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Editorially Speaking:

Whether we like it or not, the era of high technology — in virtually every facet of life — is upon us and we had better make sure we are ready for it. This, in essence, is what Bob Long, executive director of the Canadian Advanced Technology Association (CATA), is saying in his opinion piece on Page 6. He looks back from the 21st Century on a gloomy scene for Canada and then shows how it need not be so. And he is right! Canadians, over the years, have achieved an impressive number of technological breakthroughs. Nevertheless, there can be no resting on laurels. As all our contributors to this special edition seem to be saying, Canadians not only have to move with the times, we have to stay ahead of them!

J.C.H.

(Publié aussi en français)

Please note that Canada Commerce is available free of charge in Canada only to interested Canadian manufacturers and business persons.

High technology — microelectronics, robotics, telecommunications, fibre optics, biotechnology, among many other aspects — is the future . . . today. Canadians in virtually all walks of life are being and will be increasingly affected. The author takes an in-depth look at the whole picture of high technology in this article specially prepared for Canada Commerce

Canadian Advanced Technology Enterprise: The Key to the Future

by Paul J. Murray
Paul J. Murray & Assoc. Ltd.

The development and application of advanced technologies are bringing about revolutionary changes in the way we live and work; in the way goods and services are produced and distributed; in the human skills needed to create and manage technical change; and in the complexities and shape of our very society.

It has been said that the changes which will occur in the next 20 years or so, because of the introduction of new technologies, will be greater than all of the changes which have occurred during and since the Industrial Revolution. This "Technological Revolution" is underway throughout the industrialized world and transcends different economic, cultural and political systems. High technology, and electronics in particular, has become a truly international activity and forms a key element of economic development strategies among all the industrialized nations. The use of advanced technology offers growth potential to many of the developing countries as well.

For Canada, whose economy is highly sensitive to international developments, this universal technological revolution creates a challenge. It will be critical that Canadian industry meet the challenge in order to remain competitive in the rapidly changing international marketplace.

But as well as a challenge, the technological revolution will create opportunities for Canadian advanced technology enterprise, for it will be this group that develops the concepts, products and processes which will become the standards of industry performance and competitiveness in the future. Technological developments, here and elsewhere, will push us unrelentingly into a fundamentally different society, what might be termed, the "Technological Society".

UNDERLYING REASON — MICROPROCESSOR

The underlying reason for the fundamental changes which are underway can be found in the creation and development of the microprocessor and its application to an infinite variety of tasks. Simply speaking a microprocessor is a silicon chip which, through advances in chemical and electrical engineering, can contain the computing power of as many as 100,000 transistors on a fingernail sized chip. Moreover, the device is programmable so that the sequence of instructions it follows can be changed and the same component can be made to perform different tasks.

Microprocessors as central processors (the ones that perform the arithmetic and logic function) work with memory chips (the ones that store the information) and input and output chips (which are used to get information into and out of the central processor). All together, they become a microcomputer. The development of these very miniature computers has permitted the application of a high level of computing power to a wide variety of functions and has permitted the amazing advances that have been made, for example, in telecommunications and information processing.

Broadly speaking, electronic technologies have economic and social implications within five areas of activity. These are:

- as components in existing consumer and industrial products. A microprocessor, for example, can replace a mechanical timer in a domestic appliance, such as a dishwasher, to provide a more efficient operation;
- in the manufacturing process itself such as, for example, the use of computer aided design (CAD) and computer aided manufacturing (CAM) techniques. In this context the use of electronics is another phase in the historical evolution of automation. It also causes higher rates of productivity and therefore is an undoubted economic necessity;
- in the so-called "Office-of-the-Future" where computer and communication technologies are being applied to administrative and management functions and are having a positive impact on office productivity, as seen for example with the word processor;
- as the leading edge of new communications technologies and services to expedite information flows to and from businesses and industrial consumers. Two-way videotex communications systems are an outstanding example in this sphere of activity;
- finally, the snowballing development of electronics technology, and its wide-spread impact in society, will result in the advanced technology sector becoming a significant economic force in its own right. The enterprises developing the hardware, software and related services will be a major engine for economic growth, for job creation and for export development. This sector may well dominate the world economic stage within the next decade or so.

CANADIAN HIGH-TECH EXPERIENCE

By global standards, the Canadian electronics industry is relatively small. The 1980 Canadian production of electronic equipment and components was valued at less than $5 billion as compared with U.S. production in the same year of more than $60 billion and almost $40 billion in Japan. Nevertheless, the industry has been growing at an impressive rate — industry shipments 10 years ago, for example, were only $1.3 billion.

Historically, the industry in Canada has felt a strong foreign presence from American companies in office equipment and defence products and Japanese interests in consumer electronics, as well as from a smaller number of western European firms in different areas of technology. Many of these firms saw Canada as a market place for technologies developed from their home bases and therefore were not large contributors to Canadian-based technological development. A few firms continue in this mode, but a growing number of others recognize the value of establishing a Canadian-based presence in the high technology community and have evolved a corporate organization to achieve that goal.

A popular concept in this context is that of "world product mandate". The world product mandate is a strategy designed to provide the branch plant of a multinational organization with a full mandate from the parent for the design, development, manufacture and world marketing strategy for a particular product in the corporation's overall product line. In this way, a Canadian subsidiary of a multinational firm can achieve world scale competitiveness and make a mutually advantageous contribution to the multinational corporation and to the domestic economy.

While all the R & D and manufacturing are done in Canada, the international company's marketing connections are used to develop and serve world markets. Garrett Manufacturing and Litton Systems Canada Limited are two prime examples of how the world product mandate can be effectively utilized. There appears to be considerable scope for its utilization among other multinational firms in the high technology sector in Canada.

Among Canadian-owned firms in the advanced technology field, Northern Telecom has generally been regarded as the strongest Canadian presence in the international marketplace. Northern ranks second in North America and sixth worldwide in telecommunications equipment and is clearly a world class company. More recently Mitel Corporation, a newer telecommunications equipment manufacturer, has also become a significant factor in the international market, as has Gandalf Data Limited specializing in data transmission technology. In fact, the community of Canadian-owned advanced technology firms is emerging as a distinctive industry group with a significant contribution to make to the solution of the technical, management and operating problems of government, industry and business in Canada and throughout the technological world.

CANADIAN ADVANCED TECHNOLOGY ASSOCIATION

The Canadian Advanced Technology Association (CATA) is an industry association representing Canadian controlled high technology businesses engaged in research, development or manufacture of advanced technology products (including software) or services (including systems design). CATA is an umbrella organization and provides a focal point for state-of-the-art technology-based, entrepreneurial enterprise in Canada. As of September 1981, CATA membership stood at 102 companies, covering the broad spectrum of high technology enterprise. Although many of these companies are relatively small there is tremendous potential inherent in this group for explosive growth based on its research and development capability and its ability to maintain a flexible approach to changes in the market place for high technology products and services.

The one common concern that pervades high technology enterprise, however, is the constant and pressing need for financial resources to satisfy the heavy front-end costs of product and market development as well as funding the ongoing service and maintenance costs to remain competitive. A thriving, adequately financed high technology sector will provide benefits to investors and to the society at large and should remain a priority objective of public policy.

An obvious characteristic of high technology industry is the diversity of new products and services which are being created in what is a highly competitive international market place. In this environment a policy approach in the form of focussing national technological development resources on areas which offer the greatest potential to develop an internationally competitive product line is being pursued. Based on this approach, existing and perceived strengths in areas of technological specialization are identified. These key technologies should be advanced, state-of-the-art, and they should be capable of penetrating foreign markets against intense competition including, in many cases, formidable non-tariff barriers.

AREAS OF SPECIALIZATION

In the Canadian context a number of areas of specialization have emerged and Canadian companies and products have achieved well-earned reputations for technological excellence and market place competitiveness at home and abroad. As a matter of fact Canada has a longstanding record of leadership in selected areas of technology — particularly in communications. Ever since Alexander Graham Bell made the world's first long distance telephone call in Ontario, Canadian geography has compelled us to be innovative in long distance communications.

Canadian strengths in the communications field are found in satellite systems (the Anik inaugurated the world's first domestic satellite system in 1972); in fibre optics and in telephone systems (there are over 15 million telephones in Canada — one of the largest systems in the world).

Impressive strengths have been developed in broadband microwave and co-axial cable systems and, of much current interest, in the development of the Telidon system of two-way videotex communications.

In the information and data processing field Canadian firms are involved in the design and manufacture of a variety of computer products and in the development of advanced computer applications and sophisticated data processing. Canadian manufacturers produce main frames, peripherals, terminals, data entry and retrieval equipment and word processing systems. A good deal of the activity in the information and data processing area has centred on the "office-of-the-future", but other important applications are occurring in industrial processes and new opportunities are emerging in education and in home or personal computers. In all of these areas Canadians, and Canadian firms, have demonstrated the entrepreneurial capability and technical expertise to conceive and develop world class products and systems.

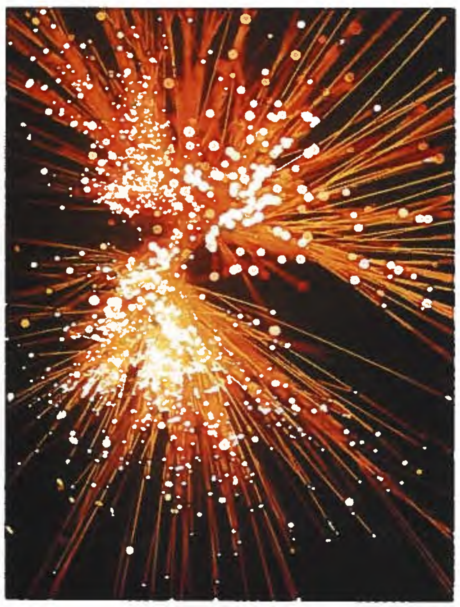
POTENTIAL IMPACT

In considering Canadian technological strengths and areas of specialization, it is useful to remember that virtually all of Canadian industry and commerce is a potential user of advanced electronics technology in their products, processes and services.

Essentially there are four ways electronics technology will have an impact on Canadian business. These are: i) as a component in a product; ii) as part of a new manufacturing or processing technology; iii) in the office; and iv) in business communication.

In the other areas of human communication, most notably in the home and educational environments, the introduction of new communications technology, together with the creation of an indigenous microcomputer manufacturing capability, hold equal promise for the development of new opportunities for Canadian high technology enterprise. These developments are important to Canada because they create the means to upgrade the effectiveness and productivity of Canadian manufacturing and commercial activities, but also because they create the potential for new ways of exchanging information and knowledge in the society at large.

If these are the areas of key technology from the demand perspective, they should be viewed in the context of Canadian capabilities on the supply side. Although Canadian high technology industry is small in the global context, it has the same opportunities as industries in other countries to develop and supply technology, to service existing markets and to pioneer new markets. In some cases this means building on an existing capability; in others, it means identifying new market opportunities through new applications of existing technological concepts; and in yet other cases it means the creation of new markets through the introduction of innovative products. Above all it means that technological development must have a direct market



place orientation and strongly suggests that a close relationship between the users of technology and its suppliers will optimize the benefits of application.

Because of the rapidly evolving nature of technological enterprise, and the complexity and sophistication of the solutions, benefits will be greatest where the synergism between user and supplier is most logically developed. An obvious example of this phenomenon is the telecommunications sector. Others can be found in office automation, integrated circuits, industrial process equipment and the software and services sector.

The telecommunications manufacturing sector has been the Canadian electronics industry's strongest element and has succeeded by continuing to build on existing strengths and capabilities. But there are fundamental, technology-driven, changes taking place in this sector which are leading towards a merging of computer and communications technologies into a new communications services market place.

Technological developments in satellite communications, fibre optics, digital transmission and switching are leading towards a more universal technical capability outside the traditional telecommunications manufacturers. At the same time, changes in regulatory policy have opened up the market place to small innovative firms to compete with the large vertically integrated firms. The overall result is to create a more competitive market place and to provide wider opportunities for supplier-user synergism in component integration and product design. It also means the Canadian telecommunications market becomes more vulnerable to competition from foreign suppliers.

Canadian-based manufacturers cannot become complacent but must maintain an aggressive, soundly financed development stance.

OFFICE-OF-THE-FUTURE

A second opportunity area for technological specialization lies in the creation, development and application of new information processing technologies — the so-called "office-of-the-future".

Recent years have seen many new developments in electronic office products such as word processors, facsimile transmission and private automatic branch exchanges (PABXs), all designed as stand-alone pieces of equipment to do a particular task more efficiently. However, significant further potential for productivity improvement is felt to exist through the linkage of these various pieces of electronic office equipment with eachother within an office as well as with other offices through the telecommunications network.

This is an emerging area and one in which Canadian capability and potential can be equal to anyone else's. The office products market has been dominated by U.S. multinationals and Canada's trade deficit in this area is substantial. In 1980, for example, Canada incurred a trade deficit of just over one billion dollars in office equipment; in 1979 it was $700 million; and in 1978 $600 million. So there is a significant domestic market place for the "office-of-the-future" and the development of a Canadian-based systems capability to meet this demand must be a policy priority.

The work of AES and Micom in word processing and the companies associated with Telidon in interactive business information systems provide the elements for building a strong Canadian presence in this area.

The basic building block of the new electronics technology is the integrated circuit or microelectronic "chip". Despite earlier unsuccessful attempts by Canadian industry to develop an indigenous chip manufacturing capability, there appears now to be reason for optimism for a Canadian capability in the production of "semi-custom chips" (chips of a standard design which can be modified to meet custom needs). The manufacture of integrated circuits, therefore, may be another key technological area with potential for Canada.

A domestic presence in the integrated circuit business is important in that it provides the users an opportunity to maintain a relationship with circuit designers. The consequent interchange of information between market requirements and technical expertise tends to heighten the effectiveness of the overall activity through its synergistic impact.

In the industrial manufacturing sector there are further prospects for the use of microelectronics technology to improve productivity in industrial processes but Canadian firms, in general, have not developed a strong capability in this field. Nevertheless there are some examples of specialized firms which are world competitive and there is potential for encouraging the development of microprocessor-based manufacturing techniques in Canadian industry. The use of sensor responsive robotics is a typical example of how microprocessors can be used to improve the productivity of a conventional manufacturing process.

SOFTWARE LINK

Finally, the area of technological specialization that is of basic importance in the effective utilization of advanced technological concepts is software. Software is the link between maker and user. The software program instructs the hardware to perform a particular function on a pre-programmed basis. However, software production is a human function — it is done by people and machine capability has been improving at a rate faster than human capability. As a result, software development is assuming a disproportionate share of the cost of designing and implementing new systems.

The industry response to this situation has been to emphasize the development of standard software packages that can apply to a variety of similar needs. A standard package may not suit a specific set of requirements perfectly but, because of a substantial cost differential — as much as 10 to one in favour of the standard package — it is becoming a preferred alternative for many business and social service applications.

In Canada there is a widespread, predominantly Canadian-owned

capability in the software and special data processing services field. These firms develop custom software for specific customer needs, or develop, as proprietary software, standard packages for sale to a variety of users with similar requirements (e.g. patient record keeping for a doctor's office). Data processing support services include technical advice on computer selection and installation, ongoing facilities management, data entry shops and training programs for users of management information systems.

Software development is forecast to be one of the fastest growing business areas over the next few years as microcomputers and distributed processing become a more common feature of the business environment. The development and marketing of standard software packages has tremendous commercial potential as a business activity unto itself and also will be key to the effective implementation of new electronics technology.

GOVERNMENT INTEREST

The Canadian government has had a long-standing interest in the economic and societal implications of developing and applying new technologies and has maintained a close association with advanced technology industry developments on a variety of fronts. Government interest in high technology is not unique to Canada since virtually every developed country in the world has identified advanced technology, and electronics in particular, as a priority industry sector. This support takes different forms: direct government procurement, research and development contracts, non-tariff barriers and direct financial support.

In the United States the electronics industry derives major support from the military and space programs through no-risk R & D contracts. NASA and other military programs, for example, provided the impetus for the development of computer and integrated circuit technologies in the U.S. The massive financial resources provided the U.S. high technology industry through defence spending permeates throughout the U.S. economy and gives a substantial and ongoing boost to American high technology enterprise.

Similarly in Japan, the government has created an environment conducive to the development of Japanese-based technology through the use of procurement and massive financial assistance. As well, the Japanese government has followed a policy of protectionism and, through the use of non-tariff barriers, has prevented access to its domestic market for foreign manufacturers of high technology products.

