The Birth of the CANADIAN REVIEW

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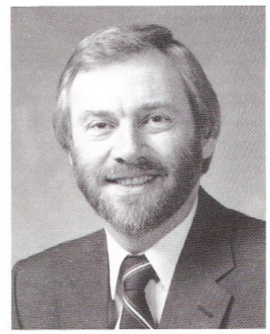
IEEE Canada and the *Canadian Review*

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.

Sample Contents from Early Issues

Taken from Premier issue

Free Trade and Electricity

Canada has an export opportunity if it can economically displace existing oil- or gas-fired units.

by Mitchell P. Rothman
Chief Economist, Ontario Hydro
Toronto, Ontario

In the last ten years, electricity trade between the United States and Canada has gone from a roughly balanced seasonal interchange to Canada's present position as a major net exporter of power. This change elicited some political reaction in the United States,primarily in the form of a coalition opposed to the further expansion of such trade, claiming both that it posed a potential threat to US economic security and that Canadian electricity producers had various unfair advantages by reason of their public ownership[1].

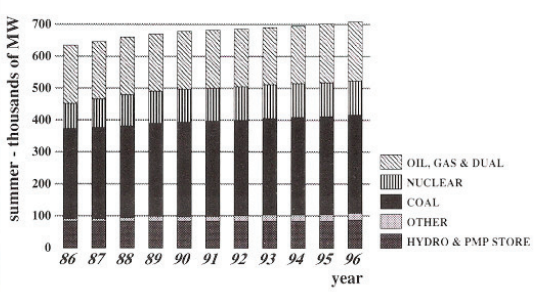
In light of this challenge, when looking at the future of electricity trade, analysts differentiated between the prospects for two types of traded electricity.[2]

Short-term exports from Canada seemed likely to continue. They depend only on the relative levels of demand and short-term marginal generation costs in the two countries. This trade dispatches the cheapest generation sources to be used first. Whenever the marginal generation capacity in one country uses a cheaper fuel than the marginal generation in an interconnected utility, electricity will be traded and the cheaper fuel will displace the dearer. In such trade, hydraulic sources will displace any fuel; nuclear sources will displace any fossil fuel; and coal will displace oil. Because many utilities in the states bordering Canada, especially in the Northeast, will frequently have oil-fired generation capacity operating at the margin, and because neighbouring Canadian utilities will have either hydraulic, nuclear, or coal at the margin at least some of the time, short-term electricity trade will continue to be profitable. Because it is priced in a way that renders the protectionist arguments invalid, the Free Trade Agreement (FTA) is unlikely to affect it either way.

For longer-term trade the story is quite different. There are numerous risks inherent in long-term power contracts. These contracts would have to cover the construction and operating costs of new generation facilities. With the long lead time in construction, and the long lives of the facilities, both US buyers and Canadian sellers can be expected to want a clear statement of how the risks are to be shared before they would sign contracts. So development of long-term sales could be slow in the absence of a mechanism for these issues. Further, the protectionist arguments are aimed directly at such sales.

CHART 1

Actual and Projected Installed Generating Capacity by Fuel (1987-1996 forecast)



The impact, positive or negative?

By providing a more stable trade climate generally, by removing some irritants and impediments and by preventing the imposition of others, the FTA will have a positive effect on the amount of long-term firm power and energy sales to the United States that will benefit both countries, as international trade should.

Le bilan: positif ou négatif?

Grâce à l' accord sur le libre-échange, la mise sur pied d' un climat commercial stable, l' élimination "d' irritants" et de barrières traditionnelles et le freinage de la création de nouveaux obstacles devraient augmenter les ventes fermes de puissance et d' énergie à long terme, bénéficiant aux deux pays.

Even so, new long-term sales have developed rapidly. The government of Quebec has made the construction of a second phase of hydraulic generation facilities on its northern rivers flowing into James Bay a major priority. Accordingly, it has negotiated and announced some major increases in long-term export sales contracts, and the start-up of the James Bay II project.

Given all this activity, how will the FTA affect these electricity trade prospects?

Of course, it is not possible to be certain of the effects of the FTA. Its language is to be translated into implementing legislation, which will then be subject to litigation on both sides of the border. So, although the position of the principal negotiators on both sides, at least with respect to energy, is clear, the ultimate resolution of the effect of the FTA will have to await experience of it in operation. Therefore, although they are reasonably well informed through reading and personal contact, the opinions on the effect of the FTA expressed here must be considered to be those of the author.

FTA Provisions and Electricity Trade

Before starting on the impacts, it would be useful to lay out some background information. First, we will briefly examine the provisions of the FTA that relate to electricity, and indicate how, if at all, they change the current position. Second, we will consider in more detail the underlying economics of the electricity trade. Finally, these two put together will suggest conclusions about the impact of the FTA on this trade.

Electricity is included in the FTA by being defined as an energy good. This follows North American practice, and clarifies the status of electricity but does not follow the practice of the General Agreement on Tariffs and Trade (GATT). Also, some specific statements in the Agreement relate to electricity trade.

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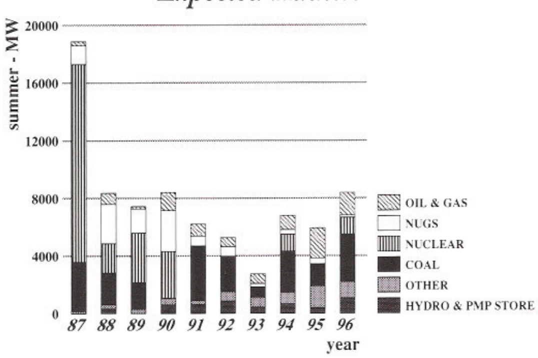
The general intent of the FTA in the area of energy, as in other areas, is to reduce all tariffs to zero and to reduce the ability of the respective governments to impose or maintain new tariff or Non-Tariff Barriers (NTB's). In energy trade, the barriers to be prohibited include restrictions on exports as well as restrictions on imports.

As it is for other goods, the FTA's treatment of energy is generally modelled on the GATT. Conditions added to GATT treatment relate to the possible imposition of export taxes, export price floors, and quantitative export restrictions. The FTA provides for consultation in the event that a regulatory action taken by one country is felt to discriminate against the energy goods of the other. (This would preclude unilateral actions like Federal Energy Regulatory Commission Ruling 256, for example). The FTA also

CHART 2

Generating Capacity Expected Additions



limits the national security argument for import restrictions to the actual energy needs of the military establishment.

Two measures relate specifically to electricity trade. The US agrees to have the Bonneville Power Administration give British Columbia Hydro access to its interties on the same terms as other utilities from outside the Pacific Northwest. Canada agrees to drop its third price test for power exports, which stated that the export price had to be close to that of the price of replacement energy. The surplus test, which Canada's National Energy Board had administered for electricity and gas exports, is left intact but subject to other provisions of the Agreement.

However, the Agreement will have other impacts on electricity trade. That their direction is not completely clear is seen from the fact that two major electricity-exporting provinces, Quebec and Manitoba, have taken opposite positions on the FTA, with Quebec a strong supporter. This partly reflects their overall political philosophies, as well as their economic self-interest, but is indicative of the different readings given to the FTA.

Underlying Conditions of Trade

It would be informative here to review the conditions underlying electricity trade between the two countries. In the recent past, US electrical utilities have planned very few new generation facilities. This was due to several factors: a period of chronic excess capacity; the surge of non-utility generation spurred by the US Public Utilities Regulatory Policy Act (PURPA) legislation; the general economic climate; and the reactions of regulators to companies that did build. Utility executives learned that to build a new plant was to bet the company, because regulators would disallow its costs if they decided that the plant was not needed at the time it was finished.

For most of the 1970's and early 1980's, this approach was fine. The existing generation facilities could more than meet the demand, even if they did have to use some expensive fuel to do it. Legislatures helped, federally with the PURPA legislation and locally with various state regulations requiring utilities to pursue conservation.

However, since the recession of 1981-82, the North American economy has gone through one of its longest unbroken postwar expansion periods, producing a corresponding increase in demand for electricity. It now begins to look as if the United States will collectively begin to run short of electric power by the mid-1990's. That time is within the planning horizon of electric utilities, so they must begin thinking about it. Right now there is more than enough generation capacity to meet peak demand with an adequate reserve margin. But demand is forecast to grow by about 2% per year, about twice the 1.1% growth rate of capacity, so that reserves will be on the border of inadequacy by 1996.[3]

Chart 1 shows the existing and planned generation mix in the United States. Chart 2 shows how that additional capacity will be fueled. The chart includes both Seabrook and Shoreham, because the reporting utilities expected to bring them into service at the time the survey was taken. As usual, a lot of new nuclear capacity is expected to come into service in the first forecast year. Many utilities have plants that they always plan to have operating next year.

Whenever that overhang is absorbed, coal will fuel most new capacity in the United States. However, there is also a significant number of oil- or gas-fired generation additions. Further, much of the non-utility generation, or NUG, is planned to be gas-fired.

Chart 3 shows the results in terms of the balance between demand and supply at peak. In the first years, there is no problem: existing capacity can easily meet the load, with an adequate reserve. However, in the later years, the reserve margins become disturbingly thin. Further, Chart 4 shows that about one-eighth of total electricity in the United States will still be generated by high-cost fossil sources, oil or gas.

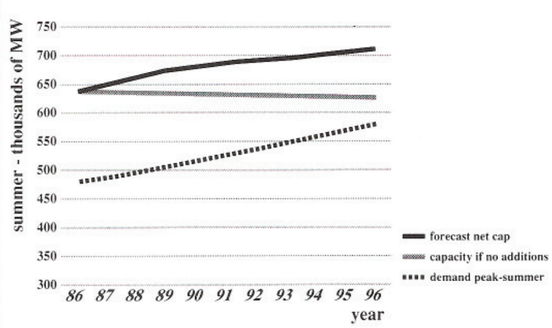
In summary, demand growth in the United States clearly requires some additional capacity to maintain an adequate reserve margin. The North American Electric Reliability Council (NERC) has warned that several events could reduce the margins of reliability below acceptable levels: failure of the non-utility generators to produce as much electricity as they now plan; imposition of tougher emission standard for fossil plants; failure to get operating licenses for new nuclear stations; removal of licenses for existing nuclear stations; or stronger than expected load growth.[4]

So, at least some new generation is needed. The question on electricity trade therefore comes down to who has the cheaper sources of new generation potential. And even if no net additions are needed, Canada has an export opportunity if it can economically displace existing oil- or gas-fired units.

Canada clearly has that potential. A recent study by the US Department of Energy, using Canadian models, showed that new Canadian hydraulic generation would be cheaper than new US generation, even if the alleged subsidies received by Canadian utilities were removed.[5] This study compared costs for US coal-fired generation in New England, Minnesota and California under medium and high oil price cases. The costs for Canadian

CHART 3

U.S. Demand & Capacity at Summer Peak



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Taken from Premier issue

export power included estimated transmission costs. The study concluded that 80 to 90 per cent of potential Canadian hydropower would be cheaper than power from US coal-fired plants.

So there is a ready market in the United States for untapped Canadian hydro-electric generation potential. How will the treatment of electricity under the FTA affect the development of that potential?

