Canada Foundation for Innovation
Fondation canadienne pour l'innovation

2006 Report on Results:

An Analysis of Investments in Research Infrastructure

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Executive Summary

The Canada Foundation for Innovation (CFI) (www.innovation.ca) is an independent corporation that was created by the Government of Canada in 1997 to fund research infrastructure in Canadian universities, colleges, research hospitals and non-profit research institutions. *Research infrastructure* includes state-of-the-art equipment, buildings, laboratories, and databases required to conduct research. Through its infrastructure programs, the CFI strengthens the capacity of Canadian institutions to carry out research and development (R&D) and training. Strategic Research Plan summaries are required from the institutions, and proposals to the CFI are expected to be aligned with these Plans. Research infrastructure project proposals are invited for all areas of research and technological development.

The CFI normally provides 40% of the capital costs of the infrastructure, with institutions expected to raise the remaining 60%. On average, 40% of the costs have been provided by Canada's provinces, with the remainder supported by the private sector and the institutions themselves. Starting in 2001, the CFI began supporting the operations and maintenance costs of the infrastructure projects, at a level of up to 30% of the CFI funding.

The CFI infrastructure investment funds are designed to:

- attract and retain highly skilled research personnel in Canada;
- stimulate the training of highly qualified personnel through research;
- promote networking, collaboration, and multidisciplinarity among researchers, institutions, and sectors;
- ensure the optimal use of research infrastructure within and among Canadian institutions;
- strengthen Canada's capacity for innovation.

The purpose of this analysis is two-fold. It is to measure the CFI's progress in achieving the aims set out for its funds, and to produce information relevant to the future of research infrastructure support in Canada.

At the outset of the writing of this report, October 1, 2006:

- > $3B of the CFI's funds had been awarded to ~4,800 projects at institutions in 62 municipalities across Canada;
- 3,256 projects remained within the 5-year timeframe for progress reporting;
- 3,137 project progress reports were submitted, for a submission rate of nearly 97%.

The data in the progress reports is survey material based on the submissions of researchers, and subject to certain caveats that are detailed in the report. The following are the highlights of the 2006 analysis.

Attraction, retention and training

Infrastructure investments by the CFI and other funding partners appear to be achieving the aims of attraction, retention and training of research personnel. According to the progress reports, **since 2001,** approximately:

- 8,050 researchers at faculty level have cited research infrastructure as an important factor in their decision to stay in Canada or to come to Canada from abroad, and of these, about 1,670 (21%) have come from the US; and 1,480 (18%) from other countries;
- 41,300 post-doctoral and graduate students have undertaken research projects where the infrastructure was or is a key resource;
- 11,270 trainees have completed their training at the host institution, and

- 10,960 technical personnel have been trained on the use and maintenance of research infrastructure.

Are the graduates and technical personnel transferring their knowledge of the latest infrastructure and research to employers in Canadian society? According to the data in the sample, **since 2001**, approximately:

- 4,840 (43%) of the graduates have proceeded to join the business, public and non-profit sectors;
- 6,430 (57%) of the graduates have been hired by institutions, usually institutions other than the one that hosted the infrastructure;
- 9,480 (87%) of the technical personnel have been retained by the host institutions, or attracted to other institutions, a signal of their importance to the infrastructure.

Enablement and transformation of research

The impact of the investments in research infrastructure in enabling research and encouraging networking and collaboration appears to be dramatic. In the year **2005-06,** approximately:

- 21,600 researchers advanced their research through use of infrastructure at their host institutions;
- an additional 18,800 researchers from outside the institution used the infrastructure.

In other words, more than **40,000 researchers took advantage of Canadian research infrastructure that has been funded since 2001 to undertake their investigations in 2005-06.** Almost half of these came from beyond the host institution where the infrastructure is located.

The investments made in research infrastructure by the CFI and other funders are encouraging cross-sectoral collaboration. Of the 18,800 outside users of research infrastructure, approximately:

- 70% came from other institutions;
- 14% came from the private sector;
- 10% came from the public sector;
- 6% came from the not-for-profit sector.

Team approaches to research are confirmed by other lines of enquiry. Researchers report that, **since 2001,** approximately**:**

- 1,700, or 61% of the infrastructure projects, have helped to draw together different disciplines;
- 2,360, or 82% of the sample, have enhanced opportunities for collaborative research across organizations.

There are indications that research infrastructure investments at institutions are contributing to regional centres of innovation. There is an upward trend in the use of the research infrastructure hosted by institutions by "outside researchers" working within the province. The approximate, aggregate number and proportion of "outside" but intra-provincial researchers trend is as follows:

- 2004 – 4,670
- 2005 – 5,360
- 2006 – 7,020

However, while the absolute numbers are growing, the *proportion* of outside users based within the province is not. Our analysis indicates that a threshold is being reached due to a slower growing "supply" of researchers at the local level, whereas demand is growing nationally and internationally.

The data bear this out. Total use of research infrastructure by "outside" researchers from all across Canada stands at 59%. However, the R&D endeavour at Canadian institutions is, for the moment, increasingly attractive to the global research world. The trend data on international, "outside" users of Canadian research infrastructure, in approximate figures, is as follows:

- 2004 – 3,700 (36% of users outside the institution)
- 2005 – 4,900 (39%)
- 2006 – 7,650 (41%).

Much of the increase in international research use appears due to a jump in the number of U.S. researchers working at Canadian installations. These overall findings on international researcher use are consistent with another line of enquiry. S**ince 2001**,

- approximately 82% of researchers submitting progress reports considered that the infrastructure had some influence in fostering international collaborations, and
- 17% reported that the collaboration would not have happened without the infrastructure.

In sum, R&D linkages of a significant scope are being marshalled around institutional research infrastructure in Canada, at regional, national and international levels.

Sustaining the R&D edge

Two key aspects on the topic of infrastructure must be considered in the bid to sustain the gains that have been made.

- First, infrastructure must be frequently refreshed, upgraded or replaced to remain "state-of-the-art". Without further investment, there is a high risk that competitive teams will dissociate and new, young researchers will not stay in Canada.
- Second, adequate operations and maintenance (O&M) support must be provided to ensure maximum capacity utilization over the lifetime of projects. The overall data at the CFI indicate that the Infrastructure Operating Fund (IOF) of the CFI is adequate for the great majority of projects. However, there remain several large, complex and long-term research infrastructure projects in Canada that will require O&M support beyond the 3-5 year time frame provided by the IOF.

Social and economic benefits

Research infrastructure enables research and development (R&D), and therefore is only one of many inputs for the generation of economic and social benefits in Canada. Also, it is still early in the development of many of the infrastructure projects. Nevertheless, the CFI considers it important to collect preliminary information, in order to give an indication that, even in these early days, some tangible results are already being obtained. Project leaders provided the following data on *instances* of the various measures suggested to them. Frequently, one project can generate more than one benefit. **Since 2001**, research infrastructure investments have aided in:

- 653 new or improved public policies & programs;
- 837 new or improved products, processes or services;
- 528 intellectual property rights applied for or awarded;
- the creation of 504 of public or private sector jobs and
- the development of 155 spin-off companies.

Examples of these promising projects are included in this report. The CFI views these data as a useful pointer that will aid in the undertaking of more comprehensive outcome measurement studies.

1. Introduction

1.1 ROLE OF THE CFI IN CANADIAN R&D

Canada's future as a prosperous and secure nation is dependent on improvements in productivity—that is, producing relatively more goods and services from a given population base and all its economic and social assets. For an advanced modern economy, which must compete through improvements in quality, increased productivity is tied to the building of a knowledge economy. The notion of a knowledge economy includes ideas and practices related to the continuous and highly specialized training of people, and the diffusion and capture of their knowledge locally, nationally, and globally. The concept also includes reliance on advanced organizational schemes within and among enterprises, and beyond these to include an increasing range of relationships with other organizations in society. The entry into the mix of increasingly complex equipment, instruments, tools, and facilities produced by highly trained people is also a characteristic of the knowledge economy.

Canada's research and training institutions comprise the foundation stones of a knowledge economy. They conduct research and development, they produce trained graduates, and they form linkages with other societal partners to encourage dynamic information flow and knowledge translation.

The Canada Foundation for Innovation (CFI) assists Canadian research institutions in contributing to the knowledge economy. The CFI's mandate is to strengthen the capacity of Canadian universities, colleges, research hospitals, and non-profit research institutions to carry out world-class research and technology development that benefits Canadians. It is an independent corporation that was created by the Government of Canada in 1997 to fund research infrastructure. *Research infrastructure* includes state-of-the-art equipment, buildings, laboratories, and databases required to conduct research.

1.2 PURPOSE OF THIS REPORT

The purpose of this analysis and the overall report is to measure the CFI's progress in achieving the aims set out for its funds, and also to produce information relevant to the future of research infrastructure support in Canada. It is an annual effort that, with the passing of time, becomes richer in detail, but also more challenging to manage. The CFI is the custodian of a national science and technology (S&T) infrastructure; namely, its own database, containing progress reports on which this analysis draws, and other information.

1.3 HOW THE CFI WORKS

To be eligible for CFI investments in research infrastructure, Canadian institutions must submit summaries of their Strategic Research Plans. Proposals to the CFI are expected to be aligned with these Plans. Research infrastructure project proposals are invited for all R&D areas undertaken at institutions; for example physics, engineering, health, and economics, to name a few.

The CFI infrastructure investment funds are designed to:

- attract and retain highly skilled research personnel in Canada;
- stimulate the training of highly qualified personnel through research;
- promote networking, collaboration, and multidisciplinarity among researchers, institutions, and sectors;
- ensure the optimal use of research infrastructure within and among Canadian

institutions;
- strengthen Canada's capacity for innovation.

The notion of innovation embraces activities involving the diffusion of knowledge, technology and practices, and the development of human resources that contribute to these.[1] The commercialization of discoveries, and the transfer of expertise to different societal partners, leading, for example, to improvements in public policy, constitute forms of knowledge translation. The movement of trained graduates to different sectors of society also form a part of the innovation dynamic—indeed, some regard the mobile human resource factor as the most important in the long run, but the most difficult to measure.[2] Innovative organizations use these inputs in a variety of ways that lead to economic and social benefits.

The CFI's financing of the capital costs of infrastructure is normally based on a 40:60 funding formula, with the exception being the International Fund.[3] The structure of the CFI is such that it can make secure commitments for long-term funding while retaining the management, disbursement and monitoring of these funds in a responsible but flexible manner.

The CFI's 40% investment comprises the initial financing that enables an institution to seek partnership funds for the infrastructure project. Other funders of research infrastructure within Canada include provincial and regional organizations, private enterprise, non-profit entities and the institutions themselves. In practice, the provinces or regional organizations provide approximately 40% of the funding of the research infrastructure projects. The CFI also assists with operations and maintenance costs of the infrastructure projects, at a level of 30% of the capital investment by the CFI.

