

***THE ROLE OF ENGINEERING
IN BUILDING A NATIONAL STRATEGY
IN SCIENCE AND TECHNOLOGY
IN CANADA***

A BRIEF SUBMITTED JOINTLY BY

The Canadian Academy of Engineering (CAE)
The Canadian Council of Professional Engineers (CCPE)
The Association of Consulting Engineers of Canada (ACEC)
The Engineering Institute of Canada (EIC)

RELATING TO THE FEDERAL S&T REVIEW

September 1994

EXECUTIVE SUMMARY

The Canadian Academy of Engineering, The Canadian Council of Professional Engineers, the Association of Consulting Engineers of Canada and the Engineering Institute of Canada, on behalf of the more than 155 000 professional engineers nationwide are pleased to submit this brief to Industry Canada as part of its very timely science and technology policy review process.

We recognize that this initiative is both complex and far-reaching in its impact on the Canadian economy. As such, we offer comment on science, engineering and technology issues that we consider to be of high priority. Furthermore, we recognize that this review process comes at a time when the Government is faced with the daunting tasks of re-shaping science and technology policy to meet the needs of the next century while striving to achieve its goal for deficit reduction. The recommendations offered in this brief are sensitive to these challenges and aim to provide solutions that are not tied to increased spending. Moreover, the recommendations offered come with our pledge of support and active participation as required to ensure their successful implementation.

Recommendation No.1

The Federal Government should take the necessary steps to ensure that universities as well as the national granting councils supporting university research are sensitive to the special nature of engineering and that their program criteria reflect this through added emphasis on innovative problem-solving approaches and interdisciplinary projects.

Recommendation No.2

The Federal Government should be supportive of and provide enhanced support for research undertaken by engineering professors and their graduate students that is directed at real and relevant issues of significance to the present and future needs of society and the industrial and services sectors.

Engineering schools should have much more autonomy than they now have, being immersed in a sea of science faculties, and should focus more on problem-solving and interdisciplinary approaches in the curricula than they presently do. They should encourage business sabbaticals and value more the professional experience of their recruits than just academic credentials. The "publish or

perish" policy should be replaced by "excellence through relevance".

Recommendation No.3

The Federal Government should provide NSERC with the funds necessary to successfully accomplish the goals and university/industry roles expressed in its latest strategic plan, particularly the financial assistance required by universities to undertake joint research with industry.

Recommendation No.4

The Federal Government should:

- . increase its financial commitment to IRAP
- . develop an open client-server attitude
- . consider transferring fundamental research to universities
- . open its laboratories to industry.

Recommendation No.5

As a way of creating durable new jobs for Canadians in the global economy, the Federal Government should expand its collaboration with the private sector in the establishment of a coast-to-coast worldclass Information Superhighway and the effective use of that facility.

Recommendation No.6

The Federal Government should help ensure that faculties and schools of engineering and applied science become actively involved in partnership with industry in the technological development and the applications deployment of the Information Superhighway, particularly with respect to broadband development of interactive multimedia and the delivery of education at a distance.

Recommendation No.7

The Federal Government must move ahead with its intention to help finance the new economy as announced in the Budget Speech on February 22, 1994. It must facilitate to small business, particularly the emerging high-tech companies, access to adequate capital.

Recommendation No.8

The Federal Government in collaboration with the provincial governments and the engineering community, should establish the "Engineers and Scientists Program", as announced in the 1994 budget, to increase rapidly the employment of engineers in small and medium size enterprises following the very successful PSES program in Quebec.

Recommendation No.9

It is incumbent on the Federal Government to provide leadership in public awareness programs relating to science, engineering and technology and, jointly with the provincial governments and the business community, to launch educational initiatives to make Canadians more aware of the spectacular advances of science and technology and the remarkable achievements of engineering in today's society.

INTRODUCTION

Canada can be rightfully proud of its achievements as one of a handful of technologically advanced countries of the world. This mastery of technology has afforded the citizens of Canada with an enviable standard of living and prospects for an even brighter future. Nonetheless, Canada cannot rest on its laurels. The number of countries competing in the S&T arena has increased dramatically over the last 10 years and many are now meeting and surpassing the technological levels of the original industrial powers.

The translation of science to practical application is to a large part the domain of the engineer. Canada must improve its ability to translate basic research into products and services to improve our economy. Investments in long-term research by large companies and in medium-term research by small and medium sized companies must be encouraged.

A 1968 report by OECD sums it up well:

"Countries which are unable to turn science to practical uses will not be able to finance fundamental research on an up-to-date level, however much they appreciate science for its own sake".

It is therefore our view that we should rebuild the historic and increasingly important linkages between industry and engineering and emphasize the application of science.

