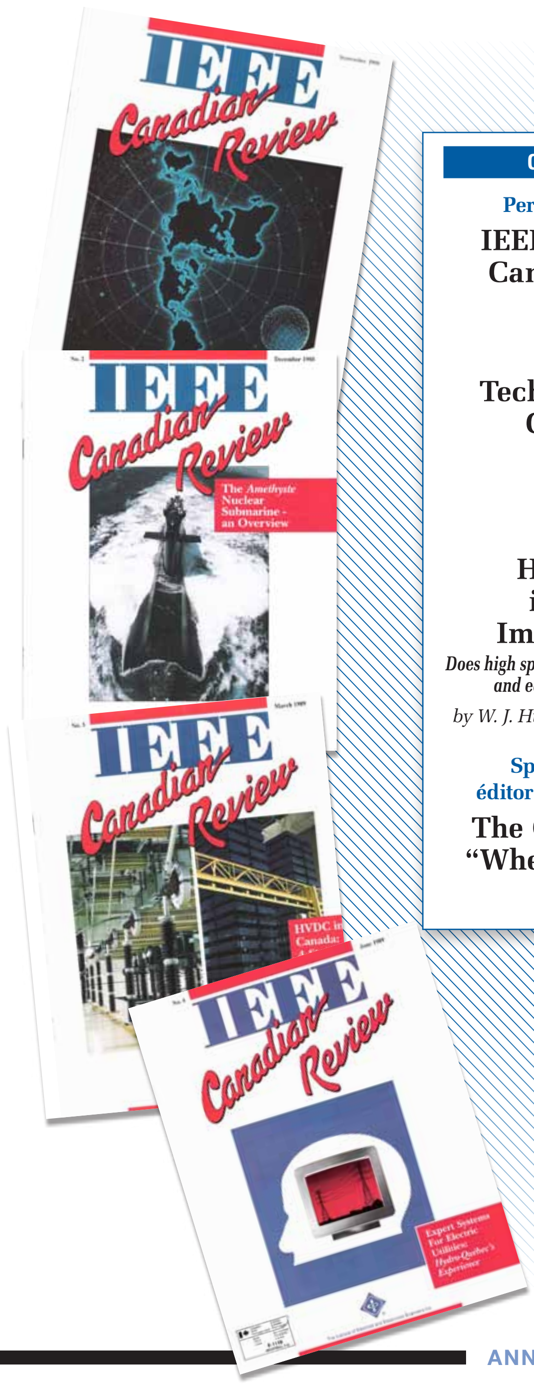
Laying out the vision

Like the first few words of a speaker at a podium, the earliest issues of a magazine must capture the audience's interest. *Check*. And followup with substance. *Check again*. But the *IEEE Canadian Review* was also launched with a vision. This is nowhere better articulated than by Bob Alden in the first article of the first issue (please see the following page).

The other articles chosen for our sampling of the publication's launch phase give full expresssion to that vision. Founding editor Richard Marceau's essay contends that government must make technology an instrument of national policy, and sketches out a blue print to achieve this.

With Canada one of the few industrialized countries still without a high-speed passenger rail system, the arguments concerning this investment are worth revisiting.

Does the mere mention of organizational structure make your eyelids heavy? The late Wally Read's discussion of the place of the Chapter in the IEEE family constellation brings "home" his message with wit and his inimitable style.



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IEEE Canada and the *Canadian Review*

by Dr. Robert T.H. Alden
Director, IEEE Canada

Since this is the first issue of this new publication, and my first opportunity to write to all Canadian IEEE members as your Regional Director, I would like to share some observations about our Region with you, and introduce our new Region publication.

I am pleased to report to you that our Region is alive and well. Our Region membership passed the 15 thousand mark at the end of last year, while the Institute total is now approaching 300 thousand. You have an enthusiastic Region Committee, 20 active Sections, over 40 dynamic Student Branches, and a highly effective Region office.

Many of you will remember receiving NEWS7 three or four times per year as a Region-wide newsletter. With the increasing quality and number of Section newsletters, we decided to build on this strength, feed information to local groups more rapidly, and create a new Region magazine that would complement the other publications that you receive.

NEWS7 is now a one page newsletter sent monthly to Sections, Student Branches, and Committees of the Canadian Region. This is an efficient way to get information out quickly to about 150 IEEE volunteers for their immediate use, and allows for incorporation in Section newsletters. Please don't hesitate to send any items you would like published to our IEEE Canada office.

The *Canadian Review* replaces NEWS7 as the quarterly publication mailed to all IEEE members in Canada. I hope that you will find it informative and a pleasant reminder of your membership in IEEE and our Region, and also that you will enjoy this and future issues.

This year is being marked as the twenty-fifth anniversary of the IEEE and the Region structure as we know it today. IEEE was formed in 1963 by the merger of the two predecessor Institutes, AIEE (American Institute of Electrical Engineers) and IRE (Institute of Radio Engineers). Each Region has been given a commemorative Region banner to display at meetings and conferences. Region 8 (Europe, the Middle East and Africa) is celebrating its anniversary this October in Munich, West Germany with a special Region 8 committee meeting with the IEEE Executive Committee (and, I am told, suitable amounts of "Octoberfest" rituals).

The launching of the *Canadian Review* is, in one sense, a culmination of "25 plus" years of development within this Region. It seems appropriate that a brief review of our history should appear in this first issue.

