| Discussions with federal agencies to gain in-depth knowledge of:<br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | Mar./ April '84 |
| Discussions with regional offices to:<br>a) assess regional strengths and weaknesses;<br>b) determine aspirations;<br>c) identify major regional issues with respect to the technology which need to be addressed. | | Mar./ April '84 |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| Discussions with provincial organizations (departments, PROs, etc.) to determine:<br><br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | April/ May '84 |
| To establish, in conjunction with ISBs and ROs, a dialogue with both relevant industries and industrial associations to determine:<br><br>a) impact of technology on industry;<br>b) markets;<br>c) constraints on, and stimuli for, development;<br>d) likely future impact;<br>e) potential for future development;<br>f) imports and exports of the technology. | | May/ June '84 |
| Discussions with universities to determine:<br><br>a) likely future trends in the technology;<br>b) constraints on university research in the area; | preparation of background notes and summaries | June/ July '84 |
| Create and maintain a data base within OII which will contain key information on industrial involvement in the field. | recognized source of information | Oct. '84 |
| **PHASE III - Production of Status Report** | | |
| Write a draft report in the agreed upon format. | | |
| Circulate for comment and revise accordingly. | | |
| Respond to enquiries from industry, universities and government on biotechnology. | | |
| Organize seminars. | Status Report | Nov. '84 |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE IV - Strategy** | | |
| If appropriate, develop recommendations to assist in further industrial development of biotechnology and pursue the implementation of these recommendations. | Action | Dec. '84 |

HEALTH CARE TECHNOLOGIES (HCT) May 1984

## 1.0 OBJECTIVE

To provide a general introduction to the field and to outline a phased work plan for the portfolio.

## 2.0 DESCRIPTION

HCT covers a wide range of scientific and engineering disciplines that are combined to produce goods and services for ensuring the health and well-being of humans and animals. These goods and services are developed to serve a variety of purposes ranging from preventive medicine to treatment of diseases.

The health care products industry in Canada can be divided in the three categories described below. The HCT portfolio will restrict itself to the high technology application aspects that can be found in each of them.

### 2.1 Personal Health Care Products

This group includes products such as plasters, elastic bands, sterilized gauze, wadding, sanitary towels, toothpaste, etc. These products are those used in a person's everyday life and generally do not involve high technology. However, in the last few years the market has been faced with an increasing number of new product resulting from the application of high technologies such as sensors, computers and microelectronics and materials which are now replacing commonly used ones for, a large variety of personal products.

### 2.2 Pharmaceuticals

This group includes about 50 major therapeutic classes of products ranging from unpatented drugs such as analgesics and vitamins to patented ones including active drug ingredients such as antibiotics and drugs used for the treatment of cardiovascular troubles. Pharmaceuticals also include biological products such as blood, blood products and vaccines. In pharmaceuticals, we intend to address only the production process aspects such as quality control, packaging, handling, etc.

### 2.3 Medical Devices

This group includes a very wide spectrum of products which range from relatively low technology mass-produced items such as wooden tongue depressors and surgical dressings to highly capital and technology intensive industries involved in the manufacture of radiation therapy devices, heart pacemakers and computer assisted diagnostic equipment. It also includes use of new materials such as alumina for dental and middle ear implants, ceramics for implant coating, helically woven suture devices for tendon repair etc.

In 1981, the medical devices group represented a market of $1.2 billion (4.7% of the Canadian Health Care Delivery System costs or 3% of world market). Imports were approximately $800,000. It is estimated that this market will grow rapidly in the next decade to reach approximately $2.8 billion by 1990, about the same size as the pharmaceutical market. Efforts will be concentrated in areas where Canada has a recognized advantage e.g. fields for which a recognized research infrastructure already exist, small batches product lines, etc. Special attention will be given to application of technologies, already proven in other fields, to medical devices for example use of expert systems for diagnostics, use of video equipment for behavioural treatments, etc. It will pay special attention to applications of technologies such as sensors, computers and micro-electronics which are addressing the home and self-care mass-markets that are very rapidly developing. There is an increasing number of persons using medical devices that up to now were reserved strictly to doctors and nurses, for example, apparels to measure blood pressure, blood sugar, to clean ears etc. It will also address areas of high technology equipment such as the now well known and largely used ultrasonic scanning devices that were first introduced in obstetrics in the early 70s and spread rapidly to other disciplines (eyes, kidneys, brain, etc.), imaging diagnostic methods using high speed, high resolution devices working at molecular level such as Position Emission Tomography (PET), Nuclear Magnetic Resonance (NMR) Radioimmuno-essay (RIA) etc. The use of laser in micro-chirurgy, of fiber-optics for internal diagnosis etc., and of nuclear devices, such as the cobalt bomb produced by Atomic Energy of Canada Limited, for cancer treatment.

In 1981, the leading product groups in terms of market share were:

- Medical, Surgical Hospital Supplies Appliances, Equipment & Instruments: 26%

- Diagnostic Instruments, Reagents, Radiographic and Imaging Equipment: 21%

- Scientific Equipment, Laboratory Supplies: 20%

- Implants, Prosthetics, Orthotics and Sensory Aids: 10%

- Dental, Veterinary, Opthalmic and Obstetric products account for the remainder.

## 3.0 INTERNATIONAL TRENDS

Society is changing rapidly, better standards of living, earlier and more accurate diagnostics, letter and more easily accessible health care facilities, increased awareness in 3rd world countries and use of state-of-the-art and more efficient medical devices result in a significant increase in life expectancy all over the world. Furthermore, the advent of new technologies yielding preventive, curative, palliative and substitutive possibilities permits now to treat previously incurable diseases. As a consequence, populations of both developed and developing countries are ageing rapidly. For example, it is predicted that by the year 2000 over one third of the Canadian population will be over 45 years of age. This, combined to the fact that people are constantly asking for more and better health care services, brings a significant increase in the market size and in the costs of health care services. For example, it is projected that the world market will grow from $95 to $185 billion from 1981 to 1990 with medical devices passing from $30 to $60 billion. The Canadian market for medical devices represents about 3% of the latter. As a comparison it represents 36% for the U.S.A., 12% for Japan, 6% for the Federal Republic of Germany and 5% for France.

Humanitarian and political considerations are forcing countries to maintain a minimum level of health care services and pressures are constantly exercised on them by their respection populations to raise this acceptable minimum level. This, coupled to the above demographic factors, forces all countries to face the dilemma of simultaneous cost increases resulting from an increased demand for services, development of new services and devices, rapid obsolescence, etc. and a reduced active population to support them. They all look for means to maintain services at the highest level possible and the drain on scarce national financial resources as low as possible. Since this cannot be achieved through service reductions, they look for modern state-of-the-art more productive medical devices and health care systems. For many countries the drain is amplified by the fact they are net importers of health care products. As a consequence this creates a tendancy for them to encourage the implementation of firms on their territory, at least in the unsophisticated medical devices sector, to produce replacement goods and thus decrease the currency drain. Development of new products require a multidisciplinary team of first class researchers, state-of-the-art laboratory, years of research and huge amounts of capital. These conditions are usually met by a very few number of large firms operating in the more advanced countries. Indeed, due to the large sums of money involved (both in expenses and revenues) there is a tendency for greater concentration. It is becoming more and more difficult for newcomers to enter the high technology health care.

# 4.0 CANADIAN ACTIVITIES

## 4.1 General

From the several reports and analysis produced on this industry we can deduce that:

a) In the pharmaceutical group:

- the industry is dominated by large international companies (mainly U.S. ones) and most of the manufacturing activities are composed of compounding packaging and the quality control of products in final dosage forms. Companies are using equipment and operating below full capacity; and

- application of advanced manufacturing technology to activities such as packaging and quality control could increase productivity and competitiveness.

b) In the medical devices group:

- the industry comprises in excess of 280 companies employing 16,000 people and is composed of a large number of firms, dominated by large companies which are mainly foreign controlled (according to a study published in 1980, 47% of the firms were entirely Canadian owned, 43% were foreign owned and the remaining 10% had minority Canadian participation);

- for many companies, medical devices manufacture is a spin-off from other technologies and represent a relatively small part of their total sales;

- imports play a dominant role in supply of the domestic market (in 1981, exports were estimated at $1 billion for a domestic market of $1.35 billion);

- the great diversity of medical devices and the high ratio of obsolescence make it difficult to access the market;

- small Canadian producers are competing with success in individual productions; and

- R&D is carried out by approximately 50% of the firms active in the medical devices group. It is concentrated mainly in fields such as radiation, diagnostic and therapeutic equipment (66% of total research), chemical and laboratory instruments, etc.

Furthermore, in general there is a recognition that:

- The public research infrastructure is of a high international standard, investigators are engaged in health science research at universities, hospitals and associated health institutions. It provides important support to private sector research activities. For example, the National Research Council's Rehabilitation Technology Unit develops models and subsequent improvements of aids for disabled persons for production by small manufacturers; the Ecole Polytechnique of Montreal is developping prototypes to measure and analyse biological signals, etc.

- Government policies and regulations have a major impact on the health care product industry. For example, innovation and development of new products tends to be slowed down by the fact that the Canadian regulatory system is more rigorous than in almost all other countries. Canadian custom tariffs compared to those of other industrialized countries are such that, in general our industries is less protected than that of the latters.

- Canada is in a dependency situation for products and technologies.

- Financial assistance programs and industrial co-operation activities of the federal government contribute to creating a favourable climate for R&D on medical devices and pharmaceuticals in Canada. Tax allowances and investment credits are making incremental increases in R&D expenditure more attractive in helping to lower average cost of R&D to the firm. For example, as a result of these combined tax provisions a large pharmaceutical manufacturer located in Ontario, with an effective combined federal-provincial tax rate of 42 per cent, would now incur a net cost of 31 per cent of expenditure for new increments of R&D expenditures compared to 58 per cent before the tax credit and additional tax allowance were introduced.

- Though incentives such as tax credits, direct financial assistance etc, Tax Haven Countries such as Ireland and Porto Rico are offering fierce competition to Canada for new capital investments.

It is recognized that the Canadian market for health care products is limited in size and fragmented. There are more than 5,000 distinct kinds of medical devices including very sophisticated and specialized products for which Canadian demand amounts for just a few units due to either low market or to the custom design nature of many of the products (i.e. cobalt bombs). Very often medical devices represent only a small portion of large firm activities and many of the newest ones have been established for the exploitation of a single product. The Canadian market in itself is too small to permit economies of scale. It is dominated by a few large firms (generally U.S. owned). According to an IT&C survey (1977) only 15% of the firms had more than 100 employees and 56% had less than 20. Furthermore, 69% had a shipment value of less than $1 million and only 2% had shipments over $20 millions. Export and R&D of foreign controlled firms are controlled (limited) by the parent company.

In the next decade rapid development and application of medical device technology to Health Care together with the necessity to contain costs will lead to significant restructuring of our health care system. Demographic pressures and a rapid pace of innovation in the industry are expected to continue to sustain market growth at more than 7% per year. The domestic market for medical devices is projected to grow from $1.3 billion in 1981 to $2.4 billion in 1990.

## 4.2 Federal Activities

The federal government is very active in the health care sector and a number of measures have been taken to ensure adequate protection of the Canadian consumer, reduce health care costs, and encourage R&D and domestic manufacturing. Major federal players involved in this sector are DRIE, NHW, NRC, MDC and NSERC.

The Department of Health and Welfare provides legislation and regulatory framework necessary to ensure the safety of health care products. Through stringent legislation and regulation NHW ensures that "Canada approved" products are respected worldwide.

At present there are no assistance programs for industry directed especially to the health care sector. Assistance is provided through programs available to industry in general. In the 70's federal assistance to medical devices manufacturers has totalled approximately $7 million. These monies were allocated through the following programs:

The federal government is also actively pursuing ways and means to reduce the price of health care products through reduced custom tariffs, the compulsory licensing of drug patents, etc.

The National Research Council, The Medical Research Council and NSERC are providing financial support mainly to institutional R&D (hospitals, universities, etc.) For example, total national expenditures in 1977 for health science research and health care products R&D are estimated to have reached nearly $200 million. Of this amount the federal government disbursed about $100 million, the health care products industry $50 million, provincial governments $25 million and philantropic associations $25 million. It was also estimated that about 50% of the manufacturers of medical devices were spending about $9.4 million on R&D. This has led to the establishment of a well developed R&D infrastructure which is among the finest in the world. NRC is involved in the health care sector mainly through its Medical Engineering Section and Rehabilitation Technology Unit. Amongst other things, the latter develops models and subsequent improvements of aids for production by small manufacturers.

Industrial development and R&D are also encouraged through patent protection under the Canada Patent Act.

## 4.3 Provincial Activities

Health care programs and costs are the responsibility of each province which have recognized the need to cut the rapid increase of these costs. Some provinces are centralizing their purchasing in order to benefit from quantity discounts. Such purchasing programs can be at a province level, a city level or take the form of federal-provincial arrangements.

There is indirect provincial government support for health science research in universities and hospitals through education budgets and provincial health schemes. Besides that, provincial governments also contribute, with the federal and philanthropic organizations, to the funding of various types of health science research which is directed primarily to basic biomedical and clinical research. The provinces of Ontario, Quebec and Alberta are providing some support to domestic producers.

Provincial purchasing is also used to encourage domestic production, for example, provincial governments, which are the principal purchasers of biological products (vaccines hormone extracts, etc.) generally give preference to Canadian suppliers.

Manufacturing and/or distributing firms involved in medical devices products are concentrated in the provinces of Ontario and Quebec.

## 4.4 Industry Activities

As already pointed out, in Canada, the medical devices industries is made up of a large number of firms with the majority of them being subsidiaries of large, foreign-owned multinational corporations.

In the medical devices industry imports play a dominant role and distributors outnumber manufacturers. For the large firms, medical devices represent a relatively small part of the firm's total activity. Firms with a single product line usually have limited financial resources and are dependent of government assistance for their development. Approximately 50% of the companies in this sector are Canadian owned. Firms are conducting R&D in areas such as radiation, diagnostic and therapeutic equipment, etc. They obtain important assistance and support from neighboring university, hospital and other institutional health care facilities. In 1977, about 90% of manufacturers and/or distributors were located in the provinces of Ontario and Quebec.

## 4.5 R&D Activities

R&D activities are conducted at universities, federal, provincial and industrial laboratories.

Universities are playing a very important role in the Canadian health care system. Nearly all of them are carrying out R&D in one aspect or another of the health care field. They have teams of very qualified scientists conducting applied clinical research, in university laboratories and affiliated hospitals/centres, connected to the health products industry and training research personnel in diverse disciplines such as biophysics, cell biology, genetics, bio-engineering, etc.

