Planning Now for an Information Society

Tomorrow is too Late

March 1982

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March 1982

The Honourable John Roberts, PC, MP
Minister of State for Science and Technology
House of Commons
Ottawa, Ontario

Dear Mr. Roberts,
In accordance with Section 13 of the Science Council of Canada Act, I take pleasure in forwarding to you the Council's Report 33, *Planning Now for an Information Society: Tomorrow is too Late.*

Yours sincerely,

Stuart L. Smith
Chairman
Science Council of Canada

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Preface

Early in 1978 the Science Council of Canada established the committee on Computers and Communication: Information and Canadian Society to review developments in microelectronics, related to high-speed data manipulation, machine memory and intelligence, and the substitution of digital for analog transmission systems. An assessment of the possible effects of microelectronic technology on industry, employment, education, scientific research and individuals was also initiated.

Council's interest in this entire area began as early as 1968 when, in Report 4, it concluded "...the computer industry will play a major role in shaping the society of tomorrow." Report 13 (1971), observed that "... the computer industry is the world's fastest growing industry" and that "...a strong Canadian computer industry...is essential to supply Canada's needs in this field and for Canada's future social and economic health." In 1973, Report 21 characterized the impact of the computer technologies as "revolutionary" and in view of their rapid growth called for "...the development of a national policy with appropriate industrial strategies, for the production of computer hardware and software, the training and certification of men and women capable of working with the new technology, and the provision of adequate standards and safeguards for ensuring that this industry serves our national interests."

At first the committee was of the opinion that the national interest could best be served by publishing a number of position papers, summaries of workshop proceedings and other materials.[1] These would alert various sectors of Canadian society to the implications of computer and communication technologies, in general, and the effect of the integration of the two through the use of digital systems, in particular.

However, it soon became obvious that the "revolution" identified in 1973 would likely be as great if not greater than the industrial revolution of the early 19th century. Indeed, mastery of microelectronics technology would be necessary for the economic and social wellbeing of any country.

In 1981, Industry, Trade and Commerce announced that the Canadian trade deficit in electronics had grown to $2 billion for the fiscal year 1979-80 and private projections indicated this deficit would grow to over $5 billion by 1985 (current dollars). The committee became concerned that Canadian governments, education, industry and labour were not reacting to this situation with the same urgency as their counterparts in other industrialized nations. This was true despite commendable efforts by the federal government to stimulate activities in space, videotex and other high-technology areas and despite a number of provincial initiatives in microelectronics and fibre optics. By and large, government activity was fragmented. At the same time major industries seemed slow to appreciate the importance of trends in computer-assisted design, manufacturing and the allied use of industrial robots. Retraining programs introduced by major corporations in other countries were virtually unknown here. In addition, educational institutions had largely failed to provide needed training in hardware and software skills.

The committee concluded, therefore, that a report should be prepared to identify areas of prime concern, to stimulate public debate and to place recommendations before policy and decision makers. A draft background study by Arthur J. Cordell, science adviser to the committee, was endorsed by both the committee and Council with the recommendation that it be published and given the widest possible distribution. This study will be available in late 1982.

The report that follows is based upon this larger work, although some of the topics, such as shared visual space and artificial intelligence, have been barely touched upon. Our recommendations are general rather than specific because of the rapidly changing nature of the technologies. In our view it is critical that ongoing developments be monitored regularly not only by the Science Council but also by all responsible institutions in our society. The new technologies can provide opportunities for an improved quality of life only if we are sufficiently knowledgeable and possess the necessary will to take advantage of them.

T.R. Ide
Chairman
Computers and Communication Committee

I. Introduction

In the course of social and political history, an interval characterized by rapid change or upheaval is referred to as a revolution. This is usually preceded by a period of intellectual ferment and striving for a "better way." Afterwards, a new order prevails: the younger generation is culturally different from the old and society struggles to accommodate itself to new realities.

Industrial evolution seems governed by the same laws. Today, technological developments are occurring at lightning speed. Indeed current advances in microelectronics are causing a worldwide technological revolution which all societies must accommodate. This revolution may cause fundamental changes in human thought and action.

At each stage, inventive reordering of the natural world must be integrated into social, cultural and economic life. This takes time, for human societies do not internalize change easily. In the past, the span of generations was available and usually sufficient. Today we do not have that luxury. Change itself is the new imperative. J. Robert Oppenheimer, father of the atomic bomb, once remarked:

> "One thing that is new is the prevalence of newness, the changing scale and scope of change itself, so that the world alters as we walk in it, so that the years of a man's life measure not some small growth or rearrangement or modification of what he learned in childhood, but a great upheaval."

The New Technologies*

Microelectronics and related developments in communications, computers, education, entertainment, and design and manufacturing have already made an impact on our society, but we are only beginning to understand how far-reaching that impact will be.

Microelectronics, as distinct from the traditional forms of other known technologies, is characterized by two changes of such magnitude that they have brought about, in effect, the creation of a new kind of technology. These changes are:

- enormous reductions in size; and
- enormous reductions in cost.

This transformation has brought with it additional, less dramatic,

*Many reports have been written in recent years on the new developments in this field. Some authors sought to illuminate one aspect of the "new technologies." Others have tried to place these developments in a future-historical context and to give us a new perspective from which to view the world. In this report, we will avoid detailed discussions of the engineering and theory underlying these developments, and will simply refer to the "new technologies."

but nevertheless important, benefits:

- increased speed;
- increased reliability;
- improved energy efficiency; and
- portability.

In turn, these benefits have made possible rapid dissemination of the new forms of computing power and control systems throughout a vast range of products, processes and systems. The microelectronic devices are not only being applied on a massive scale to more products and processes, but are enabling the invention of new goods and services. In addition, they are stimulating expansion and a new sophistication in our communications industries.

The new technologies, based on the integrated microelectronic circuit, comprise such great quantitative changes that another kind of revolution is taking place; not merely a technological one, but a quantum leap in human capabilities. How has this come about? In Report 21, *Strategies of Development for the Canadian Computer Industry* (September 1973), the Science Council, referring to computer and related technologies, stated: "We confront a *transformative technology*, a technology which gives impetus to fundamental change in human thought and action."[1]

The concept is entirely appropriate. From time to time throughout history, a technology comes along that alters forever people's conception of their world. Just as the steam engine was the culmination of a Renaissance dream of a power economy, so in our own day the airplane for example has transformed transportation, annihilating distance.

What was once impossible or extraordinarily difficult and dangerous, involving journeys lasting sometimes years, is now possible, easy and safe; so that an individual might travel from one continent to another on no more than a few hours notice. The management of international crises by shuttle diplomacy is a matter of routine. And costly or perishable goods are daily cargo. Even the name "space shuttle" is a tribute to the conquest of distance and, indeed, of space itself.

Powered flight, together with increases in range, speed and load-carrying capacity, has brought about fundamental changes in human perceptions, attitudes and patterns of life. Yet these changes took place over the span of three generations. The new technologies have made their impact in one.

The Information Economy

The modern industrial state is a complex held together by information. Indeed, we live in what has come to be known as an "information economy."

The structure of a nation's work force is a useful index of the society's evolution from agricultural to industrial to postindustrial. During the past century, for example, the percentage of the work force in the United States engaged in agriculture has declined from about 50 per cent to 4 per cent. Agricultural production became more efficient as an increasingly educated farm population applied mechanization, fertilizers and new crop strains. More and more workers left the farm for other industries and professions; many now work in information-related areas. In Canada, there have been similar patterns of development. For example, from 1931 to 1971, the proportion of Canadian workers in information-related occupations rose from 21 per cent to 40 per cent, and the transition continues at a rapid rate.

The production, processing and distribution of information goods and services is made possible today by a great many developments in computer and related technologies. Our information-dominated society is built upon a foundation of microelectronic chips and an increasingly sophisticated understanding of their use. Related developments in this area include digital transmission of data, increased use of fibre optics and satellites, and improvements in electronic switching and memory.

In the face of continuous, rapid development, it is impossible to predict a final outcome or even to speculate with any degree of confidence beyond the immediate future. Nevertheless, certain changes and trends deserve immediate attention. How and in what ways are the new technologies transforming the lives of Canadians?

The Human Dimension

As consumers, we can afford and use devices that only a few years ago were the preserve of large corporations, institutions and governments. These include electronic calculators, quartz-controlled timepieces, microcomputers, and communications appliances that can be interconnected to the telecommunications network.

Less visible microprocessors are part of our home appliances – stoves, refrigerators, dryers, microwave ovens – and our automobiles, cameras and toys. Entertainment systems, many of which simply did not exist until recently, incorporate the most advanced technology: consider the CB radio, recorded-music systems, cable television with remote control of 100 channels, video games and laser-disc players.

The application of solid state technology can be thanked for a dramatic drop in the unit price of some goods, such as wristwatches. In other cases, such as entertainment systems, improved models have defied inflation and international currency fluctuations, maintaining more or less stable price levels for a decade. Some products are so revolutionary that we have nothing with which to compare them. People also have access to dramatically improved services, such as telecommunications, airline reservation and banking facilities.

On an institutional level, record keeping, high-speed transmission of data and increasingly sophisticated methods of input, data manipulation and output have made possible economies of scale and increasingly flexible and sophisticated services. This is seen in such areas as health insurance, motor vehicle registration, and filing and audit of income tax returns, to name a few. Cradle-to-grave social safety nets would not be possible beyond a rudimentary level without the new technologies.

Space flight, video games and electronic newsgathering are other manifestations of the new technologies. But what of the individual? As consumers, parents, citizens, we are affected, some would say overwhelmed, by these developments. One effect is clear. Our expectations increase; we hunger for more.

As workers, we must cope with changing patterns of employment. Whole classes of unskilled occupations are being rendered obsolete. But not only the unskilled are being displaced. Industrial workers in sectors based on an earlier electromechanical technology are losing their jobs as their employers either go out of business or (to survive) adapt to the new technologies, often replacing skilled workers with the semiskilled.

The dedicated integrated circuit has given rise to product simplification over a vast range of product lines. Assembly of modular components does not require workers trained in traditional trades, and often component manufacture is highly automated. Assembly line workers may find the job market inhospitable as the demand shifts to electronics technologists and computer programers.

A National Response

The historic struggle of Canadians to conquer distance and exploit our rich resources has imposed both constraints and extraordinary demands. Agriculture, forestry and mining in this country require exceptional transportation systems. Our industrial and cultural development demands unique solutions to problems of communication.

