TRIUMF BUSINESS DEVELOPMENT

PLAN 2001

Presented to the

Agency Committee on TRIUMF

31 March, 2001

"IN ITS PRESENT STATE, AND EVEN CONSIDERING THE IMPROVEMENTS POSSIBLE WHEN ADOPTING THE HIGHER TEMPERATURES PROPOSED FOR THE IMMEDIATE FUTURE, THE GAS TURBINE ENGINE COULD HARDLY BE CONSIDERED A FEASIBLE APPLICATION TO AIRPLANES MAINLY BECAUSE OF THE DIFFICULTY IN COMPLYING WITH THE STRINGENT WEIGHT REQUIREMENTS IMPOSED BY AERONAUTICS.

"THE PRESENT INTERNAL COMBUSTION ENGINE EQUIPMENT USED IN AIRPLANES WEIGHS ABOUT 1.1 POUNDS PER HORSEPOWER, AND TO APPROACH SUCH A FIGURE WITH A GAS TURBINE SEEMS BEYOND THE REALM OF POSSIBILITY WITH EXISTING MATERIALS."

THE COMMITTEE ON GAS TURBINES
appointed by
THE NATIONAL ACADEMY OF SCIENCES
June 10, 1940

Good Aug. I was too stupid to know this

Frank Whittle

Extract from John Golley's book, *Whittle: the true story*, published in 1987.

TRIUMF BUSINESS DEVELOPMENT PLAN

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BUSINESS DEVELOPMENT PLAN

"Heavier than air flying machines are impossible" (Lord Kelvin, 1885)

Executive Summary

The primary TRIUMF mandate was originally established as, and continues to be, the pursuit of excellence in fundamental research into sub-atomic physics. Since its inception, the annual TRIUMF operating budget has been funded almost entirely through contributions from the Canadian government, initially through the Atomic Energy Control Board, and since 1976 through the National Research Council of Canada, plus the Natural Sciences and Engineering Research Council.

In June 1995, the Federal government initiated a new approach to funding the continued operation of TRIUMF, with the announcement of a commitment of $166.59 million over five-years. The administration of this funding was designated as the responsibility of the National Research Council under the terms of a Contribution Agreement between NRC and TRIUMF, dated December 12, 1995. Section 10 of that 1995 Agreement identified the requirement for a Small Business Development Plan, and specified the contents of that Plan. These were, in summary, to target procedures for enhancing the impact of TRIUMF on the economies of Western Canada.

In recognition of the conditions of the Contribution Agreement, in May 1996 TRIUMF implemented a system that, where possible, gave reasonable preference to small Western Canadian suppliers, such that their products and technical abilities were appropriately showcased internationally through the CERN and ISAC projects at TRIUMF. The system also provided ready accountability for the TRIUMF applied and commercial transactions.

Following the expiry of this initial five year funding program, in March 2000, the Federal government initiated a new five year funding program for the continued operation of TRIUMF, with the announcement of a commitment of $200 million over five-years. Again, the administration of the funding was designated as the responsibility of the NRC under the terms of a new Contribution Agreement between NRC and TRIUMF, dated 19 July, 2000. However, Section 10 of this current Agreement changes the commercial focus from a Small Business Development Plan concentrating on Western Canada, to a Business Development Plan that applies throughout the country. The specified contents of this Plan target procedures for enhancing and measuring the impact of TRIUMF on the economy of all of Canada.

In assembling any set of indicators to measure performance, there are two primary questions that must be answered:

1. What are the objectives of recording the data?
2. Do the indicators meet those objectives?

It is clear that, for Canada, the objective of recording the values of indicators on the commercialization of technology that emanates from publicly funded research is to optimize the impact on the Canadian economy.

During the first Five-Year Plan, 1995 through 2000, TRIUMF worked within a financial envelope made up from $166.6 million of federal funds plus an additional $2.628 million which were added from TRIUMF's commercial revenue, making a total of $169.218million.

This envelope was applied in a "base budget" funding scenario. Capital items could only be taken from the envelope after laboratory operations have been covered. In the years 1995-2000 TRIUMF pursued a strong program of capital investment in the CERN LHC and ISAC. If the fixed costs, power costs, and salary bill are removed from the total amount, $44.5 million remained to be spent on running the laboratory's program and capital items. Over the five years the total capital dedicated to CERN and ISAC amounted to $32.7million, leaving only $11.8 million for operations. These figures reveal the extent to which the basic TRIUMF program was curtailed.

The sacrifices have not been in vain. TRIUMF has provided an excellent contribution to LHC and by the end of 2000, had built ISAC-I to an energy of 1.5 MeV/u with a 100 1A capability. In fact the total cost of the ISAC-I facilities is ~$49.5 million, which is made up of $18.7 million of materials, $9.77M of civil construction using provincial money, and ~$21 million of TRIUMF salaries.

This Business Development Plan will provide an approach to evaluating the economic impact of TRIUMF in Canada. The developed indices are measurements that concentrate on output effects from TRIUMF rather than the traditional approach of looking at inputs. The targets themselves should be viewed as evolving challenges, that have to be modified to reflect the ongoing changes in TRIUMF's operational plan. If additional target indices are required, then they should be added as appropriate, and similarly, indices and targets that may become irrelevant for one or more years should be skipped during that period.

During the five-year period of the Business Development Plan, the Technology Transfer Division will constantly undertake new initiatives in commercial interaction and development, to fulfill both the requirements and intent of Section 10 of the 2000 Contribution Agreement.

The targets that are set for TRIUMF must be both realistic and, at the same time, challenging for the facility. The local desire for research centers, such as TRIUMF and the universities to act as economic engines for growth can easily lead to unrealistic expectations.

The twenty-first century is being heralded as the start of the era during which knowledge based economies will be the leaders in an increasingly global marketplace. In this new age, TRIUMF will continue to emerge as a pivotal component in Canada's research mosaic, pushing the boundaries of recorded knowledge in their targeted areas of sub-atomic physics. At the same time, by clearly establishing itself as an international center for research into accelerated radio-active beams, TRIUMF will provide the Canadian link in the world-wide international network of sub-atomic research facilities. It is through research links and networks such as these that Canada will be able to maintain its role as one of the leading industrialized nations in the world.

With this in mind, and building on the experience of the preceding 'TRIUMF Small Business Development Plan - 1995 to 2000, the following targets have been established:

Figure 1: Targets Established by TRIUMF

Item	Description	2000/01	2001/02	2002/03	2003/04	2004/05
1.	Dollar Value of Sponsored Research for the Year	$10 million	$11 million	$12 million	$13 million	$14 million
2.	Number of Disclosures During the Year	15	16	17	18	19
3.	Number of Disclosures Reviewed During the Year	4	5	6	7	8
4.	Number of Disclosures Funded During the Year	2	3	4	5	6
5.	Value of Funding for Disclosures During the Year	$25,000	$30,000	$40,000	$50,000	$60,000
6.	Number of Patents Applied for During the Year	5	6	7	8	9
7.	Number of Patents Granted During the Year	2	3	4	5	6
8.	Value of Purchase Orders Placed by TRIUMF in Canada During the Year	$18 million	$20 million	$21 million	$22 million	$23 million
9.	Number of Start-up Companies During the Year	1	2	2	3	3
10.	Number of Spin-out Companies During the Year	1	2	2	3	3
11.	Number of Licences Granted During the Year	3	4	5	6	7
12.	Cumulative Number of Licences	8	9	10	11	12
13.	Royalty Income for the Year	$400,000	$500,000	$600,000	$700,000	$800,000
14.	Contract Income for the Year	$100,000	$200,000	$300,000	$400,000	$500,000
15.	Number of Students Employed by TRIUMF During the Year	40	45	50	55	60
16.	Value of the TRIUMF Sponsored Canadian Conferences During the Year	$1 million	$1.25 million	$1.5 million	$1.75 million	$2 million

"Scientists cannot predict the future any better than anyone else - even about their own field of research"
(Nobel Laureate John C. Kendrew, *The thread of life: an introduction to biology*, p.10, G. Bell, London, 1966)

1. Introduction

TRIUMF (the Tri University Meson Facility) is the result of a collaborative effort in the late 1960s, between the three universities in British Columbia, the University of Victoria, Simon Fraser University and the University of British Columbia. The concept for TRIUMF originated in the UBC Physics Department. It was intended to be a university-based, university-managed facility, primarily for fundamental scientific studies in meson and proton physics. The project received final approval in 1968, on the basis that the federal government, through the Atomic Energy Control Board, would fund the construction of the equipment, with the Province of British Columbia funding the construction of the buildings, and UBC contributing the site. The first maximum energy beam at TRIUMF was extracted in December 1974. By then, the University of Alberta had joined the consortium, with a contribution of some funding for building construction. The current TRIUMF facilities are utilized by Canadian universities from across the country, with Carleton University joining as a member, and the University of Manitoba, the University of Montreal, the University of Regina and the University of Toronto having joined as associate members.

In June 1995, the Federal government initiated a new approach to funding the continued operation of TRIUMF, with the announcement of a commitment of $166.59 million over five-years. The administration of this funding was designated as the responsibility of the National Research Council under the terms of a Contribution Agreement between NRC and TRIUMF, dated December 12, 1995. Another innovative aspect of the funding was Section 10 of that Agreement which identified the requirement for a Small Business Development Plan, and specified the contents of that Plan. These were, in summary, to target procedures for enhancing the impact of TRIUMF on the economies of Western Canada.

In recognition of the conditions of the new Contribution Agreement, in May 1996 TRIUMF implemented a system that, where possible, gave reasonable preference to small Western Canadian suppliers, such that their products and technical abilities were appropriately showcased internationally through the CERN and ISAC projects at TRIUMF. The system also provided ready accountability for the TRIUMF applied and commercial transactions.

Following the expiry of this initial five year funding program, in March 2000, the Federal government initiated a new five year funding program for the continued operation of TRIUMF, with the announcement of a commitment of $200 million over five-years. Again, the administration of the funding was designated as the responsibility of the NRC under the terms of a new Contribution Agreement between NRC and TRIUMF, dated 19 July, 2000. However, Section 10 of this current Agreement (shown following) changes the commercial focus from a Small Business Development Plan concentrating on Western Canada, to a Business Development Plan that applies throughout the country. The specified contents of this Plan target procedures for enhancing and measuring the impact of TRIUMF on the economy of all of Canada.

This Business Development Plan has been produced in response to Section 10 of this 2000 Contribution agreement. It will review the performance of TRIUMF under the previous Small

Business Development Plan for Western Canada, and introduce some enhanced approaches for the dissemination of procurement opportunities and technologies to potential suppliers and licensees throughout Canada. There are also a series of initiatives for formalising a system to optimize the interaction between TRIUMF and Canadian industry. The objective is to enhance the ability of Canadian companies to benefit from the technical competencies and skills that are resident in TRIUMF.

The strength of any facility such as TRIUMF is in its people. The salary bill at TRIUMF will average $25 million per year over the five year period, which is a modest sum for nearly 400 highly skilled technical employees in the current international labour market. Fixed overhead costs for the operation of the TRIUMF cyclotron and the regular running of the facility adds a further $6-8 million per year of non-discretionary spending. While much of this $165 million total is spent within Canada, it is expended on essentially routine material and human resource costs. After these fixed operating costs, only about $7 million per year, or $35 million of the $200 million five year funding, is available as discretionary spending.

CONTRIBUTION TOWARDS THE OPERATION OF TRIUMF

THIS AGREEMENT is BETWEEN

NATIONAL RESEARCH COUNCIL OF CANADA

whose address for the purposes of this agreement is:
1500 Montreal Road
Ottawa, Ontario
K1A 0R6
(called throughout **"NRC"**),

- AND -

THE UNIVERSITY OF ALBERTA, THE UNIVERSITY OF BRITISH COLUMBIA, CARLETON UNIVERSITY, SIMON FRASER UNIVERSITY, THE UNIVERSITY OF VICTORIA

whose address for the purposes of this agreement is:
4004 Wesbrook Mall
Vancouver, British Columbia
V6T 2A3
(called throughout the **"Universities"**),

Preamble

WHEREAS TRIUMF is an unincorporated association established under a Joint Venture Agreement by the University of Alberta, the University of British Columbia, Carleton University, Simon Fraser University, and the University of Victoria. It operates a research laboratory. Since it started in 1975, it has become Canada's largest research laboratory for sub-atomic physics, and a major research facility used by Canadian and foreign scientists;

WHEREAS The Universities, and other collaborating universities, entered into a consortium that operates the TRIUMF laboratory as a national facility for research in sub-atomic physics and related disciplines;

WHEREAS The Government of Canada wishes to contribute towards TRIUMF's operations for the five-year period from 1 April 2000 to 31 March 2005, to support on-going experimental programs; to support the operation and expansion of the ISAC accelerator facility; to assist the development and construction of components which would form Canada's contribution to CERN; to enable TRIUMF to provide general infrastructure support to the Canadian sub-atomic physics research community; and to maximize the economic benefits to Canadian companies from the federal investment;

WHEREAS The Government of Canada has made NRC responsible for funding and supervising the effective management of the government's investment in TRIUMF.

TRIUMF on those functions. Among other matters, the Advisory Committee will monitor TRIUMF's interactions with CERN, and the current needs and possible future directions of the national and international user community.

9.3 NRC, in consultation with the Advisory Committee, will make a thorough scientific and management review of TRIUMF's activities, to be completed before 31 March 2004, to guide government consideration of support for any future plans for TRIUMF.

9.4 NRC will also form an Agency Committee of senior officials from selected federal departments and agencies, for the purpose of assessing the Project. In particular, this committee will monitor financial, economic, and commercialization aspects of TRIUMF's activities. The Board of Management of TRIUMF will provide this committee with any requested information about the performance of the Project, or the management and expenditure of money provided under this agreement.

10.0 Traceable Economic Benefits

10.1 TRIUMF shall exercise its best efforts to ensure that over the five years of this agreement, direct and substantial industrial benefits accrue to Canadian companies by assisting Canadian companies in developing new competence in high technology, and in developing products to be demonstrated in international high-technology showcases, such as ISAC-II and CERN.

10.2 TRIUMF shall develop a Business Development Plan to be implemented over the life of this agreement, that will assist Canadian high technology firms and entrepreneurs to commercialize technology flowing from the Project and to sell the resulting products in the international scientific market. This Plan should outline measurable goals and targets for the commercialization of TRIUMF technology, and contain a procurement strategy and specific steps, such as the use of an 'open bidding system', designed to maximize benefits to Canadian firms. The Plan must be provided to NRC before 31 March 2001. TRIUMF must report regularly on its success in achieving the goals and targets of the Plan.

10.3 TRIUMF shall encourage Canadian suppliers to develop the necessary capabilities and talents to support the follow-on manufacture in Canada of any products arising from the Project.

10.4 TRIUMF shall make reasonable efforts to collect data on the industrial benefits traceable to this agreement, and shall calculate the Canadian and regional content of all its major expenditures funded by this agreement, in a manner that is auditable and verifiable. TRIUMF shall provide NRC annually with all necessary information to enable NRC to report that data to the Minister of Industry.

