TECHNOLOGY AND INNOVATION IN CANADA: THE CASE FOR NATIONAL ACTION

A REPORT
BASED ON THE NATIONAL
AND REGIONAL CONFERENCES
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BY

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Foreword

Dr. Robert Richardson, Executive Director, National and Regional Conferences on Technology and Innovation.

The National and Regional Conferences on Technology and Innovation were historic meetings because leading Canadians — from industry, universities, governments and labour — came to a vital consensus about what we must do together, to help Canada to become more competitive in the international marketplace through technology and innovation.

The emergence of new international competitors and changing global markets have meant that Canada cannot be complacent about its economic well-being. Trade in high value-added goods and services, particularly those with new and innovative technology content, has become far more important than it was even 20 years ago. Trade in resource products, while still important, has also become more competitive as new, lower-cost producers have begun to compete in export markets against traditional producers like Canada. Furthermore, in the resource sector, just as with manufactured goods, companies and countries are using technology and innovation to provide a competitive edge. Canada has to rise to the technology and innovation challenge.

This challenge was the principal reason for organizing the National and Regional Conferences on Technology and Innovation. At the core of this challenge is the critical significance of leadership, for effecting the changes that will be necessary to enhance Canada's competitive position. Accordingly, the conference participants were invited from amongst the highest-level Canadian decision makers in large and small companies, universities, government agencies and organized labour. The conferences were formally convened by the Prime Minister and were co-chaired by the two federal ministers with responsibilities for science and technology at that time.

The Prime Minister and his two Cabinet colleagues emphasized the government's commitment to science and technology. At the same time, the Prime Minister challenged the participants in the private sector and in other non-federal government institutions to help themselves to make Canada more competitive in the international marketplace, through the use of technology and innovation.

In his opening remarks at the National Conference in Toronto, the Prime Minister set the charge to the participants for all the conferences. As he put it, "I have asked you here for a very simple reason—we need your help. We need you to help Canada create a consensus on technology and innovation, to help find ways of achieving comparative advantages, to help us define new goals for attaining excellence through research and development. . . Canadians are aware that our future prosperity largely depends on our ability, as a nation, to use science and technology to our advantage. They know that we must maximize the strengths of our resource-based economy and that, as a national priority, we must develop new industries, produce new goods and offer new services."

He added, "The issues you will identify will serve to define a national agenda for action, an agenda for government, an agenda for business and the academic community, for business and labour alike. . . In examining federal funding, we welcome your advice on how to spend smarter (on): procurement, contracting out, basic research versus product development and departmental expenditures versus granting councils. . . Economic renewal means establishing government as a partner in economic growth—not as an obstacle to it."

The Prime Minister emphasized, "With this conference, we begin a new stage in consultation and co-operation among government, business, labour and the academic community. We can meet the challenge of technology and innovation if we only strike a resolve to meet it together."

The National Conference participants heard from leaders in Canada's corporate world about the importance of technology and innovation, and what Canada, particularly the private sector, must do to develop and use technology and to become more innovative. For the participants, the conference provided an opportunity in workshop sessions to have a meaningful dialogue on the constraints to technology and innovation in Canada. They identified five dimensions critical for enhancing technology and innovation in Canada. These in turn were further discussed at the five Regional Conferences held across the country.

A strong consensus did emerge on how to enhance technology and innovation on a national level. This report is the compilation of the substantive conclusions on issues, positions, and recommendations that emerged from hundreds of hours of collective discussion. In keeping true to the spirit of the participants' discussions, this book is organized along the five dimensions they identified for enhancing technology and innovation. It describes the key issues, the character of the discussions, and the recommendations put forward by the participants. Some of the recommendations are controversial and call for wide ranging change in many areas. Above all, one conclusion came through loudly—the private sector must now lead Canada's search for measures to lift our competitive spirit and achievements.

It may seem remarkable that the consensus for action the Prime Minister called for at the opening of the conference process, does indeed exist in Canada. This consensus reigns over the wide range of technology and innovation issues that affect Canada's competitiveness today and that will do so even more in the future.

In closing, I wish to thank all the participants from the National and Regional Conferences for attending and contributing to this vital national exercise.

I also wish to thank all the members of the Conference Secretariat, whose discipline, commitment and planning skills ensured that participants to the conferences were focused on the task at hand, and that the participants had the necessary tools at hand to make their discussions worthwhile.

Finally, I wish to thank Janet Ferguson, Rick Clayton and Azim Mohamed. Their research and assistance were invaluable to me in the writing of this book.

Introduction

In October 1986 the federal government announced in the Speech from the Throne that the Prime Minister intended to convene a National Conference on Technology and Innovation. This decision signalled a growing concern in Canada about the ability of our business and industry to make effective use of technology and innovation. Although they were facing new challenges as a result of major changes in the global economy, many Canadian companies seemed slow to adopt and adapt new technologies to strengthen their competitive positions. Despite a number of important government policy steps in science and technology, including signing the first National Science and Technology Policy with the provinces in 1985, it was becoming increasingly evident that more direct involvement by the private sector was required to make real progress.

The conference was to bring together senior decision-makers from business and industry, education, government and labour to discuss the role of technology and innovation in improving industrial competitiveness, to identify the reasons why Canada appears to lag behind other industrialized nations in these areas, and to develop a national consensus among the participants on the urgent need for a proactive approach from each sector to respond to the challenges facing the country.

The National Conference, which was held in January 1988 in Toronto, was organized around three themes: Challenge, Change and Celebration—the challenge facing Canada to become more competitive in the international marketplace; the need for Canada to change to become a more knowledge and technology-intensive economy; and celebration of the distinguished record of Canadian achievements in science and technology on which we can build a strong national effort.

The celebration theme found expression in an exhibit which accompanied the conference showing Canadian technological achievements and celebrating, in particular, the accomplishments of our youth. Nearly 2000 people visited the exhibit hall during the conference, to view examples of Canadian innovations as wide ranging as the microwave airplane and the zipper.

The notion that the Canadian economy is facing an unprecedented challenge to its competitive position has, rather suddenly, become almost commonplace. The advent of free trade with the United States has raised our awareness of a wide range of global changes, affecting not just our relations with the U.S. but also our relationships with all our trading partners. Changes in the world

economy will cause changes in Canada. All of our social, educational and economic institutions are feeling the pressure of such changes and are facing problems and new opportunities. It is clear that if, as a nation, we are to make the best decisions for our country in this time of great change, Canadians must understand the broad impacts of these changes.

In addition, we must respond to change rapidly and effectively using the most sophisticated tools available. Today as never before, technology and innovation are presenting companies around the world with dramatic new opportunities—opportunities to do new things, and opportunities to do traditional things better. In the competitive world of the 1990s technology and innovation are our front line defences. Canadians must use them to revitalize established industries; to develop and use new products and processes that will increase the value of our rich resource base and strengthen our manufacturing sector; and to build the expertise needed to enable us to develop, adapt and market the new technologies which are becoming important commodities themselves.

Recognizing the growing strategic importance of technology and innovation, the government took a number of important steps between 1985 and 1987. The National Science and Technology Forum, which was convened in Winnipeg in June 1986, identified a number of over-riding concerns to which the government was able to respond. For example, the pressing need to give greater weight to science and technology in government decision-making led to the creation, in October 1986, of the National Advisory Board on Science and Technology. This Board, chaired by the Prime Minister, provides direct advice to the most senior level of government. The National Science and Technology Policy represented a response to concern about the need for better co-operation between federal and provincial governments to strengthen the relevance of their activities to local needs. Under the policy a National Council of Science and Technology Ministers was established to provide a forum for ongoing discussion and cooperation among federal and provincial governements. Finally, in March 1987, the government announced its science and technology strategy, InnovAction, which aims to ensure that our efforts in these areas are clearly focussed in the national interest.

But government action is not enough. Policy can create a good climate for innovation but the private sector must provide the driving force. The issue at stake in the National Conference on Technology and Innovation was how to mobilize and support the private sector in Canada to use technology and innovation to improve our competitiveness. At the end of the National Conference, the Prime Minister announced his intention to draw a larger group of Canadians into the discussion by convening a series of follow-up conferences across the country.

As a result of this decision, five Regional Conferences were held between March and June of 1988, beginning in Vancouver and continuing in Regina, Saint John, Hamilton and Montreal. Regional conference participants examined the recommendations of the National Conference, and brought their own special interests to bear in an effort to develop a truly national response to the challenge. The text of the Keynote Speakers at the five Regional Conferences, and the reports and recommendations presented by the Discussion Leaders of each of the workshop sessions, are presented in an accompanying Proceedings document.

At all the conferences, a great sense of excitement about the potential for Canada to compete successfully in the changing world of the 1990s grew rapidly among the participants. We have the tools: the rich resource base; highly developed educational institutions; research and development expertise; and a relatively skilled labour force. It remains for all sectors to pull these riches together into a strong national effort.

This book has been written to spread that sense of excitement and optimism about the future and to involve an even larger group of Canadians—including teachers and students, journalists, labour unions, business managers, investors and policy makers at all levels in this effort to build a strong future. There is a role for every Canadian, in every walk of life, in helping to shape Canada's future.

Building on background papers prepared for the conferences, this book opens with a discussion about the competitive challenge facing Canada, and goes on to examine and to take stock of our current performance in technology and innovation. Chapter 2 presents an overview of the papers and discussions of the National Conference in Toronto, which identified five key constraints to better technology and innovation in Canada: lack of leadership; risk averse finance and investment; neglect of workplace issues; the quality and relevance of education; and inadequate public awareness of the growing importance and impact of technology and innovation.

Chapters 3 to 7 examine these issues separately. They describe why participants felt each was a major impediment to progress, the specific problems in each area, and the key recommendations for change. These chapters, which are based on a detailed review of the taped discussions of the six conferences, attempt to portray, as briefly and accurately as possible, the flavour of the debate and conclusions of the participants.

In his opening remarks at the National Conference, the Prime Minister asked participants to "define new goals for attaining competitive excellence through research and development." In the interest of moving this process forward, a mission statement, based on participants' views, has been developed for each

of the five key issues. These statements reflect the author's interpretation of the participants' intentions. However, it should be noted that these intentions were not explicitly stated in this form at any conference. The mission statements are intended to serve as a starting point for debate and for developing a plan for future action.

Chapter 8, the Agenda for Action attempts to bring the threads of these diverse discussions together under the five mission statements and to propose plans for each sector with respect to these goals that could have a long-term impact on our ability to develop and apply technology. This chapter is intended to stimulate discussion. It is our hope that it will be sufficiently controversial to provoke an active response from readers, either positive to support and develop the proposed plans; or if negative, to provide constructive criticism and debate, and thereby improve on these suggestions.

The Prime Minister began the National Conference by issuing a challenge to all Canadians to take action in the area of technology and innovation, which is critical to our economic well-being. In the spirit of spreading that challenge this book aims to bring all Canadians into a national effort to prepare for the year 2000 and beyond.

CHAPTER ONE

The Competitive Challenge

"This group represents the leadership of those who genuinely understand and believe in a competitive Canada and our role in the 21st century."

The Prime Minister of Canada
The Right Hon. Brian Mulroney
Opening Address, Jan 13, 1988

In his opening remarks to the participants at the National Conference on Technology and Innovation in Toronto, the Prime Minister said, "We must work together—on behalf of the future well-being of all Canadians—to develop and implement a national approach to science and technology that will prepare Canada for the next century. These issues and others you will identify, will serve to define a national agenda for action, an agenda for government and the academic community, for business and labour alike." He added, "We should at this conference, take stock of where we are coming from, where we are, and where we want to go."

In considering how to respond to this challenge, conference participants looked at how Canada might change and develop in the light of our economic history, the roots from which today's economy has grown; our current performance in key areas; and participants' vision of the kind of future they want for Canada.

A. Canada and the global marketplace: Where we are coming from

Canada has prospered in the last 100 years by exploiting, upgrading and trading the natural wealth endowed by its lands and seas. By marketing our wood products, minerals, agricultural and fishery products, Canada has become one of the world's wealthy nations. We have even entered that most prestigious group of nations within the Organisation for Economic Co-operation and Development—the Group of Seven.

In the last 20 years, economic growth in Canada has been strong (Table 1.1). Since 1867 the Gross National Product (GNP) has increased nearly 40% virtually every decade. A large part of this growth has been, and continues to be generated by trade. In recent years, the volume of international trade has expanded rapidly, and Canada has participated in this growth.

Table 1.1

Canadian Economic Growth (constant 1981 $)

Year	Gross Domestic Product ($ billions)
1968	203.1
1973	264.4
1978	325.8
1983	355.4
1984	377.9
1985	395.2
1986	407.7
1987	424.1
1988	441.3

Overall compounded growth 4.1% annually. *Source: Bank of Canada Monthly Review*

However, despite the current strong performance of Canada's economy, there are some worrisome trends—both in the patterns of Canadian trade and in the rapidly changing structure of the world economy.

Relative to other major industrial economies of today, Canada is a very small open economy. Foreign trade, primarily in raw resources or semi-finished materials, accounts for close to 30% of Canada's GNP: this is twice the level of Japan and more than three times the level of the United States. In addition, approximately 80% of Canada's trade is with one country, the United States. These trade figures emphasize the vulnerability of Canada's resource-based economy to changes in demand or patterns of international trade.

Over the last twenty-five years, world trade in manufactured goods has grown substantially faster than that in raw materials or agricultural products. Canada has certainly participated in this trade, as Table 1.2 shows, and the proportion of manufactured goods in our total exports has increased steadily.

Table 1.2

Percentage Commodity Distribution of Canadian Exports 1960 – 1985

	1960-70	1970-80	1980-85	1985
Export of goods and services (as a proportion of GNP)	**18.8**	**23.4**	**26.9**	**29.9**
Distribution:				
Merchandise	**78.9**	**81.7**	**82.5**	**84.1**
Agricultural products	8.2	5.4	5.7	4.1
Mining products	12.1	10.7	6.0	6.0
Manufactured goods	54.3	63.4	69.5	72.3
Durables	31.0	42.9	47.3	53.1
Wood & lumber	6.1	4.5	4.5	3.6
Iron & steel & non-ferrous metals	11.3	7.1	6.2	6.3
Machinery and equipment	4.2	5.9	8.2	8.1
Transportation equipment	8.2	23.6	26.5	33.3
Nondurables	23.3	20.5	22.2	19.2
Services	**24.4**	**18.3**	**16.6**	**14.3**
Investment income	3.9	4.1	4.6	4.5
Other services	5.1	4.5	4.4	3.8
Travel	7.7	4.9	3.8	3.2
TOTAL	100.00	100.00	100.00	100.00

Note: The sums of the components do not add up to the totals because freight and shipping services are excluded in the case of services, as are balance-of-payment adjustments in the case of total goods and services.

It is noteworthy that Canada's exports have advanced from 18.8% of GNP to almost 30% over the last twenty-five years. Moreover, and even more encouraging, within this growing trade proportion, the share going to manufactured goods

or semi-finished products has been advancing even faster—from 54.3% of all exports to 72.3% of all exports. Our exports of transportation equipment have progressed from 8.2% of exports to 33.3%—with a particularly big jump around 1965. This, of course, represented the enhanced trade in automobiles that Canada achieved with the U.S. following the Auto Pact trade agreement.

But when one examines Canada's Current Account in the Balance of Payments, a somewhat less promising picture emerges. In only six of the last 25 years, Canada has not run a deficit in its current account. Deficits mean that Canada must, one way or another, finance from abroad to pay for our imports. Therefore, despite the hard-won improvements in our export trade position, Canadians may well have to try even harder in the future.

To export in world markets, Canada must offer its goods and services at competitive prices, which in part, are made possible by higher levels of productivity. Yet from 1973 to 1981, Canada's average gain in output productivity was the lowest of any industrialized country in the world. Although improvements have been made over the past few years, in comparison with other industrialized countries we still rank on the lower rungs of the productivity ladder.

Against the backdrop of recent changes in the world economy, the long-term trends in Canada's trade patterns and competitiveness are troubling because what is at stake is not just the fate of a few industries or sectors but the ability of the economy as a whole to sustain the standard of living Canadians have come to expect.