Proposals submitted to the CFI are assessed on the basis of merit by external experts, and normally a review by multidisciplinary assessment committees that make recommendations as to which infrastructure projects represent the most effective investments of public funds. Three criteria form the basis of the review:
- Quality of the research and need for the infrastructure;
- Contribution to strengthening the capacity for innovation;
- Potential benefits of the research to Canada.

As of October 1, 2006, at the outset of preparing this report, the federal government had invested $3.65B in the CFI that, with compounded interest, is expected to grow to approximately $4.85B by 2010. Given the 40% funding formula, the CFI's investment is estimated to bring a total of $11B to the R&D enterprise in Canada. As of fall, 2006, over $3B of the CFI's funds had been awarded to close to 4,800 projects at universities, colleges, non-profit research institutes and research hospitals in 62 municipalities across Canada.

The CFI and other organizations, such as provincial governments and the private sector, fund research infrastructure at Canadian institutions, and thereby help to *enable* R&D and contribute to advanced training. Research infrastructure projects at institutions span all R&D areas, and encourage collaboration among the institutional, business, government and non-profit sectors. It is important to point out, however, that the CFI is one of several funders of public sector R&D. The CFI works in complementary fashion with the other federal funding agencies, in particular: the Natural Sciences and Engineering Research Council (NSERC), the

[1] OECD, Directorate for Science, Technology and Industry, Committee for Scientific and Technological Policy, *Outcomes of the Blue Skies II Forum*, DSTI/STP(2006)33 October 17, 2006

[2] OECD, Ibid.

[3] For the International Fund, the CFI can fund, in full, the Canadian portion of the capital costs of an international joint venture, or the full costs of Canadian access to international infrastructure.

Canadian Institutes of Health Research (CIHR) and the Social Sciences and Humanities Research Council (SSHRC). The CFI recognizes the need to develop synergies among the different funding partners, and it is engaged in this effort at different levels, including program design and evaluation of the results.

1.4 TYPES OF CFI FUNDS

The CFI's program architecture has been designed to meet evolving needs and challenges that have emerged in the S&T landscape in Canada. It consists of a suite of funds that have been designed for different purposes and types of institution. This analysis provides information only on awards made under program funds that existed up to and including 2005, as it is based on reports on progress submitted by institutions and project leaders for the five years following their Award Agreement with the CFI. These funds are described in what follows, and the total investment made within each fund as at July 17, 2006 (i.e. the cut-off date for the analysis; see Methodology).

Responding to the need to restore competitiveness to Canadian institutions through the attraction and retention of leading researchers, the CFI designed a group of funds to support institutions in their recruitment efforts and strategic orientations. These included:

- The **New Opportunities Fund (NOF)**. The NOF enabled eligible universities to provide infrastructure for newly-recruited faculty members, in their first full-time academic appointment in Canadian degree-granting institutions. By July, 2006 CFI had invested more than $350 million in over 2,200 projects under this fund.

- The **Canada Research Chairs Infrastructure Fund (CRCIF).** The CRCIF was designed as part of a Canada Research Chair nomination to enable universities, together with their affiliated research institutes and hospitals, to include a request for infrastructure support from the CFI. The Chairs Program is administered by a tri-agency support mechanism designed by SSHRC, NSERC and CIHR, and its Steering Committee includes the CFI. By July, 2006 the CFI had invested over $200 million in over 1,300 projects under this fund.

- The **CFI Career Awards.** This program was administered in partnership with SSHRC, NSERC and the CIHR. These awards supported a small number of outstanding researchers by providing institutions with the infrastructure essential for their research. The CFI invested close to $7 million in this fund.

Another group of funds was designed by the CFI that specifically supported research, calling on institutions to reach for new heights in research but additionally to submit proposals that supported their strategic planning processes. Proposals were encouraged that capitalized on local, national and international intellectual resources, and which drew on collaborative, multidisciplinary and networked approaches where appropriate. The following funds comprise this group:

- The **Innovation Fund (IF).** Through the IF, the CFI challenged Canadian institutions and their researchers to use infrastructure as a platform for novel research approaches that would attain international leadership. The IF encouraged institutions, individually or in partnerships, to develop and submit ambitious proposals. To July, 2006 the CFI investment in this fund has been greater than all other CFI funds, at $1.77 billion and over 700 projects.

- The **University Research Development Fund (URDF).** The CFI designed the URDF to support smaller universities in their efforts to raise research capacity. Eligible universities were those that in 1994-96 received less than 1% of the total sponsored research funding at Canadian universities. The CFI invested $35 million in research infrastructure under this fund between 1998 and 2002.

- The **College Research Development Fund (CRDF).** The CRDF was developed by the CFI to enable Canadian colleges, institutes, and their affiliated research centres to conduct research in niche areas. The maximum contribution from the CFI could not exceed $800,000. The CFI invested $15.6 million under this fund in two competitions between 1999 and 2000.

- The **International Joint Ventures Fund (IJVF).** The CFI launched the IJVF to support the establishment of very high profile research infrastructure projects in Canada. These take advantage of extraordinary research opportunities with leading facilities in other countries. By July 2006, 3 projects had been funded, for a total investment of $87 million.

- The **International Access Fund (IAF).** The IAF was introduced to offer Canadian researchers access to world-class research collaborations and facilities located elsewhere in the world which would allow them to collaborate with the best researchers. By July 2006, the CFI invested a total of $71 million in this fund, in 6 projects.

- The **Exceptional Opportunities Fund**. This fund was created by the CFI as a rapid response mechanism to assist institutions and their partners to participate in unique and exceptional research opportunities that would be missed if a project had to wait the normal time period of a national competition and subsequent decision. By July 2006, the CFI had invested $15 million in 2 projects under this fund.

- The **Research Hospital Fund (RHF)**. The RHF was launched by the CFI in 2003 to provide for new, state-of-the-art research infrastructure support to Canada's research hospitals. Although awards of $60M were announced late in 2004, they have not been finalized, and therefore no progress reports are included in this analysis.

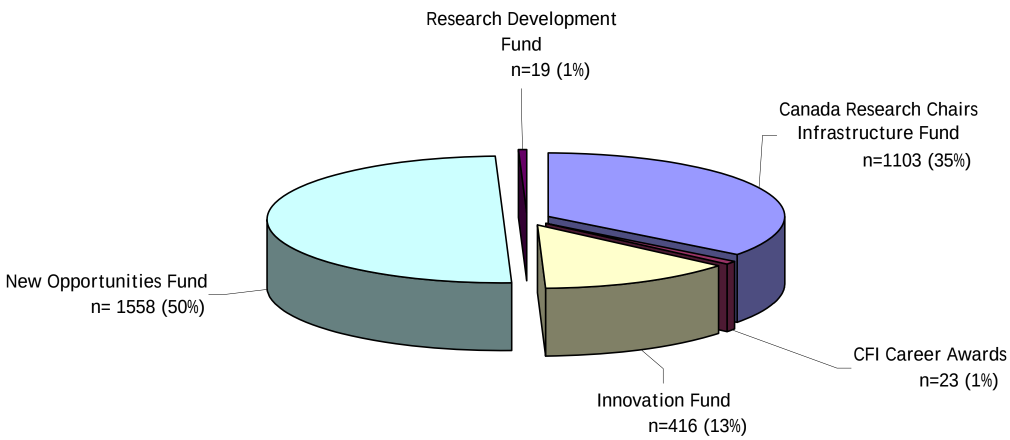
All of the funds above constitute investment in the capital costs of research infrastructure at Canadian institutions. However further support is required to ensure its optimum utilization for state-of-the-art research. The CFI assists institutions with the following:

- The **Infrastructure Operating Fund (IOF)**. The IOF was established by the CFI in 2001 to assist institutions with the operations and maintenance (O&M) of the infrastructure for which the CFI has provided funding. These funds are allocated to the institutions on the basis of 30% of the finalized CFI contribution.

Exhibit 1.4a depicts the *number* of infrastructure projects supported by CFI investments, according to the type of fund, that are included in the current analysis. Most of the projects that have been awarded have fallen under the NOF, followed by the CRCIF.

Exhibit 1.4a

Composition of the sample of 2006 CFI project progress reports, by number of projects/fund

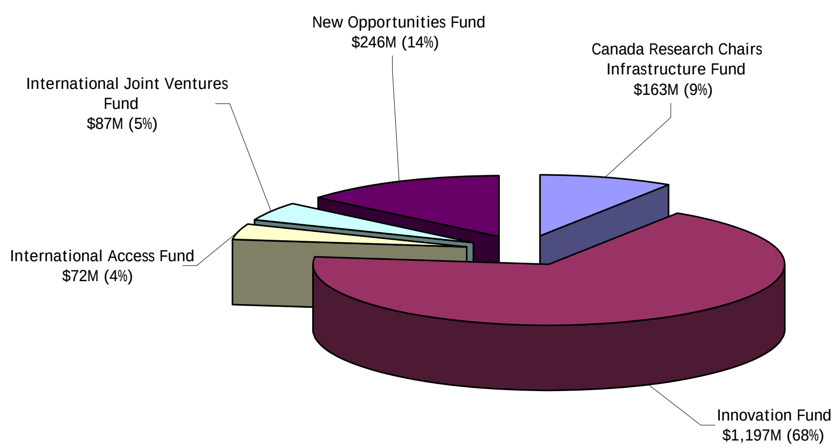


Note: Excluded from this exhibit are funds comprising of <1% of the total number of reporting projects: International Joint Ventures, International Access Fund, Research Hospital Fund, College Research Development Fund and Exceptional Opportunities Fund. Also exclude is the Infrastructure Operating Fund. Total number of projects reporting is 3137.

Exhibit 1.4b depicts the total *financial* investment, by fund, made by the CFI and that is covered by the current analysis. The highest proportion of financial investment, 2001-2006, has been made under the Innovation Fund.

Exhibit 1.4b

Composition of the sample of 2006 CFI project progress reports, by $ invested/fund



Note: Excluded from this exhibit are funds comprising < 1% of CFI's financial investment in awards amongst reporting projects: Research Development Fund, CFI Career Awards, College Research Development Fund and Exceptional Opportunities Fund. Also excluded is the Infrastructure Operating Fund. The total depicts ~ $1.7B.

A new program architecture was launched in 2005. The new assembly of funds is designed to meet the altered mix of needs for research infrastructure that had developed in the R&D landscape by this point of time. An analysis of progress reporting under the new programming will begin in 2007. In the meantime, information on the design of these new funds is available at http://www.innovation.ca/programs.

