

Report of the National Advisory Board on Science and Technology

COMMITTEE ON TECHNOLOGY ACQUISITION AND DIFFUSION

Presented to the Prime Minister of Canada

MEASURING UP TO THE BENCHMARK AND MOVING AHEAD

L'ÉTALON D'EXCELLENCE: À ÉGALER, À SURPASSER

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National Advisory Board on Science and Technology

Conseil consultatif national des sciences et de la technologie

The Right Honourable Brian Mulroney Prime Minister of Canada House of Commons Room 309-S Ottawa, Ontario K1A 06A

Dear Prime Minister:

I have the honour of transmitting on behalf of the National Advisory Board on Science and Technology, the Report of the Committee on Technology Acquisition and Diffusion entitled *Measuring up to the Benchmark...and Moving Ahead / L'étalon d'excellence: à égaler, à surpasser.*

This report is the result of our investigations into the needs of Canadian industry for more timely access and exploitation of best-practice technologies. It analyses the current situation in Canadian firms and the present programs and policies of the government which impact on their efforts to measure up to and to surpass the performance levels of their competitors.

The Committee in this report presents carefully considered recommendations on how to improve the policy and organizational framework of the government technology services. Through these the government provides an appropriate environment and establishes valuable mechanisms to encourage and enable firms, especially smaller firms, to make more effective use of up-to-date technology and business practices in order to rise to the challenge of global competition.

The findings of the Committee, and the recommendations which we have derived from these findings, present challenges both to industry and to government. Each needs to improve its ability to plan strategically and to act responsively to global market and technological pressures.

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In order that the message contained in these recommendations reach the appropriate audience, we suggest that the Report, in its entirety, be disseminated to those organizations for whom technology and its use in Canada is an important topic.

Yours respectfully,

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Guy Bufresne Chairman Committee on Technology Acquisition and Diffusion

The views expressed in this paper are those of the authors and do not necessarily correspond to the views or policies of the Government of Canada.

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MEASURING UP TO THE BENCHMARK... AND MOVING AHEAD

BACKGROUND Industrial managers and government policymakers in all parts of the world feel the urgency which has been generated by the rapid changes in the character of the global marketplace. The ever-increasing pace of technological change and the growing economic significance of knowledge-based industrial activity, in all economic sectors, have raised to the highest levels the challenge of keeping a country's firms at or near the leading edge of management systems, processing technology and new product development. Never before have firms everywhere been so aware of the need to *measure up to the competition*.

TECHNOLOGY IS
THE KEY TOGlobal Competition has changed the ways that firms must behave in order
to thrive or even survive in the marketplace. Few economists hold onto the
outmoded view of technology as a passive productivity factor. Technology
and innovation have now been recognized as the keys to competitive
advantage for firms and indeed for nations. Technology-based innovation
derives from technically confident management, from qualified, motivated
employees, from in-house R&D, and from technologies and know-how
acquired from sources outside the firm, domestic and foreign.

MASTERING
THE THREE
"FUSIONS"The objective of this report is to recommend changes to the policy
environment and to the behaviour of Canadian firms which will enhance
their ability to master and effectively employ the following three "technology
fusions":

- INFUSION OF TECHNOLOGY (ACQUISITION): To gain access to the best technology the world has to offer;
- 2. DIFFUSION OF TECHNOLOGY (WIDE-SPREAD ADOPTION): To encourage firms in all parts of Canada to be timely, effective users of appropriate advanced technology; and
- 3. *PROFUSION OF TECHNOLOGY* (EXPLOITATION, ADAPTATION AND INNOVATION): To multiply the benefits of developed or acquired technology by exploiting it, adapting it to new uses, and going beyond it to new innovations.

Canada needs firms who can act with confidence in science and technology, who have research and development (R&D) strengths, who have the capability to develop their own innovative technology, and who have the ability to identify, select and acquire appropriate technology in a timely way.

TECHNOLOGY
AFFECTS ALL
FIRMS
EVERYWHERE

The need for continual technical change is not limited to the so-called "hightech" sector. It has a strong impact on <u>all</u> sectors of the economy, including resource industries, manufacturing and, to an increasing degree, the service sector.

Technology is not containable within national borders. Those who are aware of better process technologies and better products, no matter where they originate, and who exploit them early and effectively, are the winners in the global marketplace. The Japanese government and industrial leaders recognized this and focused a national effort in bringing new technologies from around the world into their factories, thereby creating very competitive products.

INDUSTRY MUST LEAD; GOVERNMENTS MUST ASSIST Technology acquisition from international and domestic sources and the diffusion of technology to all regions and all sectors require urgent and effective action by private sector leaders. Leadership by industry is essential if change is to take root in the Canadian economy. Government and the education system in Canada must take their lead from industry and work to respond to their needs by creating the services and the environments that are conducive to success in an age of technology.

TECHNOLOGY
DIFFUSION
MUST OCCUPY
A CENTRAL
POSITION IN
INDUSTRIAL
STRATEGIESThe Committee is convinced that technology acquisition needs to be given
a much higher profile and explicit treatment in the government's innovation
policies and support mechanisms. Furthermore, there needs to be a
champion within government who is mandated to oversee the effectiveness
and the collaboration of all of the government's policies, incentives, services
and programs which relate to the productivity and technological competence
of Canadian firms.

GOVERNMENT
MUST BE
INNOVATIVEThe urgency which is driving Canadian industry must drive those within
government who develop and deliver the infrastructure and services which
support and assist industry. Governments at all levels must strive to achieve
the same levels of effectiveness, efficiency and client-centredness as successful
firms. Innovation in management and in operations is as needed in the public
sector as it is in industry.

CANADA NEEDS TO ACCESS THE WORLD'S BEST TECHNOLOGY

Canada has the world's seventh largest economy although it is only 31st in population. We have been one of the most successful societies ever. Our



domestic development and use of technology and our ability to assimilate technologies from abroad have served us well until recently, when the level of the competition and the pace of change have both changed dramatically. We can no longer afford to wait until technology "diffuses" into the country, by that time our competitors have moved beyond to higher levels.