B. The changing global economy: Where we are

i) The changing market for raw resources

There is growing recognition that the world economy is undergoing fundamental changes which will have far reaching impacts on any country that is heavily dependent on primary products. These changes are apparent in a number of ways. First, there is strong evidence that the decline in real value of many primary products that has occurred in recent years is not an expression of cyclical economic booms and busts, but represents fundamental changes in demand for these products. This is partly due to the decline in input of raw primary resources for any given volume of output of manufactured products. In Japan the output of the 1984 economy required only 64% of the inputs that had gone into that economy ten years earlier. The significance of that statistic is enormous when one takes into consideration the tremendous growth of output in the Japanese economy during that decade. And we do not have to look to the other side of the Pacific Ocean to see this trend. Canadian oil consumption

in 1987 was actually 15% lower than in 1973, while real GNP increased by more than 60% over the same period. In other words, the decline in demand for primary resources in manufacturing, in part reflects the fact that fewer raw resources are required to produce the same amount of industrial output.

Second, increased competition from newly developing countries is taking markets away from those traditionally dominated by countries like Canada and Australia. It is widely expected that India and China will be net exporters of food in the 1990s. This competition will have an impact on Canada, a leading exporter of grains. Canada's exports in wheat dropped by 38% in 1986 over 1985, and our wheat exports did not surpass their 1983 dollar value until 1988. Yet wheat is our largest agricultural export commodity. The situation is similar in the mining industry. The opening of new mines—nickel from New Caledonia and copper from New Guinea—plus excess capacity in older mines has meant a drop in world prices. In 1988, some sectors of the mining industry in Canada were beginning to recover from a prolonged slump, but many analysts predict that even after the industry emerges from its current difficulties, it will still not fully return to its previous levels of output.

Finally, new materials are replacing traditional ones. More efficient materials have been coming onto the market at an ever increasing rate, born out of the tremendous scientific and technological gains made in the last twenty-five years. For example, in the telecommunications industry, in 1985 about 45 kilograms of optical fibre accomplished what once required 900 kilograms of copper.

The first trans-Atlantic optical telephone cable, which should begin full operation in 1989, will carry almost 40,000 conversations simultaneously—four times the capacity of the last coaxial cable laid in the mid 1970s.

In 1973, copper was Canada's leading export commodity by value. It is estimated that copper savings in the United States communications industry averaged 100,000 tonnes per year between 1980-84. This decline in demand for copper in the U.S. and other countries has had a major impact on Canada's export position.

The automobile industry also shows the ongoing trend whereby new materials replace traditional ones. This industry is one of the most sensitive indicators of general economic activity and growth, mainly because of its far ranging impact on other sectors, particularly resources. Alloys, plastics, and resin-based composites are steadily replacing steel in automobiles. By 1990, the average automobile will be 26% lighter than it was in 1980. Use of copper has declined from about 15 kilograms to 5 kilograms per automobile since 1950.

Computers have accelerated the switch from traditional raw materials. For example, computer aided design (CAD) and computer aided manufacturing (CAM)

have helped reduce the size and thickness of containers. Beverage can manufacturers now produce 15,000 more containers per tonne of metal than was possible a decade ago. The introduction of modern technology has meant more efficient processing, less wastage, better quality and flow of new and better products to replace the old. Unless we can find new uses for traditional materials, over the longer term, there will be a decline in demand for Canadian raw resources.

ii) *Changing markets for knowledge-intensive products*

Perhaps the most significant trend in the changing world economy is the knowledge and technology factor.

Technology and innovation are related but distinctly different. Edmund Fitzgerald, President and CEO of Northern Telecom pointed out in his Keynote Address in Toronto, "Technology relates to scientific knowledge, and the uniqueness of an individual's or an organizations's or a nation's inventory of such knowledge". Innovation on the other hand is the conversion of the technology into what Mr. Fitzgerald calls "conspicuous customer solutions that can involve either product, process or service."

He went on to point out two key features of the innovation process within the international context. The first is that innovation requires enlightened problem definition since matching the technology to a customer solution sometimes means that the ultimate benefit of the innovation may not be initially apparent. In other words there is an element of risk, in that a market for an innovation is not always apparent and therefore an up-to-date knowledge of markets and adroit business strategies are an integral part of the innovation chain. Second, since technological advantage erodes with time, the innovative advantage is also time dependent. The faster the innovative reaction to an economic opportunity, the larger the potential reward.

There is no question that the use of technology as a key competitive tool is not only fueling growth in new products and services, but is shifting production locations and market share. Countries and firms that have made rapid gains in the last decade have made extensive use of technology and innovation. Developing countries like South Korea and Singapore have adopted technology-intensive industries and, combined with skilled low-wage labour, have rapidly increased their market share world wide. The trend toward the liberalization of trade in the world economy has encouraged many developing countries to aggressively pursue and open markets abroad. Consequently developed countries that have higher wage rates and that have been slower to adopt the new technologies are rapidly losing ground to these aggressive competitors. Ship building and automobile production in South Korea are excellent examples of

this trend. The city of Pusan in South Korea has one of the most modern ship building yards in the world, whereas thirty years ago it was just a modest coastal town. Twenty years ago South Korea had no automobile industry to speak of. Today it has a significant share of world markets.

There has been not only an increase in the volume of international trade but also changes in its composition. Patterns of world production have also changed. In general, trade in semi-finished and finished goods has been growing at least twice as fast as trade in raw materials and agricultural products. Trade in the latter has been growing at about the same rate as the world economy. The highest growth rate has been in trade in technology-intensive products which has averaged four times the growth rate of the world economy.

In general, industries today create new products based on new knowledge, technology, and innovation. Production is increasingly focussed on areas where technology and innovation, rather than increased volume of production, reduces costs. No country can rely on resource-based advantages for its continued prosperity.

iii) Research and development: The Canadian record

The problem for Canada, as Mr. Fitzgerald noted is, that although technology and innovation are different resources, they are both derived from research and development (R&D). He said, "The effectiveness of these research and development efforts will determine, to an important extent, the global competitiveness of both companies and nations and must be a high priority in public and private sector planning."

Expenditures in R&D should be given priority to ensure that production technologies used in Canadian industry are leading edge. An added benefit of R&D is that it also enables industries to keep abreast of new technologies being developed elsewhere and evaluate them effectively. Countries with knowledge-intensive industries have relatively high R&D expenditures.

Table 1.3

Selected International Comparisons of GERD, 1985
(OECD data base)

Country	GERD/GNP	Private sector R&D Funds/GNP	Total GERD
	(per cent)	(per cent)	(U.S. $ billions)
U.S	2.83	1.42	111.8
Japan	2.81	2.23	40.1
Sweden	2.78	1.84	2.9
West Germany	2.66	1.66	19.8
U.K.	2.33	1.32	14.4
France	2.31	1.09	14.6
Netherlands	2.11	1.16	3.4
Norway	1.63	0.88	0.9
Finland	1.50	0.87	0.8
Canada	1.38	0.71	5.3
Italy	1.33	0.67	7.1

However, expenditures on R&D in Canada are low relative to those of the top performers in the industrialized world. To a large extent this reflects low levels of investment in R&D by the private sector in Canada (Table 1.3). In 1985, Canada's Gross Expenditures on Research and Development (GERD) were 1.3% of the GNP, and of this sum, only half, 0.7%, was spent by industry. Both Japan and the United States invest approximately 2.8% of their GNP on R&D. If strictly private sector R&D is considered, their lead actually increases—2.2% in Japan, 1.42% in the U.S. The Japanese even have a target to increase their total R&D spending to 3.5% by the year 2000. Many European countries invest between 2.1% and 2.8% of their GNP on R&D. This was stressed by Dr. John Evans, Chairman, Allelix Inc. during his keynote speech at the National Conference in Toronto. He noted that, "The science and technology record of Canadian companies is dismal. Only 2% invest in R&D and, of these, less than 7% account for nearly two-thirds of all the R&D performed. Alcan, Northern Telecom, and a few others serve as impressive models for the central role technology must play in the long-term agenda of corporate development. But 98% of

Canadian companies have little appreciation of the potential of technology for improving the competitiveness of their products, processes and services, and very few of them even have scientists or engineers on staff."

Canadian companies will not benefit from the potential of technology and innovation until they increase their investment in R&D. The problem is rooted in history. Until now, many of our established companies have prospered without significant R&D investments. In addition, many Canadian companies are very small by world standards. As a result, few employ full-time researchers. Those that do rarely build the knowledge base which is resident in research units into the core of their strategic planning efforts. Research remains an afterthought, to be supported only when essentials have received their due.

iv) Our innovation record

On the other hand, there is more to research and development than the dollars spent. The quality of the work and our capacity to apply the results of research in industry are equally important. In his observations on technology and innovation within the Canadian context, Dr. John S. MacDonald, of MacDonald, Dettwiler and Associates, said in Vancouver, that from a technical point of view Canada need not take second place to anyone.

Our achievements in creating advanced technology over the past century speak for themselves. From the invention of the telephone to the development of the Canadarm, Canadian science and engineering has been of the highest quality. However, as Dr. MacDonald pointed out, "In spite of these and countless other achievements of similar stature, our success in commercially exploiting our technical achievements has not been remarkable, to say the least. Time after time, outstanding technical developments produced by Canadians are commercially exploited elsewhere." He observed, "It is the inability to have the confidence and the creativity to exploit the technology, rather than the inability to create it that lies at the root of the problem." As Edmund Fitzgerald would say, the problem is the lack of "conspicuous consumer solutions" rather than our lack of engineering or research skills.

To illustrate his observation, Dr. MacDonald pointed to the new aquaculture industry being developed in British Columbia. It imports most of its technology from Norway. Acknowledged to be a world leader, the Norwegian industry developed over the last decade on the basis of scientific advances, many of which were made in a Canadian government laboratory near Nanaimo, British Columbia. "While Canadians continued to hunt wild salmon, the Norwegians recognized the value of the new knowledge and developed an industry and equipment to go with it." Dr. MacDonald added, "The picture of Canada one gains from all of this is one of a superior ability to create advanced technology

and develop a world class knowledge base, but a very weak, some would say non-existent, ability to convert that advantage into economic gain."

In his Keynote Address at the National Conference in Toronto, Pierre Lortie, Chairman and Chief Executive Officer of Provigo Inc., drew closely related conclusions: "Canada is slow to adopt innovations. The diffusion of technology in Canada is lagging on several counts. We often adopt new technology later than the leading industries of other nations. Moreover, within Canada, there are significant regional time lags in technology adoption that further compound the problem."

v) What the changing world economy means for Canada

However one may view its origins or impacts, a certain scenario is already playing on the global stage. Its dynamism comes from technology and innovation, and its script is written in research labs. Their role in increasing competitiveness is vividly evident in many countries.

As we have seen, the new global economy requires fewer raw material inputs, increasingly favours countries other than Canada as primary and secondary producers, and relies heavily for growth on the application of new knowledge and technology to the development of new products and processes. For small industrialized nations, like Canada, our primary competitive edge must come from our knowledge of science and technology, our long experience in research and development, and our ability to apply these to industrial production. But as we have seen, our current performance in these areas appears inadequate for the task at hand.

At present Canadian exports are concentrated in product groups for which the rate of growth of world demand is declining, or at best, stable. Growth in world trade is focussed in manufactured goods, and more specifically in the knowledge-based industries. Canada must change.

A country like Canada that depends heavily on trade for its well-being cannot avoid the consequences of change in global economic development and trade patterns. To remain competitive, to open new growth markets world-wide, and to lessen dependence on natural resources, Canada faces real challenges. Some of the challenges are knowledge-based—our ability to apply our knowledge of science and technology to the development of new products and better processes that will generate new wealth and enhance the current standard of living. Other challenges are for Canada's social development where the crucial questions have to do with how our education, government and labour institutions, and our companies can keep pace with and restructure themselves to respond to technological change. What role should different sectors in society play, and how can we organize ourselves to harness and distribute the benefits of technology

and innovation equitably? Lastly, some challenges affect the human spirit—do Canadians have the entrepreneurial drive and vision to exploit the new knowledge that science and technology offer?

Conclusion

The challenge to Canada is clear. We stand in serious danger of being beaten at our own markets by countries with richer resources and lower wage rates. Moreover, as far as natural resources are concerned, this increased competition is coming at a time of decreasing world demand. We invest too little in R&D and are slow to apply the results of those activities commercially. To win, we must work and play smarter. We must apply our knowledge to produce new wealth and jobs. The central problem put to the conference participants, therefore, was how to build the kind of national team effort we must have to support this kind of in-depth change.

CHAPTER TWO

The National Conference on Technology and Innovation

"I have asked you here for a very simple reason—we need your help. We need your help in Canada to create a consensus on technology and innovation, to help us find ways of achieving comparative advantages, to help define new goals for attaining competitive excellence through research and development."

The Prime Minister of Canada
The Right Hon. Brian Mulroney
Opening Address, Jan 13, 1988

Technology and innovation can be applied to strengthen the Canadian economy in three ways. First, to enhance existing products, processes and services to make them more cost competitive and thus revitalize established industries; second, by using them to produce new, higher value added and better quality products, processes and services; or third, by introducing entirely new products, processes and services. This triad formed the organizational basis of the workshop sessions at the National Conference in Toronto. Participants were asked to consider what factors currently impede our ability to make progress in these areas and the role each sector could play in overcoming these constraints.

A. Workshop 1: Revitalizing Established Industries

In opening the Workshop Session on revitalizing established industries, Dr. Norman Keevil, Chairman of Teck Corporation, cautioned the participants, "When talking about revitalizing industries one must not take it to mean that they have become devitalized or that this country's industrial base has lost its vitality. Revitalization is a continuous process and business is doing it all the time." Dr. Keevil said the real issue was that Canadian corporations as a whole have failed to reinvest an adequate portion of their earnings in research and development. He added, "Too few established Canadian corporations are managed by people who appreciate this changing requirement."

Revitalization of established industries involves modernization and cost cutting measures through the introduction of new technologies. These measures can involve capital investment in computer-driven production, robotics and the like. They could also involve new management technologies to increase output and productivity. During the workshop discussions, Mr. Culver, Chief Executive Officer of Alcan Aluminum, said, "It is the traditional industries that must be most interested in technology and innovation. Not because they are facing challenges but because they are the industries that have the cash flow base to do it with. We all know that the curse of inventive minds is that they get a third of the way to the marketplace, and they run out of cash. The beauty with traditional industry is that if you apply a good dose of good technology to a traditional operation, it produces new cash flow." Fresh from the experiences of Alcan, Mr. Culver emphasized, "And a substantial part of that new cash flow should be devoted to technology and innovation."

Participants looked at a number of specific issues that are fundamental to the revitalization of industries. Each sector or group of industries in Canada tends to differ when it comes to the current role of technology and R&D, the technological opportunities available, and the focus of technological innovation. How can the private sector develop R&D and innovation strategies for future competitiveness? Do we need better ways to acquire foreign technologies (given that it is estimated that 99% of the technologies in use in Canada are imported)

or for transferring technologies from university and government laboratories to industry?

B. Workshop 2: Developing Higher Value-Added Products, Processes and Services

In opening the Workshop Session on developing higher value-added products and processes, David Hennigar, Director, Burns Fry Ltd., suggested that participants focus on what needs to be done to move products up the value-added curve. Mr. Hennigar said participants had to pay close attention to how Canadian companies can improve their skills in listening to customers, incorporating quality into the design of products, and developing strategies to fulfil market requirements. The process requires new skills and attitudes.

Mr. Hennigar said, "We must look to identifying the market, the customers and what they require; determining what resources and technology are required to fulfil market requirements; assembling the capital, resources and people to accomplish the task; and how to foster positive attitudes for their successful implementation and resolution."

By way of example, Mr. Hennigar pointed to the experience of National Sea Products which sought to provide processing plants with a higher percentage of premium products from fishing trawlers. The solution was found in Europe—a process called Boxing at Sea that reduces handling of fish and results in increased product quality. However, this solution required cutting a ship in half and adding about 6.5 metres of new steel in the mid-section. The first conversion was done in Iceland and technology was then acquired so that Canadian shipyards could undertake subsequent conversions. Finally, Mr. Hennigar said, "In order to encourage the crews to support this program, the method of compensation was changed to reward them for their increased landings of higher quality fish which were then utilized in producing higher value-added products for the marketplace."