In the more specific area of medical devices universities are, amongst other things:

- providing the specialized training facilities for the research talent needed by industry.

- conducting R&D in biomedical engineering which is one of the more important disciplines in the field of medical devices. It should be noted that virtually all the bio-medical engineering R&D is conducted at universities federal and provincial laboratories and in three of four hospitals.

- developing promising research concepts for prosthetic/orthotic devices (the Rehabilitation Institute in Montreal, the Orthotics Research and Training Unit of the Ontario Crippled Children's Centre, the Prosthetics and Orthotics R&D unit of the Manitoba Rehabilitation Hospital).

There are some industrial laboratories conducting R&D activities in the fields of radio-isotope and radiation equipment (44%), surgical dressings and related products (29%) and the remaining 23% in surgical sutures, wound-healing devices and adjuncts, ultra-sound diagnostic, anti-microbial products, electronic diagnostic and monitoring systems, dental cutting instruments, medical instruments, individual mobility aids for the physically disabled and signal processing of medical diagnostic data.

## 5.0 FEDERAL GOVERNMENT CONSIDERATIONS

There is a worldwide recognition that rapid development and application of medical device technology to health care together with demographic changes and the necessity to contain costs will lead to significant restructuring of the health care systems in the next decade. These changes will have a dramatic impact on patterns of institutional care and on the manufacturers of health care products. For example, in the next decade we will likely assist to the development of new artificial limbs, computer aided equipment for diagnosis and treatment, etc. Such developments are very risky and expensive since it takes years to develop and test the products and get governmental approval for using them on humans. Financial considerations combined with the fact that Canadian firms are either small or foreign owned encourage a low level of fundamental research in Canada which in turn, results in a low level of exportations.

The federal government is ensuring public safety through an elaborate regulatory system considered to be among the most rigorous in the world. Safety, efficacity and quality of health care products is ensured by imposing pre-market clearance for new products. This is a time consuming and costly exercise that tend to discourage innovation and R&D work in Canada.

A number of federal government assistance programs for industrial R&D already exist. The National Research Council provides the IRAP, PIER, PILP and STEP programs. The Department of Industry, Trade and Commerce has provided assistance, in the past, through its PAIT and IRDIA programs which have recently been replaced by the EDP program. The medical devices industry have made relatively limited use of these programs with the exception of IRDIA, relying instead upon their own financial resources. Generally, existing programs offering loans and grants are of greater benefit to smaller organizations in building a research and development capability, while tax based incentives have been of greater value in the support of research carried out by the larger firms.

The Medical Research Council is funding university hospital based biomedical research through research grants ($45.5 million in 1977/78) and awards to support the work of investigators ($10.3 million in 1977/78).

The government is faced with the following concerns:

- Finding ways to contain cost increases while maintaining an acceptable level of health care services.

- Finding ways to shorten the approval period for preclinical tests of new products (U.K. authorities request a shorter period of time than Canada).

- Finding ways to increase the R&D level of activities of both Canadian and foreign owned companies.

- Finding ways to encourage Canadian firms to tackle the import replacement market in 1981 our import of medical devices, including scientific and laboratory equipment and supplies, totalled $1.03 million.

- Finding ways to persuade parent companies to allow their subsidiaries to export and to encourage the formation of large enough Canadian owned firms so they can benefit from economies of scale and be in a position to compete successfully on the international markets.

## 6.0 DRIE CONSIDERATIONS

The current situation in health care as it affects DRIE is as follows:

Although small by world comparison, the Canadian market for medical devices, including scientific and laboratory equipment and supplies, is large. It was estimated at $1,46 billion in 1987 and projected to grow to $2.4 billion in 1990. The market is dominated by imports ($1.03 billion in 1981) with only $0.09 billion of exports. The world market is projected to double from $30 billion in 1981 to $60 billion in 1990. The U.S. market was estimated at $3.9 billion in 1981. Therefore, all things remaining equal, the Canadian trade deficit for medical devices could grow to $1.54 billion by 1990.

The health care products market is dominated by a few large foreign owned companies.

The market offers great opportunities for import-replacement and export. However, Canadian firms are usually too small to be in a position to compete adequately on both domestic and international markets. This comes from the fact that they don't offer exclusive products, the domestic market is relatively small so they cannot benefit from economies of scale because of a limited scope of manufacturing operation and lack of international marketing capability and experience.

Significant improvement in Canadian manufacturing activity will require the broadening of the manufacturing base do include major export-oriented operations as well as the replacement of imports.

It is urgent that manufacturing opportunities must be identified and diffused to potential Canadian manufacturers.

Group purchasing is a lever that could be used more extensively by public and private purchasing authorities to reduce costs. However, this is a dangerous practice since it could very easily lead to reduced competition.

R&D is usually conducted outside Canada. Canadian R&D is usually limited to adapting foreign products to Canadian regulatory requirements.

Canadian firms are usually too small to be able to develop and commercialize Canadian discoveries. This is usually done in other countries.

Canada has excellent public research infrastructure and innovative abilities which is funded through Provincial Governments, NRC, NSERC, and MDC funding programs. Impact of these programs could however benefit from better coordination.

The transfer of technology from universities, hospitals and other institutional health care facilities to private industry is not adequate. There is a prevailing negative attitude of the research community towards industry and vice versa.

Increasing use of non-pharmaceutical technologies such as micro-electronics, laser, fibre-optic, etc. requires the creation of multi-disciplinary research teams. Use of these technologies in the health care field also calls for new types of scientists and engineers. For example, hospitals are hiring "maintenance engineers" to ensure that their equipments are always well calibrated and performing according to standards. This is of the utmost importance since very often patient's life depends on a timely and accurate diagnostic.

Health care professionals and institutions are very conservative, therefore, slowing down diffusion and application of new products. Aggressive marketing is required to change this attitude and facilitate penetration of Canadian products. Hospitals should be attacked first since they are the main purchasers of medical devices.

In summary, the market offers great opportunities to Canadian manufacturers but to take full advantage of it it is important and urgent that an industrial strategy be developed by DRIE. This strategy should ensure that our medical-technical infrastructure and innovative abilities are exploited to strengthen the manufacturing capacity of existing Canadian companies, world-competitive, exploitable production capacity of multinational and foreign domestic companies are attracted by Canada. It should also ensure an adequate level of R&D and coordination between all sectors involved, the universities, the private sector and the federal and provincial governments. At the Federal level this will require cooperation with other departments and organizations such as NHW, Revenue Canada, MOSST, NRC, NSERC and MDC.

## 7.0 ROLE OF OII

Within DRIE the majority industrial suppliers and users of health care products fall within the responsibility of the Consumer Goods Services, and Resource Processing area and, within this area the majority of the industrial activities lies within the preview of the Chemicals Branch. However, the multi-disciplinary nature of the portfolio is such that branches of the Capital and Industrial Goods area are also concerned, i.e. Electronics and Aerospace, Machinery and Electrical Equipment etc.

In cooperation with these Branches, the office can play a major role in meeting the challenge of health care for Canadian industry by providing assessments of major long-term needs and industrial trends and a window on scientific developments in the field. In so doing the Office would highlight industrial development opportunities.

With its access to a variety of sources, its contacts with organisms outside the department, OII has a major networking and interfacing role to play in representing DRIE in catalysing exchange and technology transfer from government and university laboratories to industry.

A status report on the technology, to be prepared by the Office, will act as a major input into the development of a strategy. It will address questions of industrial development opportunities, the need for an effective information collection and dissemination program, the need for an effective technology transfer program and the need for an effective financial assistance program for the health care industry. It will also address the need of a focal point for disseminating information on medical devices and promoting the development of a Canadian industry.

## HEALTH CARE

## WORK PLAN

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE I - General Review of the Field** | | |
| Identification of major actors in the field both internationally and nationally. | | On-going |
| Review of literature to establish a knowledge base in the field and to identify:<br>a) important scientific and technological trends;<br>b) stimuli for and constraints on technological development;<br>c) likely industrial applications and their significance;<br>d) likely rates of diffusion and their significance;<br>e) domestic and foreign government policies in the area. | | On-going |
| Identify and participate in committees and task forces. | recognized source of information in the field | On-going |
| Establish and maintain files and a library of information on domestic and foreign policy, programs and activities. | | March '84 |
| **PHASE II - In-Depth Review of the Canadian Situation** | | |
| Discussions with federal agencies to gain in-depth knowledge of:<br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | Oct./Nov. |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| Discussions with regional offices to:<br><br>a) assess regional strengths and weaknesses;<br>b) determine aspirations;<br>c) identify major regional issues with respect to the technology which need to be addressed. | | |
| Discussions with provincial organizations (departments, PROs, etc.) to determine:<br><br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | Jan. '85 |
| Discussions with industry and industrial associations to determine:<br><br>a) impact of technology on industry;<br>b) markets;<br>c) constraints on, and stimuli for, development;<br>d) likely future impact;<br>e) potential for future development;<br>f) imports and exports of the technology. | | Feb. '85 |
| Discussions with universities to determine:<br><br>a) likely future trends in the technology;<br>b) constraints on university research in the area. | preparation of background notes and summaries | Jan./ Feb. '85 |
| Create and obtain a data base within OII which will contain key information on industrial involvement in the field. | recognized source of information | March '85 |
| **PHASE III - Production of Status Report** | | |
| Write draft report in the agreed upon format. | | Summer '85 |
| Circulate for comment and revise accordingly. | | |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| Respond to enquiries from industry, universities and government on medical devices. | | On-going |
| Organize seminars. | Status report | On-going |
| **PHASE IV - Strategy** | | |
| If appropriate, develop recommendations to assist in further industrial development of the medical devices sector and pursue the implementation of these recommendations. | Action | Summer '85 |

NEW COMPUTING TECHNOLOGIES May 1984

## 1.0 OBJECTIVE

To provide a general introduction to the field and to outline a work plan for the portfolio.

## 2.0 DESCRIPTION

The main difference between this portfolio and the one on informatics is that new computing technologies refer to technologies which are mostly in the stage of experimental development while informatics refers to technologies which are rapidly diffusing at this moment; such as desk top computers.

New Computing Technologies can be defined by their characteristics. First, they will be based on computers having interfaces adapted to human beings rather than vice-versa so that they can be utilized even without professional knowledge by applying new inputting/outputting technologies such as speech generation/recognition, graphics and image recognition and the like. Second, these computers will apply advances in artificial intelligence. They will no longer be data processing machines, but knowledge information processing systems performing inferences rather than calculations. This capability would allow the computer to perform automatic retrieval of related information out of a large database in response to inquiries, to draw conclusions to be drawn from inferences based on stored data when an unknown problem is given, to learn and store solutions for subsequent application to new problems.

Three basic technologies will support fifth generation computing:

a) New computer architectures: increasing by orders of magnitude the power and speed of computers;

b) microelectronics: to support the new architectures by producing fast, ultra-small devices for VLSI chips and systems-on-a-wafer; and

c) artificial intelligence: which will guide the development and exploration of concepts and techniques for intelligent systems.

For the purpose of this portfolio, fifth generation computing refers to a number of sub-technologies including: new chip design, manufacturing processes and materials related to VLSI/VHSIC chips (very large scale integration/very high speed integrated circuits), new computer architectures and emerging peripherals (e.g. videodisks), artificial intelligence and sub-fields such as vision systems, automated translation and expert systems. Also included in this portfolio are applications of fifth generation computers to fields as diverse as computer-aided learning and management support systems.

## 3.0 INTERNATIONAL TRENDS

Fifth generation computing has been identified as one of the technologies of strategic importance for the next ten years by most developed countries. First, it will allow anybody to use a computer without any special expertise or training. Second, it will provide access to information in any language by automating translation. Third, it will contribute to improve productivity, not only in the factory by providing intelligent robots and automated inspection systems but also in the office by providing primitive automation of basic intellectual functions or electronic assistant with the knowledge of experts in very narrowly defined domains.

The fifth generation computing concept is also an elegant solution to the bottlenecks computing is now facing.

This technology aims at solving technical problems currently emerging in informatics, in such a way as to create a totally new technology, and thereby dominate world markets. This technology will be based upon totally new computer hardware which operates with multiprocessors in a "parallel" fashion, and artificial intelligence software.

In today's computers, data and program instructions must be passed back and forth sequentially between the central processor and the central memory. This basic architecture has changed very little since it was conceived thirty years ago by John von Neumann. It is now becoming possible, using very large scale integrated (VSLI) chips, to put thousands of processors on a single silicon wafer. To tap the potential of this new technology, a fundamentally different conceptual approach to computing is necessary. Various types of new parallel architectures are being studied internationally as an answer to this challenge.

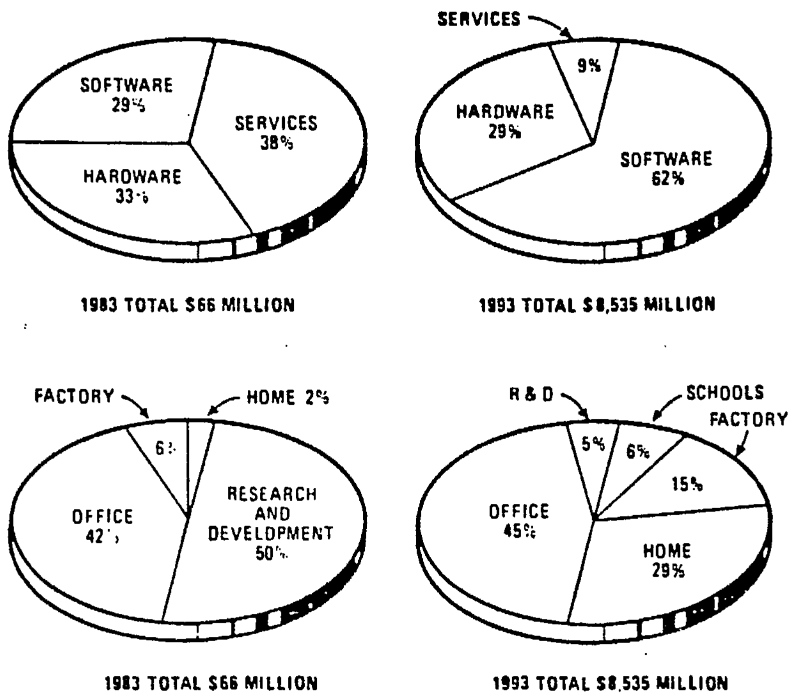
Another problem to be solved is that programming costs on today's computers have become very expensive in relation to the hardware costs, which have fallen consistently. Labour-intensive writing, testing and de-bugging of software will be reduced through the use of automated aids.

Another problem is that present day machines are good at data processing but cannot process knowledge, make inferences and judgements, nor deal with abstract or incomplete information.