GENERAL STATEMENT

- . This is not the first time that the Federal Government has conducted a national survey to better define S&T policy and strategy. Chapter 5 of the Resource Book does in fact give an interesting list of Federal S&T Policy Reports from 1963 to 1993. Before 1990, the accent was very much on science policy and since then the emphasis has, understandably, shifted to technology and industrial strategy, and now to international competitiveness.

- . In the sea of problems alluded to and the gusts of variable opinions expressed, engineers have often experienced difficulties in expressing their views adequately. This is the first time that a group of engineering organizations present a common view on the main issues relating to S&T and our national well-being and future.

- . Presently, there are over 155,000 engineers in Canada. These professionals are distributed throughout the country in all economic sectors, from natural resources through manufacturing to a wide series of services of all kind. They practice their discipline in a very wide array of fields ranging from underground exploitation of minerals to satellite communications, embracing all areas of science and reaching into economics, management, and social science.

- . Importantly, engineers are the bridge between science and technology. Without engineers, technology has little meaning. Therefore, to talk about S&T is also to talk about engineering, and a Federal S&T strategy cannot be envisaged without giving sufficient consideration to the health of engineering itself.

- . It is also important to note that engineering is not only a science but also a profession, and a very demanding one. It requires the best of training and calls for permanent education in the face of the relentless evolution of technology, growing complexity of systems, and ever-increasing international competition affecting our manufacturing and service industries.

ENGINEERING EDUCATION AND RESEARCH

- . Canada must strengthen its S&T effort by doing a better job in taking the results of our investments in science and translating them into wealth-creating goods and services. Unless we, as a nation, can improve our record in this regards, then one must question the investments we are making in fundamental research and assess them more as a **cultural activity** as opposed to one which is strategic in an innovation-driven society.
- . We need to improve our means of identifying and developping promising technologies into marketable products and services.
- . The translation of science to practical application, this portion of the S&T chain where Canada is weakest, is to a large extent the domain of the engineer. Canada is failing in this area because of a severe lack of engineering presence in small companies, because of a lack of long-term research investment in large companies, and because we are increasingly training engineers to be more a part of the science community rather the appliers of science.
- . Engineering schools must now put more emphasis on a problem-solving approach, introducing new dynamics in the solution of problems affecting our well-being and economic growth. Rather than putting emphasis on the usual disciplinary divisions (viz. civil, mechanical, electrical, etc.), the focus must now be on the main problem areas falling within the purview of the engineer: such as infrastructures, environment, processes and systems. Each one has a particular set of parameters, including materials of various types, energy in various forms, etc. Mentalities must be transformed, attitudes changed. Engineering education must place greater emphasis on problem definition and formulation. Outreach approaches toward other disciplines must be entertained.
- . Engineering design must be rediscovered and given a central role in training engineers. Interdisciplinary projects should be encouraged and special courses to that effect be introduced accordingly.

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The Federal Government should take the necessary steps to ensure that universities as well as the national granting councils supporting university research are sensitive to the special nature of engineering and that their program

criteria reflect this through added emphasis on innovative problem-solving approaches and interdisciplinary projects.

ENGINEERING SCHOOLS IN THE ECONOMY

- . In a knowledge-based society with an information intensive economy and a multiplicity of fast evolving and far-reaching new technologies, engineering schools constitute a vital part, if not the very foundation of the country's S&T infrastructure.
- . This precious asset must be continually upgraded to serve the immediate needs of the country's production system, both in terms of human resources and modern equipment. Therefore, engineering schools must be hotbeds of generic technology creation and the place where new principles of production and technology management are explored and systematically investigated.
- . Canada's thirty-three (33) engineering schools already represent a major resource, but their potential to contribute to the future of this country is not fully recognized and appreciated. They should be considered as a important component of the **Canadian Technology Network** and be given the supplementary financial resources to serve as such.
- . Being spread across Canada, they should be given the financial resources to really constitute the National Network with collaborative distance teaching. They should be made the **nodes** of the much talked-about Information Superhighway.
- . Even though spectacular progress has been achieved in recent years in bridging the gap between universities and industry, the efforts are still too timid and too sporadic.
- . In particular, engineering schools must learn how to deal better with small or medium-sized technological firms and train their students to meet the needs of this important sector of our economy. Courses on technological innovation and entrepreneurship should be regular parts of the curriculum. Interdisciplinary projects undertaken jointly with small firms should be given special attention. A professional Master's degree in technological entrepreneurship, developed and delivered jointly by the engineering school and the management/administration sciences school, should be offered in each province as a collaborative effort with local industry and the financial community.

Recommendation No.2

The Federal Government should be supportive of and provide enhanced support for research undertaken by engineering professors and their graduate students that is directed at real and relevant issues of significance to the present and future needs of society and its industrial and services sectors.