Mr. Culver of Alcan in his remarks also emphasized that, in the short term, significant new product development and market applications can occur in the context of existing technologies. "This aspect has received too little attention. The major focus has been on the necessity to cut costs or on exciting new technologies and their promise of a new generation of products," he said. "This means product development and innovation, at least initially, is within the technology we now have."

A wide variety of questions emerged from this workshop. First, are Canadian companies making effective uses of universities, provincial research organizations, industry associations and government labs? Is there sufficient large firm/small firm interaction in technological innovation?

Second, there were clear statements that what the CEO does is the single biggest determinant of how effectively a company manages and integrates technology for longer term profit. Can Canadian senior management teams operate effectively if they lack the experience in, and knowledge of, technology issues and how to manage technology for profit?

Third, a substantial proportion of Canada's small technological effort is directed at process innovation to improve production efficiency. Does this help to build new strengths and specializations? Are Canadian companies putting enough effort into product innovation, opening new markets, and satisfying customer needs? Are Canadian companies putting enough effort into both process and product innovation?

C. Workshop 3. Fostering New Technology-Intensive Firms

In opening the Workshop Session on fostering new technology intensive firms, Rita Dionne-Marsolais, Vice President of the Canadian Nuclear Association, told participants the creation of new technology intensive firms or technology producing units of established firms is significant because new firms and units are an essential component of economic growth. "Innovation requires initiative; it is to some extent confirmed by initiative. In both large and small businesses, to encourage initiative is to encourage innovation, which in turn encourages technological development."

Participants focussed not only on the factors that give rise to initiative and entrepreneurship, but also on the issues surrounding the financing of the resulting new ventures. Mme. Dionne-Marsolais said, "When it comes to venture capital, the Canadian financial community is very cautious. As all entrepreneurs from east to west see it, venture capital is much more accessible in the south, than in either the east or the west. And it should that way."

It is clear that many countries consider the formation of new technology-based firms an important part of their strategy for economic renewal. Participants examined a number of issues in this workshop. Is there a need for better mechanisms and incentives to support spin-off companies and to establish new companies? Is there a need for new incentives or regulations to improve access to start-up capital for entrepreneurs?

The whole issue of entrepreneurship in Canada has received great interest over the last few years. How can public awareness about the need for, and role of, technical entrepreneurship be raised? The rapid adoption of new technologies and development of human resources can bring economic progress. Are Canadians welcoming the new technologies? If not, why and what must be done to change the situation? What innovations in corporate leadership, unions and other organizations are required for successfully developing human resources?

D. The five dimensions for enhancing technology and innovation

When the Prime Minister opened the National Conference, he not only asked that participants take stock of Canada's current position with respect to technology and innovation but also to suggest "ways of achieving comparative advantages, to help define new goals for attaining competitive excellence through research and development."

Coming out of the three workshop sessions, participants at the National Conference in Toronto identified five overall areas, common to all three goals, in which significant improvements will be needed if Canada is to develop and use technology and innovation. These five elements served as the focus of discussions in Workshop Sessions at the Regional Conferences.

i) Leadership in business: Managing technology in Canadian companies

Whenever major changes are required, strong positive leadership from the most senior levels is essential. Leaders are needed to encourage innovative employees, and to lobby for changes in education and government, as well as in business. Now, when changes are urgently needed in all sectors, the absence of strong leadership in Canada is a serious issue.

To improve its competitive position Canada must undergo fundamental changes in attitude and behaviour in all sectors of the economy. Participants identified in Canada a critical lack of understanding of technology and innovation and other factors that are important in managing technological change in industry.

ii) Investment and finance

The financing of innovation—covering a host of issues from taxation to grants to the availability of capital—was the second key constraint to technological innovation in Canadian industry identified at the National Conference.

iii) The workplace

Participants focussed on the critical need to involve labour in the process of planning for and implementing technological change and to consider ways of successfully managing the impact of technological change on labour and enhancing the beneficial effects. Changes can hurt as well as help. We must also look for ways to harness and encourage the innovative capabilities of the workforce.

iv) Education and training

A key area of concern was science and technology education, particularly at the elementary and high school levels, but also in some respects, at universities. The capacity of a country to adopt technology and to innovate is closely

linked to the level and quality of the science and technology education of the workforce.

v) Developing a science and technology culture

Finally, a strong view was expressed that Canadians in general are not sufficiently aware of the essential role of technology and innovation in making our economy more competitive. Participants agreed that Canada needs a supportive science and technology culture to encourage the development of a knowledge-based component in the economy.

The next five chapters look in greater detail at the debates on these key issues that took place at the regional conferences, and the specific problems and potential solutions that were discussed. Each chapter concludes by presenting the key recommendations emerging from the discussions. Finally, in response to the Prime Minister's request that conference participants identify new goals for Canada in technology and innovation, a mission statement for each area is presented. These statements are based on the content of workshop discussions and are intended to provide a starting point for action and debate.

CHAPTER THREE

Leadership in Business: Managing Technology in Canadian Companies

"A leader is a person with a poorly developed sense of fear and a well developed vision of the future."

David Culver,
CEO, Alcan Aluminum
Keynote Address, Toronto Jan. 14, 1988

A. Leadership for change

Change. The word evokes emotions ranging from hope and anticipation, to fear and outright rejection. Whenever the change to be faced is large and the form of the future is not clearly defined, there will be many who are not comfortable with what is happening, and who would prefer things to remain the way they are. By definition, change requires people to abandon familiar ways in favour of riskier, less predictable paths. It forces difficult choices to be made in the face of inadequate information. And it confronts each of us with the fear that we will not be able to cope in this different world. When these changes affect our jobs and our financial security, as major changes in the business world may, they are even more threatening.

The forces acting against change are powerful. Unopposed, they allow an overwhelming inertia under which action gets bogged down in red tape, frustrated at every turn. In the end, active opposition develops to the new ways which, because of the delay and poor management, appear not to function well.

Overcoming these forces working to preserve the status quo is not a simple business. It demands a strong committed leader—someone with what David Culver, Chief Executive Officer, Alcan Aluminum, referred to as "a clear vision of the future" toward which the organization is striving, and the courage and determination to overcome opposition. To be effective, a leader should also be sensitive to the hopes and fears of the individuals affected by the change and have the management skills to deal with them.

Canadian companies currently suffer from what Dr. MacDonald of MacDonald Dettwiler and Associates called "weak innovative exploitation" and Mr. Lortie called "weak innovative capabilities". Rectifying this situation will require major changes in corporate organization to place the management of technology at the centre of business decisions. According to John Evans of Allelix Inc., "It involves a change of attitude about the basic objective of R&D—not just how to manage it more effectively to create knowledge, but how to transform new knowledge to create wealth." He pointed out that innovative technology is a strategic resource and must be integrated with capital, labour and other resources in strategic planning. In addition, planning and managing science and technology to improve wealth generation requires in-house technical competence, whether the firm is making or buying R&D. Finally, corporations must broaden their horizons for "scanning relevant technological innovation by contact with cutting edge science and technology in different disciplines in universities, government laboratories and small high tech firms." In other words the issue of R&D, once restricted to the adequacy of expenditures and quality of research, now involves a further change in attitude, one that expands broadly to include our creative, entrepreneurial, marketing and production skills so that we can

exploit new technologies in the world marketplace. These major changes demand inspired leadership from company executives.

Adopting technology from overseas may be especially important in Canada. An estimate from the National Research Council of Canada (NRC) is of value in this context. The NRC estimates that only 1% of the new technology Canadians actually use is developed within our borders. The other 99% comes from other countries. However, innovation can come from any technology, irrespective of its national origin.

This chapter is about leadership—what it is, and where it is most critically needed. But change is pervasive. As business places new demands on the workforce, and as innovation increases in importance, educators, government bureaucrats, elected officials, and union leaders will have to change their traditional attitudes and ways of working to be relevant in a different world. The issues of change and leadership in these other sectors are addressed in chapters four to seven.

B. The qualities of leadership: Case studies in effective management of technology

Some insightful cases where strong leadership made a difference in introducing change help to illustrate the kind of attributes that a leader needs to manage and respond to the changing environment. In each case the key elements include: vision and the ability to bring this vision to reality through the actions of the company, the ability to manage innovation, a clear focus on excellence, recognition of opportunities, and a willingness to co-operate with others to exercise responsibility. These qualities play in a varied mix toward success.

i) *Moving from vision to action*

The changes introduced at Alcan Aluminum required pro-active leadership to reorient this billion dollar giant. Born out of a new vision of the role of the company in the business community as reflected in the mission statement, the changes led to a new corporate culture and a major restructuring that places emphasis on new product development. This transformation did not occur overnight but over a period of sometimes trying years guided by the strategic vision of management.

Alcan undertook to reconsider its vision of the corporation when it determined that low growth and unstable prices in the aluminum industry had probably become a permanent feature of its economic life. The new perspective on the role of the company led to three new courses of action: first, a concentration on businesses that had long term competitive advantages; second, an empha-

sis on cost-competitiveness; and finally a focus on moving into new businesses that would provide above average growth and profit.

Putting these new ideas into action involved major changes in the structure and importance of the company's R&D effort. "A major enabling factor in achieving these changes was our research and development organization, which had been undergoing a major reorientation of effort." Alcan's research programs were being redefined and redirected to create new options and opportunities. For example, in 1980 Alcan spent $40 million (US) on R&D—40% on raw materials processing and primary smelting, 50% on semi-fabricating processes, and only 10% on new technologies. As a result of undertaking a new mission, Mr. Culver noted, "in 1988 we shall spend $105 million (US) on R&D, and almost 60% of it will be on new business related technology." He stressed that the important factor here was the changed attitude towards technology that was reflected in the change in orientation of the R&D program.

Strategic vision at Alcan did not simply focus on market approaches or reoriented R&D activities. It had to take into account the underpinnings of its entire operation—its corporate culture. "The magnitude of change in corporate culture should not be underestimated," said Mr. Culver, particularly when the change is from a largely production-driven company, to one that is customer-oriented with entrepreneurial strategies committed to innovation. "That means changing attitudes on a large scale as well as reallocating resources and reorienting policies. This is not easy in a workforce of 60,000 people spread over twenty-four countries."

The changes in Alcan's corporate culture led by the new mission statement also evolved a 'courage to manage' concept in the new framework of management committed to innovation. " 'Courage to manage' requires a greater preparedness to take conscious risks, and with it a greater tolerance of failure, and not setting guards on guards in the decision-making process," said Mr. Culver.

ii) Innovative management and entrepreneurship

Vic Young, Chief Executive Officer (CEO) of Fisheries Products International, said, "One of the fundamental principles of leadership is the strength to maintain a grasp of the needs for the long term while grappling with the reality of the short term." In fact in terms of leadership, the role of the CEO in an organization is extremely important. The CEO has a unique responsibility to guide the company's operations in considered ways. The successful executive is not going to allow one problem or issue to drive all other considerations. While thinking about the current quarter's earnings, the CEO also has to be thinking about the company's position five years from now.

As Fraser Mustard, President of the Canadian Institute for Advanced Research (CIAR) put it, "Those of you who sit in corporate boardrooms know that the driving aspect of our monetary system toward the quarterly bottomline profits has a strong steering effect on long-term investments. How do you engineer long-term investments when you don't have the backing of a large company to do it?" In particular, against the backdrop of changing world markets, the management team has to find the courage to say that the corporation will forego certain opportunities in the short-term in order to establish a culture that creates a compatible balance between long-term objectives and short-term performance. One element of this new culture has to do with risk-taking and entrepreneurship.

In fact, in today's business world—with its rapid changes in technology and markets—companies must learn to value risk-taking beyond maximizing short-term gain. At Alcan, this attitude came to be known as the 'courage to manage' concept which is accompanied by a climate of greater tolerance of failure. As one participant said, "The great danger is not that we will fail from these risks but that we may fail to take such risks—risks that we have to face in order to build productively for tomorrow."

The leadership of the CEO in taking an aggressive position in using technology to create competitive advantage is crucial. For example, Canadian subsidiaries should seize every opportunity to convince parent companies that they have a superior ability to respond to specific market niches, based on exploiting innovative capabilities. John Thompson of IBM Canada described the process of negotiating and restructuring the Canadian organization went through to gain a mandate from head office to develop specific new product lines. The process necessitated retraining the workforce and an active initiative to show a strong Canadian potential success.

If Alcan is an example of a healthy company that changed by creating and anticipating new market niches, then National Sea Products is an inspiring story of a troubled company that had a strong market but required innovative management to turn around. As Gordon Cummings, CEO of National Sea Products, said at the National Conference in Toronto, "There's nothing like looking over the precipice and seeing below to give you a little bit of courage. The need for survival makes it much easier to be tough, when everyone wants you to be tough." National Sea Products is currently one of the largest fishery companies in the world. Its dramatic turnaround from earlier this decade is in large part due to the leadership shown by management. Despite the heavy blow on the fish companies of the recession in the early eighties, the underlying market was strong. "Strangely enough people were interested in eating healthier and lighter. Basically the market was there and underneath it was a very healthy industry. The question was could you exploit it."

For Mr. Cummings the issue of management was critical. As he pointed out, "It seems to me that in a mature company, if management gets stagnant in their thinking, it is not likely they will find innovation. They've got all the excuses in the world. You can get tied in, as management, to the notion that there are all these terrible things happening and its not your fault. There's a point when someone has to go home at night, check in the mirror and ask the question, "Am I part of the problem or part of the solution?" Very often if you look at management you know which one you are looking at."

National Sea Products made a number of changes to their operation by acquiring a variety of new technologies from around the world, and in some cases developing new technologies in their own factories. They introduced electronics to the filleting machines that enabled blades to be adjusted 65 times per minute. Electronic fish finders were installed in the fishing fleet to improve catches. Changes were made in the company's organization. Productivity awards were eliminated in favour of awards for innovation and safety, to change the focus of employee creativity towards doing new things rather than merely improving old methods. A research company was set up for the first time as part of National Sea Products, to be drawn on by any part of the organization. However, as Mr. Cummings noted, "In terms of doing things differently, it was all aimed at one thing. It was aimed at higher quality."

iii) Striving for excellence

What is clear is that the National Sea Products' focus on quality was part of the management's drive toward 'conspicuous customer solutions.' What underscored the company's success in the marketplace was the introduction of technologies that not only improved efficiency, but also provided new opportunities for innovation. Laurent Thibeault, President of the Canadian Manufacturers' Association stressed that, "The notion of quality ripples through an organization. You don't start out to apply technology. The quality of the product and its improvement is the starting point."

The quest for quality and excellence is always a challenge for business. The road to improving product quality demands strong leadership as products and organizations have to change quickly in the face of competition. In a fast paced, technology-driven marketplace standards of quality and excellence are always changing. The challenge for management is increasingly focussed on being able to meet not only the market expectations of a product, but also the demands that those expectations place on the entire organization. Linear Technologies of Burlington, Ont. found that the quest for quality went far beyond the product in question.

Linear Technologies is one of three companies in Canada with the capability to produce silicon chips from start to finish. While they have world-wide mar-

kets, 15% of sales are in Japan. According to H. Douglas Barber, President of Linear, "When we first introduced our chips in Japan they wouldn't accept them, even though we met all their technical specifications. They said our product was not of a high enough quality. At first we thought it was another trade barrier. However, as we pursued this matter we had to ask ourselves whether we knew what quality really meant. After some soul searching we decided we didn't. We went on a search and after many months we found a company that could tell us what quality was and we implemented a program that led to many changes in the culture of the company. This was of course reflected in our product."

It requires leadership to consider that a new concept of quality might be needed, and it requires a sensitive management to appreciate the fact. Linear Technologies demonstrated this leadership.

iv) Recognition of opportunities

Leadership for change also requires that managers have the vision to recognize new opportunities for acquiring and applying technologies and courage to pursue them. They must also be aware of sources of advice and assistance.

Fraser Mustard pointed out, "It really begins with intelligence and understanding what's taking place in the world that you have to work in and out of. And that intelligence is not just of markets, it's also about technology. We are only 25 million people. We are a small population with an advanced standard of living. We are a small, low science and technology country that has to operate in a tough competitive environment." For Dr. Mustard the issue is clear cut. "You need a sophisticated intelligence system for both markets and technology and secondly you have to look hard at how to mobilize your resources so that you provide the same degree of support to your own industries as other countries provide to their firms either in the name of defence or space."