The software efforts will be oriented toward a problem solving inference system for processing problems and a knowledge based management system for accumulating and managing knowledge. These two systems will have a corresponding hardware machine supported by advanced mass storage systems such as videodisks.

Although markets for fifth-generation computers may emerge only in 7 to 10 years from now, it is reasonable to assume that advances will occur in an incremental way even though the possibility for break-throughs cannot be eliminated at this stage. Each incremental advance will probably be incorporated immediately in new evolutionary products or services. Examples of past AI research which led to widespread applications are: time-sharing, interactive editing and debugging, graphics-oriented interfaces, optical character readers and robots.

It is too early to forecast any credible market figures for fifth generation computing (in fact, even applications can only be guessed at). Examples of such forecasts are included below. However, it should be noted that forecasts in this field are regularly revised upward. Furthermore, in the Canadian context, automated translation should be added as a category of its own to the markets identified below.




Markets for Artificial Intelligence Products
(Source: Commercial Products Begin to Emerge from Decades of Research. Electronics, November 3, 1983, p. 128)

| Product Category | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|
| | Market Estimate (U.S. $ millions) | | | | | | | |
| Knowledge systems | 10 | 16 | 25 | 40 | 60 | 90 | 145 | 220 |
| Natural-language software | 18 | 32 | 60 | 105 | 190 | 335 | 600 | 1,090 |
| Computer-aided learning | 7 | 11 | 15 | 20 | 30 | 45 | 70 | 100 |
| Visual recognition | 30 | 55 | 100 | 150 | 230 | 360 | 555 | 860 |
| Voice recognition | 10 | 14 | 20 | 30 | 50 | 80 | 130 | 230 |
| Total | 75 | 128 | 220 | 345 | 560 | 910 | 1,500 | 2,500 |

International market estimates for selected artificial intelligence products.
(Source: Ibid., p. 129)

Most major countries have programs in this field, the best known one being the Japanese Fight-Generation Computer Project. The project, as a whole, is being sponsored by MITI, and although the Japanese have executed a number of national projects over the years, none has attracted more attention than this one. MITI's commitment is about $500 million over ten years, and industry is expected to contribute at least an equivalent amount. The first three year phase is being funded entirely by MITI at a level of $45 million. The new Institute for New Generation Computer Technology (ICOT) brings together eight firms which benefit from contract funds and research results (Fujitsu, Hitachi, Matsushita, Mitshubishi, Nippon Electric, Oki Electronics, Sharp and Toshiba). NTT is independently doing work in the field.

More than one U.S. program addresses the Japanese challenge. One is the Microelectronics and Computer Technology Corporation (MCC) (Austin Texas), which brings together thirteen companies to conduct joint research. Another one is Defence Advanced Research Projects Agency (DARPA), which has for some years been funding computer-related research (including AI and vision) at many universities and corporations.

Last October, DARPA announced a new program called Strategic Computing and Survivability, to foster a new generation of "superintellingent" computer for military use. These machines will have humanlike capabilities, allowing them to see, reason, plan, and even supervise the actions of military systems in the field. About $1 billion will likely be spent over the rest of the decade. It will span major areas of technology, including high performance device technology (gallium arsenide) and VLSI systems, multiprocessor computer architecture, and artificial intelligence applications. The computer architecture effort will have the goal of creating computers capable of performance three or four orders of magnitude greater than that of current machines.

Another initiative is the Semiconductor Research Cooperative (SRC) which was established two years ago to increase integrated circuits research and up-grade U.S. university laboratories. In 1983, the commitment exceeded $11 million and the 1984 budget is expected to exceed $13 million. There are five major research areas: microstructure sciences; system components; design tools; new approaches to manufacturing; and new approaches to engineering. A last example is the Microelectronics Centre of North Carolina which combines the resources of five universities, in a $30 million research facility. The $50 million budget for 1981-85 will come from the State largely, but also some from industrial affiliates.

These examples do not include the initiatives being taken by U.S. corporations such as IBM, Digital Equipment, Hewlett-Packard, Texas Instruments, Fairchild-Schlumberger, Martin-Marietta and others.

European research is being pursued on three levels -- within the EEC, within member countries, and within individual companies. Since the late 1970s, the position of European information technology industries has worsened in the world market. The European Strategic Program on Research and Information Technology (ESPRIT) was very recently formed by the EEC to reverse this decline. The main program, which is still under consideration, may involve $1.5 billion and 2000 researchers over the first five years. Half the funding will come from the private sector.

The plan calls for research in five areas: advanced microelectronics (VLSI chips), software technology, advanced information processing, office automation, and computer integrated flexible manufacturing. ESPRIT is a partnership among various companies, academic laboratories, and government agencies. The main thrust of the research in information processing will be in information and knowledge engineering, pattern recognition and man-machine interfaces, computer architecture for parallel processing, and computer-aided design.

The new U.K. program, developed by the Alvey group, will concentrate on four areas of research: VLSI, software engineering, intelligent knowledge-based systems, and man-machine interface. The aim of the Alvey Programme, which started in about April 1983, is to improve the competitiveness of the British information technology industries in the world market. The program will cost about $500 million over five years.

In the spring of 1984, the German Ministry of Research and Technology announced a comprehensive program in information technology to cost some $6 billion from 1984 to 1988. Many subprograms relate to advanced computing: VLSI ($1.2 billion), knowledge processing and pattern recognition ($400 million) and new computer architectures ($320 million).

## 4.0 CANADIAN ACTIVITIES

### 4.1 General

The Canadian industrial activity in the field is fairly limited mainly because this science is still in the infancy of commercial applications.

The situation can be summarized as follow:

a) Levels of activity are low and scattered geographically, with few centres of expertise of any size;

b) Only a few of the larger firms in Canada have expressed any significant interest in the field.

c) There is a recognition that, at present, most of the work being done in this area is in the universities. Consequently, major concerns are technology transfer and cooperative ventures (university/industry and government/industry);

d) The relatively low levels of activity in Canada coupled with the lack of significant involvement in the field by Canadian industry make information dissemination, both from domestic and foreign sources, of high priority.

### 4.2 Federal Activity

Federal activities in fifth generation computing are being initiated in many departments and agencies including DND, DOC, DSS, EMR, NRC, Environment, Secretary of State and the Science Council. Most science based departments are planning to increase their research effort in the field.

DND already has a program underway to adapt expert systems methodology to develop computer-aided systems to assist sonar operators. Within EMR, special mention should be made of the activities of the Canada Centre for Remote Sensing (CCRS), which has been conducting research in image analysis for many years and which requires AI to extract information from large volumes of remotely sensed data. The Centre is planning to establish a Working Group on Image Analysis and Artificial Intelligence.

The new office systems laboratory of DOC in Laval will include AI work and the Communications Research Centre is already investigating the following:

- an expert system for the diagnosis of brain damage in children is being constructed;
- human problem solving strategies and related models;
- computational models of human localization of objects in space and also of human form perception;
- strategies for exploring, perceiving and recognizing image objects to facilitate knowledge acquisition and decision making;
- natural speech recognition, synthesis and conversion to text;
- translation;
- intelligent data bases and applications to Telidon systems;
- advanced knowledge engineering tool employing a procedural semantic net as a knowledge representation scheme; and
- an automated adaptive space platform management system.

DSS is exploring the possibility of using procurement as a way to promote the development of new computer architectures and videodisks.

At NRC, in the Electrical Engineering Section, research is conducted in computer graphics, vision systems, computer-aided-learning, new computer architectures and photonics. Also, within NRC, the Institute for Manufacturing Technologies will conduct some research in artificial intelligence and the National Aeronautics Establishment is currently involved in research on vision systems, speech recognition and processing, and robotics. The NRC and Bell Northern Research are contributing $7.2 million each to develop new circuits that are 10 times faster than current chips. Department of Environment is presently involved in software development for parallel processing.

The Secretary of State is currently completing a major study (also supported by DOC) research needs in automatic translation and natural language processing. Consideration is being given to sponsoring a major R&D effort in machine translation, possibly through the establishment of a university centre of specialization. This centre would likely concentrate on fundamental research, training, and software development.

The Science Council has, up to now, sponsored two national meetings on AI. NSERC is already supporting university researchers in artificial intelligence but no program specifically aimed at fifth generation computing. However, it is exploring how it could better support this field. NSERC also supports a national design network aimed at enabling Canadian universities to become more involved in research related to the design of VLSI chips. The facilities related to the network are owned and managed by the Canadian Microelectronics Corporation (CMC) whose board of directors includes representtive from academia, industry and government. Furthermore, NSERC is now analyzing a proposal calling for the creation of two VLSI and Gallium Arsenide research centres.

An interdepartmental working group chaired by MOSST (on which DRIE is represented) is currently identifying policy issues in fifth generation computing. In doing so, it is conducting consultations with both industry and universities.

### 4.3 Provincial Activities

No programs specifically aimed at next generation computing have yet been put forward by provincial governments.

### 4.4 Industry Activities

As part of their research study for the Secretary of State, Cognos Inc. surveyed some Canadian companies to ascertain the extent to which firms are involved in AI either as suppliers or users. They found that a few new companies have been formed in Canada to exploit AI technology but they are mostly very small. Examples include Robotic Systems International (B.C.), Expert Systems (B.C.), N.W. Artificial Intelligence (B.C.), GOMI AI Systems (Ont.), Nexa (Ont.), Northwest Research (B.C.), Cognicom (Ont.).

Larger firms interested in either using AI products or conducting research include IBM Canada, DEC, Spar, MacDonald, Dettwiler and Associates, Imperial Oil, Bank of Montreal, Ontario Hydro, Bombardier, Bell Northern Research and others. In fact, one successful software firm changed its name to reflect a new orientation towards artificial intelligence. It is Cognos (formerly Quasar Systems).

Fifth generation computing is based, not only on artificial intelligence but it also calls on very large scale integration (VLSI) chips and new computer architectures.

The chip industry is quasi-nonexistant in Canada. In 1980, for example, imports were $157.7 million and shipments were a meagre $8.9 million according to Statistics Canada's data.

The two major Canadian players are Northern Telecom and Mitel. The first fabricates chips for its own use and Mitel uses up to 70% of its production. Linear Technology is upgrading its facility for the production of LSI bipolar ICs. A fourth firm, Siltronics, has been designing custom circuits which were fabricated in United States. They are now commencing fabrication in Kanata. Microtel Pacific in Vancouver also is setting up production, primarily for in-house requirements. Other manufacturers are very small: Anateck Electronics (B.C.) (Hybrid circuits), Pacific Microcircuits (B.C.) (Design and prototyping). Finally, there is a world renowned designer, Mosaid, which specializes in the design of memories for the major foreign producers.

The major reasons put forward for not developing capabilities in chip manufacturing have been: 1. a priority on value-added applications, 2. the high costs of a manufacturing facility and the need to regularly upgrade the equipment to accomodate the new technology, and 3. the existence of silicon foundries in United States which can manufacture designs brought to them. On the other hand, some analysts are now raising the possibility that access to state-of-the-art chips may become problematic. No concensus seems to exist on the best chip policy.

As for the Canadian computer industry, imports were $1.95 million in 1980 and shipments were $889 million of which it is estimated only about 55% was actually value added in Canada (these figures include some software). The trade deficit grew from $217 million in 1970 to $1.2 billion in 1980. Canadian owned manufacturers account for less than 10% of the Canadian industry's production and they have captured less than 5% of the domestic market. Only four of them employ more than 100 employees: GEAC, Nabu, AES Data and Northern Telecom.

MNE are mostly assembly plants although a few actually conduct research on advanced computers (e.g. Control Data). As for now, only one Canadian producer is developing a computer using the state-of-the-art in parallel architecture: Myrias Computer Systems. Concerning the next generation of peripherals such as videodisks, no drives are manufactured domestically. However, a dynamic applications industry is emerging lead by names such as Matrox.

## 4.5 University Activities

Most of the AI research community in Canada works within the university system. It is estimated that there is a total of some 135 professors, graduate students and research staff working in AI at 18 Canadian universities. The largest number is at the University of Toronto (28), UBC, McGill, Concordia and Ottawa. The University of Waterloo is also becoming very active. Thus, the research is highly fragmented, since their research covers all the sub-fields of fifth-generation computing.

A great number of universities are now conducting research in chip technology with the support of the national design network sponsored by NSERC (see p. 6).

In new computer architectures, a leader is certainly the University of Waterloo and its Institute for Computer Research.

Mention should also be made of the Canadian Institute for Advanced Research whose first research program is Artificial Intelligence, Robotics and Society, Its initial focus will be on vision systems. The group has received $1.1 million in funding up-to-date and expects to raise this amount to $1.6 million next year.

# 5.0 FEDERAL GOVERNMENT CONSIDERATIONS

Federal science-based departments and agencies will have a significant role to play in developing Canadian industry's capabilities by undertaking in-house R&D and transfering technology, awarding R&D contracts to industry and universities, and purchasing Canadian products and services.

Procurement of products and services incorporating this technology will be significant in a number of areas including intelligent access to mass data storage, expert systems, natural language front ends for a variety of systems, air traffic control equipment, remote sensing, translation, sensors, meteorology and computer-aided training. It will be important to develop a strategy for maximizing the benefits to Canada.

To counteract the actual trend towards an exponantially increasing trade deficit in electronic products and software, Canada will have to participate in the fifth-generation computing revolution. However, in doing so, it will have to accept a number of challenges, among them:

- the need to recognize that investments in R&D/innovation to keep up with the state-of-the-art should be much larger than in the past. Furthermore, Canada will have to reckon with the huge programs being put forward by EEC (Esprit), U.K. (Alvey), Japan (5th Generation Computer) and U.S.A. (DARPA and private initiatives) even if it specialized in just a few domains. As for now, it seems that international cooperation on research in this field may be difficult, if not impossible because most countries consider this technology as strategic to their economic future.

- considerations will also have to be given to the supply of qualified researchers. The level of funding should take into account the availability of manpower. In the past, many graduates went to the USA for lack of openings in Canada. For graduates to stay in Canada, jobs will have to be offered not only in universities and government laboratories but also in private industry. Furthermore, the complexity of the next generation of software may preclude college trained programmers from writing software for the new machines unless advances are made in automated programming. In fact, programming may become less important than knowledge engineering.

- Consultations with industries and universities should be conducted to develop consensus on issues such as fields of specialization, chip supply, access to new computer architectures and others. In particular, the intimacy of the relationship between VLSI chips, computer architecture and artificial intelligence is still nebulous. It is theoretically possibly that knowledge would be embedded in chip form and competitors would sell "software" and hardware in only one form. Also, it is not at all certain if the diverse new architectures will be made public; without an intimate knowledge of architecture, it may prove impossible to develop the software to be run on these machines.