Today, these sectors face the twin challenges of adapting to a postindustrial economy and competing with a rapidly industrializing Third World. What might the future hold should we fail to respond to the challenges of the new technologies and the new world they bring in their wake? This report seeks to identify those sectors where the impact of new technologies will be greatest. For if Canada wishes to chart its own course in the emerging information society, Canadians must understand and must be able to apply the new technologies.

As Walter Light, president and chief executive officer of Northern Telecom Ltd has said,

> "Canada can continue to buy, beg or borrow the technology it will need from more competitive and aggressive societies or it can create its own. Two technologies, semiconductors and software, dominate, and will continue to dominate the industrial development of the world. Without mastery of, if not leadership in these two technologies, no nation can hope for more than a peripheral existence."[2]

The impact of new technology, however, goes beyond the industrial to the social and cultural spheres. A recent report, *The Computerization of Society: A Report to the President of France* by S. Nora and A. Minc, states that society must both foster and control the development of the new technologies so that they can be made to serve the cause of democracy and human growth.[3]

It is with this spirit of urgency and breadth of concern that the Science Council of Canada is presenting a discussion of the technologies which, in our opinion, will radically transform Canadian and world society.

The Future

The exponential rate of development we have seen in recent years in the field of microelectronics will continue. The full potential for design and manufacture of integrated circuits at the molecular level is far from being exhausted.

But the real challenge will lie in applications. How can we best make use of one million transistor equivalents on a single chip? Or ten million? Software will be a major area of endeavour. At the Science Council's recent workshop on computer-aided learning (CAL), one participant put it this way:

> "If any of the computer [-aided learning] systems - micros, minis, videotex - are going to take off, it will be because of the quality of the instructional materials, not the technology."[4]

The pocket calculator has become the most tangible symbol of the microelectronics revolution, but communications, perhaps, touch us more deeply. With the majority of our population thinly distributed along the US border, Canada has long recognized the importance of exclusively Canadian transportation and communication systems - from a transcontinental railway in 1883 to a trans-Canada radio network in 1927, a trans-Canada telephone network in 1932, a domestic geostationary communications satellite in 1972, and the first nationwide digital data system in 1973. Further developments in satellites, digital networks, and the creation of Telidon indicate that Canada will continue to play a leading role in the use of communications technologies. Indeed, the merging of computers and communications technology has created a new market which will grow by an estimated 15 to 20 per cent per year for at least the next decade.

The new technologies have achieved a diffusion rate that is 7 to 10 times faster than that of any previous technology. The key is declining costs: memory costs are falling by 40 per cent per year, logic 25 per cent, and communications (overall) 11 per cent.

The power of computers has increased 10 000 times in the last 15 years, while the price of each unit of performance has decreased 100 000 times. In 1990, the cost of computer memory will be 1/400th of today's costs. Continuing developments in memory and circuit technology will produce a 1990 pocket calculator with more power than today's most powerful computer, the $7 million Cray-1.

The diffusion rates are impressive. The rate of change is accelerating. Under the spur of aggressive marketing and the widespread acceptance of microcomputer-based systems by small business, it will continue to do so. A pattern of acceptance is already emerging: first, communications; then, record-keeping and word-processing; finally, production and process control. This may be reinforced in intangible ways through exposure to new entertainment systems at home.

Some recent predictions give pause for thought:[5]

1980-85 • Semiconductor chips contain up to 300 000 transistors giving each chip the power of a mainframe computer.

• All automobiles use microelectronic controls to boost engine efficiency.

• Some 10 per cent of homes have computers or terminals with access to remote data bases, mainly through the telephone but also via two-way cable television and satellite communication.

1985-90 • Semiconductor chips hold one million transistors. Each chip has the power of the biggest IBM System 370 computer.

• All autos are equipped with microcomputers to warn when preventive maintenance is needed and automatically diagnose problems.

- One-third of all homes have computers or terminals. In the office, electronic mail rivals paper mail in volume.
- Robots and "smart" machines with microelectronic sensors replace significant numbers of factory workers.
- Microelectronic implants begin controlling sophisticated new artificial organs, such as hearts.
- Most doctors install computer-assisted diagnostic systems in their offices.
- Most banks are interconnected through a computer network.
- Schools turn to extensive use of computer-aided learning.

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- Chips contain 10 million transistors. Each chip has more computing power than is installed today at most corporations.
- "Smart" highways for semiautomated driving enter early development.
- Most homes have computers. Data communications volume exceeds voice volume, and video phones enter the home.
- Robots and automated systems produce half of all manufactured goods. Up to one-quarter of factory workers may be dislodged.
- Microelectronic implants restore sight, hearing and speech.
- Computer-assisted medicine extends into the home.

Prediction is hazardous, at best. The shape Canadian life will take in the coming decades is unknown. But it is clear we are in the midst of a profound transition that will have an impact on every facet of modern life. Canadians do not live in isolation from the rest of the world. We must formulate our responses and plan now. We cannot afford to adopt a "wait and see" attitude.

This period of transition is a time of crisis. An unstable time for Canadians as citizens and workers and for our industrial sector. It is a time when the terms "information overload," "invasion of privacy," and "global village" take on new and more personal meaning. We must come to terms with a powerful technology that has already made itself felt in many sectors of Canadian life.

Government could play an important role as an "honest broker" - to monitor developments, to alert relevant government agencies (at all levels) to key issues, to develop comprehensive policies, and to serve as a bridge between the many sectors of society that will be affected.

Educational institutions also have a responsibility for framing responses to the challenges of the microelectronics revolution. The shortage of individuals with skills related to the electronic communications age is a sad reflection on the ability of the educational system to be both a custodian of past knowledge and a leader in the development of the new.

Industry and the business community in general must shoulder part of the burden. Managements that failed to recognize the importance of research, planning, development and industrial strategies have severely handicapped such diverse industries as watchmaking in Switzerland and automobile manufacturing in the US and Canada. Canada's competitive position in the world, the pattern of employment, our very standard of living is a reflection of the degree to which Canadian enterprise faces the challenges of the coming decades.

This report highlights some of the key issues and problems that Canadians must face during the transition to the information society.

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II. Canada in an International Context

Almost every industrialized country in the western world has examined the impact of the new technologies. Some studies look at their impact on employment in the factory and office, their effect on privacy, and the extent to which increased reliance on the chip can lead to an increasingly vulnerable society. Government agencies in Sweden, France, the United Kingdom, and the United States have all conducted studies.

Here in Canada, the Consultative Committee on the Implications of Telecommunications for Canadian Sovereignty (Clyne Committee), reported its findings and recommendations in June 1979, and alerted the federal government to the importance of understanding the impact of the new technologies. The former Minister of Communications, Jeanne Sauvé, established the committee in November 1978. After a broad-ranging discussion of a number of aspects of the communications industry, culminating in 25 specific recommendations for government action, the committee concluded:

> "We have found that in almost all those areas there is a climate of uncertainty which inhibits planning and investment by both the public and private sectors, and we believe that the Minister of Communications had more than ample justification for her statement, in the preamble to our terms of reference, that, 'The Canadian communications systems is in the midst of a crisis more profound than any that has affected it since the 1920s.' Many of us were only vaguely aware of the true nature of that crisis when we accepted the Minister's invitations to sit on this Committee, but what we have learnt is not only that there is a crisis but also that it must be tackled with the least possible delay.
>
> "We conclude our work, therefore, not with another recommendation but with an exhortation: with all the force at our command, we urge the Government of Canada to take immediate action to alert the people of Canada to the perilous position of their collective sovereignty that has resulted from the new technologies of telecommunications and informatics; and we urge the Government of Canada and the governments of the provinces to take immediate action to establish a rational structure for telecommunications in Canada as a defence against the further loss of sovereignty in all its economic, social, cultural, and political aspects." [1]

Response Abroad

In a complex and ever-changing international environment, a slow but sure move towards increasing state intervention in support for indigenous electronics industries is now evident. In the

United Kingdom, a number of government-funded activities are underway, including support for the interactive videotex system, Prestel, and new microelectronics firms. General Electric Co. Ltd (UK) and Fairchild Camera and Instrument (US) announced a joint venture to mass-produce silicon chips. Inmos, sponsored by the British government's National Enterprise Board, is another project. With over $100 million in start-up money, this firm is trying to break into the international market for advanced memory devices.

Emphasis is also being placed on government procurement programs. And through a series of films and publications, the government has launched a major campaign to promote incorporation of the new technologies into business and government activities. In all, government support for microelectronics in the UK is in the hundreds of millions of dollars.

West Germany is the world's third largest producer in the field of electronics. Two of the world's 20 largest data processing companies are German: Siemens and Nixdorf. In recent years much of the industry in West Germany has been reorganized around these firms.

Despite the vitality of the German information industry, a significant amount of hardware and software is imported. Technology agreements – mainly with US firms – have been signed to keep German industry at the leading edge of world developments.

Over the years West Germany has committed hundreds of millions of dollars to the development of its computer industry. It has addressed the social impacts of the technology and has actively supported the training and retraining related to automatic data processing. West Germany makes extensive use of apprenticeship programs to fill needs for skilled workers. In 1978, West Germany trained 1.4 million apprentices. Siemens alone spent over $200 million to retrain over 10 000 workers. Industry and government have committed $150 million a year to acquire or develop advanced computer systems in the areas of information, telemedicine, computer-aided education, computer-aided design and manufacturing, and process control. To enter chip manufacture, the government has committed over $500 million dollars to a five-year program to achieve a world-scale, state-of-the-art capability.

West Germany is also attempting to develop a national policy on the transition to an information society. In September 1979, the government announced a $600-million information technology program for the period 1980-83. The announced aim was to improve understanding of the social impact of microelectronics and related technologies, to increase the country's capability in skills needed to use these technologies and to develop further the necessary communications infrastructure.

After West Germany, France is the largest electronics producer in Europe. This is the result of years of government intervention, forced mergers, technology transfer agreements from abroad (mainly with US firms) and a strict government procurement policy which favours the French electronics industry wherever possible. More recently France has embarked on a massive investment plan in microelectronics. It has recognized the growing importance of the emerging information society and resolved that France will be among the first to make the transition.

The French program is probably the most ambitious, integrated activity in the world today. Its goal is to totally transform French society in this decade. The program includes the development of a public interactive videotex system, the widespread conversion of the telephone directory to an electronic directory, the development of inexpensive fascimile machines, upgrading of the telecommunications infrastructure, and the development of a device that allows for a shared communications space. The latter will allow two or more people in different locations to manipulate and write or rewrite information, using computer terminals.

Undoubtedly the most spectacular and ambitious aspect of the government's plan is to offer free to every telephone subscriber in France an inexpensive, interactive videotex terminal. The initial purpose of this black-and-white terminal will be to provide access to the electronic telephone directory. If implementation is on schedule, by the end of 1982 a field trial of 270 000 units should be completed: 10 million terminals will be connected by 1987, and 30 million by 1992. To make all this possible the French government is committing $2.5 billion for the period 1981-85.