In western Europe, the story is the same. France has "chosen instruments" in the industrial sector and supports them heavily. In Britain, the government has sponsored a major program to develop an integrated circuit manufacturing capability and has broadly encouraged the use of microelectronics in industry through a publicly funded awareness program. West Germany, too, has invested heavily in high technology through measures to stimulate the computer industry and to develop programs to improve the manpower skills needed to create and use high technology products. So governments throughout the world have recognized the value of advanced technology as a key element of economic success and have moved in a variety of ways to promote a healthy climate for high technology enterprise.

Canadian governments, both federal and provincial, have recognized the basic importance and value of advanced technology industry and have expressed their support for the industry in different forms.

IMPORTANT INITIATIVE

An important federal initiative was the 1978 Task Force on the Canadian Electronics Industry. The membership of this task force was drawn from the industry (businesses large and small, Canadian and foreign-owned), the labour movement, academia and provincial governments. The result of the work of the task force was a comprehensive profile of the industry and a broader understanding in government of the importance of electronics technology to the competitive position of an industrialized country.

Following on this task force, the federal government announced a National Development Policy for the Electronics Industry. This program, funded through the Department of Industry, Trade and Commerce, provided an important first step in committing government to working with the industry to meet some of the challenges and opportunities identified by the task force.

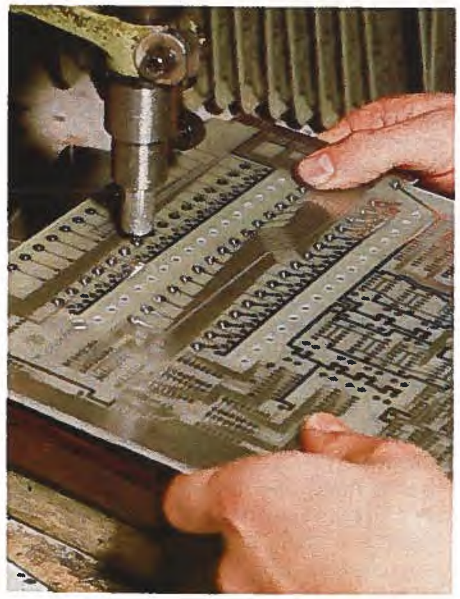
A second important step was taken by the Department of Communications, supported by IT&C, with the creation of the Office Communications Systems program to foster the development of indigenous Canadian capabilities to meet the needs of the integrated electronic office. Under this program the federal government is seeking to develop functional specifications for the electronic office as well as conducting "office-of-the-future" field trials in government departments. The program can provide support for product development as well as for the development work to integrate products into functioning systems. The objective is to create a Canadian manufacturing and systems capability to replace the heavy traditional use of imported office equipment and begin to redress the billion dollar trade deficit in this sector.

Other federal bodies, including the Ministry of State for Science and Technology and the National Research Council, have explicitly identified the need to support advanced technology enterprise and are promoting policies and programs in support of that objective.

PROVINCIAL SUPPORT

In addition to federal government attention, a number of provincial governments are also promoting policies and programs in support of high technology enterprise.

The Government of Ontario has been actively identified with the high technology industry and, through its BILD program and other measures, has indicated positive support for initiatives in the area of CAD/CAM and in the development of microcomputers for the provincial educational system. Alberta and British Columbia have both indicated a desire to broaden their resource-based economies into areas of high technology activity and have actively encouraged high technology enterprise in their area.



So the value of an indigenous technology-based manufacturing and service sector has been identified by many policy planners and forward thinkers in the public sector. It is important now that the challenge and opportunities arising out of the technological revolution (those features which will shape the new Technological Society) are more broadly understood and appreciated by all elements in the society — business people, labour leaders, politicians and government officials, and members of the general public. For there can be little doubt that the changes will be fundamental and all-pervasive and will have an impact on virtually everyone.

Looking ahead, the process of adjustment to the Technological Society will be most visible and felt most immediately in the business sector through changes in the way goods and services are produced, delivered and used by consumers. But there will be equally substantial changes in the labour force which manufactures, operates and distributes the products of an advanced technology society.

The use of microelectronics technology in the industrial workplace, in offices and in education will require a population trained in and comfortable with the new technologies. Current members of the student population will benefit from an awareness in the educational system to prepare for the new technologies, but existing members of the labour force will very likely require support in the form of labour adjustment services to help in counselling, training and to improve worker mobility in the process of adaptation. For their part, workers will need to recognize the need for and value of adopting new, more productive processes and procedures.

In order to encourage this, designers of high technology equipment and systems must ensure their products are "user friendly". The process of change can be smoother if the technology is compatible with the needs of those who will be using it and if they, in turn, are open minded in accepting it.

A considerable number of Canadians is already directly influenced by the technological revolution; an even larger number is under its indirect influence. The unrelenting pressure of technological change, both at home and abroad, requires that all members of society, and in particular the leaders of representative groups in society, come to grips with the need to deal positively with the requirements for and demands of a Technological Society.

We are just now on the leading edge of a new technological wave. It is gathering volume and momentum and we cannot afford to fall off or flounder. We must stay balanced and afloat in the ride up to the crest.

Paul J. Murray is an Ottawa-based public affairs consultant with special interests in high technology.

Countdown 2000 . . . A Time for Decision

by Robert S. Long

Robert S. Long is the Executive Director of the Canadian Advanced Technology Association which represents 110 Canadian-owned and controlled companies engaged in research, development or manufacture of high technology products or services.

SCENE: THE 21st CENTURY

The exact date is irrelevant — suffice it to say that the "future" has become the present and the 21st century, the most technology pervasive period known to men, is upon us.

Industry has become technology intensive. The personal service industry with its roots based in the skills of artisan entrepreneurs is the only exception. All the rest, those that failed to make the transition, have perished. A plethora of new technologies, some only in their embryonic stages as recently as the 1980s, have changed and shaped our lives through their impact on our food, medicine, education, work, entertainment, energy systems, etc.

In short, the technology bubble — the preoccupation of late 20th century socio-economic planners, had not burst. In fact, as technology advocates had predicted, it was not a bubble at all. It was the beginning of a new age and, in retrospect, the 20 years preceding the turn of the century were but its threshold.

The widespread use of microelectronics had become possible in this period and, driven by unprecedented densities in cost-effective silicon integrated circuitry, industry had created a system of distributed intelligence by putting affordable computing power of unimaginable dimension in the hands of individuals. The subsequent advances in process control, telecommunications, robotics, etc., had so stimulated the industrial applications of science that technological advances across a broad front of technologies had continued unabated.

The process was now into second and third generation technologies. Computer gurus were now claiming that computers with artificial intelligence rivalling man's were possible and that a new round of technological advance was about to occur.

The Information Society, or whatever you choose to call it, had been confusing at first. The interplay between the new technologies and who was going to deliver them served to mask certain fundamental characteristics. It was only when distinct trends became apparent that a hard reality became apparent. The Information Society, replete with its knowledge workers, had placed a high premium on intelligence — intelligence of all kinds. Those who could compete, the "creators", became high salaried and enjoyed the good life. Those who couldn't compete became the "consumers", the low salaried who existed at the pleasure of those who were generating the wealth.

The countries of the world were also dividing into creators and consumers. Those countries which had recognized the strategic importance of technology to the economic viability of their states had become the creator countries and those who had not had become the consumer countries. The die had been cast in the 1980s and the process had been so pre-emptive that only a handful of countries were creators.

The creators now enjoyed such a technological phase lead that marginal creator/consumer countries could not catch up and the cost of a quantum leap forward which had propelled these countries to creator status in the 1980s was now insurmountable. South Korea and Brazil were now ranked among the top six of the world's economic powers as a result of this reordering process.

Another fundamental realization was that technology intrinsically challenges the status quo. It is the antithesis of institutions. As an agent of change, technology stresses anyone or anything which fails to keep pace.

Canada had come close to being a "creator" country but in the end had failed.

One of the last great natural resource-based countries of the 20th century — Canada just couldn't break away from the conventional wisdom of the industrial society. Canadian economists, schooled in theories designed to explain and preserve the economic supremacy of other countries, had persisted in trying to transplant the French, British or American model to Canada. They ignored the fact that these models didn't work in Canada and they eschewed any thought of building a Canadian model.

Arguing outmoded concepts of comparative advantage and the inevitability of Canadian economic dependence on the United States, their advice ignored the achievements and aspirations of Canadian technology-based industry and, for that matter, the very principles of the Fathers of Confederation.

A series of disastrous federal budgets through the 1980s so destroyed the financial climate for risk capital investment in these companies, that Canada's only hope for the 21st century — a nucleus of some 1,000 Canadian-owned and controlled high technology companies — reluctantly had to shift their corporate headquarters to the United States. Unemployment skyrocketed as the creators in Canadian society dwindled in number. World demand for the limited supply of these people was so great that they could almost name their price.

In fact, the whole Canadian establishment was stressed and faltering. Wedded to the use of foreign technology — having claimed over the years that the source or ownership of the technology didn't matter, these institutions were now finding that this decision could cost them their very survival.

The Canadian banks had already been forced to withdraw from the United States and their Canadian market was in jeopardy. What the banks had failed to realize was that Japanese banks used Japanese technology, American banks American technology, etc. The Canadian banks were getting obsolete technology after their competitors had been fully serviced. Personal service just couldn't offset the lead in electronic banking services that competitor banks enjoyed as patrons or instruments of their respective national technologies.

Even the mighty forest and mining establishments had had to automate to an unprecedented level.

The creator countries wishing to be vertically integrated had intervened to set up competitors to the Canadian companies. These new companies using ocean engineering technologies and technologies for synthetic materials had developed rapidly, cutting into traditional Canadian markets. Canadians, many now second and third generation urbanized apartment workers could no longer be attracted to work in the forests and mines. Ironically these companies too were dependent on foreign technology.

Canada had lost all self-determination. Canadian sovereignty was at the pleasure of the technologically advanced countries. Without the profits accruing to ownership, regeneration of Canadian initiative had become impossible.

SCENARIO — GLOOMY BUT. . .

A gloomy scenario. No question. Could it happen? Who knows for sure? The symptoms are already here.

Countries such as Japan are committed to technological superiority — they have no choice if they are to remain viable economic states. They have structured their institutions to successfully manage technology and, capitalizing on their phase lead, have introduced Japanese products to the North American market so systematically that consumers have voted with their dollars to make Japanese technology the de facto industry standard. The United States, upset with these incursions, has already flexed its muscle and has moved to counter these actions.

Canada needs bargaining power and it can gain this power only from a position of technological equality. Whether technology is a means to an end or the end in itself is somewhat academic at this time. As long as countries like Japan are committed to technology in the way they are, technology is a proxy for the good life and national self-determination.

As a consequence, countries wishing to maintain a share of sovereignty over their national affairs will have no choice but to pursue technology as an end — at least until a better economic balance is struck. The game is deadly serious. It is hardball with no room for the faint of heart. The costs will be staggering but the cost of losing will be far worse.

NATIONAL WILL THE ANSWER

Can Canada squeak through the fast closing door? The answer is YES — if we have the national will.

My scenario traces the shape of the future to this decade — the critical 10 years of the 1980s. The trendlines are being determined now and one thing is certain — they will not be a simple extension of the past. If Canadians are to ride these trendlines to a happy and prosperous future we must ask ourselves some hard questions and respond quickly.

The first and perhaps only questions that need be answered are whether we want to be part of the technological society and, if so, to what extent do we wish to ensure our self-determination through the use of Canadian-developed technologies? One need only understand the competitive advantage that technology gives managers to realize what a powerful tool it has become.

Canadian problems can, therefore, only be solved effectively with foreign technology to the extent that the problems are common. To attempt to solve strategic Canadian problems using foreign technological solutions will reduce the effectiveness of Canadian managers and the competitive position of Canadian business to the lowest common denominator of the foreign technology.

How can Canadians, for example, effectively manage the resources of a northern latitude country with American visible light satellite technology (Landsat) when, as a northern latitude country, most of our landmass and coastline is in darkness or fog covered for so much of the time? Canadian synthetic aperture radar aboard a Canadian surveillance satellite would not only allow us to manage our Arctic with its oil tanker traffic but the chances are that we could sell realtime data to the United States for Alaska. As well, it could probably be fully financed by the private sector along with a global positioning satellite for navigation, new shipborne ice hazard and collision avoidance radars, terrestrial navigation and communications systems, etc. — if government tax incentives were such to allow Canadian private enterprise to raise competitive risk capital.

Canadian high technology industry needs this type of challenge to underwrite its entry into world markets. Large scale procurements can be used to finance Canadian development.

The Canadian Advanced Technology Association (CATA) estimates that a high technology company needs 10 to 15 times the money it will spend on R&D to commercialize its product, i.e. complete product engineering, install production equipment, produce, market, and setup an after sales service network.

The National Research Council helps to place the magnitude of this capital requirement into perspective in its Long Range Plan — The Urgent Investment, stating: "In the overall national effort to regain economic health, the R&D component, while vital, will be relatively small. It is estimated that the sector of high technology industry which can be most immediately assisted by NRC will require new capital of the order of $36 billion to **double** output while the annual research and development budget will be less than $3 billion."

POSITIVE STIMULATION NEEDED

The case for a positive stimulation process for Canadian business through encouragement of capital investment is clear. In a survey of over 200 companies conducted for the Association of Canadian Venture Capital Companies, the tabulation of data shows that significant benefits flow in the form of export sales, research and development, employment and tax revenues for all levels of government.

The performance of start-up companies (three years old), developing companies (four to nine years old), and teenage companies (approximately 10 years old), is quite remarkable. Start-up companies, many of whom are CATA member companies, produce an average $310,000 in export sales for every $100,000 equity capital. On this same equity investment, these companies expend 10 per cent on R&D, pay corporate and business taxes of $15,000 and yield $29,000 in personal income taxes. The capital formation survey shows that the ability to create jobs is far greater for start-up and developing companies than for those companies classified in more mature categories (over 14 years old).

What this tells us is obvious. Innovation and modern enterprising companies produce substantial economic returns. Encouraging sources of capital for these companies should be the object of a positive risk capital incentive policy to generate employment and prosperity for the world of tomorrow.

Another thing is also clear. Canadian institutions — be they governments, universities, regulatory bodies, the utilities, the banks, or politicians — must move to address their role in a technological society and, notwithstanding their conclusion that a lot of research will be necessary, commit themselves immediately to a co-operative Canadian solution. We can no longer continue to exist as separate solitudes. If Canada is to survive as a viable economic nation we must be no less committed to this end than are the Japanese.

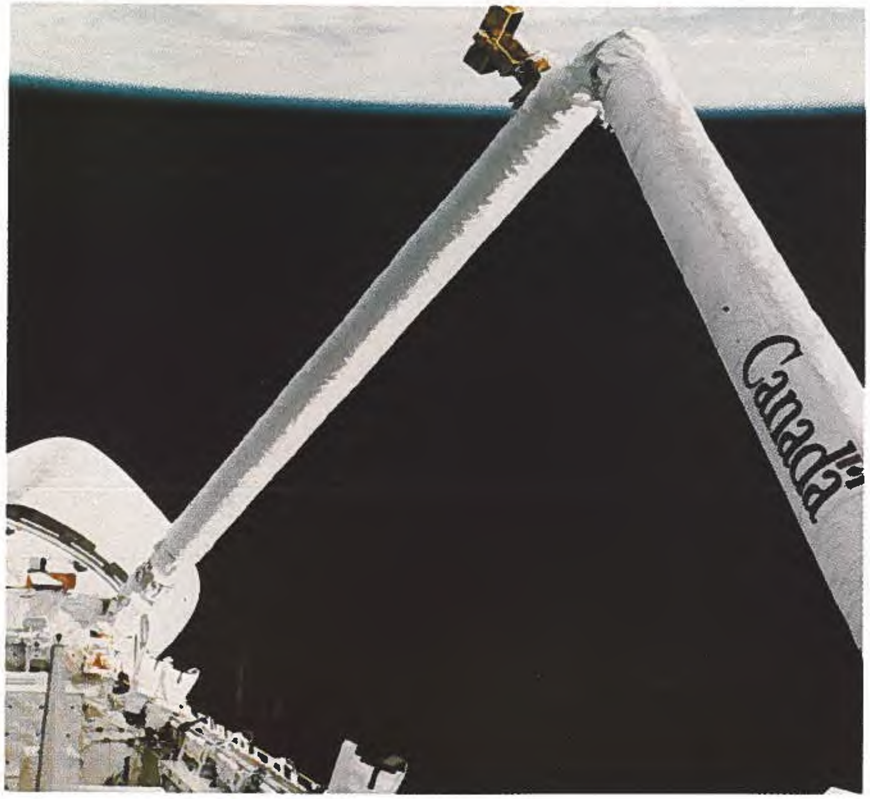
CANADA CAN DO IT

Can we do it? Canadian-owned and controlled enterprise has no doubt whatsoever — if we get the type of socio-economic environment favourable to sustain our growth and provided that Canadian institutions work together with a singleness of purpose. The CATA companies are already performing to the economic profile required. To amplify this success, they need only be brought to volume production. We have the need; we have a highly educated labour force; we have one of the highest savings rates in the world — hence the potential for a self-sufficient pool of risk capital; and we are the envy of the world in natural resources. There is no need for despair.