11.0 Indemnification

11.1 TRIUMF shall indemnify and save harmless the Crown and NRC, and their employees and agents, in respect of all claims, demands, losses, costs (including solicitor and client costs), damages, actions, suits or proceedings, that are in any manner based upon or arising out of acts of the Universities or TRIUMF, their employees, agents or sub-contractors, resulting from this agreement, whether by reason of negligence or otherwise, including:

"The wireless music box has no imaginable commercial value. Who would pay for a message to be sent to nobody in particular?"

(A response to David Sarnhoff's urging to his associates to invest in radio in the 1920s)

2. Measuring Business Development Performance

(a) Basic Concepts - Inputs versus Outputs

While natural resources and industrial production continued to play a major role in industrialized economies for much of the first part of the twentieth century, the past twenty years have seen a global shift to technology and technical knowledge as economic drivers. As a result, the importance of creating and maintaining a knowledge based economy for the twenty-first century has become a dominant issue for many countries. Governments have focused their attention on publicly funded research at universities and research institutions, which generally represents a significant portion of the gross expenditures on research and development within an economy. In Canada, the issue has been reflected in the number of studies and surveys on the economic impact of technology commercialization from research at Canadian universities and other research institutions.

The University of Calgary produced two studies related to the economic impact of technology commercialization (Chrisman, 1994; Unrau, 1995), while in 1997, the University of British Columbia published a study on spin-off companies from the University (Livingstone, 1997). Statistics Canada also entered the field in 1997, with a report it commissioned from the Impact Group (Statistics Canada 1997), followed by its own 'Survey of Intellectual Property Commercialization in the Higher Education Sector' in 1999 (Statistics Canada 1999). The largest single Canadian effort was probably the result of the Prime Minister's Advisory Council on Science and Technology commissioning the Expert Panel on the Commercialization of University Research [EPCUR]. This august body commissioned a number of supporting studies from recognized experts, before publishing its final report, entitled "Public Investments in Research: Reaping the Benefits" in 1999 (Expert Panel on the Commercialization of University Research, 1999).

Virtually every Canadian study and report on the impacts of commercializing technology from university and public institution research has recognized a similar set of critical factors, namely:

- how are the volume and value of research determined?
- how is intellectual property identified?
- what policies and procedures govern the protection of intellectual property?
- what policies and procedures govern the commercialization of intellectual property?
- how is the effectiveness of an institution's policies and procedures for commercializing its intellectual property determined?

The Statistics Canada's Impact Group report, (Statistics Canada 1997), proposed to quantify these critical factors by recommending that more than fifty indicators be measured, as reproduced in Table I, following.

Certainly these indicators provide an excellent foundation for evaluating the technology commercialization performance of a research institution. However, comprehensive data in itself are seldom sufficient. As Niels Reimers concluded in his report to the Expert Panel on the Commercialization of University Research, "Best North American Practices in Technology Transfer", (EPCUR, 1999), it is essential that performance be measured against the best practices that are reasonably achievable. In this regard, the data that have been gathered annually since 1991 by the Association of University Technology Managers (AUTM), provide something of a set of international benchmarks.

In assembling any set of indicators to measure performance, there are two primary questions that must be answered:

1. What are the objectives of recording the data?
2. Do the indicators meet those objectives?

It is clear that, for Canada, the objective of recording the values of indicators on the commercialization of technology that emanates from publicly funded research is to optimize the impact on the Canadian economy. However, the measurement of indicators can easily become an end in itself, particularly if the selected indicators measure inputs rather than outputs. For example, disclosures of innovations and patents can represent critical inputs into the commercialization potential of a body of research, but, in themselves, neither of these two indicators actually demonstrate outputs with the significant impact on the economy. As indicators for publicly funded research, they can result in numerous 'disclosures' and many expensive patents, which appear to suggest possible commercial potential, but which, in reality, have none. The key is to assemble a range of indicators that will effectively measure the flow of commercial concepts from both input to output.

TABLE I: Indicators recommended by the Impact Group (Statistics Canada, 1997)

Innovation Theme	Sample Indicator
Creating IP	
Nature and extent of university research*	Volume of research ($, # of projects, fields, etc.) Distribution among universities Type of research (grant, contribution, contract, etc.) Research quality (bibliometric data)
Training/re-training of HQP and managers*	Enrolment, graduation and employment data (FT/PT)
Identifying IP	
Identifying inventions	# of invention discoveries reported # of invention discoveries reviewed by university or agent # of invention discoveries declined for investment
Protecting and Managing IP	
Identifying & evaluating intellectual property	# of invention discoveries accepted for investment # of technology transfer personnel $ of technology transfer expenditures Field of discovery (cf. NSERC/MRC categories) Field of application (cf. SIC code)

Protecting intellectual property	# of discoveries with patent applications
	# of patent applications per discovery
	# of patents granted
	# of software copyrights registered
	$ invested to protect new IP
	$ invested to protect old IP

IP Exploitation by Institution	

Demonstrating/developing intellectual property	# of prototype, demonstration or scale-up projects
	$ investment in prototypes, demonstration or scale-up
	# of market studies
	$ investment in market studies

Exploiting intellectual property	# of university-owned commercialization companies
	$ spent to market inventions
	# of technologies licensed
	# of licenses/options awarded
	$ of royalty income
	$ from licensing fees
	$ from equity investments
	Type of company licensing IP (e.g. SME, Canadian, etc.)
	Country in which IP is being commercialized

IP Transfer by Faculty	

Transferring intellectual property	# of faculty engaged in consulting
	# of consulting projects completed
	$ of faculty consulting income
	$ of research contracted back to institution
	Impact of faculty consulting (sales, exports, jobs, etc.)
	Biological material exchanges

Support of Technology-based Companies	

Research parks and business incubators	Presence of a research park or business incubator
	$ spent on park or incubator activities
	# employees devoted to park or incubator activities
	# of tenant companies
	# of employees/employee growth at tenant companies
	$ sales/sales growth at tenant companies

Impacts of IP Commercialization	
New company formation	# of start-up companies created (from IP) # of university spin-off companies created (from IP) $ of outside investment leveraged into new companies New company growth (sales, employment, exports, etc.)

Returns from equity investments	# of companies with university equity investment
	Type of equity investment (IP, cash, etc.)
	Type of equity received (shares, warrants, debentures, etc.)
	$ returns from dividends
	$ returns from equity disposition

Job creation	# of jobs created through IP commercialization
Exports	$ of export revenues earned through IP commercialization

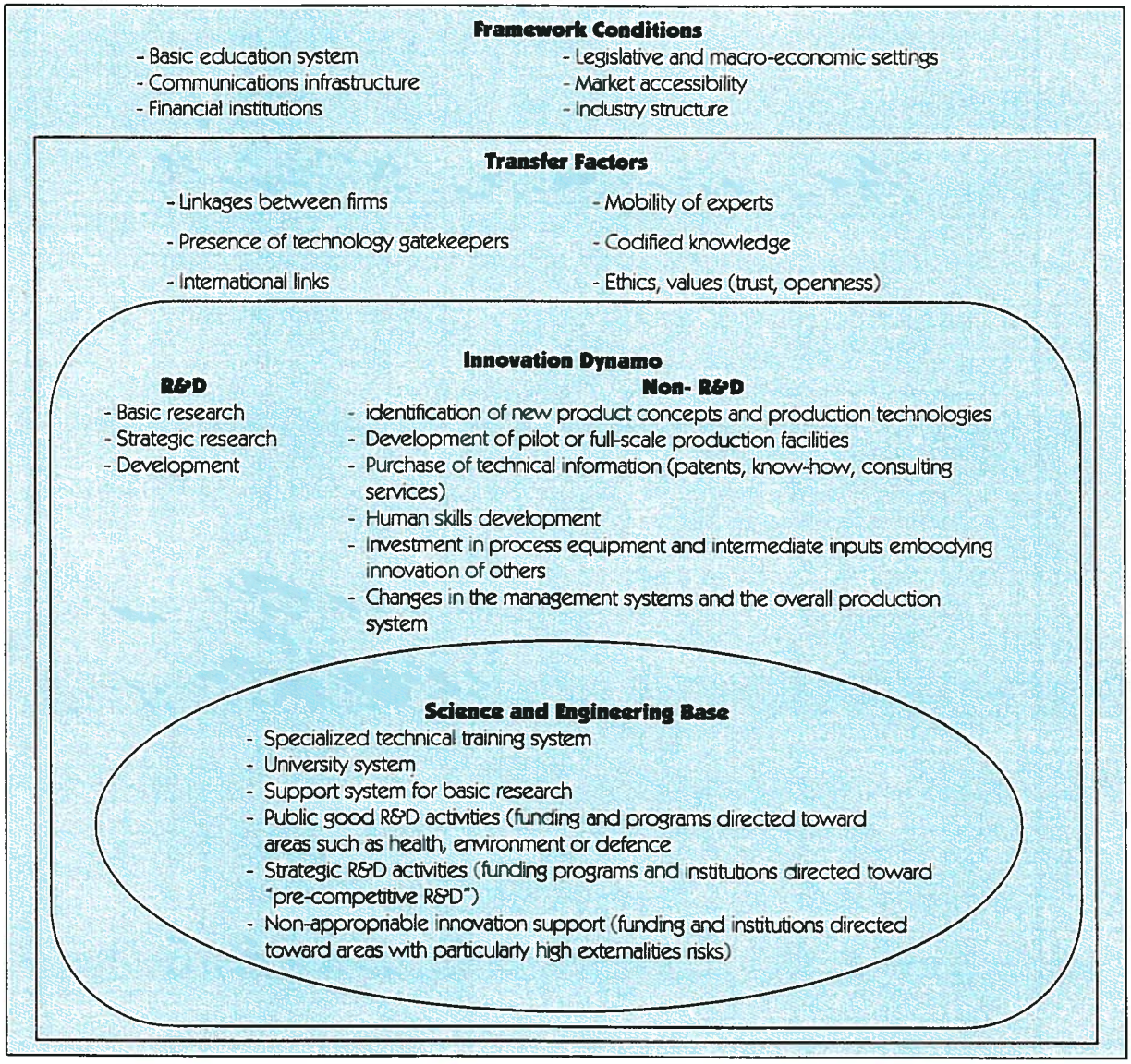
(b) Developing Realistic Targets

There have been numerous studies that have examined the potential economic impact of commercializing technology innovations that are developed through public funding at universities and research facilities. The Conference Board of Canada in its 1997 publication, *Performance and Potential*, outlined a national system for innovation which is reproduced in Chart I following.

What is evident from this Conference Board system is that it is an interactive whole, such that simply pumping up one discrete part is unlikely to significantly enhance the entire system. Every piece of the National system must be present and performing effectively for the whole system to produce the expected results.

In the May 04,1999 Report *Public Investments in University Research: Reaping the Benefits*, of the Expert Panel on the Commercialization of University Research, Annex 5 compared the economic benefits returned to Canada versus those to the United States based on licensing income. Their conclusions are shown as Table II.

CHART I: National Systems of Innovation



Source: Conference Board of Canada, *Performance and Potential 1997*

TABLE II: Public Investments in UniversityResearch - Reaping the Benefits

	Total * (Canada and U.S.)	Canada	U.S.
Section I: Canada's Share of Economic Benefits			
Proportion of Licensing Income	100.0%	1.6%	98.4%
Economic Benefit (US$ Billions)	$28.7	$0.5B (1.6% x $28.7B)	$28.2B (98.4% x $28.7B)
Jobs per Year	245 930	3935 (1.6% x 245 930)	241 995 (98.4% x 245 930)
Section II: What Canada's Share Should be Based on Our Relative Investment in Research			
Proportion of Total Sponsored Research	100%	6.8% **	93.2%
Economic Benefit (US$ Billions)	$28.7	$2.0 (6.8% x $28.7B)	$26.7 (93.2% x $28.7B)
Jobs per Year	245 930	16 723 (6.8% x 245 930)	229 207 (93.2% x 245 930)
Section III: Opportunity Loss (Section II - Section I)			
Economic Benefit (US$ Billions)		$1.5B	
Jobs per Year		12 788	

* *The calculations presented in the adjacent columns were prepared by the Expert Panel on the basis of AUTM data.*

** We increased by 50 percent the Canadian research expenditure figures reported to AUTM to account for indirect costs included in U.S. but not Canadian data.

Source: *AUTM 1997 Licensing Survey*

From these calculations, it may be inferred that Canada should enjoy economic benefits about four times the present level from the Canadian 'share of research investment'. The implicit assumption here is that the U.S. and Canadian national systems are essentially homogeneous. In terms of the Conference Board National system, it is assumed that Canada is an identical but smaller version of the U.S.

This assumption of homogeneity between the U.S. and Canadian national systems is not necessarily accurate. In his 1999 Report, entitled *Best North American Practices in Technology Transfer*, to the Expert Panel on the Commercialization of University Research, Niels Reimers devoted all of Chapter 10 to the barriers that are faced in Canada to commercialization. As well as the predictable 'culture, geography, research funding, and the Development Gap', he also identifies the 'Lack of Industry Receptors' as a Canadian barrier. Most Canadian Technology Transfer professionals are easily able to identify with this national characteristic, since, situated beside the massive U.S. industrial engine, Canadian industry tends to have a 'Branch Plant' mentality, relying extensively on its neighbour for leading innovations. This means that the Canadian System will likely never become a one tenth scale duplicate of the U.S. system. This has to be reflected in establishing realistic targets for technology commercialization from Canadian institutions.

In terms of the individual institution, there have been several theoretical models of innovation. The 1999 report of the Canadian Auditor General identified three such models in Exhibit 19.1, reproduced as Chart II.

The first model for innovation is seen to be linear, starting at Basic Research, and ending with Marketing. This model was popular some years ago, but has now been largely recognized as being overly simplistic. The reality is more closely represented by the Open System Model of Innovation that the Auditor General attributes to the Government of Quebec. Inventions and innovations seldom burst on the scene as a direct result of either basic or applied research, but usually require frequent interactions among all of the players, with many redesigns based on the numerous feedbacks from every participant along the way. It is quite common for a successful innovation to actually be a redesign of what was thought to be a failed technology. The classic example is the enormously successful 3M Sticky Notes that emerged from a failed glue development.

The result is that, to be realistic, targets for economic benefits from a technology transfer process in Canada have to be founded on the realities of the Canadian technology market place. It must be recognized that the optimum economic benefit to Canada may accrue from transferring the technology to an international receptor, preferably including conditions for, say, locating a new plant within the country. It must also be recognized that the interactive process can change the optimal direction of the innovation at any time. Further, the time frame for reaping the economic benefits of Canadian technological innovation can be quite lengthy, and are measured in years rather than months. This was identified in the 1999 paper *University research and the Commercialization of Intellectual Property in Canada*, by Wulong Gu and Lori Whewell for the Expert Panel on the Commercialization of University Research. Table 15 from that paper is based on 1998 work by Mansfield, and reproduced below. It shows the average time interval between the first commercial introduction of a new product/process and the relevant academic research finding.