Developments are also underway in other parts of Europe. In Sweden, despite a strong computer and data-processing industry, additional government intervention is planned to accelerate the move towards an information-based economy.

Developments in the US and Japan, the two leaders in the world electronics industry, are continuing rapidly. The US leads the world in computer sales, application of fibre optics, space technology and the silicon chip. In fact, in 1977 the US accounted for 40 per cent of world electronics production. One US firm, IBM, still accounts for more than half of the large mainframe computer systems installed in Western Europe. IBM, with its enormous sales worldwide, spends almost as much on computer research ($1.2 billion) as does the Canadian government for research into the natural sciences.

Japan is beginning to break into the US market with advanced memory devices and other semiconductors. It has developed a visible world lead in consumer hardware. For example, by 1977 more than 50 per cent of Japan's exports of electronic consumer durables were shipped to the United States.

The Japanese government has made a concerted effort to create an information industry, and to a large extent it has been successful. Between 1965 and 1975, Japan experienced the highest growth in electronics production among major industrialized nations: for the decade, the average annual growth rate was 23 per cent. The Japanese success story has been documented in many books and articles. The combination of vertically integrated electronics industries working in close cooperation with the banks and powerful government ministries was the key to their amazing performance. But although the growth of Japanese computer hardware has been impressive, their software is only recently becoming a factor in international markets.

The Japanese no longer rely on their ability to adapt or improve on models invented elsewhere. Increasingly they depend on strong national government support and a multi-billion dollar industry-supported research base. Some observers believe they lead the world in the development of intelligent robots, superchips and fibre optics. The announcement in late 1981 of their fifth-generation computer project indicates they intend to establish a lead position in the computer field.

Although current data on international sales are not easily accessible, Table II.1 shows the remarkable growth rate experienced by Japan. It also shows the poor position of Canada over the decade, both in absolute terms and in rate of growth.

Table II.1 - Electronics Output, by Country

	Value of shipments 1975 (Billions of current Canadian dollars)	Average annual growth rate 1965 - 1975 (%)	Contribution to GDP 1965 (%)	Contribution to GDP 1975 (%)
United States	40.4	7.4	2.9	2.7
Japan	21.3	23.0	3.0	4.3
West Germany	9.0	14.0	2.1	2.1
France	7.8	17.2	1.6	2.3
United Kingdom	6.4	11.7	2.1	2.8
Canada	2.4	10.9	1.7	1.5
Sweden	NA	16.3	1.6	2.3

Source: Canada, *A Report by the Sector Task Force on the Canadian Electronics Industry,* Industry, Trade and Commerce, Ottawa, 1978.

Response at Home

Some sectors of the Canadian electronics industry have experienced dramatic growth rates over the past few years. Growth rates of some members of the Canadian Advanced Technology Association (CATA) were in the range of 50 to 75 per cent for 1979. In the highly competitive field of word processing, Canadian firms, through sales or licensing agreements, are establishing an international presence. In the area of telecommunications, Mitel and Northern Telecom demonstrate that Canadian products can compete in international markets. However, despite federal and recent provincial government initiatives (most notably Ontario and Manitoba), much more remains to be done to ensure the development of microelectronics in this country.

Canada is barely holding its own in the international race to exploit the new technologies. In fact, developments are moving so rapidly across a broad range of hardware and software areas that we are probably already behind in even our understanding of the technologies and their implications for the future. Foreign governments have committed billions of dollars. But more than money is involved: a complex interweaving of industry, university, government and financial forces is needed to create a thriving high-technology industry. The key to a country's strategy is the integration of its efforts in one or more areas to ensure a presence in home and foreign markets.

The Minister of State for Science and Technology, John Roberts, noted in a speech in May 1981 that a national development strategy which concentrates on the fast growing high-technology sectors is critical to Canada's long-term economic future. But difficult choices will have to be made.

> "I believe that it is totally impractical for Canada to try and keep all of the technological bases covered on the questionable assumption that we will then be less exposed in international markets and at home. Our resources in research and development will be spread impossibly thin if we seek to be active in every technology and every economic sector. We should specialize in developing key technologies over time, and in a concerted effort, move these technologies from the innovation phase to the commercialization phase. I suggest that we should focus on those high-potential sectors in which Canada has a comparative and competitive technological advantage or in which Canada has an established or emerging technological capability. New technologies which are based on special long-term opportunities or challenges which stem from this country will help make Canada a world-class leader in major industrial sectors. It is these areas which offer the best

prospect for the ultimate edge for Canada – technological self-reliance."[2]

The task is large. Policy makers at all levels need to be better informed about the new technologies, their likely effects and the role that Canadians and Canadian industry can play in future developments. Educational institutions need to re-examine their curricula and priorities to take account of a rapidly changing social and economic environment. Industrial leaders must also ensure that they and the corporations they manage not only understand the new technologies, but also plan intelligently for their introduction into manufacturing and administrative processes in an orderly manner. All of this must take place within a swiftly changing international situation in which foreign governments and large multinational companies are committing vast amounts of money and labour to ensure their place in a high-technology future.

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III. Implications for Industries and Institutions

Institutions are the human embodiment of the ideals and aspirations of the society from which they spring. They rise and fall according to their ability to attract the brightest minds and the greatest resources and to command, tacitly or otherwise, the support of the community of which they are a part.

Human beings find many ways to associate themselves with the values and entities they believe in. It is no accident that in an age of alienation we see the stenciled T-shirt, touting the merits of Coca Cola or Mitel or nuclear disarmament. Recognition and acceptance are the life and strength of any institution and, though endowed with a kind of corporate personality, they are, fundamentally, human enterprises and respond to the winds of change.

In this section, our observations will be restricted to the immediate effects of the new technologies. The focus is how and to what extent they will affect the goals and objectives of a range of institutions and industries in Canadian society.

Canadian Electronics Industry

More than 700 firms in Canada make electronic products.[1] The majority of these companies are to be found in Québec and Ontario. By global standards, most Canadian electronics firms are extremely small (most have sales of less than $1 million), and even Canada's largest electronics company, Northern Telecom, is only medium-sized. Eight leading companies account for 50 per cent of sales; the remaining 50 per cent is divided among the rest. The industry contains many small firms, and some are highly innovative. In the fast-moving world of microelectronics, the major innovations have often come from these smaller firms. For example, Gandalf and AES have become major actors almost overnight.

The electronics industry, the largest industrial employer of technical and scientific workers in Canada, spends more on R&D than any other industrial sector and performs nearly 25 per cent of all industrial R&D in the country. With various national governments providing massive amounts of support for their indigenous electronic firms, competition in the electronics industry is as much between governments as it is between the companies themselves. Unfortunately Canadian governmental support for the new technologies has been miniscule compared to that provided by other countries.

Canadian industry is characterized by a high degree of foreign ownership, and electronics is no exception. Over 55 per cent of sales are by foreign-owned firms. If Northern Telecom sales are excluded, foreign-owned firms account for about 80 per cent of all sales. To put it another way, 72 of the 100 largest firms are foreign-owned or controlled. While we do not intend to digress into a discussion of the pros and cons of foreign ownership, it should be noted that with many major innovations coming from smaller firms and with the majority of these being Canadian-owned, there is a distinct possibility that, if special consideration were given to their needs, the balance of foreign versus indigenous firms might shift in Canada's favour.

With the electronics industry as a whole embracing the powerful chip it is imperative that it be used in appliances and consumer products produced in Canada, as well as in computers and telecommunications equipment. World sales of semiconductors in 1979 were about $10 billion (ten times greater than in 1970) and about two-thirds were integrated circuits sales. Sales of integrated circuits will increase in the 1980s (in both relative and absolute terms) as the more densely packed types of circuits, such as microprocessors and memories, become even more widely used.[2]

Although the global semiconductor industry is no longer having trouble keeping up with expanding demand because of current economic conditions (1981), capital in the form of skills and equipment needed to enter the business is growing as rapidly as the sophistication and complexity of the chips themselves.

Worldwide, the industry is experiencing rapid growth in capacity, leading to intense price competition. There are indications, however, that it is not earning enough profit to finance its phenomenal growth. As a result, and for a variety of other reasons, venture capital is flowing into those companies that are applying chips rather than those making them. The number of companies that use more than $100 million worth of chips per year increased from one in 1976 to seven in 1980, and is estimated to be about 20 today.

The growing demands of the large users, nearly all of whom are involved in computer and telecommunications and related businesses, have led to a wave of acquisitions. Further, large companies are buying up chip manufacturers to assure a source of supply and to ensure that the acquired design capabilities can be integrated with the other products made by the company.

Since the demise of Microsystems International Ltd in 1975, no Canadian firm has manufactured a broad line of general purpose chips. A division of opinion exists within the industry as to the need for a manufacturing capability for such chips. Nevertheless, Canadian industry does require access to a domestic custom-chip manufacturing capability.

The sales figures for integrated circuits understate their importance to the electronics industry and to the future of Canadian manufacturing. The majority of chips are used by vertically integrated companies for their own use, especially in

Canada. Thus they are embodied in the final product – or in the service rendered to the public.

The Science Council was heartened by the January 1981 announcement that Ontario will assist in the funding of a microelectronics development centre, as part of the Board of Industrial Leadership and Development (BILD) program. This centre, when completed, will have a limited chip manufacturing capability and will be aimed at specialized or custom applications – especially for the smaller users.

The Science Council believes that Canada needs a broadly-based chip manufacturing capability. There are a number of technological developments underway internationally that indicate a custom chip facility could be developed in Canada, to serve a variety of users. It is imperative that Canada have such a capability for R&D and effective technology transfer to occur. Without it the Canadian electronics industry will forever be dependent on foreign sources for chips, and the diffusion of the silicon chip throughout Canadian industry will be in the form of imported products.

The electronics industry is at the heart of the transition to the information society. It designs and produces the hardware and software for computer and telecommunication activities, and plays a major role in producing equipment and designs for the other sectors of society.

Natural Resource Industries

Natural resource industries continue to play a central role in Canadian society and in the economy as a whole. The broad sectors harvesting renewable resources – agriculture, forestry, fisheries – provide large export surpluses. These external sales have a considerable influence on the balance of foreign trade and make Canada one of the principal world suppliers of food and forest products.

Canada's nonrenewable resource industries – in particular mining and energy – are also important. It is generally agreed that these resources are very extensive and varied. Some are still unexplored, although they can be developed if the need arises and the appropriate techniques are found.