In view of the involvement of foreign governments in supporting this technology and the fact that the level of required funding is beyond the capacity of the private sector, the federal government should offer some firm commitment. It has a role to play in ensuring cooperation between governmental laboratories, universities and the private sector. It should also facilitate the supply of adequately trained specialists.

## 6.0 DRIE CONSIDERATIONS

This paper has shown that advanced computing technologies, although still in their infancy, have a tremendous potential to improve a Canadian sagging productivity, by broadening the range of functions which could be automated (in the primary and secondary sectors as well as in service industries) and by accelerating the rate and the scope of the diffusion of these technologies by facilitating the use of computers for non technical users. Furthermore, these technologies will lead to many yet unforeseen products and services.

As stated earlier, foreign governments are intensively supporting their information technology industries. If Canadian informatics is to compete under fair conditions, it will have to be supported in a similar manner, a function for which DRIE is responsible. In the case under discussion, this kind of support is timely because the technology is in its early life cycle. While IRDP could be used to support advanced informatics research leading to commercial products and processes, it could not be used to fund supporting technologies and sciences such as linguistics even though this and some other human science disciplines are an integral and fundamental part of advanced computing.

Most Canadian firms active in information technologies are rather small if not a one man operation. They do not have the resources to conduct the kind of complex, time consuming and expensive research which will be characteristic of advanced computing technologies. Furthermore, while the present generation of application software can be written by college graduates, the next generation will rely on specialists formed in the application themselves rather than translators of english ideas into computers jargon. One of the possible solutions to these problems would be the creation of centres of expertise, and area of activity where DRIE has develop a solid experience either with the Centres of Advanced Technology (CAT), the Industrial Innovation Centres (IIC) and the Industrial Research Associations (IRAs).

Financial considerations are only one part of the equation. The other is awareness to the technology. With its available resources, the networks of contacts it has developed over the year and the specialists at its service, DRIE is an obvious candidate to ensure that industry is aware of this emerging technology and its diverse applications. One solution would be to create some information clearing house on advanced computing on the model of the CAD/CAM secretariat. The same approach that was used in the CAD/CAM strategy could probably be adapted for advanced computing.

Awareness of the potential of the technology and access to funds should be complemented by an adequate supply of qualified manpower (an issue outside the area of responsibility of DRIE but for which it should press the responsible department or agencies for action) and by access to in-house gouvernmental R&D and, particularly, to university research which is at the leading edge of the technology and, in some niches, for which Canada is renowned. DRIE has a major role to play in linking industry with government research laboratories such as the Communication Research Centre or the National Research Council and with universities by referring individual firms to the right laboratory or by publishing a list of experts and their associated field of expertise for each major sub-field of advanced information technology. DRIE should also assist firms in gaining access to foreign technology by promoting trade missions, by liaising with the science advisors in our embassies, and by its membership on the sub-committee of ICISTR on information technologies.

Many departments are pursuing or initializing activities in advanced information technologies, including NRC, DOC, MOSST, EA, TC, DSS, EM&R, DND and others. These activities need to be coordinated and DRIE should explore, with the concerned departments, ways to ensure that an efficient coordination is developed which takes into account the interests of the industry and the regions. Independently of the form this cooperation takes, DRIE should ensure that industrial and regional interests are taken into account in the course of the development of policies in concerned department and agencies by developing an official departmental position and by participating or inputting into these policies.

## 7.0 ROLE OF OII

Advanced information technologies are, by definition, those which are at the stage of laboratory curiosities or at the very early phase of their life cycle. Even though the Industry Sector Branches are aware of the importance of these emerging technologies, their workload and their resources are such that day-to-day routine, and shorter term issues have by necessity priority over these longer term technologies.

Furthermore, the hardware aspects are the prime responsibility of the Electronics and Aerospace Branch while the software aspects are being pursued by the Service Industries Branch. Also, the applications of these technologies to robotics, agriculture, health care, and others are the responsibility of a great number of other ISBs. Consequently, advanced information technologies being horizontal technologies with longer term applications, OII should become the prime focus of interest for matters relating to advanced information technologies.

With its access to a variety of sources, its contacts with organisms outside the department, OII has a major networking and interfacing role to play in representing DRIE and in catalysing exchange and technology transfer from government and university labs to industry.

Technology specific reports on hardware (e.g. videodisks), software (e.g. expert systems) and their applications (e.g. vision systems) will also be prepared.

# NEW COMPUTING TECHNOLOGIES

## WORK PLAN

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE I - General Review of the Field** | | |
| Identification of major actors in the field both internationally and nationally. | | on-going |
| Review of literature to establish a knowledge base in the field and to identify:<br>a) important scientific and technological trends;<br>b) stimuli for and constraints on technological development;<br>c) likely industrial applications and their significance;<br>d) likely rates of diffusion and their significance;<br>e) domestic and foreign government policies in the area. | | on-going |
| Identify and participate in committees and task forces. | | on-going |
| Establish and maintain files and a library of information on domestic and foreign policy, programs and activities. | recognized source of information in the field | Feb. '84 |
| **PHASE II - In-Depth Review of the Canadian Situation** | | |
| Discussions with federal agencies to gain in-depth knowledge of:<br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | Mar./ April '84 |
| Discussions with regional offices to:<br>a) assess regional strengths and weaknesses;<br>b) determine aspirations;<br>c) identify major regional issues with respect to the technology which need to be addressed. | | Mar./ April '84 |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| Discussions with provincial organizations (departments, PROs, etc.) to determine:<br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | April/ May '84 |
| Discussions with industry and industrial associations to determine:<br>a) impact of technology on industry;<br>b) markets;<br>c) constraints on, and stimuli for, development;<br>d) likely future impact;<br>e) potential for future development;<br>f) imports and exports of the technology; | | April/ May '84 |
| Discussions with universities to determine:<br>a) likely future trends in the technology;<br>b) constraints on university research in the area; | preparation of background notes and summaries | May/ June '84 |
| Create and maintain a data base within OII which will contain key information on industrial involvement in the field. | recognized source of information | May/ June '84 |
| **PHASE III** – **Production of Status Report** | | |
| Write a draft report in the agreed upon format on Advanced Computing Technologies;<br>circulate for comment and revise accordingly. | | April '85 |
| Respond to enquiries from industry, universities and government | | |
| Explore the desirability of developing a set of recommendations to assist in further industrial development of fifth generation computing. | | Sept. '84 |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE IV - Departmental Studies** | | |
| Preparation of a report on expert systems. | Report | June '85 |
| Prepare a report on videodisk technologies and their applications. | Report | Nov. '85 |

SENSORS AND INSTRUMENTS June 1984

## 1.0 OBJECTIVE

To provide a general introduction to the field of sensors and advanced scientific instruments and work plan for the portfolio.

## 2.0 DESCRIPTION

Sensors are the interface between data processing equipment and the physical world. They are the means by which the processing equipment obtains critical information about such parameters as temperature, pressure, rotation, position, mineral composition, foliage composition, land use, water quality, voltage, fields, current and chemical composition. As such, sensors are critical to the development of, for example, computer controlled machinery, robotics, remote sensing, monitoring equipment for both air and water pollution, and improved diagnosis and treatment of disease.

Instruments could be defined as broadly as any means used to achieve or perform a task. However, for purposes of the portfolio, instruments refer to measuring devices used to determine the distinction between instruments and sensors is minor and has more to do with complexity than function. Instruments are in general, self-contained units for batch or sample analysis, whereas sensors tend to be one element in a complex monitoring system often for in situ applications. It is worth noting that the distinction between sensors and instruments is becoming more blurred with the development of intelligent sensors capable of signal processing and amplification. What was traditionally thought of as within the domain of an instrument is now being integrated into the sensor itself.

The instrument field is extremely broad and heterogeneous involving such industries as automobile, aircraft, chemical domestic appliance, communications, entertainment and industrial control. Increasingly, new instruments and sensors are being developed as a result of advances in scientific knowledge. They arise out of the need for more precise and more detailed knowledge of physical phenomena. Such instruments are often the fore-runners of the industrial instrumentation of the future. The focus for work within OII is emerging technologies, ones which will not have their full impact for at least five years. For this reason, the portfolio will concentrate on advanced scientific (including medical) instrumentation. In addition markets for such instrumentation, particularly in the medical field are considerable.

## 3.0 INTERNATIONAL TRENDS

There appear to be four major trends in supply side sensor development which are contributing to the rapid growth of this sector. They are:

a) Increasing miniturization to make in situ applications more feasible (most notably in medical applications);

b) Increasing measurement sophistication whereby a number of critical parameters are measured similtaneously with one probe (i.e. monitoring the concentration of a dozen chemicals at the same time);

c) Development of greater life and reliability for applications in areas with difficult access for with hostile environments (e.g. remote sensing or nuclear plants) so that in situ sensors can be used to control as well as monitor a process;

d) Increasing use of microelectronics to both control probes and to analyze results with the consequence that sensors compatible with microelectronics systems are of the greatest importance today.

Many of the recent advances in this field have arisen out of developments in silicon processing (micromachining), microelectronics, fibre optics, electrochemistry and biotechnology. It is of interest to note that developments in such fields as fibre optics and biotechnology have, in many cases, given rise to the need for advanced sensors as well as the means by which such sensors could be developed.

In addition, microelectronics find increasing use in subsystems and instruments, sometimes replacing several mechanical functions. This trend is also expected to continue, at least into the next decade. Consequently, microelectronic peripherals - such as sensors - are becoming more important. In fact, the lack of sensors technically and economically suitable for integration with microelectronics could seriously deter expansion of microelectronics applications. A good example is in the area of industrial robots where the need for a wide variety of visual and tactile sensors is imperative for the continued development of the technology.

The direct sensor element (not sensor system) market for 1985 is estimated to be about $1.5 billion (U.S.) worldwide, including about $600 million for the U.S., about $400 million for Western Europe, and about $300 million for Japan. The Federal Republic of Germany has about one third of the Western European market and Great Britain and France about one quarter each. Although the costs of measurement and engineering control are expected to be 10 to 100 times the cost of the sensors they use, the market will not develop without the availability of suitable sensor.

For microelectronic compatible sensors, 1985 markets for different user sectors in Western Europe are as follows:

| | | |
|---|---|---|
| Automotive electronics | 45% | ($180M) |
| Domestic electronics | 25% | ($100M) |
| Industrial control | 12% | ($ 48M) |
| Entertainment electronics | 3% | ($ 12M) |
| Leisure time electronics | 2.5% | ($ 10M) |
| Communication and data processing | 0.5% | ($ 20M) |
| Miscellaneous | 7.5% | ($ 30M) |

In large markets, such as those for pressure or temperature sensors for automotive or domestic appliance electronic devices, strong worldwide competition can be expected among the few large semiconductor and sensor manufacturers. For these markets, the development of intelligent sensors is of prime economic importance. In the smaller and more specialized sensor market segments, more than 500 small and medium-sized companies are operating in Western Europe and approximately 400 in the U.S.

Trends in instrumentation parallel those for sensors with increasing sophistication and control by computer being dominant development characteristics. Advanced instruments tend to have incorporated analytic capabilities whereby raw data produced by the instrument is processed to provide usable results in the form of, for example, graphs, identified compounds or concentrations. Miniturization is of secondary importance in this area although it is now possible to produce a gas chromatograph (a basic chemical analysis machine) the size of a microchip.

Another important trend is towards greater integration of instruments within one operating system. Thus, what one took three or more instruments to achieve can now be done with one.

On the demand side, factors contributing to growth include:

a) The need for increased productivity through automated processes;

b) The need for improved quality of products through automatic quality control and its integration into production processes;

c) Demands for an enhanced workplace through improved safety and the need to place as few workers as possible in hazardous environments;

d) The need to decrease energy and raw material consumption through better process control;

e) The need to reduce environment pollution through better process control.

## 4.0 CANADIAN ACTIVITIES

At this stage, there are no general reviews of the sensing industry in Canada. Remote sensing would appear to be a well developed field (i.e. Canada Centre for Remote Sensing, MDA, Dipix) but it would appear that industrial activity in the sensing field is, in general, minimal.

There is some Canadian industrial capability in the scientific instruments field. NSERC publishes a catalogue of research and laboratory products which lists manufacturers whose products have 50% or more of their value added in Canada. Using a liberal definition of instruments there are 8 manufacturers listed in this catalogue. They are:

a) Bomem Inc. which produces fourier transform infrared spectrophotometers;

b) Englelhard Industries of Canada which produce anodes, electrodes and thermocouples;

c) Lisle-Metrix which produces conductivity bridges, dissolved oxygen meters and pH meters;

d) Ontario Watch Trade which produces timers;

e) Photochemical Research Associates which produce fluorescence lifetime instruments, lasers and photon counting systems;

f) Sciex Division of MDS Health Group Inc. which produces mass spectrometers and accessories;

g) Scintrex which produces atomic absorption spectrophotometers, gamma ray detectors, radiation monitors, magnetometers and trillium monitors;

h) Torrovap Industries Inc. which produces spectroscopic interfaces and mass monitors.

The BOSS system lists some 318 firms that are involved in the sensors and instruments field. Of these some 40 to 50 could be said to be involved with scientific instrumentation.

It is difficult to determine the extent of the Canadian market in instruments. However, using Statistics Canada definitions and data, the scientific instruments market has grown from $29 million in 1979 to $41 million in 1981, and 41% increase. Physical property test equipment has grown from $33 million 1979 to $95 million 1981, a 187% increase. Virtually all of this equipment (98%) is supplied by foreign producers.

Instruments and especially sensors, are tools which can be used in a variety of ways in almost all industrial sectors. Thus a large number of federal departments including NRC, DOC, EMR and DND are involved in their development. DRIE funds the Canadian Centre for Advanced Instrumentation which provides instrument maintenance and calibration services and develops and fabricates instruments particularly those relevant to the resource industries in Western Canada and the Canadian North. Total departmental support for the centre is $1 million over 5 years.

The department is also considering a proposal for a Medical Instrumentation Centre based at the Vancouver General Hospital. This centre is designed to improve the competitive position of the Canadian bioengineering industry which supplies only <u>one tenth of the Canadian market</u>.

## 5.0 FEDERAL POLICY

The commercial potential of sensors is intimately linked with the diffusion of major technologies such as advanced manufacturing technologies, biotechnology and microelectronics. All these fields are the subject of government concern, or policies, at the present time.

The commercial significance of instruments is less bound up in the developments in other fields although advances in microelectronic and the integration of this field into the instrument industry will have a profound effect on future instrument design and capabilities. A field with considerable potential for Canadian development both from a market and a supply considerations is that of medical instrumentation.