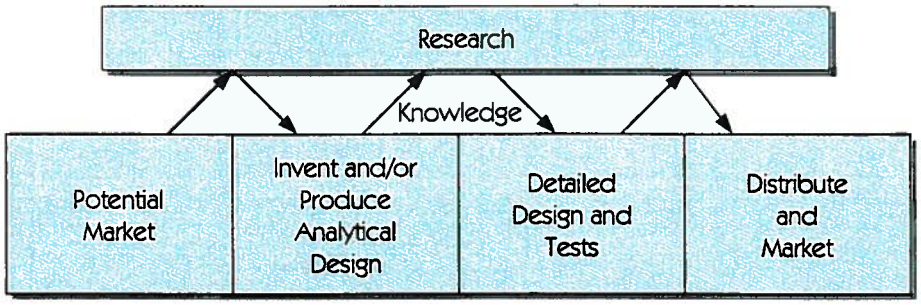
CHART II: Models of Innovation

In recent years, the traditional linear model of innovation has been superseded by new analytical frameworks.

The Linear Model of Innovation

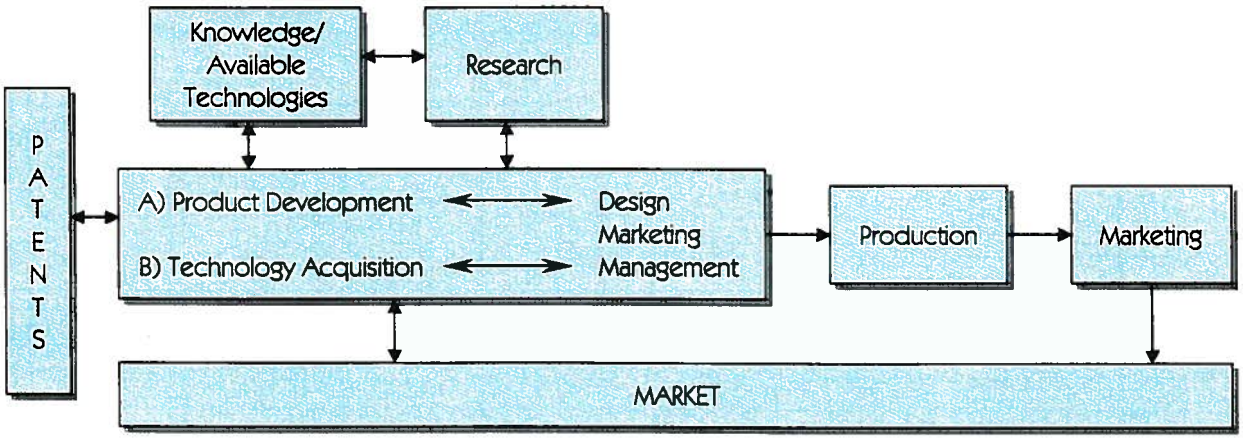
Source: Industry Canada, 1996-97 Performance Report

The Chain-Link Model of Innovation



Source: Kline S.J. and N. Rosenberg (1986), "An Overview of Innovation", in R. Landau and N. Rosenberg (eds). *The Positive Sum Strategy. Harnessing Technology for Economic Growth*, National Academic Press, Washington, DC, p. 289.

An Open System Model of Innovation



Source: Government of Quebec, *Conseil de la science et de la technologie*

Table 15: Average Time Interval Between the First Commercial Introduction of a New Product/Process and Relevant Academic Research Finding

Industry	Innovations that could not have been developed without substantial delay in the absence of recent academic research		Innovations that were developed with very substantial aid from recent academic research	
	1986-1994	1975-1985	1986-1994	1975-1985
	Mean number of years			
Drugs and medical products	8.5	8.8	6.2	10.3
Information processing	5.2	7.0	2.4	6.2
Chemical	5.4	6.8	4.8	7.3
Electrical	5.9	5.3	5.0	4.9
Instruments and metals	6.5	7.0	6.6	4.9
Machinery	5.6	n.a.	5.8	n.a.
Industry Mean	6.2	7.0	5.1	6.7

Source: Mansfield (1998)

(c) International Experience

With the advent of knowledge based economies, there has been an almost uniform concern in both developing and developed countries around the world that their economy is not benefitting adequately from the public investment in research and development funding at their universities and other public research institutions. In the United Kingdom, and most notably recently in Scotland, the universities have been subjected to a significant amount of criticism in this regard. This is somewhat surprising given the strong heritage that Scotland has for inventors, inventions and innovations. For a small, sparsely populated country, Scotland has an enviable record of successful inventions that have become standard products around the world.

To provide a first level analysis of the reality behind this perception, Bob Smailes of the University of Edinburgh's technology transfer office, called 'Edinburgh Research and Innovation', produced a short paper in June 2000, entitled *Exploitation Efficiency: US vs Scottish Universities*. It is reasonable to consider the University of Edinburgh' review of this issue since the University accounts for 24% of all Scottish Higher Education R and D, and, in total, nearly 10% of the entire Scottish R and D effort. Only the partnership of the Universities of Glasgow and Strathclyde have a larger combined research funding portfolio.

The approach taken by Smailes utilized the Association of Technology Managers (AUTM) survey data for the top 11 US institutions, plus for all 132 US institutions, for the years 1994-1998, and compared certain benchmarks indices with similar data collected from the Scottish Universities (Edinburgh, Glasgow, Strathclyde, Dundee, Heriot-Watt, Stirling and Aberdeen), although not all of them were able to supply a complete data set. The selected indices were the average values per annum as well as the average of those values over the five year period for the following categories:

- volume of sponsored research US$ millions
- number of disclosures
- number of patents filed
- number of licences granted
- royalty income
- number of spin-outs

Smailes identified the 'exploitation efficiency' by dividing each off the exploitation indices, listed above, into the average sponsored research income for each set of universities. His results are reproduced in Tables 3, 4, and 5 following

Smailes' review is not intended to be a rigorous academic evaluation, but rather a starting point for comparing international exploitation efficiencies. This is reflected, for example in the fact that he was required to use two quite distinct sources of data, with the obvious limitations on their inferred comparability. Nevertheless, from the results he is able to make three points that provide a basis for consideration.

1. The dollar volume of sponsored research at any one of the major US universities is greater than all of the sponsored research in Scotland.

2. The Scottish universities appear to enjoy an exploitation efficiencies equal to or better than those experienced by the US universities. Notably, the dollar volume of research that both the top 11 US universities, and the full 132 US universities required to produce one 'spin-out' company was $89 million, compared to only $24 million for the Scottish universities, a position endorsed by Cathy Garner of Glasgow University in a presentation to the AUTM Conference in New Orleans, March 02, 2001.

3. Even the major US universities, such as MIT, produce only a relative few spin-out companies. This conflicts with the conventional wisdom that such US institutions create a large number of companies. This, Smailes contends, is because these latter companies are predominantly 'start-ups' by University alumni, not 'spin-out' companies requiring access to University patents or technology.

TABLE III: Exploitation Efficiency Report
1. US Universities

Annual Research Funding ($M) Required For:	1998 Average Top 11	1998 Average All 132	1997 Average Top 11	1997 Average All 132	1996 Average Top 11	1996 Average All 132	1995 Average Top 11	1995 Average All 132	1994 Average Top 11	1994 Average All 132	1994-1998 Average Top 11	1994-1998 Average All 132
1 Disclosure	2.5	2.2	2.3	2.2	2.5	2.3	2.8	2.3	2.7	2.4	***2.6***	***2.3***
1 Patent	3.1	3.3	3.6	3.6	5.0	4.8	2.9	3.4	4.2	4.6	***3.8***	***3.9***
$1M pa in Royalties	34.0	37.1	31.5	41.1	40.0	51.2	42.0	57.5	43.4	60.4	***38.2***	***49.5***
1 License	7.5	6.9	8.6	7.3	8.7	8.5	9.0	8.0	8.0	7.8	***8.4***	***7.7***
1 Spin-out Company	74.5	76.7	68.1	77.0	98.8	101.6	114.8	101.8	90.9	91.8	***89.4***	***89.8***

Note: US Data from AUTM Surveys for FY1994 to FY1998

TABLE IV: Exploitation Efficiency Report
2. Sample of Scottish Universities (Aberdeen, Dundee, Edinburgh, Glasgow, Heriot-Watt, Stirling, Strathclyde)

Annual Research Funding ($M) Required For:	*1998 Average*	*1997 Average*	*1996 Average*	*1995 Average*	*1994 Average*	*Average*
1 Disclosure	1.6	1.2	1.7	2.5	2.6	***1.9***
1 Patent	5.0	3.8	3.2	5.4	6.2	***4.7***
$1M pa in Royalties	86.4	91.7	218.0	268.5	167.3	***166.4***
1 License	8.0	4.4	4.4	11.1	4.5	***6.5***
1 Spin-out Company	17.6	17.6	38.7	28.3	19.6	***24.3***

TABLE V: Exploitation Efficiency Report
3. University of Edinburgh

Annual Research Funding ($M) Required For:	*1998*	*1997*	*1996*	*1995*	*1994*	*Average*
1 Disclosure	3.3	1.9	3	5.5	6.6	***4.1***
1 Patent	8.2	5.2	2.5	2.4	N/A	***4.6***
$1M pa in Royalties	28.6	24.2	23.8	24.1	N/A	***25.2***
1 License	17.8	6.6	9.0	10.3	0.0	***10.0***
1 Spin-out Company	26.7	30.9	89.6	82.4	39.4	***53.8***

(d) The Case of TRIUMF

The primary TRIUMF mandate was originally established as, and continues to be, the pursuit of excellence in fundamental research into sub-atomic physics. Since its inception, the annual TRIUMF operating budget has been funded almost entirely through contributions from the Canadian government, initially through the Atomic Energy Control Board, and since 1976 through the National Research Council of Canada.

The TRIUMF research facility is based around the 18 metre diameter cyclotron, which accelerates H- ions up to 520 MeV, and is one of three medium energy (0.5 to 0.8 GeV), high current accelerator facilities built in the early 1970s for meson physics experiments. The other two are in Switzerland, at the Paul Scherrer Institute (PSI), and in the United States at the Los Alamos National Laboratory (LAMPF). The TRIUMF cyclotron is third in terms of current, but leads the other two with its multiple beams for independent users, plus such characteristics as its duty factor and variable proton beam energy. The TRIUMF beam intensity specification of 100 μA was not achieved routinely until 1979, although, since then, the facility has run reliably at beam current levels approximately 50% above design specification.

In addition to the main cyclotron described above, there are two other cyclotrons used for research at TRIUMF, - a small 1 MeV test facility, and a 13 MeV cyclotron that is used primarily to supply isotopes for applied medical research. There are also two small commercial cyclotrons which are owned by MDS Nordion Inc., and located on the TRIUMF site. These latter two machines are operated by a small group of TRIUMF staff, on a contract basis for MDS Nordion. MDS Nordion is a Canadian company that produces isotopes under licence from TRIUMF and markets them world wide for medical applications.

The current total TRIUMF staff complement of over 300 persons is comprised of experimental physicists, together with a small group of theoreticians, plus scientists from associated disciplines, supported by technicians, engineers, facilities operators and an administrative group. In addition, there are 6 Research Associates (RAs) and 25 students employed by TRIUMF on various fixed term bases, ranging from four months for students to two years for RAs.

Grants and other external funding provides employment for up to a further eighty persons at TRIUMF for the period of tenure of that particular funding. A breakdown of the TRIUMF staffing as of March 31, 2001 is provided in Table IV, together with a breakdown by Funding Source and Employee Category in Table V, both following.

Table IV **STAFF SUMMARY AS AT: MARCH 31, 2001**

	Director	Admin	Accelerator	Cyclotron	ISAC	Science	Tech Transfer	Total
TRIUMF (NRC)	2	28	81	106	16	107	0	340
TRIUMF (NSERC)	0	0	0	0	0	55	0	55
TRIUMF (Nordion)	0	0	0	0	0	0	21	21
TRIUMF House	0	9	0	0	0	0	0	9
TRIUMF (PET)	0	0	0	0	0	4	0	4
TRIUMF Other Grants	0	0	0	0	0	2	0	2
CUPE 2950	0	10	1	0	0	1	0	12
UBC	0	0	1*(MC)*	0	0	1*(RK)*	0	2
SFU	0	1	0	0	0	1*(PP)*	0	2
UVIC	0	1	0	0	0	0	0	1
U of A	0	0	0	0	0	2*(DG,FTO*	0	2
U of Manitoba	0	0	0	0	0	0	0	0
U of Regina	0	0	0	0	0	0	0	0
Carelton U	0	0	0	0	0	5	0	5
Visiting Sci.	0	0	0	0	0	4	0	4
LTD	0	1	2	0	0	1	0	4
Sal. Contin.	0	0	0	1	0	0	0	1
TOTALS	**2**	**50**	**85**	**107**	**16**	**183**	**21**	**464**
Uni. Faculty	*0*	*0*	*0*	*0*	*0*	*10*	*0*	*10*

TABLE V **FTE's by Funding Source and Employee Category**

Funding Source	BAE	P&S	Technician	CUE	RA	Student	Visitors	Totals
NRC	61.0	89.0	179.0	11.0	6.0	25.0	5.0	376.0
NSERC	0.0	4.0	5.0	0.0	26.0	9.0	1.0	45.0
Affiliated Institutions	0.0	0.0	0.0	0.0	6.0	0.0	0.0	6.0
MDS Nordion	0.0	6.0	13.0	0.0	0.0	0.0	0.0	19.0
Rebillable	0.0	1.0	8.0	0.0	0.0	0.0	0.0	9.0
Commercial Revenue	0.0	2.0	0.0	0.0	0.0	0.0	0.0	2.0
Totals	61.0	102.0	205.0	11.0	38.0	34.0	6.0	457.0

NRC: The permanently committed TRIUMF staff members are either Board Appointed Employees (BAE) Professional and Supervisory staff (P&S), technicians, or CUE secretarial and clerical staff. In addition, as shown above, there are 6 RAs on fixed NRC contracts, and 25 students, neither of which are part of the permanent FTE base.

NSERC: The NSERC-funded positions are appointed by the NSERC grantees to support their research programs, and depend on the continuation of NSERC funding.

Affiliated Institutions: These 6 positions are appointed by the holders of the funds at the affiliated institutions, and are dependent on the continued funding from these sources.

MDS NORDION: MDS Nordion International Inc. pays TRIUMF in full for these 21 positions that are administered through TRIUMF.

Rebillable: TRIUMF House - the TRIUMF users' residence - is totally self-financing through charges to all TRIUMF funding sources, and other external sources. Since this is administered through Intramural Accounts, the 9 FTE's for TRIUMF House, together with other similarly treated categories, appear under this classification.

Commercial Revenue: The commercial revenue fund presently supports 2 positions for the ongoing development of technology transfer.

For fiscal 2000/2001 the funds that were administered by, and through the facility totalled about $41 million Canadian. This is comprised of the aggregate of the core funding that supports operations, improvements and development, expansion of facilities, plus the NSERC, MRC and foreign funding agency funding which provides general support for experiments.