If we in Canada are to continue in our role as "hewers of wood and drawers of water," that is, rely mainly on our resource sectors, then even here we will have to make intelligent use of the new technologies. We must become familiar with control technologies of all types and apply systems engineering solutions to make us the most efficient and intelligent "hewers of wood and drawers of water" in the world.

Thus, in order to maintain internal and external competitiveness in a high-income country, the productivity of natural resource sectors must be raised constantly. This can be done only by a systematic application of R&D aimed at the continuous improvement of production techniques and product quality. This type of R&D has a long tradition in Canada. Research units established in this sector were among the earliest in the country. For historical, as well as institutional, reasons these research activities were developed mainly in federal government departments.

Agricultural processes, such as crop spraying, irrigation or drainage regulation, feeding in animal husbandry, greenhouse regulation in horticulture and produce handling, all involve control functions and are obvious areas for microprocessor applications. Traditional products and processes, such as tractors and milking systems, are already being redesigned to incorporate microprocessors.

In fisheries, more sophisticated navigational aids using microprocessors are currently being employed. This same technology is being used to improve communications and to aid in locating profitable fishing areas.

Underground mining has experienced mechanization in the last 30 years, based upon primarily electromechanical techniques. Cutting control is manual; whereas conveying, washing, general materials handling and the working environment are controlled electromechanically. The new technology makes all these control functions potential candidates for microprocessor applications.

In the forest-products industry, the use of computer and electronic controls, automation and laser techniques allows for enormous efficiency. The sawmill is becoming computerized; there are already 200 minicomputers at work in BC's estimated 175 sawmills. At Port Alberni, the new $51 million sawmill, owned by MacMillan Bloedel Ltd of Vancouver, and now testing 24-hour operation with a third shift, is the most expensive and elaborate sawmill in the world. It has five computer-controlled automated systems, which streamline lumber production. The mill will get about 10 per cent more lumber out of every log than did the old mill. It requires 40 fewer people to run it and, despite its high capital cost, is expected to pay for itself within a few years. The technology developed for the BC forest industry is also being exported to world markets.

Canada depends very heavily on its resource base in world trade. Despite these successful applications of the new technologies (every sector has a "success story"), Canada's future participation in the traditional resource sectors is in doubt. The concerns raised by the Club of Rome in its publication, *Limits to Growth*, as well as by the Science Council in Report 27, *Canada as a Conserver*

Society: Resource Uncertainties and the Need for New Technologies, have made us aware that although in the short to medium term we are not running out of resources, many of them will become increasingly costly to extract. We are moving from the most accessible areas to the more marginal frontier areas. As costs rise, Canada's participation in many areas will likely decline.

To offset future declines in revenues arising from the sale of resources, Canadians will have to be very innovative in the application of the new technologies. For example, Canada is a world leader in communications satellite technology.[3] The federal government is using satellites to help manage the environment and to continue the search for mineral deposits in remote parts of the country. Remote sensing, the sensing or measuring of some properties of an object from a distance, is a space-age answer to longstanding problems in resource management - problems that are particularly challenging to a country like Canada.

The Canada Centre for Remote Sensing, a branch of Energy, Mines and Resources Canada, is the central agency in this nationwide program. A major objective of the program is to ensure that data and available facilities are used to maximum benefit. In cooperation with NASA, Landsat satellites are used to gather data on the physical characteristics of the country. To obtain maximum benefit from the vast quantities of data collected by satellite and aircraft, ordinary visual methods of interpreting photos must be supplemented by automated systems, which can handle masses of data in a fast, accurate and repeatable way.

Canada is a leader in many areas of geophysical exploration, remote sensing, and the use of sophisticated techniques (both hardware and software) to identify new resource areas not otherwise accessible. These new techniques are essential to keep our resource sectors competitive with other world suppliers. The need is evident; the challenge must be met. The new technologies will ensure that Canada remains world competitive in the resource sector.

Manufacturing

Canadian manufacturing will be affected by the new technologies in many ways. The application of computer systems in the areas of design and manufacturing will lead to improved productivity in both products and processes. The new technologies allow for product simplification through the substitution of integrated circuits for gears, pulleys and electromechanical switches.

The production process has traditionally been characterized by a number of phases: manufacture of materials into components;

assembly of components into subsystems; assembly of subsystems into products; and, finally, testing and sales. In general, the later the phase, the more labour intensive is the process.

The new structure that emerges using microelectronics is one in which the use of the chip allows the forward integration of component manufacturing into the manufacturing of the final product. The electronic components become a much more important part of the product and a large part of the value added is therefore transferred from the final equipment manufacturer to the component manufacturer or semiconductor manufacturer. The bulk of subsystem and component assembly work is replaced by component manufacturing and much of the final stage of product assembly becomes the assembly of components. Component manufacture itself is not a labour-intensive activity.

This has implications for employment - Canadian industry in general and the electronics industry in particular. If more chips are used in Canadian products and if those chips are imported, Canadians will be creating employment and revenues abroad and unemployment and factory closures at home. Many of those industries in which high growth can be expected over the next decade - electronics, telecommunications, office equipment, precision instruments - are precisely the ones that will be using chips for product simplification.

The production process itself is being automated. Long-term trends point to the development of fully automated factories; the major components of such factories are currently being developed in different areas of the world.

Total control of the production process by distributed computer intelligence is the most sophisticated example of a more general set of technologies usually referred to as "computer-aided manufacture" or CAM technologies. These include computer-based scheduling systems, inventory-control systems, and partial-process control systems. Collectively these technologies have the potential to increase the overall productivity of factories by reducing personnel requirements, improving utilization of raw materials, decreasing levels of stock on hand and optimizing the relationships among the different processes and activities.

The microelectronics revolution allows automation to start at the level of design. When computers were introduced to Canadian industry in the mid-1950s, they were used for engineering computation. The capabilities of electronic computing power have since evolved to include logical ability, long-term storage of information, and the current emphasis on graphic display and output. Of particular note, the development of sophisticated software has made possible the automation of the draftsperson's task as well as the engineer's. As a consequence, the name of the activity has been appropriately changed from engineering computation to "computer-aided design," or CAD.

Thus CAD/CAM technology allows for the development of an integrated, automated production process. New software has enabled the interconnection of computer systems to make the totally automated factory a reality, from initial design/conception through to final manufacture, testing and shipment.

Another key element in the automation of the production process is the use of robots. Today's robot is basically a multifunction manipulator designed to move materials, parts, tools or specialized devices through programed motions to complete a variety of tasks. It is a machine that moves, manipulates, joins or processes components in the same way as a human hand or arm. However, the essential characteristic of a robot is that it can be programed and reprogramed, which means that it can be taught new tasks.

The use of industrial robots is growing rapidly. Although Japan, with perhaps 17 000 robots in operation, is far and away the world leader in their application, the number in use in the US has more than doubled to over 4000 in the past seven years and for the past three years global robot sales have been growing at a rate of 35 per cent, annually. By the end of this decade, sales of robots may reach $2 billion per year. Robots range in price from $10 000 to $120 000 and auxiliary equipment can easily double the installed cost. In 1980 the cost of maintaining a robot was estimated to be about $4.60 per hour. Contrary to popular notion, the higher productivity of robots today has little to do with higher speed; they are generally designed to work at a human tempo so that they will mesh with the existing factory operation. The productivity increase comes from the robot's ability to work consistently - without strikes or coffee breaks or sleep, all three shifts if needed.

Although robots are currently being used to increase productivity in existing plants, the nature of the technology associated with the new robots is inexorably leading to a change in the whole production process. We are entering the era of the fully automated factory. CAD/CAM technology and robotics will combine in a new plant configuration, designed to exploit the full capabilities of robotics (speed, versatility) in contrast to present practice where robots are integrated into human-scale production methods.

Japan currently produces over 150 models of robots, ranging from specialized ones that unload injection-moulded products, stack heavy loads or perform semiconductor-chip-bonding processes to general purpose robots that palletize, assemble, weld and paint with equal competence. A leading Japanese tool builder, Yamazaki, produces a sophisticated machine tool or machining centre every 40 minutes. The machining centres run unattended all night with lights off, building still more machining centres. Mitsubishi Electric Co, the aerospace-electronics company, also allows machining centres to run all night with the lights off. A Toyota automobile engine plant produces four times as many engines per employee as comparable US engine plants. A Japanese auto-assembly plant starts out with the sheet steel and processes it into finished automobiles at the rate of two per minute with half the work force of comparable US plants.

Automakers are in the lead in the use of robots in North America. Responding to the innovations in production in Japan, General Motors plans to have 14 000 robots in service by 1990: 1500 painting, 2700 welding, 5000 in assembly, 4000 loading machine tools, and 800 for parts transfer.[4]

The lack of vitality in Canada's manufacturing sector has often been attributed to the fact that we are one of the only industrial countries that does not have access to a market of at least 100 million people and therefore, our industrial plants cannot be built for world-scale production and competition. The rise of robotics can and will provide a solution to this fundamental problem.

Robots that can be programed and automated factories will change the shape of the production function. That is, rather than putting robots into existing production lines that are geared to labour, we can now build entire new factories designed around robotics. Thus, flexible automated production runs can allow us to achieve worldscale economies at a fraction of current output. This will help solve the traditional Canadian problem of building to world scale in our smaller market. While this would yield benefits in the domestic market, it would also give us the opportunity to be cost-competitive with the rest of the world, using the domestic market as a springboard.

Robotics and CAD/CAM technology will characterize *all* manufacturing in the 1990s. In the transition to an information society, the microprocessor will have a profound impact upon both products and production processes.

Education

The role of the educator and the role of education itself has been a subject of debate and discussion from the time of Aristotle. In the 1980s educational institutions will be affected by the new technologies in at least two major areas: first the enhanced role of computer-aided learning itself and, second, the need to retrain workers and managers for the variety of new skills required in an information society.

Computer-aided learning (CAL) refers to direct interaction between a computer and a student, in which the computer presents material for learning, asks questions, checks answers and varies its response on the basis of the student's answers. Since its inception, most CAL has used relatively large computers, usually through time-sharing. The microprocessor makes it possible to provide students with individual computers, which are both inexpensive and faster in response time.

The challenge is software. The creation of high-quality programs is a difficult and time-consuming task; a typical one-hour lesson could involve well over 100 hours of program development. Also, a versatile language for writing CAL courseware is not yet in use. NATAL (National Authoring Language) developed by the National Research Council, shows great promise, but has yet to be implemented in a significant number of educational institutions. The resulting lack of standardization means that it is usually necessary for educators to write and "debug" their own courseware, rather than make use of programs from other educational institutions.