IEEE Canada was born with the creation of the Toronto Section of the AIEE in 1903. In 1926, the Canadian Section of the IRE was formed. Both of these related but separate groups flourished, expanded their activities, and resulted in the creation of Region 7 of the IEEE when the 1963 merger of the two Institutes occurred. The creation of the Region office in 1972, located just north of metro Toronto in Thornhill, and the development of the three Canadian Councils (West, Central, and East) resulted from increased activities and the need for local coordination of Canadian efforts.

Due to the vision and energy of George Armitage, the first Region office manager, Student Branches and Section-based educational and technical activities flourished and enhanced the awareness of the Canadian aspects of our Region, which has become known as the Canadian Region of the Institute of Electrical and Electronics Engineers Inc., or IEEE Canada for short. Those of you who know George will be pleased to learn that IEEE is acknowledging his signal contributions in the form of a new award to recognize outstanding student branches.

We in our Region have already helped to celebrate the IEEE centennial in 1984 with our centennial book "Electricity the Magic Medium", edited by Harry Prevey of the Toronto Section (some copies are still available from our IEEE Canada office). We also organized, at the request of the Engineering Institute of Canada, the electrical portion of the Canadian Engineering Centennial celebrations in Montreal in 1987. We have just completed a 20 minute video on "Technology Transfer through Licensing". This was a joint venture with the Licensing Executives Society that involved Guy Houle, a senior volunteer officer with that Society and also a long standing member of the Montreal Section of IEEE.

We have a long heritage in the IEEE family, and there is a strong sense of loyalty to IEEE and an appreciation of the technical quality of its activities. It is with this background that we approach our new Region flagship publication.

The *Canadian Review*, as currently envisaged, will generally contain about three articles per issue, designed to be of interest to a broad range of Canadian IEEE members and others of like mind. The objective is to complement the "explanation of technology" articles that are the mainstay of "Spectrum" with articles that describe engineering projects and challenges, or that explore related fields of interest in a Canadian perspective. The Managing Editor, Richard J. Marceau, is in the process of developing a network of volunteer Associate Editors, who will seek and review articles on a wide range of topics such as national and international affairs, the industry scene, technology, education, etc.

I invite your contributions and participation, and urge any interested potential authors to contact our Associate Editors.

In addition to these major articles, the *Canadian Review* will contain information about activities and people in the IEEE Canadian Region. We expect that this type of content will evolve in response to you the reader. Please let us know your needs, interests, and comments, by contacting our IEEE Canada office.

I close by extending my personal thanks to all of the dedicated volunteers and staff who contribute so much time and talent to our Region. I would also like to recognize the friendship, good will, and assistance that is ever present from the IEEE Headquarters and Service Centre, and from the numerous volunteers from other Regions as well.

Technology, R&D and Government

If technology is strategic to the future of our nation, perhaps we need to pay more attention to how it comes into being.

by Richard J. Marceau
Secretary, IEEE Canada

In our world today, few nations will deny the strategic importance of technical expertise and advanced technological means coupled to an abundant supply of natural resources and a powerful financial infrastructure. The lack of free access to any one of these elements not only signifies dependence in the short term but vulnerability in the long term, whether seen from a political, economic, social or any other perspective.

Canada is a nation blessed by the relatively easy access to all of these elements. Nevertheless, when considering technology, it may not be so obvious that this should be taken for granted. Indeed, examples abound from recent times, primarily in relation to East-West or North-South relations, where various types of technology have not been made freely available, usually for reasons of national security. Nuclear or nuclear-propelled weapons systems immediately come to mind, but many other technologies such as more conventional weapons systems, high-precision numerical machine-tools, supercomputers and even some personal computers have seen their access severely restricted.

As other nations strive towards a higher technological base and attempt to protect whatever competitive edge they have, the access to new technology may change. In the same way that the controlled access to a national economy is one of many tools used by many nations to achieve strategic aims, the pressure to control access to technology as a lever of national economic policy may increase, not diminish.

In the past two centuries, technology has rapidly evolved to become a powerful economic vector for private enterprise, fueling social change, transforming the world we live in. Technology now stands at the very base of a nation's present and future wealth and influence, not only because an advanced technological base represents its potential to multiply the productivity of individuals, but also because it represents its capacity to continue this multiplying effect through future generations of technology.

Due to the strategic importance of technology, it is incumbent upon a nation's government to provide the leadership, nurture, stimuli, and environment whereby technology progresses and stimulates scientific breakthroughs into new areas. Notwithstanding the accelerated pace of technological evolution of the past three or four human generations, many are tempted to believe that the great scientific breakthroughs are a thing of the past. In fact, we have barely begun to understand the universe about us.

For Canada to maintain, if not increase, its relative economic weight in the rapidly changing world arena, limited as it is by its small population, it must actively search for ways to continue to amplify the efforts of its people. Technology, in this regard, must be seen as an instrument of national policy, wherein the necessity to reinforce the existing high technology infrastructure and governement technological policies.

Beyond the practical limitations of governmental financial restraint, how does one translate the concepts of nurture, stimuli, environment into a practical approach? What specific objective should be pursued? And is research and development the *only* cornerstone of a national policy on technology?

Technology and national strategy

Thanks to its own efforts and those of its principal economic partners, Canada has long had ready and economical access to almost any technology necessary for its development. However, as many nations enter into a process of rapid technological evolution, Canada finds itself in a world of increasingly fierce competition in every sphere of activity including technology. In view of the importance of technology to a nation's present and future wealth and influence, how can we, as a nation, react to this changing environment?