It is not possible, with a limited R&D resource to rely entirely on home-grown technology; not even the world's major economies can do this. Canada produces a proportionately small share of new technology within its domestic research activities, so finding and making use of technology from foreign sources is a vitally

important activity for Canadian managers. Less than \$7 billion per year is invested in R&D in Canada, while the combined annual R&D investment of the USA, Japan and the European Economic Community is almost \$300 billion. As can be seen on Figure 1, despite the excellence of Canadian R&D, as much as 97% of new technology needed by Canadian firms is first generated outside of Canada¹. Even if Canadians were to double the amount of R&D performed in Canada, we would still need to actively pursue the acquisition of the vast majority of technologies which have been developed abroad.

CANADA IS LAGGING IN THE USE OF ADVANCED TECHNOLOGY Statistical evidence indicates that while Canada has been bringing advanced technology into the country at ever increasing rates, our competitors are also doing this, and in most cases are doing it faster than we are. The data quantifying technology diffusion rates however are at times less than up-todate and the methodologies upon which they are based are variable, making cross comparisons between countries difficult. Supportive evidence in the direct testimony of firms in government surveys and in reports of industrial associations⁽²⁻⁵⁾ however, lead to the conclusion that there are serious shortcomings in the ability of Canadian firms to use best-practice technology. "While aggregate investment growth has been quite strong, Canada trails competitor countries in private sector investments linked directly to enhanced productivity. Between 1980 and 1989, investment in machinery and equipment as a percentage of GDP was lower in Canada than in most other major industrialized countries. Similarly, Canadian private sector investment in R&D as a percentage of GDP is the second lowest among the G7 countries. Moreover, investments made by Canadian firms in worker training falls well short of levels registered in the US, Germany, Japan and many other advanced nations." Canada at the Crossroads⁶ Studies by the Economic Council of Canada⁷ have found that new technology diffuses slowly in Canada: from other countries, from firm to firm and from region to region. For example, in 1984 Canada ranked 9th of 10 countries in the number of robots used per 10,000 manufacturing workers -well behind the leaders, Japan and Sweden. Statistics Canada reported in 1989⁸ that about half of manufacturing firms in Canada did not use one of 22 advanced

manufacturing technologies in their factories. More recent work⁹ indicates that fewer than six in ten use at least one of 17 selected technologies such as computer-aided engineering, robotics and lasers, while three quarters of comparable US firms do.



There is evidence to show that larger firms tend to lead the way in the use of advanced technologies with smaller firms adopting new equipment and technology later, when experience has been gained and benefits demonstrated by the first users. The relative scarcity of larger firms in Canada is holding us back. Comparison of Canadian results with the US indicates that, in general, Canadian manufacturers trail their American competitors in the use of advanced technologies by as much as five vears (Figure 2) $^{10-12}$. In fact the percentage of Canadian firms indicating that they are using or planning to use advanced manufacturing technologies is significantly lower than that of American firms. These observations are consistent with the facts that Canada also spends half as much on R&D and employs half as many scientists and engineers per capita as the U.S.

This is not to imply that the US is content with its rate of technology diffusion and application vis-a-vis its major competitors. It is no longer enough to compare our performance against our traditional G7 or OECD competitors. Even developing nations are creatively implementing mechanisms and incentives to encourage the more rapid deployment of up-to-date technologies in their firms. Emerging manufacturing and exporting powers are demonstrating productivity and performance improvements that are winning significant world markets.

AWARENESS AND MOTIVATION ARE PRECURSORS TO SUCCESSFUL TECHNOLOGY ACQUISITION AND DIFFUSION

The critical factor governing whether a firm remains competitive is the awareness and commitment of the senior managers of that firm. Too often, these managers are not aware of the pace of change in competitive firms around the world. They do not take advantage of the support infrastructure and programs which are available to them. They react too late, if at all, to the opportunities of better technology and to the need to change management concepts and procedures to permit their firms to react quickly and responsively to market demands and challenges. This lack of awareness and motivation has been identified as the most serious impediment for technology acquisition and diffusion in Canada.

BOTH HARD AND SOFT TECHNOLOGIES ARE NEEDED The technology which Canada needs to exploit is both "hard" and "soft". Some of the technical changes which lead to competitiveness are in the form of new machinery, computers, control systems, software, process instructions ("hard" technology). Others, equally if not more important, are those changes in business practice which improve both efficiency and efficacy within the firm. Management practices such as strategic technology planning, time compression management, total quality management, just in time delivery, empowerment of managers and workers, help a firm to be competitive in a very challenging marketplace.

One of the business leaders consulted by the Committee described how his firm had formerly had a production process where each stage was evaluated only on the volume of its throughput. They decided to "import" a Japanese processing approach where each production unit produced and delivered to the next stage only what was required and only when it was requested. This "soft technology acquisition" cost little but the implications within the plant were large. The workers and managers in each production unit now realize that the delivery schedule of the entire order depends on their ability to deliver quality output, just in time. There is no cushion of inventory to fall back on. This policy change has resulted in dramatic improvements to overall quality, and \$200 million from internal inventory has been freed up for more important uses within the company.

Most of the government's industrial support programs respond to requests by their clients, rather than seeking out the firm which needs their support. Thus they cannot help the firm that does not wish to help itself. The situation calls for innovative ways to awaken industrial managers to technical opportunities and to the technological imperative. Managers need to be helped to change their attitudes and to develop increased technical compctence among their employees.

YESTERDAY'S SUCCESSFUL STRATEGIES WON'T WORK TODAY As one of the members of the Committee expressed it: *'Motivation precedes innovation.''* Some Canadian SMEs are among the most successful innovators in the world. They are successfully winning high market share in niche markets which they know and serve well. In many of these markets small size is not an impediment. However, lack of awareness of and motivation to acquire and employ world-class technology means declining markets and inevitable business failure. Continuing to do what used to be right is no longer a viable option.

BENCHMARKING CANADIAN INDUSTRY AGAINST THE BEST

Benchmarking is the continuous process of measuring products, services, and practices against the toughest competitors or those companies recognized as industry leaders. David T. Kearns, CEO, Xerox Corp.¹³



Many successful firms employ a strategy where they make it a practice to acquire examples of the best products of their competitors. They examine and analyze the technology which underlies the features, quality and production these products. and thereby determine where their own products can and should be upgraded in order to stay competitive. Analysis of the manufacturing and production processes of competitors is also an effective way to identify and highlight those areas within a firm where new technology or new procedures can be effectively employed. Figure3 presents an outline of the Benchmarking process as described in the 1989 book, Benchmarking: The Search for Industry Best Practices that Lead to Superior Performance, by Robert Camp.¹³

The Committee believes that the managers of Canadian firms are too often unaware of significant technical innovations, even in their own fields of endeavour. By measuring themselves against the benchmark of the best products and processes in their markets, managers can identify proven and incremental techniques and technologies to be acquired, adapted and used, which can be of more cost-effective and immediately practical use to Canadian producers than more advanced, leading edge technical breakthroughs.