The 2000 new five-year funding plan requires TRIUMF to use part of the total funding (about $33.2 million over five years) to construct the scientific facilities for the new ISAC II facility, and to make a contribution on behalf of Canada to the Large Hadron Collider, being built at CERN, near Geneva.

Funding for the construction of new permanent buildings has been provided by the Government of British Columbia and, as such, is not included in this total. TRIUMF also administers other sources of money that are used to conduct research using the TRIUMF cyclotron for activities associated with life sciences, technology transfer and Nordion International Inc. operations at the TRIUMF site.

These sources and estimates for the 1999/2000 financial year are listed below in Figure 2.

Figure 2: Monies Administered by TRIUMF, 1999/2000

NRC Funds	$34,318,000
NSERC Funding	$7,662,451
Affiliated Institutions	$2,219,207
MDS Nordion Inc.	$2,165,597
Commercial Revenue	$ 710,283
General	$ 317,043
Total	**$47,392,581**

NSERC ($7.66 million): NSERC grants applied for, through TRIUMF, by TRIUMF personnel and researchers from TRIUMF member universities. These funds are used for performing research at both TRIUMF and external laboratories. They cover the cost of mounting the experiments, including the costs of salaries for support staff, technicians, research associates and students who are not TRIUMF employees.

Affiliated Institutions ($2.22 million): These come from a variety of domestic and foreign sources, including NSERC, MRC, DOE, NSF, and NATO. They are not directly administered by TRIUMF, and are used by the recipients to cover the costs of performing research at TRIUMF in a variety of fields.

MDS NORDION ($2.17 million): MDS Nordion utilises a group of TRIUMF staff on a contract basis to operate their CP42 and TR30 cyclotrons. Of the $1.65 million, Hydro costs and supplies account for about $0.65 million, with the remaining $1 million paying for the contract employees.

Commercial Revenue ($0.7 million): TRIUMF derives royalty revenue from licences resulting from technology transfer initiatives. These revenues are dedicated to technology development and the transfer of specialised technical knowledge to industry.

Unallocated ($0.317 million): Investment income from cash balances maintained in the accounts for affiliated institutions, MDS Nordion and royalties.

Experimentation at the TRIUMF facility is open to all international researchers, with experimental time at individual research stations being allocated on a competitive basis by independent external evaluation of experiment proposals. International participation is a key component of the research at TRIUMF, with visiting researchers including representatives from over twenty-five countries. As with any fundamental research institution, TRIUMF is measured by the quality of the research, and the quantity and quality of papers and citations that emanate from that work.

TRIUMF also has an educational function, providing many graduate and post-graduate students with research training that is unique in Canada. Without TRIUMF, the many Canadian students requiring this type of experience would have to try to gain access to a facility in another country.

TRIUMF also introduces numerous groups of Canadian secondary school students to advanced research through brief tours of this unique Canadian facility. Like most Canadian research institutions, TRIUMF accepts co-op and summer students from every level of post secondary training, plus special groups of secondary school students, such as the annual Shad Valley participants from across Canada.

As is apparent from this brief review that much of the expenditure of TRIUMF, and many of its activities are driven by external requirements. In setting Business Development targets for TRIUMF several points must remain paramount:

1. TRIUMF's primary mandate is to conduct fundamental research for Canada in the areas of sub-atomic and nuclear physics.

2. By global and North American university and research institution levels, TRIUMF's sponsored research budget is extremely modest, and it would be completely unrealistic to expect numerous spin-off or spin-out companies, or high numbers of inventions and patents with resultant high royalties.

3. TRIUMF is a research institution which may have a significant economic impact in Canada. But it is not by nature an economic engine and cannot sacrifice the pursuit of excellent science for short term economic effects.

Selecting targets for the measurement of TRIUMF's Business Development performance must recognize these factors, and, to be meaningful, provide targets and data that measure the actual

performance, - that is measure outputs rather than inputs. Also, the targets must be comparable to other institutions and realistic. Both of these can be achieved by relating them to the size of TRIUMF in terms of personnel and dollar value of sponsored research conducted at the organisation. Finally, the number of targets must be kept to a manageable level.

There are a number of similarities between the indices developed by AUTM, the University of Edinburgh and the Impact Group for the 1997 Statistics Canada report. These are identified in Table VI, following.

TABLE VI - Comparison of Institutional Performance Indices

	Impact Group	Edinburgh	AUTM
Sponsored Research	x	x	x
Employment	x		
# of Disclosures	x	x	x
# of Disclosures Reviewed	x		
# of Disclosures Funded	x		
Fields of Discoveries	x		x
# of TT Personnel	x		x
TT Expenditures	x		x
# of Patents Applied	x	x	x
Cumulative # of Patents	x		
# of Patents Granted	x		x
# of Market Studies	x		
# of Start-ups	x	x	x
# of Spin-outs	x	x	
# of Licences	x	x	x
Cumulative # of Licences	x		x
Royalty Income	x	x	x
Value of Equity	x		
Contract Income	x	x	x
Value of Levered Funds	x		
# External Jobs from TRIUMF IP	x	x	
Legal Fees Expended			x
Legal Fees Reimbursed			x

The preceding approaches of the Impact Group, AUTM and the University of Edinburgh, will be adopted by TRIUMF to identify a number of key topic areas that should be monitored, from which a series of indices can then be identified and targeted.

(e) Economic Impact

As a relatively large institution with close to 400 employees and an annual budget of $40 million per year, TRIUMF will have an impact on the British Columbian and Canadian economies. Salaries tend to be expended in B.C. although there are small components that are paid to a few staff at universities in other provinces. The significant power expenditures of TRIUMF are to B.C. Hydro, which is the locally based electrical utility. Materials and services are assigned on the basis of performance, reliability and availability, and are generally sourced from Canada, pragmatically because this allows TRIUMF easier access for monitoring and providing assistance to suppliers.

All purchasing is conducted through the TRIUMF purchasing department, which is responsible for the multi-million dollar annual procurement program for everything from insurance to superconducting magnets. Without jeopardizing the quality or function of its purchases, there is a procurement policy that requires all purchases to be made on an open competitive basis, with a preference for Canadian companies, but only if price and quality are comparable. These expenditures are assigned on the basis of a minimum of three competitive bids received in response to requests for tenders. Since some of the purchases are of specialised scientific equipment, with few suppliers in Canada, on occasion, directed requests for quotes is the most efficient approach. If there is only one supplier in Canada of a particular product or service, the TRIUMF buyers can single source that purchase, provided they have written justification from the TRIUMF purchaser. All purchases at TRIUMF above specified spending limits must be countersigned by the responsible Division Head.

TRIUMF purchasing is targeted predominantly at Canada, with a natural focus on British Columbia, given the location of TRIUMF. However, the size and level of technical skill available in the Ontario and Quebec economies has resulted in those provinces also playing a significant role in supplying commercial products for TRIUMF.

During the five year period since the June, 1995 decision committing a future five year funding envelope for TRIUMF, the federal contribution to TRIUMF averaged $33 million per annum. This level of funding was considered necessary to maintain the laboratory in a stable state in preparation for any new initiative. During that time, the basic salary costs approximated $22.5 million per annum with the remainder predominantly going toward the fixed operating costs of the facility, such as power, insurance, legal, site maintenance and the cost of running the cyclotron etc. These annualized cost of running TRIUMF are detailed in the following Table VII.

TABLE VII. A Breakdown of TRIUMF's Recent Five Year Operating Budget (NRC Contribution Only) (In Thousands of Dollars)

	1995/96	1996/97	1997/98	1998/99	1999/00
Revenues					
NRC Contribution	$33,318	$31,000	$32,954	$35,000	$34,318
Expenditures					
Salaries (Net of recoveries)	$23,606	$20,024	$20,421	$21,184	$21,361
Power	$ 2,008	$ 1,752	$ 1,345	$ 1,539	$ 1,808
Services (legal, audit, insurance etc.)	$ 1,135	$ 1,053	$ 959	$ 905	$ 1.088
Purchasing	$6,569	$8,171	$10,229	$11,372	$10,061
Total	**$33,318**	**$31,000**	**$32,954**	**$35,000**	**$34,318**

The direct economic impact on the Canadian economy is a function of a number of individual aspects:

a) Expenditures on TRIUMF salaries;

b) Expenditures on goods and services purchased by TRIUMF;

c) Expenditures in the economy from third party sources such as visitors to TRIUMF;

d) Expenditures in the economy from third party sources for activities and events that occur because of TRIUMF being in Canada (e.g. conferences);

e) Revenues to Canadian companies that result from inventions, ideas and innovations that were conceived or developed at TRIUMF;

f) Additional revenues to Canadian companies that result from inventions, ideas and innovations that were conceived at TRIUMF and enhance the product, efficiency or competitive advantage of the company;

While the first three of these items are generally fairly readily identifiable and quantifiable, the last

three can be more subjective

Any expenditure in the Canadian economy will also result in a multiplier effect, as part of the expenditure is re-spent by the initial recipient, in an ongoing albeit declining manner. It is always difficult to assign a multiplier to single institution expenditures, but it is generally accepted that a factor of 2.5 is conservatively representative for an advanced technology facility such as TRIUMF.

"Anyone who expects a source of power from the transformation of [the nuclei] of atoms is talking moonshine."
(Lord Rutherford, 1933)

3. TRIUMF's Mandate and Philosophy for Optimizing Economic Impact

TRIUMF will maintain the philosophy that was followed in the first Small Business Development Plan, which resulted in the optimization of the impact of its operations on the Canadian economy. It encompassed numerous approaches that proved to be successful, and can be summarised as follows:

a) TRIUMF will make all reasonable efforts to commercialise technical knowledge that is resident in the institution, which may include the use of the Canadian Technologies Network, to the extent that such efforts do not adversely impact the resources of TRIUMF, which are committed to the pursuit of fundamental physics research.

b) TRIUMF will encourage and actively participate in efforts to diffuse any viable scientific or technological knowledge out into the Canadian economy through whichever is considered to be the most prudent and appropriate vehicle(s), among the following approaches;

- *i) direct sale to industry*
- *ii) licence to industry*
- *iii) gift or donation to appropriate organisations*
- *iv) training of industrial collaborators*
- *v) contract development work for industry*
- *vi) employee secondments from TRIUMF*
- *vii) employee secondments to TRIUMF*
- *viii) start-up companies by TRIUMF staff*
- *ix) student training and employment*
- *x) joint ventures with industry, or other organisations*

c) In all efforts to transfer technology to the economy, TRIUMF will negotiate agreements with the commercial party to provide TRIUMF with financial or other returns that adequately compensate the institution for the value of the knowledge transferred, and the cost of the resources that are dedicated to the transfer of that knowledge.

d) Except where single sourcing is identified and approved as the only viable option, all purchase orders and service contracts placed by TRIUMF in the pursuance of its day to day operations will be on a competitive basis. TRIUMF will initiate a policy of allowing equal access to all appropriate Canadian companies, and trying to obtain bids from at least three qualified Canadian companies to compete with any offshore suppliers.

e) When appropriate for tenders of $25,000 or more, TRIUMF will utilize an open bidding system through a suitable electronic bulletin board.

f) In international competitions, TRIUMF will give preference to Canadian suppliers that can provide the required quality of product or service, at a competitive cost, and under competitive conditions.

g) Evaluations of companies will include the assumption that limited specialised assistance may be provided to Canadian companies to enhance their capability to meet contract specifications.

h) From time to time, TRIUMF may be working with a Canadian company in the international arena, for example on CERN related contracts. On such occasions TRIUMF will endeavour to appropriately recognize and publicize the Canadian industry participation.

I) With international agreements, such as the CERN project, TRIUMF will encourage the qualification of Canadian suppliers, where appropriate under the terms of the agreement in question.

j) TRIUMF will provide an appropriate broad range of annual targets for its activities with businesses within the Canadian economy.

k) The economic impact of the activities of TRIUMF on the Canadian economic community will be recorded, with the results in a format that can be evaluated, and where reasonable, audited. These records will include, and may be limited to, specific case histories where that is the most appropriate and efficient approach.

l) TRIUMF will provide appropriate, regular publicity of all major initiatives that impact the Canadian economy.

m) Within the constraints of the available funding, TRIUMF will operate an appropriate range of education and employment programs for Canadian students, at levels from secondary school through post graduate. The objective of these student programs will be to expose students to the latest scientific developments, and to encourage capable young Canadians to consider future careers in science and technology.

"I think there is a world market for maybe five computers."
(Thomas Watson, Chairman of IBM, 1943)

4. TRIUMF's Business Development Performance - Looking Back

(a) The 1995 Contribution Agreement

In June 1995, the Federal Government announced a commitment of $166.59 million dollars over five years for the continued operation of TRIUMF, with the administration of the funding being designated to be the responsibility of the National Research Council (NRC). The TRIUMF Small Business Development Plan (SBDP) was created in 1996, in response to Section 10 of the five year Contribution Agreement between NRC and TRIUMF. It outlines a series of procedures for enhancing the impact of TRIUMF on the economies of Western Canada. Challenging targets were established for each year, up to and including the fiscal year of 1999/00, for a series of parameters that were designed to measure the economic impact of TRIUMF on Canada and the four Western Provinces.

In a series of annual reports reviewing the performance of TRIUMF during the previous year in relation to the objectives outlined in the original SBDP, TRIUMF was pleased to be able to report four successful years in meeting the very demanding SBDP targets. This success represented a true reflection of the dedication of the entire TRIUMF management and staff to the spirit and objectives of the whole SBDP concept. As was recognized in the January 2000 Agency Committee report on TRIUMF, the laboratory, relative to its size, has achieved success in its commercial activities and economic impact that is unsurpassed in Canada.

In evaluating the SBDP targets, it is of paramount importance to remember that TRIUMF is primarily a facility for fundamental research into sub-atomic physics. Unlike commercial, or even development enterprises, TRIUMF does not produce "research products" at a constant rate, or with a constant rate of growth. If a target is either under- or over- achieved in one year, it should not be assumed that this will have any implication regarding the possibility of under- or over- achievement the following year. The targets themselves should be viewed as evolving challenges, that have to be modified to reflect changes in TRIUMF's operational plan.

Throughout the period of the 1996 Five Year Small Business Development Plan, the Technology Transfer Division was constantly undertaking new initiatives in commercial interaction and development, and with the numerous successful activities over the years, was able to fulfill both the requirements and intent of the Plan.

The achievements of TRIUMF in meeting the economic impact objectives of the SBDP are captured by the following statement from the 1998 Report of TRIUMF Peer Review Committee:

"In a very real sense, the outstanding science produced at TRIUMF, not to mention the longer-term and more indirect economic impacts nor the medical spin-offs, are produced at no net cost to the public."

(b) Setting The Targets

Based on the philosophical approach outlined in Section 3, above, and guided by the requirements of the Canadian Government through Western Economic Diversification, TRIUMF established the following proposals for TRIUMF's performance targets in the 1996 Small Business Development Plan for the Five Years 1995 through 2000:

1. Company Contacts:
TRIUMF will institute an ongoing review of the current system and with the assistance of WED and its data base, plan to access even more Western Canadian companies.