Technologie et stratégie nationale

Grâce à ses propres efforts ainsi qu'à ceux de ses principaux partenaires économiques, le Canada a depuis longtemps accès aux technologies réquises pour assurer son développement. Toutefois, plusieurs pays amorcent un processus d'évolution technologique rapide: le Canada se retrouve dans un monde de compétition féroce où toutes les sphères d'activités sont touchées, en incluant la technologie. Étant donné l'impact de la technologie envers la richesse et l'influence d'une nation moderne, comment devons-nous réagir, en tant que nation, à cet environnement évolutif?

Technology and R&D

R&D is a familiar catchword that means different things to different people. Though one can easily associate the term "research" to a quest for understanding or new knowledge, "development" has been seen to describe anything from building a laboratory prototype to establishing the groundwork for new markets. In order to fill this gap, other terms, such as "demonstration", "innovation" and "qualification", have arisen. But regardless of how one defines the exact meaning behind the words, development is linked in some way to the application of knowledge. One intuitively senses that R&D represents the first few stages of a larger process involving the successful introduction and commercial exploitation of successive generations of technologies.

To make this process effective requires an understanding of how knowledge and technology interact, resulting in the advancement of both. Inventors, engineers, innovators or researchers will happily point out this iterative process as its relates to specific projects. And as one examines the macroscopic interaction between technology and knowledge on a longer time scale, they seem to combine, from seemingly unrelated fields, through apparently improbable scenarios, to advance the technological base of a nation to new generations of technology and new knowledge. In other words, the macroscopic process of technological evolution is a closed-loop process.

As every engineer has learned at one time or another, open-loop systems are inherently unstable. A national technology policy hinged solely on R&D, ignoring how it interacts with the remainder of the process, is like inputting a process whose output and feedback are not being monitored or controlled downstream. There is a very real danger that no output emerges: critical paths

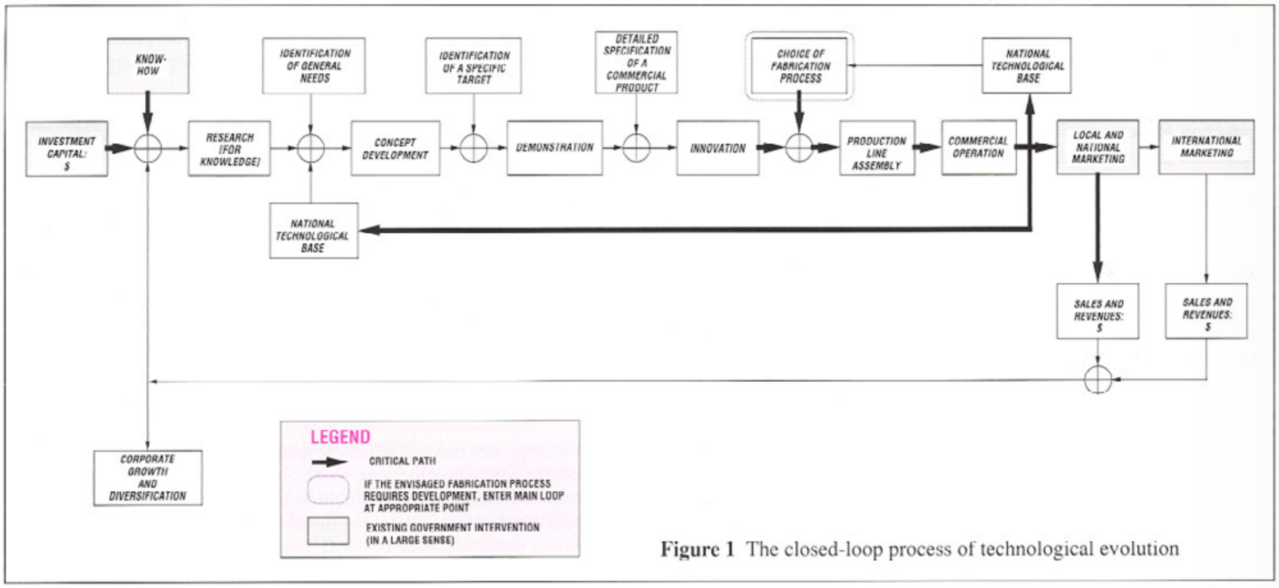


Figure 1 The closed-loop process of technological evolution

exist at several points in a loop, not just at the input stages where we find R&D. Let us examine this closed-loop process more closely, as illustrated in Figure 1.

The Process of Technological Evolution

As a working hypothesis, let us define R&D as having, at any one time, one or several of the following objectives:

a) The quest for knowledge;

b) The training of researchers, engineers, innovators or scientists;

c) The active prospecting of new technologies;

Establishing the basic concepts for:

d) the improvement of existing products or processes;

e) the introduction of new products or processes.

In Figure 1, one can directly relate the stages of *Research (For Knowledge)* and acquiring *Know-How* to a) and b) respectively, while d) and e) correspond to the *Concept Development* stage. Item c) can belong to either one of the three, according to how loosely it is coupled to specific needs.

Let us momentarily examine the impact of the availability of different types of technology to the initial R&D stages. The particular path of development taken in specific instances is heavily influenced by a society's present technological base. The higher the level of this base, the more ambitious the concepts which can, in one form or another, find their way to the marketplace. These in turn contribute to incrementing the base, which facilitates the emergence of new knowledge, from which springs further development. A mutual feedback consequently develops between knowledge and technology, resulting in a closed-loop system. And the enrichment of the technological base is the key to understanding the closed-loop nature of the process.