2. Methodology

2.1 DATA COLLECTION PROCEDURES

All institutions and projects funded by the CFI are required to submit an institutional progress report, along with progress reports for each project, by June 15 of each year. Like applications to the CFI, this is administered through an on-line, electronic process. This requirement applies to projects for the five fiscal years that follow approval of their budgets by the CFI, and the issuing of an Award Agreement with the institution. Institutions and project leaders provide numeric and textual data requested in a questionnaire format (Appendix 1). Institutions are asked to prepare an overall report that addresses progress over the past year in achieving the objectives of their strategic research plans. These take into account the various contributing factors for the building of capacity for innovation and the generation of social and economic benefits. All of these reports are posted on the CFI Web site each year.[4] The institutional reports furnish input that will be used for the CFI's outcome measurement studies, which at the time of preparation of this report were being designed. The outcome measurement studies are to form a part of the CFI's overall evaluation approach.

The focus of this analysis, therefore, is on the project reports that have been prepared by project leaders, and reviewed and assembled by their host institutions. The collection of these project reports comprise the source of aggregate data for this analysis. They also furnish the descriptions that are used as examples in this report (text boxes and mini-case studies). However, that is not their only use. Project progress reports are critical for all of the evaluation and analysis activities of the CFI, including program evaluations, outcome measurement studies and special studies.

2.2 NATURE OF THE SAMPLE

The data included in the CFI's annual, overall analysis of progress reports represents a heterogeneous, aggregate *sample* of projects. In the following, the nature of the sample, and the key differences among the infrastructure projects included in it are explained.

The CFI's database for 2006 progress reports contains information on projects that have started anytime from April 1, 2001 to March 31, 2006. Some projects, therefore, have just begun, whereas others will be nearing the end of their cycle of progress and financial reporting and may have been operational for years. Thus an important limitation to keep in mind is that this sample relates only to those projects that have been funded by the CFI between 2001 and 2006. Results from earlier projects no longer submitting reports have been excluded, even though these projects may have richer information in terms of longer-term effects such as social and economic benefits. The outcome measurement studies are designed to address this information gap.

There is a great variety in terms of the size and complexity of research infrastructure projects. Smaller projects, especially those intended to attract and retain researchers, are reasonably easy to plan, purchase and develop, whereas large complex awards such as those provided under the Innovation Fund may take well over a year, and sometimes more, to plan, contract, purchase, construct, assemble, and develop. Therefore, the scope and sophistication of such projects affects the speed of implementation, and generation of outputs and outcomes.

[4] http://www.innovation.ca/evaluation/index.cfm

There is a diversity of scientific disciplines and sectoral areas covered by the projects, and these evolve in different ways. In addition, some fall at the more fundamental end of the spectrum of R&D, and some at the more applied.

From a statistical point of view, then, the aggregate data set is heterogeneous. Nevertheless, even with the aggregate data, there is a constant time interval between data collections. Questions that remain the same over the years will produce responses that are meaningful as increments, so long as the investment levels and fund types remain reasonably constant and considerations are made for lag times. With this in mind, a baseline year of 2000 has been established as of last year. Because of this, the change between data sets each year may be analyzed over the long term for some interesting results (see Appendix 2 for an overview of data sets).

Another characteristic of much of the data is its subjective nature. In this regard, it is worth noting that there is little or no incentive to include false information on the forms, as these progress reports have no bearing on potential future funding. More probable is a lack of administrative capacity to fill out forms comprehensively and track all numbers, especially for large, complex projects. Although institutions review and assemble all project progress reports, the degree of quality control by them appears to be variable, dependent on many factors, such as available resources and the priority assigned to this task.

The CFI is not in a position to verify the numbers in the reports, however it undertakes a scan of the data to determine if there are any irregularities, for example "outlier" reports with suspect numbers. In 2006, one such report was removed from the sample. The CFI has also noted that some year over year data appears to be inflated. For example, in the past, when the CFI asked project leaders to provide their personal assessments of the impact of the research infrastructure for a given year in attracting new faculty, some numbers were higher than expected.

In 2005, the CFI began to address this problem of a possible inflation of year over year data. It added new lines of questioning pertaining to the life of the project, as well as continuing with questions concerned with the previous year. The additional lines of questioning have now become possible as many projects have reached full development and have been operational for years. A focus group, including a professional statistician and institutions, was constituted in the summer of 2006, and informal discussions took place with researchers. It was confirmed that, at the project leader's level, it is often more meaningful to ask questions about the trajectory of a research project related to infrastructure from its start–for example, the number of researchers attracted, the number of PDFs and graduates who have been trained on it, etc.

According to the statistician, who was contracted to review the CFI's progress reporting procedures, including its questionnaires, there remains a problem of "double-counting". For example, in the responses to questions related to attraction and retention of researchers and students, different project leaders may regard their infrastructure project as a significant incentive for these personnel to join institutions and/or pursue research careers, when in fact the researchers or students might be viewing a collection of infrastructure awards as significant incentives. If each project leader counted the same researchers/students, this would cause an overestimate of data points. On the other hand, some data points go entirely missing, where questions may be not be clear or the answers require immense effort to obtain. The latter situation pertains where there are very large or highly distributed projects. This would cause an underestimate of data points. With advice from the statistician and the focus group, these problems are being addressed and changes will be in place for the 2007 progress report questionnaire.

Finally, there is the issue of attribution. The research infrastructure investment made by the CFI, provincial and regional organizations and the institutions is only one contribution to a larger R&D endeavour at Canada's institutions. In addition to research support provided by federal and other agencies, there are many other contributing factors that affect the ability to precisely attribute impacts of investments to any one organization.

2.3 INTERPRETATION OF THE DATA

Despite the caveats listed above, the professional statistician and the CFI regard the yearly progress reports as a valuable source of trend data that now exceeds 3,100 entries for 2006. The CFI database of progress reports constitutes an important and unique source of Canadian R&D information that can be analyzed and mined for special studies. It is noteworthy that this database includes projects that span all disciplines and the full range of higher education institutions: universities, colleges, research hospitals and non-profit research organizations.

As evaluation projects and special studies are launched, homogeneity in data sets can be achieved by slicing the data into categories—such as by program, by sector, by size, and so on, depending on the topic to be examined.

3. Results

3.1 Overview of the CFI's Impact

The CFI established July 17, 2006 as the cut-off date for inclusion of data from 2006 project progress reports. By this date, 3,137 project progress reports had been received, out of a total of 3,256 required, a submission rate of nearly 97%. Of the 110 institutions expected to produce a summary report, 90 (82%) had submitted one.

According to the reports, approximately:

- 1,600, or 51%, of projects were fully developed and used for research throughout the past year;
- 1,150, or 37%, were partly developed, or developed at some point in the past year but not used for the whole year;
- 380 projects, or 12%, were still under development and had not been used for research in the past year.

3.2 Attracting, retaining and training R&D talent

Attracting and retaining creative and dedicated researchers, as well as helping these researchers to encourage and equip students in R&D careers, is a continuing challenge for institutions. Competition for highly skilled research personnel is intensifying around the world. Within Canada, state-of-art infrastructure acts as a significant incentive that institutions rely on to recruit and retain faculty. These researchers, in turn, are able to entice students and other highly qualified personnel to their facilities. Upon completion of their training many of the graduates join private enterprise, government or the non-profit sector. Others join other institutions in Canada or abroad, and some remain at the institution. Canada aims to achieve a net gain in research talent within the country and across different sectors. Canada can also benefit from the access to world knowledge that is aided by continued contact with departed trainees who go abroad.

Investments in research infrastructure are having a significant impact on the attraction and retention of researchers. **Since 2001**, the availability of research infrastructure has been an inducement for approximately:

- 8,050 researchers to join Canadian institutions at the faculty level—with 1,670 (~21%) coming from the US and 1,480 (~18%) coming from other countries.

These results are depicted in more detail in Exhibits 3.2a and 3.2b., showing geographic and sectors of origin of the researchers.

It is interesting to observe that 11% of the new research recruits come from outside the institutional sector. The S&T literature reports that researchers with experience in various sectors maintain their contacts and networks in different organizations throughout their career. These linkages help to sharpen their knowledge of different perspectives and applications and can lead to more effective knowledge translation in society. Knowledge translation is also greatly aided by mobile trainees. Graduates with training and exposure on the latest infrastructure, equipment and research methodologies may be the source of much value-added from the perspective of employers. These types of human flows contribute to increasing productivity and competitiveness in the economy.

Exhibit 3.2a
Geographic area of origin for researchers recruited to infrastructure projects (since 2001)

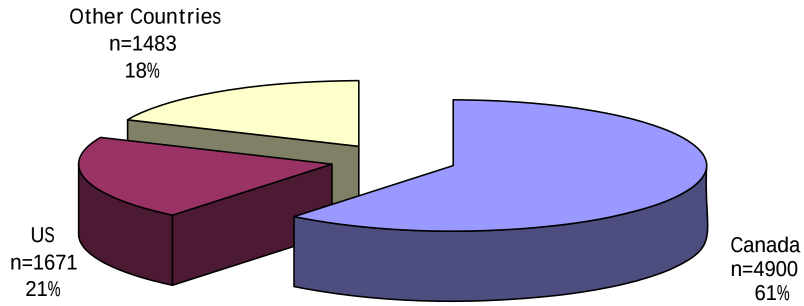
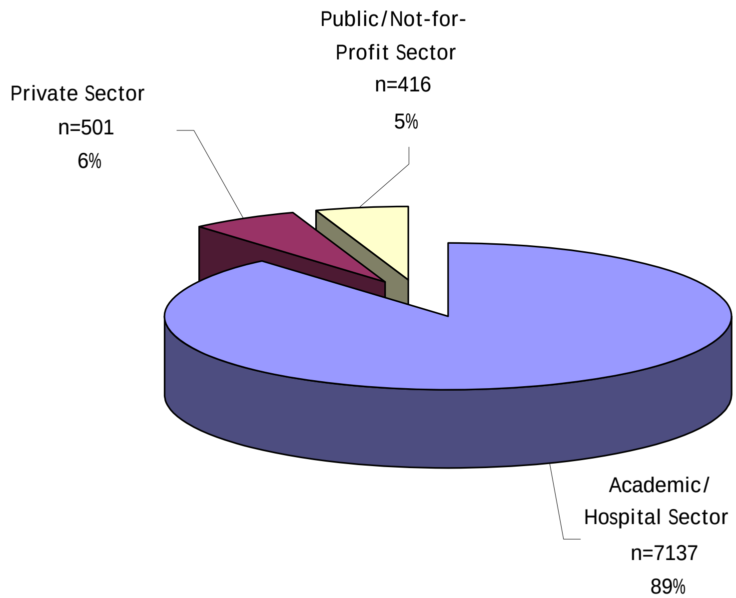


Exhibit 3.2b
Sectors of origin for researchers recruited to infrastructure projects (since 2001)



Critical care services can account for more than 30% of hospital budgets. The Critical Care Unit for Research Excellence (CCURE) at St. Michael's Hospital in Toronto (with a number of collaborating institutions) aims to increase the capacity of innovative critical care research in Canada by establishing state-of-the-art facilities and promoting multi-disciplinary collaborations ranging from the study of cellular mechanisms that lead to organ failure to the development of new tools for patient diagnosis, treatment, and monitoring.