GOVERNMENT PROGRAMS SHOULD SUPPORT BENCHMARKING

The government should explore ways to equip its industrial support program managers to encourage and challenge firms to use benchmarking as an aspect of their strategic and technology planning. This could be carried out in cooperation with industrial associations or multi-firm consortia as well as with individual firms. The resources of External Affairs and International Trade Canada (EAITC) could be used to help firms to identify best products early after their market entry. The expertise of Canadian technology institutes and universities could be used by the firms to help them analyze these products and develop technologies in response to the challenge of their competitors' products.

Recommendation 1:

Industrial managers should practice benchmarking to evaluate their performance continuously against the toughest of their competitors and the best performers in their fields of endeavour.

Government industrial support programs should be mandated to help industry in their benchmarking. Program managers and advisors should help firms to locate best practices, using, where appropriate the services of the Trade Commissioners and Technology Development Officers in Canadian posts abroad and the services of the Technology Inflow Program (TIP).

Industrial support program criteria should be broadened to include cost sharing for benchmarking and other technology acquisition activity.

Private sector technology centres and agencies, and industrial associations should become more active participants in industrial benchmarking.

Benchmarking Canadian Hockey

The strongest image which I retain from that unforgettable 1972 Canada-Soviet Hockey series is from a television interview between the second and third periods of the fourth game, in Vancouver. Phil Esposito is at the boards at the end of the rink being interviewed by Pat Marsden. The game is not going well. It is painfully obvious that the "dream team" of the most talented group of Canadian hockey players ever assembled; the Team Canada that everyone, in Canada at least, expected would frighten the Soviets just by showing up; was being thoroughly humbled by the superbly disciplined and well-conditioned Soviet team. They were literally skating rings around the very talented and desperately striving Canadians.

Esposito is telling Canadian televiewers that every player is giving it everything he has; they are putting out 110%; they are playing for Canada and for personal pride. Esposito is breathing heavily, his hair plastered to his forehead, his jersey drenched with sweat. Meanwhile, in the background, you could see the Soviet team skating calmly to their bench.

As every Canadian over the age of thirty knows, Team Canada and the Soviets continued their series in the USSR and by dint of some last minute heroics by Paul Henderson, the Canadians eked out a 3-2-3 "victory" in the eight game series. They learned a valuable lesson, however. While they had been concerned only with local NHL competition in North America, assuming that their's was the superior game; while they were continuing to train for and to play hockey the way it was always done before in Canada; the Europeans and, in particular, the Soviets were applying much more intensive fitness and skills training in their hockey programs. Obviously their approach was bearing fruit. Ironically, the guidebook the Soviets were using was written by a Canadian, Lloyd Percival, whose recommendations for a much more all-round approach to sports-training had been almost totally ignored by his compatriots.

Today, as a result of being exposed to European methods, the level of fitness and of play in the best of Canadian Hockey is measurably superior to what used to be the case. Now, when the best Canadian hockey players take the ice against the best the rest of the world has to offer, in the Canada Cup series for example, Canadians measure up to the highest world standards. They don't always win, but at least they are in the game no longer disadvantaged in comparison to their competition.

SUCCESSFUL TECHNOLOGY ACQUISITION DEMANDS HIGH MANAGERIAL AND TECHNICAL COMPETENCE

Today's managers need to use technology acquisition as an essential strategic tool but, as was recently stated by one of Canada's industrial leaders: *'Technology transfer works best when the recipient has technical competence which matches or exceeds that of the donor'*¹⁴. Management and labour have to work together to build technological competence within their firms in order to be able to develop competitive products and processes as well as to be able to identify and adapt for their own use the best technology the world has to offer. This competence has to extend over the full development-exploitation cycle: from the idea stage, through the technical skills required to realize it, to the successful marketing of a world-class product or service.

"Nations that spend relatively large amounts on R&D (in the relevant industry) tend to be relatively quick to begin producing a new product, even if they are not the innovator. ... firms that spend relatively large amounts on R&D tend to be quick adopters of new technology developed by others. .. R&D provides a window opening on various parts of the environment, and it enables the nation or firm to evaluate external developments and react more quickly to them.

In some economic models, R&D is viewed as an invention-producing or innovation-producing activity. While correct as far as it goes, this view misses much of the point of R&D, which also is aimed at a quick response to rivals and at clever modification, adaptation and improvement of their results.¹¹⁵

Several of the previous studies show astrong correlation between the rate of diffusion of technology and the R&D expenditures in a particular sector. Canada's relatively weak industrial R&D expenditures, indicating a weaker technological base, would therefore be expected to inhibit diffusion.''

Technology Diffusion in Canada: Myths and Realities¹⁶

Societies which carry out significant amounts of research and development are also those most involved in technology adoption and adaptation. Similarly, those nations (like Japan) which have emphasized technology acquisition soon found it necessary to increase domestic R&D activity apace. Canada's relatively weak level of industrial R&D investment is therefore a handicap when it comes to technology acquisition and diffusion, in the ability to identify appropriate and select technologies, and in the ability to adapt and exploit those which are acquired.

The expertise and awareness which is gained from participating in ongoing research enables a firm to choose well in technology acquisition. One consequence of technology acquisition is that the firm is able to move to higher levels of adaptation and innovation in order to catch up to and surpass the originators of the technology acquired. Thus Technology Development and Technology Diffusion are two sides of the same coin. They are not considered separately by managers, but form options and alternatives within their technology strategies.

INCREMENTAL CHANGE IS AN EFFECTIVE FORM OF TECHNOLOGY DIFFUSION Successful technical change is often incremental rather than revolutionary. Firms develop competitive products and processes through a continuous process of making improvements, matching or surpassing competitors' innovations, eliminating weaknesses and faults, and by introducing new and better information, techniques and practices into the factory and into the offices of firms. Acquired technology comes not only in the form of advanced products and licences (technology) but also as guidance and training in their

"While technology creates competitive advantage, seizing that advantage requires a workforce skilled from top to bottom...If the bottom 50 percent cannot learn what must be learned, new high-tech processes cannot be employed." Lester Thurow¹⁷

....no strategy to enhance the rate of acquisition and diffusion of best-practice technology can work without addressing the low level of capability of managers in many sectors to introduce advanced technologies, and the inadequate skill levels of many workers to use them. In other words, as with so many other issues, people are at the heart of the problem, and also at the heart of its solution.