Effects of FTA on Barriers to Trade

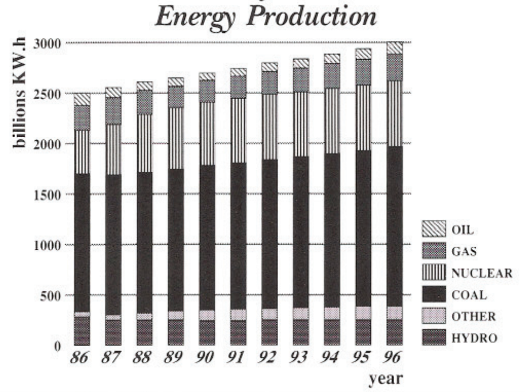
To start with, the effect of the FTA on tariffs is nil, and on NTB's almost nil, because there are no tariff and few non-tariff barriers to remove. So its effect on long-term electricity trade might also be expected to be very small. However, it will be just as important to have the rules firmly set as it would be to remove barriers. As noted earlier, one of the major barriers to increased long-term contracts is the presence of high risk. Some of this is regulatory risk, on both sides of the border. By reducing this risk, the effect of the FTA could be a significant boost to electricity trade.

The specific mentions of electricity are all intended to improve trade. Access to the Pacific Northwest Intertie has long been an issue for British Columbia. Last year's large drop in electricity exports from BC to the United States was mostly due to problems of intertie access. The provision in the FTA helps that specific problem. More importantly, perhaps, it shows that the negotiators took the opportunity to remove a trade irritant that was within the direct power of the contracting parties. Most observers think that this was also meant to lead the way in removing trade barriers that discriminate by national origin.

Another specific mention of electricity was to Canada's third export price test. The National Energy Board (NEB) of Canada administers three price tests for the export of electricity. The first test ensures that the price recovers all costs, including environmental costs, incurred in Canada; the second tests that the price is not below that available to other Canadians, and the last tests whether the price is materially below that of alternative fuels available in the export market. In the FTA, Canada agreed to drop the last test, which by implication leaves the other two intact.

CHART 4

Fuel Used for Electric Energy Production



The effect of dropping the third price test will be minimal at most. The test was hard to administer, and Ontario Hydro had asked that it be abandoned. It does not appear to have affected decisions in actual contracts.

There have been suggestions that the FTA will affect the other price tests, along with the surplus test. In effect, the NEB has administered the second price test and the surplus test with a first-offer mechanism. To get an export license, a Canadian utility must first offer the same electricity on the same terms to other Canadian utilities. The NEB recently denied Hydro Quebec an export license because it had not made that offer. Ontario Hydro has supported the use of the first offer test, because it is a net purchaser of power from Quebec.

But under the FTA, if the NEB were to deny an export license on the grounds that the power is not surplus to Canadian needs, based solely on the existence of a shortage or possible shortage in Canada, that could involve the consultation, inquiry and sanction provisions. So it does appear possible that the operation of the FTA will upset the operation of the first two price tests. However, the best information the author has is that the negotiators intended to leave these tests intact.

One thing the FTA is unlikely to do is remove barriers caused by interprovincial disputes. One of Canada's best undeveloped hydroelectric sites is in Labrador, part of the province of Newfoundland. However, electricity produced from this site for export would have to travel through the province of Quebec, which has its own northern resources to develop. So development of this site will await interprovincial agreements, which could take some time.

Effect of FTA on Regulatory Actions

Given that government policy impediments to electricity trade are likely to be regulatory, the question of the impact of the FTA turns on how it affects regulation. Does it reduce the regulatory freedom of the state governments and regulators? Does it limit the ability to introduce new regulations? Does it create a more secure environment for long-term contracts? Last year, this author suggested that an international treaty might be necessary to ensure that the terms of a long-term contract would not be changed by governments on either side.[6] The FTA is an international agreement; can it help guarantee contracts? Will it reduce uncertainty, or will it, at least in the short run, create additional uncertainty?

The answer is that the Free Trade Agreement does reduce uncertainty for both the buyer and the seller. It does this by reducing the likelihood that governments will interfere in the negotiation or operation of contracts between electrical utilities and their export customers.

By reducing one of the major barriers to long-term sales, it should increase their number.

Since electricity is under provincial jurisdiction, and only the federal governments are parties to the Agreement, how does it cover government action at all levels? The answer is that actionable steps by a junior government must ultimately be compensated for by the signatory governments. The mechanism is the consultation provisions, which can be invoked when one party thinks that the regulatory actions of the other would "directly result in discrimination against its energy goods or its persons inconsistent with the principles of this Agreement",[7] in the language of the Agreement itself. These consultations would involve all the governments concerned. If the consultations fail, the matter would be referred to the Canada-United States Trade Commission. The Commission will arbitrate the dispute and determine compensation or remedial action. If the offending Party fails to take that action, then the other Party is entitled to "suspend application of equivalent benefits of this Agreement".[8]

The Commission can set remedies for the actions of governments; it cannot force policy changes. Even if the offender is a lower-level government, it is the federal governments as parties to the Agreement who agree that they could be subject to the "equivalent" retaliation. Of course, we could expect the federal governments will likely try to induce lower-level governments to comply with the Agreement, to avoid such consequences.

Electricity and the Sharing Provisions

Some people have suggested that the treatment of electricity as an energy commodity brings new uncertainties about the operation of the provisions dealing with the declaration of a shortage. One country may (under certain provisions of the GATT) declare a shortage and impose restrictions on the export of a good. But when it does so, it must also restrict domestic use, and it must guarantee to its trading partner at least its historical share of the available supply of that good.

This provision would apply to electricity through the mechanism just described. That is, if there were an established export relationship, and exports were cut off because a government had indicated a shortage and wanted to retain the electricity for domestic use, the consultation provisions would be triggered. The intention is that national governments would

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Taken from Premier issue

have to compensate for any discriminatory cutoff of exports.

These provisions would not apply if the cutoff occurred for technical reasons during an emergency, or if it resulted from the application of the contract terms. They would only apply if the electrical utilities cut off export customers, but not domestic customers, who were being served under similar contracts.

For a firm power exporting province like Quebec, Manitoba, or New Brunswick, this sharing arrangement reinforces their contractual commitments. Firm electricity export agreements imply that the export customer must get treatment similar to the domestic system in times of shortage.

It has been suggested that the power sharing provisions would make exporters more reluctant to sell firm power, because it limits their ability to protect their domestic system from shortages. However, for customers to treat imported power as part of the capacity of their systems, the sellers must commit themselves to deliver it. To make its sale, the exporting utility must be able to convince its firm-power customers that it will give them equal priority, if that is written into the contract. The sharing provisions of the FTA do not go that far, but they do help increase the credibility of the assurances that the selling utility must make in any case. Therefore, their effect on the likelihood of concluding these contracts is likely to be small, but positive.

Other Effects on Trade

In addition to the sharing provisions, the FTA intends to provide more certainty and stability in electricity as in other trade areas. It is harder to make certain kinds of protectionist arguments under the FTA. The consultation and notice provisions make any restrictive trade move against Canada less likely, because they ensure that the entire political process of competing interest groups will take place. Special interests on either side cannot quietly obtain legislation or regulatory decisions that satisfy only themselves. Finally, if the negotiations on subsidy definition are ultimately successful, the FTA will help increase certainty in long-term contract situations.

Similarly, the FTA assures US buyers that Canada will not impose an arbitrary and discriminatory export tax on electricity. Canada can still impose taxes on electricity, but they can be placed on exports only to the same extent as they are on domestic consumption.

In summary, then, the FTA has enhanced the prospects for electricity exports from Canada to the United States. There is plenty of potential demand for Canadian electricity from south of the border. By removing some irritants and impediments, preventing the imposition of others, and generally providing a more stable trade climate, the Agreement will have a positive effect on the amount of long-term firm power and energy sales. That will benefit both countries, as international trade should.

Footnotes

1. Ad Hoc Coalition on International Electric Power Trade, *"Imports of Canadian Electrical Power - A Growing Concern,"* Cleveland, Ohio, March, 1981.
2. Mitchell Rothman, *"Exporting Blue Gold: Long-Term Electricity Sales in North America,"* presented at the International Research Center for Energy and Economic Development, Boulder, Colorado, April 21, 1987.
3. North American Electric Reliability Council, *"1987 Reliability Assessment,"* September, 1987, pg. 26.
4. *Ibid.*, Pg. 27.
5. Jeffrey Skeer, *"The Public and Private Costs of Canadian Power in World Energy Markets: Coping with Instability"*, Proceedings of Ninth International Conference of the International Association of Energy Economists, Calgary, Alberta, July, 1987.
6. M. Rothman, *op. cit.*
7. *Canada-US Free Trade Agreement*, Article 905.
8. *Ibid.*, Article 1806.

Sample Contents from Early Issues

Taken from ICR issue no. 3

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?

Sample Contents from Early Issues

Taken from ICR issue no. 3

Direct Current Power Transmission in Canada

by Leonard A. Bateman
Associate Editor, International Affairs
IEEE Canadian Review

Since the first commercial transmission of Direct Current (DC) power in 1954, great strides have been made in the voltage levels and in the technology associated with this form of transmission. These developments have, in turn, helped to revolutionize the control of power systems.

Canada has been one of the most aggressive countries in using DC transmission, from the first installation in British Columbia between the mainland and Vancouver Island to the multi-terminal system now being installed in Quebec.

The unique features of the Canadian projects and the vast experience gained in the operation of DC systems has produced a wealth of knowledge on DC transmission which is well recognized internationally. Many engineers and scientists of the DC community in Canada are leading members of international technical organizations such as IEEE, CIGRE, and IEC. Electric power research institutes such as the Hydro-Quebec Research Institute (IREQ) and the Manitoba HVDC Research Centre are world renowned for their research contributions in the advancement of High Voltage DC (HVDC) technology. Canadian universities such as the University of Waterloo and the University of Manitoba are well known for their graduate and research programs in HVDC transmission. Canadian consulting companies have been invited and are involved in major DC projects in many countries including Brazil, China, India, New Zealand, the United States and Zaire. Capabilities to manufacture converter transformers, filter reactors, capacitors for filters and reactive power equipment have been long established in Canada. In the near future, there might be facilities to manufacture thyristor valves as well.

DC transmission is high-tech. It requires up-to-date and in-depth knowledge of the latest power electronic devices, the latest associated control techniques, the latest materials technology for external and internal insulation of high voltage high power equipment and systems, the latest techniques and devices for the control of power quality (i.e. control of system overvoltages and flow of harmonics into the system). It involves extensive research and development of computer models and programs for the design and operation of integrated power systems. And, of course, this Canadian expertise is based on the large, world-class DC projects required by Canadian utilities to respond to demanding Canadian conditions.

Of the many important DC links installed, the largest of these remains the Nelson River Transmission system in Manitoba. This system can deliver some 3200 MW from the Nelson River to the load areas of southern Manitoba. It was decided in 1966 to proceed with the development of the Nelson River and use ±450 kV DC transmission. At the time, this was the highest operating voltage for a DC transmission system in the world and it required the reliable transmission of firm power over some 900 km.