Downstream of the process, beyond the *Concept Development* stage, one targets a specific application which leads to the *Demonstration* of a scale- or life-sized prototype under real-life conditions. Much detailed design and fine-tuning follows even with highly successful demonstrations. If the technology is a specific product (hardware or software), a detailed commercial specification relating to the optimization of unit cost, quality and efficient manufacture represent the main challenges of the *Innovation* stage. If the technology is a process, the challenge is to implement the process in such a way that unit cost and quality are once again optimal. What then follows is the actual *Construction* of the production line and its subsequent *Commercial Operation*.

For an incremental advancement of the technological base to be permanent, the economic self-sufficiency of the means of production is essential until the product or process is no longer competitive, can be replaced by something better or is no longer socially or environmentally acceptable. Of course, economic self-sufficiency generates profits which are the sinew of further activity.

When applied to specific cases, some of the stages illustrated in Figure 1 take on more importance than others. In fact, in an effort to reduce lead time to product introduction, much effort has been directed to reducing the time required at each step. Powerful and reliable simulation can even permit the short-circuiting of certain stages altogether. However, each stage represents a specific need in the process, whether it exists implicitly or explicitly.

Critical Paths

The various government levels bring considerable support to different points in the process. For instance, many existing measures:

a) ensure the existence of a comprehensive education system, which supplies expertise and know-how;

b) provide partial or complete funding for many pure and applied R&D programs and projects;

c) stimulate partnership between industry, university and government;

d) facilitate the availability of investment or venture capital for job-creating projects of varying degrees of risk;

e) encourage the purchase of products from companies based locally or nationally;

f) promote the availability of Canadian products in foreign markets.

At first glance, one may be tempted to ask if there is anything left to be done. However, there is a weakness: these individual measures are not orchestrated as a coherent whole in tune with the technological process. The access to one set of measures and the consequent success of a particular stage in the process by no means translate into eligibility to another set of measures, or that appropriate measures even exist to exploit or weather the next stage. And need it be said that many obstacles must be overcome before a new technology is economically self-sustaining?

But when do obstacles become critical paths? One can suppose that obstacles which are not under direct organizational control can become critical paths. Of course, technology itself may present insurmountable obstacles. However, once a specific project is considered feasible and given the green light, one must assume that all technological task forces, pitted face to face against unforgiving matter, are on an equal footing.

According to this definition, there are three critical paths to the process, two being at the point of entry: Availability of personnel having the necessary knowledge and expertise, and Accessibility of financing. The third critical path lies closer to the process output: inasmuch as R&D requires funding, the greatest financial risk lies in the generally far more considerable capital investment required to construct, commission and start-up new means of production. Between the initial go-ahead and the time a new production unit is generating a cash flow in line with its financial obligations, the fear of uncertainty and exposure may stifle the initiative to go with an otherwise promising technology, unless one can convince everyone concerned in the process that the risk is worth their while.

Incentives to the Process

Of course, this is far more simple to say than to do. On the one hand, motivation, though a necessary condition, may not always suffice to carry the day. On the other hand, nor are unlimited financial means a guarantee of success. However, one must recognize that motivation has the intangible attribute to provide far more margin than can be quantified *a priori*, if the proper incentives exist.

A national commitment to incrementing the technological base is precisely the type of objective that is best addressed by a global policy on technology. By means of a comprehensive set of incentives that reinforce the critical paths of the technological process, an appropriate policy can galvanize the physical and psychological energies of all those contributing to the process; the researchers, engineers, inventors, innovators, who will champion a project; the middle-managers who believe that the return is worth the investment; the high-level decision-makers who see new technology fueling growth and generating higher profits; the corporations that wish to increase their competitiveness or diversify into new areas; and, lest we forget, the production workers whose toil will permit a new technology to see the day.

One way to generate motivation is to provide contributor-specific incentives at every stage of the process. To ensure the eligibility to these incentives, one need only enter the process by investing in research, concept development, prototype demonstration, or any combination thereof. Four potential types of incentives, driven by self-interest, can thus be identified:

1. a corporate incentive;
2. an incentive at the individual level, for each employee involved in an individual project;
3. an incentive that will stimulate the *purchase* of products emerging from the incentives' program by those themselves engaged in the process: for instance, using products having emerged from the program as building blocks of new technology in the upstream stages (i.e. R&D, Demonstration, Innovation) or purchasing and exploiting such products when constructing new factories;
4. an incentive that will stimulate the *sale* – at large – of products emerging from this program.

Measures 1 and 2 directly target the motivation of those with a vested interest in the success of a new technology (i.e. a company and its employees) while attempting to reduce obstacles at the point of entry. At the output end, measures 3 and 4 will accelerate the purchase, acceptability and credibility of new products and help reinforce the competitive position of more traditional products emerging from a new process. In addition, the latter measures will encourage those having invested most heavily in time, effort and financial resources: a psychological intangible which may help smooth over some difficulties. Finally, corporate incentives provide margin for an enlightened company to reward its employees even further when the payoff appears.

A concrete example of each of these could be as follows:

1. in addition to all other incentives presently available at the point of entry, a reduction or absence of corporate income tax on all revenues associated with a new production unit for the first few years of commercial operation; for example two years.
2. a reduction or absence of personal income tax for the first few years of production (again, for example, two years) for all employees involved in the risk of realizing a new production unit, from R&D all the way to commercial operation;
3. a reduction or absence of sales taxes for 2 years associated with the *purchase*, by those who are themselves engaged in the process of building means of production, of earlier products having emerged from the process;
4. a reduction or absence of sales taxes for 2 years associated with the *sale* of products from new means of production emerging from the process.