NABST Statement on Competitiveness.¹⁸

effective use (know-how) by those who have developed them. Examples abound of firms who acquired advanced technology but were unable to profit from its use for lack of adequate understanding of its most effective use.

Continuous upgrading of both managerial and employee skills are the hallmarks of successful companies. The governments, both federal and provincial, have important roles in encouraging industry and the education sector to work together to improve Canada's ability to educate and train a productive workforce and to develop those management skills which are required to lead us forward.

Recommendation 2:

Industrial managers should seek to upgrade their own skills and those of their employees through on-going training programs and through active cooperation with the education sector.

Industry and governments should encourage and foster universities, colleges and the performance of R&D in both the industry and academic sectors in order to increase the supply of technically qualified personnel.

Industry, government and labour must work together to create more effective mechanisms to promote technical awareness and to encourage firms to increase the levels of technical competence of Canadians through training and apprenticeship programs.

Small and medium sized firms should seek to employ engineers and other technically trained personnel to help them to make more effective use of advanced technologies.

ECO-TEC AND PROCEP

Eco-Tec is a small Canadian owned and controlled company with 75 employees and sales of \$10 million which exports equipment for the recovery of minerals, metals and chemicals from industrial processing wastes to 25 countries. They reinvest 6% of their gross earning in R&D, with a heavy emphasis on development.

They were founded in 1970 by a partnership based on an autoparts company and a group from the University of Toronto who had expertise in ion exchange processing for water purification. They were assisted in the start-up phase by a grant from NRC's IRAP program. They regard this support as having been catalytic; they would not have been able to start out without it.

Later, when their parent was bought up by an American company, they did a leveraged buy-out to keep control of the company. In the mid-70's they sought complementary technologies to fill out their product line and broaden their service offerings. They found what they were looking for in Japan and successfully negotiated a licence agreement which gave Eco-Tec the entire western hemisphere market for the Japanese technology.

In the 80's they went looking for another technology for the recovery of copper, which they found in a U. S. electro-winning process. They acquired a world-wide licence for environmental applications of this technology. IRAP helped them obtain the services of a consultant to adapt the technology to their needs. This was the technology which later won them the Award for Business Excellence in the Environmental Category.

In the 90's they again went looking for new technology to pursue a business opportunity in the aerospace sector. IRAP helped them again and with TIP support they negotiated a licence to a Japanese patent. The Japanese company already had an American licensee but were unhappy with their performance. This market will take longer to penetrate than they had hoped so the break-even on their \$70,000 licence fee (over 5 years) will take longer to reach. They wish they had had help in analysis of the market.

Recently they have set up a research and development subsidiary (Procep) to facilitate the development of technology to stay at the leading edge of their market. They have also set up a U.K. subsidiary to help them penetrate the European marketplace.

(Permission to use the above text was granted by Ecotec on August 14, 1992.)

FISCAL INCENTIVES SHOULD BE NEUTRAL WITH RESPECT TO THE DECISION TO "MAKE OR BUY" TECHNOLOGY

	The processes whereby a firm absorbs, creates and exchanges technology are inextricably interwoven in a complex innovation system with feedback and interaction between all aspects from original conception to product marketing. In this web of activities, the strength of the whole process is dependent on the strength of each component. Success comes from a mastery of the entire system of innovation. Government sponsored incentive programs however, have traditionally been biased to encourage only one form of innovative activity: research and development. More recently, it must be noted, governments have been acting to encourage the development of alliances and consortia in which firms work together on innovations which need more competence and economic strength than can be provided by a firm acting alone.
TAX INCENTIVES ENCOURAGE R&D	Canada, like most governments around the world, encourages and supports industrial research and development through tax-based incentives. In fact, Canada's record for tax support of R&D is one of the most generous in the developed world. Industrial research and research collaboration is also supported through a range of contribution programs. These incentives are designed to encourage the creation and development of original innovations.
ACQUISITION OF TECHNOLOGY IS AS IMPORTANT AS ORIGINAL RESEARCH	Several industrial managers have reported to the Committee that they are increasingly finding that it is more cost effective and strategically wiser to mix in-house R&D activity with a judicious selection of technologies purchased or licensed from other experts outside the firm. The currently available fiscal incentives however, are biased to internal R&D and therefore away from technology acquisition. This sometimes means that technical managers have difficulties justifying to their financial officers the costs of acquiring technology through licence.
DEVELOPMENT AND ACQUISITION MUST BE BALANCED IN COMPANY STRATEGIES	The innovation process involves a complex balancing of several options, including in-house development, technology collaboration and exchange, and technology acquisition. The aim of all government incentive programs and policies should be to encourage firms to develop and/or to acquire, as appropriate, those best-practice product-related and process-related technologies which will make them more competitive.
ACQUISITION AND DEVELOPMENT INCENTIVES SHOULD ALSO BE BALANCED	The government should strive, therefore, to implement more balance in its S&T incentive measures so that acquisition and in-house development are equally encouraged. A system of tax incentives and accelerated depreciation for the acquisition of best-practice technology should be created. These incentives should be equivalent to those which encourage in-house research and technology development. Current cost-shared funding programs should also be authorized to offset the costs of technology acquisition. In this way,

the management of firms will be enabled to consider the options of in-house development and external acquisition of technology on their intrinsic merits when preparing business and technology strategies.

MOST TECHNOLOGY TRANSFER OCCURS WITHIN CORPORATE FAMILIES

Information provided by Statistics Canada¹⁹ shows that in 1989, Canadian firms made payments of about \$3.5 billion for management and administrative services, research and development, and royalties, patents and trade marks. Corresponding receipts in these same categories were \$1.4 billion. The vast majority of the payments were made by companies to their affiliates (\$3.3 billion). Payments made to non-affiliates totalled \$238 million of which \$20 million was spent in Canada. If a tax incentive for technology acquisition were to apply only to technology brought into a firm from outside its corporate family, the total cost of such an incentive would not be great, but it would clearly signal the government's recognition of the importance of technology based opportunities and solutions from the world-wide pool of advanced technologies.