This first phase (i.e. Bipole 1) of the total development used mercury arc valves because, at the time that the decision was made, there were no thyristor valves in service. The performance of this system, after the several years it took to reach the full bipole rating of 1610 MW in 1977, has been very satisfactory. In 1978, power began to be transmitted from the second phase (Bipole 2) of the project. This phase uses thyristor valves and reached full voltage operation (± 500 kV) in 1985. Full power rating will be achieved in 1990 when additional generation from the Nelson River is connected to the system.

Over the years, Hydro-Quebec has also been involved in DC interconnections to its system. In 1984, a 1000 MW back-to-back station was commissioned at Châteauguay, and is used as an asynchronous tie between the Hydro-Quebec network and that of the Power Authority of the State of New York. This was followed, in 1985, with a 350 MW connection to New Brunswick at Madawaska and a 200 MW connection to New England at Highgate. In 1986, the first step in a multiterminal line was placed in service between Des Cantons and Comerford, with a rating of 690 MW. As the reader will see in the first article of this Special Report, by Jacques Lemay of Hydro-Quebec, the latter system will be expanded to 2000 MW and will connect Radisson near James Bay to Sandy Pond near Boston.

The development of any new technology is not without its problems, and DC transmission is no exception. Much has been documented in the technical literature, but many scientists, engineers and technicians are still engaged in research which will, hopefully, solve the remaining problems.

In this respect, Dr. M.M. Rashwan and W. McDermid of Manitoba Hydro have contributed an excellent article discussing the flashover problems of 450 and 500 kV DC wall bushings. It is very timely as this problem is not limited to the Canadian scene. The development work on new types of construction for these wall bushings to ensure that oil fires will not develop, resulting in long outages, is very important.

Our last article, by D.A. Woodford and A.H. Young of the Manitoba HVDC Research Centre, points out the possibilities of increasing the power transfer over a given right-of-way by either converting the line to DC or adding a DC circuit to an existing line. This should be of interest not only to transmission engineers, but to all those who are interested in an overview of this problem.

We shall all see more use of DC technology, not only in long distance transmission and the interconnection of electrical systems separated by large bodies of water, but also for the interconnection between adjacent systems. There will undoubtedly be many challenges and opportunities for innovation and excellence. And Canadian expertise will continue to make substantial contributions to its advancement.

Sample Contents from Early Issues

Taken from ICR issue no.3

Current HVDC Activities in Quebec

Phase II of the Hydro-Quebec/New England HVDC interconnection will result in the first high-performance multiterminal DC (MTDC) system in the world.

by Jacques Lemay
Hydro-Quebec
Montreal, Quebec

In the past decade, significant amounts of surplus hydroelectric energy were made available by Hydro-Quebec to power utilities in the northeastern United States at lower costs than those of operating fossil fuel power plants. This led to interconnection agreements, energy banking agreements and, more recently, to firm energy and power contracts.

As the Hydro-Quebec transmission system is not designed for synchronous operation with the large interconnected eastern U.S. system many times its size, DC interconnections are required and provide the most economical solution for large-scale exports.

Energy Contracts with NEPOOL

The initial energy contract between Hydro-Quebec and the New England Power Pool (NEPOOL) covers the sale of up to 33 terawatt-hours (i.e. 1 TWh = 1 billion kilowatt-hours) of surplus energy over a period of 11 years. Consequently, a 690 MW point-to-point DC transmission system was placed in commercial operation on October 1, 1986. It consists of a 170 km, 450 kV bipolar DC line linking the Des Cantons converter station located near Sherbrooke, Quebec and the Comerford converter station located in the town of Monroe, New Hampshire.

Phase II of the energy contract calls for an additional 70 TWh over a ten-year period currently scheduled to begin in September of 1990. This is a firm energy contract as compared to the Phase I agreement which involved only surplus energy. The Phase I installations are consequently designed to accommodate the following Phase II: the capacity of the Des Cantons converter station is to be increased to 2000 MW by the addition of parallel converters and the DC line is to be extended south of Comerford to the new Sandy Pond 1310 MW converter station, located near the existing Sandy Pond 345 kv substation near Boston, Massachusetts. However, this doesn't explain the reasoning behind the necessity of a multiterminal system. To understand this, let's have a closer look at the Hydro-Quebec environment.

First of all, the Hydro-Quebec development plan calls for the completion of the La Grande power generation complex, in the James Bay area, before the end of the century. This will add some 4500 MW of generation and two additional 735 kV AC lines were originally planned to carry this power to the province's load centers. The first generating plant will be the additional capacity at the LG-2 site: six 330 MW units, identical to the original LG-2 units but located in a separate plant called LG-2A.

A second element of this environment is that the final planning studies for Phase II of the interconnection established operating restrictions based on security requirements for the northeastern U.S. transmission system because of the high power level involved. In practical terms, this means that when the total export power fed from all the interconnections connected to the Hydro-Quebec system exceeds a certain level, it becomes necessary to isolate from the Hydro-Quebec system the generation feeding Phase II. As a result, of the many scenarios studied to achieve isolation of generation in 1990, part of the LG-2 generating plant was chosen. However, this requires the extension of the DC line north from Des Cantons all the way to the James Bay area. The choice of LG-2 is a temporary solution while the LG-2A generating station is being built. Thereafter, the generation from LG-2A will be assigned to the MTDC system for either transmission to the load centers in Quebec or export to NEPOOL, or both. But, by the same token, this means that a change of strategy in Hydro-Quebec's original AC transmission plan is required.

Construction is under way...

Completion of a1500 km, 450 kV DC line between the Radisson converter station, near the LG-2 generating station of the La Grande complex, and Sandy Pond, near Boston, will increase the capacity of the interconnection from 690 to 2000 MW. Commissioning will start in January 1990 and commercial in-service of Phase II is planned for September 1, 1990.

Shortly thereafter, the initial installations will be integrated into what will become the world's first truly multiterminal high-voltage DC system. Finally, the addition in 1992 of the 2000 MW Nicolet converter station near the load centers of Quebec will allow the multiterminal to fulfill its dual role of transmitting power within Quebec and exporting to New England.

Mise en service l'an prochain...

La construction de la ligne à courant continu à 450 kV et des nouveaux postes convertisseurs de Radisson, près de la centrale LG2 du complexe La Grande, et de Sandy Pond près de Boston, va bon train. Lors de leur mise en service commerciale en septembre 1990, les installations de la Phase II porteront la capacité de l'interconnexion avec la Nouvelle Angleterre de 690 à 2000 MW.

Quelques mois plus tard, les installations initiales y seront raccordées pour former le premier vrai réseau multiterminal au monde. Enfin, la mise en service en 1992 du poste convertisseur de Nicolet de 2000 MW, près des centres de charge du Québec, permettra au réseau multiterminal de remplir complètement son double rôle qui est de transporter de la puissance pour les besoins du réseau d'Hydro-Québec et d'exporter de l'énergie en Nouvelle Angleterre.

Mission of the Multiterminal System

In fact, Hydro-Quebec and NEPOOL have agreed to kill two birds with the same stone by building the Phase II MTDC system to meet two objectives:

1) increasing the capacity of the James Bay transmission system by approximately 2000 MW to supply the Hydro-Quebec system;
2) increasing to 2000 MW the capacity of the interconnection while allowing the possibility to isolate generation from the Hydro-Quebec system.

Sample Contents from Early Issues

Taken from ICR issue no. 3

DC Wall Bushings on the Nelson River HVDC System

Canadians continue to contribute to the evolution of HVDC technology.

by M. M. Rashwan & W. McDermid
Manitoba Hydro
Winnipeg, Manitoba

The flashover of wall bushings in wet weather, and in light and heavily polluted areas, has been reported for a number of High-Voltage Direct Current (HVDC) systems operating at voltages of up to ±600 kV. In addition, it has been reported that the flashovers occur more frequently on negative polarity bushings than on positive polarity bushings. Only recently, it has been demonstrated by laboratory tests that the mechanism of flashovers of horizontally-mounted bushings is related to the non-uniform wetting along the insulator surface.

This non-uniform wetting can occur due to the partial shielding of the bushing by the wall of the converter building. This shielding leaves a dry zone near the grounded end of the bushing. Even under conditions of very low pollution, non-uniform wetting can lead to flashovers.

Nelson River Bipole 1

Bipole 1 first achieved rated voltage as follows:

Pole 1	*Pole 2*
-450 kV	+450 kV
1975	1977

The dimensions and ratings of the wall bushings are:

Nominal voltage [kV]	450
Basic Insulation Level (BIL) [kV]	1550
Outdoor Creepage [mm]	14783
Outdoor strike [mm]	3500
Specific Creepage [mm/kV]	32.9

Following the commencement of Bipole 1 operation at -450 kV in 1975, flashovers began to occur; most of these involved wall bushings. Following the completion of Bipole 1 in 1977 (± 450 kV operation), some flashovers were also experienced on the positive polarity bushings, although the majority continued to occur on the negative polarity.

The flashovers were experienced primarily during light and heavy rain conditions, and also occurred under fog and wet snow. The worst conditions seemed to involve the first rain after a long dry spell. As a first attempt to solve the problem, the bushings were cleaned and greased with Castrol WT185 petroleum grease. However, after service experience of 5 years, it was realized that the grease would have to be reapplied every 2 to 3 years in order to achieve significant improvement in the flashover performance. The process of cleaning old grease and recoating bushings proved to be time-consuming and costly.

As an alternative to greasing, supplementary sheds (booster sheds) were installed on all Bipole 1, 450 kV bushings. Six booster sheds were installed per bushing, as is shown in Figure 1. The sheds were constructed from NEMA Grade GPO-3 resin bonded fiberglass sheets, 3 mm thick.

Booster sheds on vertical Alternating Current (AC) bushings eliminate water cascading effects. Although the function of booster sheds on horizontal DC wall bushings is not fully understood, it has been suggested that they act to: (a) improve the uniformity of the wetting, or (b) serve as barriers to restrict the travel of surface scintillations.

Technological Supply and Demand...

In October 1987, the catastrophic failure of a 500 kV wall bushing occurred at the southern terminal (Dorsey) of the Nelson River HVDC system. This was followed in 1988 by forced outages involving major defects in other 500 kV wall bushings.

This problem is typical of how power companies, when operating beyond the limits of their technology, must invariably contribute to its evolution....

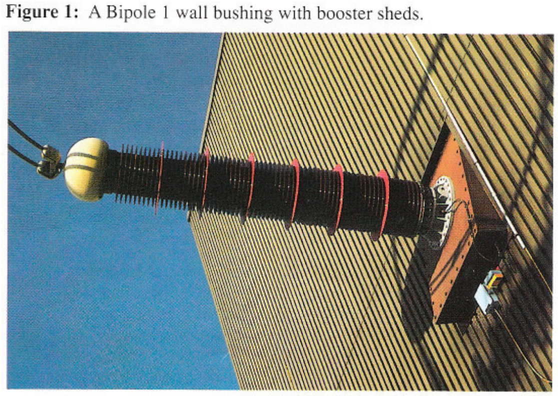
L'offre et la demande technologiques...

En octobre 1987, une traversée murale à 500 kV du système à CCHT de Nelson River, au poste Dorsey, a subi une défaillance explosive. En 1988, celle-ci a été suivie de nombre d'arrêts imprévus, dûs à des défectuosités majeures de plusieurs autres traversées murales à 500 kV.