As a whole, by encouraging the rapid utilization of locally emerging technologies and the reinsertion of new "technological building blocks" in downstream developments, one generates interest to enter the process and a technological momentum arises as a result of the closed-loop process. This momentum drives the rise of the technological base, which, in the long run, increases the overall productivity and competitivity of industry.

At first glance, one may suppose that such measures are unthinkable in this age of increasing national deficits. However, one can also suppose that much of the additional economic activity generated by virtue of the implementation of such measures would not have existed otherwise.

Such an approach may not be easy to manage, but this must not appear as an impossible obstacle. One way to do this would be to create exclusive, geographic zones where they would be in effect in such a way as to favour regional development. Of course, there may be other ways. But the bottom line is that something must be done.

Conclusion

Technology is of strategic importance to the future of our nation. Though support of R&D is essential, the emergence of new technology is a closed-loop process: to drive this process effectively and advance the national technological base, a national technology policy must not only provide incentives at the input (R&D) end but at all critical paths throughout the process.

The basic principle behind such a policy must be motivation. Everyone in the process, at every level, must find some incentive to deliver his or her best, at all times. And when government provides leadership, industry plays its part. Otherwise, individual, heroic efforts aren't enough to maintain our competitive edge in the world economic arena. It's a question of national strategy.

About the IEEE

The Institute of Electrical and Electronics Engineers, Inc. (IEEE), with headquarters in New York, is a transnational organization with 300,000 members in 137 countries. The world's largest engineering society, its objectives are technical, professional and societal.

The IEEE's technical objectives center on advancing the theory and practice of electrical, electronics, communications and computer engineering and computer science. To meet these objectives, it sponsors conferences and meetings, publishes a wide range of professional papers and provides educational programs. In addition, the Institute works to advance the professional standing of its members. It also has a mandate to enhance the quality of life for all people through the application of its technologies, and to promote a better understanding of the influence of these technologies on the public welfare.

Today, the IEEE is a leading authority in areas ranging from aerospace, computers and communications to biomedical technology, electric power and consumer electronics. When it began its second century in 1984, it rededicated itself to Innovation, Excellence, the Exchange of information and the quest for improved Education. In so doing, it underscores the initials IEEE.

IEEE Canada is the Canadian entity of this transnational organization, with approximately sixteen thousand members. The Canadian Region is divided into twenty Sections, each centered in a Canadian city, from Victoria, B.C., in the west, to St. John's, Newfoundland, in the east. For information on whom to contact in your area, the many IEEE products and services available, or how to join IEEE, write, phone, or fax our IEEE Canada office (page 3).

High Speed Rail in Canada: An Impossible Dream?

Does high speed rail transportation make financial and economic sense in Canada?

by W. J. Hurley, J. Jones and A. R. Eastham
Kingston, Ontario

An idea whose time has come?

The concept of high-speed rail (HSR) in Canada has attracted considerable media attention. Given the success of high speed rail in Japan, France and elsewhere, the technical feasibility of such a project is not seriously in question. But is such a project economically viable in Canada?

Le temps est-il mûr?

L'idée d'un train à grande vitesse au Canada a attiré beaucoup d'attention ces derniers temps dans les grands médias. Étant donné le succès de différents types de trains à grande vitesse au Japon, en France et ailleurs, on ne met plus en doute sa faisabilité technique. Toutefois, un tel projet est-il économiquement viable au Canada?

Much media attention has recently been given to the possibility of an electrified high speed rail system (HSR) between Montréal, Ottawa and Toronto. This discussion occurs against a backdrop of cutbacks and uncertainty regarding the future of VIA, the Crown corporation responsible for rail passenger transport in Canada. The Canadian government is planning to reduce the subsidy to VIA to $350 million, a cut of 45%, by 1993. In this climate of budgetary restraint, it seems unlikely that the federal government would make a major investment in HSR. Yet, our estimates suggest that it may be possible to move people in the Montréal-Ottawa-Toronto corridor more cheaply by HSR than by air transportation (Air).

The Relative Cost of HSR and Air

Let us first consider the basis on which costs are to be compared. Currently, there is no high speed rail; there is only an air system. It is appropriate, then, to compute the savings in discounted cost that would result if a given level of traffic is moved by HSR rather than by air. Costs are discounted over the life of the HSR infrastructure, which is assumed to be 40 years.

The total cost for each system comprises three categories: direct fixed costs; direct variable costs; and indirect costs.

- Direct fixed costs for HSR are the costs of providing the right-of-way and track. For Air, they consist of two major elements: the cost of airports, terminals and related fixed plant; and the cost of the air navigation system.
- Direct variable costs include all other direct costs exclusive of infrastructure costs. For HSR, direct variable costs would include: operations; rolling stock maintenance; maintenance of way; overhead; and an amortized capital charge associated with the rolling stock investment.
- For Air, direct variable costs would consist of comparable items.
- Indirect costs include the cost of travel time, pollution and other such items which are not borne directly by the providers of the transportation service.

Indirect Costs

On indirect costs, HSR compares favourably with Air. For instance, consider the cost of travel time. Table 1 compares the total cost of travel - including time spent traveling to and from the terminal and waiting at the terminal - for the three major corridor trips. Between Ottawa and Montréal, HSR is faster; for the other two, HSR times are competitive.