Recommendation 3:

Firms should plan strategically to enhance their production processes, products and services giving due consideration to both developing new technology in-house and acquiring best available technology from elsewhere.

The government should encourage firms to develop balanced technology development and technology acquisition strategies by establishing new tax incentives, accelerated depreciation and cost-shared funding mechanims aimed at technology acquisition, which are as favourable as current incentives for in-house technology development.

ZTEST Electronics

ZTEST Electronics Inc. of Mississauga, Ontario, began operations in 1986. Their primary business is the design, development, manufacture and marketing of state-of-the-art electronic test equipment. ZTEST introduced its first product, the TESTMATE 3000, in August 1987 and marketed it in Canada and in Japan, so successfully that it received the Best New Product award at the Toronto 1987 Hi-Tech Show.

Their technical leadership led them to a 5-year technology and marketing agreement with John Fluke Manufacturing (USA) and through Fluke with Philips (the Netherlands). Through these arrangements, ZTEST products are marketed in North America, Europe and the Far East.

The recent recession and marketing direction changes at Fluke led to a decrease marketing emphasis for the ZTEST products by that company. ZTEST needed to take more direct control of their own destiny. They learned of a large Spanish electronics service company, Ingenieria de Sistemas Y Servicios (IS2) who had developed a PC-based emulation system for in-house testing of microprocessor-based systems.

After reviewing the performance of IS2's technology in June 1990, ZTEST determined that the basic technical content was sound but that it needed further hard/software development. With the support of IRAP and the Technology Inflow Program (TIP), ZTEST sent two of its personnel to Spain to determine the feasibility of incorporating the Spanish technology into ZTEST products with the intention of developing full turnkey PC-based systems.

The result was ZTEST's first independently marketed product. The niche-market for this product was very receptive and now other hybrid products are under development. The new product has already gained significant sales with substantial increases projected for the next two years.

By combining ZTEST expertise with that of the Spanish company, ZTEST was able to broaden and strengthen its product base into PC-based emulation systems, increase its in-house expertise and cut product development time and risk by a substantial amount.

(Permission to use the above text was given by ZTEST on August 6, 1992)

THE ROLE OF GOVERNMENT IN INDUSTRIAL TECHNOLOGY DEVELOPMENT IS TO PROVIDE THE APPROPRIATE ENVIRONMENT

"Governments worldwide have long intervened in their domestic economies to increase the productivity and the international competitiveness of firms operating, if not originating, within their borders. However, as more countries have recognized the importance of technical advance for economic growth and competitiveness, governments have focused more on creating a domestic environment conducive to developing, applying, and diffusing advanced technology for commercial advantage."

National Interests in an Age of Global Technology²⁰

Governments establish the appropriate financial and industrial climate and infrastructure to enable firms to make more effective use of technology in order to develop competitive goods and services for the world's markets. National and provincial governments are striving to create fertile environments for technically confident managers, globally minded marketers, insightful strategic planners and engineers competent and technologists, all of whom are able to recognize, evaluate, acquire, adapt and exploit the best technology the world has to offer.

MANY GOVERNMENTS HAVE ESTABLISHED INDUSTRIAL EXTENSION SERVICES

SUPPORT PROGRAMS ARE GETTING CLOSER TO THEIR CLIENTS

NEW SUPPORT SERVICES ARE MORE FLEXIBLE Policy makers in governments throughout the developed and developing world are recognizing that their industrial and technology policies of the past are no longer the most effective means to assist their industrial innovation objectives. Increasingly, governments are establishing *extension service infrastructures* with decentralized advisory units which pro-actively seek to assist firms to develop, or to identify, acquire and adapt best practice technology. Such advisory services help small and medium sized enterprises (SMEs) in particular to obtain access to a wide range of experts and facilities as appropriate to their needs. They are typically empowered to react responsively and to adapt their services to the specific needs of the client.

Instead of passively waiting for spontaneous requests from industry as in the past, government agencies in many countries are now actively promoting their services, often through private sector intermediaries. They work through networks, clubs, industrial associations, consultants or regional development agencies such as chambers of commerce. Programs are literally getting closer to their clients, opening several smaller offices in local communities in order to be more aware of and more responsive to the needs of their local clients. Local rather than national level mechanisms are being developed and expanded.

These new support structures permit *ad hoc* flexibility which allows a unique set of support mechanisms to be brought together to meet the specific requirements of a given client-firm. In this way, consulting engineers, private research institutes, the research laboratories of large firms, engineering schools and government research laboratories are being used as sources of technical competence in innovation projects. Technical assistance is often

augmented with the support of experts in other critical business areas such as commercialization, seeking capital, building alliances, licensing, market analysis and training.

NATIONAL AND UNIVERSITY LABORATORIES ARE VALUABLE RESOURCES

The technology infrastructure (businesses, consulting engineers, government and university laboratories) and the generic science and technology which these laboratories produce are increasingly being seen as national resources. The research base of university, government and private laboratories is being treated by governments around the world as a reservoir from which both expertise and technology can be transferred to companies. New policies and activities have been established to facilitate cooperative R&D projects and technology licensing with federal laboratories.

"Ministers reaffirm the importance of fostering diffusion and a wide acceptance of technology within their economies and societies. Governments should consider developing policy measures to facilitate technology diffusion, such as technology extension services, particularly as regards small and medium size enterprises, and removing market impediments, such as excessive regulatory burdens. They should also encourage a broad range of information on and public discussion of technology issues, support technology assessment at national, regional, and international levels, and promote in their societies a climate which is receptive to technological change."

OECD Ministerial Statement, June 1991²⁶

In summary, governments everywhere are establishing diffusion policies which are integrated with their more traditional technology development policies and offer a multiplicity of decentralized end-user oriented mechanisms for actively transferring know-how to small and medium-sized enterprises. The most important tasks of diffusion policy are encouraging appropriate levels of investment in qualified human capital and building up the infrastructure which supports the injection of technology directly or indirectly into smaller firms⁽²¹⁻²⁵⁾.

Joldon Diagnostics

Joldon Diagnostics is a Canadian firm which develops detection kits for a variety of body malfunctions, primarily through thyroid testing. Joldon has expanded its capabilities through a process of selective technology acquisitions. The first case was initiated by NRC's encouragement to seek technologies from abroad. Joldon identified a specific technology need and NRC and External Affairs combined resources to identify a technology under development in the UK whereby magnetic particles could be coated with an antigen.