Larry Clarke, President of Spar Aerospace, discussed the spin-off opportunities that have emerged from the development of the Canadarm. Spar had tried to interest the mining industry with little success. However, "When Teck Corp. wanted to put up a plant to make their new battery, they came to us and asked us to design an automated plant. They wanted to turn out hundreds of thousands of batteries. This was nothing we had experience with—but because our people had the systems approach in robotics, we took on that job and have designed a plant. Dr. Keevil (President, Teck Corp.) understood technology and he knew where to go for something novel. We didn't try to sell him, because we didn't know he had a need."

There is a clear need for industry leadership to begin to create linkages among Canadian companies at home and to begin to exploit world-class technologies

that are being developed in Canada. The larger leadership issue here is not only about awareness of technological opportunities abroad but awareness of opportunities and capabilities at home.

George Jenkins, President of Advanced Integrated Technologies (and also currently with the National Research Council) owned Process Technologies Limited in New Brunswick, manufacturing a semi-conductor technology that he had invented and patented. "One of the problems we have in Canada, that has come up time and again at the National Research Council, is lack of communications in the transfer of knowledge," he said. During an explosive growth period at Process Technologies Limited, Jenkins was looking for a robot for their production line. They found one in Hollywood, from a company that had won an Academy Award for the technology. The company had developed the robot for filming scenes in simulating outer space, where the cameras had to move with great precision and dexterity around stationary sets. According to Jenkins, the lack of vibration and the precision with which the robots moved was exactly what was needed in the company's clean room to move wafers around. "It was a transfer of a sophisticated technology, which had a sixty axis robot. We needed a three axis robot. It was a downgrade but we had the best robot in the semi-conductor industry. But how do you transfer the idea that maybe we should have talked to Spar instead. How do you get that interplay of information?"

According to Fraser Mustard, of the Canadian Institute for Advanced Research, the lack of these types of technological linkages is a typical Canadian problem that needs to be addressed. "How do you get the players together to develop new technologies and get the bugs out? I've sat with people from steel and high tech who had never come together before. And the high tech people said why didn't you come to us before, because we've got the sensors you could have used."

v) *Cooperation and consensus*

The need for better awareness and a change in attitude is not confined to those directly concerned with research and development. As John Evans of Allelix pointed out, this change in attitude affects not only the way of doing business within industry but also affects labour, education, and government. He said, "Canadians must be un-Canadian in two important respects: first, they must act, not just talk, and they must act boldly. Second, the actors must work in concert. With limited resources, industry needs the full collaboration of government, labour and universities in order to make significant progress. The challenges are formidable, and no country can afford to dissipate precious science and technology resources in unproductive competition. Japan, Sweden, and even the United States have recognized this."

The National Sea Products experience provides an example of cooperation between business and government. Government was involved in setting the climate for change with a review of the fishery industry in Atlantic Canada. The old quota system was found to be inefficient because its structure essentially made it a 'race to fish'. The new quota system resulted in more "rational management, and product and market development. Out of this came two other things. First it attracted new investors, with a much broader and longer term view of the fishery industry, and it enabled professional managers to be brought in. We've had to deal differently with our people and treat them differently, all those things you must do right to manage properly."

There are clear implications in this statement for industry, educators and policy makers. There is a dangerous tendency, however, to view appropriate policies as a panacea for our shortcomings in technology and innovation. Simply put, policies do not create, adapt or apply technologies—people and companies do. Policies set the climate in which technology and innovation can flourish. It is the entrepreneur who must have the imagination to perceive the market need, to develop the products and services to fill it and follow through on production. As Mr. Culver emphatically told participants, "Governments, federal or provincial, can only do so much. They can stimulate, they can provide the framework. But the thrust must come from the private sector."

Conclusion

In today's business environment, according to Brian McGourty, President of Honeywell Ltd., the issue is clearly one of management leadership. "Finding technology is easy, it is the faster adoption of the technology through people that is difficult. From my point of view it really is a leadership issue that we are dealing with in terms of business today. It is a matter of organizing work, managing people and diffusing learning more rapidly in our organizations."

He added, "Business has to lead. Business has to step up to the idea that this is a competitiveness issue, an issue of adopting technology and turning it into products that are useful and create wealth. That is what our commercial system is all about."

Recommendations

1. Canadian companies should re-evaluate their long-term business plans in the light of ongoing changes in global markets and the growing role of technology and innovation in competitiveness.
2. Senior executives should aggressively seek out opportunities to apply technology and innovation to create competitive advantages.

3. Industry should include technology and R&D managers in the strategic corporate planning process.
4. Companies must recognize the essential role of technology and innovation in the quest for excellence.
5. Large firms should set up specific offices and networks to search out innovative small Canadian firms who could act as suppliers and sub-contractors.
6. Government and industry should co-operate to strengthen the market and technology intelligence services available to firms.
7. Governments should introduce a wage-subsidy support program to encourage small and medium enterprises to hire scientists and engineers.

Mission Statement: Leadership

To develop and support a generation of leaders in business and industry that understands the role of technology and innovation in enhancing competitiveness; is able, with support from investors and government, to take risks in the interest of the long-term benefit of the corporation; and is capable of managing the integration of technology with capital, labour and resources into the strategic planning and management of the corporation.

CHAPTER FOUR

Investment and Finance

"What does someone starting up a high technology business have to do to get investment in R&D?"

George Jenkins
President
Advanced Integrated Technologies

Changes in the global competitive environment and the concurrent rapid advances in technology have brought a much sharper focus to the process of innovation, particularly in terms of financial support for the various stages. No longer can innovation be considered synonymous with simply support for research and development. The different phases of the innovation process require more finely tuned measures in terms of both government policies and programs and the response of the financial marketplace.

The innovation process develops through the creation of knowledge through research; the conversion of that knowledge into technology by applying the knowledge to solve problems; the development of a prototype which is the physical embodiment of the knowledge and technology; the sometimes lengthy period of testing, scale-up, meeting standards and improving the product; the critical stage of the start-up of production with its significant capital expenditures, and finally market penetration. Each stage of the innovation process requires different forms of financing to succeed.

Government support, which helps to set the 'climate' for innovation, is aimed at stimulating innovative practices in industry, with particular attention to small and medium sized enterprises. Such support aims at facilitating the start-up of new business, promoting collaboration in research activities and to sharing and managing risk. The financial marketplace should respond with creative mechanisms to channel venture capital and other funds to enable companies to commercialize the results of R&D and bring products and services to market.

In attempting to meet the different needs of companies at the various stages of product or process development, both government and the financial community are working within a diverse and complex innovation environment. In so doing they are also stimulating the overall innovation environment by, among other things, stimulating regional technological networks and joint ventures between sectors.

It is no surprise that second to strong leadership, participants identified finance and investment as the major factors affecting successful innovation. Participants raised many questions. What actions are needed to provoke the necessary behavioural change to create a stable, supportive environment that channels more funds to technology and innovation? How can we better manage risk? What kind of actions will have the strongest leverage effect on the organizations involved in technological innovation?

A. Financing innovation

i) Finding adequate risk capital

Many small and medium-sized high-tech firms in Canada face a frustrating task in trying to find adequate financing for promising and innovative projects. As

George Jenkins, formerly of Process Technology Incorporated, asked at the conference in Saint John, "What does someone starting up a high technology business have to do to get investment in R&D? How do you convince people who usually put funds into real estate, fishing and lumber to fund R&D?" A significant number of participants voiced similar concerns about the difficulty in acquiring risk capital.

Erick James, President of Cangene, a small Canadian biotechnology company currently conducting cancer research, recounted his difficulty in finding investment capital. He claims that Canada's existing financial institutions are not investing in high risk areas.

"Canadians are not risk takers. There are no venture capitalists in Canada at all. There are investment bankers maybe, but they're not prepared to take risk. They will come in to Cangene and say, 'Gosh, that's wonderful, you say you can make this drug that would cure cancer? Are you sure you can make it?' ". If James replies as he usually does, "We're 80% sure", investors respond with "Well once you've done it come back and then we'll buy some stock at $15 per share."

James continued, "We just have to recognize the fact that we've got to somehow or other develop a means of leveraging our investments. It's absolutely clear that equity is the route to go. There's no way we can go to a bank. I went to the bank last year and said, "the government owes me $700,000 in tax credits. Our accountants can guarantee that. Will you lend me $500,000?" The bank turned down his request. "Now that I've got five million dollars in the bank, they'd love to lend me $500,000. But I don't need it now. I could have used it last summer. A bank is not going to give us any money—not a nickel—unless we don't need it."

It is tempting to infer that Canada lacks capital. However, after careful examination, the opposite scenario unfolds. First, the Canadian economy is supported by a strong financial sector. Chartered banks in Canada rank among the world's largest. Trust and mortgage loan companies have seen rapid growth in the past five years and have built up a strong capital base as a result. In fact, these financial institutions in Canada have been highly innovative and have, in the past few years, begun to challenge the strongly established chartered banks. Pending legislation to de-regulate various areas of the financial system may well induce all financial institutions to innovate further in order to retain their domestic positions, as well as to enable them to compete in the global financial market.

Second, Canadians have a strong tradition of saving. In 1986 the ratio of savings to disposable income was 11.3 versus 4.3 in the United States. This pool of savings remains a largely untapped resource.

Finally, holdings in private pension funds and individual Registered Retirement Savings Plans (RRSPs) have grown at a rapid rate over the past decade. This

also could represent an enormous potential equity investment in new R&D ventures. Several participants suggested that a percentage of these funds could be invested in high technology projects.

Venture capital firms have an important role to play in financing the early stages of the innovation process. Relative to the United States, the Canadian financial system does not have an abundance of venture capitalists. Many business people, especially in Atlantic Canada, were reluctant to consider this option, because the costs associated with venture capital in the form of lost equity were seen as being too high. The limited venture capital market didn't give them enough flexibility in their financing options.

Participants felt strongly that there is no shortage of capital in Canada. The problem is that an insufficient portion of the funds available is being channelled into high technology and R&D ventures. There is a shortage of risk capital mainly because investors are naturally risk averse and R&D ventures have high failure rates.

ii) Risk-averse private investors

The crux of the problem in obtaining venture capital appears to be that Canadian investors perceive the risks to be much higher than do investors in the United States and other countries. As Erick James, President of Cangene, pointed out, "What we have to focus on is how do we manage to persuade, for example, Manufacturers Insurance Company, Great West Life Co, the Kellog-Salada Company—any of these companies—to part with some of their well earned dollars and risk them in a gamble? You see very few Canadians do that."

Risk reflects a particular perception of a set of circumstances. Participants felt that education, public awareness, and incentives to invest in risk ventures were needed to change the response of Canadian investors. As John MacDonald, of MacDonald, Dettwiler and Associates, observed, "In this world, with high risk goes high reward—they balance one another. One of the problems we have in Canada is that we don't value risk. In modern economies that is becoming a more important thing. Change and risk, in many ways, are synonymous."

iii) Long-term equity investment

Third, and very importantly, participants knowledgeable about financing technology and innovation argued that R&D would be best financed through equity investment, rather than debt investment. Debt investment requires short-term immediate payment of interest. R&D frequently does not generate income for many years. Accordingly long-term equity investment is usually required. Current Canadian tax laws do not encourage equity investment in R&D because debt is tax-deductible whereas equity investment is not. In order to obtain maximum return on total investment, Canadian companies are often highly

leveraged with debt. Mergers and takeovers through "leveraged buy-outs" do not help to solve this problem. As Maureen Farrow, President of the C. D. Howe Institute emphasized, "We cannot make the structural changes, and take risks to get new products to market and be really competitive without long-term investment. We have to recognize that it takes risk and we have to provide for the failure of that risk."

iv) Unstable government policies and programs

The problems and insecurities inherent in relying on government tax credits, loans and grants to finance R&D is another area of frustration. Participants were critical of the abrupt shifts in government policies and programs that play havoc with a company's operations—or even cause its demise, as happened to one small firm in Atlantic Canada that undertook research in the semiconductor process area.

Government grants and investment tax credits (ITCs) constituted a major portion of this small company's funding. The company's growth was very rapid—accepting a contract for four million dollars actually caused its downfall. The Department of Regional and Industrial Expansion (DRIE) agreed to finance half of the contract. At the time, the firm was receiving a 15 cent investment tax credit on each dollar invested. However, under new government budget rules the loan became a grant and as a grant, the funds became taxable income. Instead of attracting a 15% investment tax credit, they attracted a 50% income tax. In the short term, the company was losing 35 cents on each dollar (even if the longer term prospects had been better). Slow government action, in awarding promised grants and tax credits, eventually led to the company going into receivership. This experience is typical of many small research firms in Canada. As the president of this small firm said, "It's scary to be the only company in Canada doing research in the semiconductor process area. . . except possibly for Northern Telecom and Mitel. We believed in the year 2000, but the banks and the government didn't."

B. Non-tax incentives for innovation

i) Government procurement policies

Participants at all the conferences emphasized that government procurement policies can be a powerful lever in providing the impetus for industrial innovation. They pointed to the "Buy American" policy of the United States, whereby the procurement budgets of government agencies are used to provide a ready market for industrial products manufactured within the country. The expenditures of the U.S. Space Program and the Department of Defence are also instruments to encourage and support small and medium-sized innovative companies. The goal of such procurement policies, with their emphasis on R&D, is to pro-

vide a "technological pull" for many start-up and established companies. In meeting the requirements, the companies develop new technologies, new manufacturing processes, and management expertise that can subsequently be employed in profitable production runs. From the government's perspective the benefits are in the impetus that its procurement dollars provide for companies to develop and become competitive industries to serve world markets.

Participants urged both federal and provincial governments to review their procurement policies to create an environment in which Canadian companies can benefit by developing higher value-added products as well as new capabilities. In addition, policies should favour the procurement of entire systems rather than the piecemeal approach of purchasing individual components. It is in the development of entire systems that the maximum benefits accrue to companies because of the higher value-added in the integration of components. Where off-shore procurement is involved, government should insist on off-sets and transfer of technology to Canadian companies.

Some government agencies are already using procurement as a means of encouraging technological innovation. Jacques Bernier, President of Technoprise, said, "Utilities like Hydro Quebec have demonstrated a great deal of courage in fostering the development of technology intensive firms. They used a buy-at-home policy to replace things that were procured elsewhere. They also acted as a mentor for companies to emerge as a supplier for a technology-intensive product or service. Now we have to encourage large firms to foster the suppliers of technology intensive products."

ii) Linkages with small firms

A significant number of smaller firms in Canada possess highly innovative ideas and inventions. Since they often lack funds and expertise to bring these ideas to commercialization, several conferences recommended the establishment of new linkages between small and large firms. The latter have important resources of both management expertise and cash flow. The benefits of the collaboration can be many and diverse for both partners. While the small firm gains a stable support and source of management advice, the large firm can gain access to leading-edge technology without the long-term heavy capital investment and extensive commitments to the employees involved in establishing an in-house capability. These links come in many forms, from simple contracts through equity investments and R&D partnerships. Whatever the form, success depends on effective management and commitment by both partners.

Participants from small business stressed the importance of big business support. Large firms may provide facilities to test prototypes at their plants. This often helped small firms gain credibility when marketing their products or services. Larger firms can often provide an initial stable market for a small busi-

ness just entering the production phase. This patient client can assist the small company with the difficult tasks of working out unexpected flaws and developing a servicing capability.

While it sounds reasonable to develop some mechanism to link large and small firms, larger firms frequently want to be compensated in the short-term for their efforts. Smaller firms have to be willing to give up equity, a concept not readily acceptable to many small firms. Regina participants suggested that large firms be encouraged to sub-contract to smaller firms on large procurements/production runs. Developing appropriate linkages will require some compromise from both partners. As Jacques Bernier put it, "When you act as a mentor for a company to emerge as a supplier, it is not a straightforward business decision. It is more than that. You have to be willing and ready to face a situation that is not cost efficient all the time. You have to be patient, because the benefits are there."

iii) Market intelligence

Many participants indicated that there is a need for better market information and sophisticated market intelligence in Canada. "Marketing is a weakness, especially for start-up companies" said Micheline Bouchard, Vice President of CGI Inc. She pointed out they often don't know where to begin to do market research or how to reach potential markets. "We have seen companies that have been set up and disappear just as quickly because of the lack of comprehension of the market and a lack of support to get at the market," said Bouchard. This situation is particularly critical when it comes to knowledge of foreign markets. While participants lauded government efforts in organizing foreign missions abroad, they felt it was not enough. They suggested that governments set up a market research organization in other countries to help small and medium sized enterprises expand in foreign markets. "It takes a lot of money and time to position new products successfully in new markets. Governments should support market research before they support export programs," said Micheline Bouchard.