Ce problème est typique du contexte des compagnies d'électricité, lesquelles n'ayant d'autre choix que de fonctionner parfois au-delà des limites de leur technologie, se retrouvent obligées de contribuer à son évolution...

Booster shed installation on the 450 kV wall bushings began in 1984 and was completed in 1986. To date, there has not been a flashover at this voltage on a Manitoba Hydro bushing that is equipped with booster sheds. As part of an on-going research project, one 450 kV wall bushing was left without booster sheds during 1987, and one flashover was experienced during strong wind and heavy rain.

Figure 1: A Bipole 1 wall bushing with booster sheds.



Sample Contents from Early Issues

Taken from ICR issue no. 3

Using DC to Increase Capacity of AC Transmission Circuits

Adding or converting existing lines to DC: a solution to limited rights-of-way?

by D. A. Woodford and A. H. Young
The Manitoba HVDC Research Centre
Winnipeg, Manitoba

Electrical Power Transmission: Facing New Challenges...

Power system planners determine what power lines are needed to meet the ever-increasing demand for electricity. However, notwithstanding the strategic importance of electrical power transmission to our civilization, it is becoming very difficult, if not impossible in some cases, to license a new transmission line. Is there an alternative?

Le transport d'électricité: les nouveaux défis...

Les planificateurs de réseaux savent concevoir à l'avance les lignes de transport requises par la demande sans cesse croissante d'électricité. Nonobstant l'importance stratégique du transport d'électricité pour notre civilisation, il devient de plus en plus difficile - voire impossible, à certains moments - de faire approuver une nouvelle ligne. Comment sortir de cette impasse?

The demand for electric power is steadily increasing, and despite efforts in conservation of energy and load management, the reserve capacity of existing transmission systems is gradually being depleted. The utility engineer today is faced with mounting public concern over transmission lines being built in their community or across their property. Licensing procedures now involve a significant degree of public participation and proposals for new lines are often met with fierce opposition.

Concern has spread with reports that alternating current (AC) magnetic fields are a possible cause of biological effects on humans. In Texas for example, a situation where a school is located alongside a transmission right-of-way (ROW) raised the biological effects issue to such an extent that the public demanded that either the school or the lines be moved. Where public concern is so heightened, it is a *fatal flaw* to assume that economic necessity will permit new lines to be constructed and brought into service within a reasonable time frame.

Increasing Line Capacity

The utility transmission engineer is forced to seek innovative ways to get power to the load centres under circumstances where no new right-of-way for the transmission can be acquired. There are many techniques for increasing the power transfer capacity of a given right-of-way. These include:

1. Reconductoring the transmission line.

The current-carrying capacity of AC lines can be increased by replacing the existing conductors with larger ones. This solution, however, may require reinforcement of the line towers, and is feasible only for short line sections where thermal loading - and not impedance - is the dominant limit.

2. Increasing the voltage of the circuit.

Conversion to a higher voltage can be an effective way of increasing power transfer capability if there is enough margin in the original design to allow for the increase. Higher electric field gradients, resulting from the higher voltage, may necessitate raising the conductors by increasing the tower height (which may be expensive or even impractical). Corona effects, such as audible noise and radio interference, require consideration to ensure that standards are not exceeded.

If the conductor-to-tower clearances are insufficient at the higher voltage, the insulator strings may need to be lengthened or formed into "V" strings to reduce conductor swinging. Tower modifications may also be required to accommodate these changes.

If the right-of-way has sufficient width, the existing transmission line may be entirely replaced with a new higher voltage line or a line with an increased number of circuits. Conversion to a higher voltage also requires replacing switchgear and adding new transformers in the substations.

3. Rebuilding the line with six phases.

The rebuilding of an AC circuit with a six-phase line has been investigated in the United States. In comparison with a conventional double-circuit line, the six-phase line is characterized by lower electric and magnetic fields at the edge of the right-of-way. However, the six-phase line is not without its drawbacks: it requires the complete rebuilding of the transmission line circuit, and special phase-shifting equipment is needed at the line ends.

4. Conversion to Direct Current (DC) transmission.

Much has been written about converting AC transmission lines to DC. The economics of AC to DC conversion are more favourable on long circuits without taps since DC taps tend to be relatively expensive. When the AC circuit is judiciously designed to anticipate eventual conversion to a DC circuit, the cost of the changeover and upgrade can be kept to a minimum. This may be accomplished by designing the line with bundled conductors, and making provisions for future transfer of the centre phase conductors to the outer phases, thereby utilizing all conductors for DC operation.

5. Series and shunt compensation.

The power transfer capacity of an electric transmission system can be marginally increased with the addition of series and shunt compensation. Capacitor installation is the least costly way to compensate the power system. Static var systems and synchronous condensors are more costly alternatives, but these have the advantage of increased voltage control capability.

6. DC overbuild

Some configurations of AC transmission lines, such as the 230 kV Gulfport structure (Figure 1), lend themselves to the addition of a DC circuit carried above the AC circuit. Another option for overbuild is to build a new structure immediately adjacent and in line with the AC structure and to carry the DC circuit (at a higher level than the existing AC circuit) on the new structure.

The utility engineer can examine all the options listed above in his search for the most effective and least costly way to increase the power transfer capability of an existing electric power transmission corridor.

Sample Contents from Early Issues

Taken from ICR issue no. 5

Free Trade: A Telecommunications Perspective

Opportunity has arrived, but we have to work at it.

by R. Charles Terreault
Assistant Vice-President,
Network Technology
Bell Canada, Montréal

More competition at home and abroad ...

The world is becoming more of a single market. The Canada-U.S. Free Trade Agreement (FTA) means change, challenge, and opportunity for increased profits. Is Canada ready ?

Une intensification de la concurrence au Canada et à l'étranger ...

La mondialisation des marchés continue de se concrétiser. L'accord de libre-échange entre le Canada et les États-Unis (ALE) entraîne de nombreuses modifications dans son sillage, pose de nouveaux défis et donne l'occasion d'accroître les profits. Le Canada est-il prêt ?

More than $400 million a day. Every day. That's the value of trade between Canada and the United States - and it's growing.

Each country is the other's best customer, and the Canada-United States Free Trade Agreement is already stepping up the pace. The Agreement is having a direct impact on the high technology industries of both countries.

In the telecommunications industry, all tariffs on telephones, modems and private branch exchanges (PBXs) were eliminated on January 1, 1989, the day the Agreement came into effect. Trade in this area is about even: in 1988, Canadian companies sold about $1 billion in goods to U.S. customers and U.S. producers sold about the same amount.

Status Quo Not An Option

Canada's international trade outlook is for change, challenge...and opportunity.

Change is rippling through world trade, whether or not Canadian companies recognize it, respond to it, and use it as a powerful vehicle for our future prosperity. In the past, governments have been prone to spend hundreds of millions of dollars propping up businesses that, for one reason or another, couldn't make a profit.

In today's demanding world markets, businesses must adapt, discover changing needs and fill them - or disappear. Analysts tell us that global integration - not isolation - is the pattern for the 1990s. The world is fast becoming more of a single market, and there is no place for an enterprise to hide from competition. The status quo is not an option. Many informed observers agree that it is not a question of whether Canada's trading relationships will change, but how they will change.

As Leonce Montambault, Chairman and Chief Executive Officer of Bell Canada, has declared, "If we (Canadians) wish to ensure our place in the North American economy - and the world economy - we should pursue free trade with vigour and determination."

Bell Canada is already carrying out a major transformation - from a monopoly provider to an aggressive competitor. About one quarter of Bell Canada revenues now come from competitive services.

With current world trends, every Canadian company will have to make a similar change: from occupying a comfortable position in a small, domestic, market, with little outside competition, to scrambling aggressively to capture - and keep - market shares both at home and abroad. This will require major transitions - conversions - in perception, attitude, self-image.

Telecommunications: Your Competitive Edge ?

This Agreement offers many benefits, not only for us at Bell Canada but for our customers as well. Lower, or no, tariffs mean lower prices on our purchases of U.S.-made products or those with significant U.S. content. Our customers will also benefit - indirectly from our lower costs, and directly from the increased competitiveness of U.S. terminal suppliers.

It follows that the Agreement will necessarily increase competition for Canadian businesses, putting such efficiency and productivity tools as telecommunications near the top of the business priority list. It is anticipated that creative new applications of telecommunications will continue to develop at an ever-increasing pace. For telecommunications to take its place as an instrument for creating profits, the move toward cost-based pricing must gain momentum.

This Agreement is a pioneering trade effort, introducing the concept of international trade in services. It will serve as a model for future GATT (General Agreement on Tariffs and Trade) negotiations.

Advance Rulings on Enhanced Services a Must

The Agreement addresses telecommunications in several areas:

- monopolies
- basic telecommunications services
- enhanced telecommunications services

Sample Contents from Early Issues

Taken from ICR issue no. 5

- research and development
- standards
- equipment

It provides for competition in some areas, and not in others.

The Agreement defines monopoly as "any entity, including a consortium, that...is the sole provider of basic telecommunications transport facilities or services."

The Agreement states that nothing shall prevent either country from maintaining or designating a monopoly, as long as the designating country notifies and consults with the other, and endeavours to minimize any effects on the benefits of the Agreement.

There will be little effect on basic telecommunications services - those limited to the offering of transmission capacity for the movement of information (e.g., basic local and long-distance telephone services).

The federal government has issued a policy statment, relevant to proposed legislation, which defines roles for:

1) telecommunications common carriers, i.e., those operating local and long-distance networks, and
2) providers of enhanced services, i.e., those offering customized telecommunications services that involve generating, acquiring, storing, retrieving, transferring, processing, or making information available in computerized form.

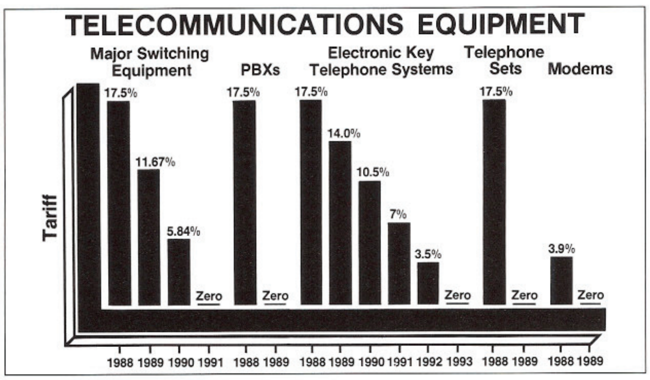


Figure 1 The progressive elimination of certain tariffs as a result of the Free Trade Agreement.

A stated objective of the Agreement is "to maintain and support the further development of an open and competitive market for the provision of enhanced services."

These services are facilitated through the enhancement, via computer programs, of the telecommunications network's basic transmission capabilities. Two examples are the iNet 2000* database information retrieval, and Envoy 100* electronic messaging services, both offered nationally through Telecom Canada.

According to the Agreement, each country may use its own definition of enhanced services, as defined by the regulator in that country. Canadian companies are already selling enhanced telecommunications products in the United States and anticipate excellent future markets in this field.