The CCURE Infrastructure has been instrumental in the recruitment of top researchers in the field of critical care research–enabling collaborative research into lung injury, trauma, sepsis (including pre-eclampsia), and cardiovascular disease. The equipment has attracted international fellows and enabled linkages with industrial partners for sponsored research and clinical trials.

Since the beginning of the CCURE project, access to state-of-the-art equipment has allowed investigators to train approximately 50 postdoctoral fellows, students, and technical personnel. The trainees have gained a competitive advantage within the scientific community, with many pursuing further training and positions within the private sector community.

On the topic of training, data supplied in project reports indicate that in 2005-06, the research infrastructure was an important factor in the attraction of more than:

- 4,700 post-doctoral fellows (PDFs);
- 13,800 graduate students.

Exhibit 3.2c and 3.2d indicate the origin for these trainees. "Host institution" refers to the institution where the infrastructure is located.

Exhibit 3.2c

Geographic origin of PDF researchers attracted to infrastructure for their research projects in 2005-06

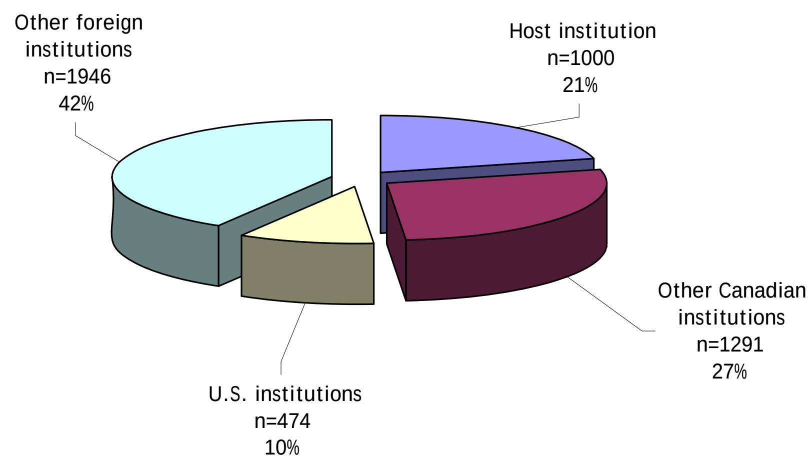
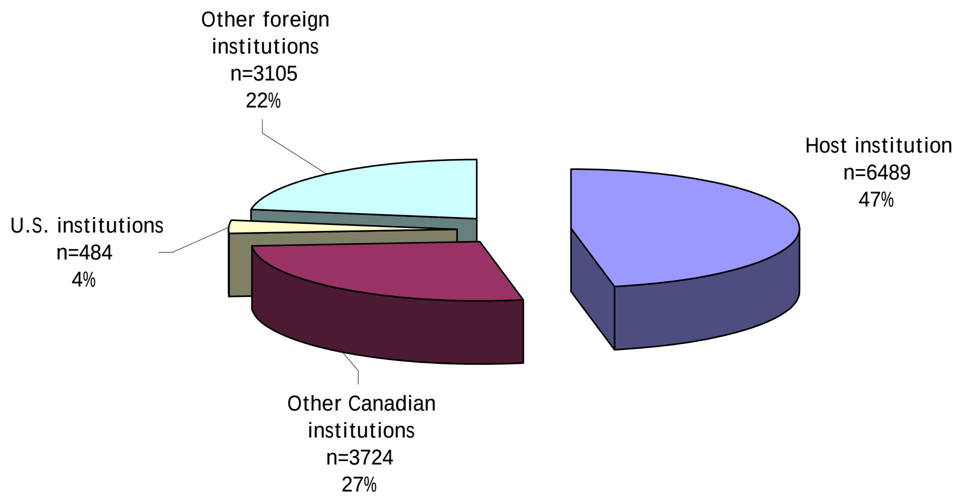


Exhibit 3.2d

Origin of graduate students attracted to infrastructure for their research projects in 2005-06



The Multidisciplinary Laboratory of Scanning for Natural Resources and Civil Engineering at the Université de Québec -- Institut national de la recherche scientifique is a world-class facility for image scanning. The laboratory has developed a new process for analyzing medical and non-medical images, using algorithms. It is a centre for excellence in environmental science and civil engineering.

This infrastructure has facilitated major breakthroughs in environmental sciences, including: significant insights in analysis of eco-systems in biology and geochemistry; analysis of climate change and paleo-climatic indicators, wood techniques, paleontology, and mineralogy; and focus on new norms for risk assessments of natural hazards, for example, mud slides.

The laboratory has also facilitated exploration of new alloys and ways to improve quality control in metallurgical engineering, the metallurgical industry and the study of composites, including concrete. The infrastructure has also been used to develop a new means of finding diamonds and new techniques for wood production.

In the first year of operation, only 5 students were involved. In the 4-years since, 7 PDF, 17 PhD, 24 MSc students and 11 trainees have participated in the project. Furthermore, another PhD student and 1 MSc student used the facilities for research. As the infrastructure opens to new research fields, collaborations with researchers from the U.S, the U.K., France and Sweden are expected.

The research infrastructure projects appear to be attracting trainees to Canada and retaining some of them. **Since 2001:**

- nearly 41,300 post-doctoral and graduate students have undertaken research projects where the infrastructure was or is a key resource.

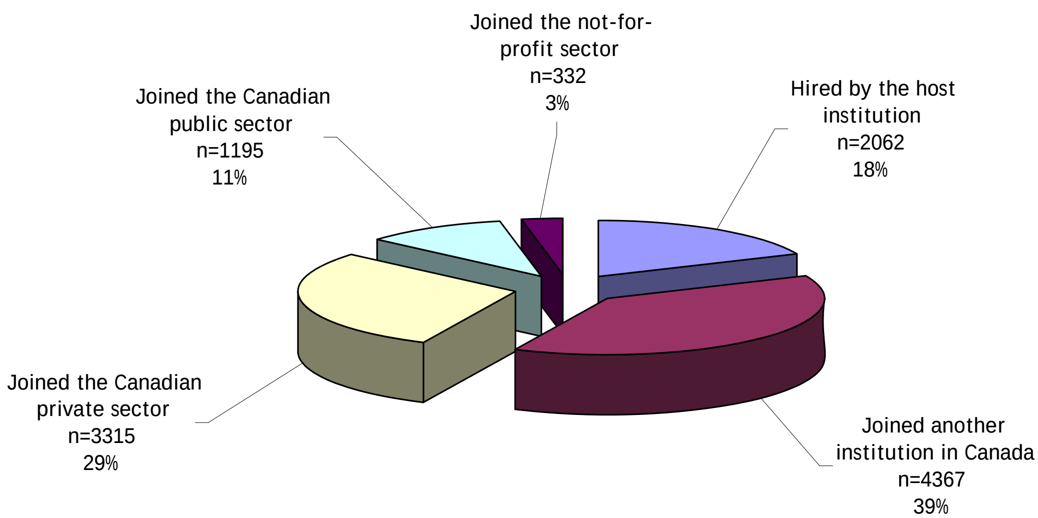
Project leaders often follow the career paths of the students that have worked in their labs. Respondents have provided information on the training and employment status of some 33,000 post-doctoral and graduate students who have received training on infrastructure in their laboratories. The data indicates that around two-thirds – approximately 22,000 - remain at the institution where the research infrastructure is located to complete their training. This is to be expected, given that it is still early in the life of some of these projects. About 11,270 graduates in the sample have finished their training and moved into various sectors of the Canadian economy. It is interesting to note that, since 2001, approximately:

- 4,840 (43%) of the graduates have joined the business, public and non-profit sectors;
- 6,430 (57%) have been hired by institutions, usually institutions other than the one that hosted the infrastructure.

Exhibit 3.2e provides further detail on the employment outcomes of these highly qualified employees.

Exhibit 3.2e

Graduates in the economy: Career paths of trainees with research exposure to research infrastructure (since 2001)

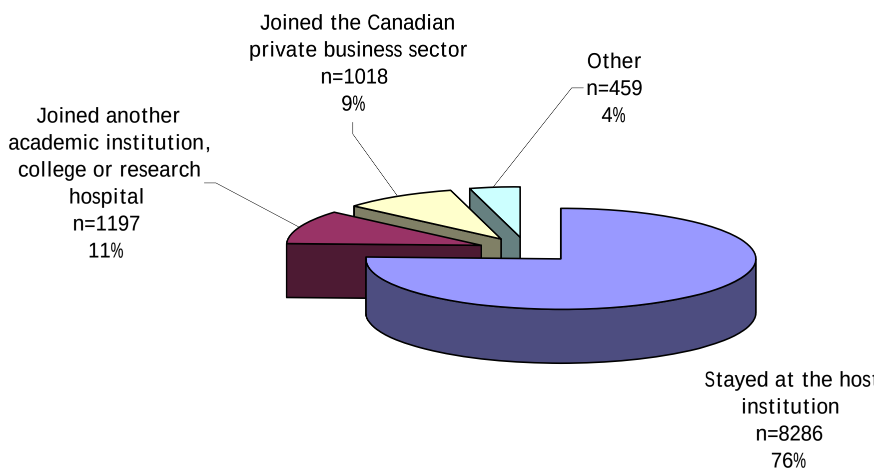


Different types of trained technical personnel are also being produced as a result of investments in infrastructure. Sophisticated research facilities, databases and equipment require highly qualified personnel for their operation. Some of the facilities may require new types of skills and knowledge that have not existed in the economy before. It may take years for management and technical personnel to develop complete mastery over the new scientific tools and to pass these skills onto others. Hence, institutions generally attempt to retain such people, who may take many years to train.

Since 2001, approximately 10,960 technical personnel have been trained on the use and maintenance of research infrastructure. The majority (87%) have been retained by institutions – usually the host institution but they have also been recruited by other institutions. Details are provided in Exhibit 3.2f.

Exhibit 3.2f

Highly-qualified personnel: Employment of technical personnel trained on research infrastructure (since 2001)



The people who are trained on the leading-edge infrastructure as its managers and technicians are often the same who will be required to upgrade, re-develop or master the new facilities of tomorrow. These highly skilled personnel—such as those capable in high-performance computing, mass spectrometry, robotics, and magnetic resonance imaging are critical to the maintenance of innovation capacity at Canadian research institutions.