Canadian companies have a beachhead with the best in the world in a host of critical technologies ranging from telecommunications to nucleotide (DNA/RNA) synthesis chemistry and automation. All they need is a coherent national policy of unconditional encouragement and Canadians must buy their products.

The decision is now. If we are too caught up in living history to listen, then the future will pass us by. If we are prepared to act, Canada can become the country of the future. The Canadian Advanced Technology Association is prepared to do its part — are you?

CANADARM — Canada's Arm in Space



by Jeffery W. Rochon

Aerospace Industries Directorate
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On board the second, historic, flight of the space shuttle Columbia, launched on November 12, 1981, rode Canada's Remote Manipulator System, or RMS, recently dubbed the "Canadarm". The arm's success in space was a highlight of the flight and won a reputedly rousing ovation from the ground control crews.

Canadarm was built by a Canadian industrial team under a prime contract from the National Research Council (NCC) of Canada to Spar Aerospace Limited which has headquarters in Toronto and divisions in Montreal, Ottawa, Calgary and in California.

NRC's $100 million plus commitment to develop the RMS drew from the resources of the industrial team which consisted of Spar, CAE Electronics Ltd. and DSMA Atcon Ltd.; and from a Canadian government team from NRC's National Aeronautics Establishment, the Department of Communications (DOC) and Supply and Services Canada (SSC) with assistance from the Department of Industry, Trade and Commerce (IT&C).

The first Canadarm was a gift from Canada to the U.S. National Aeronautics and Space Administration (NASA) and, like the three additional arm systems to be produced for $74 million, will be used primarily to deploy and retrieve satellites from space or perform maintenance operations in space.

In September 1972, IT&C awarded Spar Aerospace a Defence Industry Productivity Program (DIP) grant of $750,000. This materially assisted Spar to compete for and acquire the task of developing the RMS for the U.S. Space Transportation System (or shuttle).

The department continues to finance Spar in developing new state-of-the-art manipulator technologies not only for space but for underwater and nuclear applications as well. By 1995 the expected market will likely approach $900 million with the market for space applications nearing $500 million.

The RMS, or Canadarm, is a six degree-of-freedom, 15 m (50 ft.) long manipulator arm attached to the port longeron of the shuttle orbiter cargo bay. The display and control system, the manipulator controller interface unit between the orbiter computers and the arm, and the CCTV and light systems complete the total RMS package.

The RMS is a major subsystem of the shuttle's Payload Deployment and Retrieval System (PDRS) and is used for deploying payloads from the orbiter cargo bay, retrieving them from orbit and returning them to the cargo bay. It also supports crew EVA (extra vehicular activity) and payload servicing.

The RMS is operated from the aft port window location of the orbiter crew compartment by a payload specialist using dedicated RMS controls and with the aid of direct viewing and closed circuit television (CCTV). TV cameras and lights are located in the cargo bay and on the arm.

The arm has six rotary joints connected by structural members. The sequence of joints starting from the orbiter interface is — shoulder yaw, shoulder pitch, elbow pitch, wrist pitch, wrist yaw and wrist roll. The arm booms are thin walled tubular sections made of graphite-epoxy with internal stiffening rings.

An upper boom (6.4 m — 21 ft. long) connects the shoulder joint to the elbow joint. The lower arm boom (7 m — 23 ft. long) attaches to the elbow joint and terminates at the wrist pitch joint. The end-effector is attached to the wrist roll joint.

Environment and weight considerations favoured the selection of an electromagnetic drive system. Each joint contains a motor module driving a high reduction gear train. The motor module is an integral assembly containing a brushless DC motor, a tachometer and an electromechanical brake. The drive systems are similar for all joints.

The standard RMS payload interface is the snare end-effector which mates with a grapple fixture attached to the payload, the result of IT&C funding.

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The word "laser" conjures up visions of the 21st Century. However, as the following article points out, this remarkable advanced technology is fast becoming a major factor in today's life. Canada has been making important contributions to this increasingly important field.

LASERS. . . Canada Taps New Technology Markets

A number of Canadian companies have developed a strong international presence in the "new technology" industries. State-of-the-art digital displays, marriage of computer and communications technologies, semi-conductor production, space and bio-engineering technologies — all have become exciting rapid growth players on the world stage.

Of particular interest is the Canadian laser industry.

The word "laser" is an acronym for "light amplification by stimulated emission of radiation". A laser is a device that uses an energy source and lasing medium (a material that gives off its own light when stimulated or excited) to amplify light waves and generate an intense and highly concentrated beam of light.

A great variety of laser systems and applications exists. Lasers can be solid, liquid, semi-conductor or gas. Output can be pulsed, as with a flashing light, or continuous. Thousands of applications range through almost all areas of human activity from medical and manufacturing to communications and warfare.

Several Canadian companies are involved in laser technology using a laser as a component of special systems benefiting from the unique characteristics of laser radiation or offering complete lasers as a part of a production line. The largest Canadian manufacturer of lasers, Lumonics Inc. of Kanata, Ontario, manufactures laser products exclusively and has become a specialist in the field of pulsed gas lasers.

Lasers have been developed for a wide range of applications such as for industry as on-line high-speed marking devices; for scientific research in the fields of photochemistry, spectroscopy, isotope separation and fusion; and for military as new types of range finding systems.

Photochemistry involves chemical changes produced by light, as in photography. Many chemists believe that laser beams have the potential for creating new and more cost-effective industrial chemical processes. Technical feasibility of several laser photochemical processes has been demonstrated at a research level and interest in such has been growing rapidly.

Spectroscopy is a well-established technique for analyzing the composition of matter. The use of lasers as spectroscopic light sources has extended the range, sensitivity and accuracy of spectroscopic instruments. Laser spectroscopy in the future may be used for real-time industrial analysis and control.

Controlled fusion research relates to the harnessing of the thermonuclear reaction to create electrical power and Canadian laser components have been provided for fusion research experiments in major western countries.

As Canada's largest laser manufacturer, Lumonics has pioneered in all of these fields and has developed considerable international markets.

One of Lumonics' major developments is pulsed gas lasers used in industry as high-speed on-line marking devices under the trade name of LaserMark®. This is an electro-optical system which forms patterns such as numbers, letters and logos by projecting a laser beam onto the surface to be marked. The surfaces absorb the laser energy by an instantaneous heating effect that changes the surface and produces the desired image.

The actual method of marking depends on the target surface. For example, ink is instantly removed from paper by vapourization; some plastics undergo a change which results in colour contrast; glass etches. Current LaserMark® systems cannot mark such surfaces as bare metals that reflect the laser energy or certain plastics that are transparent to energy.

The LaserMark® system consists primarily of a laser combined with beam delivery modules.

The laser is a pulsed carbon dioxide laser which has a demonstrated capability of safe, reliable operation in an industrial environment. Beam delivery modules include a right angle beam bending module, a mask holder, a focussing lens and beam delivery tubes. These modules can be assembled in a variety of configurations to

satisfy the requirements of specific installations.

Patterns are formed by placing a template or mask, usually made of brass and containing the desired mark, in the path of the laser beam. The beam passes through the mask and a lens creates an image of the mask on the target surface in much the same way that a slide projector projects an image on a screen. LaserMark® projects a reduced image that can be adjusted in size up to approximately 2 cm^2 (0.3 sq. in.).

Some important LaserMark® features are a high quality inkless mark that does not smear; a fully automatic and unattended operation resulting in increased productivity and reduced costs; and the ability to mark products moving at high speeds. In addition, it can clearly mark characters as small as 0.25 mm (0.01 in.) high and can mark on fragile or thin materials difficult to mark by conventional methods.

The Lumonics story demonstrates how a successful independent company, with financial help from the Department of Industry, Trade and Commerce, can evolve from the research activities of a government laboratory.

In 1968, scientists at the Canadian Defence Research Establishment in Valcartier, Quebec, achieved a breakthrough in laser technology. They developed a new laser that could be operated at atmospheric pressure rather than under the near vacuum conditions necessary for the operation of most other gas lasers.

It was called the TEA (Transversely Excited Atmospheric) laser and demonstrated the possibility of constructing a relatively low cost, compact but powerful laser which would have many commercial applications. It created immediate international interest.

Early in 1970, the founders of Lumonics applied for and received a licence from the Canadian Patents and Development Limited (the federal agency responsible for licensing government technology) for manufacture and sales rights to the new laser technology. Operations commenced in 1971 and the company has since grown to 150 people and has annual sales of close to $10 million.

As the Lumonics experience shows, there is an exciting future of continuing growth and personal opportunities in the laser industry. Interest in Europe for Canadian systems, particularly LaserMark®, is currently strong and continuing solid growth in both Europe and North America is confidently anticipated. An easing of world economic problems would result in even more rapid growth.

Keen interest and substantial expenditures on applied research and product development is a common characteristic of technology-based companies and can directly involve up to 25 per cent of a company's total staff. These activities force back technical barriers and open up unforeseen opportunities for young Canadians which did not exist and would not have been understood only a few years ago.

Canadians are rapidly losing the international image of being simply "hewers of wood and drawers of water". The exploitation of natural resources is being substantially augmented by the conversion of bright new ideas and technology into rapidly growing industries.

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Software: The Education of the Computer and the Opportunity for Canada

by J.R. Davies President, Systemhouse Ltd.

As computer hardware has progressed from the vacuum tubed monsters of the 1960s to the compact, powerful pastels of the 1970s and 1980s, one thing has remained constant — the computer is nothing but a paperweight without its software.

Computer programs — the software — are the line-by-line series of instructions which are fed into the computer hardware system, telling it what functions to perform.

It is software that sends the messages to the airline clerk to confirm your reservation, reads your bank card and dispenses funds, calculates your tax deductions on your pay slip, reads the message on your Atari console and blasts a Space Invader. It is software which our children are learning in the elementary schools; which was responsible for the million dollar hydro customer bills; which was blamed for the delay of the recent U.S. space shuttle; and which is touted as the billion dollar phenomenon of the 1980s.

Types of Software

There are two basic types of software — systems software and applications software.

Systems software controls the internal workings of the computer, such as the activation of a printer to generate reports or the movement of information from one area in the computer to another. It is similar to the human nervous system and the systems which control bodily movement. Systems software is generally unique to each computer manufacturer and is typically supplied by the manufacturer.

Applications software instructs the computer to perform specific user functions such as accounting, inventory control, temperature control or graphics design. Initially such programs were written in codes of ones and zeroes called machine language, corresponding to electrical pulses being on or off. The next generation of programming language introduced was assembly language where simple words like ADD or SUB automatically generated the codes associated with addition or subtraction. In the '50s and '60s, successively higher level languages emerged allowing programmers to tell the computer what to do with fewer and less complex instructions. These languages carried the names COBOL, BASIC, FORTRAN and PL/1 and are still used today.

The development of applications software is a time-consuming and meticulous exercise. Systems analysts must document the users' requirements and design the computer programs which will meet the information needs of the organization. Computer programmers then code, test and debug the programs according to the analyst's design. This whole process may take many person-years of effort.

Typically, larger computer users have satisfied their software requirements through their in-house system development departments. Smaller users, who could not justify their own departments, have relied upon independent software houses to develop their systems.

In recent years, as hardware costs dropped dramatically and labour costs increased, the cost of software grew — in some cases to two to three times that of the hardware. Businesses began to look for, and the system houses began to offer, packaged software or "proprietary products" which offer dramatic savings, both in terms of cost and implementation and debugging effort.

The Software Industry

This is the setting for the billion dollar phenomenon of the 1980s. The term is not used lightly and the statistics are compelling.

In the U.S., 1980 sales of software and other computer related services totalled $13 billion and this figure is projected to grow to $33 billion by 1985 — 60 per cent as large as the hardware business. Sales of proprietary software products (packages) will grow from $2.6 billion in 1980 to $8 billion in 1985 and $25 billion in 1990, or 30 per cent per annum.

Similar growth is expected in Canada. Evans Research Corporation predicts that total software revenues will grow from $253 million in 1980 to $745 million in 1985 and $2.2 billion in 1990, a rate of 27.3 per cent. Application package revenues will progress from $58 million in 1980 to $164 million and $549 million in 1985 and 1990 respectively, or 30 per cent.

This growth is spurred by the increasing penetration of computing into smaller businesses as hardware costs decline and by the growing awareness on the part of the modern executive that technological innovation will drive corporate growth and, indeed, survival. An issue last year of the Economist spoke of the emergence of three super industries, each based upon systems rather than products:

- **production systems** — which are expected to take over the business of today's machine tool manufacturers, providing versatile, intelligent manufacturing and control equipment, incorporating programmable robots and artificial intelligence;
- **administrative systems** — such as the oft-forecast "office of the future";
- **household systems** — which are expected, perhaps optimistically, to form the basis of one of the world's biggest growth industries for the next two decades.

All of which require software.

Perhaps one of the most impressive predictions is that which forecasts the revenue for the computer services industry to be $95 billion in 1984; however, if there were no software constraints, this revenue could be as high as $125 billion. It is within this marketplace — in which industry watchers are predicting there will be a $30 billion of unfilled demand in 1984 because of shortage of supply — that Canadian companies have enormous opportunities.

While Canada is unlikely to reverse the trade deficit in computer hardware and office automation products, which Statistics Canada currently puts at $1 billion and warns of $5 billion by 1985, the potential for a positive balance of trade exists in software.

Canadians have the technical skills and the ingenuity to build the programs which will balance the books and drive the robots worldwide. Due largely to the successes of companies like Bell-Northern, Mitel, Lumonics and Systemhouse, to name a few, Canada is developing an enviable reputation in high technology. Systemhouse recently opened nine offices across the United States to distribute and support its line of software products and within two months had signed over $1 million in orders. There is no question that the markets are there.

The going will not be easy. In an article in Business Week last year, John Imlay, the Chairman of Management Science of America, one of the leading U.S. software product companies, was quoted as "seeing many $100 million companies merging after 1985 to form billion dollar software houses." The small companies are threatened and traditionally small Canadian companies are the first to go.

Seizing the Opportunity

There are strategies which the survivors will follow. These strategies hinge on research and development, marketing and distribution and export market development.

Research and development is fundamental to the software industry. The trends point out clearly that companies will not survive and grow by focussing upon offering custom system development.

Funds must be rolled back into capitalized development programs to produce innovative and stable software products and to develop the appropriate marketing strategies to ensure successful product performance. The world of high technology moves quickly and an active research arm is critical to ensure that product offerings remain current and are not eclipsed by technical innovation.

This does not come cheap. For example, in the past year, Systemhouse has invested $8 million in product development and internally funded research exceeded $4 million. As a guideline, software companies should look at 6 per cent of revenues as a minimum investment in R&D, recognizing that anything less than $1 million will not do very much. Furthermore, governments must encourage such R&D primarily with tax incentives, but also with selected stimulative programs such as the Department of Communications' Office Communication program.

No less important is the establishment of a comprehensive marketing, distribution and service capability to sell and support product and service initiatives. Today's user is increasingly looking for a one-stop systems office where he can deal with a company which can not only advise as to his needs, but deliver the product, provide the after sales support and be a partner as his company grows and technology changes.

The marketplace will no longer tolerate a youthful band of itinerant programmers as the support group for its computing infrastructure. Within Systemhouse, one of the principal divisions is soley responsible for marketing and distribution analysis, performing sophisticated analysis of vertical markets and geographic deployment. Through this process, the company can justify its plans for expansion, a plan which calls for 16 new offices a year in the U.S. alone. Investment in each new office, to provide the necessary support to sales and service, typically averages $600,000.