2. Value of Orders Placed:
TRIUMF will endeavour to extend and increase the Western Canadian value and proportion of its purchasing.

3. Canadian Industry Supplier Shows and Seminars
WED proposed that it will organise and host industry awareness supplier shows and technical supplier information seminars. TRIUMF will provide the technical expertise for these Canadian industry supplier shows and seminars these shows which are planned initially to be two in each of the Western provinces over the first two years.

4. Scientific Conferences
TRIUMF staff are frequently on scientific conference committees and will endeavour to increase the number of such conferences in Western Canada. Most major conferences select future locations several years in advance, so the ability of TRIUMF to influence such decisions will be limited.

5. CERN Corporate Pre-Approvals and Orders
Although obviously lacking direct authority over CERN, TRIUMF will be required to facilitate pre-qualification tours for the Canadian contribution to CERN, and will endeavour to optimise the number and exposure of Western Canadian companies involved in the LHC project.

6. Number of Component Manufacture Contracts
TRIUMF will work closely with a number of Western Canadian companies in the manufacture of experimental research components, to enhance the skill sets of the private companies, and increase the number and value of Western Canadian contracts.

7. Number of Commercial Disclosures
TRIUMF will initiate a strong proactive approach to maximize the annual number of commercial disclosures.

8. Funding Disclosure Development
TRIUMF has an established system of evaluating commercial disclosures and funding development, and will encourage disclosures with commercial potential, while subjecting them to informed evaluation by industry and academic experts prior to making any major investments in patenting or other commercial processes.

9. TRIUMF Technology Workshops

WED proposed that they would organise one technology workshop at TRIUMF each year. The objective of these workshops was to bring together appropriate Western Canadian business people and financiers with TRIUMF researchers and their technology opportunities. TRIUMF provided the research and technology discussions, and examples of technology currently available for commercialisation.

10 Student Training

TRIUMF has a tradition of employing summer students, and will continue and enhance its student training, provided adequate funding can be found.

11. Performance Publicity

TRIUMF will print a brief quarterly bulletin on commercialization and Technology Transfer at TRIUMF, showcasing Successful Western Canadian companies, for general distribution across Canada

12. Recording of Statistics

TRIUMF will introduce a new system of recording the data and statistics relating to its overall expenditures in Western Canada specifically, and Canada generally.

(c) The Five Year Record

The following Table VIII summarizes TRIUMF 's record in meeting the targets established in the Small Business Development Plan, for the four years from 1996 through 2000.

The main issue with most of these target indices is that they measure inputs rather than outputs. While this provided a realistic indication of the focus that TRIUMF was placing on technology commercialization, it did little to evaluate the impact that TRIUMF was having on the Western Canadian and Canadian economies. This is particularly true for measuring the transfer of technology from TRIUMF, or any other research facility. As the previous models showed, commercialization is an interactive process, that progresses from concept to commercial application. Merely measuring one or two input indices shows nothing with respect to the flow of technology through the system, nor does it provide any indication of the successful commercial application of innovative concepts.

For example, holding Technology Workshops at TRIUMF each year *might* bring together appropriate Western Canadian business people and financiers with TRIUMF researchers and their technology opportunities, but merely recording that such a Workshop was held provides no indication of any tangible benefit to the industry at all.

Table VIII **TRIUMF's Record in Meeting Targets**

TRIUMF's Small Business Development Plan
Update: June 2000

No.	Proposals/Targets	Target '95/96	Actual '95/96	Target '96/97	Actual '96/97	Target '97/98	Actual '97/98	Target '98/99	Actual '98/99	Target '99/00	Actual '99/00
1	No. W. Cdn Co.'s Accessed	750	865	1000	776	1100	1545	1200	1455	1200	1366
2a	Value of W. Cdn Mat. Orders placed	$5,990,000	$5,990,000	$4,950,000	$8,100,000	$5,445,000	$13,338,518	$8,000,000	$10,447,968.85	$6,400,000.00	$10,485,117.61
2b	Percentage W. Cdn Mat. Orders	50%	50%	55%	55%	60%	70%	65%	54%	65%	44.6%
3	No. W. Cdn Industry Supplier Shows	2	2	4	4	4	4	5	5	5	0
4a	No. of Conferences	3	5	2	5	3	7	3	7	4	5
4b	No. of Conference Attendees	825	840	100	154	1000	2046	1250	1335	1250	755
5a	No. W. Cdn Co.'s CERN visited	5	3	5	6	n/a	n/a	n/a	n/a	not specified	n/a
5b	Value CERN Orders awarded to W. Cdn Co.'s	$100,000	NIL	$200,000	$500,000	n/a	$1,100,000	$1,200,000	$985,000	$1,200,000	$753,000
6a	No. W. Cdn Component Manufacture Contracts	300	300	330	386	350	180	350	185	350	147
6b	Value of Component Manufacture Contracts	$1,800,000	$1,800,000	$2,000,000	$1,620,000	$2,200,000	$1,882,811	$2,200,000	$1,166,897	$2,000,000	$1,348,196.15
7	No. of Technology Disclosures	20	20	25	15	25	25	30	28	35	17
8	No. of Disclosure Developments Funded	2	2	3	6	3	4	3	3	4	6
9	No. of Technology Workshops	n/a	n/a	n/a	n/a	1	1	n/a	n/a	n/a	n/a
10	No. of Students Employed	40	42	40	44	45	55	45	50	45	37
11	No. of Info. Bulletins Distributed	1000	1000	1500	1611	1500	2500	1500	4427	2500	>3700

(d) The Economic Impact

During the five year period, 1995 through 2000, Canadian companies generated significant revenues and commercial sales for themselves as a result of technologies that have evolved at TRIUMF. These technologies have been transferred to commercial recipients, generally in the form of a licence. In specialised cases that demonstrate specific social benefit, such as the Terry Fox Foundation and the B.C. Cancer Agency, technological assistance may be provided through a contribution from TRIUMF. Commercial confidentiality precludes detailing these revenues by corporate source, but the following Table IX provides an aggregated summary.

Table IX: Aggregated Annual Revenues to TRIUMF's Commercial Associates, 1995/00 (In Thousands of Dollars)

Category	1995/96	1996/97	1997/98	1998/99	1999/00
Commercial Sales	$12,500	$11,500	$15,000	$22,000	$24,000

From this Table IIX, it can be seen that the total cumulated revenues that have accrued to commercial companies from the development and sale of TRIUMF developed technology, during the period 1995 through 2000 was $85,000,000. This number is a conservative estimate although it reflects direct sales by companies employing TRIUMF technology, as well as by TRIUMF licensees.

TRIUMF has maintained an active interest in these commercial activities, even though they are not related to fundamental research. As appropriate, TRIUMF receives royalties and/or consulting revenues or other consideration from these activities that are pursued for defined ancillary purposes. The revenues that have been received from these commercial activities have been used to fund the ISAC project, and applied research and development projects, including such essential TRIUMF expenses as patenting.

In addition to the facility operational expenditures over the past five years, detailed in Table VI, Figure 2 identifies the supporting revenues that TRIUMF has attracted, with its concomitant expenditures, through external research funding, as well as Canadian grants from such agencies as NSERC and MRC, plus external funding. These funds have been used to support experiments and applied research at TRIUMF. Such funding falls into four main categories:

(i) Researchers at TRIUMF receive funding for research at TRIUMF (e.g. MRC, NSERC).
(ii) Researchers at other Canadian institutions receive funding to perform specified scientific work at TRIUMF (e.g. NSERC).
(iii) External funding received by TRIUMF for non-research activities (B.C. Government funding, B.C. Science Council, IRAP, plus private and corporate funding).

These funds flow through TRIUMF and are administered by the institution on behalf of the funding agency and researcher, but represent no additional funding for TRIUMF itself. However, they do have an economic impact on the local economy. The following Table X shows the allocation of these funds administered by TRIUMF over the past five fiscal years.

Table X. Outside Funding, Administered by TRIUMF 1995/00, by Category (In Thousands of Dollars)

Category	1995/96	1996/97	1997/98	1998/99	1999/00
Affiliated Institutions	$3,449	$3,053	$1,980	$1,427	$2,219
NSERC	$3,438	$2,818	$4,285	$5,317	$7,663
External Funds	$1,144	$4,724	$3,877	$ 50	$ 50
Totals	$8,031	$10,595	$10,142	$6,794	$9,932

From the preceding Table X, it can be seen that the total cumulated outside research funds attracted by TRIUMF and administered by the institution, 1995 through 2000 was $45,494,000.

In certain circumstances, TRIUMF donates its knowledge and technology to non-profit recipients, such as the B. C. Cancer Agency, and the Terry Fox Foundation. Without such contributions from TRIUMF, it is likely that projects such as the proton cancer therapy for ocular melanomas could not have proceeded.

The following Table XI shows the Aggregated Revenues to TRIUMF from activities that are not directly related to fundamental research.

The category of "Corporate Funding" is intended to account for income from such sources as the Proton Irradiation facility, B.C. Cancer Agency, for TRIUMF's activities related to proton therapy, as well as commercial development funding as, for example, the Contraband Detection System during the period 1995 through 1998.

Table XI: Aggregate Revenues to TRIUMF from Non-Research Related Sources (In Thousands of Dollars)

Category	1995/96	1996/97	1997/98	1998/99	1999/00
Royalties and Corporate Funding	$ 1,003	$1,216	$1,210	$503	$710

The final factor through which the activities of TRIUMF impact the Canadian economy is the steady flow of visiting researchers to the area, both to participate in research at TRIUMF, and to attend conferences and seminars related to sub-atomic physics. These visitors are attracted to Vancouver by the presence of TRIUMF.

Visiting scientists to TRIUMF are estimated at 200 per annum, spending an average of $100 per day for five days. (This is a representative number is based on TRIUMF records of annual visitors over the period 1995 through 2000). The per diem expenditure estimate is a crude average, intended to reflect the mix of visiting scientist from such places as Japan and Russia with very different spending patterns.

Another aspect of TRIUMF that attracts people to the area is the ability and willingness of the staff to assist in the organization of conferences. Vancouver is a popular conference location, and TRIUMF staff are called upon to organize, or assist with the local conferences and seminars. The following Table XII is a summary of the estimated expenditures at conferences and seminars from 1995 through 2000. These estimates have been calculated at the rate of $350 per day per person, which is again quite conservative since this includes the conference fee, accommodation and meals, but excludes any adjustment for accompanying persons.

Table XII:
Estimated Expenditures at Local Conferences Organised by TRIUMF: 1995 - 2000 (In Thousands of Dollars)

1995/96	1996/97	1997/98	1998/99	1999/00
$1,360	$309	$3,297	$2,958	$830

The preceding tables and charts provide the elements of data that, when cumulated, identify the direct and total economic impacts of activities that have been causally generated from TRIUMF over the past five years. As a standard procedure, it is necessary to avoid double counting, such as, from the inclusion of both royalty figures and the sales on which they were based, as well as netting out the TRIUMF operating budget and expenditures. The results are shown in Tables XIII and XIV, following.

Table XIII: Direct Canadian Economic Impacts Causally Generated by TRIUMF (In Thousands of Dollars)

Category	1995/96	1996/97	1997/98	1998/99	1999/00
Salaries (Net of recoveries)	$23,606	$20,024	$20,421	$21,184	$21,361
Power	$2,008	$1,752	$1,345	$1,539	$1,808
Services (legal, audit, insurance etc.)	$ 1,135	$1,053	$ 959	$ 905	$1,088
Purchasing	$6,569	$8,171	$10,229	$11,372	$10,061
Licensee Net Sales	$12,500	$11,500	$15,000	$22,000	$25,000
Outside Funding	$8,031	$10,595	$10,142	$6,794	$9,932
Non-Research Revs.	$ 1,003	$1,216	$1,210	$ 503	$ 710
Visitors	$ 100	$ 100	$ 100	$ 100	$ 100
Conferences	$ 1,360	$ 309	$ 3,297	$ 2,958	$ 830
Total	**$56,312**	**$54,720**	**$62,703**	**$67,355**	**$70,890**

To develop a more complete estimate of the impact of TRIUMF on the Canadian economy, in Table XIV, the dollar values of Table XIII have been increased by the appropriate multipliers. This reflects that each of these expenditures is passed through the economy, to be spent several more times by the recipients of the payments. Although some people view the use of multipliers sceptically, they do provide a truer estimate of the economic impact. By including the Tables XIII and XIV without and with multipliers, there is a comparison of effects to choose from.

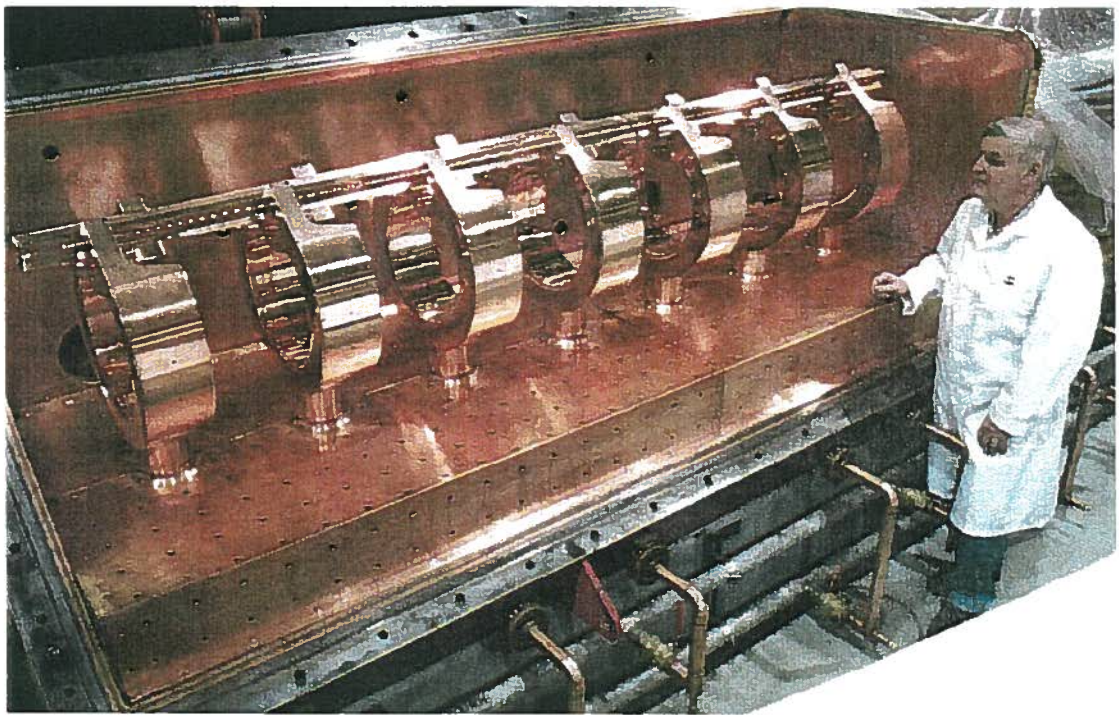
Table XIV, following , incorporates the multipliers with the values of Table XIII, to give a more realistic estimate of the actual annual economic impact of TRIUMF.