Engineering schools should have much more autonomy than they now have, being immersed in a sea of science faculties, and should focus more on problem-solving and interdisciplinary approaches in the curricula than they presently do. They should encourage business sabbaticals and value more the professional experience of their recruits than just academic credentials. The "publish or perish" policy should be replaced by "excellence through relevance".

NSERC AND ITS STRATEGIC PLAN

- . The Natural Science and Engineering Research Council (NSERC) has recently published its new strategic five-year plan. The debate which led to that plan raised very important issues regarding the role of university research within the S&T activities in Canada.
- . Engineers in Canada do recognize the importance of university research in the advancement and application of knowledge without which technology development would be virtually impossible. This is not to say, however, that every university professor has strong capability and an inherent right to obtain special funds to carry out basic research as he/she pleases. The granting councils should avoid "saupoudrage" and be encouraged to award grants to the most creative and the most productive researchers. Quality and productivity should be measured not only in terms of numbers of papers published but other means as well, such as the significance of their research to the long-term needs of industry or the number and application of their inventions.
- . Engineers in Canada are very supportive of NSERC's new business plan and appreciate its intent to increase interactions with industries. The "research alliances" discussed in the plan will lead to increased wealth and job creation through sustainable development.
- . Granting councils and industry should recognize that one of the outputs of greatest value from academic research is people highly educated and well trained. People constitute the best form of technology transfer. Research funds should be allocated mainly according to the quality and quantity of this input.
- . It should also be recognized that government and other financial incentives are necessary to entice academic researchers and industrial people to undertake cooperative projects. These incentives must be strong enough to encourage companies with no previous history of such interaction and/or no previous involvement in R&D to approach and work with the universities in collaborative projects. This applies particularly to small or medium-sized manufacturing firms.

Recommendation No.3

The Federal Government should provide NSERC with the funds necessary to successfully accomplish the goals and university/ industry roles expressed in its latest

strategic plan, particularly the financial assistance required by universities to undertake joint research with industry.

NEW RESPONSIBILITIES FOR NRC

- . The National Research Council of Canada (NRC) is a venerable institution which has been in existence for over 75 years. Inevitably, throughout such a long period, it has experienced a number of important changes but its adaptation to financial constraints and new industrial conditions may not have been as innovative as some wished.
- . Among its many notable achievements, is the unquestionable success of the IRAP program, which provides technical and financial assistance to innovation in small firms. In terms of new jobs created and practical assistance delivered, the program has produced impressive results at relatively modest cost. However, even within the NRC, the program has not always received the recognition and financial support it merits.
- . IRAP's demand-driven client-oriented activities are decentralized from Ottawa and operate through a network of over 100 organizations, which include provincial research organizations (PRO's), universities and colleges (with their industry liaison offices, industrial associations and other professional bodies).
- . Engineers in Canada recognize the importance of IRAP and consider this program as an important component of the Canadian Technology Network (CTN) announced in Ottawa on August 5, 1994. However, as stated previously, Canadian engineers stress the need to base that network also in the engineering schools across the land as these have very important resources that industry could profit from.
- . NRC has, over the years, become a center of excellence of international stature well known for its fundamental research. Effective mechanism should be devised whereby Federal Government support for longer-term applied research would be delivered increasingly through university.

Recommendation No.4

The Federal Government should:

- . ***increase its financial commitment to IRAP***
- . ***develop an open client-server attitude***
- . ***consider transferring fundamental research to universities***

. open its laboratories to industry.

INFORMATION SUPERHIGHWAY

- . Engineers of Canada consider the advent of the electronic information highway not only inevitable but also most desirable.
- . All Canadians will ultimately benefit from this development. It is not only a matter of technology and telecommunications; it involves all segments of industry and a myriad of services. It encompasses not only science and technology but culture as well. It embraces practically all realms of human activity of the information age that we are about to enter.
- . Even now, there are more Canadians employed in the information industry than in mining, fishing, forestry, pulp and paper, steel making, car manufacturing, sea shipping, railroad and air transport combined. As John Naisbitt put it, in the global economic network of the 21st century, information technology will drive change just as surely as manufacturing drove change in the industrial era.
- . One of the best illustrations of the advent of the electronic highway, is the spectacular growth that **Internet** has experienced in the last 10 years. This mega-network is already reaching 25 million subscribers through 2.5 million computers, in 30,000 networks in 72 countries, covering 30,000 domains.
- . In Canada, the Federal Government has launched jointly with the telecom industry an ambitious program for the development of new applications and services relating to the information superhighway, called CANARIE (for Canadian Network for the Advancement of Research in Industry and Education).
- . The existence of this electronic highway will enhance considerably Canada's attractiveness as a good country to locate head offices, research laboratories, production and marketing facilities for dynamic companies operating worldwide.
- . The existence of an advanced communications infrastructures at competitively priced services is becoming essential for many types of business activities. It is already critical in terms of Canada's competitive positioning with regard to the North American Free Trade Agreement (NAFTA). In addition to facilitating the creation and design of new products, new services and new information-based firms, as well as R&D and other essential parts of the innovation process, the electronic highway will radically alter existing modes for instruction delivery.