Recognizing the limitations of the Canadian market, Canadian companies will have to develop the export markets for their software products. This will, of course, put additional pressure on the R&D effort to ensure products are adapted to foreign users. But the markets are there. Systemhouse has had success in selling its computerized graphics products in Australia and India and its systems development capability in Hong Kong and Malaysia. Canada's international image of relative neutrality facilitates entry into these markets. However, a greater effort is required on the part of the industry and the federal government to promote the Canadian software capability and ensure its inclusion in trade missions, trade fairs and so on.

The world is awakening to the software boom. The Americans are there, it is part of the Japanese industrial strategy and it must be part of Canada's. It will require recognition of the industry on the part of government, a concerted effort on the part of our educational institutions to produce the appropriate graduates and aggressive business planning by the member companies.

Canada has the opportunity to produce the billion dollar software houses mentioned earlier and Systemhouse intends to be the first.

CAD/CAM — while it might appear as just another of those acronyms that spew so glibly off so many tongues, the letters CAD/CAM are the keys for survival to an ever increasing number of Canadian manufacturers. In this article, Commerce's Bob McDonell examines the implications of Computer Aided Design/Computer Aided Manufacture (CAD/CAM) in the Canadian context.

Social Nightmare or Great White Hope?

All Canadians, whether they are associated with industry, commerce, finance, education or government, are now in the initial stages of what author Alvin Toffler described in his best seller of the same name "Future Shock".

While most of us are aware of the impact of microelectronics on data and word processing, few are aware that microelectronics when applied to manufacturing are having a similar effect on manufacturing from small machine shops to the largest multinationals.

Taken in total, the microelectronic revolution threatens the very fabric of our society as we now know it, and the question is not whether Canadians can afford it with our small population and diversified, scattered markets, but how we can adapt this new technology to the socio-economic realities of the 20th Century.

While the energy shortage has camouflaged the impact of CAD/CAM on our ailing automotive industry, one has only to look at the Japanese and German industry to see that both nations, through the extensive use of this technology, have been able to take advantage of the rapidly changing automotive market brought on by the worldwide energy shortage.

While North American automakers were saddled with an average seven-year gestation period from concept, through design, retooling and manufacture to the salesroom floor, the Japanese have, by their commitment to computer aided design and manufacture and their head start in compact cars, been able to cut this cycle to a fraction of the time required by our domestic producers. With North American manufacturers now making use of this technology, they will be able to narrow this gap, if not eliminate it.

The Japanese are also making full use of computer aided manufacturing. For example, one of Toyota's plants, the Kamigo engine plant built in 1965, is now so fully equipped with automatic equipment that you can hardly see any humans at all in the seven acres of floor space. Only 90 men work on each of two shifts at Kamigo's No. 9 machinery plant which produces 40,000 engines a month or 222 for every worker. Similar stories are found in many Japanese and to a lesser extent German industries.

As a result, they are capturing an ever increasing share of both our domestic and foreign markets. Toyota, for example, has taken over from Ford as No. 2 auto manufacturer in the world. Some Canadian manufacturers, however, are showing that similar results are possible in our domestic industry.

Canada's current successful entry into the executive jet transport market — the Canadair Challenger — has received worldwide attention as an innovative aircraft design. One of the reasons for this acceptance is the imaginative design concept of the Challenger wing which has been a significant factor in enabling the aircraft to meet performance criteria for a long-range business jet.

The aerodynamic performance of the aircraft is largely the result of an advanced airfoil, designed to offset the drag rise that normally occurs at high speed, thereby achieving fuel-efficient high cruise speeds. The airfoil has the added advantage that its wings can carry more fuel than similar sized wings due to a lighter wing structure which in turn results in a greater maximum range.

At Canadair, extensive use has been made of the computer for solving complex aerodynamic problems in the areas of analysis and design. According to Fortis Mavriplis, senior staff specialist at Canadair, "the computer saves a considerable amount of time and money on wind tunnel testing and configuration testing.

"With the techniques we used, we were able to reduce both the time and cost of developing the Challenger configuration. With the aid of the computer methods we were able to study many aerodynamic configurations before selecting the final basic one for wind tunnel testing."

The performance requirement placed on the Challenger and the proposed first delivery date for late 1979 pointed to the need for an extremely short design and development cycle. The project was given the go-ahead in November 1976 and just over two years later the first aircraft was flown. Typically the aircraft industry takes at least four to five years to complete this cycle, and Canadair engineers credit computerized design with being the major factor in its reduction, and the development of a more efficient aircraft design.

With the aircraft now in production, Canadair is using its numerical control program to perform the intricate precision milling, cutting and drilling needed to produce the various aircraft component surfaces.

This latter use of computers on the production line is one that will have a profound effect on smaller Canadian machining firms which have traditionally supplied parts and sub-assemblies to the large manufacturers. To remain competitive and indeed to even be invited to bid on sub-contracts, it will be necessary to have automated machinery capable of using the prime manufacturers' numerically controlled (NC) tapes or computer programs.

While most companies still provide their suppliers with blueprints for parts and sub-assemblies, as the number of NC and computer program controlled machines increase this practice will decrease and the sub-contractor will be required to bid on the basis of the NC tape or computer program supplied. Without the ability to utilize this technology, markets, profits and jobs will all disappear.

But CAD/CAM is not just computer graphics or design and numerical control of machine tools.

In its concepts and applications, CAD/CAM goes far beyond these two elements, and is much more integrated or systems oriented. As Jack Scrimgeour, consultant in the Technology Branch, IT&C, explains: CAD/CAM includes:

- Product design, including graphics, functional analysis, stress strain analysis, heat and material balances, simulation and modelling, data reduction and analysis and cost estimating of the proposed product or system to determine fitness of purpose, and economically optimized production.

- Record keeping, tracking and reporting on the status of individual customer orders, particularly when part of an integrated on-line manufacturing system.

- Scheduling and information handling pertaining to material requirements planning inventory control and order scheduling.

- Numerical and computer control of machine tools, lathes, milling, boring machines, pattern and fabric cutting, welding, brazing, flow soldering, casting, flame cutting and spray painting.

- Integrated materials handling using computer operated conveyors or robotic units.

- Automated inspection of machined parts, testing of electronic components, circuits and products, automated material inspection and grading using sensor based computer systems, pattern recognition.

- Computer implemented co-ordination of material and information in packaging, bottling, labelling and weighing systems.

- Computer implemented storage and retrieval systems involving order picking and material handling for both work in progress and finished goods inventory. Automatic label reading, routing of packages, parcels and baggage in shipping, sorting and distribution centres.

CAD/CAM technology will yield its greatest economic and productivity gains when all or most of the above application areas are married together to form an integrated system. Hence there is a strong development trend in this direction.

While there is a good deal of speculation as to when the factory place will become the fully automated computer operated manufacturing centre, there is no doubt that the pace at which machine is replacing man is accelerating, not only in the developed world but also in the less developed countries.

This acceleration will have a profound effect on our society, as thousands of factory blue collar jobs are replaced with hundreds or even as few as a score of highly skilled computer trained technicians capable of supplying the consumer market for specific products. Perhaps the most noticeable effect will be a shrinking employment market in manufacturing processes. In fact there is now a great deal of evidence that present very high unemployment rates throughout the industrialized world are as much a result of automation as they are of a worldwide recession brought on by escalating fuel costs. In the initial stages of automation, this has not proved to be the case as the development of new processes merely transferred jobs from the production machines to the design office and to the production of the new facilities.

And while automation threatens employment, many experts claim that a shortage of skilled people capable of programming and operating CAD/CAM machines and systems is holding up even faster development of the sector. This factor, the lack of competence, in turn presents a challenge to our educational system which must now gear up for the formidable task of providing the appropriate educational and re-educational facilities to retrain the thousands of workers with outmoded skills and the thousands of new employees coming out of our schools, colleges and universities with the knowledge and skills required to meet the challenges of the microelectronic revolution.

Is there a bright spot in this rather gloomy picture?

If one subscribes to Future Shock author Alvin Toffler's latest scenario expounded in his book "The Third Wave", the opportunities for agile, quick thinking businessmen are better today than they ever have been and this will continue in the foreseeable future. Toffler defines "the first wave" as the agricultural revolution which lasted 10,000 years. The second wave — the 300-year-old industrial revolution — is now in decline, he states.

As fewer and fewer workers handle material goods, Toffler explains, "advanced electronic technology will allow for greater and greater diversity in the marketplace, and much of it will be produced in the home.

"The third wave has an almost spooky relationship with the first wave when families worked in their fields together," he told delegates to the eighth International Symposium on Small Business held late last fall in Ottawa. "Now it is the electronic cottage family."

Toffler says the prolonged world economic downturn is not a recession or a depression, but a restructuring of our whole way of life. Whether a nation is capitalist, socialist or communist, he argues, it is undergoing similar pressures caused by energy shortages, price increases, unemployment, high interest rates and falling productivity.

As an indication of this trend to home employment he points out that in the U.S. alone 350,000 small businesses are run by women from their own homes. There are also work patterns emerging, with two days spent at home and three days at the office, since the single most unproductive activity is commuting. It is far cheaper to transmit information than to transport employees.

This, in turn, will have profound effects on cities — a social order dictated by the industrial revolution, when efficiency demanded that large numbers of factory and office workers be located in close proximity to each other.

When information, whether computer graphics or programs for machines, can be sent around the world within a fraction of a second more than it takes to send them from one office to the other in the same building, the necessity for large concentrations of population is greatly reduced.

While many people are apprehensive that the technology will result in greater and greater concentration of industrial power into the hands of huge international cartels, others are equally convinced that the opposite will happen, that the multinational corporations will find competition so great that they will not be able to cope.

Just such a revolution is now invading the computer and microelectronic fields, where many of the older, larger and more cautious companies are being forced out of business or adjusting their product lines to compete with small but innovative competitors.

Taken in this context, the very diversity that is possible through the use of the new technology will have special meaning for Canada with its relatively small and scattered markets. As world leaders in the communications field, with a sophisticated education system, and a very real need to cut our huge transportation costs, the new technology will enable us to develop Canadian products designed for the wide range of conditions found in this vast land mass.

Whereas previously, most of our major industrial products, due to the necessity for economies of scale, were adaptations of North American or European designs, the new technologies will allow us to design products for the diversity of Canadian conditions.

On the other hand, Canada cannot afford the huge costs of developing this technology on a piecemeal basis, in effect re-inventing the wheel for each step of the process.

To meet this challenge, The CAD/CAM Technology Advancement Council was formed in April 1978 by IT&C to provide a focal point for encouraging and assisting in the application of CAD/CAM technology in Canada. The council consists of 18 members, mostly from industry, with four from academic institutions and four from government.

The council's objectives include identification of general areas where Canadian industry can successfully utilize CAD/CAM, provision of a centralized source of information, promoting liaison between interested parties, maintaining liaison with foreign organizations and making representations to the government.

The council disseminates information on CAD/CAM technology through professional journals and business publications and co-sponsorship of conferences and seminars.

Perhaps its most ambitious project to date has been the compilation and publishing of the study "Strategy For Survival" which outlines the issues and recommendations of the council concerning the Implementation and Impact of CAD/CAM technology in Canadian industry.

The council report identifies many issues, discusses each in turn and makes specific recommendations. In summary, however, the council makes three main recommendations, one each to government, industry and educational institutions.

• To government, council recommends that a small inter-departmental task force be formed to prepare a formal response to the recommendations involving government contained throughout the report, and to initiate action where appropriate. There is a degree of urgency to this. Priority should be given to establishing the proposed Canadian Centre for CAD/CAM in an effective manner at the earliest date possible, and to those recommendations concerned with awareness, manpower, education and training.

• Council recommends to industry that virtually every manufacturing company in Canada should designate at least one person in a technical management capacity within the organization to become aware of developments in CAD/CAM technology, if this is not already being done, and to plan the response of the firm to the threats and opportunities that this new technology involves. A second step should be to establish links and mechanisms through development centres and technical societies for the definition and undertaking of projects meeting common needs on a group basis at minimum cost.

• To educational institutions, particularly universities and community colleges, council recommends that they examine their course curricula to ensure that CAD/CAM technology, particularly its systems and application nature, is adequately represented. It is further recommended that educational institutions examine opportunities open to them for the education and training of personnel in industry in computer aided design and computer aided manufacturing, with emphasis being given to course material and programs for in-plant training.

Further information on CAD/CAM may be obtained from the following publications, put out by the council and IT&C:

• **"Strategy for Survival".** The 1980 report of the CAD/CAM Technology Advancement Council

• **CAD/CAM and Canada Reprint.** An IT&C publication containing reprints of 28 informative articles on CAD/CAM technology.

• **CAD/CAM Directory.** A directory of companies and organizations providing CAD/CAM products and services in Canada. To be available in the near future.

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Technology Branch (61)
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Those Amazing Robots!

by Shirley Plowman

A humorous cartoon during the Seventies features two tape recorders in a psychiatrist's office — one representing the patient, the other the doctor. The patient's tape recorded voice drones on and on interrupted only by the psychiatrist's bored pre-recorded response.

Today this scenario is more real than funny. In fact, if we could step into a time machine and touch down in the year 1990, your doctor may be a computer, and the machine an excellent diagnostician. Dr. Computer will flash the questions to you over his video screen and you will type the answers. At the end of the session "your computer, the doctor" will make an instant and complete diagnosis along with recommendations for medications and treatment. Psychiatric evaluations can also be easily computerized.

George Orwell in his book "1984" was almost dead-on in his prediction of Big Brother watching you. By 1985 your TV set could be connected to a revolutionary pay-cable system called Qube. Through this unique device you'll be able to talk back to politicians and TV executives letting them know what you think of their platforms and programs. The chilling Orwellian feature, however, is that while you're watching Qube, Qube is watching you.

The central computer sweeps each subscribing household every six seconds, monitoring the programs you're viewing. The concern is that the privacy of a prospective employee could be invaded if a hiring company could persuade central computer executives to release information on personal viewing habits and political views. And this is only a fraction of a step away from the Big Brother abuse of Orwell's prophetic nightmare.

Warner Communications, which markets Qube, plans to offer interactive television within the next two years to subscribers in the two U.S. cities of Akron and Pittsburgh. From there it will go international and by the late 1980s it's predicted that two-way television will be in 8 million homes growing to 50 million by the year 2000.

Telephones, too, may soon be turned into miniature lie detectors. Equipped with tiny electronic devices that can measure emotional stress in a caller's voice, they intimate when a person is deviating from the truth. So much for the future success of the ear-to-ear salesman.

The truth detectors were a natural offshoot to the Psychological Stress Evaluator (PSE) now in use by psychologists, clinicians and the long arm of the law. PSE picks up microtremors too slight to be detected by our ears — and records them. The refined telephone truth boxes will be much more accurate and could open a Pandora's box of ethical and legal problems.

Less frightening and even funny are the lovable household robots who can be programmed to answer the door, wash and put away your dishes, vacuum your rugs and even have your martini chilled and waiting for you (complete with two olives) as you settle down in front of the Qube tube.

Stepping out of our time machine and into the present, we find ourselves in an automated factory of 1982. Here the industrial robots are busily loading and unloading parts from machine tools, punch presses and forging presses, injection molding machines and die casting machines. They are used for spot welding in automobile assembly and for spraying paint, fiberglass, enamel and other coating applications.

Unlike the awesome robot machine in the Stanley Kubrick movie "2001", industrial robots are not yet programmed to think on their own. They can be expected, however, to faithfully do the tasks assigned to them over and over again without once stifling a yawn or breaking for coffee.

"Like a numerically controlled (NC) machine tool, the robot assumes that the external environment is always the same," says Dr. John Evans, U.S. Office of Developmental Automation and Control Technology, U.S. National Bureau of Standards. "They cannot cope with uncertainties. A missing section or a section out of place can end up with damaged parts or with the robot welding itself to a car body."

Future robots will have more sensory capability to allow them to cope with unforeseen factors. "They will also incorporate self-diagnostic and error recovery routines to prevent predictable situations from becoming problems."

Industrial robots are only one aspect of computer-aided manufacturing.

Says Charles Panati, researcher and author of **Break-Throughs**, "Advances in microelectronics will permit the planes of the 1980s and 1990s to fly and land by themselves. Lightweight onboard computers will be programmed with entire prearranged flight plans in case of bad weather.

"All the calculations, including throttle settings, course headings and descent instructions, will be decided instantly by computers instead of flight navigation engineers."

A 1950s joke has the voice of the captain booming confidently from the cockpit: "Ladies and gentlemen, this is your captain speaking. We have levelled off and are cruising at 5,000 feet and everything is looking good from here. . . from here. . . from here."