C. Tax incentives for innovation

Participants from all regions agreed that there is a need to find mechanisms to encourage investors to view risk more positively. In addition, policy makers must understand the different stages in the innovation process in order to develop a tax regime that recognizes that the various stages require different types of financial support. Tax incentives were seen as the first line of approach.

i) Narrow definitions of R&D

Participants felt that the definition of R&D for tax purposes was too narrow. Investments in market research and production engineering are ineligible for

R&D tax credits even though these activities are crucial to the successful commercialization of technology. Research by itself does not generate income. A company only benefits from its investments in research when the results of that research are successfully commercialized. This requires that expenditures on market research should be included in tax credit programs. As one participant indicated in Toronto, "Revenue Canada's rule book reads like a text on scientific methodology in the 1950s. It still assumes that innovation comes from basic scientific research in the lab. The reality is that innovation now comes from integrating knowledge into new and better systems. So you need tax breaks from concept to market."

Participants also called upon the federal government to review the definition of what qualifies as R&D, particularly in regard to imported technology and the development of extensions to existing products. In essence they felt that the later stages of the innovation process can be more costly, just as long, and riskier than the research phase. To benefit from the investment in research, tax measures should be directed at sharing the costs and risks of bringing research results to market.

ii) Innovative tax measures

Tax incentives have a strong impact on a company's ability to finance innovation and to apply technology. All levels of government should consider tax measures to encourage risk-taking on the part of investors and entrepreneurial activities within the companies.

At all conferences, participants recommended that flow-through shares, as used in the mining industry, should apply to other high-risk R&D areas. With flow-through shares, an investor takes an equity position by purchasing shares in a firm that undertakes R&D. If the firm turns a profit the investor is compensated with dividends. However, if the firm is not profitable, the tax benefit normally applied to the company would by-pass or "flow through" the company and be given to the investor. The advantage of this scheme is that it provides an incentive to raise venture capital in selected industries. In the first years of research it is not unusual for companies to run up losses. Thus, the investor is compensated for his/her loss through the tax system. Once the firm produces a profit, then the dividends are realized. This mechanism clearly allows for the reduction of risk and could provide a powerful incentive to invest in high-tech companies.

Many participants felt that some form of the Scientific Research Tax Credits (SRTC) should be brought back. They indicated that while the SRTC program may have been poorly designed, leaving it open to wide abuse, the concept was sound and warrants reconsideration.

The tax regime may be an even more important environmental factor for supporting technology and innovation than appears to Canadians at first glance. This is because Canada does not make large defence procurements. Canada is blessed with good overseas relations generally, as well as a strong network of military alliances to help in providing for Canadian defence. Canadians are fortunate that heavy expenditures on military equipment are not required by our government. The fact remains, however, that major defence procurements can be used adroitly for supporting domestic industry, by creating a useful high technology market, as has been done by numerous other countries, for example, the USA, Great Britain, Sweden, and France. In turn, this throws the federal government back on its tax measures as the important mechanism for setting a positive environment for technology and innovation.

D. Other financing solutions

The challenge for the financial community is to begin to develop secondary capital markets and to be creative in developing mechanisms that will be responsive to the needs of innovative companies. Experiments are underway in other countries and can be adapted to Canada. Not only will these creative mechanisms help to channel money toward technology and innovation, but they will reduce the dependence of companies on government grants and loans. As Tom Nickerson, President of the Nova Scotia Research Foundation said, "One of the underemphasized points about letting the tax system work and the market forces work, is that you not only bring investment to the start-up company but you bring the business expertise of the people who are investing. Government grants do not bring that expertise. It can be just as valuable as the money itself."

The United States has many strong regional initiatives to encourage and support start-up companies. For example, the city of San Antonio in Texas, received five million dollars from the U.S. Federal Government to constitute a revolving fund. If an individual has one dollar, then the revolving fund gives them four more dollars and therefore, they are eligible to obtain a five dollar loan from the bank. Banks as a general rule will lend one dollar for every dollar registered by the investor. Consequently, with the help of the revolving fund, the one dollar investment by the individual leads to ten dollars. This is an effective means of sharing risks.

The participants also underscored the value of existing initiatives geared to help small businesses. The Federal Business Development Bank program, Consulting Assistance to Small Enterprises (CASE), offers some marketing and management assistance to small companies. However, some participants in Saint John felt that while the program was undeniably effective, it could be strengthened if advisors were more intimately involved in the project's success or failure.

Some interesting mechanisms for small business financing have been developed recently in Quebec. One example is the "Groupe des Entreprises Quebecois", a self-help organization comprised of 500 companies organized into small regional groups. Members help each other acquire funding and provide business advice. This network of contacts and expertise is maintained by regular meetings and common activities.

Conclusion

At most of the conferences, participants felt strongly that the marketplace rather than government should pick winners. The government's most effective role is to facilitate by establishing ground rules (i.e., tax laws, grants, financial regulation) that provide an environment conducive to more science and technology investment by the private sector. While existing government schemes may be flawed, it can be argued that these schemes are among the most generous and comprehensive in the world. The question that one returns to once again is "Why is investment in high technology relatively low in Canada vis-à-vis other nations?"

Aside from risk, one reason is that there are other more profitable investment options. Investment in research and development ranks low in priority in many boardrooms. One cannot escape the conference conclusion that unless technological innovation is seen as a key competitive tool, the status quo will weaken Canada's economic position both internationally and domestically. Strong leadership is needed: leadership on the part of government to provide an environment conducive to investment in science and technology; and leadership by industrial and financial leaders who can not only cope with change, but can use it to exploit new opportunities and strengthen the Canadian economy. The Canadian financial system will have no choice but to consider applications for technology-oriented proposals and to develop the capacity to deal with these effectively. Financial institutions will have to gain the experience in investing in knowledge-based industries if we are to capitalize on new areas of growth in a dynamic economy.

Recommendations

1. Governments in Canada should aim to provide a more attractive investment environment for technology and innovation than in competing industrialized countries within the next five years.
2. The federal government should change the balance of favour in the tax laws to enhance equity investment over debt investment.
3. The reward/risk ratio of investments favouring new and/or impoved technology should be enhanced.

4. Invent a 'pooling' concept within equity markets, possibly involving the insurance industry, to spread risky investments over a broader base.

5. Stock exchanges in Canada should establish a separate list and index of high technology firms. This could be particularly important in regional markets, such as the Prairies, not notably associated at present with high technology ventures. The Quebec Stock Savings Plan is an excellent operating model for working through stock markets to support high technology R&D.

6. Provincial governments should establish tax policies and programs to encourage R&D in which some measure of risk to investors is preserved.

7. The current definitions of R&D for tax purposes and technology transfer are too narrow and should be reviewed.

8. Government policy on intellectual property should be changed to assist the private sector: for example government research centres and labs should be able to engage in joint ventures with industry without all rights of ownership reverting to the crown; where intellectual property normally resides with government, if the private sector has contributed to technology development, it might retain the intellectual property by paying a royalty.

9. Governments should use their purchasing power to help build technological capability in Canada by acting as a stable, patient client for start-up firms and by contracting out research projects to build broad new capabilities in Canadian companies.

10. Governments could assist in the innovation process by providing better access to information, such as by a Science and Technology Information Centre where industry could access information.

11. The federal government should, in conjunction with private sector organizations, consider establishing sectoral R&D targets over the next ten years within Canada.

Mission Statement: Investment and Finance

To develop a financial environment for business that encourages investors to support high-risk advanced technology ventures, including within established industries trying to enhance their competitive position; that assists new companies to grow and stabilize; and that recognizes and responds to the different financial requirements of all phases of the innovation process that generate wealth from the results of R&D.

The Prime Minister with Dr. Robert Richardson at the National Conference in Toronto.

Dr. Richardson in conversation with Dr. MacDonald at the opening of the Regional Conferences in Vancouver.

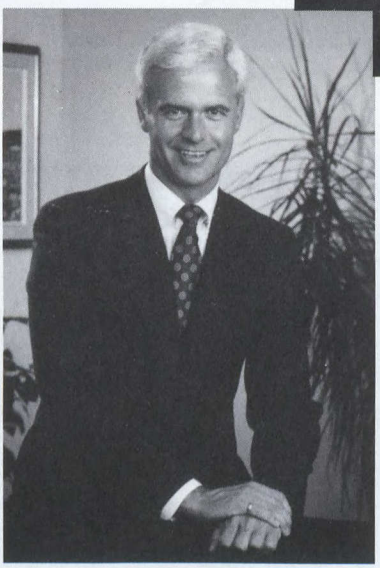
Participants worked to achieve consensus on vital issues.

A workshop session underway at the Pacific Regional Conference.

William Cochrane M.D., Chairman and Chief Executive Officer, Connaught Laboratories

John S. MacDonald, Chairman, MacDonald Dettwiler and Associates Ltd. Limited. Keynote Speaker, Ontario Regional Conference.

Rita Dionne-Marsolais,
Vice President, Information
Canadian Nuclear Association
Keynote Speaker
Quebec Regional Conference

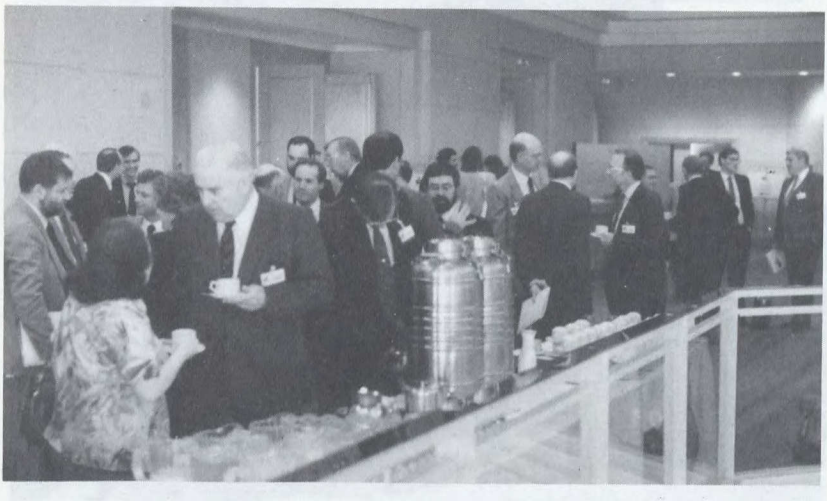


Victor Young
Chairman and Chief Executive Officer
Fishery Products International
Keynote Speaker
Atlantic Regional Conference

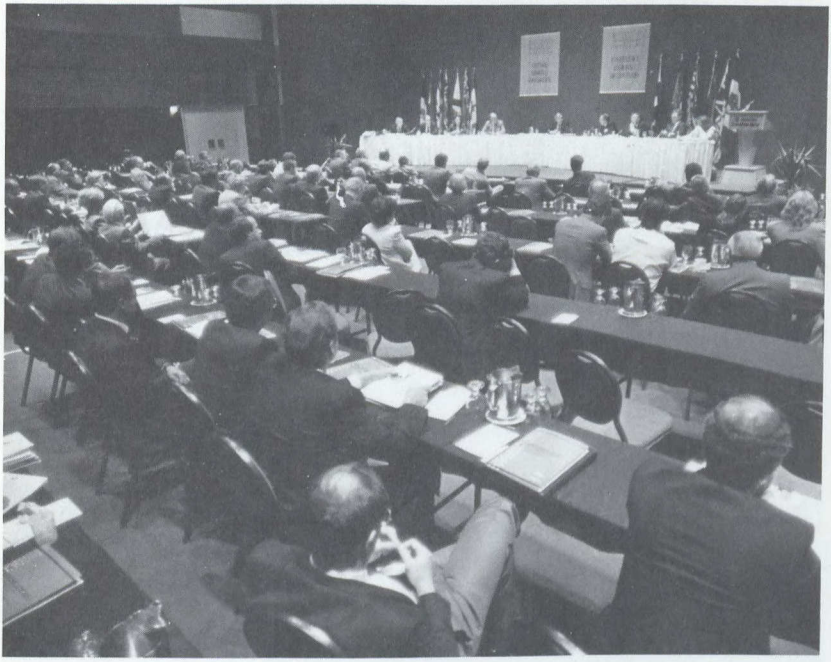
Several Ministers (including the Hon. Frank Oberle, extreme right) participated in workshop sessions.

Dr. Stephen Acres, Director, Veterinary Infectious Disease Organization. Keynote Speaker, Prairie/N.W.T. Regional Conference.

At each workshop, participants had the opportunity to contribute their views.



Lively discussions continued at coffee breaks.



Plenary session in Hamilton.

CHAPTER FIVE

The Workplace

". . . it is not just a technological issue, but a management of change issue."

Thomas Knowlton
President, Kellogg-Salada Co.

Workplace issues related to technological change are sensitive both politically and socially because the changes can have a profound effect on the livelihood of many people. One of the most contentious and emotionally charged issues related to technological adoption and diffusion is the direct impact on employment of technological change. While there is considerable debate among economists and social planners over the possible long term impact of technological change in the workplace, it is accepted that such change is currently affecting almost all forms of employment, creating both opportunity and dislocation. Further, there is a strong perception that technological change is an especial threat to blue collar workers.

However, technology affects the workplace well beyond the issue of the quantity of jobs available. It also changes the skills people need to participate in new jobs; the way in which people are organized and work together in the workplace; and the perception of employees about what is expected of them and how they can best contribute to organizational effectiveness. In addition, the introduction of a new technology into an existing workplace will succeed or fail depending on whether the technology fits, or is at odds with, the established organization and culture of the corporation. The quality of management applied to the introduction process and the response of the workforce are critical to its success.

Conference participants spoke of examples where the issues of technological change in the workplace have been met head on—under many different circumstances and pressures. In each case, the solutions involved not only the flexibility of individuals in the company but also the structures of the organization. Five key features of successful case studies were communication; training and retraining of the workforce; motivation; participatory management; and thoughtful planning.

A. Communication

The Kellogg-Salada Co. was involved in building an automated high-technology plant in Canada, at a cost of over $200 million. According to Thomas Knowlton, President of Kellogg-Salada, "We realized that the introduction of technology into the workplace could lead to fear and doubt. In many cases the justification for the new technology is to improve productivity, and people interpret productivity improvement as meaning fewer jobs. One thing we must learn in terms of addressing the fear and the uncertainty and doubt that is created by a traditional organization that moves into high tech is to recognize that it is not just a technological issue but a management of change issue." Knowlton went on to point out, that one of the implications of this view is that an organization must be open about the objectives of the technology and the impact it will have on people and jobs. On a concrete level it means being open with all levels

of the organization about the company's plans and what the objectives are in advance, and it means thoughtful, creative planning on an individual basis. As Knowlton observed, "The implementation plan must recognize that it is not just the production workers who are affected by the change but all individuals. The plan must also address the issue of redundancy and what the corporation will do about it."

B. Training

The Kellogg-Salada experience also afforded opportunities to experiment with new methods of training. As they adopted new technology they used computer aided instruction (CAI) wherever possible. However, the retraining of people was not restricted to only one part of the workforce. "We found that we needed to develop and up-grade skills in retraining our workforce. And we found the effect was different with older individuals than younger individuals," said Knowlton, "Older individuals were more intimidated in classroom situations and we had more luck dealing with them in small groups and on a one-to-one basis."

New ways to approach labour unions and to take advantage of the move to new technologies are clearly evident in the experience of the B.C. Telephone Co. Seven years ago the workforce numbered 17,000 as contrasted with the 12,000 currently. According to Gordon MacFarlane, Chairman of B.C. Tel, the company is the most advanced telephone company in Canada in terms of technology. The main measure of the advance is that B.C. Tel is 93% converted to electronic switching while the average across Canada is 60%. The move brought a very clear recognition. "We recognized that conversion to electronic switching was a threat to our employees and that if we were going to be successful, we had to be serious about it and remove that threat," said MacFarlane, adding that while the numbers in the workforce have dropped by over 4,000, none were laid off. Every employee, according to Mr. MacFarlane, goes through training programs at least twice a year. "As a result of our human resource program our employees are coming up with more innovative ideas than we ever thought possible."