Much has been written about CAL, and there is growing activity in Canada. At present, the implementation of CAL can be seen as taking place in the following ways:

- CAL will not be introduced in such a fashion that it will displace a significant number of teachers; it will be employed principally as a teaching aid to provide for the individual differences of students and to provide new opportunities for interaction between the pupil and the material to be learnt.
- CAL in the home is a future possibility, especially when connected with a videotex system such as Telidon. Home-based education is on the increase and the number of correspondence students is growing very rapidly in Canada. CAL will accelerate this trend and improve the quality of off-campus courses.
- CAL is presently being used in specific situations: in the armed forces for training; in industry for training and upgrading; in a growing number of colleges and universities throughout Canada; and in simulation training where there is an economic incentive. The prime example is the modern aircraft simulator, a Canadian product that has been adopted by all major airlines in the world. It is far cheaper and safer, for example, to learn the basics of flying a 747 in a simulator.

Educators and educational institutions also have a major role to play in supplying skilled workers for high-technology industries. With ever-decreasing hardware costs, the software costs begin to emerge as one of the prime factors in implementing computer systems of all types. Software skills are in great demand today, and the need for graduates who can program individual applications as well as design systems will grow throughout this decade. A cursory glance at the employment section of any major newspaper gives some indication of the extent and urgency of this demand.

One industry periodical summarized the problem in the following way:

> "The computer personnel shortage is fast becoming the Achilles' heel of the industry as hardware costs continue to fall while the price of labour goes on rising. It's a situation that will persist well into the 1990s and is likely to get worse before it gets better."[5]

The information society needs large numbers of highly trained individuals. The new technologies, however, upon which the information society is predicated will cause structural unemployment and job loss, and will fundamentally alter the way in which work is performed in our society. At the same time, new jobs will be created. Whole new classes of occupations are emerging which were undreamt of even a decade ago.

Both industry and educational institutions with the aid of government must undertake extensive programs of retraining workers displaced by the revolutionary changes to our economic system brought about by the new technologies. To a great extent, the growing need for information industry skills can be met through such retraining.

Research and Development

Much has been written about Canada's relatively poor R&D performance. Indeed, the Science Council has dealt extensively with the problem in a number of policy statements, background studies and statements of concern.[6] The federal government has set as a goal the raising of R&D expenditures in Canada to 1.5 per cent of GNP, or double the $2.5 billion spent in 1979, by 1985.

We leave discussion of the best ways to reach the 1.5 per cent target to other agencies and other Science Council reports. However, we strongly support the January 1981 background paper of the Ministry of State for Science and Technology, *R&D Policies, Planning and Programming*. In particular we endorse the sector-oriented programs for industrial R&D.[7]

As a Science Council not only do we urge support of R&D in computers and communications as part of an industrial strategy, but also urge recognition of the role of the new technologies in the process of R&D itself!

R&D in government, industry and universities is undergoing a change with the introduction of inexpensive microelectronically-based instrumentation. Computers allow for accelerated and more intensive research and allow for scientific inquiry into areas that were considered impossible or impractical because of the enormous amounts of labour required. With fast, inexpensive computing machines, new frontiers are opened in all aspects of R&D in Canada.

Not only the quantity but the quality of research in Canada must increase. The use of advanced computing techniques allows for a qualitative increase to take place. To increase quantity without regard for quality would be a grave error. Although the 1.5 per cent goal might be achieved by 1985, Canadian science would not be able to make contributions to and learn from state-of-the-art international developments.

Services

A wide range of services will be made more effective and more efficient with the application of computer/communication technology. The range of applications is limited only by our imagination and by the still evolving computer networks which, when completed, will allow full electronic interconnection of Canadian society. The following are only a few examples of likely applications that will be implemented or may well be underway by 1990:

- CAL will become common as courseware is developed and languages are standardized. The use of computers should not lead to displacement of teachers; rather it should allow for a more effective use of teachers or, better yet, could allow for a decrease in the size of the average class.
- The medical system will probably be transformed. Simple diagnostics could be undertaken through a home terminal linked to a remote computer. For example, the computer could interview the person and a decision might be taken to switch the person to communication with a physician. Computerized medical records will lead to better diagnoses at an overall lower cost to society.
- Banking services are now and will continue to move towards electronically-based systems. The eventual outcome is electronic funds transfer (EFT). In the US, financial institutions already use EFT to transfer about 80 per cent of all internal transactions.
- Electronic mail is already underway in governments and major corporations. In both Canada and the US, some 70 per cent of first-class mail is generated by computers. Much of this is ultimately destined for other computers.

The infrastructure of the industrial society consists of roads, highways, railways, airlines, and telephone and telegraph systems.

The information society will demand a far more complex infrastructure to allow the myriad electronic signals, impulses and data streams to be communicated to one or more people and to allow for switching and execution of orders and responses. This will demand the creation of new networks.

The emergence of networks for an information society is described in Northern Telecom's annual report for 1980. The report traces the development of voice and data networks and the merging of voice and data into all-digital systems. It notes many reasons why network creation is both important and inevitable. The reason why "intelligent" networks are inevitable is best depicted in this quotation from the report.

> "Despite the seemingly pervasive role that the computer already plays in our lives, only about 10 per cent of communications is now in the form of data. The remaining 90 per cent is still voice communications. It is widely recognized that data communications will experience a manifold increase in the unfolding Intelligent Universe. In the 1990s, data communications is expected to exceed voice. . . . The public telecommunications network was originally designed and built for voice. That is obviously no longer adequate or efficient since the amount of data, video and image signals is constantly increasing. Accordingly, one of the most significant developments for public and private telecommunications networks [is the] concept that in future all telecommunications will be based on digital technology."[8]

Within the coming decade a significantly broader range of network services will be available to meet needs in transmitting voice, video and data. While distributed data processing continues to evolve, new developments are also occuring in the use of satellite systems to transmit information.

A potential problem with the increased use of satellites by business is the area of sovereignty. Canada is a country still dominated by branch plants of multinational corporations. The efficiency of such corporations depends on the flows of information between headquarters and the subsidiaries.

With the increased use of inhouse computer facilities, there appears to be a tendency to centralize information activities. Concern has arisen in Canada (and in many European countries) regarding the flow of such information. Two major issues are:

- Information vital to the Canadian economy will be located abroad, and therefore will not be under the jurisdiction of any Canadian legal authority.
- High-level employment, necessary to the creation and operation of these data bases, will be lost to Canada (one estimate is the loss of up to 100 000 such jobs in Canada by 1985).

While national governments are concerned about the growth of this largely unregulated traffic, industry is worried that regulations will hurt efficiency. For a host of reasons (including possible tax evasion, employment, privacy, national sovereignty, access to information regarding Canadians and Canadian resources), the Science Council is concerned with the whole area of transborder data flows. We firmly support the research into this question underway at the OECD in Paris and the efforts of the Canadian government to define the issue and measure its magnitude.

Offices

A major target for the application of computer and communications technologies is the office. The rapidly emerging office of the future will be largely automated. Electronic products and sophisticated communications terminals will replace the electromechanical products.

The relatively labour-intensive office of today is a target for increased productivity. The nature of the change depends greatly upon how new capital and technology-intensive processes are installed. However, change is taking place. Even while productivity is itself being defined vis-à-vis today's office, the office of the future is slowly taking shape. The familiar "stand-alone" typewriter, filing cabinet, telephone and officer copier are slowly, but surely, merging into a single office communications and information processing network. Some offices already have multipurpose, complex work stations where office workers (including managers and support staff) perform a wide range of functions. From these same work stations it will be possible to make simple telephone calls, leave digitally encoded voice messages, activate microelectronically controlled copiers, print forms or letters, and write and/or edit reports or memos. In turn, all work stations will be linked to computer data bases, a duplicating and printing centre and a communications centre that will be the voice, video and data gateway to other electronic offices in the building, across town or around the world.[9]

In 1978, expenditures in Canada for office products and related services amounted to $6 billion; this is expected to double by 1985 and double again to well over $20 billion by 1990. Canada is a net importer of computers and office automation systems. In 1980 the trade deficit in this area was over $1 billion and the deficit is expected to grow. It is estimated that by 1985, the trade deficit will be $5 billion. While Canadian firms have been competitive in "stand-alone" products, the trend towards integrated systems imported as entire operating systems is likely to put Canadian firms at a severe disadvantage.

Many smaller high-technology companies are participating in the drive towards office automation. Two such examples, Mitel Corporation and Gandalf Data Communications Ltd, are active in Canada and around the world. The hardware sector in Canada still remains largely a branch-plant operation. Even with the successes mentioned above, this sector is less than 10 per cent Canadian owned. Most hardware is either imported, or manufactured in Canada by subsidiaries of multinational firms.

In contrast to the hardware sector, the computer services industry - the business of selling computer time and related services - is about 80 per cent Canadian owned. Datacrown, Systemhouse and Canada Systems Group are but three outstanding examples of the software thrust now being made by Canada. Many of the software companies are involved in exports as well. For example, Datacrown Inc of Toronto recently built a $10-million installation in Washington, DC, to serve the US market better.

The greatest potential for Canadian participation in the drive towards the integrated electronic office lies in the area of software products. An outstanding example is the development of systems and applications software, the latter partially automates the complex task of computer programing.

With the software area growing by 20 to 30 per cent per year, many Canadian firms are moving rapidly to take advantage of global market opportunities.

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IV. Implications for Individuals

In the early pages of this report, the point was stressed that computers, communications and the widespread application of microelectronics are a *transformative technology*. Then, possible effects upon aspects of Canadian society, the economy and industrial sectors were explored. Now we turn to the ways in which individual Canadians - as citizens, workers, consumers, and persons - are and will be affected during the transition period and beyond.

Employment

The impact of the microelectronics revolution will be felt first by women, middle managers and workers in manufacturing industries. Not just older workers will be affected; a very large proportion will be young, with more than half their working lives before them. One appropriate response is massive retraining and, to a lesser extent, relocation of workers and their families. Other types of structural changes may be foreseen - increasing specialization of job skills by individuals, more work at home, increased leisure time, and a rejuvenation of the arts in every sphere. For the majority of workers, however, the solution to structural unemployment will be re-education. Such programs, costing billions of dollars, will require substantial reordering of government priorities. Ultimately, it is not inconceivable that as much as 5 per cent of GNP will be dedicated to retraining and relocation on a continuing basis.

Over the past few years a number of books, articles and governmental inquiries (e.g., Australia, Sweden, West Germany, United Kingdom) have examined the employment issue in varying detail, and with varied results. From the enormous amount of material available, there appears to be growing consensus.