Table 1 - Air and HSR Trip Times for Selected City Pairs

City Pair	HSR	Air
Toronto-Ottawa	3 hours 20 minutes	3 hours
Toronto-Montréal	4 hours	3 hours 20 minutes
Montréal-Ottawa	2 hours 10 minutes	2 hours 20 minutes

Other aspects of indirect costs are convenience and comfort. HSR and Air come out roughly equal. A TGV-type HSR service would be more comfortable than Air. On the other hand, Air would generally offer more departures.

A final category of indirect costs are "externalities" like noise, air pollution and congestion. Since TGV-type service is electric, it is both quieter and cleaner than Air. With the existing congestion at Pearson International Airport in Toronto and the prospect that it will get worse, HSR is an alternative to airport capacity expansion.

Direct Costs of High Speed Rail

To get a high speed rail system operational between Toronto and Montréal will require approximately $2.6 billion, consisting of $2.3 billion for infrastructure (see Figure 1 for breakdown) and $300 million for rolling stock.

We take $2.3 billion, the total infrastructure cost, to be the direct fixed cost of the high speed system. We estimate that it will take 6 years to put the infrastructure in place and, once in place, it will last for 40 years with normal maintenance. Rolling stock is not included as a fixed cost for reasons to be discussed below.

There are two items of direct variable cost. One is a period charge which includes operation, overhead, maintenance of rolling stock and maintenance of way. The other is rolling stock. We estimate the period charge to be $.052 per passenger-kilometer, calculated as shown in Table 2.

Table 2 - Annual Operating and Maintenance Costs for High Speed Rail ($ millions)

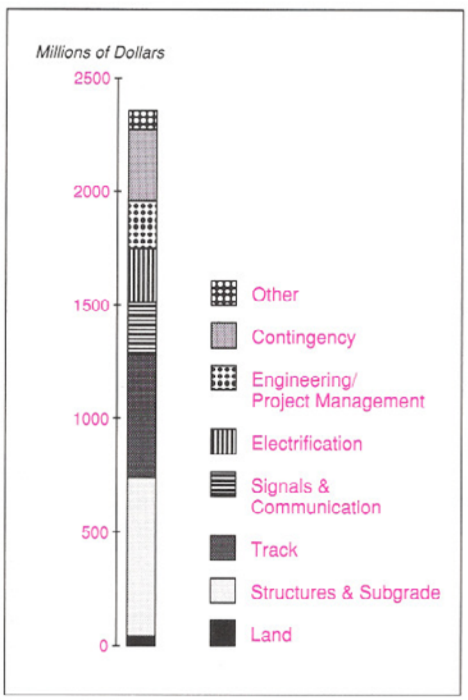
Crew and On Board Services	24.4
Equipment Maintenance	22.8
Stations and Sales	18.0
Train Control	1.5
Track and Facilities Maintenance	12.5
Insurance	3.0
Corporate Offices	5.5
Total	87.7
Total passenger-kilometers (millions)	1 679
Cost per passenger-kilometer (cents)	5.2

These costs have been developed under the assumption that the operator of a Canadian high speed system would not be constrained by traditional railway industry workrules. In particular, it assumes that the crewing levels practised on the French TGV could be implemented here. Also, the cost per passenger-kilometer is for the forecast level of demand. For higher levels of demand, this cost would fall.

To check that 5.2 cents per passenger-kilometer is reasonable, we examined the TGV Southeast accounts over the years 1981-1985. These indicated that the average costs decreased from 5.4 cents in 1981 to 3.9 cents in 1985, therefore supporting our cost analysis.

The other variable cost is the capital cost of the rolling stock. We have chosen to amortize the capital cost over a 15 year period. An equipment analysis based on 65% occupancy factors and an annual workload of 350,000 km per trainset indicated that 15 trainsets will be required, at a cost of $300 million in 1988 dollars. This translates into 1.5 cents per passenger-kilometer over the useful life of the equipment. Thus, we calculate the total direct variable cost to be 5.2 + 1.5 = 6.7 cents per passenger-kilometer.

Figure 1 Breakdown of infrastructure costs for High Speed Rail.



There is one additional cost, and that is the cost of capital. We have assumed a required real rate of return of 5%.

To get a total direct cost, we discount the annual variable cost over the 40 year life of the high speed infrastructure and add to it the cost of the infrastructure. The total net present cost of the HSR then becomes $3.8 billion.

Direct Costs of Air

We take a different approach to estimate the variable direct costs of the Air mode. Airline fare data for major origins and destinations across Canada was obtained as well as the distance in kilometers between each. With this data set, we regressed price on distance. The resulting regression equation is as follows:

$$P(d) = 89.3 + 0.135\, d, \quad R\text{-squared} = 0.997 \qquad [1]$$

where P(d) is price (i.e. in dollars per passenger) and d is distance. The high R-squared indicates that the data fit the linear relationship quite well.

We take this as the airline cost function for several reasons. First, North American airline companies have not been exceptionally profitable since deregulation, even with substantial increases in traffic. Table 3 presents the breakdown of operating profits for US airlines on domestic services between 1970 and 1985 for selected years. With the exception of 1985, revenues are just enough to cover operating expenses. Even in 1985, the margin is only about 2%. Second, the theory of contestable markets applied to air passenger transport suggests that, given the mobility of capital in the industry, airline prices may be close to competitive prices. Table 3 provides evidence in support of this contention.