The Agreement heightens the urgency for our regulator, the Canadian Radio-Television and Telecommunications Commission (CRTC), to have the authority to render advance rulings on whether or not a proposed service is, in fact, an enhanced service, rather than simply a resale of basic service, which is to be offered only by common carriers.

Currently, providers may offer enhanced services without scrutiny by the CRTC until challenged. In Bell Canada's view, this scrutiny should occur before introduction of the service, not after.

Free Trade and Research and Development

Making the most of the Free Trade Agreement requires a constant, productive commitment to research and development (R&D).

Unfortunately, Canada is considerably behind major competitors, such as the United States and Japan. Canada's total spending on research and development is less than 1.5 per cent of Gross Domestic Product, compared to almost double that in the U.S. and Japan.

Canada's total is about $8 billion a year, and the telecommunications industry alone accounts for almost 20 per cent ...the largest percentage of any Canadian industry. Bell Canada's research and development investments last year totalled $123 million, nearly two per cent of total operating revenues.

Northern Telecom (our sibling company within the BCE Inc. family) spent 13 per cent of gross revenues - $860 million - in research and development in 1988. The spending by both companies was largely through their jointly-owned subsidiary, Bell-Northern Research, the leader in high technology R&D in Canada. We expect this level of commitment to continue over the next several years.

The federal government is beginning to recognize the crucial role R&D will play in our international competitiveness, but we need a much larger, stronger, accelerated commitment to stay in the race.

Standards and Equipment

The Free Trade Agreement raises another issue of mutual concern: standards.

Canada and the United States have agreed to "... endeavour to make respective standards-related measures more compatible, to reduce the obstacles to trade and the costs of exporting which arise from having to meet different standards."

Neither country is to create standards designed to keep out the other nation's equipment and services. Such organizations as the Canadian Standards Association and the American Underwriters Laboratory are to work more closely together. In telecommunications, we are already working closely on developing mutually-acceptable standards. With its Integrated Services Digital Network (ISDN), the telecommunications system of the 90s, Bell Canada is extending the scope of its international work on standards.

Regarding telecommunications equipment, as mentioned earlier, the Agreement has already eliminated tariffs on telephones, modems and PBXs. Those on major switching equipment are going in three equal annual reductions - there are two more reductions to come. Similarly, tariffs on electronic key systems will be gone in less than four years - on January 1, 1993. Further negotiations could very well accelerate this schedule as many companies have requested that the dates be moved up.

Conclusion

Bell Canada is making the transition from a monopoly to a vigorous competitor. This transformation over the last few years is challenging to our employees, beneficial to our customers, and profitable to our shareholders.

Free trade with the United States is an opportunity to do business profitably at home and abroad...a prelude to competing successfully anywhere in the world.

But every Canadian company will have to work at it.

At a rate of $400 million a day with the United States alone, the effort will be amply rewarded.

* TM Bell Canada

Sample Contents from Early Issues

Taken from ICR issue no. 6

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 time 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.

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Taken from ICR issue no. 6

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

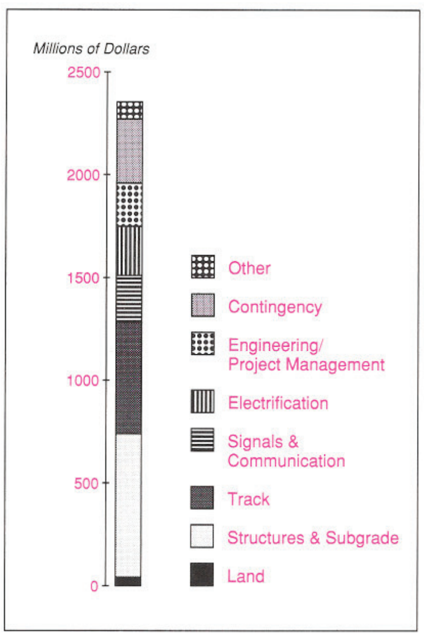
Crew and On Board Services	24.4
Equipment Maintenance	22.8
Stations and Sales	18.0
Train Control	1.5
Track and Facilities Maintenance	12.5
Insurance	3.0
Corporate Offices	5.5
Total	87.7
Total passenger-kilometers (millions)	1 679
Cost per passenger-kilometer (cents)	5.2

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 de-regulation, 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.

Sample Contents from Early Issues

Taken from ICR issue no. 6

Some Background on High Speed Rail

The Japanese were the first to introduce high speed rail. The *Shinkansen* or *Bullet Train* (Figure 2) began operation in 1964. Since then, other jurisdictions have introduced high speed service through heavily populated corridors. In the United States, high speed rail is being considered in Pennsylvania, Ohio, Florida, Michigan-Illinois, Nevada-California, Texas and New Mexico.

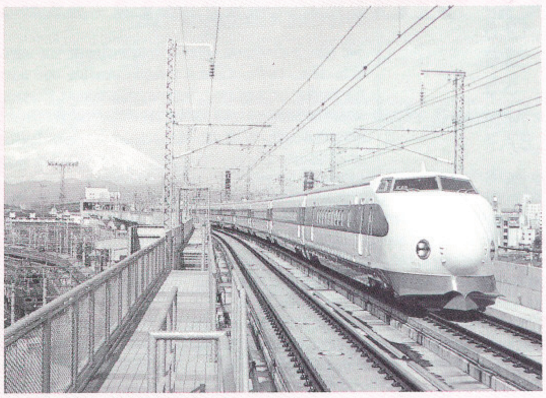


Figure 2 The Japanese *Shinkansen* or *Bullet Train*, in operation since 1964.

The TGV (Figure 3) began operation between Paris and Lyon in 1981. Construction of a dedicated line was begun in 1976 and completed in two sections, the southern in 1981 and the northern in 1983. Approximately 425 kilometers long, this line is designed for speeds in excess of 300 kilometers per hour. The TGV has a top speed of 270 kilometers per hour

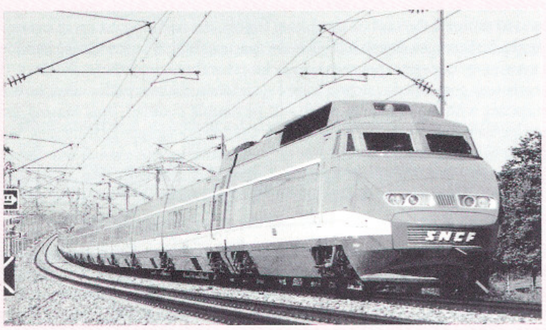
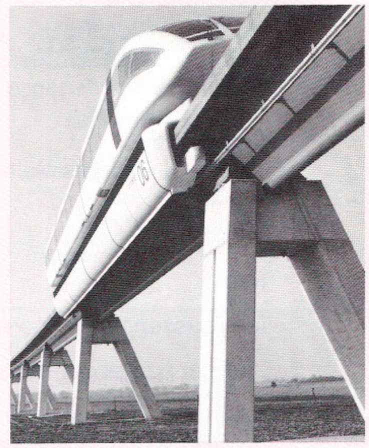


Figure 3 The French Paris-Lyon Train à Grande Vitesse (TGV), in operation since 1981.

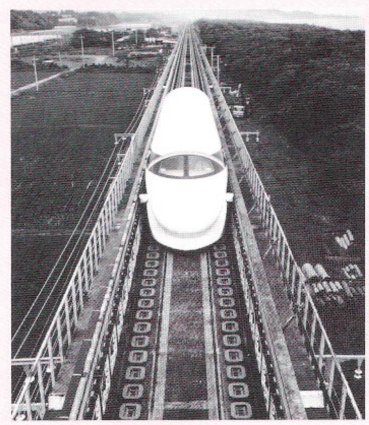
and averages 213 kilometers per hour on the Paris-Lyon route, for trip time of about 2 hours. In comparison, the existing line between Toronto and Montréal is some 539 kilometers long. Existing service on this route is supplied by Bombardier's LRC equipement which is designed to run at speeds of 190 kilometers per hour. However, freight interference, limitations of the roadbed and the LRC itself restrict the best time to 4 hours 30 minutes for an average speed of 120 km/hour. In contrast, the TGV is capable of a Montréal-Toronto trip via Ottawa in under 3 hours (on new dedicated right-of-way).

Figure 4 The German *Transrapid*, in final phase of prototype test and demonstration (electromagnetic attractive suspension, linear synchronous propulsion).



TGV traffic has grown 500% since its inception and the train has captured 56% of pre-TGV air traffic between Paris and Lyon. Table 5 shows the growth of the Paris-Lyon route between 1981 and 1985.

Figure 5 The Japanese *Linear Express*, planned for the turn of the century (electromagnetic repulsive suspension, linear synchronous propulsion).



Looking to the future, high speed non-contact magnetic levitation systems are likely to become available in the nineties. The German *Transrapid* (Figure 4) with 400-450 km/h capability, using controlled electromagnetic (attraction) suspension and linear synchronous propulsion is now in the final phase of prototype test and demonstration. This vehicle system is planned for a link between Orlando Airport and Disney World in Florida. The Japanese *Linear Express* (Figure 5) with 500 km/h capability, using superconductive electrodynamic (repulsion) suspension and linear synchronous propulsion is also under development. This technology should be ready for implementation by the turn of the century, after thorough testing on a new 47 km test track to form part of a Tokyo-Osaka line.

Table 5 - Selected Traffic Statistics - Paris-Lyon

	1981	*1982*	*1983*	*1984*	*1985*
Passengers (thousands)	1 014	3 227	4 025	4 819	5 318
Passenger-kilometers (millions)	511	1 885	2 040	2 460	2 822

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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.

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.

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.

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!

Sample Contents from Early Issues

Taken from ICR issue no. 7

Perspective / Perspectives

University Research in Canada: Are We Getting Good Value?

by Dr. Tony R. Eastham
Director, IEEE Canada

The Royal Society of Canada has embarked upon an extensive study of research in Canada. Substantial core support for a period of five years is being provided by Industry, Science and Technology Canada (ISTC). As the first phase of its Evaluation of Research in Canada, the Royal Society, under the chairmanship of Dr. Peter A. Larkin, from the University of British Columbia, is undertaking a Study of University Research.

A discussion paper, entitled "A Study of University Research in Canada: The Issues", was distributed widely late last year - not only to universities but also to professional societies and to other bodies perceived to have an interest in the issues. IEEE Canada was among those asked to respond.

In these days of government fiscal restraint as attempts are made to get Canada's deficit under control, both federal and provincial expenditures are being scrutinized for effectiveness and relevance. Thus, support for the federal granting councils, the Medical Research Council (MRC), the Natural Sciences and Engineering Research Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC), and for a number of Departmental and Ministerial research programs, is being examined. The question that is being asked: Is the country getting good value for this investment?

The Royal Society's discussion paper reviews a wide range of issues relevant to research and funding programs in Canadian universities. Many questions are asked and, in responding to these on behalf of IEEE Canada, I have tried to lay aside my faculty cap and take the perspective of a large technical society - one which represents over 16 000 members of the electrical engineering profession in Canada, including engineers in the private and public sectors, university faculty and researchers, and post-secondary students. Here is how I have expressed my position.