The role of training and retraining within an organization is probably best evidenced by the full employment policy at IBM Canada. "Our feeling is that if you have good people and they continue to perform, you owe them a lifetime job and we have a full employment policy," said John Thompson, the President of IBM Canada, at the National Conference in Toronto. "The only proviso, other than keeping up your performance, is that you have to be prepared to be retrained." Every employee, regardless of where they are, whether on the plant floor or whether they are systems engineers or management, has to undergo the training. He added, "And that is an investment we have decided to

put into people. In fact you can write out a business case that says that training is worthwhile." He pointed out that when the cost of losing a skilled employee, hiring a new one and retraining him/her is compared to ongoing training, it is better business to retrain people. Last year at IBM Canada, nearly 800 people were involved in career changes. The company worked with Ryerson Polytechnical Institute in Toronto to use their facilities to retrain people from the manufacturing division to work as programmers. IBM provided the materials and the people. "This liaison worked very well. We did the retraining at half the cost of doing it in-house," said Thompson.

Each of these cases illustrates a variety of circumstances and the responses of the large firms. While they are exemplary, participants were quick to point out that small and medium sized enterprises often simply do not have the resources to undertake such extensive training and retraining programs. As Roy Woodbridge, President of the Canadian Advanced Technology Association (CATA) pointed out, "The whole issue of human resources may be an area for the new Industry, Science and Technology Canada (ISTC) to examine and try to come to grips with, by finding out what the options are for small and medium sized companies, to give them flexibility to keep that resource base competitive."

C. Motivation

However it is rarely sufficient for a company introducing technological change in the workplace merely to be open with employees and to provide opportunities for retraining. Successful innovation is much more possible when the workforce is actively supportive and motivated to participate in the changes.

National Sea Products CEO Gordon Cummings, admits that during the 1982 recession just about all the fishing industries failed, "but the basic market was there." The question was, "Could you attack it?"

"One of the hidden assets we've had in all this was the labour force." When asked how the workforce was motivated, he said it was by setting targets that were small enough for each, and then of course really reinforcing people. One such target program was the "3% campaign". At the time the company was losing 5% of every sales dollar. Each area—fleet, operations, engineering and marketing—was challenged to recover at least 3% more to reduce the loss. The campaign was implemented because everyone agreed that 3% was highly attainable. In fact, the company attained 15% in total when the campaign ended. "We have an employee of the month and a big President's Night of the Year Award. The big awards are not for productivity—they're for innovation. In fact, there are virtually no productivity awards. There are awards for quality, innovation and there are awards for safety, rather than just straight productivity. We communicate with our people through video. This was new for us.

We'd communicate every second month with a fifteen minute newscast which honoured an individual, average employee doing something new."

The focus here was on providing reasonable goals and on recognizing achievement, both key factors in motivation.

D. Participatory management

Participants at all conferences expressed the view that there were many workplace models for Canada in the experiences of other countries. Japan and Sweden were often mentioned. Invariably the examples cited were those that valued the input of workers on the plant floor in management decisions that affected not just the introduction of technology but also matters of design, quality, efficiency and sometimes profit sharing.

It was clear that structures that pitted management and labour in adversarial roles were inefficient and led to stagnation. One participant had recently attended an international policy conference in Australia where the Swedish auto maker, Volvo was present. She described the new methods used by Volvo in organizing the workplace to incorporate new technologies and to involve labour in the decision-making process. Volvo summed up their evolution in the workplace as, "being one foot in the 60s and one foot in the 90s". In the case of Volvo, the company has reconciled traditional methods with new ones as part of its evolution toward a more innovative workplace.

There are numerous examples of new organizational structures that have been implemented to improve work methods and incentives. Neil Foulds represented a company of 24 people that has been in operation for six years. It is an R&D oriented company that produces small instruments. At present, their products are sold world wide. This company could foresee a lot of change. After careful examination of their situation, the company decided that quality was its most important asset. Influenced by the Japanese experience, it established quality circles and shared ownership among employees. As a result, the entire company is involved in management decisions and the staff is committed to the agreed-upon solution.

When asked if management was fully prepared to include labour in the decision making process, Foulds replied, "In our company, management and labour are one and it really works." Sales in 1987 were $1.2 million and were expected to reach $6 million in 1988.

Such work settings are not confined to small enterprises. As Don Lowe, President of Canadair told a workshop in Toronto, "Our union representative is expected at each management meeting and any other meeting that will have an impact on the way we handle something on the plant floor. And that situation is working very well."

E. Planning

Managing technological change has long-term wider implications for both companies and government. While many participants recognized and lauded the efforts of companies to carry out in-service training for their employees, there was a larger concern—how can we predict, with better insight, the skills that will be needed down the road so that future employees can be trained adequately and so that retraining programs will not produce people for obsolete jobs. What does technological change mean for future employment, and future job design and job classifications? Do we currently have good enough models to gauge these trends?

Participants concluded that the current models for forecasting trends in employment and in the workplace are not very reliable. To improve projections, they called upon companies to develop five year plans with indications of the kind of activities and skills that will be required over that period of time.

Educators and industry leaders all seemed to agree that skills development and training should focus on flexibility. As one participant at the Regional Conference in Hamilton stated: "I think it's a mistake to target very specific, short-term kinds of technological changes and objectives that we might identify. We will never be able to predict those accurately enough, and it leads to a kind of ground glass cycle. We need to prepare people much more fundamentally, basically and generically to be able to adjust to whatever specific changes may come along."

The conclusion was that proficient skills in "learning to learn" are fundamental since much learning will occur after school graduation in the workplace.

Given the profound changes that have already occurred in the workplace and in the demand for highly skilled labour as a result of technological innovation, solutions to those unique problems that arise from technological change will have to be innovative. These issues deserve much greater attention from labour, management, and government.

Conclusion

Unlike other workshops, the participants clearly struggled with the issues related to technological change in the workplace and had difficulty in constructing innovative solutions for the different problems in the workplace brought about by innovation and new technology. Many noted with regret the absence of many labour organizations at the conference. Clearly, successful management of change will require participatory planning at a national level, as well as at the individual company level.

Appropriate solutions are complex and require a great deal of serious thought. New attitudes are needed on the part of labour and management towards management of workplace issues, new work organization, the new technologies, skills training and remuneration.

Recommendations

1. Recognizing that labour must be a full participant in the process of technological change, Canadian industry will need to develop new and innovative approaches to managing technological change that stress employee skills updating and retraining strategies. Industry should regard the spending of a specific percentage of profits on training as an investment in competitiveness.
2. Industry should be involved in the planning, financing and operation of education and training programs, including co-op programs.
3. Companies should develop plans for managing technological change that recognize and deal with the uncertainty such changes create in the workplace.
4. Industry, Science and Technology Canada should develop a major focus on the issue of human resource management in respect of technological change and competitiveness of Canadian industry.
5. Industry should develop techniques for managing technological change and to motivate the work-force to innovate.
6. A centre of excellence should be established to study the social impacts of technological change and how they can best be managed in the national interest.

Mission Statement: The Workplace

To develop relationships among players in the workplace that recognize the need for open, co-operative management and participatory planning to make effective use of both human and technological resources and to ensure that the workforce is aware of and prepared for the changes that accompany innovation.

CHAPTER SIX

Education and Training

"To succeed we need a concerted effort that transcends our industries and public institutions."

Pierre Lortie
CEO
Provigo Inc.

A. Education in a knowledge-intensive economy

The issue of education generated more controversy and a wider range of recommendations than any other subject at all conferences. By their very nature, knowledge-based economies place a very high premium on education and training. The vitality and creativity of a country's workforce is what ultimately leads to innovation and greater competitiveness. The explosion in technological development and the increasing importance of knowledge as a component of products and services are placing tremendous pressure on all of our educational and training institutions. They affect not only colleges and universities but also primary and secondary schools and the wide range of agencies that attend to the retraining and upgrading of those already in the workforce.

At the core of the challenge facing the education system are two different views of the role of education in today's world. First, and foremost, education is clearly the front line instrument for providing our young people with equal opportunities in the human race. Accordingly, there is strong emphasis on addressing the particular needs of each student, on ensuring equitable access to the system, and on providing a wide choice of courses to ensure the needs and interests of all can be met.

On the other hand, an increasing number of people see the educational system as responsible in the first instance for providing the economy with a workforce willing and able to make Canada more competitive in a world where knowledge and technology are the key tools for economic success. This approach suggests a strong core curriculum in mathematics, sciences and communication skills. It values quality education over equal opportunity when these conflict, and would tend toward less choice in the school system.

The manner in which these two perspectives are reconciled will help to shape the Canadian educational institutions of the future. The answers are neither simple nor inexpensive. Dr. Graham Orpwood noted in the background paper on education prepared for the National Conference *(Educating for Technology and Innovation: A Canadian Report Card)* that, for geographical and political reasons, Canada already spends a larger proportion of its Gross National Product (GNP) on education than any other Group of Seven nation. How much can we spend to prepare for the knowledge economy?

Participants grappled with a wide range of questions related to these issues. How well prepared is the present Canadian workforce to support industry in its transition to a knowledge-based economy? What are the important skills that students will need to enter and participate in the workforce in this new era? Should more students take more science, mathematics and engineering courses? Do we need more or different teachers? Should the private sector play a role in shaping the education system of the future? In an era when most people will have several different careers in their working lives how do we make it

socially and financially possible for them to be retrained? Above all, does science and technology education develop skills in innovation and entrepreneurship that we want to encourage or are different educational approaches needed? Is it really creativity that we want to encourage?

Education seems to be a subject on which everyone has opinions. We all have direct experience of it, as students and often as parents involved in the education of our children. Participants brought their experiences as executives, trying to provide leadership in a changing environment of skill requirements, and as educators trying to respond to the varied, often ill-defined demands of society.

Education was the central issue addressed in the Keynote Speech of Pierre Lortie at the National Conference in Toronto and continued as both a prime focus and subtheme of all discussions throughout the conferences. Discussions on education revolved around two themes, excellence and relevance: the quality of primary and secondary education and its relevance to the world of work; the role of colleges, universities and researchers in education and the relevance of higher education to the needs of industry. Most participants felt that fundamental changes in attitude and expectations are vitally important if we are to provide enhanced skills, life-long learning opportunities, and creativity for the knowledge-based economy. The future belongs to those who prepare.

B. The Canadian situation

It is clear that the challenge of science, technology and innovation affects the whole fabric of society. In his Keynote Speech, Pierre Lortie observed that it would be erroneous to focus policy efforts entirely on R&D or the emergence of high-tech firms. "These are admittedly important elements of a knowledge-based economy but they blossom best in an environment that is conducive to their growth. Our national infrastructure must be one that will sustain our capacity to innovate."

As we have seen, international trade based on created rather than natural competitive advantages is becoming the norm in many industries. Competition among advanced economies will be knowledge-based, through organizational innovation, product innovation and technological innovation. "To succeed we need a concerted effort that transcends our industries and public institutions. First, we must significantly raise the overall quality of education." he said.

Mr. Lortie pointed to recent international studies where it was found Canadian high school students, on average, were medium to low performers on science tests in comparison with students from other countries. He suggested that the relative lack of depth and intensity of science programs at the secondary level in Canada deprives students of the opportunity to gain a comparable level of scientific instruction. In Canada nearly 30% of all youngsters drop out of school

before obtaining a high school diploma. "These are serious shortcomings, not only in terms of wasted personal opportunities for young Canadians, but also for Canada as a whole," observed Mr. Lortie.

He also pointed out that the inadequate quality of science education has some unfortunate consequences, one being that students are not particularly interested in or excited by mathematics and the natural sciences. While Canada has an excellent record of accessibility to university education, the proportion of undergraduate students in science and engineering remains stable at a time when there are shortages of graduates in these key disciplines. Canada is second only to the U.S. in the number of university graduates it produces as a percentage of the workforce. However, we have the lowest relative numbers of scientists and researchers among the Group of Seven countries—about 90 per 100,000 population, compared with 140 in Britain, 150 in West Germany, 240 in Japan, and 280 in the U.S.

In light of concern about the quality of science education, high drop out rates in high school, and the relatively low numbers of scientists in Canada, Mr. Lortie concluded, "Public policy must encourage a pattern of educational development that sustains complex jobs and long-run productivity gains. And in the modern world, this means strengthening and extending our typically meagre science, mathematics, and technology core to give our students a strong science foundation."

In discussing what science and technology mean to the education system in a knowledge-intensive economy, participants came to the conclusion that overall there was a need to enhance both the quality of science teaching and its relevance to the world outside the classroom. Participants' concerns were particularly directed to the primary and secondary school levels where they saw a clear need to provide more and better quality teaching of science and technology.

C. Enhancing the quality of science education

i) Quality teaching

Challenging and motivating students to strive for excellence is an important component of a quality education. Participants were concerned that students do not have role models that exemplify the commitment to excellence in reaching their goals. Astronaut Marc Garneau is an important role model for children, not simply because he can relay his experiences in space, but because of the years of hard work, personal sacrifice, and the drive for excellence that are behind his accomplishments. As one participant said "Students see someone like Marc Garneau and think that is what they want to be. But when they discover that science isn't easy for them, they drop out. It wasn't easy for Garneau either." Students need to be challenged to take part in study and research, and

to learn through experience the rewards of tackling a difficult problem and working it through. These attitudes, which are at the core of the scientific spirit of inquiry, are dependent on the quality of teaching students receive and the attitudes and priorities of the education system as a whole.

Participants also felt that science teachers should be encouraged to upgrade and renew their qualifications by taking advanced science courses and degrees. Sabbaticals could be used for this purpose. A participant at the Prairie Regional Conference in Regina suggested that a special scholarship program be established for science teachers interested in pursuing further studies. Another popular recommendation was that greater use be made of secondments and staff exchanges with industry as this would enable teachers to keep abreast of current developments in the role science and technology are playing in industry. Participants strongly endorsed the suggestion that teachers be certified to teach only in their specialities at the secondary level.

The issue of standardized testing as a mechanism to measure the quality of science education was raised at all conferences. While some participants supported the introduction of tests, many remained skeptical. They noted that although sophisticated testing instruments and techniques have been developed in recent years, the outcome of these tests is still conditioned by the choice of instruments, the methods of administration, and the interpretation of data. In other words, the tests may measure certain skills and abilities but are not sensitive enough to measure the quality of science education being delivered.

However, the apparent lack of quality teaching in the classrooms cannot be blamed on teachers alone. Today's education system is complex and multifaceted. Increasingly schools and teachers are called upon to provide basic child care and supervision, as well as instruction in areas such as sexual behaviour, "street-proofing", and societal values, previously regarded as the purview of the family. In the face of these wide ranging demands the ability of the teachers to concentrate on providing quality substantive instruction may be seriously diminished. One participant noted, "The problems of education are the problems of all of us, and if we fail as a society to produce the best scientists that we can it is the fault of all of us, and not of a particular group that happens to stand in the front line." Perhaps it is time for Canadians to review their expectations of schools and decide which functions are of first importance and how other demands can be managed new ways.

ii) Quality science curricula

In a complex, rapidly changing world, the education system must take particular pains to ensure that all students have basic knowledge of science and technology. "Everyone in the society we live in today must have some concept of

what science is and how it works and what it can and cannot do. And anyone that doesn't know those things is not really prepared for life in today's world."

For non-science students, senior level courses on science in society which are designed to explain the relevance of science, have only had limited acceptance. It is not because they are considered to be invalid, but because constraints within the system make it difficult to introduce them. Constraints include the number and availability of teachers; the background of these teachers; the school facilities; and the capital investment required for the course. Many high schools in rural areas do not appear to have the appropriate equipment to teach general science courses. Interest among high school students in enrolling in new courses is inhibited by the reluctance of universities to give serious consideration to these courses in their admission requirements.