More than 4.2 million Canadians are affected by impaired or disabling mobility function. The infrastructure at Queen's University *enables the collection of key metabolic, biomechanical, and neuromuscular measurements to understand the physiological mechanisms of mobility, develop ways to measure impairment and disability, and evaluate new treatment interventions. It is unique in its focus on activities of daily living rather than gait alone. New interfaces to enable simultaneous data acquisition and the continued development of analysis modules to integrate the data have created an innovative approach to study human mobility and its limitations.*

The work has enriched our understanding of the limitations to mobility in aging or disability. As a critical step in rehabilitation science, it provides benchmark data for introducing new intervention strategies or programs to help evaluate, enhance, and restore function and mobility.

The facilities have been instrumental in recruiting five new faculty members since the beginning of this project, and all but one have been retained. Technical personnel have also remained constant. This staff continuity has created an enriched environment for exchange of ideas and collaborative projects. Consequently, the laboratory is attractive to trainees and new research programs are developing.

3.3 TRANSFORMATIONS TO MULTIDISCIPLINARY, COLLABORATIVE RESEARCH

The R&D enterprise of the 21st century is remarkable because of its transition to a more team-oriented approach, drawing on different disciplines, and demanding collaboration across sectors. The complexity of contemporary scientific challenges requires different perspectives, methodologies and data sets, along with sophisticated tools. In addition, research is accelerating, enabled by information and communication technology which itself is undergoing constant change and upgrading. Many governments actively support the development of networked and multidisciplinary initiatives that encourage collaborative R&D, within countries and among countries, such as in the European Union. Research infrastructure is a catalyst for these new forms of interaction.

Data provided in the progress reports suggest that investments in research infrastructure—in particular large, complex facilities requiring buy-in by different research groups and funding partners—both enable and provide an incentive for multidisciplinary, collaborative research. Relationships are proceeding in Canada between institutions and their R&D partners in the wider Canadian society, and around the world.

Mouse models of human genetic disease are powerful tools to study the roles of individual genes or combinations of genes. At the University of British Columbia, the Laboratory for Functional Genomics of the Mouse (LFG) offers state-of-the art infrastructure for health research, including the Laboratory for Experimental Therapeutics in Animal Models of Human Disease. These facilities provide the opportunity for ongoing collaborations with researchers who need therapeutic compounds, cells, genetic material, etc. tested in mouse models. One collaboration has been with the Mouse Atlas of Gene Expression Project (Atlas), a five-year project that has collected data for both clinical and basic researchers.

The success of the Atlas project inspired the recently approved "Pleiades Promoter Project", funded by Genome Canada, Genome B.C., and others. This international project unites experts from different disciplines to focus on the regulatory sections of the gene. Insights gained will be used to build "MiniPromoters," paving the way for future gene therapies and research into the regions of the brain relevant for many diseases, including Alzheimer's, Parkinson's, Multiple Sclerosis, Depression, Autism, and Cancer. The Pleiades Promoters Project is a direct result of the state-of-the-art facility.

The LFG has drawn collaborators from both academia and industry, representing Canada, the US, Italy, Sweden, and the UK. Experts in bioinformatics, psychiatry, zoology, paediatric oncology, genetics, molecular biology, embryology, cardiology, neurology, and bioethics make use of this infrastructure.

In 2005-06, approximately:

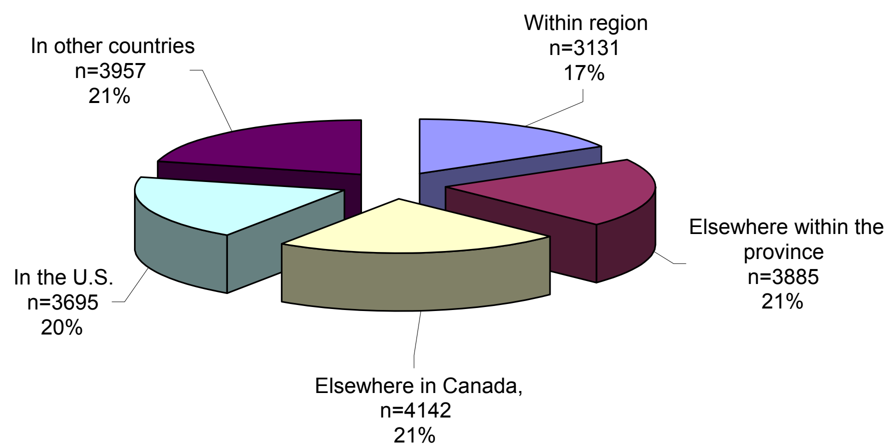
- 21,600 researchers advanced their research through use of infrastructure at their host institutions;
- an additional 18,800 researchers from outside the institution used the infrastructure.

In other words, more than 40,000 researchers took advantage of Canadian research infrastructure to undertake their investigations, and almost half of these came from beyond the host institution where the infrastructure is located.

Where are all of these outside researchers from? They came from all parts of Canada and around the world as shown in Exhibit 3.3a.

Exhibit 3.3a

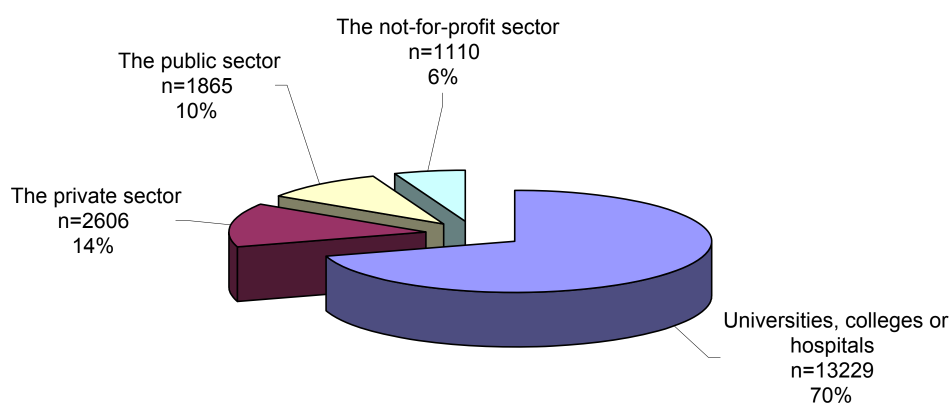
Geographic origin of researchers from outside the host institution using infrastructure (2005-06)



The outside users of research infrastructure at Canadian institutions come from different sectors of the economy, as shown in Exhibit 3.3b. It is evident the research infrastructure at Canadian institutions of benefit to many societal partners.

Exhibit 3.3b

Sector of employment of researchers from outside the host institution using infrastructure (2005-06)



On the measure of multidisciplinarity, project leaders report that since 2001, infrastructure has played a significant or critical role in drawing together different disciplines for 1,700 (or 61%) of research projects. However, there were differences between the types of fund, as follows. In nearly:

- 300 (or 79%), of developed IF projects, the infrastructure played a significant or critical role in drawing together disciplines;
- 1,400 (or 59%), of developed NOF and CRCIF projects, infrastructure played a significant or critical role in drawing together disciplines.

These results are consistent with the objectives of the three primary CFI funds. IF projects are normally expected to involve other researchers who are drawn together to tackle multidisciplinary research projects, often of large scale. NOF and CRCIF projects usually consist of smaller scale infrastructure investments that assist institutions to recruit and retain researchers. Such projects may involve team approaches, but may, on the other hand, simply form a critical piece of equipment in the laboratory of a newly recruited faculty member.

As for cross-sectoral collaboration, project leaders report that, for research projects enabled by infrastructure since 2001 the infrastructure has enhanced opportunities for collaborative research across organizations in more than 2,360 (or 82%) of projects. Interestingly, the differences between the different types of funds were slight. Approximately:

- 91% for developed IF projects;
- 82% for the developed NOF and CRCIF projects.

The Institute for Materials Visualization and Analysis at the University of New Brunswick conducts leading-edge research using magnetic resonance imaging, scanning and transmission electron microscopy, electron-probe microanalysis, and radiation tomography. Most equipment was installed in UNB's Microscopy and Microanalysis laboratory. More than 100 internal and 40 external users were in the lab last year. External users included other universities, companies, federal and provincial R&D agencies, and municipalities.

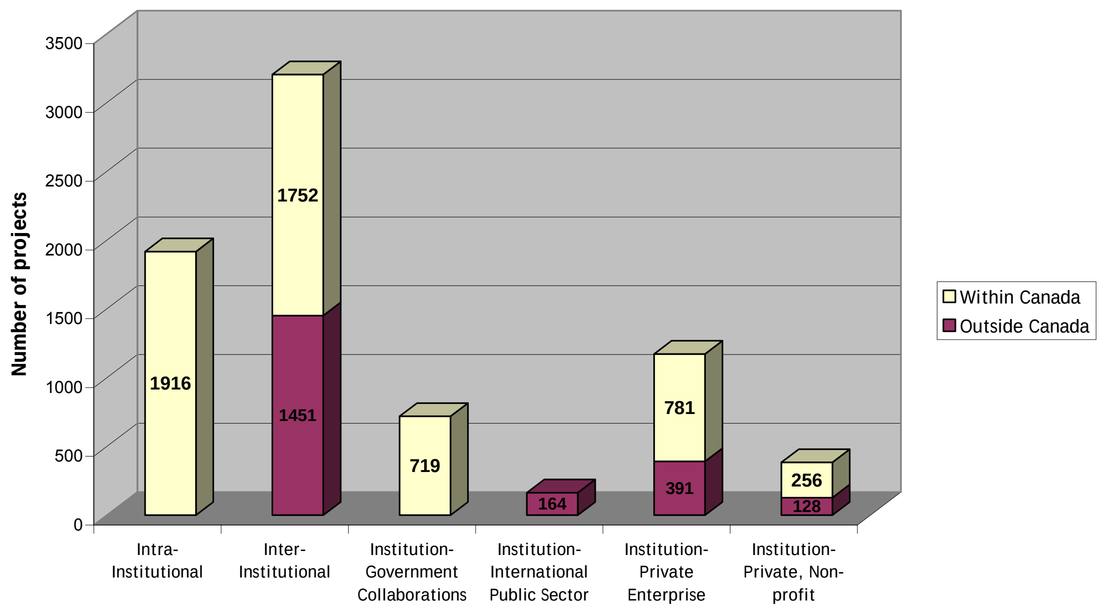
The techniques and infrastructure are the best available in the world for the study of fluid content and fluid movement in porous media. This is critically important in the petroleum industry. In the last two years the Institute has received grants, contracts, and collaboration requests from numerous international oil companies. Perhaps more importantly, the technologies developed employing the CFI-funded infrastructure have led to the establishment of a new spin-off company, Green Imaging Technology, which is developing and marketing a new testing technology for the oil industry.