- Any discussion of the impact on employment must distinguish between short- medium- and long-term impacts. And, even more important, it must distinguish between structural unemployment and net unemployment. The former refers to change in one subsector of industry or set of subsectors, which leads to job loss, while the latter refers to job loss throughout the entire economy. The consensus to date (1981) is that structural unemployment will definitely be a feature of the 1980s.
- The new technologies will be used to improve productivity in every place where labour-intensive activities predominate. From the shop floor, to offices, to middle and senior management, computing power will displace human intelligence and computer memory will take the place of paper-based records, files and memos.

• The British Association of Professional, Executive, Clerical and Computer Staff, in a March 1979 position paper on office technology, pegged the productivity of word processors at twice that of mechanical office machines.

• Product simplification, the use of integrated circuits to replace gears, pulleys and electromechanical switches, leads to a dramatic decrease in labour requirements in manufacturing.

• Studies on a sample of eight companies, located in different countries, that produce mechanical and electronic "information products" revealed employment reductions averaging 20 per cent between 1969 and 1978. The proportion of production personnel in relation to total personnel dropped in all eight firms.

• In offices, the labour-reducing effects of information technology are concentrated in the clerical area. Because the service industries employ over 80 per cent of all women in the labour force, automation in the clerical area will seriously affect employment opportunities for women.[1] The new technologies also increase the skills disparity between clerical and professional information-related work. This is unfortunate because clerical workers generally have the fewest opportunities for educational leave and staff training, and many women have problems upgrading qualifications because of family and related considerations.

• The new job openings are in all areas of computer design and applications. The hardware area needs skilled people with an electrical engineering background to design chips and their applications. The software area requires men and women who understand control, production and mechanical systems. The shortage ranges from data processing to logic, systems and software skills of all types.

• The introduction of machine intelligence into the manufacturing and service sectors will lead to a division of workers into highly-skilled and low-skilled categories, wiping out the intermediate skill range which is vital for both the reality and possibility of upward mobility. This trend will not be restricted to unionized workers, but will affect middle management as well.

As one participant noted in a workshop convened by the Science Council:

> "A Canadian local bank manager pointed out that his regional vice-president knows precisely the state of his branch at any point during the day by pressing the appropriate buttons. He can know the state of deposits in the bank, the state of withdrawals, the state of payments of loans, defaults on loans, everything that is put in the data banks, the bank's central

place. So I asked the branch manager, 'What is your role?' His response was 'I'll be damned if I know'."[2]

The new technologies have the capability to centralize information and change the focus of decision making. In this case the authority of the middle-management person, the local branch manager, has been changed and potentially reduced by electronic data processing.

The role of work and working in the information society is unclear. Some trends, such as those outlined above, are obvious; others are still indistinct. The new technologies will change the nature of work, the place of work and the importance of work to society. With sophisticated communications technology, the office, for many people, will gradually become more a concept than a place to be from nine to five. Anywhere a person can reach a telephone will be the "office" for that person. With portable intelligent terminals the individual can send memos and mail, receive messages, and write and file reports at any time and from any one of the over 400 million telephones in the world.

The trade union movement fears that the new technologies will reduce the number of jobs. Concern also exists about the extent to which the nature of the job will be transformed so that it becomes in fact a different job and whether and to what extent fewer skills will be needed. Like the assembly line before it, the computerization of work is ushering in a new economic era, one that will disrupt long-established customs in labour relations. In its most basic form the issue is power. One union spokesperson noted, "If labour does not find a way to control technology, then management will use technology to control labour."

The impact of technological change on workers has been an almost constant source of tension in Canadian labour relations. The prevailing buoyant economic environment of the 1960s allowed for job mobility, and tensions relating to the introduction of new technologies were alleviated. During the 1970s, the situation changed: new technologies and economic slowdown caused the impact of technological change on jobs to become a major item on the labour-management agenda.

The situation is not entirely one-sided. Technological change often eliminates boring, strenuous and hazardous jobs. The drudgery associated with repetitive tasks can be partially or entirely eliminated with the introduction of machines. Balanced against this are the often-reported monotony cited by some operators of automated equipment and the isolation from fellow workers.

Whenever new technologies are introduced, territoriality becomes a central problem. Many of the measures which might be used to alleviate adverse effects on employees – retraining, job transfers, relocation, a slower rate of introduction of technology – involve production and planning functions, traditionally controlled by management. Union leaders complain that they do not have a voice in the personnel or technology policies of the firm or government department in which their workers are employed. Management contends that decisions to introduce new production techniques have to be made months and sometimes years before the actual delivery of the new technology. Millions of dollars are often committed long before an automation decision is finally made. These decisions – which workers often only learn about days or months before implementation – are held to be one of the prime prerogatives of management.

Some experiments and successful cases have been recorded where *joint* decision making has been undertaken regarding the introduction of new technologies. Procedures have been instituted in some industries by which workers often are kept informed of developments, are consulted about them and are given an opportunity to influence management decisions.

The adversarial stance of Canadian labour and management must be changed to one of enlightened cooperation. A model, which might be considered, is the "General Agreement of 1978 between the Norwegian Federation of Trade Unions and the Norwegian Employers' Federation on Computer-Based Systems." This precedent-setting agreement established the position of "data shop steward" and gave workers the right to prior notification about all proposed technological change, access to company data banks, and participation in all decisions that affect the form and content of their jobs. Other countries have developed successful methods to ensure cooperation. For example, West Germany has had labour representatives on corporate boards for some time.

Canadian labour-management relations must move towards a cooperative approach in a variety of areas and for a variety of reasons. Fear, distrust and territoriality must be put aside – for the best interests of both parties – as the automated workplace moves ever closer to realization.

Privacy

The role of privacy in our society is both complex and confusing. To the extent that the public perceives its privacy is being infringed upon, then a problem will exist. There can be no easy technocratic solution to the human desire/need for a private life – especially when this need or desire is perceived to be in jeopardy from a fast-moving new technology.

The growing use of data banks poses such a threat. Industry indifference has led to increased availability of information about individuals. Ensuring the confidentiality of health records, for example, is a growing problem.

Concern is heightened when data banks are linked through networks to other data banks. It is one thing to enter an office and physically open a file to extract information on someone else. The linking of electronic data files, however, means that information on individuals can be extracted through terminals in another location. In fact with distributed data bases it is difficult to know exactly where the information is; it need only be accessible and retrievable.

The incorporation of massive personal data bases into communications networks presents a serious threat to conventional considerations of privacy. First, the various services provided on a network require the compilation of a great deal of personal data: medical information for health care; financial information for business activities; legal information for legal services; and educational aptitude, ability, and performance information. Second, data which alone is considered nonsensitive can become sensitive when correlated with other information that can lead to a detailed profile of an individual. Finally, because data can easily be transferred between systems, security becomes complex and difficult. Both individuals and organizations require legal protection of their right to privacy in the face of the problems presented by large-scale data bases.

Questions such as the following must be addressed and, we hope, answered constructively. How should the collection, use, and distribution of personal data bases be controlled? What rights does the individual have to be informed as to the content and use of her or his records? How will security be guaranteed? What rights will government agencies or private organizations have to exchange personal data with other agencies or organizations?

There are few easy answers. Already telemedicine, teleshopping and electronic funds transfer systems are widespread.

Sacrifices have been made to achieve our present standard of living. In the transition to an information-oriented postindustrial society, trade-offs must inevitably arise and conventional notions of privacy will be affected. Unless there is widespread public understanding of both the benefits and the costs inherent in a transition, the result will be social disharmony at best – a neo-Luddite reaction at worst.

Home Uses

The range of alternatives for the average Canadian household forecast for the mid- to late-1980s varies, depending on the forecasters. The emergence of a public videotex system, such as

Telidon, will allow for the introduction of television sets with a built-in Telidon capacity or the use of personal computers that can access and input to such a system. The Yankee Group of Cambridge, Massachusetts, forecasts that "the wired home of the future will have electronic newspapers, a virtually limitless selection of 'narrowcast' entertainment, teleshopping, home banking, and centralized control of energy conservation and home appliances."[3]

To this should be added home-security devices which automatically alert the fire or police department in the event of emergency; medic-alert buttons for the elderly, ill or disabled; a wide range of home entertainment and education devices built around videodiscs and video tape units; message systems built into the telephone that record or forward messages; increased capacity to work in the home and telecommute to the office. By the end of this decade the home will have fundamentally changed. Continued inflation, rising energy and transportation costs, increased fear of urban violence, all point to more activities centred about the home.

The projected rate of market development of Telidon, for example, is in accord with other technological developments in the consumer market. It took radio, colour film and television each about 12 to 15 years to grow into widespread use. The first videotex systems, introduced in England, date from 1976. Although few now argue over forecasts that videotex is going to be big business, there are several key problems that need to be solved. For example, it is still unclear how quickly consumers will accept such radically different ways of communicating or how much they will be willing to pay for such services. Government regulations and policies to protect privacy, to ensure the integrity of electronic financial services, and to preserve the ownership of information are needed before videotex takes off.

Market forces will ultimately determine how the new technologies are used in the home, but electronic banking, an electronic Yellow Pages which can be updated daily or hourly if needed, and electronic mail are clearly at the leading edge. Classified ads and news bulletins as well as specialized news stories lend themselves to videotex and it is likely that the newspaper of the future will be different; it may disappear or become thinner, with less advertising and more indepth reporting.

The personal computer, located in the home (or office), would be part of the emerging network. Forecasts indicate that it will become as ubiquitous as the telephone – and as essential. (Although the average telephone is only used about 20 minutes per day most subscribers are quite willing to pay the monthly service charge that allows them to communicate via a sophisticated network with over 400 million telephones around the world.)

The new technologies have the potential to increase the alienation and sense of powerlessness prevalent in our society today. Alternatively, they can be configured in such a way that social interaction can be increased and facilitated. Telidon could be the town hall or community bulletin board of the future, and could provide a means of interaction with other persons. In isolated areas and during our cold winter, much interpersonal activity could take place via sophisticated videotex systems. For the aged and disabled, the use of such systems could profoundly transform their lives. The ability to interact with central data bases has been demonstrated by Telidon, which can now be developed into a truly interactive system; one that will allow for person-to-person communication.

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V. The Need for Policy on Future Networks

Canada's ability to make a successful transition to an efficient, integrated information society depends on the strength of the telecommunications infrastructure. This infrastructure is composed of terrestrial telecommunications networks, communication satellites, the computer-services industry and the industries that provide the hardware for the system.