But there are obvious objections to this approach. First, it may be that there is a cross-subsidy between long and short-haul flights. If short-haul subsidizes long-haul, the true airline cost function may be flatter that [1]. Hence, if [1] is used to estimate the cost of short-haul flights, the resulting cost will overestimate the true cost. Second, if [1] is the true cost function, it will also include a provision for capital payments to airline shareholders and bondholders. If yearly unit costs are developed from [1] and then discounted for comparison purposes with HSR, capital costs will be double counted, thus biasing the comparison towards HSR. Airline costs would also include landing fees. We do not net these from Air costs for two reasons: they are a small fraction of airline costs; in our analysis, we are not going to charge any of the capital and operating charges of the airport and air navigation system against the Air alternative.

With these qualifications noted, we proceed as follows. For a trip length of 539 kilometers, the distance between Montréal and Toronto, the cost from [1] is $162 or 30.1 cents per passenger-kilometer. However, as noted above, this cost includes all airline costs as well as capital charges to the various stakeholders. To take out these capital charges, the data in Table 3 are used to estimate the percentage of total expenses which are made up by capital charges. We take the expense item "depreciation and amortization" to be a suitable proxy for capital charges. In 1970, the depreciation and amortization constituted 10% of total expenses. For 1975, 1980 and 1985, it averaged 6%. To be conservative, we use 10%. Therefore, the direct variable cost adjusted for capital charges is:

$$30.1 - 10\%(30.1) = 27 \text{ cents.}$$

To this point, the analysis indicates that HSR has a significantly lower variable cost. Now to the problem of direct fixed cost for Air. As mentioned above, this cost has two components: airports, terminal and other fixed plant; and the air navigation system. Adoption of the new microwave landing system and maintaining the existing infrastructure will require approximately 6 to7 billion dollars over the next 20 years for the country as a whole. This expenditure does not include any provision for expansion at Toronto. Whatever these planned expenditures, the key number is the savings in Air capacity cost which would result if a high speed rail system were implemented.

For our purposes, it is enough to assume that the savings in Air capacity cost as a result of HSR are zero.

Based on the variable direct cost of 27 cents and zero fixed direct cost, the net present cost of Air is $5.8 billion. To arrive at this number, we have made the same traffic assumptions that we used for HSR: there is no traffic for 6 years; after 6 years, the traffic is a constant 1.7 billion passenger-kilometers per year.

In summary then, HSR is some $2 billion cheaper that Air over the 40 year period.

Table 3 - Operating Income of U.S. Airlines on Domestic Operations (1970-1985, $ millions)

	1970	1975	1980	1985
Total Revenues[1]	7 131	11 911	26 404	37 629
Expenses:				
Flying Operations	2 098	3 869	11 029	12 684
Maintenance	1 127	1 595	2 758	3 604
General Administration	3 157	5 050	10 545	17 324
Depreciation and Amortization	745	883	1 560	2 318
Transport Related	n/a	383	517	681
Total Expenses	7 127	11 780	26 409	36 611
Passenger-miles (billions)	104.1	131.7	200.8	270.6

[1] Revenues include freight and other revenues which range between 12% and 15% of total revenues.

Source: Statistical Abstract of the United States, 1988, 108th edition.

The Investment Value of HSR

We have shown that it is more efficient to move people by HSR than by Air. However, this does not mean that the returns will be sufficient to justify private sector investment. For this assessment, we need to test the profitability of HSR at various revenue levels.

Table 4 presents the Net Present Value of the high speed rail investment at levels of revenue ranging from 15 to 25 cents per passenger-kilometer.

At a fare level of $0.20 per passenger-kilometer, which is about 70% of the current Air fare between Montréal and Toronto, the HSR investment has a positive Net Present Value using a discount rate of 5%. However, the net present value calculation is sensitive to the revenue assumption. If fares are raised 25% to $0.25 per passenger-kilometer, the net present value increases by about 350%. Thus, given the structure of our analysis, profitability is very sensitive to the revenue assumption made.

This sensitivity suggests a role for the public sector. High speed rail profitability turns on the level of fare that can be charged. Since the initial investment is quite large, it is doubtful whether a private company or consortium of private companies would be willing to take the risk. However, if a government (or a group of governments) undertook to supply a sufficiently large part of the initial investment, the private sector risk of the project could be reduced to the point where the project would be attractive.

Table 4 - Net Present Value of the HSR Investment ($ millions)

Revenue per passenger-kilometer	*Net Present Value*
0.150	-661
0.175	-153
0.200	354
0.225	861
0.250	1368

An interesting issue related to public sector involvement is the structure of this involvement. One alternative is to have the government supply a fraction of the infrastructure cost. This will have two effects on the private sector investment. It will increase profitability and reduce the payback period. For example, suppose the fare level is fixed at $0.20 per passenger-kilometer. With no public sector involvement, the payback period is 16 years; if the public sector were to contribute $1 billion, the payback period would be reduced to 6 years.

Conclusions

The main finding is that, for a given level of demand over the Montréal-Ottawa-Toronto Corridor distances, high speed rail is cheaper than air transportation. However, our profitability study suggests that HSR may be too risky for private sector investment alone. This suggests a role for public-private sector cooperation to reduce these risks to acceptable levels and enable the benefits of HSR to be reaped.

There are also other benefits which have not been included in the economic analysis:

1. Bombardier has the North American manufacturing rights for the TGV. If high speed rail is adopted by other North American jurisdictions, Canada is well positioned to supply this market.
2. There will be economies from CN and CP's increased capacity to move freight.
3. The high speed option has the potential to reduce the congestion which currently plagues the air mode, especially at Pearson International Airport.