Several of the original applicants are involved in environmental geochemistry research. This work continues and will be utilized by Ontario Power Generation, among others, in evaluating low level nuclear waste storage sites.

Much of the work examining materials involves the study of processes for their fabrication and also deterioration. These studies are very general in their application, ranging from studies of hydrogen storage media to remediation of concrete materials.

There are different types of collaborations, and for large projects, one or more types can be taking place. Since 2001, types and instances of collaboration in the projects are illustrated in Exhibit 3.3c

Exhibit 3.3c
Collaborations enabled by the infrastructure (since 2001)



The data indicate that ample collaboration between organizations is occurring. It is interesting that the number of inter-institutional collaborations at the international level is approaching the number at the domestic level. Also noteworthy is the large number of collaborations reported with the private sector.

3.4 SUPPORTING REGIONAL INNOVATION

Many policy analysts regard innovation as primarily a local and regional process, driven by competitive business or agency needs, but involving knowledge translation—the movement of people and ideas across organizational boundaries—and the application of resources, including investment, to capitalize on ideas and new capability. These same analysts often view

The Centre for Marine and Aquatic Resources (CMAR) at the University of Prince Edward Island is working in collaboration with a number of academic, government, and private institutions to safeguard marine resources, and lead in the field of aquatic biology and fish health research.

Projects include a reference laboratory for infectious salmon anaemia (ISA) at the Atlantic Veterinary College. A database of all ISA virus isolates from disease outbreaks on Atlantic salmon farms in the Bay of Fundy from 1997 to October 2005 provides an understanding of the viruses, better strategies for early recognition of viruses with an epidemic potential, and design of better control methods and vaccines. The world's first effective vaccine directed against a microspordial disease was developed, working on the fish parasite Loma salmonae. Work is also being done with the Lobster Science Centre to study the population structure of Homarus americanus in the PEI region. In addition, in 2005 the CMAR's electron microscope was instrumental in the diagnosis of viral haemorrhagic septicaemia (VHS) in the Great Lakes, never previously described in Eastern North America. The equipment has proven both essential and timely in screening wild birds in Atlantic Canada for avian influenza as part of Canada's Inter-Agency wild Bird Influenza Survey (2005-2010).

universities and other training institutions as real or potential cornerstones for regional economic and social development.[5] Different S&T policies around the world include a focus on the role of universities, technical institutes and colleges to support or stimulate local research, technology development, relevant training and professional development that cultivates regional entrepreneurialism, and helps to link expertise and knowledge with other societal partners.

With these notions in mind, the CFI has begun to determine whether investments in infrastructure have had some influence in encouraging researchers within a locality or region to collaborate across different sectors. According to the project progress reports, the number of outside users of the research infrastructure that come from the local level is essentially at a plateau, with data for the past three years, as follows:

- 2004 ~ 3,080 (30% of users outside the institution)
- 2005 ~ 2,960 (23%)
- 2006 ~ 3,130 (17%)

The decrease in proportion of local outside use is due to the increase in proportion of outside use by national and international researchers. (See next section) A sample of more specific data is presented in the following table.

Average number of outside, local users of research infrastructure at groups of Canadian institutions per city, 2004-05-06.

Rank	City	Average # of local users
1	Montreal	694
2	Toronto	685
3	Vancouver	264
4	Edmonton	191
5	Ottawa	167

An interesting finding was that there was, on average, more intensity of outside use by municipal residents in smaller communities and cities, measured as number of municipal users per $M of CFI investment in the municipality, for 2004-05-06. Winnipeg (rank 4) and Victoria (rank 6) showed high municipal intensity of use, but Toronto scored high in this measure (rank 2) as well.

In contrast to the flat trend line for outside use of research infrastructure by local researchers only, there is an increasing use of this infrastructure by researchers working within the province, at least on average in Canada. However, this increased use holds true for the absolute numbers of users, but not the proportion of total outside use, as follows:

- 2004 ~ 4,670 (46% of users outside the institution)
- 2005 ~ 5,360 (42%)
- 2006 ~ 7,020 (37%)

Hence it appears there is a growing supply of provincial outside users of the research infrastructure, but that the growth rate is more pronounced for researchers from all across Canada and from abroad. This is discussed further in Section 3.5.

Project leaders were questioned as to whether they consider that the investments made in research infrastructure have had any influence in the development of local technology clusters.

[5] For example, a summary of the debate and the literature is available in Chrys Gunasekara, “The generative and developmental roles of universities in regional innovation systems,” *Science and Public Policy*, 33 (2) March 2006, pp.137-150.

Over two years, there was an increase in the number of institutional infrastructure projects that are deemed to be important in such clusters, as follows:

- 2005 – 890 (36%) of infrastructure were judged important to clusters;
- 2006 – 1110 (38%).

Hence, in absolute terms, research infrastructure investment appears to be contributing to R&D relationships at the local and regional levels. The flat trend line for the municipalities indicates that there is a given number of relationships that can be formed —at least in the short term—within the smaller geospatial area. In other words, there is limited supply of researchers at the local level in the short term. Another conclusion that may be drawn is that the research capacity that has been developed through investments in research infrastructure is being broadly exploited – and the regional centre may stand to benefit from the relationships being formed between the different types of R&D partners.

Fieldbus technology is primarily a networking protocol (using digital communications) for the process industry. The lab infrastructure provides a vendor-neutral site to evaluate and demonstrate interoperability among control equipment, products, and systems. With access to real-time plant processes, automation manufacturers, developers, and end-users are able to test and evaluate equipment in an academic backdrop. The primary mandate of the SAIT Polytechnic Foundation Fieldbus lab is to support the adoption of fieldbus technology through training and applied R&D opportunities.

This technology benefits Canadian process industries by streamlining operations and maintenance activities, thus reducing project lifecycle costs. Other benefits of using this technology include increased safety, greater preventative maintenance opportunities (asset management) and more reliable and tighter control of industrial processes (higher quality products).

The lab was the first in the world sanctioned and mandated by the Fieldbus Foundation (Austin, TX) for the development of a training curriculum, construction of a lab facility, and establishment of that facility as a demonstration and research site. It continues to be recognized as the premier training and demonstration site in the world.

The infrastructure has had significant influence in the formation of regional technology clusters. SAIT Polytechnic has conducted training throughout Alberta and provided the host site for adoption of fieldbus technology by a major oilsands producer. In addition to the oil and gas industry, training has also been provided to wastewater and waterworks industries.

3.5 ENHANCING INTERNATIONAL COMPETITIVENESS

The increases in public funding of R&D at Canada's institutions in the past several years have transformed the research landscape. Many of Canada's researchers and institutions have achieved an international profile; a transformation that is critical for Canada in its efforts to establish an R&D niche in the global economy.

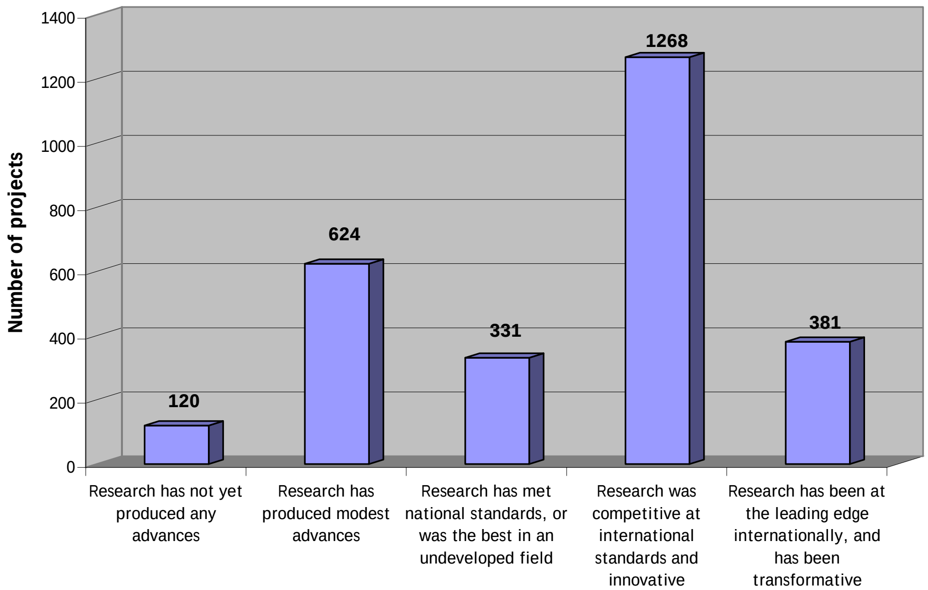
Research infrastructure takes on a particular importance in this endeavour. Canada is seen as a country with the facilities to conduct leading-edge research that secures the interest of colleagues around the world. It also attracts students and helps to lever domestic and international financial support beyond the traditional public sector sources. The net result is an advancement in research quality and productivity that can compete with the best in the world. These themes emerge for the research infrastructure projects supported by the CFI and other funders. The findings from project progress reports are documented in what follows.

With respect to research quality and productivity, project leaders indicate in their reports that, for projects started anytime since 2001:

- 44% have been competitive at international standards and innovative;
- 13% have been transformative and at the leading-edge internationally.

Exhibit 3.5a provides more detail on the responses of researchers to the question of research productivity.

Exhibit 3.5a
Research enabled by the infrastructure since the beginning of the project



Note: Excluded from this exhibit are infrastructure projects that were not yet sufficiently developed for research (ie. recent awards).

Respondents to the questionnaires were asked to provide their own measures of research productivity. They cited traditional indicators such as publications, citations, speaking engagements at conferences, patents, spin-off companies and prizes. Other measures cited were the development of new experimental models and methodologies that will be tested in clinical research or that have been accepted for clinical trials, development of libraries of biological probes, mathematical models successfully applied to systems issues in the public sector (eg. traffic flows). Some reported increased international interest by foreign researchers for faculty positions opening up at the host institutions of the infrastructure, others the securing of outside sponsorship for new faculty positions due to quality of the facilities and the research.