Canada has one of the most advanced and efficient telecommunications sectors in the world. We continue to lead the world in the use of advanced communications technologies. Canada was the first country to establish a geostationary communications satellite system. Canada has two operational national packet-switching networks. Telidon, a second-generation videotex system developed by the Department of Communications, has features superior to any competing videotex system in the world. We are at the forefront of change in electronic switching and the use of fibre optics. We have an extensive cable system with the capacity to deliver nonbroadcast services to the home and office.

The appropriate level of competition in providing various services has been a continuing subject of discussion. Questions of monopoly, competition, technical change and regulation are central to the telecommunications industry. New developments in information technology, concern about the burden of regulation and the US trend towards deregulation have caused telecommunications policy makers and regulators to consider whether the public interest is best served by maintaining the present industry structure, a principal feature of which is the far-reaching monopoly of the telephone companies. In the past, a central rationale for regulation of the telecommunications industry has been the presumption that it is characterized by large economies of scale and is therefore a natural monopoly.

For computer networks to operate efficiently and serve the greatest number of people they must be tightly integrated systems geared to speed, maximum capacity and minimum interference. For the computer-communications industry to achieve its full potential it must move towards a few all-encompassing systems, expanded customer bases, and a complete commonality of product and service that will allow for full domestic compatibility and provide the basis for international expansion. There is a need for standards, whether by agreements or legislative decisions, to allow a progressive merging of computer networks in the major governmental, industrial and commercial institutions.

The range of new services raises questions of ownership and control. Who will deliver the services? How can standardization be assured? How can access to the system be guaranteed? Can the historic separation between carriage and content – long a hallmark of the telephone industry – be maintained? Should it be maintained?

The introduction of Telidon is being inhibited by uncertainties as to who will provide the service, who will have access to the system, how will the data bases be structured, how will payment be made, and what is the role of advertising? These uncertainties are slowing development by increasing risks for potential investors.

The creation of a national telecommunications system to provide the infrastructure for the future cultural and economic development of Canada means that telecommunications policy development will require serious attention by the relevant provincial and federal government agencies.

An up-to-date universal network capable of serving regional and national interests, as well as permitting international transactions, must be developed using the nation's economic resources in the most efficient manner. This may be more difficult than it looks initially, for Canada has considerable redundancy in its network today because of its technical expertise in the transmission field, the rush to provide hardware solutions for what are essentially issues of sovereignty and, of course, the existing industrial structure. The transformation of the existing technological and institutional structures into a integrated structure may be more difficult for Canada to achieve than for most other nations. With the exception of the US and Canada, the telecommunications structure in most countries is government owned and operated. Canada has a mixed public and private telecommunications structure under divided jurisdiction and regulation.[1]

At the moment a confused pattern is emerging regarding the future roles of existing and planned networks. A number of networks are vying for the business market and are preparing to service the projected home market. In addition there is a growing strength in network capability in the US; this will become especially clear when the new satellite systems for home and office are operational. In addition we have a cable industry that has saturated its markets for distribution of TV signals and is seeking to expand its role. While competition is important it can lead to overlapping roles, especially where there is no clear jurisdictional authority.

If we do not develop a comprehensive telecommunications policy soon, the resulting confusion will lead to wasted resources, and loss of time in the world race to develop networks and possibly allow the entry into Canada of powerful competing networks from abroad. It is imperative that a policy be enacted, designating areas of activity for existing participants, yet providing the needed flexibility to accommodate new competition and the emergence of new technologies.

VI. Recommendations

The information society is upon us. The manner in which Canadians choose to participate will have far-reaching implications. The microelectronics revolution, upon which the information society is predicated, presents both threats and opportunities. How we respond will determine the shape of our own lives and Canada's future role in the world community.

Most advanced nations of the world are preparing to place themselves at the forefront of the information society. Many of the changes described will take place whether we like it or not. The question that remains is whether Canada will be an active or a passive participant. Canada has been fortunate in having participated in the early stages of this worldwide technological revolution. But what has been accomplished to date has only been a beginning.

Other countries have backed their initiatives with billions of dollars in public and private sector investment. If Canada's present failure to act continues, Canadians face a bleak prospect and the country will be left even more vulnerable.

Many sectors of our manufacturing industry would be rendered obsolete, virtually overnight. Our trade balance, already precarious, might never recover. Structural unemployment could lead to permanent joblessness for many Canadians, a decline in living standards and, for some, emigration. The personal privacy and integrity of Canadian citizens could be compromised in ways and on a scale never before seen in an independent, democratic country; indeed, our cultural and political sovereignty would be permanently jeopardized. Failure to respond adequately to these clear and present dangers could spell an end to Canada as we know it, precipitating a decline which would bring Canadians inevitably to a condition of pastoral servitude by the middle years of the twenty-first century.

If, on the other hand, Canadians are willing to make the political and financial commitments needed to master the new technologies, particularly in the areas of computers and communications, resource extraction and processing, energy, research and education, then we will reap the benefits of new employment opportunities, reversal of trade deficits, and strengthening of our cultural sector and achieve a new and powerful competitive position in the global marketplace.

Many of the recommendations in this report are directed towards governments, in particular, the federal government. This is not to suggest that all or even most of the impulse for development and evolution should come from the public sector. Much valuable and innovative work in the new technologies is being done now by the private sector in Canada. Some Canadian companies are today world leaders in their specialties. With a few notable exceptions, however, Canadian industry as a whole has been slow to recognize the far-reaching impact the new technologies are having on virtually every aspect of Canadian life and business.

We have identified the key actors (governments, labour organizations, educational institutions, professional, commercial and industrial associations), and attempted to alert them to important facts, trends and problems. It is up to them to play a role in informing Canadians of the massive changes being wrought by the mighty chip, and, of course, to frame their own response to the enormous challenges confronting us all. No one is exempt.

The recommendations and statements of concern that follow are based on a spectrum needs ranging from the importance of heightened awareness to requirements for immediate action.

1. *The Science Council recommends that the First Ministers of the governments of Canada create an advisory committee on the new information technology.* The committee would be a collaborative group of industrial, federal, provincial and information-user representatives. With a small action-oriented secretariat the new committee would gather and disseminate information on domestic and international activities in the new technologies, act as an authority on technological trends and make policy recommendations. *The creation of this group by the First Ministers would be an expression of commitment at the highest level.*

2. *The Science Council recommends that the Communications Research Centre of the federal Department of Communications be restructured to form the nucleus of a national research institute for the development of advanced systems and applications software associated with the theory and practical use of the new technologies.* It would also stimulate development of the pool of highly trained personnel needed for the rapid expansion of industries based on the new technologies. Financed by industry and government to meet their needs, the new national research institute would be able to second personnel from universities and the private sector.

3. Cooperation and coordination between federal and provincial governments is essential if Canada is to have a role in an information-dominated future. *The Science Council recommends the creation of a national communications policy that is forward looking, integrative and comprehensive.* It should encompass a wide range of subject areas from distributed data processing to cultural sovereignty to Teli-

don, and include establishment of standards that will ensure widespread compatibility of systems.

4. Canada cannot duplicate all of the initiatives underway worldwide. *We must realistically choose which products will be developed in Canada, which will be imported from abroad and which can or should be licensed for manufacture in Canada.* In order to do so intelligently, we must have state-of-the-art knowledge about the technologies and the ways in which they are likely to develop. In addition, we must understand the costs of the various alternatives – including direct costs and the multipliers, both positive and negative. *The federal Department of Communications, together with other federal departments or agencies with responsibility for industrial development, should have such functions included in their terms of reference.*

5. Microelectronics will increasingly permeate all facets of Canadian society. Of special importance is the manufacturing sector, where microelectronically controlled machines of all types will be used. The Science Council supports the recommendations of the CAD/CAM Technology Advancement Council in its report, *Strategy for Survival: The Canadian CAD/CAM Option* (September 1980), concerning the diffusion of the technologies throughout Canadian industry.

6. Canada is a resource-rich country and derives much of its national wealth from resource extraction and processing for export. In order to maintain our competitive position in the world both in resource exploitation and the technologies used for that purpose, *we must ensure that our resource industries are aware of the role the new technologies can play in improving productivity.* There are important roles here for the private sector on the one hand and the National Research Council and the departments of Energy, Mines and Resources; Industry, Trade and Commerce; Agriculture; and Communications, on the other.

7. Canada is recognized as a world leader in many areas of geophysical exploration, remote sensing and the use of sophisticated electronic techniques (both hardware and software) to identify new resource areas not otherwise accessible. *Both government and the private sector must work to ensure that we maintain this lead and build on this strength so that Canada can maintain a healthy economy.*

8. Robots, which can be programed and used in automated factories, will change the shape of production in the future.

Manufacturing plants can be designed to achieve world-scale economies at a fraction of today's output. Industry, universities and governments are urged to analyze the advantage inherent in the use of robotics. *The Science Council recommends that "centres of excellence" be established to ensure the development of expertise in this area so that policy makers and planners can determine the extent to which we build robots in Canada or import this technology from abroad.*

9. With the transition to an economy that will be characterized by the increasing use of microelectronically controlled instruments and machines in the home, office and factory - in fact, throughout Canadian society - R&D takes on new importance. *In developing new programs to support this activity, industry and government must recognize the relative importance of software.* In many applications, experience has shown that software costs, in both human and financial terms, exceed those of hardware by several orders of magnitude. With declining hardware costs, this trend can only accelerate.

10. The new economics of customized mass production, based on extensive use of robotics, will present many challenges to industrial designers and manufacturers. *The Science Council recommends that industry and government collaborate to develop and maintain a custom silicon-chip design and manufacturing capability,* both to strengthen our domestic high-technology industries and to avoid dependence on foreign suppliers of this vital commodity.

11. Important innovations in the microelectronics industry tend to originate in *small firms* that may not benefit from the broad range of R&D support programs. *Council recommends that federal and provincial industrial incentive programs should be reviewed with emphasis on this aspect of the industry.*

12. *Federal and provincial governments should develop new mechanisms to support small, promising ventures in the new technologies, for both hardware and software.* For example, a program of grants could be offered, disbursed by a body similar to the Natural Sciences and Engineering Research Council. To assure equal opportunity and to avoid conflicts of interest, a review system should be created to oversee this program.

13. *Federal and provincial procurement policies should be designed to provide strong support for Canadian high-*

technology companies. Such support would be particularly beneficial due to the "multiplier effect" on component suppliers, including microelectronic chip manufacturers, systems designers, software developers, technical schools, universities, venture capital suppliers and many other sectors that contribute to the development of Canadian expertise in the new technologies.

14. *Governments at all levels, including municipal, should accept the objective of harmonizing their procurement policies to ensure system compatibility, and should take steps to set up coordinating mechanisms to realize this objective.* Just as standardization enables us to direct dial to any telephone in Canada, so the appropriate jurisdictions must ensure the same high-quality system standardization for such areas as computer-aided learning, electronic funds transfer, teleshopping, communicating word processors and electronic mail.