Joldon invited the UK firm to Canada and eventually developed a technology transfer agreement. Formerly, Joldon's products were dependent on radio-immunoassay techniques which were based on the use of radioactive iodine. Hospitals were moving away from the use of radioactive technology because of increased concerns about radioactivity and increased licensing fees charged by AECL for inspection and certification of their labs. With the new technology Joldon has introduced a new series of tests based upon the magnetic particle technology.

In a second example, Joldon formed a joint venture with an American company which had a diagnostic technology but which was not able to stabilize its production technique. Joldon was able to complete the development of the product and appropriate packaging requirements, and to introduce the product successfully into the market. Unfortunately, the US firm with whom they were working exercised an escape clause and gave production rights to another company.

Joldon is entering into a joint venture with a small California company which had developed a number of unique technologies for diagnosing problems like stomach ulcers. Through this agreement Joldon will have full production rights for a series of new diagnostic kits based on the combined expertise of the two companies which will be marketed world-wide.

In another case, Joldon has teamed up with the Allegheny Singer Research Institute and Brussels University. They are conducting a research project in Brussels University, the results of which are being transferred to Allegheny from where they will be incorporated in Joldon production technology. This technology is not available anywhere else in the world.

(Permission to used the above text was received from Joldon on August 6, 1992)

THERE IS A NEED TO SET PRIORITIES AND CONSOLIDATE TECHNOLOGY AND R&D SUPPORT PROGRAMS IN CANADA

The federal and provincial governments of Canada have been active proponents of a more proactive approach to technology policy. Members of the Committee have been briefed on current activities which are focused on determining ways to improve Canada's performance in technology diffusion.

- A PLETHORA OF PROGRAMS The government offers a wide variety of programs and services which assist firms in different ways to improve their awareness and abilities in technology acquisition and diffusion. A listing of these numerous programs, which one Committee member describes as a "patchwork of ad hoc programs", is provided in Annex 2 of this report.
- A POSITIVE TREND The Committee notes the trend within the federal government's industrial support agencies to work to build a more integrated assistance system. This system would involve consolidation around four major areas: Information Services, building upon the ISTC Business Service Centres; Business Diagnostic Services, building upon the AMTAP and MAS programs; Technology Advisory and Acquisition Services, building upon IRAP and TIP; and a new more comprehensive industrial extension infrastructure to train and develop the staff in these services and to interconnect them with each other and with other service agencies through an electronic network²⁷.
- **TOO MANY PROGRAMS** While each of these individual programs and services has value and laudable objectives, the existence of such a large number of programs is in fact an impediment to effective service to the public. It is difficult, if not impossible for the manager of a small firm to identify, understand and effectively use all of the government resources available to him. Even those delivering government programs are not aware of all other services. Furthermore, not all programs are equally valuable, nor are the funds or services provided proportionate to the needs and opportunities faced by Canadian firms.
- DON'T CREATE
MOREThe Committee commends the work of the federal and provincial governments
aimed at extending and enhancing networks, programs and services for
SMEs, while making significant efforts to improve their accessibility; but
cautions that, in the effort to create one-window shopping services, the
government should build on what has been proven to work and should not
create new organizational structures.

BUILD ON IRAP'S EXCELLENT TRACK RECORDThe Committee notes that the Industrial Research Assistance Program (IRAP) of the NRC has an excellent record of collaboration with federal, provincial and private sector agencies²⁸ and as such should be the technology network foundation upon which government program consolidation and delivery should be based. A significant factor in the delivery of IRAP services to its clients is that the Industrial Technology Advisors who deliver the IRAP services have considerable direct experience in the management of technology in the SME.

INDUSTRIAL
EXPERIENCECommittee members have noted that this direct industrial experience
contributed in no small way to the value of the services of the Trade
Commissioner service in Canadian embassies and consular posts abroad.
All those who serve client-firms through government industrial and technology
support programs should have experience and backgrounds related to small
business and the technology which is needed by these firms.

INTERNATIONAL TECHNOLOGY INFORMATION MUST BE DISSEMINATED

INDUSTRIAL BOARD TO ADVISE PROGRAM MANAGERS The technology advisors in the domestic network and those operating in Canadian posts abroad should collaborate in bringing needed technical information to Canadain firms. This information should be collected in accessible databases and should be disseminated to those who need it through the technology extension service and through industrial associations as appropriate.

The Committee recommends that a Board be established to oversee the quality of technology acquisition and diffusion program management and delivery, and to recommend the appropriate mix, scale and scope of the services and program elements offered by the government. The membership of this Board should be predominantly drawn from the private sector including representation from the university community.

Government program managers would be responsive to the Board which would determine the appropriate apportion of funding for different elements and services on the basis of feedback from the marketplace and through evaluation of the performance and benefits of each aspect of the program. Program monitoring and evaluation should be based upon the impact of the program to profitability and competitiveness of its clients and its contributions to the economy, and not merely on how much is spent or how popular the program is with its clients.

Recommendation 4:

The government should, wherever possible, consolidate programs and services with similar or complementary mandates to allow more accessible and comprehensive service to be provided. This consolidated service network should be organized and oriented to provide fast and responsive service within the timeframe appropriate to the needs of the client-firm.

The government should enhance technology acquisition and diffusion by Canadian firms through the establishment of a <u>single</u> national technology extension service which promotes awareness of and access to existing public and private sector support mechanisms and centres of expertise.

This extension service should feature active, technically qualified advisory agents located in easily accessible offices in all regions of Canada. It should be built upon the proven, effective IRAP program, which should be strengthened and enhanced, rather than creating new parallel organizations, programs or support systems.

The government should carry out an intensive process of setting priorities among all of its technology-related incentives, programs and services based upon how well they are filling a market-driven need and are contributing to the competitiveness of their clients. Stronger and more effective programs and services should be augmented at the expense of less effective ones.

The Trade Commissioner service of EAITC should be combined with the Science and Technology Counsellors and Technology Development Officers in Canadian Posts abroad, and all of these positions should be staffed with personnel having relevant business and technology experience and backgrounds.

A Board should be set up to recommend strategic directions to the managers of the consolidated program for technology acquisition and diffusion. This Board, which should have a majority of industrial representatives, would advise on the relative apportioning of funds to different forms of assistance to firms, in response to an annual analysis of market needs. The Board would also oversee the results of program evaluation.