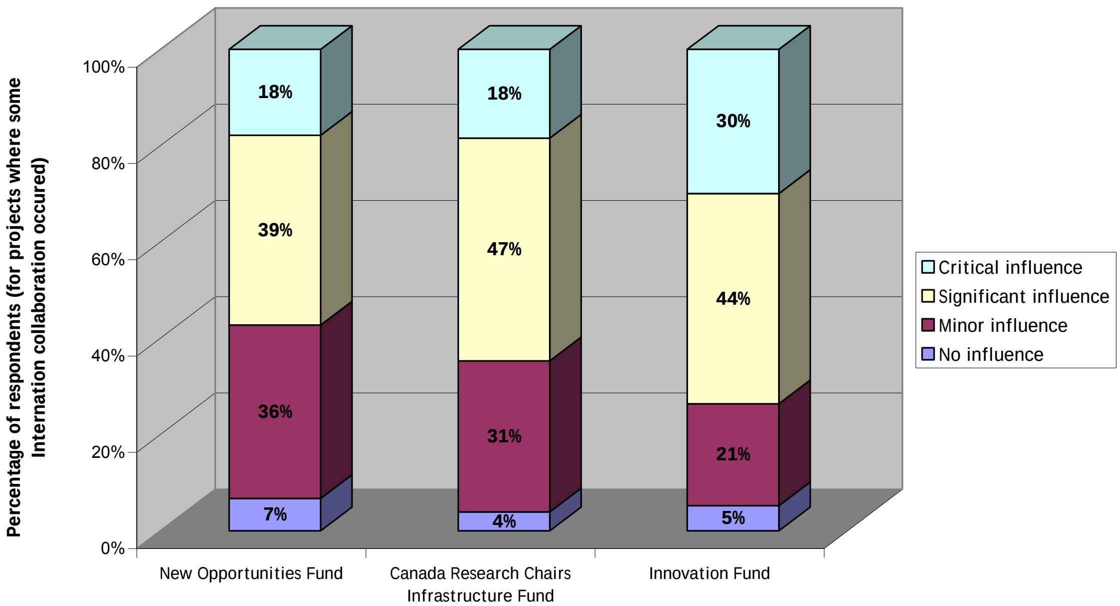
On the question of the influence of research infrastructure in fostering international collaborations **since 2001**, approximately:

- 82% of respondents considered that the infrastructure had some influence in fostering international collaborations;
- 17% report that the collaboration would not have happened without the infrastructure.[6]

[6]International collaboration is defined in terms of joint research, the mobility of students and technical personnel, and participation in international networks.

There are differences among project types on the question of how influential the infrastructure has been in encouraging international collaboration, as depicted in Exhibit 3.5b. Innovation Fund infrastructure projects have exerted the strongest pull to global partners.

Exhibit 3.5b
The effect of infrastructure on international collaboration



The use of Canadian research infrastructure facilities by foreign researchers is increasing substantially. Researchers are coming to Canada to work in partnership and take advantage of the facilities. According to the project progress reports, the number of outside users of the research infrastructure that are coming from abroad is as follows for the three preceding years:

- 2004 ~ 3,700 (36% of users outside the institution), of which 1,550 were US researchers;
- 2005 ~ 4,900 (39%), of which 2,100 were from the US
- 2006 ~ 7,650 (41%), of which 3,700 were from the US.

The computational infrastructure at the iCore Wireless Communications Laboratory, (iWCL) at the University of Alberta, has facilitated leading-edge international research. The infrastructure has enabled collaborative research with MIT, Ohio State University, and the University of Missouri. Beyond North America, collaborations are in place with researchers at the University of Modena, Italy, and Huawei Technologies in China, as well as Samsung and ETRI in Korea. Closer to home, the infrastructure has assisted in forging links with the University of Calgary and the University of Alberta's own Mathematics Department.

Work at iWCL has been instrumental in papers on: environmental management, environmental and resource economics, acoustics, water resources research, physics, operational research, chemical physics, fluid physics, and health physics. Since the beginning of the iWCL's project, members have published 144 papers in international journals, delivered 242 conference papers in leading international conferences, and filed eight patent applications. The infrastructure is a significant factor in recruiting the best foreign graduate students. And, the iWCL laboratory sponsors invited guests from universities, distinguished industry groups and research laboratories from around the world.

This increase is primarily due to an influx of visiting researchers from the US: its trend line as a proportion of total outside use of the infrastructure has moved from 15% to more than 19%, while the proportion of use by researchers from other countries has remained at about 21% for the three years.

Funding from sources other than the Canadian public sector is a signal that the research is relevant to various societal users of the knowledge. Private sector and international funding is quite significant among research projects that have also received infrastructure funding. **In the past year**:

- 1,174 or 37% of project leaders report that they have received Canadian industry funding. Of these:
    - 674 (57%) said that the research infrastructure had a significant impact on their ability to attract these funds—an increase from 569 (54%) in 2005.
- 1,091 or 35% of project leaders report receiving international funding, and of these:
    - 607 (56%) stated that research infrastructure funding had a significant impact on their ability to attract funds from this source; an increase from 525 (54%) in 2005

*National and international projects at **Dalhousie University's** Cosmogenic Nuclide Exposure Dating Facility span the fields of active tectonics and related earthquake hazards, glacier dynamics and paleoclimatology, geodynamics and landscape evolution over timescales of thousands to millions of years, DNA-based phylogeography, and applied research involved in the analysis of desert environments for military tactics, mineral exploration, archeology, and regulatory decisions for nuclear waste disposal.*

Over half of the 700+ isotopic samples measured by the group since 2001 are for internationally-collaborative projects, including partners from the United States, Argentina, and Norway.

Many applications of cosmogenic nuclides have or will have an impact on climate models, natural hazard risk analysis, and landscape evolution in response to climate change.

The Large Optical Telescope (LOT) is the Canadian portion of an international effort to design and build a powerful new ground-based telescope. The project is supported by a new national consortium (ACURA) of 21 Canadian universities in partnership with the National Research Council of Canada. The University of Toronto hosts the LOT project. ACURA is one of four equal partners in the Thirty Meter Telescope (TMT) project, along with Caltech, the University of California and AURA, the US counterpart of ACURA.

The telescope will be a landmark facility of the 21st century and will address new science with new technology that will enable performance improvements and cost reductions. The large aperture will have 10 times the light gathering power of any existing telescope, and will make images ten times more precise than any other telescope. Scientific goals include characterizing extra-solar planets (which were unknown a decade ago), searching for the very first stars to have formed after the Big Bang, studying the million solar mass black hole in the centre of our own galaxy, and measuring properties of the dark matter and dark energy that dominates the dynamics of the expansion of the universe. TMT will be an important complement to a major new radio telescope being built in Chile and the successor to the Hubble Space Telescope, the James Webb Space Telescope, both of which include Canadian participation.

3.6 Sustaining Leading-Edge R&D

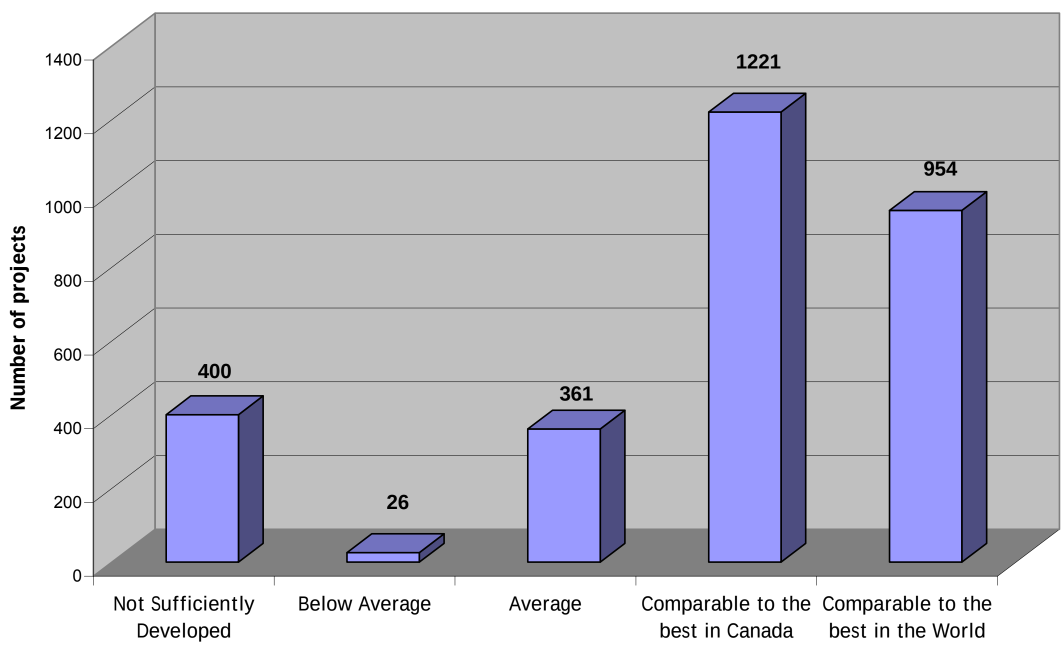
The CFI's mandate is to strengthen the capacity of Canadian institutions to carry out world-class research and technology development. This mandate is being achieved, through investments in research infrastructure by the CFI and its funding partners in the provinces, regions and the private sector. Creative, dedicated researchers have been attracted to the Canadian scene and world-class R&D centers have emerged. A key challenge, today, is to sustain the levels of investment in research infrastructure to keep Canada at the leading edge.

Respondents were asked about the comparability of their research infrastructure with that in the rest of the world. In the past year**,** among the projects fully or partially developed:

- more than 950 (37%) indicated that their infrastructure projects were comparable to the very best in the world; if only the larger, more complex IF awards are considered, the proportion rises to 52%;
- more than 1,200 (48%) considered that their infrastructure projects were comparable to the best in Canada;
- 26 (1%) stated that their infrastructure projects were below average compared to other labs.

The 26 projects that reported "below average" in comparison to other infrastructure cited concerns such as delay due to instrument repair, project relocation, and difficulty finding technicians. One project noted growing pains due to a facility that was too small for a rapidly growing project. Obsolescence was also a theme, especially among older projects in fields such as computing where technology was evolving rapidly.