Figure 1 Canada's Gross Expenditure on R&D (GERD) as a percentage of Gross Domestic Product (GDP) has changed little since the early 1970s, and has actually dropped slightly since 1986, despite greater public discussion of the issue. With the exception of the United States, other countries of the Organization of Economic Cooperation and Development (OECD) have been increasing the GERD share of GDP during the 1980s.

The Role of Universities

The twin missions of all universities should be education (in its true meaning) and research/scholarship. These two functions are synergistic; an institution without research cannot be a university.

The first of these expresses itself tangibly through the "output" of educated, enlightened people who can enter, participate in and lead a highly skilled workforce. Canada needs a continuous flow of such persons to build its industry and economy. These persons learn and benefit from contact and collaboration with faculty who are at the forefront of research in their particular fields. This contact provides graduates with not just professional training but with positive attitudes and enquiring minds.

However, as we examine their second mission more closely, universities must also be storehouses of knowledge. While Canadian universities contribute only perhaps 2% to the world bank of knowledge, if one measures productivity by the number of patents and papers in journals and conference proceedings, one finds - in Canada - experts in essentially all fields of human endavour. These faculty train both undergraduates and graduates, and it is the movement of these people from university to the public and private sectors that provides the most effective knowledge-transfer from universities for the benefit of the country.

Canadian researchers must be contributors to the world bank of knowledge and one can easily see why. Research funding provided by the federal government, largely through the three granting councils, and to a lesser extent by the provincial governments and by private sector companies, allows Canadian researchers to participate, and as a result, become experts and leaders in specific fields. In turn, a knowledgeable professoriate and staff in private/public sector research establishments are thereby able to

■ **Continued on page 6**

Sample Contents from Early Issues

Taken from ICR issue no. 7

Electric Utilities: The Next Hundred Years

As the Canadian Electrical Association approaches the anniversary of its first century of existence, it is timely to consider the present and future challenges facing the industry.

by Maurice Huppé
Executive Vice-President,
Technology and International Affairs, Hydro-Québec
and Chairman, Canadian Electrical Association

The centennial of the Canadian Electrical Association (CEA) in 1991 will be an opportunity to celebrate the achievements of the Canadian electric utility industry and to speculate on what the future holds.

CEA, as a national association representing the interests of the electric utility industry in Canada, has seen the amazing changes this industry has undergone in the past century. A little over one hundred years ago, the several thousand people who witnessed J.A.I. Craig demonstrate Canada's first electric street lamp at the Champs-de-Mars in Montréal probably never dreamed that electric technology and the electric utilities would become what they are today. Similarly, with developments in nuclear power and in EHV transmission, for example, and research into fusion and superconductivity, one can safely say that we can look forward to an equally dramatic future and CEA will undoubtedly play a key role in that future.

But, what is our current situation? What are the issues facing our industry?

The Challenge of the Future

Utilities must produce and supply power for a prosperous Canada and, above all, in a manner compatible with a healthy environment. Furthermore, our country draws its energy from a wide range of sources, nuclear, hydro, fossil fuels and some alternative sources, which makes the scope of the challenge even greater.

Canada generates 80% of its energy from renewable hydro resources and CANDU nuclear. For both of these sources, we have been very innovative in keeping possible negative environmental impacts to a minimum. But there is still much room for improvement. And as for the number one environmental issue today, namely atmospheric emissions, the predominance of hydro and nuclear sources means that our record is good.

Coal, however, remains an abundant and cost-effective source in several parts of the country. Electric utilities and CEA are actively researching and developing ways to use this source more efficiently and with minimum environmental impact.

When we look at the massive fossil-fuel resources available elsewhere in the world, it becomes clear that Canada will have an opportunity to lead in finding solutions to the emissions challenge so that the inevitable growth of developing countries will not result in atmospheric disaster.

These, however, are mainly what could be called raw supply issues. Supply needs can and must also be met on the other side of the equation, namely by smart demand management, or what people simply call energy conservation. This is also an excellent response to environmental concerns. With supply and environment in mind, many Canadian utilities have adopted effective programs to reduce demand.

In short, the challenge is to optimize energy efficiency and reduce negative environmental impacts by taking action on both sides of the energy equation. And this, in fact, is a precondition to expansion of the utility infrastructure.

Utilities and R&D

Research and Development will be an important aspect of the industry's efforts to meet this challenge. Let us briefly review Canada's overall R&D efforts, which are somewhat disappointing.

Only 1.3% of Canada's Gross Domestic Product goes into R&D, exactly the same as in 1971, whereas Japan, the United States, West Germany, France, Sweden, Switzerland and several other countries are fast approaching 3.0%. The Soviet Union has been spending an average of 3.7% for the past 18 years. In the United States and the Soviet Union, a lot of R&D money is budgeted for defence, which means that resulting technology is slow to be applied to other industries. It is to be hoped that with the easing of world tensions, defence-related R&D efforts will be re-oriented directly towards normal industrial applications.

What's more, Canadian industry funds represent only 43% of the national R&D effort versus 70% in Japan, Switzerland and Sweden, 62% in West Germany and 50% in the United States.

Canada's electric utilities can be instrumental in correcting this situation. For example, Hydro-Québec finds it necessary to spend $135 million annually on R&D and is convinced that these investments pay off handsomely. Large sums of money are budgeted for a wide variety of engineering testing programs.

In addition, utilities can also form R&D consortiums, together, or with other industrial partners. The technologies developed can help our private and secondary sector industries become more competitive and, at the same time, encourage them to take a greater interest in research and development activities.

Meeting the Challenge

Let us now examine a few concrete examples of how R&D will help us meet the challenge described earlier.

In an age of EHV transmission, an important environmental question is the biological effect of electric and magnetic fields. A major study is being conducted jointly by Hydro-Québec, Ontario Hydro and Électricité de France.

The most popular utility buzzwords today are clearly demand-side management. However, without well-oriented R&D, the capacity that can be freed by this action is limited. Hydro-Québec projects in this area aimed at

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shaving off the peak or conserving energy include the evaluation of hot water heaters on peak demand and development of industrial prototypes, integrated dual-energy heating and energy-efficiency testing of home electric appliances.

Long-term R&D projects are also crucial. Last year the energy world was rocked when two researchers claimed to have succeeded in carrying out cold nuclear fusion. Obviously, the mastering of nuclear fusion will be an important step in solving the world's supply and environmental problems.

In this respect, the Varennes Tokamak is not only part of Canada's National Fusion Program, but it will also be used in the ITER project launched by Europe, the U.S., Japan and the Soviet Union.

Other important long-term research includes superconductivity, ACEP batteries and hydrogen from electricity.

Utilities and the Environment

One theme frequently recurred through all of the deliberations at the 14th Congress of the World Energy Conference held six months ago: the environment.

All participants agreed that the time had come to act. Futhermore, the Energy and Environment Division concluded that the most-efficient, lowest-cost solution to the world's energy-related environment problems is conservation. This division also stressed that initiatives in this area should not be left to the consumer but must also come from the producers and suppliers.

In the past, CEA has been a leader in responding to such important energy concerns. For instance, its Engineering and Operating Division facilitates information-sharing among individuals to help the utilities assume their responsibilities. CEA research focuses specifically on areas of environmental protection, cost control, productivity and customers' needs. The Association's Customer Service Division operates national energy efficiency programs and is organizing a series of demand-side management conferences throughout the year. And CEA also ensures that the industry's voice is heard at the federal policy level.

If the past is any guarantee of what the future might be, the Canadian Electrical Association will continue to take a leadership role among utilities here and abroad.

Perspective

■ **Continued from page 4**

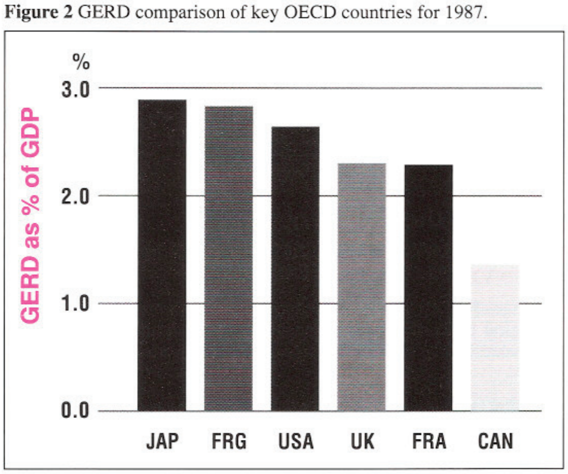
understand, appreciate and take advantage of the 98% of scientific development not undertaken in Canada. And in the same vein, it is part of the function of technical societies, particularly those with an international scope such as the IEEE, to disseminate this information for the benefit of all mankind.

The National Outlook

It is often noted that, with a Gross Expenditures on R&D (GERD) index of only 1,3% of the Gross Domestic Product (GDP), Canada occupies a lowly position in the big-league table of industrialized nations (Figures 1 and 2). This is certainly indicative of a lesser committment to R&D than our competitors.

However, from the perspective of industrial development, it is perhaps just as important for companies to be able to comprehend and take advantage of research and technological developments undertaken elsewhere, as it is for those companies to maintain competitive research units. Canada needs many more competent engineers who can recognize advantageous developments, and many more competent managers who have the foresight to employ such engineers and the courage to implement their ideas. And, as we can no longer depend on immigration of highly qualified individuals to the extent that we have in the past, Canadian universities are at the forefront of the challenge of producing graduates with these capabilities for Canadian needs.

Figure 2 GERD comparison of key OECD countries for 1987.



Consequently, research in Canadian universities is essential. We must have the commitment and flexibility to support a broad range of programs throughout the R&D spectrum, from basic/fundamental research all the way to product development. University attitudes to research are not stagnant, but evolve in response to the expectations and desires of academia on the one hand, and of industry and government on the other. Certainly, targeted funding can have a steering effect. A good example is the federal Networks of Centres of Excellence program, which succeeded in stimulating the best scientists and engineers in the country to propose collaboration to focus on many areas of research which were deemed to be strategically important to Canada. The response to this program alone can be taken as evidence of the underfunding of Canadian research.

To Conclude...

Government policy should consequently be such as to maintain a strong base of research in Canadian universities, and to maintain or enhance programs which create collaborative research linkages between the universities and the private sector.

However, one cannot neglect the question of the public's awareness of the overall benefits of science in our society. With this in mind, the Royal Society is currently undertaking a project to this effect. This is certainly just as important as maintaining a healthy research environment in Canadian universities. The secondary school system must bear the responsibility for the present low level of scientific literacy in school leavers. We must ensure that the general population is reasonably made aware of the importance of science and technology, and that a steady flow of competent, stimulated students continues to move into our universities. These people are the researchers of the future and, to a significant extent, will control the economic destiny of our country.

Have I covered all the bases? I understand that the Royal Society of Canada, having reviewed all the responses to their discussion paper, will be holding a series of regional public meetings across Canada. If you feel as strongly as I do about this issue, I urge you to come out to these meetings and to express your support for university research.

The Royal Society will still be pleased to receive your written submissions. A copy of the discussion paper can be obtained from, and any written briefs should be sent to:

Dr. Michael R. Dence
Executive Director
The Royal Society of Canada
P.O. Box 9734
Ottawa, Ontario
K1G 5J4

I would appreciate receiving a copy of any submissions.