BANKS AND OTHER PRIVATE SECTOR SERVICE ORGANIZATIONS SHOULD BE ENCOURAGED TO PARTICIPATEMORE FULLY IN NATIONALTECHNOLOGY EXTENSION NETWORKS

The Committee advises the managers of government services to use private sector organizations to the degree possible in program promotion and delivery. Many private sector services are used on a day to day basis by firms. These should be brought closer into the delivery of programs and support services. In this way the costs to the government will be reduced and the awareness and involvement of a greater number of organizations will be assured. **BANKERS HAVE** The Canadian banking system is one of the nation's strengths and yet most A ROLE TO PLAY Canadian entrepreneurs feel that the intrinsic conservatism of Canadian banks is an impediment for firms wishing to undertake higher levels of technological change and its attendant risk. The Committee believes that greater efforts should be made to make the banking community more aware of and more actively involved in the networks of agencies working to support technological change within firms. With this increased awareness and the contacts that would be developed the banks will be able to advise their client to avail themselves of the appropriate programs and services. **BANKERS NEED** Increasingly it is being recognized that the intangible assets of a firm are TO APPRECIATE vitally important to its success, particularly in the long term. These **INTANGIBLE** intangible assets include the firm's competence in R&D and technology ASSETS acquisition, the quality of its personnel and its ability to train and re-train them, the organizational structures and management of quality by the firm, marketing intelligence and the ability to serve diverse markets, and its capabilities in complex software systems. These are often even more important to the technology-based firm than its tangible (physical) assets. As a more active promoter and partner in a technology extension network, BANKS CAN **BENEFIT FROM** the banking community would gain invaluable experience and insight with INVOLVEMENT IN the various forms of technical and other expertise and the support infrastructure EXTENSION which assists firms to build up these intangible assets. The experience **SERVICES** gained will also help the banks to evolve to a more effective partnership role with firms, as is demonstrated by the European "Merchant" or "Universal" Banks. Preliminary discussions with a representative of the Canadian Banking BANKS ARE READY Association leads the Committee to believe that the banking community is TO PARTICIPATE ready and willing to experiment with such as relationship. The auditing community could also participate in such a technology/ AUDITORS ALSO business network. Auditors are already involved in the verification of HAVE A ROLE environmental factors in the firm's operations. They could be encouraged

to verify that firms have adequately informed themselves about the state of the art in the technologies of relevance to their operations through appropriate benchmarking activity.

Recommendation 5:

Banks, industrial associations, chambers of commerce and other private sector service organizations should participate in the national technology extension service through experimental programs designed to encourage private sector agencies to be more aware of technology and other business support programs and services and to promote their appropriate use by their clients.

PROGRAM PERFORMANCE AND SUCCESS MUST BE MEASURED PERIODICALLY AND PUBLICLY

All government programs and services must be evaluated continuously against meaningful and measurable objectives. These objectives are valid only if they are expressed in terms of increased economic performance of the firms which avail themselves of the services offered. Success must result not only in the development of new technology but also in the profitable production and commercialization of products and services through the use of that technology. Programs which are not delivering the desired result should either be changed or their resources employed in programs and services which have been proven to be more efficacious.

COLLABORATION AND TIMELINESS ARE KEY PERFORMANCE PARAMETERS

A key factor against which all programs should be measured is their ability to interact effectively with other, complementary programs. The timeliness of response of the program should also be evaluated against standards which are sensitive to the need of the client. Program services and funds need to be made available with very short turn-around time, not the delay of months which is the case with some centrally administered government programs. Otherwise the opportunity or challenge faced by the firm may by missed. All federal programs and services should be evaluated at least every three years against performance standards and desired results.

Recommendation 6:

The government should carry out regular, hard-nosed evaluations of all industrial technology support programs and services in terms of their effectiveness in achieving measurable economic results, their performance in interaction with other programs and services, and the timeliness of their response to client need. These evaluations should be made at least every three years and their findings should be made public.

CONCLUSION

	The Committee has been struck by the general recognition of the urgency of the industrial crisis in Canada. Many of the experts with whom the Committee has spoken have expressed the idea that Canada had been altogether too "comfortable" for too many years and that tough economic times are the driver for firms to question old beliefs and traditions. Unfortunately, these tough economic times also make it hard for the firms to find the funds necessary for implementing the desired changes.
FIRMS MUST ADAPT TO MODERN MANAGEMENT PRACTICES	The Committee has been told that much of the adjustment which has to occur within Canadian firms is based less on technology and more on the way businesses manage themselves. These changes while not as costly as technical change, have greater impact on the profitability of the firm. In fact changing technology without preparing the organization to make most effective use of it has been described as "paving the cow path"; the productivity improvements hoped for were often not realized in firms which failed to change their way of doing business.
MOTIVATION AND SKILLS ARE ESSENTIAL	There is also a universal realization that one of the keys to industrial competitiveness in Canada is the challenge of improving the motivation, educational and skill levels of all employees, both management and labour. Only through improvements in the capabilities of their personnel can firms effectively take advantage of the opportunities based on more effective organization, better involvement in the pursuit of quality and up-to-date technology.
TECHNOLOGY ACQUISITION NEEDS A STRONG TECHNOLOGY FOUNDATION	Industrial executives told the Committee that the dynamic search for best- practice technology has become a necessity for maintaining a competitive edge in their markets. Even firms in specialized niches must take advantage of other more specialized expertise in the development of their products and processes. Technology acquisition alone, however, is not a panacea. Only those firms with a good technological foundation are in a position to identify, acquire and profit from technology generated by others, in Canada and abroad.
FIRMS NEED A MORE COORDINATED GOVERNMENT SUPPORT SYSTEM	Too many managers have not yet reached the level of awareness and motivation to actively and professionally seek out best-practice technologies appropriate to their firms. These managers and their firms need help. The government has an important role to prepare and provide the environment within which the managers of Canadian firms are encouraged and enabled to lead their firms into productive and competitive use of technology. This help needs to be delivered in a more comprehensive and comprehensible way. A greater degree of consolidation and coordination of programs would help firms to receive the appropriate assistance and support they need when they need it.

ANNEX 1

RECOMMENDATIONS

Recommendation 1: BENCHMARKING AGAINST THE BEST

Industrial managers should practice benchmarking to evaluate their performance continuously against the toughest of their competitors and the best performers in their fields of endeavour.