Table XIV: Total Canadian Economic Impacts Causally Generated by TRIUMF (In Thousands of Dollars)

Category	Multiplier	1995/96	1996/97	1997/98	1998/99	1999/00
Salaries	2.5	$59,015	$50,060	$51,052	$52,960	$53,403
Power	2.0	$ 4,016	$ 3,504	$ 2,690	$ 3,078	$ 3,616
Services	2.0	$ 2,270	$ 2,106	$ 1,918	$ 1,810	$ 2,176
Purchasing	2.5	$16,423	$20,428	$25,573	$28,430	$25,153
Licensee Sales	3.0	$37,500	$34,500	$45,000	$66,000	$72,000
Outside Funding	2.5	$20,078	$26,488	$25,355	$16,985	$24,830
Non-Research Revenues	2.0	$ 2,006	$ 2,432	$ 2,420	$ 1,006	$ 1,420
Visitors	2.0	$ 200	$ 200	$ 200	$ 200	$ 200
Conferences	2.0	$ 2,720	$ 618	$ 6,594	$ 5,916	$ 1,660
Total		**$144,228**	**$140,336**	**$160,802**	**$176,385**	**$184,458**

This Table XIV shows that the economic impact of TRIUMF on the Canadian economy exceeded four times the amount of the basic contribution from the federal government in each of the past five years, and has exceeded five times the basic contribution for each of the past two years.

The RFQ prototype tank copper plated by Superior Electro Plating.



Mr. Roger Poirier, TRIUMF's senior RF Engineer, beside the RFQ accelerator (the final version of the above) built by Siges Spinning, Sunrise Engineering, Superior Electro Plating and EDM Wire Specialists.

"A few decades hence, energy may be free, just like unmetered air."
(J. Von Neumann, 1956)

5. The TRIUMF Five-Year Plan 2000 - 2005

Background

In September 1998, TRIUMF produced its second consecutive Five Year Plan covering the period 2000 through 2005. This Plan identified where TRIUMF resources will be focussed during the five years of the Plan, and sets out the targets in the various operational areas for the laboratory during that time frame. This Plan was then accepted by the NRC, the Federal funding agency, and the operational areas were identified in the subsequent Contribution Agreement.

The following is a brief summary of the main areas of identified activity for TRIUMF during the period of the Plan, 2000 through 2005.

A Brief Summary of the Five Year Plan

The priorities of the Canadian subatomic physics community are still those which were set by the Fenton Committee in November 1995, namely *A Toriodial LHC ApparatuS (*ATLAS), ISAC, and Sudbury Neutrino Observatory (SNO). TRIUMF maintains a modest involvement in SNO, but ISAC and ATLAS are major ingredients in the Five-Year Plan beyond 2000.

The TRIUMF-CERN collaboration has been so successful that Canada is highly regarded as a non-Member state partner in the LHC project. Besides hardware contributions, CERN and TRIUMF staff have been collaborating on a variety of beam dynamics studies. For the LHC this includes optimization of the beam optics and of the collimator locations and orientations in the betatron and momentum cleaning insertions; calculation of hardware impedances potentially affecting beam stability; and development of a simulation tool for testing online control of betatron tune and chromaticity. CERN would very much like to see Canada play a major role in providing the components for the beam cleaning insertions in the LHC. The most costly part of this system will be the twin aperture quadrapoles, of which the initial unit has already been built by ALSTOM in Canada, and delivered to CERN.

ISAC-I has created an opportunity to put Canada on the international map of radioactive ion beam facilities. The energy increase to 6.5 MeV/u with a mass range up to A~150 provides a world-class centre for research in a large variety of topics: nuclear astrophysics, nuclear structure physics, weak interaction, condensed matter research and biosciences.

The possible life science applications from ISAC that hold the most promise include the production and separation of radio toxic nuclides for use in therapy as well as exploring the feasibility of using the post accelerator for generator production via ion implantation.

ISAC holds the promise to provide a unique scientific opportunity at TRIUMF supporting a strong, diversified program in nuclear physics, nuclear astrophysics, condensed matter research and biosciences. The current Five-Year Plan, supported by the Canadian nuclear physics community, includes the start of an extension of ISAC-I to ISAC-II.

"The abdomen, the chest and the brain will forever be shut from the intrusion of the wise and humane surgeon."
(Sir John Erickson, Surgeon Extraordinary to Queen Victoria, 1873)

TRIUMF Life Sciences Program

Proton Therapy Facility

The TRIUMF proton therapy facility, funded by a grant of $500,000 from the Mr. And Mrs. P.A. Woodward's Foundation, is a collaborative project of TRIUMF, the British Columbia Cancer Agency and the UBC Department of Ophthalmology. It uses the existing 65-120 MeV beam line 2C for treatment of ocular melanoma.

To March 31, 2001, about 60 patients have received treatment. About half of the patients are residents of British Columbia, with the remaining from the other Western provinces except for one patient from Quebec. The treatment protocol is similar to that used at the other eye therapy centres such as PSI, Harvard and Clatterbridge.

This facility will continue to operate as at present for the foreseeable future. The number of ocular melanoma patients could be doubled if Eastern Canadian patients were sent here. Possible extensions of the facility to treatment of other sites have been discussed but no definite decisions have been made as yet.

Life Science Projects

Positron emission tomography (PET), is the only imaging modality that can quantitatively measure physiological functions such as metabolism, the kinetics of enzymes and the density of receptors. The strengths of the TRIUMF research programs in radionuclide production, radiopharmaceutical synthesis and tomograph development, along with the University of British Columbia Clinical Neurology Division, combine to make the UBC Neurodegenerative Disorders Centre a world leader in using PET to study movement disorders such as Parkinson's Disease.

Provision of ^{13}N to Dr. Glass' group in the Botany Department at UBC has allowed for a sustained active program of research in plant nutrition. This program combines research at many levels, from physiology to molecular biology.

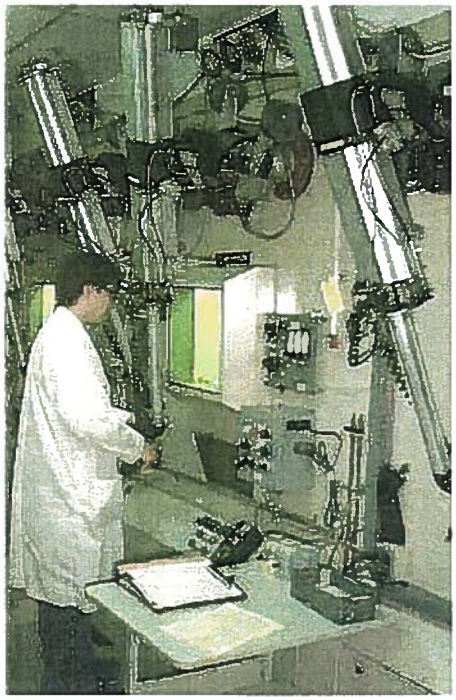
The 3-way collaboration between TRIUMF, Ottawa Heart Institute, (OHI), and MDS-Nordion resulted in the first ^{82}Rb myocardial perfusion studies performed in Canada at the OHI, starting in 1997. The success of this collaboration between TRIUMF and the Ottawa Heart Institute has recently been confirmed by a new Agreement for TRIUMF to provide a second perfusion system to OHI.

TRIUMF also sends, on a regular basis, batches of ^{18}F-FDG to the Department of Nuclear Medicine at Vancouver General Hospital, for imaging lung nodules as well as the heart. We also ship FDG to Lions Gate Hospital in North Vancouver.

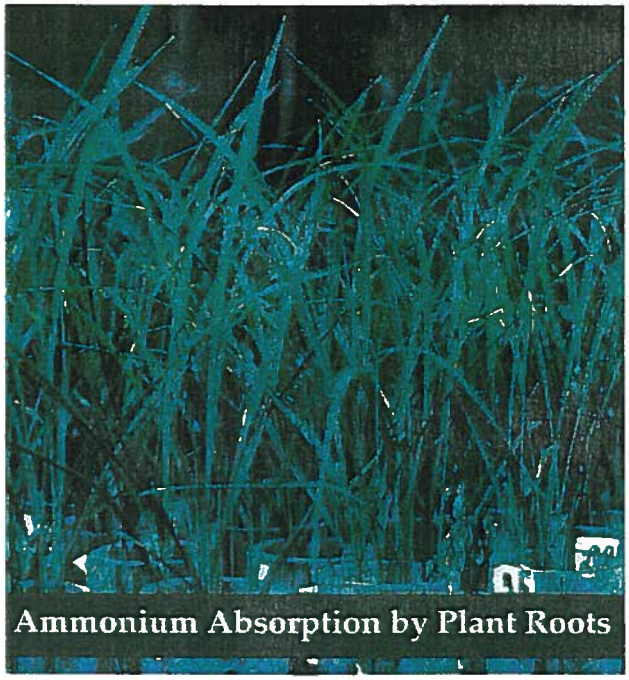
Proton Irradiation Facility

The BL1B Proton Irradiation Facility (PIF) was originally financed in part with a grant from the Space Systems and Technology Section of Defence Research Establishment Ottawa (DREO) and the Canadian Space Agency and delivers proton energies between 150 MeV and 500 MeV. The proton therapy line BL2C which is located in the same area is used to extend the measurements from 120 MeV down to about 20 MeV. In addition, by stopping the protons upstream, energetic neutron beams can be produced which are also of interest for space applications and biological studies.

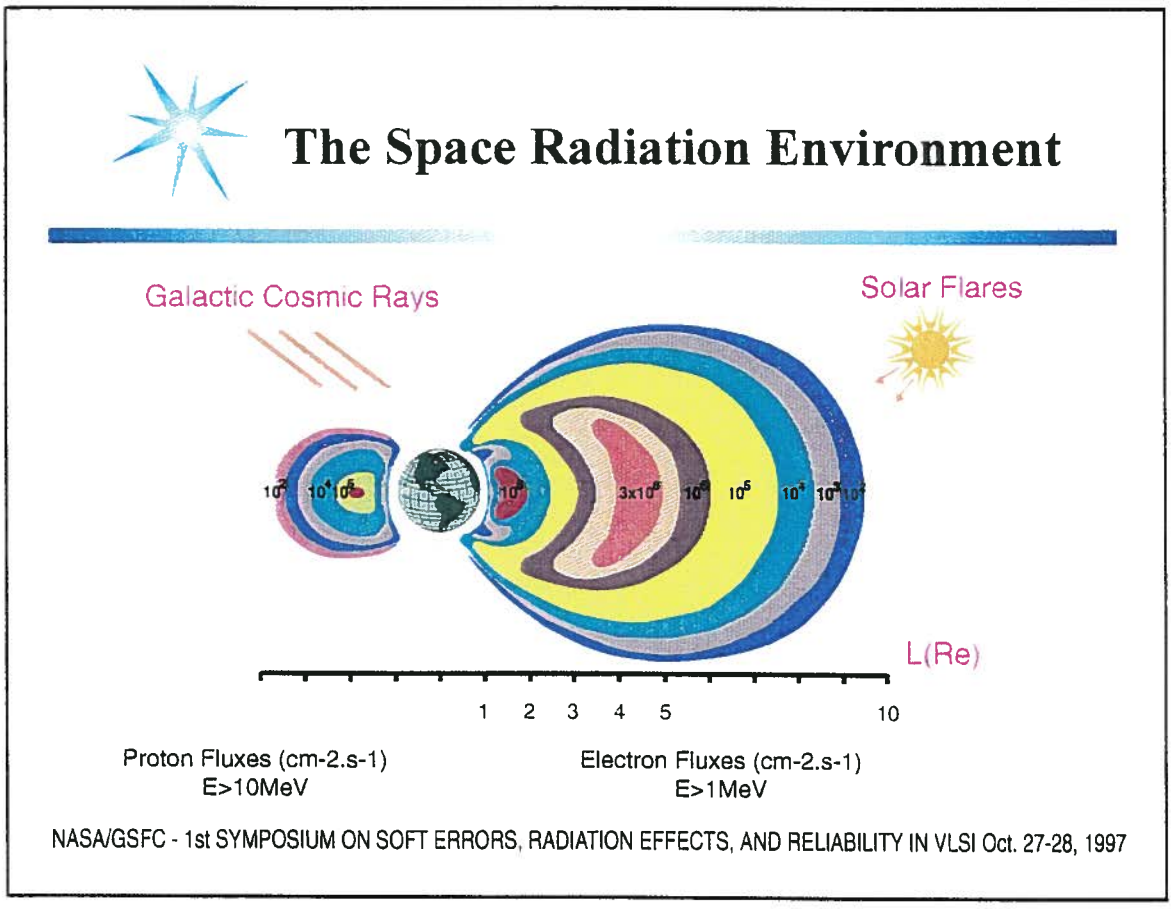
To date, groups from Canada, the United States and England have made use of the PIF facility. Typical studies include single-event upsets in memory chips such as SRAMs, response of optoelectronic devices, radiation damage to CCDs, and high energy neutron and proton response in bubble detectors. There is an hourly charge for beam usage, unless a researcher submits an experimental proposal which is approved by the TRIUMF Experimental Evaluations Committee.



Medical isotope production at MDS Nordion.



Studies on Plant Nutrition using Nitrogen-13 by Dr. Anthony Glass of UBC.



TRIUMF's Proton Irradiation Facility tests electronic components for space studies.

Table XV : Canadian companies involved in the TRIUMF-CERN LHC accelerator work

System	Item	Company	Province
Instrumentation	Current calibration equipment	Measurements International	Ont
	Beam diagnostic modules	Link Technologies	BC
	Surface mount hybrids	CDI Canada	Ont
Power Supplies	Transfer line power supplies	Inverpower Controls*	Ont
	Power supply control cards	Pachena Industries	BC
	High voltage supplies	Inverpower Controls*	Ont
	Ferrite tuning supply	IE Power Inc.	Ont
	Bias/amplifier supplies	Xantrex Technology	BC
Power Distribution Components	Rectifier transformers	Ferranti Packard*	Ont
	Static var compensator	GEC Alsthom*	BC
	Containment structure	Elmec Engineering	BC
	Cooling Package	Berg Chilling Systems	Ont
	Air core reactors	Haefly Trench	Ont
	Busbars/interconnects	High Voltage Construction	Ont
Magnets	Laminated core assembly	Talvan Machine Shop	BC
	Lamination machining	EDM Wire Speciality	BC
	Quadrupole assembly	Ebco Technologies	BC
	Twin aperture quadrupole	GEC Alsthom*	Que
	Copper conductor	Wolverine Tube	Que
Kicker Magnets & Pulsed Power	RCS cabinet	Talvan Machine Shop	BC
	Panels, busbars	Pacific Design Engineering	BC
	Dummy load tanks	Sunrise Engineering	BC
Radiofrequency Systems	HOM damper fabrication	Cannon Machine Works	BC
	RF components	Leblanc & Royle Telecom	BC

Listed are all orders	> $5000
***Orders**	> $500,000
Canadian Content	> 75%

"Space travel is utter bilge."
(Sir George Paget Thomson, 1956)

6. TRIUMF's Business Development Performance - Looking Forward

(a) The 2000 Contribution Agreement

In June 2000, the Federal Government announced a commitment of $200 million dollars over five years for the continued operation of TRIUMF, with the administration of the funding being designated to be the responsibility of the National Research Council (NRC). This TRIUMF Business Development Plan (BDP) is being created in response to Section 10 of that five year Contribution Agreement between NRC and TRIUMF. It will build on the previous SBDP from 1996, and establish a series of parameters to enhance and measure the economic impact of TRIUMF on Canada.