At the same time, it was generally felt that children are being asked to deal with far too much choice in terms of course selection. Participants believed that students are being asked to make decisions about their futures at a point in their lives when they are neither certain about what they want to do, nor fully aware of the importance of studying certain subjects. Mathematics and science may seem especially difficult, and their importance in the modern world is not generally understood by students in early high school. In many instances, early exposure to science has not sparked interest in the exciting new developments that are revolutionizing the world today. As a result, students drop out of science and math courses early in school without a clear understanding of the impact of their decision on future job options. The importance of guidance counsellors and their knowledge of changing requirements in the labour force is clear.

D. Enhancing the relevance of science education

Participants questioned over and over again why the teaching of science and technology in schools was turning so many students away from the subjects. They were concerned that the lack of early and persistent interest on the part of students in science led to poor performance and lack of desire for excellence and further study. They came to the conclusion that this problem could be alleviated if the curriculum linked the relevance of science in the schools more clearly with the "real world".

The major study of science education published in 1984 by the Science Council of Canada *(Science for Every Student)* discusses this issue in depth and reports on the approach currently reflected in Canadian science textbooks and curricula. The report proposes a range of actions that could be taken to enhance the relevance of science education to students. In light of concern expressed by conference participants, the recommendations deserve study and attention.

i) The need for more role models

Role models in science, particularly female role models, would enhance the relevance of science. The lack of female science role models was raised at all the regional conferences. Female science teachers and well-known female scientists are rare entities. Young girls receive an implicit message early in their lives that science is something in which they should not be interested. School boards such as the North York Board of Education, have begun to experiment with segregated classes in some subject areas.

Participants at the Ontario Regional Conference in Hamilton recommended that greater effort be made to explain the breadth of career choices to school children as well as to teachers and guidance counsellors, and that all three groups needed to be better informed about the importance of science in the workplace. There are many initiatives currently underway to try to draw a greater proportion of young women into science studies.

ii) The role of industry

A number of examples of initiatives to increase the relevance of science that involve school boards, industry and government were cited. At the Atlantic Conference, Angus Bruneau of the Newfoundland Light and Power Company told participants that the company sponsors a major school science activity that involves the host of a popular television science program. In addition, it provides opportunities for employees to meet with school administrators and provide resources to teachers. The New Brunswick Telephone Company has funded research on how children learn, and has also been involved in science fairs. Both Newfoundland Light and Power, and New Brunswick Telephone have been associated with the Shad Valley Program—a program that was cited by participants across Canada as an excellent example of collaboration among high schools, universities, business and government. The Junior Achievement Program was another initiative that was popular among participants. Across the country similar programs involving science and technology based companies were outlined. Connaught Laboratories in Ontario has a special open house for both students and parents to help increase awareness of their research and products. Programs of this kind were seen by participants as being vital to the greater understanding and relevance of science teaching in the schools. For students in high school, they have the added benefit of enabling them to make more informed career choices.

iii) Co-op programs

Participants were also concerned about the notion that high schools were gearing their curricula toward university education. Not all students are interested

in or can benefit by a university education, yet the focus of high school science education tends to be on preparing students for university. Participants felt that this situation was partly to blame for the high drop out rates in some regions. Greater flexibility in high school programs would allow average students in the system to remain in school. The introduction of co-op programs, where students would work with businesses as part of their course requirements, was seen as an effective mechanism to help students gain work experience as well as broader understanding of career choices.

E. Post-secondary education

i) Colleges

Discussions about post-secondary education focussed primarily on the issue of relevance and the role of the universities, colleges and institutes in preparing students for the "real world." Many participants in each of the workshops took exception to the tendency among some members of their group to consider only the university system when discussing post-secondary education. The importance of looking at all facets of the higher education system when planning for the future was aptly described by one participant from Ontario in the comment that whether one is working as an advanced research scientist, a machinist, or a tool and die maker, the entire spectrum and team is what the country needs if we are to remain competitive. The problems that Canada has encountered in the past, he continued, have occurred when we have focussed on one segment, rather than looking at the total team.

Reinforcing this comment was the criticism that the discussions regarding post-secondary education were focussing almost entirely on the education and training of engineers and scientists, and that little mention was being made about whether we were developing a sufficient number of technicians and technologists to support these engineers and scientists in the future. This appears to be a valid concern at least in Ontario where the Ministry of Colleges and Universities commissioned a study on the problem of declining enrolments in college technician and technologist programs.

Many participants from business noted that the colleges are much better equipped than the universities to provide the tailor-made courses required by industry, as colleges are more adaptable and flexible. In Ontario, Rick MacDonald from Mohawk College told members of his workshop group about a program review that was conducted by the Physical Sciences Department in the fall of 1987. The department surveyed approximately 200 companies to determine their needs in terms of human resources and training and retraining courses and activities. They organized a number of committees of employers, with whom they met to dissect the department's programs topic by topic, then

course by course. As a result of this process they assembled a new program. It became clear during this process that there is a need for a common core in the first few semesters in the three year technology programs. Mohawk now offers three technologists programs in which the first three semesters are clustered, that is, common to all three programs. For the final three semesters, students specialize in one of three technology areas. One of the benefits of clustering is that students can make a better informed decision on an area of specialization.

One participant however, noted that industry is becoming more and more inclined to catch the students as soon as they emerge from high school and to train them in-house. Industry is developing its own courses with support from the provincial government. The comment raised the question why companies find it more desirable to train in-house than to work with institutions to improve their facilities. Is this a desirable trend in Canada?

ii) The universities

While the quality of teaching was not extensively discussed by any of the workshop groups the need for more flexibility in the university system was of great concern to participants—flexibility that would allow students to earn interdisciplinary degrees. Paul Ziemkiewicz observed at the Prairie Conference in Regina that increasing specialization in various disciplines discourages movement among faculties and departments within a university. The rapidly changing and challenging aspects of science and technology have resulted in a growing need for scientists and engineers to have other skills. They must also have an adequate understanding of business and management if they are to be responsive to the needs of industry. Many scientists and engineers find themselves in management positions for which they have little formal preparation, only a few years after their graduation.

It was not surprising therefore, that some participants strongly supported the concept of including business courses in the science and engineering curricula. In addition, many also suggested that if Canada is to maintain its competitive position in the global marketplace, business leaders will have to acquire an understanding of science and technology and of the importance of research and development to our economy. They must be able to comprehend the significance of various technologies for their industry and more specifically, their organization. They must learn how to manage the process of technological innovation and how to facilitate the adoption of new technology in the workplace. Thus, participants also recommended that there be opportunities for business students to take science and engineering courses.

However, participants cautioned against moving too far and too rapidly to respond to needs of industry. Are we over-teaching our students? As one parti-

cipant noted, a four-year degree today barely provides sufficient time to teach the essentials required for one discipline. Can we expect to produce graduates competent in more than one field, in the same amount of time? Perhaps industry has a role to play in taking new business graduates and showing them, in the context of a corporation that actively builds technology into its strategic planning, that knowledge of technology and innovation is a key attribute of the progressive manager.

McMaster University offers a five-year program in which the student studies both an engineering discipline and the core courses of the commerce degree, and graduates with a Bachelor of Engineering and Management. This program has far more applicants than it can admit, indicating that the demand for this interdisciplinary degree is quite high.

Another participant observed that if, as so many economists believe, the future is with small businesses and the entrepreneur, then we need to recognize that we may need a different type of business education in the academic world. As he noted, "Somewhere along the line the spark of entrepreneurship has to be lit in the science student." A participant from a college in Ontario observed that at his institution, business courses were mandatory in all the technology programs.

Participants in the education workshops seemed more accepting than those in other groups, of the need for universities and colleges to interact more extensively with industry. They recognized the importance of students obtaining relevant work experience as part of their education.

The best example of such collaborative ventures is the cooperative education program. Participants felt that this program was highly successful, and for the most part, a positive learning experience for students. One participant noted that his company won't hire anyone without co-op experience.

However, the Atlantic and Prairie Regions expressed some uncertainty regarding the capacity of businesses in the region to absorb co-op students, especially given the growing popularity of the program. Their particular concern was that they may have to begin placing students in other parts of Canada, and that this in turn will increase the cost of the program. There was a suggestion at the Prairie Conference that perhaps funds from existing employment subsidy programs could be used to subsidize co-operative education.

iii) Research

Universities and the research they conduct have a particularly important role to play in a knowledge-based economy. Although not specifically classed as education, the training of highly qualified personnel that occurs during the research process has a critical impact on competitiveness. The quality of the

research activity and the attitudes and values about research conveyed by faculty to graduate students have important implications for the future generation of researchers. As John Evans pointed out, "Universities are another area where attitudinal changes are crucial. The quality and accessibility of university research is increasingly recognized by industry as a critical factor in technological innovation. Canadian universities have tended to view relations with industry with suspicion. The potential threat to academic independence seems to have outweighed the potential benefits for faculty and students of planned interdependence."

He also suggested that in addition to greater collaboration with industry, universities have to bring their programs in economics, commerce and management into the technological era. Finally, universities have to fulfil their traditional mission to pursue world-class excellence in research. However, Dr. Evans did acknowledge that problems of underfunding of research in both the public and private sectors, and an aging research infrastructure at the universities are serious impediments to progress.

Many participants saw a vast potential waiting to be tapped in universities if the distinct cultures of the universities and industries could be bridged. They focussed their attention on a variety of arrangements including consortia for pre-competitive research, the creation of specialized research institutes, and the creation of companies on the part of universities to market the results of their research. Many of these arrangements are operating at universities in Canada, but participants felt that much more could be done. Other participants saw the primary role of universities in a different light. John Roth, Vice-president, Northern Telecom, said, "The problem in Canada is that science and technology has been driven largely by the university sector which pictures itself as a supplier of technology. Universities are not suppliers of technology. They are suppliers of good people and good ideas. The technologies come from other companies."

James Downey, President of the University of New Brunswick, pointed out that it is only now that even our largest universities are becoming well established in terms of their basic research base. In moving from basic to applied research and the transfer of technology, he pointed out that Canadian universities are really in their infancy. "We are groping to find ways and means, in fact to getting things we produce and should be producing, that is ideas, into a form and shape that others can take from us. Anybody who looks to universities to provide them with full blown technology is going to be very disappointed. We can't do it." He observed that most universities are at the stage where they are establishing brokerage offices to determine how best to serve the needs of industry. "We are having a devil of a time getting the more promising stuff out of the labs because often the professors don't want to let it go and often there isn't anyone outside with enough experience to market it."

According to Dr. Downey, it is very easy to be critical of the universities and the educational system. "It is important to recognize that our whole educational system is operating under duress in a political environment in Canada that makes any concerted action to renew or reform the system very difficult. This is because it is not one system, it's an archipelago of systems with often no bridges, and scarcely a ferry service operating between the islands. This has a considerable effect on education, its reform, and the contribution that universities make in a utilitarian way to society. These factors are very important."

F. Continuing education and lifelong learning

In knowledge-intensive economies, education can no longer be viewed as something with a clearly defined beginning and end. It must instead be seen as a continuous, lifelong process. The shifts in technological horizons and the importance of knowledge in products and services were clearly seen by many participants to mean that the educational system is overdue for a change. Not only must existing teaching methods be enhanced in schools, so too must the quality and relevance of the curriculum be improved. Formal education has to ensure that students become more aware of the role of science and technology in society. The stucture of formal education must become much more flexible so that it creates opportunities for those students that are in need of different experiences to develop their skills. The whole concept of education needs serious thought beyond the needs of students in formal educational institutions.

It is of vital importance that educational institutions, governments and industry support, fund and create new educational opportunities that will ensure the creativity and drive of the workforce. Perhaps by striving to produce a workforce that can support and enhance competitiveness we can also stimulate the interest among the large number of students who drop out of science and math courses and out of school. It may be that the road to reconciling the different views on the role of education lies in the common concern about quality and relevance. These themes could become the watchword of the education sector in the coming decades.

Recommendations

1. That all sectors recognize the life-long nature of the learning process. Work experience should be viewed as an integral component of education, and retraining as an integral part of the workplace activities. This should include greater recognition of students' work-related experience.
2. Industry should consider arranging secondments for teachers to provide them with relevant private sector work experience.

3. Governments should establish industrial advisory boards to examine existing school curricula, funding, teacher training, etc., with the objective of encouraging an interest in science, technology and innovation at all educational levels.

4. Canada should consider introducing national standardized testing. Although support for standardized testing was not unanimous, there was general consensus that such tests could be of value, if used in conjunction with other measures of achievement.

5. Business should help students to see the relevance of science and technology, through programs such as 'adopt-a-school', co-operative education, internships and advisory committees.

6. Business should establish a mentor program through which students with average abilities have an opportunity to work on projects alongside someone in industry. This could help to motivate students and to stimulate an interest in the sciences, where traditional teaching methods have failed.

7. Special training subsidies should be made available for small and medium sized enterprises.

8. Universities should encourage multidisciplinary studies among students, collaboration among faculty, and provide scholarships for existing primary- and secondary-level teachers to undertake science courses and degrees.

9. Industry-university liaison should be strengthened through sabbaticals, joint R&D projects, etc.

Mission Statement: Education and Training

To develop and support an educational system: that challenges students at all levels to strive for excellence; that clearly conveys the relevance of science and technology courses to the world outside the classroom; whose organization, attitudes and content recognize that education and training are lifelong activities; that includes technology content in all courses; and that encourages more students to pursue careers that involve science and technology.

CHAPTER SEVEN

Developing a Science and Technology Culture in Canada

"As a society we have not yet understood how powerful the tools of science and technology are for a nation as it prepares for the 21st century."

David Johnston
Principal
McGill University

A. The need for a science and technology culture

In his closing remarks at the National Conference, the Prime Minister underlined the importance of fostering and consolidating a science and technology culture in Canada. He spoke of a climate within which excellence in science and technology wouuld be recognized and celebrated for its contribution to national life. "But how will this new culture come about? We have to make the public more aware of the importance of science and technology in the life of our country and of the need for progress in this area to ensure our future international competitiveness," he said.

Participants were keenly aware that the critical elements in meeting all the challenges of technology and innovation are recognition and awareness. There must be recognition of the potential threats that technology poses to existing business. There must be awareness and recognition of the opportunity technology and innovation offer for economic development. There must be an awareness of the significance of the relevance of technology to Canadians in their daily lives. Lastly, there must be awareness that the scientific method means something in terms of making sense of the world around us, both natural and man made.

Undeniably Canadians do have a science culture in the sense that we have accomplishments in science and technology that are world class, born out of our domestic research infrastructure. As a society we are familiar with and use sophisticated technological products in our everyday lives.

Yet, participants at every conference raised concerns about how deeply scientific awareness and scientific literacy actually goes in the Canadian psyche. The major concern was that a lack of adequate awareness of, and poor attitudes toward science and technology, would impinge on the ability of society as a whole to support and be involved in the benefits that science, technology and new knowledge have to offer. Participants stressed that the need for scientific awareness cuts across all activities in society because of the pervasive nature of science and technology. Participants observed that society is undergoing nothing short of a technological revolution that affects all aspects of our lives. Their concern was for the long-term and the ability of society as a whole, through its institutions, to adjust to rapid changes in science and technology.

The discussion on Canada's science culture raised a number of questions. Should individuals have more education and training in science and technology, or should more people be scientists? Should society as a whole debate and discuss science and technology to a greater extent? Are there adequate rewards for scientists and engineers in Canada? How can all sectors in society, particularly businesses and the media, participate in enhancing public awareness of science and technology?

According to David L. Johnston, Principal of McGill University, the issue of science culture is a large one. "As a society we have not yet understood how powerful the tools of science and technology are for a nation as it prepares for the 21st century. And how important it is to understand the changes in a society from the increasing power of science and technology—both positive and negative consequences. Some societies understand that better than we do—how to marshall those forces and how to deal with the dislocation and opportunities that come from the new tools of science and technology. The barrier that lies in the way of solving that problem is the fairly superficial understanding of science and technology in our country."

The remedy is a long term one, that in the first instance resides in our educational system. Dr. Johnston said, "The teaching of science and technology beginning with the very first grade of the primary school system is simply not up to the standard we should expect." He said that universities and in particular faculties of education were not doing a satisfactory job of preparing professionals to teach science subjects for primary and secondary schools. The apparent lack of quality teaching culminates in fewer students taking an active interest in the sciences, and ultimately results in fewer people being trained for careers in science and technology. Many participants agreed with this observation and concluded that both teaching methods and the current science curricula need to be changed if there is to be a favourable change in attitude among students. The development of co-op programs and the use of out-of-school resources that give students a first-hand look at the workings of science and technology in the workplace, were seen as a high priority.