Government industrial support programs should be mandated to help industry in their benchmarking. Program managers and advisors should help firms to locate best practices, using, where appropriate the services of the Trade Commissioners and Technology Development Officers in Canadian posts abroad and the services of the Technology Inflow Program (TIP).

Industrial support program criteria should be broadened to include cost sharing for benchmarking and other technology acquisition activity.

Private sector technology centres and agencies, and industrial associations should become more active participants in industrial benchmarking.

Recommendation 2: DEVELOPING MANAGERIAL AND TECHNICAL COMPETENCE

Industrial managers should seek to upgrade their own skills and those of their employees through on-going training programs and through active cooperation with the education sector.

Industry and governments should encourage and foster universities, colleges and the performance of R&D in both the industry and academic sectors in order to increase the supply of technically qualified personnel.

Industry, government and labour must work together to create more effective mechanisms to promote technical awareness and to encourage firms to increase the levels of technical competence of Canadians through training and apprenticeship programs.

Small and medium sized firms should seek to employ engineers and other technically trained personnel to help them to make more effective use of advanced technologies.

Recommendation 3: TAX INCENTIVES FOR TECHNOLOGY ACQUISITION

Firms should plan strategically to enhance their production processes, products and services giving due consideration to both developing new technology in-house and acquiring best available technology from elsewhere.

The government should encourage firms to develop balanced technology development and technology acquisition strategies by establishing new tax incentives, accelerated depreciation and cost-shared funding mechanisms aimed at technology acquisition, which are as favourable as current incentives for in-house technology development.

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Recommendation 4: PROGRAM CONSOLIDATION AND PRIORIZATION

The government should, wherever possible, consolidate programs and services with similar or complementary mandates to allow more accessible and comprehensive service to be provided. This consolidated service network should be organized and oriented to provide fast and responsive service within the timeframe appropriate to the needs of the client-firm.

The government should enhance technology acquisition and diffusion by Canadian firms through the establishment of a <u>single</u> national technology extension service which promotes awareness of and access to existing public and private sector support mechanisms and centres of expertise.

This extension service should feature active, technically qualified advisory agents located in easily accessible offices in all regions of Canada. It should be built upon the proven, effective IRAP program, which should be strengthened and enhanced, rather than creating new parallel organizations, programs or support systems.

The government should carry out an intensive process of setting priorities among all of its technology-related incentives, programs and services based upon how well they are filling a marketdriven need and are contributing to the competitiveness of their clients. Stronger and more effective programs and services should be augmented at the expense of less effective ones.

The Trade Commissioner service of EAITC should be combined with the Science and Technology Counsellors and Technology Development Officers in Canadian Posts abroad, and all of these positions should be staffed with personnel having relevant business and technology experience and backgrounds.

A Board should be set up to recommend strategic directions to the managers of the consolidated program for technology acquisition and diffusion. This Board, which should have a majority of industrial representatives, would advise on the relative apportioning of funds to different forms of assistance to firms, in response to an annual analysis of market needs. The Board would also oversee the results of program evaluation.

Recommendation 5: A ROLE FOR THE BANKS

Banks, industrial associations, chambers of commerce and other private sector service organizations should participate in the national technology extension service through experimental programs designed to encourage private sector agencies to be more aware of technology and other business support programs and services and to promote their appropriate use by their clients.

Recommendation 6: PERIODIC, PUBLIC, PROGRAM EVALUATION

The government should carry out regular, hard-nosed evaluations of all industrial technology support programs and services in terms of their effectiveness in achieving measurable economic results, their performance in interaction with other programs and services, and the timeliness of their response to client need. These evaluations should be made at least every three years and their findings should be made public.

ANNEX 2

FEDERAL PROGRAMS CURRENTLY SUPPORTING TECHNOLOGY ACQUISITION AND DIFFUSION

Canadian federal and provincial governments offer a large number of incentives and programs to encourage the performance of research and development and the development of proprietary technology in private sector firms and the laboratories which serve them.

Many of these are targeted at helping firms to analyze their performance against future needs and to identify and tackle areas for improvement. Programs in this category include:

a) Manufacturing Assessment Service (MAS)
b) AMTAP (Advanced Manufacturing Technology Application Program)
c) Interfirm Comparisons Service
d) Sector Campaigns

Other programs promote self-help and learning from others' successes. These include:

a) Manufacturing Visits Program (MVP)

b) Workshops on Informatics for Senior Executives (WISE)

c) Canadian Awards for Business Excellence (CABE)

Firms are also helped to identify specific new opportunities, technologies and markets through such programs as:

a) dISTCovery

b) Technology Opportunities Showcases (TOS)

c) Market Intelligence Service (MIS)

d) Business Opportunities Sourcing System (BOSS)

e) Technology Outreach Program (TOP)

f) Technology Inflow Program (TIP)

g) Communications Applications Program

Other programs help firms to reduce the risk of research and experimental development through cost shared funding. These include:

a) Strategic Technologies Program (STP)

b) Defence Industries Productivity Program (DIPP)

c) Industrial Research Assistance Program (IRAP)

d) Atlantic Canada Opportunities Agency (ACOA)

e) Western Economic Diversification Fund (WED)

f) Defence Industrial Research Program (DIR)

g) Matching Funding of University Research (via NSERC)

h) Technologies for Solutions Program (Green Plan)

The federal government also maintains Business Service Centres, International Trade Centres and Industry, Science and Technology Canada's (ISTC) Regional offices to provide information access and service points for industrial clients.

The laboratories of Government departments and the NRC are also involved in several cooperative research projects with industrial firms, individually and through consortia. Several federal laboratories are active members, together with universities and firms, in National Networks of Centres of Excellence and other consortia and alliances.

The Department of External Affairs and International Trade (EAITC) offers the services of its network of Trade Commissioners and Technology Development Officers in Canadian posts abroad and the financial support of the Technology Inflow Program (TIP). This program, delivered through the collaboration of IRAP and ISTC offices, helps firms to identify foreign technology specific to their identified needs and supports company managers and/or engineers to travel to assess, confirm and negotiate access to foreign technology. Although EAITC did not fund this program in the current fiscal year, NRC used IRAP funds to keep the program alive until a more permanent arrangement could be made.

ANNEX 3

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ANNEX 4

COMMITTEE MEMBERS

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