Instruments have become a major policy issue with respect to R&D in recent years. Studies have shown that a significant proportion of the instrumentation in Canada laboratories is obsolete. NSERC has implemented new initiatives to correct this situation which involve the infusion of $120 million over three years and a buy Canadian policy. Although the university market in Canada is not large, this may prove a stimulus to Canadian manufacturers in the field.

## 6.0 DRIE CONSIDERATIONS

In summary, the current situation in the fields of sensors and instrumentation as it affects this department is as follows:

a) Recent interest in the field is due to advances in other areas of high technology. Developments are both driven by and dependent upon advances in fields such as microelectronics and biotechnology;

b) Although the commercial importance of the field appears to be considerable, its major significance lies in its ability to expand the capabilities of other fields such as integrated manufacturing and disease diagnosis. This is less true of the instruments field where the demand for quality control tests, monitoring and analysis provide a strong market. However, growth in the instruments market appears to be linked to improvements in instruments derived from advances in high technology;

c) At present knowledge about Canadian capabilities in this field is limited, but initial impressions are that manufacturing capabilities are limited.

## 7.0 ROLE OF OII

What these preliminary observations would suggest is that OII activities should be guided by the following considerations:

a) Work in this area should be closely linked to the work being done in other portfolios;

b) Since the field is broad and diffuse, initial activities should focus on a clearer delineation of the structure of the industry, current and potential applications, linkages between developers and users, markets and future trends. Particular emphasis should be placed on the potential for Canadian development;

c) Initial work should focus on the new sensors and instruments arising out of developments in other areas of high technology with particular emphasis on scientific, medical and manufacturing applications.

With these considerations in mind the first task would be to let a contract which would:

a) Provide a categorization of the sensors and advanced scientific instrumentation fields;

b) Link this categorization schemes to usage (industry, government and universities) of sensors and instruments in Canada;

c) Determine, over time, the net import/export characteristics of usage in Canada by category;

d) Determine the Canadian content of this import/export profile.

On the basis of this work, a second contract would be let to identify:

a) Trends in sensor and instrument technology development;

b) External forces (e.g. regulation) affecting sensor and instrument development.

Combined these two studies would provide the background materials for a status report on these technologies.

## SENSORS AND INSTRUMENTS

## WORK PLAN

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE I - General Review of the Field** | | |
| Identification of major actors in the field, both internationally and nationally. | | on-going |
| Review of the literature to establish a knowledge base in the field and to identify:<br>a) important scientific and technological trends;<br>b) stimuli for and constraints on technological development;<br>c) likely industrial applications and their significance;<br>d) likely rates of diffusion and their significance; and<br>e) domestic and foreign government policies in the area. | | on-going |
| Identify and participate in committees and task forces.<br>Establish and maintain files and a library of information on domestic and foreign policy, programs and activities. | Recognized source of information in the field | Jan. '84 |
| **PHASE II - In-Depth Review of the Canadian Situation** | | |
| Let contracts as indicated in work plan. | Establish data base | Feb. '84 |

**IF THESE CONTRACTS JUSTIFY FURTHER WORK THEN**

| | | |
|---|---|---|
| Organize seminars of government, industry and university experts to:<br>a) identify trends and issues;<br>b) promote linkages between suppliers and users. | Enhanced communication enhanced appreciation of capabilities | |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
| --- | --- | --- |
| Discussions with federal agencies to gain in-depth knowledge of:<br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | |
| Discussions with Regional Offices to:<br>a) assess regional strengths and weaknesses;<br>b) determine aspirations;<br>c) identify major regional issues with respect to the technology which need to be addressed. | | |
| Discussions with provincial organizations (departments, PROs etc.) to determine:<br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | |
| Discussions with industry and industrial associations to determine:<br>a) current impact of technology on industry;<br>b) markets;<br>c) constraints on, and stimuli for, development;<br>d) likely future impact;<br>e) potential for future development;<br>f) imports and exports of the technology. | | |
| Discussions with universities to determine:<br>a) likely future trends in the technology;<br>b) constraints on university research in the area. | Preparation of background notes and summaries | |
| Create and maintain a data base within OII which will contain key information on industrial involvement in the field. | recognized source of information | |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE III - Production of Status Report** | | |
| Write draft report in the agreed upon format. | | |
| Circulate for comment and revise accordingly. | | |
| Respond to enquiries from industry, universities and government on sensors and instruments. | Status Report | |
| **PHASE IV - Strategy** | | |
| If appropriate, develop recommendations to assist in further industrial development of sensors and instruments and pursue the implementation of these recommendations. | Action | |

PHOTONICS June 1984

## 1.0 OBJECTIVE

To provide a general introduction to the field of photonics and a work plan for the portfolio.

## 2.0 DESCRIPTION

Photonics refers to the combined fields of lasers and fibre optics. Lasers employ high-intensity light or electric current to cause atoms, molecules or ions in a medium to radiate at frequencies corresponding to the separation between discrete energy levels. The process generates light of essentially a single wavelength (coherent light) which varies with the nature of the light-emitting medium selected. Mediums may be solid, liquid or gas with common materials including ruby, organic dyes and carbon dioxide. Unique properties of laser light which give rise to the diversity of its application include high directionality, high power and single colour emissions. Industrial applications derived from these unique properties include drilling, cutting, welding, sensing, surgery, separation of materials, communications, microchip manufacture, medical diagnosis, and defence target designating. In general terms, lasers can be classified into four types, pulsed, gas, liquid and semiconductor. Communications applications tend to be drawn from semiconductor lasers and high-power applications, such as welding and drilling, from gaseous lasers.

Fibre optics can be classified into two broad areas of application: the transport of light and the transport of visual information. In the first, bundles of optical fibres which are not aligned serve as light guides. In the second, the fibres are aligned and the resulting bundles are called coherent. This latter category can be further classified into two groups, one of which uses a flexible bundle and the other a solid bundle.

In the light guide group, the main commercial applications have been the provision of illumination for medical instruments and the sensing of holes in punched-card readers. The dominant application of fibre optics is in the flexible coherent group where its use in the communications field has seen considerable growth. Solid bundles are used almost exclusively as a face plate in electron optical image tubes.

The major advantages of using fibre optics over other modes of transmission include:

1) fibre optics systems, being non-electric, are not vulnerable to interference caused by lighting, high tension wires, current variations or the influence of other telecommunications systems;

2) fibre optics allow the transmission of greater quantities of data with superior speed and reliability compared to those of existing systems. A single fibre can transmit more than 20,000 telephone conversations simultaneously, many times more than can be transmitted over paired copper wire;

3) fibre optics are especially valuable in potentially explosive environments since they use light instead of electricity thus eliminating the risk of sparks;

4) fibres are protected from the risk of wire tapping since traditional listening devices take advantage of the electromagnetic fields surrounding electric cable which are not present in fibre cables;

5) fibre optics have the capacity to transmit, on one line, audio, video and data signals. In rural areas, or over vast distances this could eliminate duplicate transmission media making installation of fibre cable that much more economical;

6) fibre cable is thinner in diameter making them preferable wherever there is a problem of space such as in overloaded ducts in large cities.

## 3.0 INTERNATIONAL TRENDS

In the words of A. Buchanan, Chairman of Lumonics, "Lasers are solutions looking for problems". Lasers have been in existence for approximately 25 years but it has been only in the last decade that industrial applications for the phenomena of coherent light have begun to appear. The first fibre cables were demonstrated about 120 years ago while the main development activity started less than 20 years ago. Commercial exploitation of fibre technology is less than 10 years old. Thus there is little doubt that, as diverse as current applications are, the next decade will see an ever increasing range of applications and a much wider acceptance of photonics-based products.

Excluding the military and consumer photographic sectors, the size of the optics industry (an industry which includes photonics) globally now exceeds $6 billion annually. A recent U.S. Commerce Department report projects that the growth rate in the 1980's of the optics industry will outstrip that of the electronics industry. This same report states that the annual compounded growth rate of the optics industry ranked fifth among the most important industries in the U.S. during the 70's and is expected to rank third in the 1980's. Another U.S. report predicts an annual growth for the laser industry alone of 25-30% per annum through 1990.

At the present time, the major areas of application of photonics are as follows;

a) communications,

b) industrial processing,

c) medical diagnosis and surgery,

d) sensing.

The predominance of communications applications of photonics in the market place means, however, that the field can in essence be divided into two areas, communications and non-communications applications.

The fastest growing area of laser applications is in the communications field. Major areas of development appear to be telephone subscriber systems, data bussing and local networking. In these areas, developments are closely linked to developments in fibre optics. Market growth in fibre optics in the communications field is expected to be 39% annually over the next few years. At the present time, demonstrations have been made of optical transmissions of more than 100 km at high data rates, without repeaters and with low error rates. At the end of 1982, the Bell system in the U.S. has installed nearly 200,000 km of fibre and 10,000 repeaters. Within 2 years the U.S. expects to lay 1.3 million miles of optical fibres and by 1990 the yearly total is expected to hit 4.5 million miles.

The ability to heat material locally in a remotely-controlled environment is one of the key attractions of using lasers for materials processing. In many uses, the ease with which laser processing schemes can be incorporated into computer-controlled fabrication technology make them candidates for displacing conventional processing schemes. In many other applications, such as cutting and welding titanium, laser processing is almost the only technique that works well. Laser processing now includes applications as mundane as piercing holes in baby-bottle nipples and cloth cutting and as esoteric as punching holes in bismuth tillurium and the reading of high-density optical storage devices such as video-discs.

In the medical field, applications of lasers are in two areas, diagnosis and surgery. Demonstrated uses of lasers for diagnostic purposes include non-invasive analysis of blood and fluorescence logging and identification of biomolecules.

The driving force behind the acceptance of the lasers as a surgical tool is in its ability to vaporize and remove biological tissue without physical contact. Lasers offer several advantages in such applications including immediate sealing of small blood vessels and minimal danger of spread of malignancy or disease after surgery.

An area showing considerable promise is the use of photonics in sensing devices. Rapid progress in fibre-optic sensors is expected during the rest of this decade but such devices are expected to appear initially, in small market niches where their unique features are most easily commercialized. Photonic sensors are unaffected by electromagnetic radiation, they make no radiation of their own and cannot produce sparks. Applications will then extend gradually to replace and extend more complex sensing functions. World-wide markets for optical sensors are expected to grow very rapidly but remain relatively small in dollar volume.

However, the market for instruments that incorporate optical fibres could reach the billion dollar range by the 1990's. For example, in total, markets for non-communications uses of fibre optics were worth $47 million (U.S.) in 1982 of which $30 million was in military applications. By 1990 these markets are expected to have expanded to $475 million of which $200 million will be military/aerospace. At the present time there are approximately 10 companies, world-wide, that produce optical sensors and none of these are electric or electronic firms.

Another area of photonics application is in the defence industry. Laser weapons, although the subject of considerable debate, have as yet to be demonstrated. Other applications which show promise in the longer term are the use of laser beams to deposit integrated circuits directly on substrates such as silicon.

The industrial leaders in photonics are the U.S. and Japan. In 1981, MITI started the Optoelectronic Joint Research Laboratory as part of their plan to dominant the informatics industry. The Laboratory tapped 15 companies to support a $75 million 8 year program to develop optical integrated circuits. Today more than 150 companies are members.

NTT is the driving force behind Japan's move into fibre optics. It spends roughly 7% of its annual $350 million R&D budget on optics-related work and plans to spend $80 billion over the next 15 years to replace existing plant to gear-up for fibre optics production. At present Japan holds approximately 13% of the U.S. fibre optics market.

Major U.S. companies in the field include ATT, Continental Telecom, GTE and MCI Communications. Recent developments include a $3 million Defence Department contract to McDonell Douglas Corporation to design the communications elements of a sea-floor fibre-optics system for tracking foreign submarines and the creation at Carneige Melon University of a centre concerned with optical processing funded with $1 million from Westinghouse Electric Corporation. Another major development is the installation of ATT of a transatlantic fibre-optics cable over the next 4 years which will cost approximately $400 million.

The U.K. and several other European countries are active in the field. Several European countries have established institutes of optics and Germany has recently announced the creation of a new research centre in integrated optics.

In summary, photonics is a fast growing field which, although at present dominated by communications applications, shows considerable promise in a wide variety of commercial applications. In such applications, the technology is still emerging and its true commercial impact will not be felt for at least a decade. At present, Canada has 5% of the total optics market and is well positioned to exploit the rapidly growing photonics field.

## 4.0 CANADIAN ACTIVITIES

To the author's knowledge, there are no reports dealing with the state of photonics technology in Canada. However according to a recently released report by the NRC's Task Force on the need for an optics research centre at Laval University, Canada is at the forefront of developments in both the fibre optics and laser fields but activities tend to be unfocussed and lacking in critical mass.

### 4.1 Federal Activities

At the federal level, the three major research groups are at the NRC, the Laser and Plasma Physics Group, at DOC, the Communications Research Centre and at National Defence, the Defence Research Establishment, Valcartier. Lumonics, the preminent laser company in Canada evolved from research undertaken at DND and the NRC. Combined PILP and IRAP expenditures in the photonics field are estimated at $400,000.

NSERC provides support for research in Canadian universities. Over 20 universities conduct research in photonics with a major emphasis on lasers and laser spectroscopy. Research groups tend to be small (less than 10 people) with the three notable exceptions being at the universities of Laval, Toronto and Alberta.

The NRC will build and Institute in Laval to conduct and coordinate research and development concerned with the industrial applications of optics. This institute would focus its activities in four areas, namely,

1) technical optics to include design fabrication and testing of conventional optical components and systems, micro-optical components and integrated optical systems,

2) electro-optics to include materials, sensors, integrated devices and liquid crystals,

3) image science to include holography and coherent optics, image processing, vision and inspection processes,

4) special projects.

Recently, Ryerson established a Centre of Advanced Technology with funding from the Federal government. This centre, which will focus on the training of manpower, will initially concentrate its efforts in flexible manufacturing and photonics. Total federal support for this centre is $11.4 million over two years provided by CEIC.

## 4.2 Provincial Activities

At the present time, no province has an explicit policy or program for photonics. However, the recent announcement that Ontario is to finance university centres indicated that one of the centres would be in the laser field.

## 4.3 Industrial Activities

The Canadian optics industry (excluding the military and the direct consumer markets) is estimated to be approximately $250 million in size or 5% of the world market. Photonics is a smaller sub-set of this market and total industrial revenue from laser manufacture in Canada is estimated at between $45 and $60 million in 1983. Lumonics Inc. accounts for 1/2 to 1/3 of these sales and has a 3 year compound annual growth rate of 60%. Lumonics specializes in gas and solid state lasers with particular emphasis on laser coding of products. It is considered to be in third place in world-wide sales behind two California companies. In 1982, Lumonics acquired J.K. Lasers Ltd. of the U.K. which specializes in solid-state lasers for medical applications, industrial cutting and welding. Recently, Lumonics also acquired the U.S. based company Laser Identification Systems which has developed a YAG laser capable of marking almost any substance.