During the flight, the computers will continuously analyze each engine's performance and fuel consumption, providing the crew with constant feedback on the flight's status. "The dashboard clutter of bobbing indicators and dozens of dials will be replaced by a concise digital read-out panel; one indicator will even signal bad weather ahead and the length of time left before the plane encounters it."

With the advent of magnetically levitated tracks, trains could be making a major comeback and at eventual expected speeds of up to 2,090 km/hr. (1,300 miles an hour) could even rival planes for intermediate distance travel. The new trains, or Maglevs, will offer smooth, silent rides over even the roughest terrain, floating above a V-curved aluminum track, levitated by supercooled magnets. It is expected that the Maglevs will be in use in Japan by 1983. They should be a common sight in North America by the mid 1990s.

Meanwhile, back at the factory. "The application of computers in manufacturing processes is just being recognized as a key way in which we can increase industrial productivity to increase our nation's wealth and standard of living," said Dr. Evans. "In turn this should reduce inflation, and improve international trade and competitive positions."

We are now in that in-between stage where the science fiction of Buck Rodgers is in the rapid process of becoming fact. The door to the future is tantalizingly ajar. We need only push through and pass over the threshhold into an exciting new world.

And what will we find? Electric cars, flying trains, and perhaps a longer, happier and healthier life.

It is predicted that by 1990 industrial robots will be a $2-billion-a-year business in the United States, a $2-billion-a-year business in Japan and a further $1-billion-a-year business in Europe. This article reviews the new technology and attempts to determine Canada's role in the use and manufacture of. . .

Industrial Robots

by John A. Beadle

Machinery Branch
Department of Industry, Trade and Commerce

The word robot usually conjures up in our mind a human-like creature, such as the friendly little androids in Star Wars. Unfortunately we are still a long way off from having these little creatures doing the dishes, mowing the lawn and taking out the garbage, but we are beginning to see their much less sophisticated cousins, **industrial robots**, appearing on the shop floor.

These robots are now loading and unloading conveyors, spot-welding car bodies, spray-painting finished parts and feeding parts into machining centres. Such operations are repetitive and very boring to human operators, but the robot is ideally suited to such work. It can work 24 hours a day without being tired or bored, it repeats the operation in exactly the same way each time and doesn't require a coffee break.

Robots are also taking over the noisy, dirty and dangerous jobs. For example one Canadian company, which manufactures leaf springs for passenger cars and light trucks, is using a robot to take spring plates, weighing up to 16 kg (35 lb.), from the exit point of a heat treatment oven.

Half of the plate is heated to about 1038°C (1900°F). The robot gripper takes the plate in the vertical attitude and turns through 90 degrees, while turning the plate to a horizontal attitude, and places the plate on the input conveyor to a roll forming machine. This was formerly done by an operator using tongs.

Most of the industrial robots currently being manufactured are considered as "dumb" since they have no problem-solving ability. If a robot is unloading pieces from a conveyor belt, the piece has to be oriented exactly right or else the gripper will not be able to locate it.

Extensive R & D is taking place to develop a vision system which will enable the robot to recognize a part that has not been pre-positioned, follow a seam for arc-welding, or select parts for an assembly operation. Another area being researched is the sense of touch so that robots can determine what they are holding.

AUTO INDUSTRY

The auto industry which has long been a user of automatic transfer machines is the largest user of industrial robots. It is reported that General Motors in the U.S. plans to spend more than $1 billion by 1990 to install more than 14,000 new robots.

In Canada, General Motors now uses industrial robots to spray-paint the inside of truck boxes, and also to weld rocker panels and rear filler panels for its trucks. At its new transmission plant in Windsor, robots will man all the major transfer equipment and will be used extensively in material handling. Ford has been using robots for a number of years to weld front floor pans of trucks and back panels of truck cabs.

At the other end of the scale industrial robots are being used by smaller manufacturers to perform tasks such as loading and unloading molds and presses. In Canada, Husky Injection Molding Systems Ltd. uses robots to remove the plastic parts from the mold.

In small batch manufacturing like metal cutting — a fragmented industry — enormous gains can be achieved by the introduction of industrial robots. The efficient utilization of modern CNC machining centres often necessitates a two or three shift operation, and it is becoming increasingly difficult to recruit shift workers. The work is also monotonous, arduous and dirty which results in a high worker turnover.

The application of industrial robots to this type of operation results in better utilization of machines, shorter throughput times and higher and more uniform product quality.

NEW TECHNOLOGY BENEFIT

It is in this area of small batch manufacturing that Canada can probably gain the most benefit from the new technology. One of the major problems encountered by Canadian manufacturers has been the relatively small domestic market and the associated small production runs compared to those of other industrial nations, especially the United States. This has resulted in higher per unit cost for Canadian produced goods.

With the introduction of industrial robots these manufacturers should be able to achieve considerable productivity improvements by way of improved utilization of machines, material and manpower savings and flexibility of operation. This will result in the production of competitively priced goods for the domestic market and in turn for the international market.

If Canada is to remain a serious competitor in the international market place for manufactured goods, manufacturers must start **now** to analyze **all** of their operations to determine whether the new technology could improve their products or processes. Our major competitors in the international market, the United States, Japan and Europe, are all committed to the use of industrial robots — can we afford to wait?

WHAT IS A ROBOT?

There are many definitions of a robot but the most generally accepted seems to be that of the Robot Institute of America. A robot is a "reprogrammable, multi-functional manipulator". It is the ability to switch from one task to another that makes the robot so attractive to the production of small batches where automation has not been possible before because of its prohibitive "up-front" costs.

In more practical terms an industrial robot system consists of three main elements:

— control equipment
— measuring and servo system
— mechanical system

The control equipment is based on microcomputer technology which allows for very comprehensive programming facilities. The measuring and servo system controls the movements of the robot. The mechanical system can have a number of configurations, the more popular being:

Polar arms — this has an extendable arm mounted on a central pivot. The arm can thus swivel around the central pivot, reach backward and forward and can tilt to reach above and below the level at which its mounted.

Anthropormorphic arms — like human arms, these can bend and swivel at the "shoulder" and bend at the "elbow". These are the most flexible of robotic arms.

The robots may be driven in three ways:

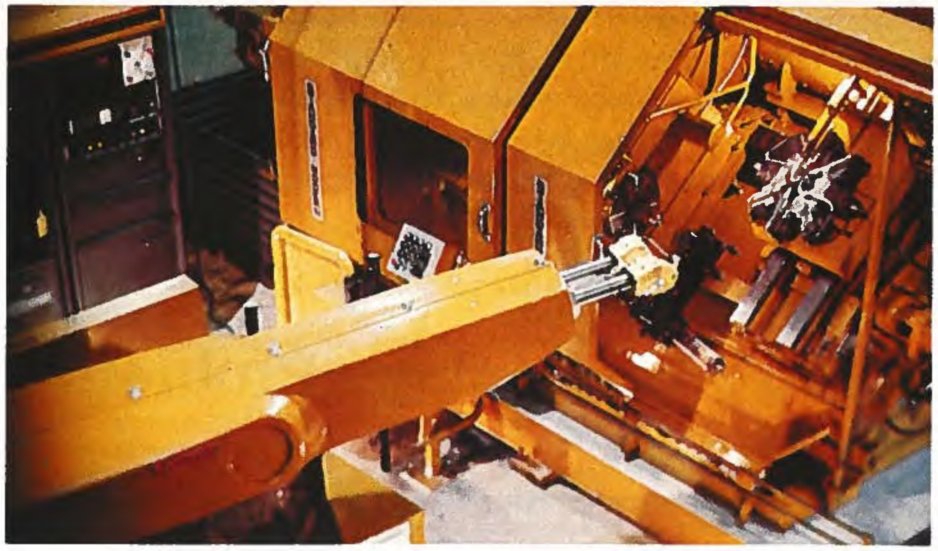
Pneumatic drives — use compressed air to move the arms. Lightweight, fast and relatively inexpensive, however cannot provide much strength.

Hydraulic drives — much stronger than pneumatic drives, but more expensive and messy.

Electric motors — the strongest and most expensive drive.

To each of these configurations, a variety of 'hands' can be attached — suction cups, ladles, pinchers, grinders, welding tools and spray-guns.

There are now more than 200 manufacturers of industrial robots, the majority of them in Japan, offering a wide range of applications and price. In Japan, Fujitsu Fanuc Ltd. has constructed a plant which employs robots and NC machines to produce other robots and computerized machine tools. At the present time the robots produce all the component parts and



employees assemble them. By 1985 Fujitsu hopes to create a robot that will be capable of assembling the robots!

In Sweden, Europe's leading robot user, ASEA robots are used in an automatic arc-welding robot station.

In the U.S. Westinghouse is developing a robot assembly line to put together five different types of electric motors. The major manufacturers in the U.S. are Unimation Inc., Cincinnati Milacron, and General Electric. Cincinnati Milacron is designing systems that will integrate robots with its machine tools and other plant machinery. General Electric is looking at complete factory automation. Unimation is concentrating on the general application of robots.

The cost of industrial robots is still quite high, ranging from $7,500 to $150,000, but the payback periods are claimed to be from one to three years. Experts have predicted that a robot will produce the same output for $1.25 an hour as a human laborer will produce for $12 to $15 an hour. And as robots become more numerous and competition grows, the prices can be expected to fall.

CANADIAN USERS

In Canada a number of companies are using industrial robots, but by international standards, Canada lags far behind its competitors. The main users in Canada are the large companies, particularly in the automotive industry and the electrical equipment industry. At the present time, to the best of our knowledge, no one is manufacturing industrial robots in Canada, although a number of companies are working with the National Research Council on research and development programs.

One aspect of the introduction of robots that is causing some concern and which may be delaying their widespread use, is the effect on employment. Will these machines be taking away peoples' jobs? Certainly robots will be taking over some of the dirty, boring and hazardous jobs.

However, it has been found in both the U.S. and Britain that increases in productivity, which result from the introduction of a new technology in an industry, are accompanied by an increase in employment within that industry.

Also to be considered is the fact that if the new technology is not adopted by Canadian industry then it will become even less competitive in the international market place and in the longer term the jobs that would have been lost to robots in Canada will be lost to robots in other countries.

This has been a very brief and incomplete look at industrial robots, but it is hoped that it will encourage Canadian manufacturers to at least start thinking about how the new technology can help them.

The Department is anxious to help Canadian manufacturers to both apply industrial robots and to encourage their manufacture in Canada.

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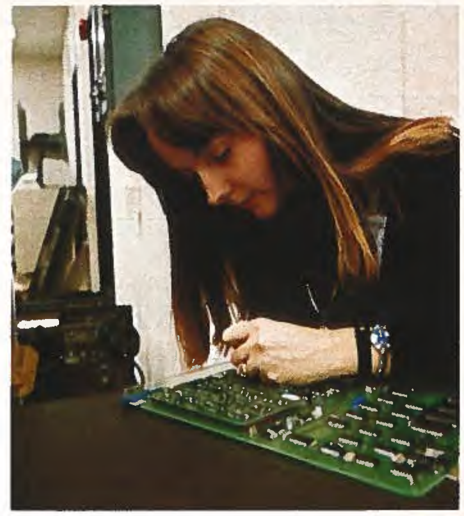
High technology is now an established fact in many aspects of industrial, commercial and even private life. But where are the highly skilled workers so absolutely necessary to meet the challenges of this fact. This article, specially prepared for Canada Commerce, looks at . . .



Manpower — A High Technology Problem

by Mark Buckshon
Canada Employment and Immigration Commission

They are a special breed, working in the world of the future.

At home with far flung ideas of practical value and comfortable in an environment of computer terminals, banks of electronic machinery and precision instruments, Canada's high technology workers belong in a class of their own.

They are sought out by new companies growing at a rate of 100 per cent a year or more. Some with special skills and competence receive several job offers a month from competing firms and private employment agencies. Others have plans to start their own businesses, turning bright ideas into products sold around the world.

It sounds like fantasy, but isn't. The high technology pioneers are exploring a new frontier — but this time it is in one or two-storey buildings in modern communities.

There is only one problem. Not enough people are following the high technology trail.

"People are the major constraint on growth," says Paul Kennedy, manager of services planning for Canada Systems Group Ltd. (CSG) in Toronto.

"The interesting thing about the high technology sector is that its growth is a straight function of available talent," notes Bob Long, executive director of the 110-company Canadian Advanced Technology Association (CATA).

A SCRAMBLE FOR EMPLOYEES

The story is the same in all the Canadian communities where high technology is big business. Companies are scrambling to find enough systems analysts, computer programmers and electronic technicians and engineers to meet the fast-paced international competition. Highly educated engineers in specialized fields are in short supply; so are two-year community college graduates who feel at ease in the world of microelectronics and computer systems.

Manpower shortages, industry spokesmen say, are high technology's most pressing problem. The $4-billion-a-year information processing industry could grow to five times that size by the end of the decade, but a shortfall in the number of people required to support that growth might reach 50 per cent, The Financial Post has reported.

Meanwhile, thousands of unemployed Canadians would be happy to have any kind of job, but they don't have the right skills. This manpower imbalance touches the raw nerves of the Canadian economy; workers and management alike are looking for a way to end the waste of economic potential.

"I don't think government can do it by itself, and I don't think industry can do it alone," says Pierre Leclerc, a Canada Employment and Immigration Commission (CEIC) official responsible for encouraging high technology manpower planning. "At least they haven't been able to do it in the past."

Industry representatives agree. "I think we need to co-operate and co-ordinate industry and government's needs," said Ronald Marriott, an executive of Honeywell Ltd. in Willowdale, Ontario.

Marriott outlined a problem for his company-sponsored training school. "As an example, I just ran an ad in the Globe and Mail for Instructors," he said. "I got 20 applications but I got not one with the qualifications I was looking for. That is pretty poor when there are so many unemployed."

Honeywell's problems are dwarfed by those of public institutions, which face simultaneous pressures of increasing enrolment, budget restraint, and employment "headhunters" luring first-rate professors away to high-paying industry jobs.

RETRAINING NECESSARY

Adding to the problems, once the students graduate from trade schools, colleges or universities, they are still not ready to work in industry. "One problem I think is we're getting people out of post-secondary institutions who in effect have to be retrained," said Paul Kennedy at CSG. "There's really no focus on what we (industry) have to do."

As an answer, industry, academic and government officials have started getting together in local councils to assess community manpower requirements and work out appropriate training strategies. The Ottawa-Carleton Industrial Training Council — in the region with the most high technology activity in Canada — has taken the lead in co-ordinating federal and provincial government and industry resources. "We appear to be breaking new ground with Algonquin (College) and the universities," said council chairman Jack Fawcett, a vice-president of the Computing Devices Company in Ottawa.

The council surveyed Ottawa area high technology manufacturers and found, among others, these results: The region alone will require 953 electrical engineers, 627 electronics engineering technicians and 590 electronics technologists by 1983. But local colleges and universities will graduate only a fraction of that number.

"We're working as fast as we can," said Rod McLeod, an Ontario region training consultant for the CEIC. "We hope to have advanced training start in the fall."

McLeod was referring to a training approach that marries the resources of colleges, employers and the CEIC. That combination of on-the-job and classroom training sponsored by industry and supported by government assistance programs is emerging as the most effective way of putting needed skills to work.

The training is costly. In the 1980-81 fiscal year, the federal government spent more than $6 million to train some 2,100 high technology workers through the Canada Manpower Industrial Training Program and the classroom-based Canada Manpower Training Program.

To make these programs work in the high technology field, traditional concepts about training have had to be revised. The CEIC training schemes have primarily been used to develop skills in occupations which do not require extensive post-secondary education (under CMTP and CMITP, the maximum subsidized training time is one year). Innovations include making use of a new program for Critical Trades Skills Training, which extends the subsidy period, and compressing conventional training for computer programmers and electronics technicians to meet specific job requirements.

A DAUNTING TASK?

That might seem to be a daunting task, especially to those who still believe a BSc degree in Computer Science is necessary to begin a programming career. But Canada's computer service industry, represented by CADAPSO (Canadian Association of Data Processing Service Organizations) is now discussing a proposed programmer training program, using CEIC financial support. The new program, if approved, could be operating within a year.

These training efforts are a start, but so far they are only scratching the surface of the industry's needs. In the Ottawa region alone, officials predict that high technology firms will generate some 100,000 new jobs in the next decade. Industry associations such as CADAPSO, CATA, and the Electrical and Electronic Manufacturers Association of Canada (EEMAC) are hearing from members across the country, all trying to come to grips with the manpower shortages.