A final benefit is related to our ability to predict the future. Our analysis does not include the modeling of shocks to the economy over the next 40 years. Yet, in the transportation industry, shocks such as the OPEC oil embargo can have substantial effects. By way of example, suppose the price of oil were to double at some time in the next forty years. Under the existing corridor transportation arrangements, this would cause significant difficulties because of our reliance on the automobile and airplane and the energy costs incurred thereby. In a sense, the HSR investment, which is much less energy intensive, is a form of insurance against such adverse movements.

IEEE Canada Newsflash

Dr Robert T. H. Alden, outgoing Director of IEEE Canada, has just been named Vice-president of the IEEE Regional Activities Board (RAB). Dr. Raymond Findlay, a long-time active member of IEEE Canada, has also just been named Student Activities Committee (SAC) Chairman for all of IEEE. Congratulations to Bob and Ray!

The Chapter Dilemma: "Where's my Mom?"

This paper is prepared and presented in the spirit of encouraging a dialogue about the responsibilities of Sections (Mama RAB) and Societies (Mama TAB) for the IEEE offspring we call the Chapter.

Wallace S. Read
Treasurer, IEEE

All is not well in the Chapter camp. This may not be accurate for all Regions or in all Societies, but given the IEEE financial and technical resources, I believe we can do better, even in those areas where Chapters seem to thrive.

Essential to the examination of parental responsibilities is a knowledge of the needs of the child. Obviously, these include a requirement for identity, shelter, nurture, guidance, discipline and reward. It is in this broad context that I would like to review the way in which Mama RAB (Regional Activities Board) and Mama TAB (Technical Activities Board) behave towards the child Chapter and whether there is any need to strengthen the parental structure or relationship to make things better.

The IEEE Family Unit

No one would dispute the IEEE operational complexity. So varied are the interests of our members that the responsibility for special services such as education, standards, publications, etc. have been assigned to separate units. And the two units which arose from the amalgamation of IRE and AIEE as the initial member contact, both with transnational interest, are RAB and TAB. The former is a geographically-organized unit and the latter is a centralized technically-organized unit.

Immediately a dilemma surfaced. How do you service the technical interests of our members everywhere? Who should be the parent? What should be her reponsibility and how should the "other" parent support this member activity?

Well, those who had the responsibility for addressing this concern did make a decision. They felt that the closeness of a geographical parent (Mama RAB) rather than the remoteness of a centralized technical parent (Mama TAB) was more likely to ensure that the Chapter structure would survive and meet the challenge of delivering technical services. It is also possible that, at that time, they saw a larger and stronger member interface developing at the geographical level in RAB rather than at the technical level in TAB. On the other hand, I am sure that they recognized the importance of Mama TAB's close supportive role and trusted to RAB and TAB to ensure a close working relationship in the administration and delivery of this member service.

Whatever the reasons, so it was decreed and so it was written. The Bylaws clearly state there shall be two mothers:

- Mama TAB, the Society, who will conceive and give birth to a Chapter, not unlike the role of a surrogate mother, and
- Mama RAB, the Section, who, following birth, will legally nurture and raise the Chapter as it would one of its own Committees.

What the Bylaws are silent on is how this entity, the Chapter, is supposed to survive and prosper given it now needs all those things which I mentioned earlier: identity, shelter, nurture, guidance, discipline and reward.

Raising the Chapter Child

While the Bylaws clearly set out the roles of the two mothers, I believe there was an implication there. Just as Mama RAB was to seek the strength of Mama TAB for the birth, she was also to expect that the surrogate mother go beyond that role and act as wet nurse. Indeed, the drama and excitement of birth often triggered in Mama TAB a greater interest in the child and she has welcomed this expanded role.

We only have to read the guidance document written by the legal mother entitled "Chapter Operations - A Guide for Sections" to understand how Mama RAB expects her child to behave. But that same document clearly identifies the need for the continued interest and support of Mama TAB.

The Introduction States:

"Chapters are units within IEEE Sections formed to serve the specialized technical interest of Society members and to coordinate these with the local activities of the Sections and the broader activities of the parent Society."

and

"The Chapter, operating in concert with its parent Society and the Section, plays a major role in fulfilling the objectives of the IEEE."

As a result, I believe that when you boil it all down, there are in fact two mothering roles. One is to be a Conscience, a facilitator, an overseer, a disciplinarian which ensures the proper operation of the Chapter. The second role is one of support, both financial and technical, to ensure that adequate and quality programming occurs.

It seems to me that the first role requires a close geographical relationship. The child needs to be physically close to its mother so that the watchful eye can detect problems very early and take steps to correct them. Enter Mama RAB. The second role of nurturing the child is best accomplished close at hand as well. It is difficult to breast feed at a distance but, on the other hand, you can't breast feed if you have no milk. Enter Mama TAB.

If either of these roles break down, you have a difficult parent/child relationship and an undisciplined or undernourished child. Neither will be a good performer. Mama TAB will have to address whether she is prepared to support a child conceived by her but growing up under someone else's guardianship. Mama RAB will have to consider whether legal guardianship requires the parent to bear the cost of feeding the child as well. But either way, grandparents RAB and TAB had better more clearly define the roles of the mothers, shake hands and get on with supporting the Chapters in their important work.

It's tough trying to serve two parents unless the parents agree on how, when, where and why they will exercise their authority. Give Chapters a break. Don't abandon them. Just lay down the rules of the game so that they can understand them.

Identifying a problem is halfway towards solving it. I've given you my views. What are yours?