Other laser companies in Canada include,

1) Ultra Lasertech Inc. which is manufacturing carbon dioxide lasers for R&D applications in industry,

2) Scintex Ltd. which has developed an analytical laser device that can be used for exploring for minerals,

3) Plato Chemical Research Associates Inc. which is manufacturing low powered nitrogen lasers,

4) Northern Telecom Ltd. which has an extensive R&D capacity in lasers and fibre optics (approximately 50 people) largely for communications applications,

5) Canartic Ventures Ltd. which has developed a high power carbon dioxide laser for cutting and welding,

6) Majestic Laser Systems Ltd., a joint venture of the University of Alberta and Majestic Contractors Ltd., a pipeline construction firm, which is developing a cutting and welding laser,

7) MPB Technologies Inc. which is marketing a carbon dioxide laser and related electronic products.

Major suppliers of fibre optics cable in Canada are as follows,

1) Northern Telecom is involved in almost all aspects of fibre optics systems and components. Bell Northern has an extensive research capacity in all aspects of fibre optics systems,

2) Canstar Communications, a subsidiary of Canada Wire and Cable, is involved principally in fibre fabrication and system development,

3) Philips Cables recently began manufacturing fibre optic cables.

Canadian companies have had considerable success in the fibre optics field. Canada was the first to develop two-way transmission techniques over a single optical fibre and was the first to develop a coupler for optical fibre. In 1978, Bell installed the first optical telephone subscriber service in North America which was linked to the switched network and was capable of voice, data, and video transmissions. London, Ontario is the site of the world's first operational fibre optic cable TV trunk system using digital TV transmission.

## 5.0 GOVERNMENT CONSIDERATIONS

Photonics has been recognized internationally as a major force molding the manufacturing processes of the future. Both Japan and the U.S. has highlighted these technologies in recent reports on science and technology and both have programs of support in place. Since the technology is still an emerging one, programs tend to emphasize the support of exploratory research and information dissemination.

Canada appears to have a relatively strong capability in photonics. The Federal government has done much to foster the development of this capability as illustrated by the support provided Lumonics and Northern Telecom over the last decade. In the communications field, continued development in Canada, if not commercial success, would seem assured in that major companies are committed to its development and commercial viability has been demonstrated. In non-communications fields, continued development would seem to depend on the integration of photonics systems into existing or evolving operating systems whether they be manufacturing or medical. The federal government can play a role in creating an economic environment conducive to these developments by ensuring both a long-term research and development capacity in the country and adequate information flow.

## 6.0 DRIE CONSIDERATIONS

In summary, the current situation in photonics as it affects this department is as follows:

a) Canada has a strong capability in photonics. Communications applications are well developed and Canada processes one of the leading firms in the non-communications field. However much of this capability rests in the hands of a very limited number of firms (e.g. Northern and Lumonics);

b) Communications applications show the greatest commercial opportunity in dollar terms for the near-term. Although commercial applications in manufacturing are limited at present, this area appears to offer significant opportunities particularly in conjunction with the evolution of flexible manufacturing systems. Medical applications also appear to show great promise.

c) In non-communications applications, an important consideration will be the collection and dissemination of information from both domestic and foreign sources. Given the broad range of possible applications (instrumentation to ice cutting) potential users of photonics will be an important audience for this information;

d) Some provinces and several educational institutions are showing considerable interest in the field and may be looking to DRIE for support.

The field has considerable promise for industrial development in Canada but, considering its emerging status, fostering capability and ensuring rapid information dissemination would appear to be the most appropriate departmental role at the present time. Clearly this would need to be done in close cooperation with the other major players in the field, the NRC and DOC.

## 7.0 ROLE OF OII

Communications aspects of photonics appear to be well covered by the NRC, DOC and DRIE. The firms involved in this area tend to be large and well informed and, at this stage, there appears to be limited justification for OII involvement in the field. Greater understanding of the field and a monitoring of developments would appear to be the most appropriate approach at present.

Greater emphasis should be put on non-communications aspects of photonics. Current industrial efforts in this area appear fragmented, firms are small in size and the technology is more emerging in nature.

Major OII efforts should be focussed on two activities. The first should be the linking of suppliers and potential users of the technology and the seeking out of application niches. This is particularly important in light of the creation of the new NRC Optics Institute. It will be an important role for DRIE to ensure that the maximum commercial benefit flows from work performed at this laboratory. Initial activities in this area will involve workshops and seminars. Consideration will also be given to mechanisms for international collaboration and information exchange in this field.

The second component of the work plan will be to provide assessments of major long-term industrial trends and a window on scientific developments in the field. The Office will highlight industrial development opportunities through the production of a status report on the technology. The status report will address questions of industrial development opportunities, the need for an effective information collection and dissemination vehicle and the state of technology transfer in the field. Priority areas for OII efforts would be,

1) integration of flexible manufacturing and photonics,

2) medical applications of photonics,

3) photonics sensing.

As the work in photonics evolves, the need for specific initiatives to stimulate industrial development in this area may be required. Such initiatives may take the form of a CAT, Information Centre or industrial association. Such measures will be given greater consideration as the Office's appreciation of the field matures and recent initiatives by other agencies begin to impact on industrial development.

## PHOTONICS

## WORK PLAN

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| **PHASE I - General Review of the Field** | | |
| Identification of major actors in the field, both internationally and nationally. | | on-going |
| Review of the literature to establish a knowledge base in the field and to identify:<br>a) important scientific and technological trends;<br>b) stimuli for and constraints on technological development;<br>c) likely industrial applications and their significance;<br>d) likely rates of diffusion and their significance; and<br>e) domestic and foreign government policies in the area. | | on-going |
| Identify and participate in committees and task forces.<br><br>Establish and maintain files and a library of information on domestic and foreign policy, programs and activities. | Recognized source of information in the field | July '84 |
| **PHASE II - In-Depth Review of the Canadian Situation** | | |
| Organize seminars of government, industry and university experts to:<br>a) identify trends and issues;<br>b) promote linkages between suppliers and users. | Enhanced communication enhanced appreciation of capabilities | Nov. '84 |
| Discussions with federal agencies to gain in-depth knowledge of:<br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | Nov. '84 |

| ACTIVITY | OUTPUT | TENTATIVE DATE |
|---|---|---|
| Discussions with Regional Offices to:<br><br>a) assess regional strengths and weaknesses;<br>b) determine aspirations;<br>c) identify major regional issues with respect to the technology which need to be addressed. | | |
| Discussions with provincial organizations (departments, PROs etc.) to determine:<br><br>a) policies, programs and activities;<br>b) expenditures;<br>c) major issues which need to be addressed. | | Nov./Dec. |
| Discussions with industry and industrial associations to determine:<br><br>a) current impact of technology on industry;<br>b) markets;<br>c) constraints on, and stimuli for, development;<br>d) likely future impact;<br>e) potential for future development;<br>f) imports and exports of the technology. | | |
| Discussions with universities to determine:<br><br>a) likely future trends in the technology;<br>b) constraints on university research in the area. | Preparation of background notes and summaries | Jan. '85 |
| Create and maintain a data base within OII which will contain key information on industrial involvement in the field. | recognized source of information | Feb. '85 |

**PHASE III - Production of Status Report**

Write draft report in the agreed upon format.

Circulate for comment and revise accordingly.

| ACTIVITY | OUTPUT | TENTATIVE DATE |
| --- | --- | --- |
| Respond to enquiries from industry, universities and government on photonics. | Status Report | April '85 |
| **PHASE IV - Strategy** | | |
| If appropriate, develop recommendations to assist in further industrial development of photonics and pursue the implementation of these recommendations. | Action | June '85 |

INFORMATION TECHNOLOGIES June 1984

## 1.0 OBJECTIVE

To provide a general introduction to the field and to outline a work plan for the portfolio.

## 2.0 DESCRIPTION

Information technology is usually defined as those technologies based on microelectronics: computers, software, office automation, CAD/CAM, communications, electronic consumer products, etc. For the purpose of the present business plan, information technology has been restricted to the following technologies, the others being covered under different portfolios: software, computer and peripherals (e.g. opto-magnetic disk technology), the integration of computing and telecommunications technologies, applications in the office (e.g. office communications systems) and others such as in agriculture, manufacturing and banking.

The main difference between this portfolio and the one on new computing technologies is that information technologies refer to technologies which are rapidly diffusing at this moment while new computing technologies are mostly in the stage of experimental development.

Since information technologies are rapidly diffusing, this portfolio looks both at the source of the technology (the manufacturing side) as well as at its applications (the users side). This cannot be done for the new computing technologies because they are still developing and are not, for the most part, ready to be applied.

## 3.0 TRENDS

Although computers have existed since the early fifties, they were for the first decade or so very large, unreliable and costly. A significant breakthrough occurred in the early seventies with the development of the microprocessor. The breakthrough was qualified as revolutionary because it permitted tremendous miniaturisation of components, massive reduction in unit costs and impressive increases in performance.

The 80's are likely to be characterised by the integration of computing and telecommunications to create some kind of electronic super-highway linking computers to each other and creating nationwide interconnecting networks.

Information technologies have been with us in their current form for some years now. However, the rates of diffusion are rapidly accelerating. For example, the revenues of the Canadian information processing industry are expected to increase from $6.8 billion in 1983 to $13 billion in 1987. By 1987, there will be 1.7 million personal computers in Canada compared to 40,000 in 1981.

The USA market for integrated circuits is forecast to increase from $7 billion in 1982 to $17 billion in 1987. Worldwide, the USA is expected to retain control of the microprocessor market while the Japanese may remain leaders in state-of-the-art memories. Technology will allow 1-2 micrometer features as opposed to 3-5 today. In the laboratory, 3-D chip circuits will emerge as well as the first systems-on-a-wafer (entire systems on a single large chip). By then, 32-bit microprocessors and 256K memory will be common. The traditional niche of Canada has been in custom circuits. The advent of standard cells libraries, the emergence of silicon compilers and expert systems, the entry of large foreign chip manufacturers into this market are factors which threaten the Canadian industry.

In electronic data processing, the distinction between mini- and micro-computers will become more fuzzy as 32-bit micro-computers become standard. The major technical improvements will be friendlier interfaces such as an increasing use of graphic pad, voice recognition and natural language, icons and the mouse for inputting data. New peripherals such as videodisks, hard disks with vertical-recording capability, laser cards, will increasingly be used in the later part of the decade. Prices will remain fairly constant, addition of new features being preferred to price reductions.

The world market for data processing equipment will increase from $80 billion (U.S.) in 1983 to some $159 billion in 1987, the most dynamic market being the personal business computer market which will experience a growth rate approaching 70% per year. The software market, now valued at $25 billion (U.S.), will reach some $90 billion by 1987.

Over the decade, important progress will be made in new computer architectures replacing the traditional Von-Neuman machines such as data-flow machines, processor arrays, etc. In the early 90's, new processors will be able to make inferences rather than (or in addition to) present day calculations. These will be fifth-generation computers.

In software, the trend is towards application packages (sold by the thousand) rather than custom applications. This trend is in response to the explosive proliferation of personal computers as it simply becomes impossible to develop custom applications for each individual machine. Packages are being developed for all sectors of the economy. They range from feed plans for cattle to complex nuclear plant simulations. Two complementary trends can be observed in the technology. One is the development of packages which are increasingly easy to learn and to use. The other is the integration of software which means that, for example, the results of a calculation done in a spreadsheet program can be used in a graphics program or in a word processing program. The later will reach maturity when file and data formats become standardized.

In the short term, opportunities exist in microcomputer packages (data base management systems, word processing systems, financial spread sheets, decision support systems, productivity tools and communications software) and speciality markets (CAD/CAM, office automation, computer aided learning, telecommunication software, graphics, fourth generation languages and portable operating systems). Also, some believe that vertical markets provide excellent opportunities for software development (banking, communications, natural resources, agriculture, health care and manufacturing).

Once the more easy and mundane applications are done, software solutions will be developed for more complex problems. These will be essentially in three areas: expert systems (electronic advisors with the competence of a human expert in a narrow domain), natural language systems (e.g. computer-aided translation), and vision systems (e.g. assembly robots or inspection systems).

As can be seen below, the USA is leading in electronic products aimed at businesses, while Japan is obviously the world leader in consumer products. Communications equipments are a particular case since most equipment for public networks have, up to now, been usually procured from domestic producers in both EEC countries and Japan. Software statistics are almost non-existant. However, it is usually said that Japan is lagging in the software field. This opinion may be unfounded. In the EEC, UK has traditionally been considered the leading country in software. However France and West Germany have both identified software as a strategic technology.

| SHIPMENT | USA | EEC | JAPAN |
|---|---|---|---|
| Computer | 49.9 | 13.6 | 12.7 |
| Communication | 28.8 | 19.5 | 12.3 |
| Other office equipment | 9.6 | 3.1 | 6.0 |
| Consumer Products | 12.6 | 11.0 | 35.7 |

Shipments of Electronics Product in 1983. ($ millions U.S.)

Microelectronics components are becoming less and less expensive and, as a result, have spawned an astonishing number of intelligent and inexpensive computer-based products and processes. These not only include high-profile goods such as word-processors, robots and telecommunications equipment, but also many less well-known applications such as microprocessor-controlled cameras and microwave ovens.

One of the most startling aspects of advanced electronics is the rapidity with which new products are being introduced into the market place, only to be replaced by newer products just a few months later. Even more important than the speed with which this technology is diffused is the scope of information technologies applications which span all sectors of economic activity from the resource to the manufacturing and service sectors.

For example, in our mines, computers are already used for planning tunnel boring and microelectronics permit the constant monitoring of the air quality. Satellites can now prospect for new minerals. In the near future, underground trucks will be remote-controlled or totally automated.

In agriculture, we now have an application of the well-known Telidon technology called "Grassroots". This commercial service is available to Manitoba farmers for weather forecasting and for providing such agricultural business information as commodity quotations. A similar service could be developed on the Atlantic and Pacific Coasts for fishermen.

Even forestry benefits from information technologies. Some sawmills are now equipped with computers to calculate the optimum way of cutting each log.