"It's a worldwide problem," said Bob Long of CATA. "We're talking about, all economics aside, a very human thing."

He added: "It's (manpower supply) a life or death matter with the industry. It gets to the point where you have to make a decision, you have an investment to protect."

Meanwhile, Leon Balcer, executive vice-president of EEMAC says: "Members of our association are very worried about having to face manpower shortages in the immediate future. The present output of the universities and technical schools, at the present rate, will certainly not meet the requirements."

SOLUTIONS SOUGHT

EEMAC, which represents about 250 firms employing some 120,000 people, has decided to do something to solve the problems. The association surveyed its member companies last summer to discover key manpower requirements through 1984. Now EEMAC and the CEIC are working together to set up a human resources development plan. This would follow the model of national manpower planning agreements signed in 1981 by Employment and Immigration Minister Lloyd Axworthy and representatives of the Canadian Council of Professional Engineers (CCPE) and associations representing the mining, coal, aircraft and aerospace manufacturing, foundries, and shipbuilding and repair industries.

The agreements set out a framework for co-operation between industry, labour and government in surveying manpower requirements, developing training schemes and implementing Progressive Employment Practices to increase opportunities for women and minorities.

Pierre Leclerc of the CEIC says the industry-wide agreements are intended to encourage individual firms to develop their own manpower planning strategies. With this approach, companies can unlock their manpower shortage problems — they have the ability to look down the road and take steps to recruit, train and retain skilled workers before serious problems arise.

Leclerc says high technology companies, large and small, can benefit by joining in the manpower planning initiatives. He said small but growing firms are able to reap real benefits through simple planning techniques. "We have staff at our regional offices in each province who can explain how manpower planning works, and possibly offer some financial support for training," he said.

Leclerc and Leon Balcer of EEMAC acknowledge that the challenge in overcoming Canada's high technology manpower shortages is great. "Co-operation between government and our industry is most welcome and is absolutely necessary to reverse the tragic trend that is forecast," said Balcer. "We have to act now because it's going to be real tough for years to come."

Leclerc, speaking for the CEIC, agrees but notes: "The ingredients for solving the problem are in place. The industry and government are aware of the difficulties and both have already started on the road to solutions.

"Training is increasing, manpower planning is growing in the industry and the co-operative spirit is present," he said.

Integrated Electronic Office

by George R. Young

Electrical and Electronics Branch
Department of Industry, Trade and Commerce

The phrases "Office of the Future", "Office of Tomorrow" and "The Paperless Office" conjure up science fiction images of banks of flashing lights and talking robots. In reality the technology is currently or will soon be available to integrate and automate a good many of today's office functions.

For example, it is possible today to buy computers and terminals, word-processors, intelligent photocopiers and electronic telephone exchanges. In spite of this, most office workers still store information on pieces of paper in filing cabinets, still call and leave messages for people not at their phones, and still feel cut off from computing power by a wall of data processing experts with their knowledge of programming languages.

There are tremendous possibilities for increased efficiency in the office, because many of the functions of the present office, such as filing, are done in the same manner now as in the office of 50 years ago.

The recent developments in the computerized information area such as the reduction in cost of computer memories and processors, have made possible the economic storage of massive amounts of data electronically rather than using paper.

Such a changeover requires investment — and the investment in the office process, for things other than land, buildings and furniture, has historically been minimal. If the manufacturing and agriculture sectors had followed this philosophy without investing in mechanization and automation, our standard of living would be much lower today.

The company which ignores the possibility of becoming more competitive by increasing efficiency in the office and instead relies on investing only in automation of production, for example, runs the risk of being left behind by other more progressive organizations.

Herb Gray, Minister of Industry, Trade and Commerce, in a speech he gave at the August 1981 official launch of the AES Data Alpha-plus self-contained word-processor, talked about the integrated electronic office as being "a means of improving productivity and efficiency in an area vital to all parts of our economy". While the development and production of electronic equipment is certainly important to Canada's

economic well-being and balance-of-payments, the efficiency gains on the user side by "adoption and diffusion" of the modern office techniques should not be ignored.

The person in the office responsible for making the decision on the degree of automation and the equipment needed is faced with many dilemmas in a rapidly evolving market.

Numerous competing companies with backgrounds in data-processing, word-processing, office equipment and telecommunications offer systems or parts of systems, and each, of course, sees its expertise as the central core technology. The trap of waiting to let the market decide on the optimal system carries with it the penalty of continued high cost conventional office techniques.

Alternatively, the many pitfalls of plunging immediately ahead await companies embracing too quickly the glittering technology available without adequate planning to assess real needs and economic benefits of automating.

GOVERNMENT PROGRAM

The Canadian government is tackling this problem, in its departments, with an interdepartmental program called the Office Communications Systems Program, jointly sponsored by the Departments of Industry, Trade and Commerce, and Communications. Under this program, user departments are encouraged to systematically examine their office automation needs rather than to proceed on an ad hoc basis. Funding assistance is provided for selected departments to hire competent consultants to determine office needs, and implement systems on a small scale pilot basis. Based on results of the pilot study, a decision on a full scale implementation is made.

The information gathered from these field trials will be made available to Canadian industry so that equipment can be developed which more accurately reflects the real needs of office users. In a rapidly evolving field such as this, where definitions of product boundaries and functions are still being formed, this kind of research can provide a valuable supplement to a supplier's knowledge of the customer.

Other, more tangible, support is available to manufacturers under the Enterprise Development Program through which the Department of Industry, Trade and Commerce assists companies with the development of innovative new products. Canadian companies with the support of this program are currently developing the integrated electronic office systems which

it is hoped will be the standard office equipment of tomorrow.

The government is not the only body that can make use of the pilot study approach. There are probably not many industries that would not benefit from increased office productivity. The difficulty lies in economically justifying the capital expenditure on electronic office equipment, because increased office productivity is often very difficult to measure or even define. Highly structured tasks such as typing have already been addressed by the word-processing vendors. But the relatively unstructured tasks of managers and professional workers make productivity and productivity increases harder to measure.

Take, as an example, non-simultaneous communications. How much is it worth to an organization for its members to be able to send instant messages to eachother, and **know** that the message has been received? If this question can be answered, the decision to acquire electronic messaging equipment can rationally be made.

The alternative procedure in the conventional office to transfer information is for one person to call another by phone (simultaneous communication) which succeeds in less than half the tries, or to leave a message with a third party and hope that it gets through. Electronic messaging is but one example of the possible features of the integrated electronic office but it is one service that any manager or professional can appreciate.

Similar benefits are available from electronic filing, distributed data processing, intelligent PABXs (private automatic branch exchanges) or whatever label attaches to a system designed to put computer power directly into the hands of the office user.

Currently, in Canada, some companies are experimenting with and using electronic messaging type systems and, in general, find that once these systems have been implemented, they become virtually indispensable. Canadian suppliers are now developing integrated office systems and the software to make the equipment user-friendly to gain the acceptance of the office worker.

This topic of user acceptance is one of vital concern to users and suppliers alike. Computers are available now but most office workers don't make use of them. The barrier of programming languages keeps many from enjoying the benefits. The requirement for keyboard skills as a method to gain access to computer power prevents still others from progressing toward the integrated electronic office concept.

The challenge then is to provide a system which office workers can use with little or no training to process information themselves by directly accessing computer power. The era of computers used only to process transactions or generate reports is drawing to a close. The software to integrate electronic office equipment is being written today.

Progress is just around the corner.

For further information, please contact:

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Canada Comes on Strong in Telecommunications

Canada's vast distances and relatively sparse population plus large urban centres scattered across the land have meant that communications links have become extremely important to the well-being of the nation. As a result, this country has developed technologies that have given it a well deserved reputation as a world leader in one of the most highly sophisticated industries of our time. While the industry must continue to refine present technologies, come up with new developments and cultivate more aggressive marketing techniques, the following overview presents an encouraging picture. . . .

Canada has three separate and complementary microwave systems across the country from east to west, as well as a domestic satellite communications network with more than 100 satellite earth stations. There are over 160,000 kilometres (100,000 route miles) of microwave system connecting Canadian communities.

Canada's telephone network, which connects more than 19 million telephones, is rapidly converting to the digital mode to take full advantage of the reliability and economics of this new technology. Canadian telephones in service are more than 60 per 100 population, making Canada number four in the world in terms of number of phones per 100 population.

Two geostationary satellites provide effective and reliable communication services to the entire country, reaching the most remote areas of Northern Canada. The Telesat domestic satellite system will soon be operating one of the first 12/14 GHz commercial communication satellites. This will be followed by the Anik D, a new design of the 4/6 GHz satellite series.

The challenge to meet the needs of the rural subscriber has been met by the employment of VHF, UHF and microwave technology where the traditional wireline telephone service cannot be extended economically. Canada operates the world's largest mobile radio system with 23,000 subscribers, primarily serving the Canadian petroleum industry in Western Canada.

Telephone Sector

A complete line of digital switching systems are among the most important high technology exports from Canada to the United States and abroad. Canada has earned a world reputation for excellence in the supply of telecommunications equipment such as PBX, data and voice transmission systems and custom integrated circuits for the telephone sector.

Among the most significant of these technological developments are the digital exchange switches, designed for both remote and densely-populated urban centres as well as for international gateway applications. These switches and sophisticated new transmission techniques are providing the backbone of the Canadian communication networks of the future. They have proved to be reliable, efficient and can operate in only a fraction of the space required by earlier electro-mechanical equipment.

Digital switching capability is gradually being extended into rural areas through the employment of remote line modules homing onto a parent switcher, thereby extending sophisticated urban-grade communication services into lightly populated areas up to 80 km (50 miles) away.

Telephone terminals have gone through a radical series of developments over the last few years and this evolution will accelerate. Increased use of electronic digital exchange switching and the addition of tone-to-pulse converters to many rotary dial phones have speeded the trend toward all-push-button telephones.

Various Canadian manufacturers offer state-of-the-art digital PBX's business communication systems and packet switching systems. Canada can provide low cost microprocessor-based units that combine

data processing, word processing and communications capabilities in desk top models. A new large capacity business PBX has recently been announced for large corporations handling requirements from a few thousand to 30,000 telephone lines.

Highly professional consulting engineering firms provide a full range of services to the telephone industry. These include preliminary investigations, advisory services, design engineering, project management, traffic and rate studies, specialized design and development services.

Fibre Optics Systems

Fibre optics has been used in communications in Canada since 1976 and many field trials have been undertaken. As a result, Canadian industry has a leading position in this new technology. Applications include a residential area of Toronto where households are being used to show the practicability of simultaneous trans-

mission of telephone, data and television in urban fibre loop facilities under working conditions. In the rural environment an extensive field trial co-sponsored by the Canadian Telecommunications Carriers Association, the Manitoba Government Telephone Co. and the Department of Communications connects 150 rural homes with telephone, television, radio and data communications.

A major installation that is to carry more than 20,000 voice circuits in the Province of Alberta is being completed, one of many trunk systems. A project that will be one of the world's longest fibre optic broadband systems is being constructed in Saskatchewan carrying 12 video channels. The system is planned to ultimately reach most major communities in the province and will have a system length of 3,200 km (1,800 miles).

Space Communications

Among the member states of the International Telecommunications Satellite Consortium (INTELSAT), Canada ranks tenth in terms of its spacecraft investments.

TELESAT Canada was formed on September 1, 1969, by an act of the Canadian Parliament to own and operate the world's first domestic satellite system, launched in 1972. With more than 100 Canadian manufactured satellite earth stations of about 14 different types and sizes ranging from large stations with 30-m (100-ft.) antennas to small transportable stations down to 1.2 m (4 ft.) antennas, TELESAT now offers a wide variety of services to the remote areas of Canada, as well as the populated areas. Its industrial centres are linked together and to the Canadian north through the TELESAT network and to the rest of the world through TELEGLOBE facilities including satellites. The Canadian space industry has established a high reputation for standard of excellence and is particularly respected for strengths in the innovative design and manufacture of satellite earth stations and satellite antennas, transponders, and specialized spacecraft components and control subsystems.

Internationally, Canadian industry has co-operated in joint ventures with U.S. and European industry to the extent that Canadian content in the form of mechanical and electronic subsystems is to be found in most of the world's commercial communications satellites. An example is the U.S. Tracking and Data Relay Satellite Spacecraft which carries essential electronic subsystems designed and manufactured in Canada.

In co-operation with the National Aeronautic and Space Agency of the United States, Canada designed and manufactured for NASA the critical Remote Manipulator System (RMS) for the Space Shuttle Transportation System. RMS is a remotely-controlled mechanical arm, some 15 m (50 ft.) long with six degrees of freedom, which will be used to unload the payload from the Shuttle while in weightless orbit. Three additional RMS units are currently being manufactured for NASA.

During 1976, the Canadian space industry was consolidated to create an industrial structure capable of undertaking prime contracting responsibility for complete communications satellites. In addition, SPAR Aerospace Limited is currently under contract with TELESAT Canada to provide the ANIK D series of two satellites. Canadian government agencies and Canadian companies are active in international co-operative space projects.

In addition to the work with NASA, Canada has a co-operative development agreement with the European Space Agency (ESA) and is strengthening its involvement in that agency's programs. Canada is currently taking part in the definition phase of ESA's L-SAT, a large communications satellite with a proposed 5.5. kW power supply, intended to provide communications coverage of Europe for a range of services.

Cable Television

Leaders in the cable television (CATV) industry since its inception, 526 Canadian CATV systems companies serve four million subscri-

bers. Thirty per cent of the subscribers have access to 30 TV channels while the remainder have 12 channels available. Canadian companies design, manufacture, install and operate the Canadian CATV systems as well as providing equipment and services in Europe

and the United States.

The world's longest coaxial CATV trunk system has been placed in service in the Manitoba Telephone System to link Winnipeg, Manitoba's capital city, to four rural communities. The cable system linking Manitoba's two largest cities, Winnipeg and Brandon, is 234 km (146 miles) long and utilizes unique low distortion amplifiers developed in Canada to provide high quality bi-directional CATV signal transmission of up to eight channels in the forward direction and four in the reverse.

There are more than 75,000 km (45,000 miles) of cable in place across Canada. The cablevision industry in Canada employs more than 5,000 people.

Videotex

In 1978, Canada's Department of Communications (DOC) announced the development of an advanced videotex terminal called Telidon, capable of producing images with a much higher resolution than currently available equipment. Superiority is also exhibited in flexibility and compatibility of data bases with different terminals and having a designed capacity for future expansion.

In early 1979, Bell Canada initiated a pilot, trial videotex system known as Vista, which used the public telephone network to transmit graphic and textual information stored in data banks. A joint $10 million industry government program is in progress whereby up to 10,000 terminals will be put in

operation to stimulate the Telidon industry.

Subsequently other Canadian firms, notably Norpak, Electrohome and AEL Microtel, have taken up the Telidon technology and are now manufacturing a range of Telidon hardware and equipment. Northern Telecom is also considering current market opportunities and could enter some specialized areas of the Telidon field.

Canadian Telidon hardware and information services companies are finding early acceptance in Venezuela, Germany and the United States. The Telidon protocol has also been recommended by AT&T and should encourage its adoption as a North American standard.

Research and Development

Canadian telecommunications equipment manufacturers maintain their own R&D and test facilities for all types of telecom systems. These include areas such as satellites, satellite earth stations, digital switching and transmission, fibre optic systems, CATV, microwave and coaxial transmission, mobile radio, etc. The Canadian telecom research annual investment is approximately $250 million per year.

Electronic Components

The Canadian electronic/telecommunication industry is supported by an active group of components manufacturers who tend to specialize in excellently engineered, high technology components for specific applications. Included in such applications are space, nuclear and the higher technology communications and industrial equipment. The military market is a major user and many Canadian component manufacturers are qualified under the well-known MIL Standards, thus ensuring the utmost degree of reliability and quality. It is becoming standard practice for many companies to incorporate the requirements of IEC specifications into their designs.

The majority of the microelectronics R&D and manufacturing capability is located in the Ottawa region. This activity includes the private sector, government and university laboratories. The technologies found in this area are silicon, compound semi-conductors, e.g. gallium arsenide, thick film and thin film.

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A world in which bacteria can be harnessed and put to work for the benefit of mankind in a host of ways is "just around the corner". It is the result of scientists working in a field of high technology that deals with chemistry, biology, bacteriology — almost anything but microelectronics. It is. . .