It must be emphasized again that, in evaluating the BDP targets, it is of paramount importance to remember that TRIUMF is primarily a facility for fundamental research into sub-atomic physics. In directing reasonable efforts to optimizing the impact of TRIUMF on the Canadian economy, great care must be taken to avoid hampering the scientific research at the institution.

The next five years will see TRIUMF focusing its technology transfer efforts in the areas of life sciences, with the addition of a new staff member who is skilled in that particular area. The work of technology transfer from an institution such as TRIUMF involves a great deal of background effort unearthing potentially commercial technologies, from which the actual successful technologies eventually emerge. It is not a haphazard or serendipitous approach, but one that nurtures the potential, and allows the market demand to pull the successful technologies forward.

As discussed earlier, it is the intention of this BDP to evaluate the economic impact of TRIUMF in Canada. This requires focusing the indices and their measurement on output effects from TRIUMF, rather than the traditional approach of input measurement. For example, the economic impact of TRIUMF can be measured, in part, by the value of purchase orders placed in Canada during the year. This output may be unrelated to the effort delivered by TRIUMF in trying to place such purchase orders in Canada. While the effort employed may be laudable, it does not identify the key factor which is the economic value to Canada of the orders placed. In this BDP, the measurement index will be the output parameters, in the example, the actual value of orders placed. No record will be reported on such input indices as the number of companies contacted, or the number of Canadian companies that remitted quotations.

The targets themselves should be viewed as evolving challenges, that have to be modified to reflect the ongoing changes in TRIUMF's operational plan. If additional target indices are required, then they should be added as appropriate, and similarly, indices and targets that may become irrelevant for one or more years should be skipped during that period.

During the five-year period of the Business Development Plan, the Technology Transfer Division will constantly undertake new initiatives in commercial interaction and development, to fulfill both the requirements and intent of Section 10 of the 2000 Contribution Agreement.

(b) Evolving the System

The major change that the 2000 Contribution Agreement introduced, when compared with its predecessor, the 1996 Contribution Agreement, was the extension of the domain of focus from Western Canada to all of Canada, plus the inclusion of all businesses, in place of only 'Small Businesses'. The effect of these changes will not be that significant in real terms, since the limitations of focusing the economic impact in Western Canadian were predominantly a reflection of the available, viable companies within that region. With the expansion to the entire country, some limitations of economic impact that have been present in the past, are now removed.

Inherent in this Business Development Plan is the retention of all of the systemic approaches that were identified in the previous Small Business Development Plan. TRIUMF has a procurement policy that requires all purchases to be made on an open competitive basis, with a preference for Canadian companies, but only if price and quality are comparable.

All purchasing is conducted through the TRIUMF purchasing department, which is responsible for a multi-million dollar annual procurement program for everything from insurance to superconducting magnets. These expenditures are assigned on the basis of a minimum of three competitive bids received in response to requests for tenders. Since some of the purchases are of specialised scientific equipment, with few suppliers in Canada, on occasion, directed requests for quotes is the most efficient approach. If there is only one supplier in Canada of a particular product or service, the TRIUMF buyers can single source that purchase, provided they have written justification from the TRIUMF purchaser. This TRIUMF approach of soliciting three quotations for purchases will continue, as will the directed efforts to source requirements from Canadian companies, with TRIUMF providing assistance where necessary and appropriate.

Students will continue to play a significant role at TRIUMF, both as visitors from high schools and universities, and as 'co-op' and summer students employed here, as well, of course, as in their traditional training role as part of post graduate degrees. The future of Canadian industry and science will be built on the students of today. It is believed that a record of student work and other interaction at TRIUMF represents a meaningful index of TRIUMF's contribution to the Canadian knowledge base of tomorrow.

From the comparison of the institutional reporting indices in Section 2(d), Table VI has distilled several extensive lists to a total of 23 indices that relate to Business Development and Economic Impact in Canada from TRIUMF. In addition, the 1996 Small Business Development Plan identified 15 target indices as listed above in Section 4(c), which were measured and recorded for the past five years. Combining this experience of the past five years with the external approaches it is now possible to evolve a set of indices that will provide clearer information on the outputs from TRIUMF that impact the Canadian economy. These are shown in Table XVI followed by a description of each item.

Table XVI - Indices for Measuring the Economic Impact of TRIUMF in Canada

Item	Description
1	Dollar Value of Sponsored Research for the Year
2	Number of Disclosures During the Year
3	Number of Disclosures Reviewed During the Year
4	Number of Disclosures Funded During the Year
5	Value of Funding for Disclosures During the Year
6	Number of Patents Applied for During the Year
7	Number of Patents Granted During the Year
8	Value of Purchase Orders Placed by TRIUMF in Canada During the Year
9	Number of Start-up Companies During the Year
10	Number of Spin-out Companies During the Year
11	Number of Licences Granted During the Year
12	Cumulative Number of Licences
13	Royalty Income for the Year
14	Contract Income for the Year
15	Number of Students Employed by TRIUMF During the Year
16	Value of the TRIUMF Sponsored Canadian Conferences During the Year

1. 'Dollar Value of Sponsored Research for the Year':- the annual dollar amount that is received by TRIUMF for research.

2. 'Number of Disclosures During the Year':- the number of possible commercial ideas that are disclosed to the TRIUMF Technology Transfer Office during the year. The 'target' for disclosures will be substantially reduced from the previous SBDP to reflect a more realistic approach looking only at disclosures with some possibility of commercial application.

3. 'Number of Disclosures Reviewed During the Year':- the number of possible commercial ideas that are disclosed to the TRIUMF Technology Transfer Office, and proceed to the next step of formal review, during the year.

4. 'Number of Disclosures Funded During the Year':- the number of possible commercial ideas that are disclosed to the TRIUMF Technology Transfer Office, are reviewed, and proceed to the next step

of receiving TRIUMF funding for further development, during the year.

5. 'Value of Funding for Disclosures During the Year':- the annual dollar amount invested by TRIUMF into the initial development of potentially commercial disclosures.

6. 'Number of Patents Applied for During the Year':- The number of patents that TRIUMF applies for during the year.

7. 'Number of Patents Granted During the Year':- The number of patents that are granted during the year for TRIUMF inventions.

8. 'Value of Purchase Orders Placed by TRIUMF in Canada During the Year':- The amount of TRIUMF purchase orders that are placed in Canada during the year, both in absolute dollars and as a percentage breakdown of total purchase orders.

9. 'Number of Start-up Companies During the Year':- The number of companies that have been created by TRIUMF staff or students, during the year, but without requiring any access to TRIUMF patents or technology.

10. 'Number of Spin-out Companies During the Year':- The number of companies that have been created during the year using TRIUMF patents or technology.

11. 'Number of Licences Granted During the Year':- The number of licences granted during the year by TRIUMF for commercial endeavours.

12. 'Cumulative Number of Licences':- The cumulative number of commercial licences granted by TRIUMF.

13. 'Royalty Income for the Year':- The royalty income from its licences that TRIUMF received during the year.

14. 'Contract Income for the Year':- The revenue that TRIUMF received during the year for commercial contract work, identified by contract.

15. 'Number of Students Employed by TRIUMF During the Year':- The total number, with breakdown by co-op, summer, etc., of all students employed by TRIUMF during the year.

16. 'Value of the TRIUMF Sponsored Canadian Conferences During the Year':- A list of TRIUMF sponsored conference, with a breakdown of the number of attendees, number of days of each conference, and an estimate of the dollar value of the conferences.

In addition, to provide a comparative measure of the commercial performance of TRIUMF there will be a series of ratios calculated using the 'Dollar Value of Sponsored Research for the Year' as the denominator. This will provide a method of comparing the performance of TRIUMF with that of other institutions and universities.

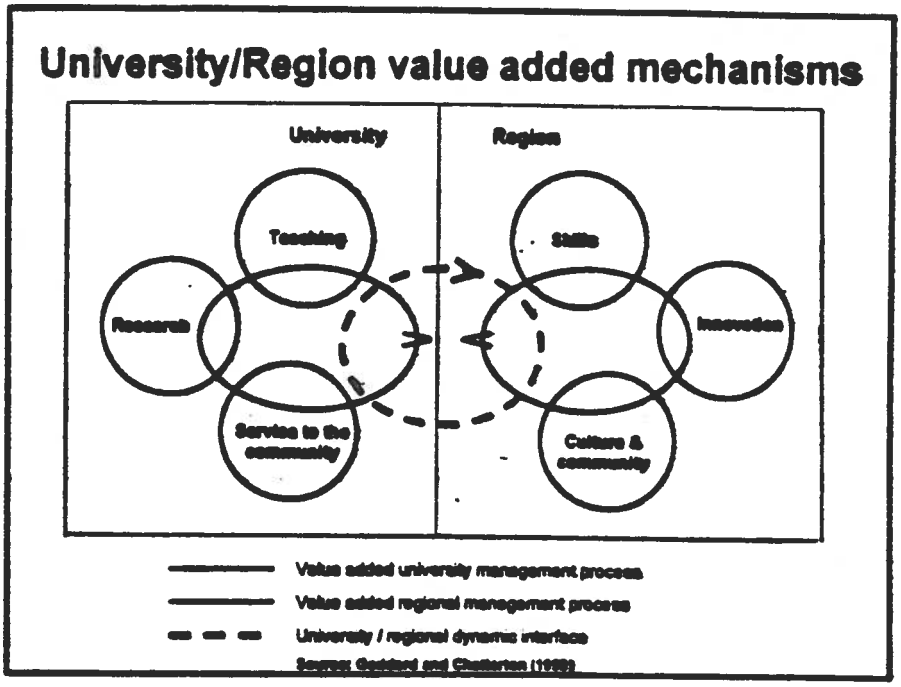
(c) Setting New Targets

The targets that are set for TRIUMF for each of the indices identified in the preceding section 6(b) must be both realistic and, at the same time, challenging for the facility. The local desire for research centers, such as TRIUMF and the universities to act as economic engines for growth can easily lead to unrealistic expectations. With this in mind, and building on the experience of the preceding 'TRIUMF Small Business Development Plan - 1995 to 2000', the following targets have been established:

Item	Description	2000/01	2001/02	2002/03	2003/04	2004/05
1	Dollar Value of Sponsored Research for the Year	$10 million	$10 million	$10 million	$11 million	$11 million
2	Number of Disclosures During the Year	15	15	15	16	16
3	Number of Disclosures Reviewed During the Year	4	4	4	5	5
4	Number of Disclosures Funded During the Year	2	2	2	3	3
5	Value of Funding for Disclosures During the Year	$25,000	$25,000	$25,000	$30,000	$30,000
6	Number of Patents Applied for During the Year	5	5	5	6	6
7	Number of Patents Granted During the Year	2	2	2	3	3
8	Value of Purchase Orders Placed by TRIUMF in Canada During the Year	$18 million	$18 million	$18 million	$20 million	$20 million
9	Number of Start-up Companies During the Year	1	1	2	2	3
10	Number of Spin-out Companies During the Year	1	1	1	2	2
11	Number of Licences Granted During the Year	3	3	4	5	6
12	Cumulative Number of Active Licences	8	9	10	11	12
13	Royalty Income for the Year	$400,000	$500,000	$500,000	$600,000	$600,000
14	Contract Income for the Year	$100,000	$100,000	$150,000	$150,000	$200,000
15	Number of Students Employed by TRIUMF During the Year	40	40	40	40	40
16	Value of the TRIUMF Sponsored Canadian Conferences During the Year	$1 million	$1 million	$1.5 million	$1.5 million	$1.5 million

(d) Economic Impact

The economic impact of a university or research facility, such as TRIUMF, can be seen in several distinct economic spheres. At the AUTM (Association of University Technology Managers) conference in March 2001, in New Orleans, Cathy Garner of the University of Glasgow made a presentation entitled "Universities: the Knowledge Factories of the New Economy". It showed that Glasgow and the other Scottish universities, have recognized their evolving role as generators of knowledge for the economy, and embarked on a proactive program, establishing links worldwide to commercialize the innovations developed at Glasgow and other universities in Scotland. Their depiction of the scope of value added economic impacts was shown in the following chart:



From this, it is evident that in addition to the direct impacts of employment and expenditures, there are indirect economic benefits to the country and region from the enhanced knowledge that is created through the existence of the facility. This is particularly true for a research laboratory like TRIUMF, that provides intangible benefits merely through its very existence within Canada. Without TRIUMF, the Canadian knowledge base would be reduced. In the Canadian academic world, in Canadian industry and in the general Canadian community, knowledge from TRIUMF is spread throughout the country through procurement requirements, the numerous visitors, as well as by direct dissemination.

"Aerial travel will be divided between two types, the dirigible being used for long distances and trans-oceanic travel, while airplanes will be the standard machine on overland routes, where the distance between stops is shorter. Experimental work which is being carried out in producing a steam drive for airplane service has given such promising results, that it is quite possible a combined steam boiler and steam turbine, admirably adapted for larger machines, will be in extensive use within the next few years."

(A 1920 *Scientific American* editorial on 'The future as suggested by developments of the past seventy-five years')

7. The Route to the Future

It is singularly appropriate that at the start of the new millennium, TRIUMF should itself be embarking on an exciting new future based on the just completed ISAC I and the soon to be started ISAC II research facilities. The next ten years will see the commissioning and start of research at both ISAC I and subsequently ISAC II at TRIUMF, as well as the completion and commissioning of the LHC at CERN, which has had a significant Canadian contribution through TRIUMF. This will make the next decade a very exciting time for Canadian research and Canadian physicists. The TRIUMF. contribution to CERN has assured places for Canadian scientists in the exciting leading edge research that will take place on the LHC, and Canadians across the country can be proud of the contribution that Canadian industry has made.

The twenty-first century is being heralded as the start of the era during which knowledge based economies will be the leaders in an increasingly global marketplace. The strength of an economy will be founded in the quality of its research and development, while in the commercial world, the competition will be fierce to commercialize the latest and most successful technological advances.

In this new age, TRIUMF will continue to emerge as a pivotal component in Canada's research mosaic, pushing the boundaries of recorded knowledge in their targeted areas of sub-atomic physics. At the same time, by clearly establishing itself as an international center for research into accelerated radio-active beams, TRIUMF will provide the Canadian link in the world-wide international network of sub-atomic research facilities. It is through research links and networks such as these that Canada will be able to maintain its role as one of the leading industrialized nations in the world.