While many participants agreed that in the long-term, improvements to the educational system as a whole was probably the best remedy, many were concerned about the consequences of poor awareness in the short term.

B. Awareness in business

A lack of general awareness on the part of companies is an impediment to the effective use of science and technology as well as to raising the overall enrolments in post-secondary science and engineering programs. As one Vancouver participant warned, "There is no point in teaching and graduating scientists if there aren't corresponding opportunities or jobs for them." Students choose courses of study at post-secondary institutions partly in light of their knowledge of the career opportunities. Until Canadian companies demand more scientists and engineers as employees, enrolments are unlikely to change dramatically.

Participants viewed the rapid changes in science and technology as requiring immediate initiatives that would make the maximum use of resources currently available.

As John Evans, CEO, Allelix Inc. said, "Science and technology should be mainstream, not backroom, in corporate decision making." They affect the way senior management—in a variety of enterprises—make day-to-day decisions involving science and technology. What is discouraging, according to George Hopkins, Vice President, Bank of Montreal, is the lack of understanding on the part of many companies of the applications of technology, "The effective application of technology has to be driven by specific business needs. It is my opinion that most corporations are very weak in terms of understanding the specifics of the needs and opportunities of the potential technology."

Roy Woodbridge of the Canadian Advanced Technology Association (CATA) made a similar observation on the issue of what deters companies from adopting new technology. "It's all related to people because they make the investment decisions on technology. It's people who assess technology, it's people who operate equipment." He noted that as far back as ten years ago, interviews conducted with over 100 Canadian companies that had introduced technological innovations revealed some interesting results. "We discovered the problem that held them back was not money. It was knowledge and information on what technology could do—what specific piece of technology could be put into their operations."

The inability of potential investors, particularly venture capitalists, to assess technology was seen as a significant impediment to new technology intensive companies or projects in securing financing.

Effective awareness in business has to do with more than giving higher profile to scientists, in rank or decision-making. As one participant pointed out, the problem goes to the core of the corporate culture. "We have to create an environment and create new incentives if we are going to have leaders who are going to appreciate all the relationships in industry and deal with the social and cultural impacts of technological change."

C. Public awareness

i) Role models

Participants singled out a number of factors that currently diminish public awareness of science and technology. Among them was the lack of high profile personalities in Canada that would stand out as role models. Participants felt that our achievements in science and technology and the people behind these achievements are under-rated in Canada. Society as a whole has simply failed to celebrate the achievements not only of individuals but also of enterprises involved in science and technology. Participants also pointed to the lack of adequate rewards and incentives to scientists and engineers. As a result there are few highly visible role models. Many participants also indicated that the un-

derlying problem is that we have simply taken Canadian achievements for granted. They called upon companies to bolster their resources for publicizing their activities and achievements in the area of science and technology, and in particular the individuals who contributed to these achievements.

ii) Science centres and museums

Science centres and museums, where the public has a chance to view a wide variety of achievements, were also singled out for greater resources to "tell the Canadian story". The development of historical and contemporary exhibits is a powerful way not only to display technological achievements, but also to provide the links from the past to the future. Science centres and museums should undertake to develop more travelling exhibits for residents of remote areas, thereby giving them access to the benefits of these institutions that they may not otherwise have.

iii) The media

Many participants felt there was simply not enough reporting on science and technology in the daily media. Despite the acknowledgement that the situation has improved over the last few years, most participants felt that the media exposure of science and technology was inadequate. They called upon media organizations to develop specialized reporters to improve the quality and quantity of coverage.

Recommendations

1. A working group should be established, with wide representation from all sectors and provinces, to implement the ideas from the national and regional conferences.
2. Industry, the media, and governments should cooperate to develop and publicize stories concerning;
   - successful examples of innovation in industry;
   - interesting applications and advances in science and technology; and
   - the vast array of ways in which technology affects individuals in every aspect of daily life.
3. Mega projects, such as the Frigate Program and the Space Program, should have a public awareness component built into them.
4. Primary and secondary schools should incorporate courses that focus on developing entrepreneurship skills and an appreciation of science. Awards programs should also be introduced at the primary school level for achievements in science activities, and such programs should be carried right

through to the post-secondary education system as a continuing incentive to students.

5. Industry should become involved in developing awareness of science in the 'real world', e.g., by participating in programs such as "Adopt a school". Successful projects such as the Shad Valley program must be marketed more aggressively.
6. Companies should be encouraged to have greater representation by scientists and engineers at management levels, or on their boards of directors.
7. The federal government should continue a public awareness campaign for science and technology in Canada.

Mission Statement: Public Awareness

To develop in Canada a society that is aware of the essential role of science and technology in society and in industry; that is able to deal effectively with the social and economic issues raised by these changes; that values and celebrates the achievements of our scientists and of innovative companies in concert with those of national heroes in other areas such as the arts and sports.

CHAPTER EIGHT

How to proceed: setting an agenda for action

The two vital conclusions at the National and Regional Conferences on Technology and Innovation were that there is a critical need to mobilize and support the private sector to use technology and innovation effectively, and that Canadians must lay the foundation, to respond to and implement, the changes that will be required to improve Canada's competitive position. There is a need for national action.

Without exception, conference participants observed that changes in the world economy will cause changes in Canada, and that all of our companies and institutions are feeling pressure as they tackle the problems, as well as the unprecedented new opportunities presented by changing economic trends. From this observation, participants drew their primary conclusions: the mainspring of the response in Canada to these new economic realities must be the private sector; and that governments, at all levels, can help by directing their policies and programs toward creating a positive environment for an innovative and internationally competitive Canadian economy.

In order to respond to the new world economy, conference participants identified and addressed five dimensions which they conduded will determine Canada's success or failure at meeting the new challenges. Discussion on these five dimensions—leadership, finance and investment, the workplace, education and training, and public awareness—generated recommendations that represent consensual conclusions of the whole group.

Canadians must follow through on the consensus that has already been developed through the conferences, and translate ideals into action. Action is essential if the spirit of the conferences is to be maintained—there is an urgent need for a genuine, national response.

Given the wide range of the recommendations, no single group can be expected to take the entire responsibility for enhancing Canadian technology and innovation that will ultimately lead to improved economic performance.

There is therefore a need for leadership. Since the private sector will be the mainspring of Canada's response to the competitive challenge, the private sector should provide the leadership needed to develop a national plan for action in this field. Given the case for national action, the new policy process must involve: educational and research institutions; industry and trade associations; labour unions; and federal, provincial and municipal governments.

In developing this action plan, Canadians must recognize the need for dialogue and consensual action, while at the same time they should support the essential innovative, competitive, and entrepreneurial actions of individuals and firms in the private sector. There are powerful organizations in Canada that can help—organizations that can be strong contributors to, and supporters in, the efforts to mobilize the nation's resources to meet the competitive challenge ahead.

However, in general, these organizations and institutions have evolved in response to specific needs within the Canadian economy, and are accordingly not currently constituted or structured to respond to the comprehensive requirements of providing a basis for national action. The issue is : How do we bridge the gap between the conferences' consensus and Canada's existing institutions?

Accordingly the author recommends that:

> the Minister of Industry, Science and Technology Canada meet with a small number of CEOs and other high-level members of private sector organizations, unions, and educational institutions, with major stakes in technology and innovation in Canada, to discuss how the private sector can organize itself to take action to respond to the conference recommendations.

In developing a national response to this challenge the following factors should be taken into consideration:

- That the effort should be led and funded by the private sector;
- That all the relevant parties should be involved, for example, national trade and industry associations, labour unions, private firms, educational and research institutions;
- That the focus of effort should be to develop national action for implementing the conferences' recommendations; and,
- That it provide opportunities for government to be consulted and involved in these activities.

The author believes that the National and Regional Conferences were successful. Talented Canadians from across the country and from many areas of endeavour contributed to the identification of issues to be addressed if Canada is to achieve its most favourable position in the international economy. These issues concern the fundamental well-being of present and future generations of Canadians. Our concerns must recognize that economic muscle is necessary to power the social justice and well-being that Canadians everywhere desire.

The following questions, which form the basis of the agenda for action, organized under the five issue categories are addressed to the private sector; governments at all levels; and, the education and research sectors. These questions try to capture the many specific implementation issues that the participants raised throughout the conferences—questions seen as being vital to relevant and focussed action.

A. Leadership in business

Mission Statement: Leadership

To develop and support a generation of leaders in business and industry that understands the role of technology and innovation in enhancing competitiveness; is able, with support from investors and government, to take risks in the interest of the long-term benefit of the corporation; and is capable of managing the integration of technology with capital, labour and resources into the strategic planning and management of the corporation.

From this mission statement, the discussions and recommendations of the conferences raise a number of questions that need to be addressed. Some of the questions include the following:

i) Private sector

1. How can the CEO take an active role in reviewing his/her company's commercial goals in light of world-wide technological developments, especially in order to identify business expansion through technology-based products, processes, and services?
2. How can R&D investments and programs be driven by a business strategy and become a part of such strategy, for example, to include total system capability and/or new product and process strategy?
3. How can CEOs of Canadian firms identify potential technology partners with whom new technology alliances could be based, in order to strengthen themselves in global (not just domestic) markets?
4. How can trade associations become an effective force for technology development and use in Canada?
5. How can mechanisms be developed to allow individual scientists and engineers to participate more effectively in the strategic and operational aspects of the company to ensure the maximum utilization of technology?
6. How can more persons with a background in science and technology be included on firms' boards of directors and senior management? How can the need for this be promoted?

ii) Governments

1. How can federal and provincial governments make technology and innovation a high priority for excellence in view of difficult deficit positions?
2. How can governments best support private sector initiatives which enhance and strengthen international competitiveness through technology and innovation?

iii) Education and research

1. How can more multi-disciplinary approaches to learning be developed, for example, technology management courses in business administration, or finance and accounting in science and engineering?
2. How can we improve the training of highly qualified personnel for the management of technology and innovation?
3. How can Centres of Excellence within universities improve Canada's ability to manage technology? What other methods can our universities utilize to improve the nation's ability to manage technology and innovation?

B. Investment and finance

Mission Statement: Investment and Finance

To develop a financial environment for business that encourages investors to support high-risk advanced technology ventures, including within established industries trying to enhance their competitive position; that assists new companies to grow and stabilize; and that recognizes and responds to the different financial requirements of all phases of the innovation process which generate wealth from the results of R&D.

From this mission statement, the discussions and recommendations of the conferences raise a number of questions that need to be addressed. Some of the questions include the following:

i) *Private sector*

1. How can co-operative investment mechanisms be developed to spread risk of high-technology venture?
2. How can banks and investment firms be encouraged to accommodate longer term strategies which incorporate R&D, rather than short term profitability, particularly with respect to equity investment?
3. How can stock exchanges develop a stronger representation of high-technology firms in Canada?
4. Do banks and investment institutions need to develop their expertise in assessing technology-based ventures? If so, how could this be accomplished?
5. Recognizing their own self-interest, how can large firms implement specific programs to assist in the development of smaller companies, e.g. through supplier and customer development, contracted-out R&D, prototype testing and evaluation?

6. How can investment vehicles be developed for workers to participate in high-technology ventures? As well, how can firms improve the reward to workers at all levels in the success of the firm?

ii) Governments

1. How can the value of equity investment, relative to debt investment, best be enhanced, given all the competing requests for government support and governments' fiscal positions?
2. How can governments ensure that timely and quality information on technologies and markets best be made available? Should government efforts in this area be encouraged or eliminated?
3. How can governments strengthen procurement, as a tool for technological development, for example through programs for supplier development, as well as aiming procurement at the total systems level?
4. How can the risk/reward ratio be enhanced to favour investment in new and improved technology?

iii) Education and research

1. What educational mechanisms and course content could be offered to help the investment community better evaluate technology-based proposals?

C. The Workplace

Mission Statement: The Workplace

To develop relationships between players in the workplace that recognize the need for open, co-operative management and participatory planning to make effective use of both human and technological resources and to ensure that the workforce is aware of, and prepared for, the changes which accompany innovation.

From this mission statement, the discussions and recommendations of the conferences raise a number of questions that need to be addressed. Some of the questions include the following:

i) Private sector

1. How can joint labour-management technology committees and/or other appropriate mechanisms be developed to both encourage the use of new technology and ensure adequate preparation for it in the workplace?
2. How best can the private sector be involved in education programs and other training strategies that deliberately take into account technology? What role should co-operative training play?

3. How can productivity or other incentives and bonuses for improvement to the success of the firm best be structured?

4. How can strategies for employment flexibility, through in-house retraining and redeployment programs, best be developed to prevent lay-offs and assist the firms' expansion?

5. How can labour unions develop policies and strategies for the long-term development and employment flexibility of their workforce members, in order to become a force in technology development in Canada?

ii) Governments

1. How can better cost-effective mechanisms be structured to encourage worker re-training?

2. How can new programs be developed to make stronger linkages between industry and other institutions for technological re-training?

3. How can governments ensure that the social impacts of technological change be adequately researched in the public interest?

iii) Education and research

1. How can stronger linkages to industry be developed, for both formulating courses and also for co-operating on training?

2. Should significantly enhanced research on technology forecasting be conducted in order to project workers' long-term training needs? If so, how could this be accomplished?

D. Education and training

Mission Statement: Education and Training

To develop and support and educational system: that challenges students at all levels to strive for excellence; that clearly conveys the relevance of science and technology courses to the world outside the classroom; whose organization, attitudes and content recognize that education and training are lifelong activities; that includes technology content in all courses; and that encourages more students to pursue careers that involve science and technology.

From this mission statement, the discussions and recommendations of the conferences raise a number of questions that need to be addressed. Some of the questions include the following:

i) *Private sector*

1. How can firms develop programs that encourage life-long learning for employees through schooling experiences and educational assignments?
2. How can firms best contribute to ensuring that the supply of scientific and technological personnel, including technicians as well as professional scientists and engineers, is properly matched to the private sector's needs?
3. How can firms encourage individual employees to act as a "mentors" to students in schools and universities, in order to enhance the relevance of their educational experience?

ii) *Governments*

1. How can advisory boards be established to recommend new approaches to integrating education and technology?
2. How can the quality of guidance programs to students be up-graded and rendered more relevant in light of both a changing technology environment and students' educational options?
3. How can specific retraining assistance programs be developed for small and medium sized enterprises, in view of both their special needs and generally limited resources?
4. Should standardized testing be implemented in primary and secondary schools? If so, how?
5. How can programs be developed to ensure that the teaching of science and technology reflects its importance?
6. How can mechanisms be established to ensure an adequate level of interprovincial and federal co-ordination of education in science and technology and related fields?

iii) *Education and research*

1. How can specific responsibilities be assigned for reviewing teacher training, and developing long-term career development for teachers, in light of on-going technological changes?
2. How can the quality and quantity of technological content in general educational courses such as social studies and history be improved?
3. To what extent could practical technology courses in community colleges be accepted for credit at universities?
4. How can educational institutions be encouraged to use new technology in classrooms?

E. Public awareness

Mission Statement: Public Awareness

To develop in Canada, a society: that is aware of the essential role of science and technology in society and in industry; that is able to deal effectively with the social and economic issues raised by these changes; that values; and that celebrates the achievements of our scientists and of innovative companies in concert with those of national heros in other areas such as the arts and sports.

From this mission statement, the discussions and recommendations of the conferences raise a number of questions that need to be addressed. Some of the questions include the following:

i) Private sector

1. How can the private sector involve itself in raising public awarenes of the relevance of science and technology (e.g., through programs like adopt-a-school, Shad Valley, etc.)?
2. How can the achievements of scientists, engineers and industry be better publicized?

ii) Governments

1. How can better scholarship and award programs for recognizing achievements in science and technology be structured?

iii) Education and research

1. How can educational institutions at all levels structure relevant courses on both entrepreneurship and science appreciation?
2. How can technology-related courses, that describe the significance of technological change be introduced to non-science students?
3. How can school boards play their role with the public in respect of highlighting the significance both of science and technology education, and the vital role of innovation in the economy?
4. How can the media be influenced and alerted positively to the vital, yet often subtle, changes that new technology and innovation bring about?

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