Biotechnology — Making Microbes Work for Man

by David Spurgeon

A growing number of far-seeing scientists, policy-makers and industrialists are trying to ensure that Canada does not get left out of the promising new high technology field called biotechnology. Spurred on by its enormous potential in such diverse areas as mining and medicine, they are following the lead of other major industrialized powers, stepping up R&D in the field and establishing new agencies in which to carry it out.

And with good reason. Industrialists and scientists alike are using superlatives to describe the promise of the new field and the importance of the scientific discoveries that led to it.

William N. Hubbard, president of the Upjohn Company, describing one of biotechnology's basic techniques (genetic engineering), said it would "place into the hands of men one of the most potent technologies that has been developed since fire was employed and stone tools developed." Maxine Singer, chief of the biochemistry laboratory of the U.S. National Cancer Institute of Bethesda, Maryland, wrote in a special issue of the journal **Science**: "It would be foolhardy to try to predict specific outcomes. We can be certain only that they will be unexpected and astonishing." And Dr. Stanley Martin, retiring head of microbiology at Canada's National Research Council, said: "I was at a symposium in Guelph recently and the general opinion was that we're in the midst of a biological revolution."

REMARKABLE PRODUCTS AND PROCESSES

It's a revolution that eventually may lead to remarkable products and industrial processes. For example:

- Plants (perhaps including food crops like wheat and corn) that provide their own nitrogen fertilizer, and new varieties of plants with genetic characteristics that protect them against disease, salty soil or drought.

- Vaccines and antibiotics of exceptional specificity and efficiency, tailor-made from the molecules of the disease organisms they are designed to prevent or attack.

- Synthetic hormones and other bodily substances (such as insulin and interferon, already being produced) that are replacements for the originals because the originals will have been used as models in making them.

- Pesticides and herbicides that are much more efficient than those of today yet non-toxic to animals and humans.

- Microbes that can recover fuel oil economically from heavy petroleum deposits such as tar sands or shale, and others that can leach base metals economically from lean ores and currently inaccessible areas.

- Chemical feedstocks made from relatively cheap and accessible biological sources, such as wood or vegetable oils, rather than expensive and scarce petroleum, as at present.

- New microbial processes to convert wood wastes from lumber mills economically into alcohol or animal feed.

- New food-flavouring agents and spices made from plant cells grown in nutritive cultures, which will not cause cancer.

- Microbial methods of removing sulphur from coal to make it less polluting.

Biotechnology, which could open this Pandora's box, is the name that has been given to a collection of increasingly sophisticated techniques drawn from the biological sciences. Those sciences have been progressing during the past two decades at a spectacular rate.

Since 1953, when the American James D. Watson and the Briton Francis Crick proposed a structure for DNA — the substance that carries the heredity of living things — that later won them the Nobel Prize, there has been what Dr. Singer called "a dizzying succession of advances, each deep-

ening our understanding of biology at the molecular level." In essence, the advances have allowed science and technology to use microbes, living cells or molecules, to produce entirely new products or to vastly improve the efficiency of established processes such as fermentation.

Canadian scientists have contributed to some of the advances in this biological revolution. But, according to the 1981 report of a task force on biotechnology set up by the Minister of State for Science and Technology, John Roberts, "there has yet been little Canadian industrial interest in pursuing the commercial opportunities offered by biotechnology." Dr. Lou Visentin, NRC biologist, put it more bluntly in an interview. "Genetic engineering," he said, "happened as a surprise here."

Within the past two or three years, however, interest in commercial opportunities has increased. The MOSST task force called on the federal government to establish a 10-year National Biotechnology Development Plan, funded by $33 million the first year, rising to $50 million annually. NRC, through its Program for Industry/Laboratory Projects (PILP), plans to spend some $16 million in the field over the next several years. NRC will spend a further $1 million per year on fermentation projects through contracts to universities, private companies and research foundations.

PROJECTS ACROSS THE COUNTRY

With the Department of Energy, Mines and Resources, NRC also has projects planned in ethanol production, primarily for fuel, using renewable resources such as wood. The Department of Industry, Trade and Commerce funds some biotechnology projects, mainly in traditional fields such as dairy and food products manufacture, amounting to some $5 million. And Agriculture Canada also provides substantial funds for special projects.

A mix of federal, provincial and private money is behind a new company called Allelix, Inc., which is building a 7,430 m² (80,000-sq.-ft.) plant outside Toronto. It intends to spend $105 million over the next 10 years on development and marketing of biotechnology products and processes. Allelix (the name is a combination of the words allele and helix, both of which describe aspects of genes) is owned 50 per cent by the Canada Development Corporation, 30 per cent by John Labatt Limited, the brewing firm, and 20 per cent by the Ontario government.

The University of Calgary proposes to establish an Alberta biotechnology research organization called Alta-Biotech, with funds from the Devonian Foundation and other sources. The University of Saskatchewan, supported by the provincial government, is developing new teaching and research programs in the field, with emphasis on agriculture. Manitoba has a Crown corporation in Winnipeg known as Canertech, designed to develop a pilot plant and R&D for new processes for extracting ethanol from vegetation. And the Quebec and French governments have signed an agreement for biotechnological development.

Canadian commercial activity in producing new biotechnology products has been confined to a handful of companies. Bio Logicals, set up in 1978 by Robert Bender, is a major private company. Connaught Medical Research Laboratories in Toronto produces medicinal products that include biotechnological items, as does L'Institut Armand Frappier in Quebec. And the Veterinary Infectious Disease Organization in Saskatchewan makes products for animals. By comparison, worldwide, there were 104 companies "at last count," according to Dr. Visentin.

Those involved in the current push towards biotechnology in Canada see for it a promising future, but many fear that if both public and private investment is not forthcoming in sufficient amounts, Canada could miss out in a field that countries like the United States, Britain, France, West Germany and Japan are heavily exploiting.

"A major effort is required," said the MOSST task force, "to stimulate the growth of an industrial sector based upon biotechnology, and at the same time to promote a focussing of the country's research effort in this area."

This concern arose partly from that of the Canadian Society of Microbiologists, which claimed in a letter sent to MOSST before its task force report was published that Canada has lagged in industrial development of biotechnology despite Canadian scientific work of international repute in the field: "Lack of funds, lack of industrial incentive programs, and lack of recognition of the importance of these endeavours by the federal government, as well as by industry, have all contributed to the present situation."

The society warned further that Canada faces a severe manpower shortage in biotechnology because few are trained in applied and industrial microbiology and many who have been trained are attracted to countries offering better opportunities.

What then are the techniques that biotechnology uses, and what special opportunities do they offer for Canada?

FIVE MAJOR TECHNIQUES

The MOSST task force identified five major techniques: genetic engineering; enzymes and enzyme systems; fused-cell techniques; plant-cell culture; and process and systems engineering.

- **Genetic engineering** arose from a laboratory trick known as recombinant DNA methodology. As a result of the Watson-Crick model of DNA structure mentioned earlier, together with discoveries that took place as recently as 1973, scientists found they could take selected genes (i.e., pieces of DNA) from one microbe (or even from another species, such as a mouse), splice them into the DNA of another microbe, and thereby produce a new individual with desired genetic characteristics. Furthermore, this new individual was then capable of reproducing itself indefinitely in the form of other individuals bearing the desired genetic characteristics. These new organisms could subsequently be used to make new products or mediate new processes.

The scientists had, in short, constructed what Dr. Saran Narang, NRC organic chemist, calls a "bug factory." By giving the "bugs" the necessary genetic characteristics, scientists could make the "factory" produce all sorts of things: insulin (perhaps with the help of Dr. Narang's own pioneering work in the first synthesis of human proinsulin,

a precursor of the hormone itself); interferon (which the body uses to fight infections); more useful yeasts for alcohol production; and so on.

- **Enzymes** have been used for many years in industry. In traditional industrial fermentation processes, scientists were able to get large batches of microbes to make products ranging from ethanol to antibiotics to vitamins by selecting the right microbes and production conditions. What the new techniques do is allow industry to custom-make as many microbes as it needs with exactly the qualities desired — and also to inject into them characteristics that will enable them to function under practical operating conditions.

Extra-pure enzymes could thus be produced and immobilized in a reactor (or tank), where they would continually produce a product at low cost: in the United States and Canada more than a million tons of high fructose (sweet) syrups are produced annually this way from the glucose in starch.

- When **two cells are fused** to produce a hybrid, new possibilities emerge: for example, plants with the ability to fix nitrogen (i.e., render it useable by the plant), or plants with greater disease and climate resistance. If a cancer cell is fused with a non-cancerous one, the resulting hybrid can grow in an unrestricted way, as cancer cells do, thus providing the possibility of reproducing indefinite numbers of useful cells. Such "hybridomas", as they are called, could lead to new vaccines for use on a massive scale, as well as other valuable products.
- **Plant cells** can also be produced in laboratory **cultures** to avoid the uncertainties of supplying medicinal agents from plants grown in nature.
- Systems like the above obviously require special processing techniques. As a result, **systems engineering** will be important in future applications of technology.

IMPORTANT TO CANADA

A number of new products and processes in biotechnology could be particularly important to Canada. Plants with the ability to fix their own nitrogen, as legumes do, would have obvious advantages at a time of escalating chemical fertilizer costs. Similarly, with its extensive agricultural and forestry resources, Canada could readily use an economical method of converting crops and trees into fermentable carbohydrate — and thus into chemicals, solvents, foodstuffs and fuels.

Canadians as a whole are becoming more conscious of the need both to reduce wastes from industrial processes and to ensure that as much waste as possible is either de-toxified or transformed into useful products. Biotechnology can help in these ways. Most current efforts are directed towards improving the efficiency of waste treatment and waste conversion.

In the same way, while mineral leaching by microbes is currently carried out for copper and uranium recovery, through biotechnology these methods could be made much more efficient, with microbes better designed for the job.

Canadian scientists are already following up some of these leads. The NRC is the focal point for much of the research being carried out. For example, Dr. Henry Schneider and colleagues have discovered a yeast that will convert five-carbon (pentose) sugars from biomass into alcohol. The yeasts normally used for the conversion could convert only six-carbon sugars. This discovery should make it possible to convert an addition 5-40 per cent of the sugars to alcohol.

The discovery came about unexpectedly: "We started out trying to engineer an organism that would convert five-carbon sugars, and on the way found one (**Pachysolen tannophilus**) in nature," said Dr. Schneider. "But an engineered one may still do it better."

Because brewer's yeast is the yeast type industry knows best how to handle, and not **Pachysolen tannophilus**, Dr. Schneider says it would be ideal if they could simply "plug in" to brewer's yeast the required characteristics, and they are trying to do that now. They are also trying to improve their existing five-carbon sugar fermenters to enable them to work on an industrial scale.

If such methods could be applied to spent sulphite liquor, a by-product of pulp and paper manufacture, the resulting alcohol could be sold commercially, thus providing an economical means of utilizing wastes. This would find an immediate application, because at least one Canadian mill already ferments the six-carbon sugars in sulphite liquor.

Other NRC groups also are interested in engineering an organism that could hydrolize wood and then ferment the resulting sugars to alcohol, because considerable interest has been shown in obtaining large amounts of fuel in this way. U.S. scientists involved say that a key factor in doing so is finding a process that uses five-carbon sugars.

Two Canadian companies are trying to transfer Schneider's methods to industry under PILP contracts: Canadian International Paper in Hawkesbury, and Tembec in Temiskaming, Ontario. Schneider says it looks as though a practical process could result in about two years.

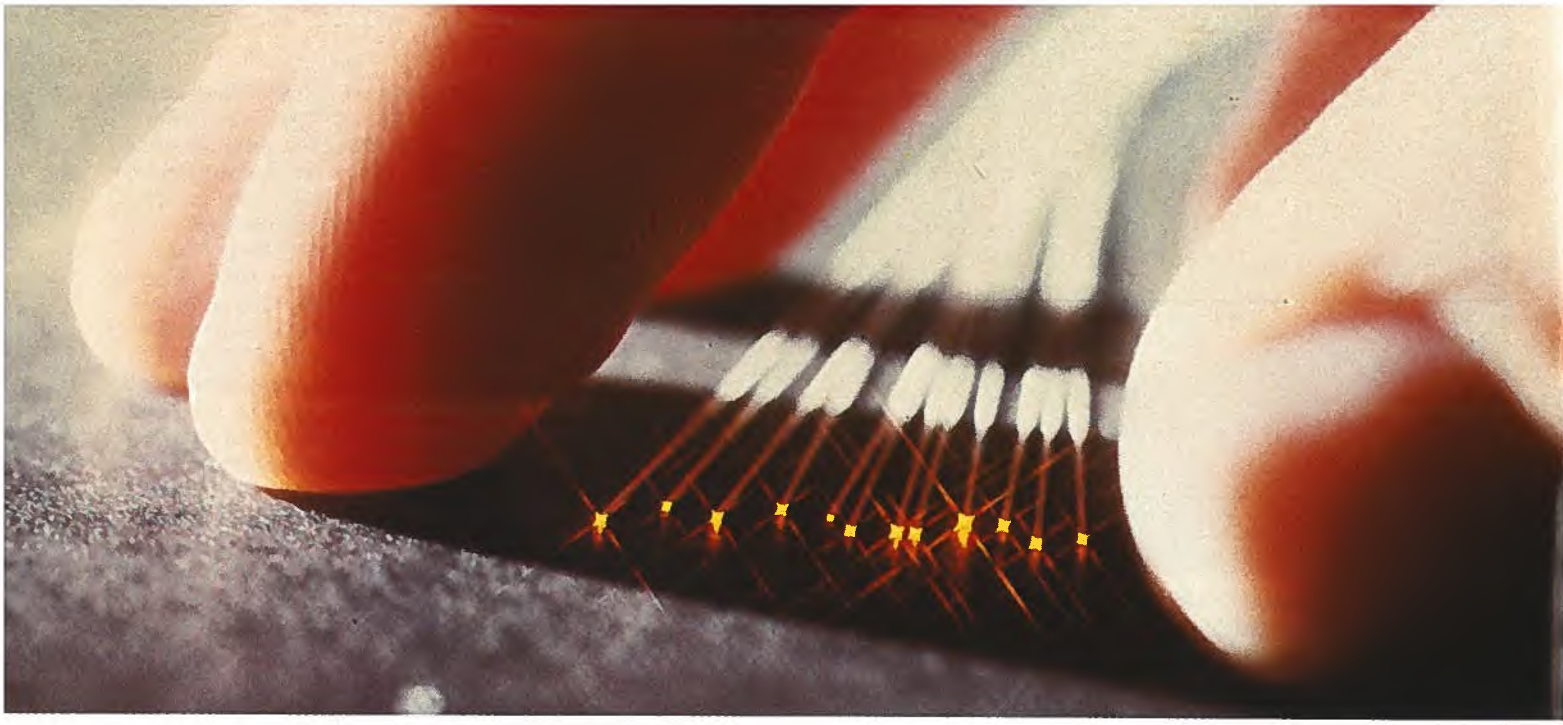
This case neatly illustrates a point often raised by scientists involved in biotechnological research: although biotechnology offers the possibility of spectacular new and unimagined advances, much of its value will lie in making more economical processes already used by industry.

"Efficiency is the key," says Dr. Martin. "It looks as though we have the means to get organisms to do what we want **efficiently**. This to me is the revolution."

Another point on which many involved in biotechnology are agreed: the revolution will take time to bear fruit. Results may not come tomorrow. And although the biotechnological revolution has often been compared with the one that stemmed from integrated circuit technology in the electronics industry and sent stocks soaring in the 1960s, the return from biotechnological companies may not be so immediate, and money may be lost as well as won.

Nevertheless, most seem to agree that big things are bound to happen in this exciting field in the next five to 20 years.

David Spurgeon is a leading Canadian science writer with experience both in Canada and internationally.



As telecommunications technology advances and becomes more cost-effective, people and equipment around the world will be communicating more and more over hair-fine glass wires. . .

Fibre Optics — The Future Link

by John C. Hughson

A strand of glass with the diameter of a hair and so pure that if the Pacific Ocean were made of it, one would be able to see bottom at the deepest point . . . that is the basis of the newest and one of the most promising developments in communications — fibre optics.

Canada, along with the United States and Japan, is one of the leaders in the research and development into the effective use of fibre optics, potentially the communications link of the future, replacing such things as copper-based coaxial cables and complementing microwave systems. It has been estimated that there will be a world market for fibre optics worth at least $6 billion by 1987.

Canada's main thrust in fibre optics has been a wide variety of applications in the telephone sector and television transmission systems. Since Canada is concentrating on the commercial telecommunications applications, a commanding volume of expertise now exists.