TRIUMF will also continue to play a role in the development of technology and the application of innovative techniques within Canadian industry. By focusing its purchasing practices within Canada and working closely with companies to ensure that their techniques are appropriate to produce the required products to the specified tolerances, TRIUMF will continue to transfer technical knowledge to the Canadian economy. Transferring technology from TRIUMF to industry is sometimes an implicit event. Frequently knowledge is transferred indirectly to a supplier through technical advice, or to a third party company through staff movements. The effect on the Canadian economy can be every bit as significant as a formal transfer of technology through an agreement.

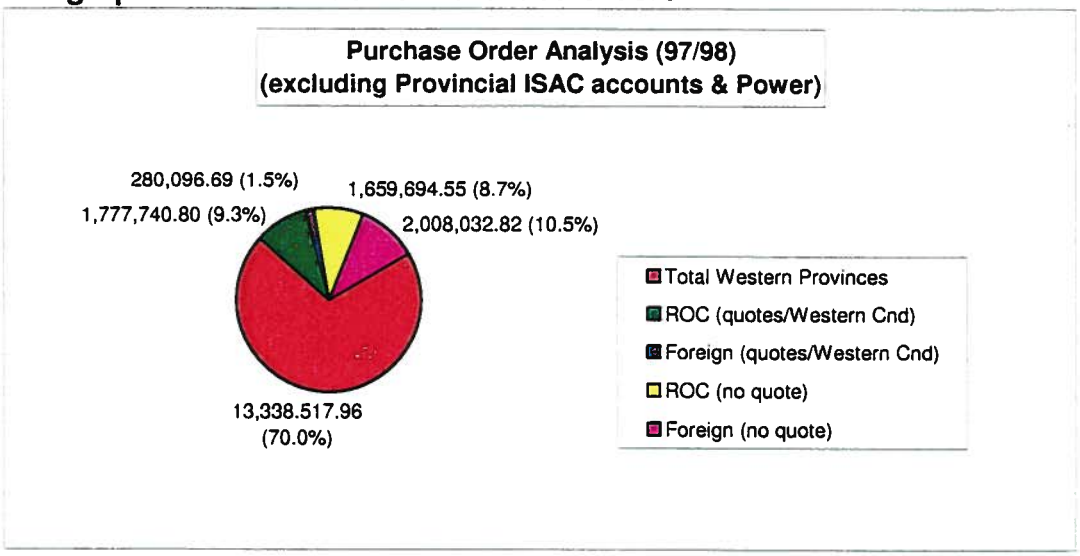
There have already been some particular successes in the implicit transfer of technology from TRIUMF, for example to Alstom, of Quebec during the course of a CERN quadrapole magnet contract, worth some $12 million in total, and to Superior Electroplating of British Columbia in an

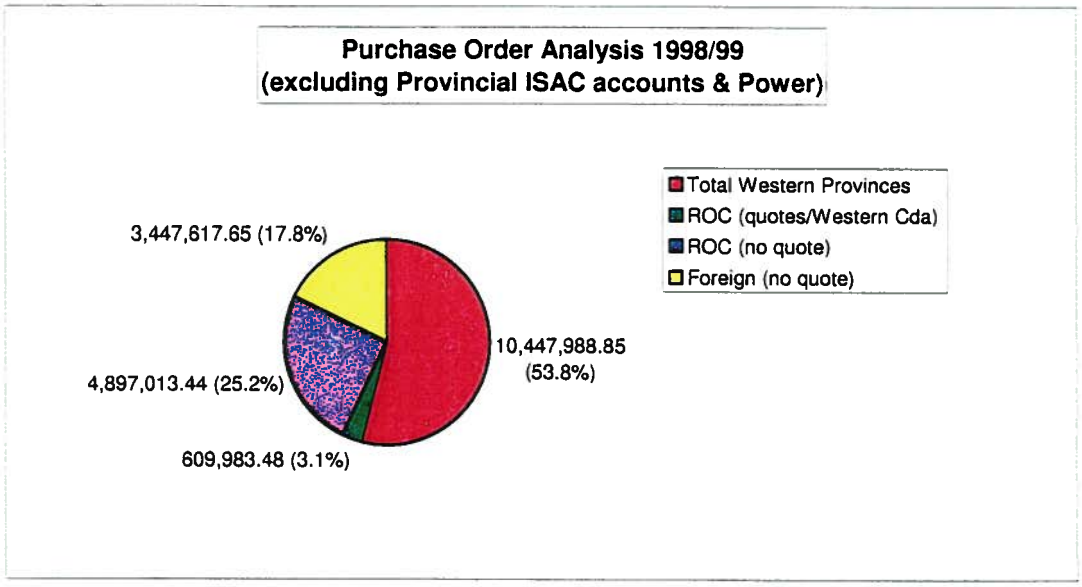
order for copper-plating of the Radio Frequency quadrapole for ISAC. Both of these contracts have enhanced the supplier's technical experience, and led to increased ability to meet other non-TRIUMF contracts in the marketplace.

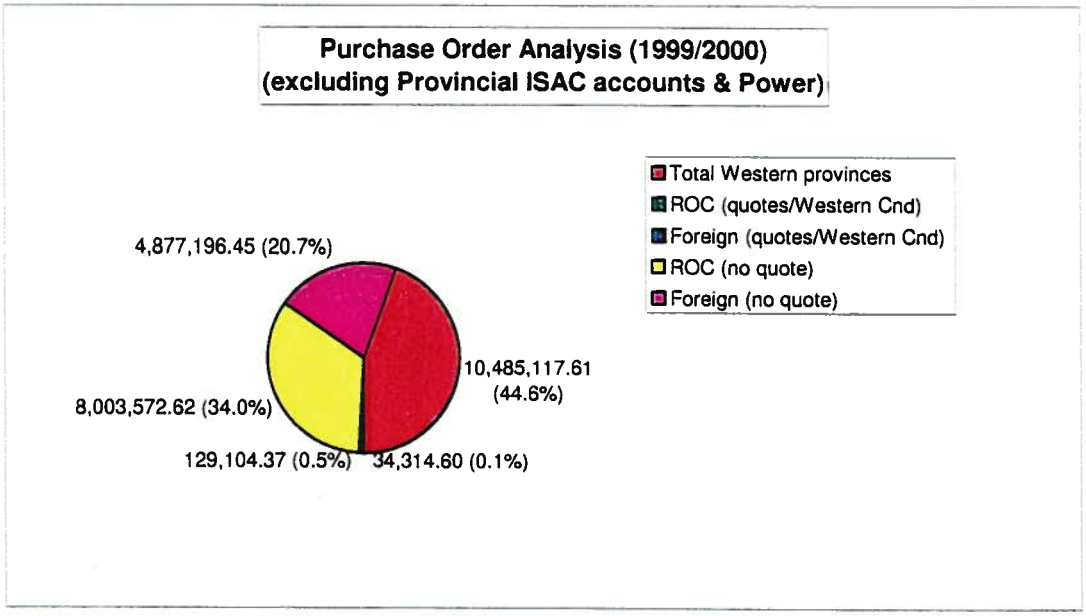
One of the major ways that TRIUMF can implicitly transfer its technology and knowledge is through movement of staff. It is well recognized that TRIUMF provides an outstanding technical training for technicians, technologists, engineers and scientists. During the past five years, over ten percent of the TRIUMF technical staff have left for better paying employment in Canadian industry. This is an accepted, vital component of the spread of the technical knowledge that is accumulated at TRIUMF. Examples of this type of knowledge transfer include Heatwave Drying Systems of Castlegar British Columbia have developed a radio frequency vacuum system for drying wood, hay and many other products. Although there is no formal contract between TRIUMF and Heatwave, there has been considerable interaction between the two, resulting in several TRIUMF staff being hired into key senior positions by the fledgling company in the year 2000, as the orders started to come in. The president of Heatwave is emphatic in his praise for the technical expertise that exists at TRIUMF, saying that without it, his company could not have been successful. There are numerous other companies that have benefitted from TRIUMF trained staff, including CREO, Quadra Logic (QLT), MacDonald Dettwiller and Ballard.

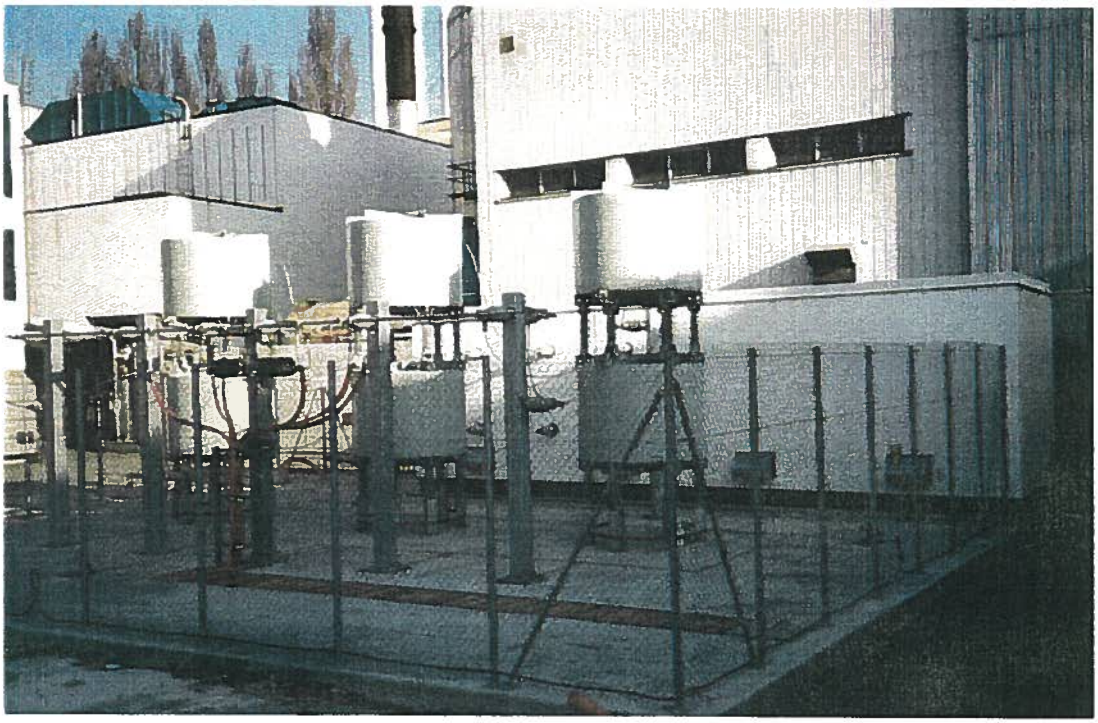
The following charts give a breakdown of TRIUMF purchasing, by location, over the past five years.

Geographical Distribution of Purchase Orders

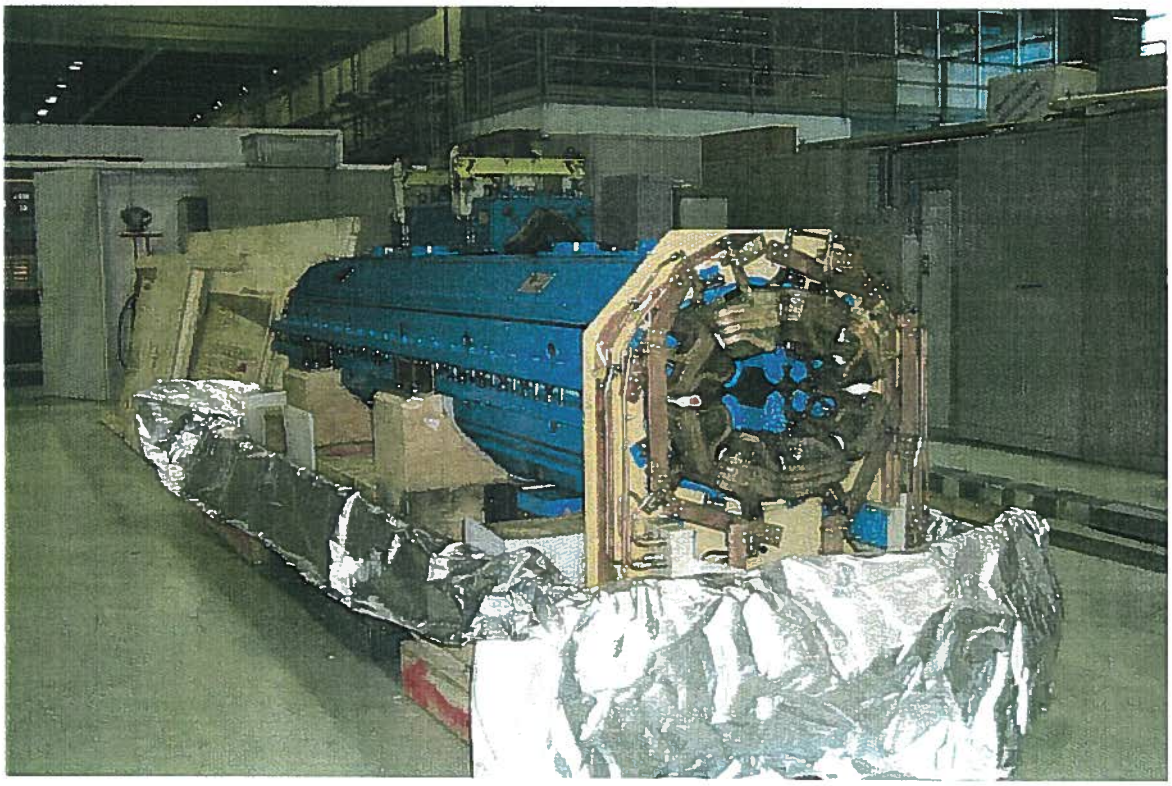








Static Var Compensator built by GEC Alsthom, installed and operational at CERN.



The first of fifty-two twin aperture quadrupole magnets from ALSTOM of Quebec shipped to CERN.

"640k ought to be enough for anybody."
(Bill Gates, 1981)

8. Conclusions

Since the inception of the first Small Business Development Plan in 1996, TRIUMF has demonstrated the significant effect that it has on the Canadian economy through both its purchasing and the transfer of its technical knowledge into the Canadian economy. The new Contribution Agreement of 2000 between the National Research Council and TRIUMF has expanded the scope of consideration for the impact of TRIUMF, from the economy of Western Canada to that of all of Canada. At the same time it has given TRIUMF an opportunity to review and evolve the indices that record the impact.

Based on what was learnt from the prior experience, this Report establishes a new set of indices that attempt to evaluate the economic outputs from TRIUMF's activities, rather than the inputs. These new indices, together with their targets for the next five years, have been identified in Sections 6(b) and 6(c) of this Report. This type of measurement and recording of the economic impact of research activities is becoming more and more prevalent around the world, although in many respects, it is still in its evolutionary infancy. The TRIUMF approach must therefore be considered as an evolved second stage, which doubtless will evolve still further in the years ahead.

TRIUMF has an enviable record within Canada and internationally, both in its scientific achievements and in technology transfer and the overall impact of the institution on the Canadian economy. With the caveat that expectations must be kept realistic, the next five years promises to continue and improve on the achievements to date.