Sample Contents from Early Issues

Taken from ICR issue no. 8

The Need to Increase Industrial R&D in Canada

Where do we want to be as a nation and how do we get there?

by Roger A.Blais, O.C., Eng.
Professor of Industrial Innovation
École Polytechnique de Montréal

An increase in the level and effectiveness of industrial R&D in Canada is of paramount importance in order to ensure our economic and social future. This is NOT a motherhood statement. It is a FACT based on the harsh realities of the global economy and the extreme competitiveness in the production of high quality goods and services in a world marked by rapid and unrelenting technological change.

Markets around the world are becoming increasingly homogeneous. The costs of physical capital and skilled labor are on the rise and converging in industrial countries. However, as I have argued elsewhere[1], the relatively high cost of money in Canada is particularly detrimental to long-term investment such as R&D. As shown in Figure 1, the Japanese can afford to wait twice as long as Canadians to reap equal benefits from R&D. Added to this financial advantage is Japan's strategy of betting on the long term rather than mostly on the short term as we so often do in Canada.

My purpose here is to draw attention to some of these issues, some of which have already been introduced by Maurice Huppé in a guest editorial last March in this journal.

Too Little Industrial R&D

Everyone recognizes that in order to compete effectively in the international marketplace Canadian firms must be productive and innovative. Poor productivity still plagues Canadian industry: according to the U.S. Department of Labor (1989), from 1978 to 1988 the growth in manufactured output per employee has grown by only 11.1% in Canada compared with 16.5% in Sweden, 18.8% in West Germany, 19.1% in Great Britain, 23,4% in France, 23.8% in Italy, 35.3% in Japan and 71.6% in South Korea.

Industrial productivity and innovation are closely linked to industrial R&D and to technology transfer. In Canada we are weak on both counts. For example, Canada's gross expenditures on research and development (GERD) are only 1.3% of gross domestic product (GDP) compared with nearly 3.0% in Japan, West Germany, Switzerland and Sweden, and about 2.5% in the U.S.A., France, Netherlands and Great Britain. After hitting a "high" of 1.43% in 1986, we are now back to the level of 19 years ago when international competition was much less fierce than it is now and the demand for high value-added goods and services was very much smaller.

Studies by the Economic Council of Canada have shown that Canadian industry has been slow to benefit from technology transfer. In fact, it has often taken an inordinate amount of time for technologies to move just from one Canadian province to another. This problem is particularly acute in small firms. In order to alleviate this, the National Reseach Council of Canada has now embarked on an ambitious technology transfer program. But without real industrial leadership, the situation will not improve much.

I think that the main reason why Canadian industry, both indigenous and foreign owned, has not invested more in R&D is simply that it did not have to do it. In other words, it could get by without it. But this is no longer the case. For example, even our primary industries, which have contributed so much to our export strength and to our economic well-being, are seriously threatened by foreign competition, particularly from low-wage and less environment-conscious countries.

In the services sector, where two-thirds of all jobs are now concentrated, the need for more R&D is also felt. There, too, the development and application of new technologies are required in order to curb costs and increase productivity.

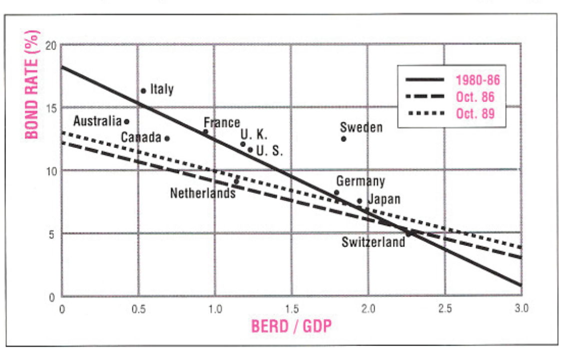


Figure 1 Relationship between business expenditures on R&D (BERD) and long-term bond rates, average for period 1980-1986 and for October 1986 as well as October 1989.

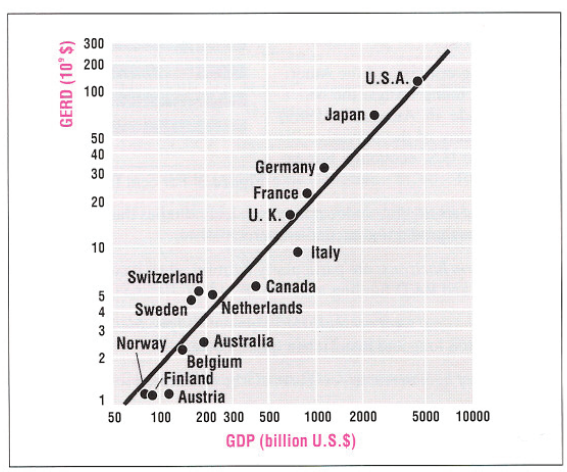


Figure 2 Log-log correlation between GERD and GDP; selected OECD countries, 1987.

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A New Economic Paradigm

The world has changed tremendously during the past 25 years. As British economist Christopher Freeman now argues, we are seeing the emergence of a new techno-economic paradigm, one that combines system innovations, affecting the entire economy, with common sense incremental innovations brought about by technical managers and shop floor personnel in the various industries.

The contrast between the "old" fordist approach and the new economic paradigm is striking:

Old approach	*New approach*
Energy intensive technologies	Information intensive technologies
Standardized production	Customized production
Rather stable product mix	Rapid changes in product mix
Dedicated plant and equipment	Flexible production systems
Automation	Systematization
Simple firms	Network arrangements
Vertical hierarchies	Flat horizontal structures
Departmental divisions	Integration
Products with service	Service with products
Centralization	Distributed intelligence

The fastest growing industrial firms are using the new approach. While it would be ludicrous to merely copy the Japanese model of production without at the same time changing our mentality and value system, the spectacular technological developments and even more spectacular commercial achievements of Japan can be a source of deep inspiration. For example, the Japanese use the factory as a laboratory, with everyone contributing to the experiments to develop the best quality product. In the modern Japanese model, the firm is an innovative and dynamic organization that is continuously learning. Collaborative research networks add to the output of individual R&D laboratories, and the capital markets are geared not only to short-term but also to long-term investments in technologies. The friendly takeover of Lumonix, an Ottawa-based laser company, by Sumitomo, and that of Moli Energy, a Vancouver company specializing in rechargeable Li-battery cells, by Mitsui & Co., the giant Japanese trading company, are vivid illustrations of the Japanese industrial philosophy. One of Canada's biggest economic woes is the fact that virtually the only investors who are willing to put up risk capital to build enterprises here are foreigners or governments.

In a scathing criticism of the American way of doing things, the M.I.T. report "Made in America" (1989) describes many of the pervasive ills plaguing the U.S. economy. For example:

- *Outdated strategies:* undue reliance on technologies that are past their peak, mass production mentality, parochialism.
- *Short-term horizons:* are particularly harmful when it comes to capital markets and R&D funding.
- *Organizational weaknesses in development and production:* lead times that are too long and insufficient quality control.
- *Neglect of human resources:* particularly with regard to education and training.
- *Extreme individualism:* failure of cooperation.

In Canada the situation is not better. Clearly, structural change and a greater investment in industrial R&D are needed to ensure Canada's competitiveness in world markets.

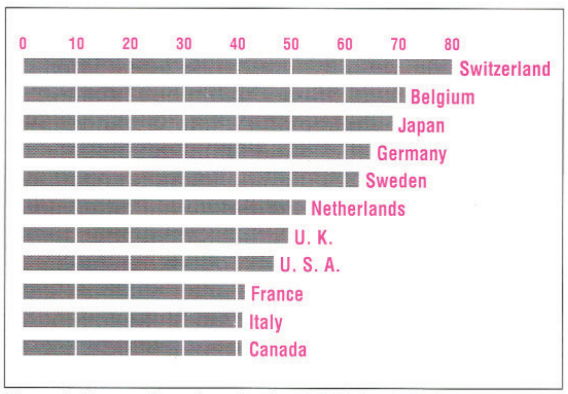

Figure 3 Per cent financing of national R&D by the industry, 1987

A Realistic Target for the Canadian R&D Effort

While R&D is only one of many factors affecting the performance of our industries in world markets, it should nonetheless be a determining factor in Canada's future success if it is well targeted and managed.

What should our national R&D level be? In 1976, the Honorable Judd Buchanan stipulated that the objective of his government was to raise the national level of R&D from 1.0% to 2.5% of gross domestic product (GDP) over the following five years. As I have indicated, the highest level reached was 1.43% in 1986 and the predicted figure for 1989 is 1.28%, close to that of Italy. With Prime Minister Mulroney having restated recently the national objective of 2.5%, a re-examination of that goal appears in order.

The first rule is that our gross expenditures on R&D (GERD) be proportional to the *size* of our economy. As shown in Figure 2, there is clearly a "massification" effect in GERD versus GDP. The larger the economy, the larger the proportion of GDP spent on R&D. For example, the big economic powers are spending between 2.5 and 3.0% of GDP on R&D and the smaller economies proportionately less. In the case of the OECD countries shown in Figure 2, the correlation is very high, in the order of r^2=0.95.

On this basis, just to be in line, Canada would have to spend US $2.4 billion more on R&D, i.e. we would need to move up by this amount on the graph to reach the regression curve.

The second rule is to consider the *type of economy* we have. Most primary industries in the world have long product life cycles and they spend relatively little on R&D. To use comparative figures, it is deemed appropriate to subtract from the Canadian GDP the portion relating to forests and mines which have very low R&D intensity, or 6.6% of US $411 billion, i.e. US $27 billion. Agriculture (3.0%) is not subtracted as it is important in most OECD countries as well. Thus, by moving Canada's point horizontally to the left by US $27 billion on the chart in Figure 2, it can be seen that an extra US $1.8 billion of GERD would be needed to reach the regression line. With this additional capital, the "normalized" rate of GERD versus GDP would have reached 1.92% in 1987 and not 1.35% as was actually the case.

The third rule is to have Canadian industry *fund a much larger proportion* of the total national R&D, an amount at least comparable to that of our trading partners (who are, in fact, our industrial competitors). As shown in Figure 3, the proportion of R&D financed by industry in Canada is only 42% compared to 80% in Switzerland, 73% in Belgium, 69% in Japan, 66% in West Germany, and 63% in Sweden. In the U.S., industry contributes 47.4% but this amount is considerably increased by the huge government contracts in defence and aerospace which help U.S. industries develop many new technologies – from A to Z – thereby enhancing their position in world markets.

In 1989, Canadian industry spent an estimated C$3.33 billion on R&D when the % GERD/GDP fell to 1.28%. If Canadian industry had contributed its fair share to the national R&D effort, let us say 66% of the total as is so often the case in many advanced countries (cf.Fig.3), then industry should have spent C$4.52 billion more on R&D in 1989 to ensure its own competitiveness, viz.:

$$3.33 \times \frac{1.92\%}{1.28\%} \times \frac{66\%}{42\%} = \text{C\$7.85 billion}$$

Although this increase in industrial R&D appears at first glance to be exorbitant, it is really not, considering the level of R&D investment made by our industrial competitors. However, the big question is what will bring

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Canadian industry to invest twice as much in R&D just to be proportionately at par with its competitors?