The Department of Industry, Trade and Commerce has invested several million dollars in this new technology and is prepared to consider additional research and development projects.

The Department of Communications has also been active with the private sector in fibre optics field trial installations, as well as maintaining a fibre optic research facility near Ottawa.

INSTALLATIONS IN CANADA

Experimenting in fibre optics installations, Canadians since 1976 have completed successful programs in Montreal, Toronto, Ottawa, Vancouver and London, Ontario.

As technology has grown, projects have become more ambitious. A 54 km (34-mile) cable has been successfully laid in Alberta and an even more promising project in a rural Manitoba community will connect some 150 homes with telephone, television, radio and data communications.

Perhaps the most ambitious program so far is the massive undertaking underway for Saskatchewan Telephones to link 51 communities with 3,400 km (2,100 miles) of fibre optic cable, primarily for video transmission.

In the 1980s Bell Canada and its subsidiary Northern Telecom are expecting to install up to 100,000 km (62,000 miles) of optical fibre telephone lines.

With all this activity going on, the next question is: just what is fibre optics?

LIGHT PULSES AND GLASS FIBRES

Basically, optical fibre is used to transmit messages — voice, video and data signals — by means of light pulses along glass strands (optical fibres). In contrast, telephone cables send messages by electrical pulses along copper wires.

Electrical signals (the messages) are converted to the light pulses which travel down the glass strands or fibres to be converted back to electrical signals and then to audio or visual messages at the destination. The fibres are so constructed that a narrow beam of light is bounced down the inside of a fibre, being reflected inwards off the fibre walls to keep it from escaping. The result is that almost all the light comes out the end of the fibre with all its pulses virtually intact.

Fibre optics systems use cables containing many strands or optical fibres, increasing the message carrying capabilities. Most cables being installed in Canada have 12 fibres but cables of up to 144 fibres and larger are being considered.

Some of the more important advantages of fibre optics are: voice, video and data can be combined on the same fibre; fibre optics has a high data rate or information carrying capability; and fibre optics cables are extremely light and compact with freedom from interference while providing a secure system.

To demonstrate the high capacity (bandwidth) of fibre optics, a single fibre pair can combine 672 two-way telephone conversations as compared with 24 two-way conversations that can be combined on two pairs of copper wires (one pair for each direction). A single fibre can bring the subscriber telephone service, several television channels, videotex, a digital link, alarm service, remote reading of electricity, gas or water meters, and the shedding of electrical loads at peak periods.

The light weight and compactness characteristics are key attractions for the telecommunications industry. It has been shown that an optical cable of 144 fibres, capable of carrying 96,768 two-way telephone conversations, would only be 25.4 mm (1 in.) in diameter and weigh less than 0.5 kg/m (6 oz./ft.). A comparable copper coaxial cable would probably be 76.2 mm (3 in.) in diameter and weigh 15 kg/m (10 lb./ft.).

Telephone companies are already running into some difficulties with overcrowded cable conduits in urban areas. To accommodate additional copper cables for expanding communications networks either new conduits must be dug or existing conduits enlarged, costly and time-consuming operations. Fibre optics cables with their considerably smaller size, lighter weight and greater capacity alleviate this problem.

OTHER ADVANTAGES:

- No electrical current. Fibre optics is the transmission of light, not electrical current. This eliminates the spark danger inherent in electrical systems and gives freedom from lightening faults, thus making fibre optics ideal for use as communications links in potentially explosive environments (such as refineries, mines).
- No electromagnetic interference (EMI) or radio frequency interference (RFI). Unlike electrical signals transmitted over copper wires, optical signals are impervious to EMI and RFI and they also do not generate either. Thus signals can be sent and received without the error such interference may induce — a considerable boon to industrial applications.
- Increased communications security. The lack of EMI/RFI generation in fibre optic systems means that they cannot be "bugged" remotely using these electromagnetic fields for homing in. The system can be "bugged" by physically tapping the light-carrying fibre but this causes an immediate and noticeable light and signal loss.

Some facts about fibre optics — the glass fibres are mostly of silica or sand, one of the most abundant materials on earth while copper is a diminishing resource; the fibre has the same tensile strength as steel wire of the same

diameter; fibres are flexible to the extent that a single strand can be bent into a circle 6 mm (1/4 in.) in diameter without snapping; a telephone system employing fibre optics cables would use about one-third the amount of electricity required by today's networks.

EXPERIMENTS IN CANADA

Experiments in the use of fibre optics have been going on in Canada for some years. For example, in 1977 about 1.5 km (1 mile) of glass fibre cable was installed underground between two Montreal streets to take the place of copper telephone cables. A year later two Vancouver telephone exchanges were linked by a fibre optic cable five times longer without repeaters.

More recently, a 54 km (34-mile) cable with a data rate capacity of 274 megabits per second was successfully laid between Calgary and Cheadle, Alberta. Also, the first optical supertrunk with a capacity of 18 television channels was installed in London, Ontario, running about 8 km (5 miles) to the head-end of the cablevision distributor.

A much larger and more ambitious program is being carried out at Elie-St-Eustache, Manitoba, and is considered a most promising Canadian integrated services project. In that rural community, 150 homes are being serviced by a fibre optic system that incorporates party telephone, television, FM radio and a 56 kilobit per second data channel.

The technological content of the Elie-St-Eustache project is 95 per cent Canadian and the overall cost has been set at $9.6 million. Its success gives Canada a strong bid for taking the lead in this field of optical distribution.

By far the most ambitious Canadian undertaking is the $56 million project for Saskatchewan Telephones (Sasktel) — a 3,400 km (2,100-mile) "optical highway". The world's longest commercial fibre optics network, this integrated broadband system will connect 51 Saskatchewan communities and carry voice, data and video signals.

The cable used in the Sasktel project will bundle 12 optical fibres, each fibre capable of carrying 672 telephone conversations, one video channel or 45 megabits per second of data. New technology, available in the not too distant future, could increase the system's capacity by three to five times.

CANADIAN COMPANIES

The most prominent company in the Canadian fibre optics field is Northern Telecom. The company has the Canadian capability of manufacturing fibre, cable and electronic and optical hardware — completely integrated systems. At present Northern Telecom is making optical fibre and cable from a new multi-million dollar plant in Saskatoon and is anticipating further expansions to facilitate on-going research and development.

Canada Wire and Cable Ltd. of Toronto and Phillips Cables Ltd. of Brockville, Ontario, are two other Canadian companies involved in telecommunications applications of fibre optics. Both produce cable and Canada Wire and Cable, through its subsidiary Canstar Communications, also produces entire systems as does Phillips, teamed with Digital Communications Ltd. of Mississauga, Ontario.

As the demand for instant, accurate communications . . . telephone, television, videotex, computer, data transmission, the whole field of telecommunications . . . continues to grow, Canada's need to contribute to this demand will grow accordingly. Canadian companies already in the field have developed a wealth of experienced and a certain leadership in optical telephone links and an excellent position in optical distribution. With a world market of $6 billion by 1987, the prospects are more than encouraging.

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Financing High Technology Enterprise

The origins of most high technology enterprise are found in the creation of a new technological concept or in the identification and new market application of an existing concept or device. In other words, the founding rationale of a high technology firm is usually technology or market-based.

However, like everything else in our economic system, it takes money to translate concepts into commercial reality, and financing therefore is the third cornerstone of a successful high technology venture.

In the beginning, the original risk capital for a high technology enterprise will come from personal sources — usually the entrepreneur himself and often from his relatives and business associates. As the business becomes established, however, and begins to move along a steepening growth curve, its capital requirements can quickly outrun the personal capacity of the entrepreneur and/or his associates.

For most small businessmen, and high technology entrepreneurs are no exception, the first point of contact with the capital market place is through a branch office of a chartered bank. The bank provides the day-to-day administrative support to business in the form of deposit, chequeing and other banking services and is an important source of operating or working capital. But there is a wide variety of other sources of capital available to the businessman/entrepreneur and, depending on his requirements, some, or all, of these other sources of capital can be approached and effectively utilized in financing the changing capital requirements of high growth enterprise.

Many small businessmen in the more conventional sectors such as retail trade or mature-technology secondary manufacturing sectors (those who are not experiencing fast growth and rapidly increasing capital requirements) may find their personal resources along with some operating credit from the bank to be perfectly adequate.

But in the high technology sector, where growth rates in excess of 100 per cent a year are not uncommon, a sustained infusion of risk capital is required to satisfy the continuing investment in research and development which is required to remain at the leading edge of technology. It is also needed to fund the heavy expenses involved in creating and developing new market opportunities for the products.

RISK CAPITAL PROBLEM

In 1978, a task force sponsored by the federal Department of Industry, Trade and Commerce to study the problems of and prospects for the electronics industry in Canada, reported that the availability of risk capital was the central financial issue confronting the electronics industry. While there has been an increased awareness of high technology as an attractive investment medium since the task force report, the availability of capital remains a central issue for the sector because of its high risk nature.

Among the features of the industry which add to the risks for investors are the rapid pace of technological obsolence; a rapidly changing product marketplace; a small domestic market for electronics products and services; a long gestation period from funding the research and development to delivering a commercial product; and the perceived vulnerability of small Canadian firms operating in a fiercely competitive market against the large multinationals.

Nevertheless, successful firms in the high technology sector have encouraged more of the investment decision makers in the Canadian financial system to be interested in high technology enterprise. Many financial organizations have decided to be involved in this dynamic sector. As a result, there are some interesting patterns developing in the relationship between the members of the high technology community and the members of the world of finance.

What was once a fairly distant relationship has become much closer. To a large extent, the distance between the two groups was a result of a lack of understanding or a communications gap. As the two communities continue to move towards a better understanding of one another, the risk capital financing needs are being more adequately understood and may be more readily met through the conventional financial infrastructure.

One very effective approach to bridging the communications gap between the industry and the financial community has been the use of theme conferences. Two of these were held in 1981, one in Toronto on the theme Investment Opportunities in Canadian High Technology Enterprise, and the other in Ottawa on Financing Canadian High Technology Enterprise.

HIGH-TECH THEME CONFERENCES

The first of these events was designed to provide financial analysts and professional investors with an insight into the fundamental elements of Canadian high technology enterprise. Executives from several high-tech firms, large and small, described the various facets of developing and managing high technology enterprise and outlined some of the opportunities ahead.

Discussion centred on the four basic elements of a high technology business, namely: financing; management; marketing; and products and R & D. The role of government in the industry was examined and attention was given to such topics as: a model for a new enterprise; growth in an existing enterprise; managing the technology investment program; and financing from profits.

Throughout the day speakers from high technology firms explained their activities in organizing and managing high technology enterprise. The members of the investment community found it an extremely useful day and, as a follow-on, a second conference was arranged to include members of the high technology and financial communities. This time the theme was Financing Canadian High Technology Enterprise and the speakers and panelists were financial people, while the audience was mainly the high technology community.

The purpose of this conference was to provide the high technology entrepreneur/manager with an understanding of the different financial institutions in the marketplace — how they are the same and how they differ. It was also designed to provide the seekers of capital with an insight into how the investment decision making process works and what sort of information is required in order to evaluate a financing proposal.

There were basically three sources of capital identified for the high-tech entrepreneur — debt financing, equity capital and government programs.

Included among the panelists were representatives from the chartered banks; the investment dealers and underwriting community; venture capital investors; government program managers; term lenders and equipment lessors. All of these financial intermediaries addressed the central theme of financing Canadian high technology enterprise by describing how they all have different roles to play.

CHARTERED BANKS

The chartered banks, for example, emphasize that they are not risk investors and, generally speaking, they are not major suppliers of equity or venture capital to the high technology (or any) industry. On the other hand, the banks are an important source of operating or working capital to finance receivables, inventory and other operating requirements provided the borrower has appropriate security. Security usually includes an assignment of receivables and a charge over inventory.

Other financial instruments available through the chartered banks are term loans for capital investment, factoring and loans under government programs. As well, the banks provide a variety of support services to managers of high technology enterprise including: letters of credit; foreign exchange transfers; reports on the credit status of other businesses; and payroll services. These are in addition to the regular deposit and cheque clearing facilities which all businesses use.

Thus, while the chartered banks are not aggressively involved in risk financing for high technology they are an important source of working capital and an important financial contact for high technology enterprise. Moreover, there are moves underway in the banking community to better understand the risks inherent in high technology as more bankers become high tech specialists. The Canadian Imperial Bank of Commerce, for example, has appointed a vice-president in Ottawa who has a special interest in high technology business and who is actively involved in working with high technology enterprise in the Ottawa-Carleton area.

In addition to the chartered banks, debt capital is available to the high technology industry through the Federal Business Development Bank and through private sector term lenders such as RoyNat Inc. A further source of debt can be obtained through a leasing contract with an equipment lessor. All of these forms of capital are secured and are based on obligations to repay.

VENTURE CAPITAL

At the other end of the financing spectrum from the bankers and term lenders are the high risk, venture capital investors. They are prepared to invest equity capital in small and medium-sized firms, often on a minority interest basis, and usually are interested in a seat on the board of directors. Very often the venture capital investor will provide managerial as well as financial assistance. The objective of a venture capital investor is to become involved in an emerging situation and build it to a point where he can realise a capital gain by selling his interest directly to other investors or by selling shares to the public through an underwriting.

Venture capital investors have been fairly active in financing high technology enterprise and there are a number of success stories on the record.

One firm in the Ottawa area, for example, has successfuly invested in Mitel, Lumonics and Norpak and has become well known as a source of equity capital for high technology enterprise. Unfortunately for many capital seeking entrepreneurs, the sources of venture capital are not always obvious. Not nearly so obvious, for example, as the branches of the chartered banks which are found in every neighbourhood.

One publication which does help bridge the gap between the entrepreneur and the risk investor is The Source of Funds Index, published by SB Capital of Toronto. It lists a large number of known sources of venture capital and can be a useful first step in identifying potential risk investors.

DISTRIBUTION OF SHARES

A further source of equity capital for the high technology community is through a distribution of shares through an underwriter to members of the public. There have been a number of recent examples of this in the high technology sector, among them Mitel, Lumonics and Systemhouse. While a so-called "public offering" is generally used only for raising relatively large amounts of risk capital and therefore has not been available to the smaller firms in the high technology sector, members of the financial community have recognized the unique problems with respect to providing access to the public market-place for these firms and work has been undertaken to develop this mechanism further.

The Toronto Stock Exchange, for example, has recently prepared a discussion paper with proposals to foster capital formation for junior enterprises. In essence these proposals would reduce the administrative requirements for a public listing and would open up the public market to more small companies. These proposals are now in an early stage of public discussion.

Governments are an important fact of life in most industry sectors and high technology is no exception. Indeed for many in the high technology industry, government has a key influence through its procurement and regulatory policies. Government can also play a supportive role to the industry through financial assistance for technological innovation.

The federal government, for example, through the Department of Industry, Trade and Commerce, has provided some support to Canadian high technology enterprise under the Enterprise Development Program. The National Research Council also operates a program of assistance for technological innovation and seeks to encourage technology transfers from government to industry. Because of government's pivotal role with respect to high technology, continued and expanded support will be important to the continuing success of Canadian high technology enterprise.

UNIVERSAL REQUIREMENT

Regardless of the source of capital that a high technology businessman approaches there is one universal requirement that must be met. The entrepreneur must have a well developed and clearly articulated Business Plan. He must have a sound idea of where he wants to go and why; and how he will get there. In general this will mean preparing a well documented presentation, in writing, along the following lines:

- a brief description of the company, its products and its market-place as well as its goals and objectives;
- a brief personal resume of the principals of the company;
- past and projected financial data including balance sheets profit and loss statements, sources and use of funds, etc.;
- financing requirements should be well laid out and preferred methods of obtaining financing should be presented.

This material will be supplemented by personal visits and should be kept comprehensive and factual. A carefully developed business plan will not only help in raising outside financing, it will cause the entrepreneur to really think through his situation and thereby provide himself with a realistic assessment of his chances of success.

Financing Canadian high technology enterprise has been and continues to be an important concern for public policy in Canada. Over the last year or two private sector financial organizations have taken a greater interest in understanding and investing in high technology ventures. Governments have provided innovation assistance and support through procurement policy. The payoffs to investors in successful high technology firms has been sometimes spectacular, but there are broader pay-offs for the society at large.

A thriving high technology sector will provide a multitude of economic and social benefits and a healthy climate for investing in Canadian high technology enterprise must remain a priority public policy objective.

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