Recommendation No.5

As a way of creating durable new jobs for Canadians in the global economy, the Federal Government should expand its collaboration with the private sector in the establishment of a coast-to-coast worldclass Information Superhighway and the effective use of that facility.

Recommendation No.6

The Federal Government should help ensure that faculties and schools of engineering and applied science become actively involved in partnership with industry in the technological development and the applications deployment of the Information Superhighway, particularly with respect to broadband development of interactive multimedia and the delivery of education at a distance.

FINANCING THE NEW ECONOMY

- . World economies are changing rapidly. New ideas and innovations are becoming increasingly the drivers of economic growth and societal progress. Industries are becoming knowledge-intensive. Even traditional industries are caught in the swing of the information revolution. Powerful new industries unimaginable a few years ago are now emerging. However, the most important phenomenon is the globalization of the economy and the net increase in international competition. It is in this tough and vibrant environment called the New Economy that Canadian firms must grow and prosper.
- . It is a well-known fact that Canada's industrial structure is truncated, lacking the manufacturing strength of several advanced countries and small economies like those of Switzerland, Denmark, Sweden and others. It is also a recognized fact that small and medium-sized enterprises (SMEs) are playing a very significant role in the New Economy, particularly with regard to innovation and new job creation.
- . However, it is also a fact that even though the technology-based SMEs are thriving on innovative products and services, relatively very few of them in Canada even have an engineer in their employ. This is in strong contrast with SMEs in Germany, France, U.S., and several other countries. How can these SMEs hope to successfully enter world markets without having the basic requirements to deal with fast advancing technologies? How can they enter the world of total quality without having engineers in design, production and services to clients? How can they position themselves with regards to emerging technologies? How can they benefit from research carried out in our universities with regard to emerging technologies transfers when they do not even have an "interpreter" of technology or of scientific advances?
- . Yet, it is anachronistic that due to the present recession, many competent engineers, including many new graduates, cannot find employment in their field of competence.
- . Another basic problem facing SMEs is their chronic undercapitalization and insufficient involvement in R&D. The Federal Government should recognize that financing has become a critical determinant of the success of knowledge-based SMEs, of which there are thousands now in Canada. Many studies have shown the great difficulties encountered by SMEs in obtaining both debt and equity financing.

Recommendation No.7

The Federal Government must move ahead with its intention to help finance the new economy as announced in the Budget Speech on February 22, 1994. It must facilitate to small business, particularly the emerging high-tech companies, access to adequate capital.

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PUBLIC AWARENESS OF SCIENCE, ENGINEERING AND TECHNOLOGY

- . Scientific culture and public awareness of S&T are considerably enriched by considering "engineering" at the same time. Indeed, engineering is about the transformation of science into technology, and about the translation of technology into industry.
- . It should be a matter of concern to the Federal Government and all other levels of government to increase, rapidly, the level of public awareness of science, engineering and technology (SET), especially in kindergarten through Grade 12 schooling.
- . Programs such as the "Outreach" program sponsored by universities for secondary and high school students and innovators in the schools, supported by the engineering community and aimed at elementary schools across Canada, are exemplary and should be supported. It is at these formative ages that teenagers learn about the technological world surrounding them and about industry that makes the economy turn. It is important that the incoming new generation be made better prepared to enter the highly competitive world that will be their's.
- . Much has been said about public awareness of science, but much less about technology and even less about engineering. Now is the time to move ahead and SET the course.
- . SET awareness also applies to politicians of all parties who, often, are unaware of the major issues facing Canada in this regard. There is a need at all levels of government for decision-makers or pace-setters to become knowledgeable about the SET issues affecting Canada's well-being and future prosperity and quality of life.

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It is incumbent on the Federal Government to provide leadership in public awareness programs relating to science, engineering and technology and, jointly with the provincial governments and the business community, to launch educational initiatives to make Canadians more aware of the spectacular advances of science and technology and the remarkable achievements of engineering in today's society.

CONCLUSION

Engineers of Canada constitute for the Federal Government a very important resource in all matters relating to the applications of science and the full deployment of technology in the production of goods and services. Any federal strategy in S&T must therefore take that fact fully into account.

In view of the many inputs provided through the national consultative process relating to the S&T strategy, this brief addresses only some of the major issues. That does not mean that engineers are not sensitive to the other issues but rather that they feel very strongly about the few points they have raised.

Engineers of Canada are committed to contribute to the finalization of the resulting strategy. They offer their services to the Federal Government for its implementation.

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