A fourth rule is to consider Canada's R&D position on a *sector-by-sector basis*. Indeed, global goals such as x % GERD/GDP, or so much R&D funding by industry versus government, are difficult to grasp and implement. It is in each individual sector that the competition is felt most keenly and it is there that international comparisons in % GERD/GDP ought to be made.

It is encouraging that Industry, Science and Technology Canada is now working in this direction. Not only is there a need to align the statistics of industry-funded R&D by sector but also to discover and correct the other impediments to Canada's competitiveness in world markets. One of these is Canada's growing shortage of qualified scientists and engineers with good training and real appreciation of the international marketplace and of the way it works.

Conclusion

One of the most perplexing issues for our leaders is how to manage technological change in transient environments characterized by fast-moving technological targets. Industrial R&D, although important, is not a panacea for correcting Canada's weak position in high-technology markets. Obviously, what we need is an integrated and balanced approach to the *strategic management of technology*. Indeed, as the Assistant Secretary of the U.S. Department of Commerce has said:

"Advancing technology has become a primary driving force for all world economies, and effective management of this function will determine the rise and fall of nations as well as of industries and individual businesses. Management, by definition, has now become the management of technologically driven change, marked by the progressive collapse of product and process life cycles, previously measured in decades, but now more often in two to five year periods."[2]

New technology has become a primary energizing force in the economic revitalization of nations. In the U.S. it is credited for more than 40% of GDP and 50% of the increased productivity. Nowhere has this technological revolution been more spectacular than in Japan. South Korea and other Asian countries are now quickly entering the race. The most progressive countries are all investing heavily in industrial R&D because of a major change in the prevailing economic paradigm.

These major shifts call for LEADERSHIP, particularly from planners and decision-makers in industry. One important aspect of leadership is VISION: where do we want to be as a nation and how do we get there – that is the question.

[1] Blais, R.A. (1989) "The Case for a Major Increase of Industrial Research in Canada," Corporate-Higher Education Forum, Seminar on Private Investment in Research, Toronto, Dec 6, 1989, 45 pages.

[2] Merrifield, D.Bruce (1988), "Industrial Survival via Management Technology" Journal of Business Venturing, Vol. 3, No.3, pp. 171-185.

IEEE Canada Shapshot

Ray Findlay has done it again!

We had come together for the Central Canada Council Training Meeting, Gordon Chen, John Cortes, Julian Egglestone, Steve Swing, and Pam Woodrow during one of Ray Findlay's Professional Development Exercises. The task: "How to Make our Section Great".

We knew what to do, we had just been through it. First, we brainstormed for ideas, no matter how "way out." Second, we put them in priority order. Finally, we identified a method to achieve our goal.

We selected to achieve an enthusiastic and involved membership.

We identified our resources as: Region 7 Office, Region 7 Financial reserves, Meeting facilities, Personal contacts, Newsletters, Retired members, Student members.

Next we identified our problems, which included: Apathy, Perceived reputation, Diversity of members' needs, Distances of travel.

After discussion, and dissension, we moved on to our roadblocks. In our case, there were:

- We can't please all the people all the time
- Time demands of executives and members
- Little industry support
- We cannot reimburse executive members for their time and expenses.

We came up with this plan:

1. Use personal contacts by executive members to poll a cross-section of the membership for their needs and wants. With these identified, enlist their help to implement them.
2. The executive committee then radically changes existing programs to suit these needs.
3. Use resources to implement new programs, then use personal contacts, improve newsletter and get students to advertise.
4. Follow up with awards/prizes and recognition of Section heroes with "warm fuzzies" all around for the good work done.
5. Go back to No. 1 and start again.

Naively, we presented this as requested to the Council group, feeling that this was a reasonable way to improve Section affairs, but Ray was not finished. No, Sir! "I want you to write it up for the Canadian Review" he said. Well, here it is!

John Cortes and Julian Eggleston - London Section.

IEEE Conferences in Canada - 1990

May 13-16	IEEE 6th Semi-Insulating Materials - Toronto
June 3-6	IEEE International Symposium on Electrical Insulation - Toronto
June 11-14	IEEE Conference on Precision Electromagnetic Measurement - Ottawa
June 19-21	IEEE Industrial Automation Conference - Toronto
June 19-21	IEEE ESMO/Construction 90 - Toronto
June 27-28	Canadian Conference on Engineering Education - Toronto
July 6-7	IEEE WESCANEX 90 Telecommunications for Health Care - Calgary
August 12-14	33rd IEEE Midwest Symposium on Circuits & Systems - Calgary
August 14-16	5th Canadian Semiconductor Technology Conference - Ottawa
August 20-24	IEEE 36th Holm Conference on Electric Contacts - Montreal
September 4-6	CCECE "Ten Years to 2000" - Ottawa
October 4-7	IEEE 3rd Sections Congress - SC90 - Toronto
October 11-13	1st IEEE International Workshop on Photonic Networks, Components and Applictions - Montebello, Quebec
October 21-23	CCVLSI '90 - Ottawa
October 22-24	4th Biennial IEEE Conference on Electromagnetic Field Computation - Toronto
October 23-26	IEEE Inter Comm 90 - Vancouver
October 25-26	2nd IEEE Alberta Conference and Exposition on Power Quality Issues - Edmonton

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Taken from ICR issue no. 8

Essay / Essai

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

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?

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 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

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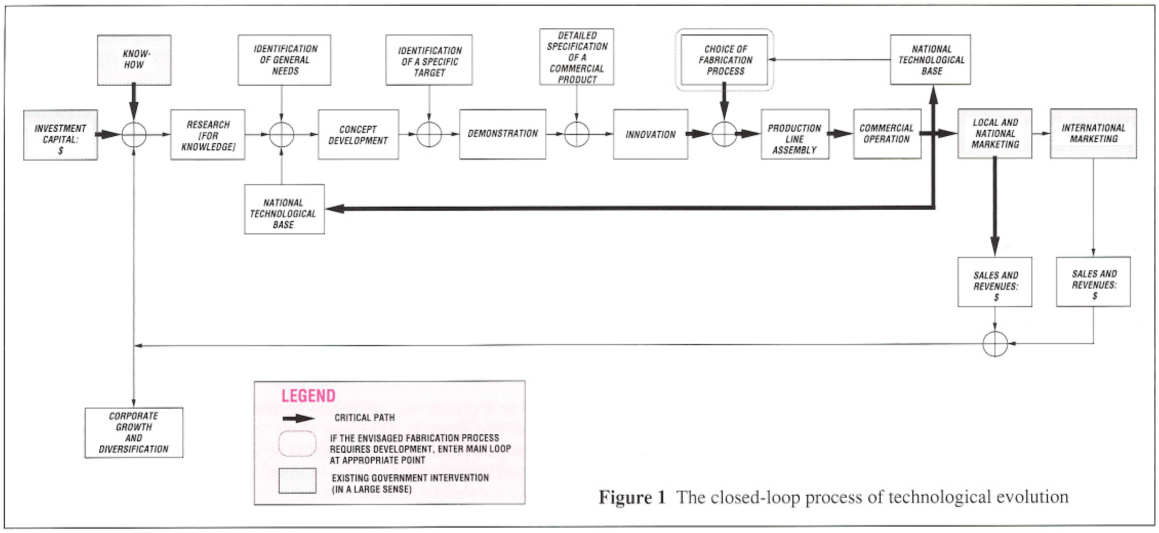

Figure 1 The closed-loop process of technological evolution

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

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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.

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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).

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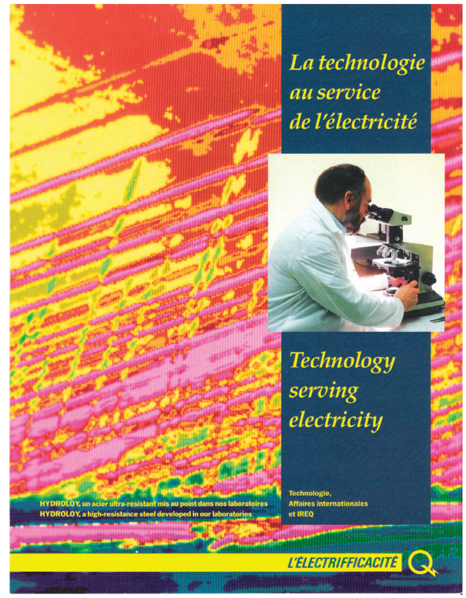

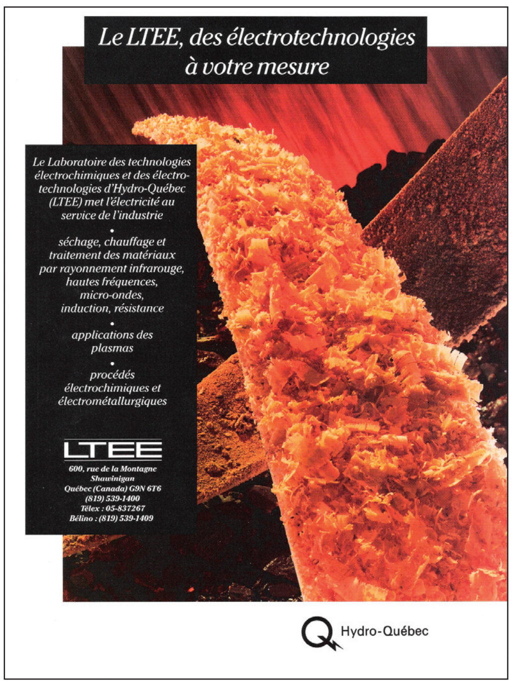

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Robert V. Anderson, directeur
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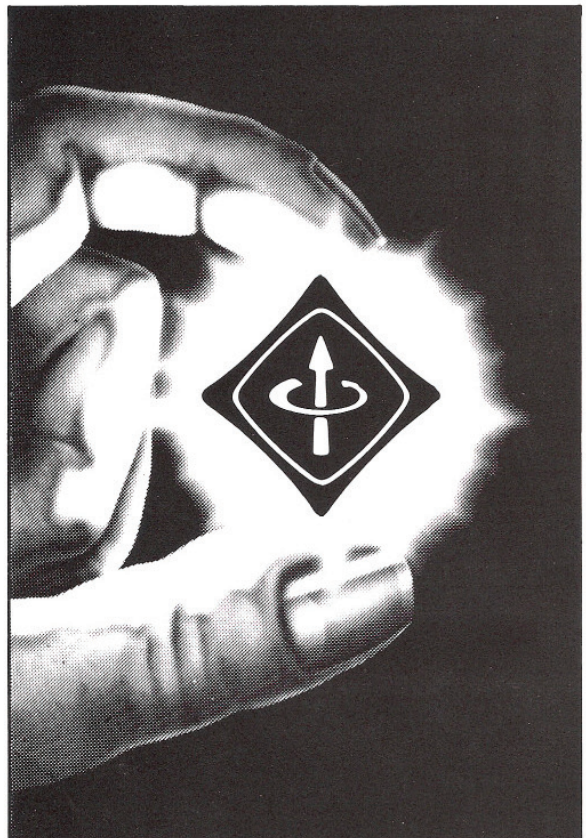

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