15. The rate of diffusion of microelectronics technology will be conditioned by a number of factors. Key among these will be the attitude of workers who are affected or who perceive that they might be affected. *There is an important role for Labour Canada and provincial departments of labour to work with companies and labour organizations to provide for dialogue and planning for orderly transition.* Reduction in tensions and avoidance of economic losses due to strikes would be among the benefits resulting from such an approach.

16. Canadian trade unions, in contrast to their European counterparts, have not developed a sufficient knowledge base regarding microelectronics technology. Without an understanding of the implications of the new technologies the union movement will continue only to react to real or perceived change rather than carry on an effective dialogue with industry, which is so essential. *Council recommends that major unions, perhaps in conjunction with the Canadian Labour Congress, establish centres of science or technology policy* with the following aims:

    - to inform workers about new technologies, taking into consideration both threats and opportunities;
    - to promote understanding of new employment opportunities;
    - to provide capable and knowledgeable individuals for meetings, conventions and educational programs

in order to present the labour position in a creative and constructive way;
• to aid in the policy and decision-making process at all levels of government.

17. Despite the great demand for Canadian workers trained to design and build hardware and to develop systems and applications software associated with the new technologies, provincial governments have failed to assess realistically the urgency of this problem and make the necessary realignments of priorities. *Rigidities in university funding mechanisms should be removed so that highly-qualified people will be available in sufficient numbers. Both federal and provincial governments should develop capital and operating programs that will increase funding for education in this vital area.* An important role also exists for industry, both to make clear its projected personnel needs (expected to be critical by the mid-eighties) and to develop new inhouse training programs, perhaps modeled on the successful apprenticeship programs in Western Europe.

18. Telidon still requires extensive government support to ensure its speedy introduction in Canada. *The Science Council recommends that both federal and provincial governments embark on a large-scale introduction of Telidon into their own operations.* This will provide a body of operational experience, invaluable in promoting export of the technology abroad. In addition to improving productivity, such an introduction would lead to widespread computer literacy among government workers exposed to the system in the course of their everyday work.

19. The use of computer-aided learning (CAL) is increasing. An entirely new, related area of endeavour is the authoring of courseware. The need for Canadian-produced courseware in both official languages is great and with the adoption of standards for CAL, the demand will grow steadily in coming years. *Teachers should be encouraged to participate in authoring courseware for CAL, as they have done in the past in writing textbooks.* In this way teachers may be part of development rather than apart from it.

20. In a world where information is power and increasingly proprietary, restricted access to videotex systems and data banks could create a new form of poverty. An information-poor class could emerge, one that is either

unable to afford the services or lacks the requisite knowledge to interact with the system. *We recommend that governments adopt a national policy aimed at increasing computer literacy among the public. To help accomplish this objective large numbers of videotex terminals should be placed in public libraries across Canada.*

21. The widespread use of microelectronics and computerization raises serious questions regarding privacy. *It is our contention that use of the Social Insurance Number as an identifier should be restricted. Further, the sale of information stored on computer tapes to marketing agencies should be questioned.* It has been demonstrated that data banks are easily penetrated and, therefore, either legitimately or illegitimately, the privacy of all Canadians is threatened. *The Science Council recommends that federal and provincial departments of justice provide strong legal remedies, both civil and criminal, for misuse of personal information.*

22. We view with concern the questions associated with transborder data flows. The predicted impact on Canada in terms of balance of payments, employment and, of course, national sovereignty are serious problems that call for creative solutions. While recognizing the difficulties inherent in this area, we feel there are some instances where government intervention is justified; for example, in the areas of personal privacy, sovereignty and national security. *The Science Council recommends that the work underway under the direction of the federal Department of Communications to measure the extent of the problem be intensified. We also encourage government agencies and the private sector to cooperate in support of similar efforts underway at the OECD.*

23. The free flow of information is essential to Canada's future. Barriers of geography, culture or language must not hinder individuals from interacting with public information networks. *Federal and provincial regulatory agencies must guard against the creation of unnecessary artificial barriers.*

24. The principle of separation of carriage and content is paramount; that is, carriers must not be allowed affect the content of material. *It is recommended that regulatory agencies ensure that public videotex networks of the future meet all reasonable demands for services at tariffed rates.*

25. Increased energy costs have become a widespread fact of

life. The use of telecommunications can do much to alleviate the problems we face due to the rising cost of petroleum-based transportation systems. A number of studies have indicated that teleconferencing will become increasingly acceptable. *The Science Council recommends the enhancement of the existing and planned telecommunications infrastructure to promote teleconferencing in both the public and private business sectors.*

26. The new technologies are fostering a revolution in health care. Documentation, diagnosis, pharmacology, treatment, prosthetics and research, for example, will be greatly affected. *Industry, medical and nursing schools, provincial and federal departments of health, universities and granting agencies, including private foundations, must be sensitive to the changes in this field and their potential benefits to, in particular, the disabled and those suffering from degenerative diseases.*

27. *Vastly increased public awareness of the problems and opportunities inherent in the transition to an information society is essential if Canadians are to understand and master the new technologies.* This public information function must involve governments, educational institutions, the print and electronic media, labour and industry groups.

Notes

Preface

1. The committee published a number of papers, including *Communications and Computers: Information and Canadian Society* (1978); *A Scenario for the Implementation of Interactive Computer-Communications Systems in the Home* (1979); *The Impact of the Microelectronics Revolution on Work and Working* (1980); *The Impact of the Microelectronics Revolution on the Canadian Electronics Industry* (1981); and *Policy Issues in Computer-Aided Learning* (1981).

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2. John Roberts, Minister of State for Science and Technology, "The National Economic Development Strategy and its Importance for the West," Speech to the Joint British Columbia and Alberta Law Societies and Bar Associations at Jasper, Alberta, May 1981.

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1. Much of the data on the Canadian electronics industry in this section has been obtained from Canada, Department of Industry, Trade and Commerce, *Canadian Electronics Industry: Sector Profile*, Government of Canada, 1978.
2. The integrated circuit at the heart of the microelectronics revolution can be devised to perform a predetermined set of functions. With given inputs, or with given operations involving its memory, it will produce an output based on its fixed logic. Thus an electronic watch will

change the date once a day, using its prior knowledge of the differing lengths of months. The integrated circuit can also be given new instructions so that it operates on a different logic. The microprocessor is basically a microcircuit that can be programed; with input and output devices and with a memory (which can be on the same or related chips) it becomes a computer.

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7. Canada, Ministry of State for Science and Technology, *R&D Policies, Planning and Programming*, Background paper, January 1981, pp. 26-28.

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1. Heather Menzies, *Women and the Chip*, Institute for Research on Public Policy, Montreal, 1981, pp. 5-7.

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3. Howard Anderson, "The Home of the Future," Speech at DATA 81 - The Home of the Future, Winnipeg, Manitoba, 15 June 1981, Conference sponsored by Whitsed Publishing Limited.

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1. Charlotte Anne Reed, "A Perspective for the Development of Telecommunications Policies for Canada," School of Public Administration, Queen's University, June 1978, pp. 66-67.

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Committee on Computers and Communication: Information and Canadian Society

Chairman
Mr. T.R. Ide,*
T.R. Ide Consultants Inc.,
Scarborough, Ontario.

Members

Dr. D.A. Chisholm†
President,
Innovation and Development,
Northern Telecom Limited
Mississauga, Ontario.

Mr. W. Edwin Jarmain
President,
Jarmain Communications,
Toronto, Ontario,

Dr. J. Kates**
President,
Teleride Corporation,
Toronto, Ontario.

Professor Tom McPhail
Faculty of Graduate Studies,
University of Calgary,
Calgary, Alberta.

Mr. Peter Bower
Managing Director,
Education Telecommunications,
TV Ontario,
Toronto, Ontario.

Professor James R. Taylor
Department of Communications,
Université de Montréal,
Montréal, Québec.

Dr. M.D. Vogel-Sprott*
Professor,
Department of Psychology,
University of Waterloo,
Waterloo, Ontario.

Dr. B.T. Wigdor*
Director,
Program on Gerontology,
University of Toronto,
Toronto, Ontario.

Professor Eric Manning,
Departments of Computer Science and Electrical Engineering,
University of Waterloo,
Waterloo, Ontario.

Mr. D.F. Parkhill
Assistant Deputy Minister,
Research,
Department of Communications,
Ottawa, Ontario.

Project Officer
Dr. Arthur J. Cordell

---

* Past Member of the Science Council.
† Member of the Science Council.
** Past Chairman of the Science Council.

Members of the Science Council of Canada

Chairman
Stuart L. Smith

Members

Bernard Roland Belleau,
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McGill University,
Montréal, Québec.

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Associate Dean (Academic),
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Université Laval,
Québec, Québec.

Roger A. Blais,
Director,
Industrial Innovation Centre (Montréal),
École polytechnique,
Montréal, Québec.

John Philipp Borger,
President,
Arctic McKenzie Consultants Ltd.,
Edmonton, Alberta.

J. Lionel Boulet,
Director General,
Institut de recherche d'Hydro-Québec,
Varennes, Québec.

Donald W. Branigan,
Physician,
The Branigan Clinic,
Whitehorse, Yukon.

Donald A. Chisholm,
President,
Innovation and Development,
Northern Telecom Ltd.,
Mississauga, Ontario; and
Chairman of the Board,
Bell Northern Research Ltd.,
Ottawa, Ontario.

E. Lawson Drake,
Associate Professor and
Chairman of Biology,
University of Prince Edward Island,
Charlottetown, Prince Edward Island.

Mary-Lou E. Florian,
Conservation Analyst,
British Columbia Provincial Museum,
Victoria, British Columbia.

Jean-Paul Gourdeau,
President and Chief Operating Officer,
Le Groupe SNC,
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Cold Ocean Resources
Engineering,
Memorial University of
Newfoundland,
St. John's, Newfoundland.

David Suzuki,
Professor of Zoology,
University of British
Columbia; and Broadcaster,
Canadian Broadcasting
Corporation,
Toronto, Ontario.

Vaira Vikis-Freibergs,
Professor of Psychology,
Université de Montréal,
Montréal, Québec.

J. Tuzo Wilson,
Director General,
Ontario Science Centre,
Toronto, Ontario.

Henry C. Winters,
General Manager, Marketing,
Algoma Steel Corporation,
Sault Ste. Marie, Ontario.

C.T. Wolan,
Clinical Associate Professor of
Surgery, Urology,
Saskatoon, Saskatchewan.

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