Our manufacturing processes are being transformed by computer-aided design and computer-aided manufacturing. (Although this application is the responsibility of another portfolio, it has been included here to show the pervasive nature of information technologies applications). For example, in the automobile industry, it previously took months to alter or to renovate conventional assembly lines. In the past one of the barriers to developing a competitive Canadian manufacturing industry was the small size of the production runs. Robots offer a way of changing this situation because they can work very easily on a new production run once a library of programs has been built up. Computers are now used for planning, for inventory control as well as for part ordering.

In the service industry, which involves creation and manipulation of information, information technologies will relieve us from boring and repetitive information processing chores. Word-processors are already commonplace in our offices and desk-top computers are mushrooming on professionals' desks. Some businesses are already using electronic mail on a daily basis and leading hotel chains can now provide their customers with access to teleconferencing.

Entirely new services will be available to consumers. For example, newspapers will be distributed over telecommunications systems and banking chores will be completed from the comfort of one's home. Information technologies also hold far reaching possibilities for improved and cheaper health care education. In fact, it will soon influence most aspects of our lives.

This description could go on and on. It is usually accepted that information technologies of one form or the other can advantageously be applied in every industrial sector. The real expert who can best determine the most appropriate applications to a given sector is the end user. For example, textile experts are the most qualified to determine the best applications of information technologies to the textile sector. The same way, a veterinarian is the best advisor for the development of software packages aimed, say, at optimizing feeds. The computer expert is there more in quality of translator than as designer.

## 4.0 CANADIAN ACTIVITIES

### 4.1 General

Canada has no real commercial chip manufacturer although Mitel sells some of its production (Northern Telecom produces chips for its own use). On the other hand, there is a world renowned designer, Mosaid.

Computer hardware activites consists mostly of foreign assembly plants with little manufacturing. The few Canadian success stories can be found in specialized niches such as library systems. In software, contrary to public opinion, the Canadian position is not very healthy either, most packages being imported.

The situation is much better in applications of these technologies. For example, Canadian banks have been leaders in the development of a nation-wide banking computer network. Unfortunately, the situation varies from sector to sector. Here it should be noted that analytical data is non-existent except for telecommunications. Therefore, despite the importance of technology diffusion and application, little reference will be made to these in the remainder of this text.

The trend in information technologies is now the integration of computers and telecommunication networks. This could represent a tremendous opportunity for Canada since telecommunications is a field in which Canada has shown a tradition of world leadership. For example, it was one of the first countries to use communications satellites and fiber optics, and Northern Telecom is one of the largest international manufacturers of advanced switching equipment.

To compete with success in information technology, a number of challenges will have to be addressed, including:

- Most Canadian firms are very small by industry standards and the Canadian market is too small. Joint ventures and research cooperatives are just two examples of possible solutions.

- An important proportion of R&D is performed in government laboratories and the research is not always related to market realities.

- Most Canadian activities do not reach the critical mass necessary to ensure success. For example, most provinces have plans to develop a computer-aided learning industry but most of these plans are aimed at a selected provincial firm with consequence that none is emerging as strong enough to compete on world markets.

- The information industries are mostly concentrated in the Montreal-Ottawa-Toronto triangle and around Burnaby in British Columbia. Activities are picking up speed in all other regions but there is a desire by all regions to excel in all and every information technologies. Success will be ensured only through specialization in areas related to specific comparative advantages.

- The question of diffusion of information technologies has not been given enough attention in comparison of R&D despite its critical role if the technology is to be widely applied throughout the Canadian economy.

## 4.2 Federal Activities

Until the creation of IRDP, the Federal Government had five major programs for support of the Canadian microelectronics industry. The major Government initiative in this area was the STEP Program (Support for Technology-Enhanced Productivity Program) of the Department of Regional Industrial Expansion. This program promoted the manufacture and application of microelectronics to products and processes. Between 1980 and 1986, $106 million was to be spent under this program. It has now been merged into IRDP. Furthermore, $12 million have been approved for the Office

Communication System Program of the Department of Communications. This program will ensure that Canadian manufacturers capture a significant part of both the domestic and foreign markets, by establishing field trials in selected federal departments. Under the Telidon Program, $57 million will have been spent between 1980 and 1985. On May 3rd, 1983, NSERC announced that $7.5 million would be allocated to the creation of a National Microelectronics Design Network. The Canadian Microelectronics Corporation is the entity responsible for the ownership and management of the facilities of the network.

Finally in June 1984, the government announced the creation of a Task Force on Information Technologies. The Task Force will identify the competitive challenges facing Canada's information technology industry and will provide advice to the government on approaches and actions to meet those challenges with the goal of encouraging the development of the sector on a commercially sound basis. More specifically, it will identify the business developments in Canada and elsewhere that have significant implications for the growth and competitive abilities of the domestic industry, technologies critical to the competitiveness of the industry for the balance of the decade and the constraints which may limit Canadian firms and labour from seizing full benefit from emerging opportunities. The Task Force will identify the impact of the developments on employment within the information technology industry. It will also propose strategic approaches for Canada, together with recommendations concerning the respective roles and actions for industry, labour, and universities, as well as for government.

To these initiatives, a great number of research centres and institutes should be added, such as DRIE's Microelectronics Centres or Doc's Office Automation Research Centre. (A complete listing of federal activities is included in annex.)

## 4.3 Provincial Activities

A majority of provinces have taken initiatives to promote information technologies. Only the most important will be covered here.

In Quebec, the Department of Education has announced its intention to buy some 39,200 microcomputers over 5 years for its schools. From a science and technology point of view, the Ministry of Science and Technology plans to establish over the next three years, six research centres at a cost of $77.2 million. They will include a graphics centre (Montreal), a telematics centre (Montreal), a computer aided learning centre (Montreal) and a centre on office communication systems and human resources (Quebec).

Ontario leads the way with a similar approach. In 1981, it announced an initial $15 million commitment for the introduction of microcomputers in schools. Of this amount, $10 million was earmarked for the Canadian Education Microprocessor Corp. (a consortium involving Meridan Technologies, North American Ventures Management and Campus Consortium Consultants, three companies from Toronto) to design, manufacture and supply a standardized educational microcomputer system for schools. The other $5 million was to go for Canadian-developed educational software.

In 1981, the Ontario Ministry of Industry, and Trade announced a series of initiatives which resulted in the creation of six high-technology centres representing a projected expenditure of more than $96 million over five years. One of them is the Microelectronics Centre (Ottawa), a $20.1 million centre whose mandate is to assist small and medium-sized manufacturers to obtain, understand and adapt custom-made chips for new product innovations. As well, it will be responsible for the design and testing of microelectronics circuits and custom devices.

British Columbia took a different approach. Rather than focus on one specific technology, it sought to advance scientific, technological, industrial and management research and skills. The instrument chosen to achieve this objective was the creation of four Discovery Parks, a concept which involves linking academia with business by developing parks where companies can engage in R&D and manufacturing. They are located at University of British Columbia, British Columbia Institute of Technology, Simon Fraser University and University of Victoria.

Other provinces are also actively being involved but at a lesser level of activity. However, it seems that their effort are now being increased.

## 4.4 Industry Activities

The chip industry is non-existant in Canada. In 1980, for example, imports were $157.7 million and shipments were a meagre $8.9 million according to Statistics Canada's data.

The two major Canadian players are Northern Telecom and Mitel. The first fabricates chips for its own use and Mitel uses up to 70% of its production. Linear Technology is upgrading its facility for the production of LSI bipolar ICs. A fourth firm, Siltronics, has been designing custom circuits which were fabricated in United States. They are now commencing fabrication in Kanata. Microtel Pacific in Vancouver also is setting up production, primarily for in-house requirements. Others manufacturers are very small: Anateck Electronics (B.C.) (Hybrid circuits), Pacific Microcircuits (B.C.) (Design and prototyping). Finally, there is a world renowned designer, Mosaid, which specializes in the design of memories for the major foreign producers.

The major reasons put forward for not developing domestic capabilities in chip manufacturing have been: 1. a priority on value- added applications, 2. the high costs of a manufacturing facility and the need to regularly upgrade the equipment to accommodate advances in technology, and 3. the existence of silicon foundries in United States which can manufacture designs brought to them. On the other hand, some analysts are now raising the possibility that access to state-of-the-art chips may become problematic in the near future. Furthermore, it is said that a shortage of chips could occur as soon as 1987. However, no concensus seems to exist on the best chip policy although a majority of analysts believe that the development of a strong design capability is necessary.

As for the Canadian data processing and office machines industry, imports were $1.95 billion in 1980 and shipments were $889 million of which it is estimated only about 55% was actually value added in Canada (these figures include some software). The trade deficit grew from $217 million in 1970 to $1.2 billion in 1980 and it is deteriorating at an accelarating rate.

Canadian owned manufacturers account for less than 10% of the Canadian industry's production and they have captured less than 5% of the domestic market. Only three of them employ more than 100 employees: GEAC, AES Data and Northern Telecom. In fact, most of the activity going on in Canada consist in assembly only.

Statistics for software do not exist because of the practice of "bundling" software prices along with the hardware prices. However, some estimates have been developed by industry analysts. The Canadian market for software was $457 million in 1980 and is expected to reach $5.4 billion in 1990, the fastest growth sector being application packages. It has been estimated that export revenues were in the order of $35 million for 1980. Imports were $330 million from foreign computer services suppliers. The trade deficit thus reaches $295 million. To this figure, however, we should add approximately $570 million of imported bundled software.

Of the approximately 1,000 firms which supply software in Canada, the top 53 suppliers accounted for 77% of the market in 1981. Of these 53, 28 firms were foreign firms and accounted for 54.4% of the market. Furthermore, of the 53 key software suppliers, hardware manufacturers accounted for 69% of the sales of the group, and it should be remembered that Canadian owned firms are doing poorly in the hardware sector.

A challenge for the Canadian software industry will be to re-orient itself toward supplying software packages which requires a completely different marketing strategy from sales of custom software. In the longer term, the firms which will survive may be those which provide total solutions including both hardware and software.

It should be noted that information technology firms are concentrated in Ontario, Quebec and British Columbia. However, new firms are being created in all provinces.

## 5.0 FEDERAL GOVERNMENT CONSIDERATIONS

Information technologies are being applied across all sectors of the Canadian economy. They are the building blocks leading to CAD/CAM, robotics, flexible manufacturing systems, computer-aided learning, office of the future, remote sensing and many other applications.

Foreign governments have recognized information technologies as strategic to their development and are massively supporting their electronics industry. For example, West Germany will be spending $1.5 billion in this field during the period 1984-1988 and France, some $3.6 billion from 1982 to 1986. Another example is Japan which launched the Fifth Generation Computer Project in June 1982. MITI is sponsoring the project and it will commit about $500 million over the ten years that will last the project. Industry is expected to contribute at least an equivalent amount. The European Strategic Program on Research and Information Technology (ESPRIT) was formed by the EEC to reverse the European decline in electronics. For the first five years, the program may involve $1.5 billion and over 2,000 researchers from member countries. The United States is not standing idly by. One example is the Microelectronics and Computer Technology Corporation (MCC), which brings together 13 companies to conduct joint research. Other cooperative initiatives are the Semiconductor Research Cooperative (SRC) and the Microelectronics Centre of North Carolina. In addition to private endeavours, we should add the example of the Defense Advanced Research Projects Agency (DARPA) which has announced a new program called Strategic Computing and Survivability. This program has been established to develop a new generation of "superintelligent" computers for military use. About $1 billion will likely be spent over the rest of the decade for this project. As can be seen, competition is not between firms anymore, but between governments. Some suggest that Canada has no choice but to support its industry in the same manner as competitors because the country cannot rely on importing the technology anymore as barriers to the free flow of technology are rising and international cooperation is becoming difficult if not impossible. Furthermore, given the strategic nature of some of these technologies, security of supply is not always guaranteed.

It is likely that Canada's traditional exports will not grow fast enough to counteract the trend towards an exponantially increasing trade deficit in electronic products and software. Canada should urgently address this issue. However, in doing so, Canada will need to identify niches otherwise the R&D expenditures needed to address all information technologies would greatly exceed the revenues of the industry. Even though a domestic industry has to be developed, it is believed that it is yet more urgent for Canadian firms to apply these technologies to their operations (that they be resource processing, manufacturing or services industries) in order to improve their productivity.

In summary, the Federal government needs to address the challenge raised by information technologies, because they are a strategic technology which represents a tremendous opportunity. Furthermore, it is urgent that the exponentially increasing deficit in information products and services be brought under control. Finally, the federal government should also address the need to accelerate diffusion of the technology.

Given that most Canadian firms of this sector are very small and given the level of support given to domestic firms by foreign governments, it is necessary for the federal government to be active in this field.

The Canadian approach has been characterized by a number of uncoordinated, isolated and often counterproductive activities such as DOC's Telidon and the Office Communications System Program, MOSST's Interepartmental Working Group on Artificial Intelligence and the initiatives of the Secretary of State in automated translation, to name a few (a list of federal activities is listed in annex 1). By adopting this approach, we end up with programs which fail to develop the level of synergy attained by foreign countries, such as Germany for example. An integrated approach would avoid duplication and conflict of objectives. The government needs to develop a mechanism to better coordinate its own activities in the field and to consult the private sector on establishing priorities for the support of these technologies. This is necessary because other nations are massively supporting their electronics industry and Canada cannot thrive in all information technologies. There is an urgent need to develop, in consultation with the private sector, a priority structure for the support of information technologies. This should be part of any strategy which should also seek to establish a balance between support to manufacturers and support for the diffusion of the technology, irrespective of origin.

## 6.0 ROLE OF DRIE

The rest of the decade will witness the emergence of a wealth of new products and services. Furthermore, information technologies have the potential of being used in most firms' operations to improve productivity. For example, these technologies have the potential of saving declining industries such as the footwear industry. Bata Shoes has demonstrated that the footwear sector can become a high-technology sector.

DRIE has a leading role to play not only in the support and development of a thriving Canadian information technology industry but also in promoting the diffusion of the applications of this technology through all sectors of the economy to improve efficiency and competitiveness by applying the technology to processes, to generate a wealth of new products and to create new services.

Considering the lack of national focal point on these technologies and the need to develop a coordinated approach, DRIE should use the output provided by its Task Force on Information Technologies to build a national strategy.

Furthermore, DRIE has an important interdepartmental role to play in ensuring that research and development conducted in universities as well as in governmental laboratories be industrially and regionally relevant. There is an important advisory role for DRIE to play with NSERC, MOSST, DOC, DND, NRC and other departments which can have impact on industrial development.

With few exceptions, most Canadian firms in information technologies are relatively small which precludes them from undertaking very complex projects such as those involving advanced information technologies. DRIE might assume leadership in promoting cooperative projects between firms and in ensuring that any S&T strategy be based on regional strengths and opportunities and that resources be pooled to ensure that the effort will not be scattered or duplicated. For example, DRIE could promote the creation of a R&D cooperative which would be government funded but privately managed.

## 7.0 ROLE OF OII

Information technologies can be applied to all sectors of the economy and the applications of these technologies are of interest to all ISBs. For example, on the supply side, the Electronics and Aerospace Branch and the Service Sector Branch are responsible of the hardware and the software aspects respectively. On the demand side, computers will be used by sectors as diverse as transportation services, finance institutions, resources processing industries, and architects, to name only a few. Sector Branches are and will remain the centres of prime responsibility within DRIE for individual information technologies and its development in the shorter term. However, OII can support these ISBs as well as regional offices by providing information on developments abroad and longer term trends, and by insuring that development in one sector diffuses to other sectors.

There is a need for an interface between ISBs, other departments, industry associations and universities which will ensure that innovation is industrially relevant and which will facilitate the transfer of technology between these groups. Since OII will develop contacts with all these actors, it could play such a role.

## 8.0 WORK PLAN

One focus of OII is the facilitation of the diffusion of information technologies. It will therefore develop initiatives aimed at:

- increasing awareness in Canadian industry of threats and opportunities resulting from new developments in information technologies;
- facilitating access to best practise technology, from around the world, to Canadian end users;
- maintaining a net work of contacts and information for the Canadian industry;
- ensuring existence of an appropriate infrastructure for industrial developments in these technologies; and
- identifying impediments to innovation such as regulations and standards, and ensuring that these impediments are addressed in a timely manner.

These functions will be carried by organizing seminars, workshops and conferences, by preparing articles in trade journals, by establishing networks of information and by directing inquiries to the best source of information, to name just a few.

In order to meet these objectives, and considering all the centres of expertise already existing in the federal government, the OII will work closely with DRIE's Sector Branches, Regional Offices, as well as with industry associations.

# Addendum

## Federal Activities in Support of Information Technologies

## 1.0 DEPARTMENT OF COMMUNICATIONS (DOC)

### 1.1 Telidon

The Telidon Program was initially established to stimulate the creation of a commercially viable videotext industry in Canada with the capability to compete on the world market. The Program, which had already channelled more than $40 million since 1979, was extended by the announcement in February 1983 of an additional allocation of $23 million to the program. The objective of the extension is to assist the videotext industry in exploiting the Canadian technology and reaping the benefits of investments previously made by both the Government and the private sector. The program is scheduled to end at the end of the current fiscal year.

### 1.2 Office Communications Systems

The objective of this program is to develop an industrial capability in integrated electronic office systems by supporting integrated field trials, fostering research into systems, behavioural and productivity matters, conducting public awareness programs and addressing social human factors.

By 1985, $12.5 million will have been spent for this program. It is hoped that industry will have gained the following benefits: development of methodologies, user test of their office communications systems strategy, user assessment of the functions and reference show case.

### 1.3 Office Communications System Research Centre

On May 12, 1983, the Government announced the establishment by the Department of Communications (DOC) of the Office Communications Systems Research Centre (OCSRC) in Laval, Quebec. The role of this national research centre is to develop Canadian expertise and competitiveness in the international market for office communications products and systems. The Centre will likely be funded to the tune of a total of 100 positions and a budget of $10 million by the 1987-88 fiscal year.

### 1.4 International Collaboration Assistance Fund for Research New Information Technologies

DOC recently announced the creation of the International Collaboration Assistance Fund for Research on New Information Technologies, a $800,000 per year program to support the interchange of information, the organization of workshops, conferences and seminars, as well as, the exchange of scientists and the initiation of joint research.

## 1.5 ANTEM

DOC is also responsible for ANTEM (Application des Nouvelles Technologies Educatives Multi-media) created by the Summits of Versailles and Williamsburg. Run jointly with France, the working group is creating a network of reference centres involving participating countries.

## 1.6 Canadian Communications Informatics and Space Research and Development Institute

To integrate public and private efforts, the federal government has proposed the creation of a Canadian Communications, Informatics and Space Research and Development Institute (the CCIS Corporation). A Task Force composed of members from the government and the private sector will assess the viability of the proposed institute.

## 1.7 Others

The DOC's Communications Research Centre is conducting research in all areas of information technologies.

# 2.0 DEPARTMENT OF REGIONAL INDUSTRIAL EXPANSION (DRIE)

## 2.1 Microelectronic Centres

The initial impetus for the creation of the Microelectronics centres was to increase the awareness of the small and medium sized firms across the country about microelectronics. The Centres were a key part of the Support for Technology Enhanced Productivity program instituted by the former Department of Industry, Trade and Commerce (IT&C). After initial funding by DRIE of $1 million over five years each (or $200,000 per year) the Centres are expected to become financially self-supporting.

Functions of the Centres include: providing consulting service to industry in identifying applications of microeclectronics; serving as a regional focal point for dissemination to industry of information on microelectronics and its applications; providing technical assistance to industry in development projects concerning applications of microelectronics; providing training programs and courses to industry and facilities at which regional industry can develop or participate in development projects involving application of microelectronics; providing microelectronics technology transfer to industry; and conducting ongoing research and development to maintain and enhance the centre's ability to provide the above services to industry on a current basis.

The Centres are located at the University of Toronto, the University of Sherbrooke, the University of Manitoba, the University of Alberta, the University of Saskatchewan, the University of British Columbia and the University of Moncton.

Here, it should be noted that STEP was much more than the Centres. Part of it was devoted to major projects, another part supported the services of a consultant to undertake a study of the feasibility of incorporating chips to products and processes. The program was supporting the applications of the technology as well as the design of a custom circuit.

### 2.2 Task Force on Information Technologies

In June 1984, the Government announced the creation of a Task Force on Information Technologies to identify the competitive challenges facing Canada's information technology industry and to provide advice to the Government on approaches and actions to meet those challenges with a goal of encouraging the development of the sector on a commercially sound basis.

### 2.3 Others

The other activities carried out by DRIE are listed in the computer-aided-manufacturing portfolio.

## 3.0 DEPARTMENT OF SUPPLY AND SERVICES (DSS)

DSS is playing a major role in the support of information technologies by its procurement lever. For example, it initiated a major study on the procurement needs for videodisks storage systems, it demonstrated an interest for computer-aided-learning systems and identified software in its Annual Procurement Plan and Strategies (APPS). It is also promoting broader technology development such as supercomputing by supporting Canadian ventures such as Myrias Computer. Finally, DSS is chairing a new Ad Hoc Interdepartmental Committee on Strategic Technologies which is strongly oriented toward information technologies.

## 4.0 ENERGY, MINES AND RESOURCES (EMR)

This department supports information technologies development mainly through the work of the Canadian Centre for Remote

Sensing (CCRS) which was a pioneer in artificial intelligence applications to remote sensing.

The new Working Group on Image Analysis Systems and Artificial Intelligence of the Canadian Advisory Committee on Remote Sensing helps to bring together the universities, federal agencies, and industry to exploit this emerging technology.

## 5.0 EXTERNAL AFFAIRS

### 5.1 ICISTR sub-committee

In 1984, the Interdepartmental Committee on International Science and Technology Relations (ICISTR) created a sub-committee on information technologies. With membership drawn from DND, DOC, DRIE, MOSST and NRC, the committee will provide a clearing house for information on Canadian activities and foreign initiatives affecting Canada; develop effective contact points in departments to ensure the flow of information both within the government and to the private sector; undertake review of important foreign technology developments; assess the opportunities for initiating or developing specific S & T relationships with foreign countries and organizations; consider international implications of domestic programs and activities of the federal government in information technologies; contribute the international components to the development of international strategies in information technologies; and other related functions.

### 5.2 VHSIC

After the announcement of the VHSIC project (Very High Speed Integrated Circuits) by the USA, External Affairs was informed that the Canadian defense industry was having difficulty obtaining defense contracts relating to the VHSIC project. EA, jointly with DRIE and DND, initiated consultations with industry on how best to gain access to VHSIC technology.

### 5.3 Catalytic Seed Fund for International Collaboration in Science and Technology

The Catalytic Seed Fund (CSF) has been included here because it applies mainly to six technologies including information technology. The CSF will support such activities as: meetings of experts in Canada held for the purpose of identifying and planning international initiatives in specific sectors with specific target countries; exploratory missions and visits by experts for the purpose of initiating collaborative activities; travel costs for Canadians to participate in meetings in Canada with foreign S&T mission;

in exceptional situations, travel costs of foreign scientists; and medium-term visits to allow Canadians to work at foreign research establishments on promising collaborative activities.

## 6.0 MINISTRY OF STATE FOR SCIENCE AND TECHNOLOGY (MOSST)

The Ministry of State for Science and Technology has created an Interdepartmental Working Group on Artificial Intelligence and Advanced Computer Technology. The Working Group is preparing a report identifying policy issues raised by these technologies.

## 7.0 NATIONAL RESEARCH COUNCIL

The National Research Council has been a pioneer in information technologies. In its electrical engineering laboratories, research is conducted in computer graphics, machine vision, computer architectures, sensory controls, photonics, software, computer aided learning, data bases, robotics and many others. NRC recently announced a $14.4 million research project to develop gallium arsenide circuits with Bell Northern Research. Finally, it should be noted that NRC's Institute for Manufacturing Technology in Winnipeg will include an artificial intelligence laboratory.

## 8.0 NATIONAL SCIENCES AND ENGINEERING RESEARCH COUNCIL (NSERC)

a) Strategic Grants

They apply to eight fields of endeavor: biotechnology, communications and computers, energy, environmental toxicology, food/agriculture, industrial materials and processes, oceans and an open category.

b) Fifth Generation Coordination Committee

In March 1984, NSERC organized a meeting bringing together academics interested in artificial intelligence, to begin the process of focussing future university support. This group created the Fifth Generation Coordination Committee which was charged with obtaining inputs from the university community at large. The Committee reported back to NSERC sometime in September 1984.

c) Canadian Microelectronics Corporation

The Canadian Microelectronics Corporation (CMC) was officially announced in January 1984. The CMC is the legal entity that will be responsible for the management of the national microelectronics design network, announced in the government technology policy of May 1983. The network includes:

- computer aided design work stations located at various Canadian universities for integrated circuit design;
- test stations located at various Canadian universities;
- a VLSI Implementation Centre (VLSIIC) which will allow it to accept chip designs from all of the participating universities and forward them to silicon foundries for fabrication;
- a communications network.

The federal government, through NSERC, will spend $19.5 million on this microelectronics network during the first five years of its existence.

As a second phase to this initiative, NSERC created a committee responsible for exploring how to enhance Canadian capabilities in chip technology. The committee proposed the establishment of two state- of-the-art centres for microelectronics technology accessible to the university, industry and government communities. Total cost could reach $130 million.

## 9.0 SECRETARY OF STATE

From 1965 to 1972, the National Research Council and the Social Sciences and Humanities Research Council provided grants for research in machine translation at the University of Montreal and the University of Saskatchewan. Since 1973 the Translation Bureau of the Secretary of State Department has been the only federal agency to sponsor automation of translation. Total investment has been about 3.5 million dollars. More recently, this department and DOC commissioned a study on appropriate strategies for a national research and development program in natural language computer processing. The study has just been completed by Cognos.

## 10.0 SCIENCE COUNCIL

The Science Council published a few studies in information technologies such as "Planning Now for an Information Society" and "Government and Microelectronics - the European Experience". Lately, it has organized seminars bringing together industry, academics and government officials. The latest was "Machines which think, sense and act, and their applications" held in March 1984.

# APPENDIX

## TECHNOLOGY SITUATION REPORT

## GUIDELINES FOR A TABLE OF CONTENTS

| | Suggested number of pages |
|---|---|
| 1. Description of the Technology | 1 to 2 |

Definition and scope, with examples where necessary.

Persuasive rationale for the examination of the technology.

| | |
|---|---|
| 2. Status of the Technology (Global view) | 2 to 3 |

- Scientific aspect;
- Applications;
- Linkages with other technologies;
- Current diffusion; and
- Negative impacts (e.g. environmental, etc.).

| | |
|---|---|
| 3. Technology Trends (Global view) | 3 to 4 |

(A) Medium-term (1-5 years)

- Scientific directions;
- Applications; and
- Diffusion.

(B) Long-term (5-10 years)

- Scientific directions;
- Applications; and
- Diffusion.

(C) Summary of technological changes and their potential impacts (i.e. intersectorial, socio-economic, etc.) with examples.

| | |
|---|---|
| 4. International Perspective | 5 to 7 |

(A) Identification of key nations (e.g. USA, Europe and Japan) and rationale for their selection.

Suggested number of pages

For each selected nation (with supporting data):

a) Motivation to develop the technology

- Capabilities;
- Constraints;
- Needs;
- Economic and market forces; and
- Applications;

b) Priority, thrust, emphasis given and its focus on the technology with respect to others.

c) Direction followed to develop the technology;

- Nature and efforts of the private and public sectors (i.e. companies, universities, programs, etc.).

(B) General Summary

- Similarities;
- Differences;
- Trends; and
- Canadian position compared to others.

5. <u>Canadian Perspective</u> — 10 to 20

(A) National Dimension

a) Key players (organizations, size, R&D level, policies, programs, etc.) with supporting data:

- Industry;
- Universities; and
- Public sector.

b) Economic and market forces

c) Applications (current and new)

Suggested number
of pages

d) Import vs. exports

e) Rate of diffusion

f) Strengths and weaknesses of
Canadian industry

g) Socio-economic factors related to
the adoption of the technology and
socio-economic impacts

- Job creation;
- Lack of skilled manpower;
- Structural changes; and
- Public perception.

h) Business environment

Unique aspects and implication for
the technology related to:

- Tax system;
- Competition factors;
- Tariff and non-tariff barriers;
- Patents; and
- FIRA.

i) Negative impacts

- Environmental issues; and
- Competitive threats, etc.

(B) Sectorial Dimension

a) Applications in major sectors

b) Intersectorial relationships and impacts

- Unique strengths and needs;
- Markets;
- Opportunities; and
- Potential threats.

Suggested number of pages

(C) Regional Dimension

Subdivision by key region

- Unique strengths and needs;
- Markets;
- Provincial policies, programs and aspirations;
- Opportunities for applications; and
- Potential threats.

(D) International Dimension

- Flow of information;
- Bilateral;
- Cooperative; and
- Multinationals.

(E) General Summary

- Players;
- Competitive environment (international and domestic);
- Niches for Canadian industry (applications and supply sides); and
- International, regional and sectorial dimensions.

6. <u>Canadian Issues and Options</u> — 3 to 4

- Outline of issues (10 to 12) and rationale for their choice;
- Implications of issues;
- Need for action; and
- Potential ramification of suggested action.