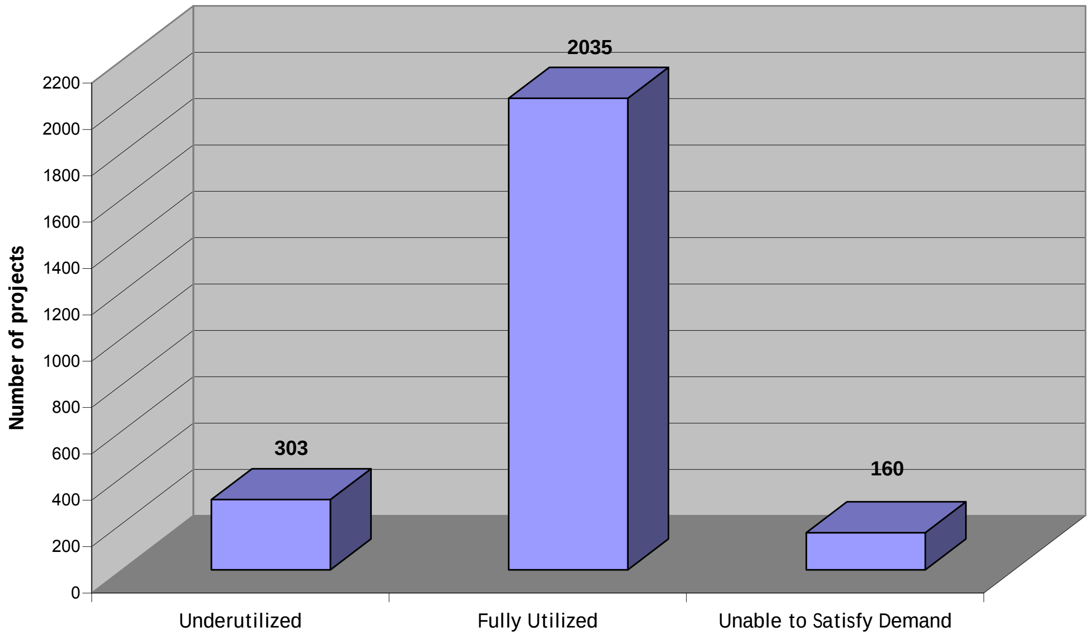
Exhibit 3.6a
Infrastructure status (2005-06)



Among the sample of projects that were fully or partly developed in the past year, about:

- 2,035 (82%) were fully utilized;
- 160 (6%) were not only fully utilized, but unable to keep up with demand;
- 303 (12%) were underutilized.

Exhibit 3.6b
Infrastructure Utilization (2005-06)



The data point to two primary reasons for underutilization. Some projects are only partly developed while nevertheless being used for at least some research. Until they are fully developed with all components, technical personnel in place, and so on, they are often not fully utilized. Another reason is that some projects lack funds and technical support for ongoing operations and maintenance (O&M). Approximately one-third of the underutilized projects indicate that it has been difficult to obtain O&M funds.

O&M funding is used for technical personnel, to purchase supplies, to undertake minor upgrades, and to secure maintenance contracts. The need for O&M funding to support the capital investment in infrastructure has intensified in recent years. Of the infrastructure projects sufficiently advanced to require funds, difficulty in securing sufficient O&M support was experienced by approximately:

- 18.2% (329) projects in 2004;
- 19.8% (437) projects in 2005;
- 20.4% (525) projects in 2006.

Closer analysis carried out by the CFI reveals that the NOF awards, for example, experienced somewhat less difficulty in obtaining O&M funds—with 18.4% of these projects experiencing challenges in 2006, whereas 27.1% of the large IF projects have encountered difficulties in obtaining O&M funding. The CFI recognized this problem and, with the approval of the federal government through its Funding Agreement, established the Infrastructure Operating Fund (IOF). The IOF has contributed to the O&M costs of projects approved after July 2001 and data indicate that it has been largely successful in addressing the O&M needs of these newer projects.[7] However, issues remain for the larger-scale, long-term projects whose state-of-the-

[7] For example, among the sufficiently developed IF projects reporting difficulty with O&M in 2006 (n=92), the majority, or 68 (~74%) did not receive IOF support, usually because they were not eligible for it. In contrast, for those IF projects funded after 2001, and which were eligible for the IOF, 39 (~14%) experienced difficulty with O&M costs.

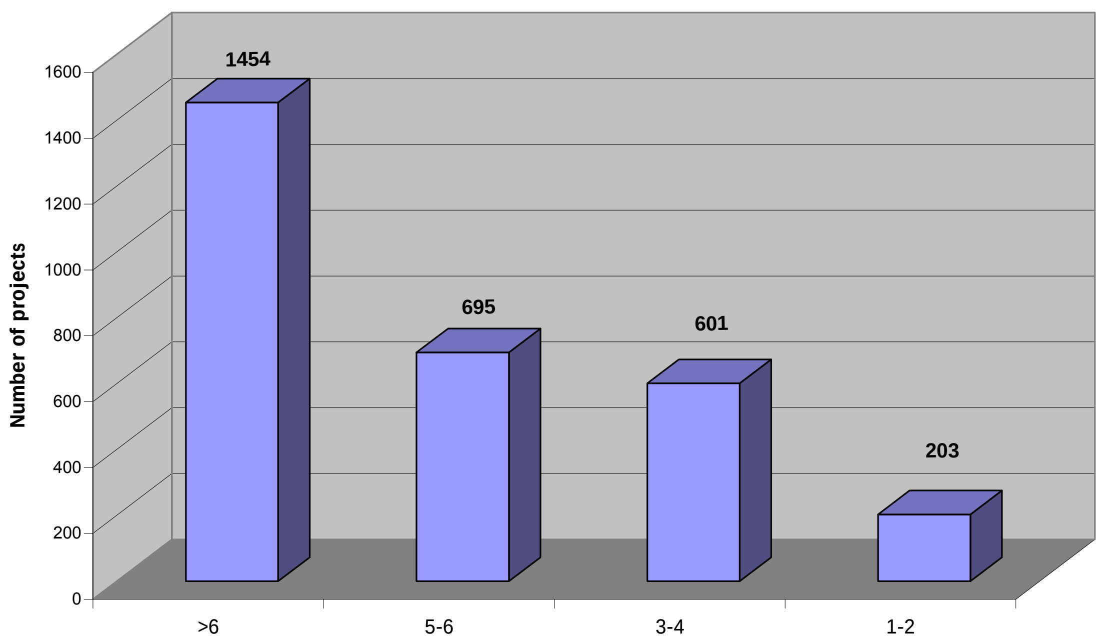
art lifetime exceeds the three to five years estimated by the IOF.

Research infrastructure—especially buildings—may in fact have a much longer *useful l*ife. Data collected on this topic from the 2006 reports indicates that for projects funded since 2001, approximately:

- 2150 (73%) of infrastructure projects have more than five years of useful life left;
- 600 (20%) have three to four years of useful life left;
- 200 (7%) have only one to two years of useful life left.

These results are depicted in more detail in Exhibit 3.6c.

Exhibit 3.6c
Years of useful life of infrastructure remaining (2005-06)



Just as critical for the future of R&D at institutions is the need for infrastructure to be continually refreshed, upgraded or replaced to remain "state-of-the-art". Without further investment, there is a high risk that competitive teams will dissociate and new, young researchers will not be attracted to research or to Canada. The CFI launched an independent report in 2006 to look into this matter.[8]

Hence, there are, at minimum, two issues to be considered on the question of sustaining Canada's capacity for innovation as it relates to research infrastructure: the need for adequate O&M, and the need to sustain state-of-the art capability. These issues are being explored and considered by the CFI.

[8] KPMG, *Future Investment Required in Canadian Research Infrastructure: Final Report*

3.7 GENERATING ECONOMIC AND SOCIAL BENEFITS FOR CANADA

As is evident from the data presented in this report, the CFI's infrastructure investments are attaining their goal of building the capacity for innovation at Canadian research institutions. The question is, in Canada and elsewhere, how do investments in R&D at institutions, including research infrastructure, translate into social and economic benefits for the nation? Providing a reliable answer, based on a standard methodology, is currently beyond existing approaches. A great many agencies throughout the world are grappling with the issue, working with the Organization of Economic Cooperation and Development (OECD), for example.[9] The CFI aims to elaborate evaluation approaches that will contribute to an understanding of the role of research infrastructure, and the overall Canadian effort.

For the purposes of this analysis, overall results are provided that summarize the reported experiences and perspectives of researchers on the topic of social and economic impacts. This is an imprecise measure that is only provided to indicate trends. In addition, a small sample of "mini-case studies" is documented to provide insights on some projects.

> *The infrastructure for Molecular Genetics in Muscular-Skeletal Diseases at the Université de Montréal has contributed to major breakthroughs in understanding the molecular mechanisms that cause idiopathic scoliosis – a type of spinal deformity. In fact, researchers have discovered new methods for early detection of idopathic scoliosis and four patents are pending.*
>
> *An agreement with Paradigm Spine of New York will enable clinical validation and eventual commercialization of technologies developed with this infrastructure.*
>
> *Work is also underway to find ways to prevent or stop scoliosis. In the field of osteoarthritis, new tools are being developed for molecular screening, in the hope of creating innovative pharmaceutical treatments.*

The following overall results can be reported. Of the total 3,137 project reports submitted, approximately 2,515 (80%) stated that the research supported by the infrastructure has helped to generate economic and social benefits. Respondents were asked to provide data on various measures, and the quantitative results were as follows. Note that many reported that their projects had impacts in more than one area, and that the figures refer to the *instances* of the measures. Project leaders report that, **since 2001**, there have been:

- 653 instances of new or improved public policies & programs;
- 837 instances of new or improved products, processes or services;
- 528 instances of intellectual property rights;
- 504 instances of public or private sector jobs created;
- 155 instances of spin-off companies;
- 1139 instances of other benefits.

MINI-CASE-STUDIES ILLUSTRATING SOCIAL AND ECONOMIC BENEFITS

The Centre for Global eHealth Innovation, a joint effort of the University Health Network and the University of Toronto, provides human, physical and virtual resources to explore how to improve health care through the use of information and communication technologies. Using the state-of-the art infrastructure at the Centre, funded by the CFI's **Innovation Fund**, experts in the social sciences, technology and health fields collaborate to improve people's quality of life and the efficiency of health services.

[9] See http://www.oecd.org/document/24/0,2340,en_2649_34451_37075032_1_1_1_1,00.html

Services at the Centre focus on two fundamental questions: How can we adapt technology to satisfy the needs of the user? How can we promote collaboration across traditional institutional, political, cultural and geographic boundaries? And in the search for creating/improving technology, the limits of technology are also recognized. For example, in designing security devices (with the blackout of August 2003 in mind), traditional keys and locks are used, instead of electronic systems, to open doors in many parts of the facility.

Some of the current programs/services at the Centre include:

- A broadcast studio with state-of-the-art equipment used to promote remote collaboration and group activities. This infrastructure supports Webcasting to up to 400 different locations, "webinars" (web seminars) and simultaneous videoconferencing to up to 80 different sites. Secure or public (depending on the circumstances), this facility can involve an almost unlimited number of people via the Web, cell phones and interactive television.
- Use of this studio to compress geographical and political distance. This was evident in a recent conference that supported CISEPO (Canada International Scientific Exchange Program) to involve Jordanian, Palestinian and Israeli "moderate" academics and clinicians routed through Toronto, to exchange ideas with each other, while accessing British resources.
- Precise technical support. As an example of eHealth innovation, the Centre's human factors engineers determined that the camera used in "face to face" interaction needed to be placed above the screen at a seven degree angle to create the impression of eye to eye contact, thus allowing virtual intimacy to be comparable to real physical intimacy.
- A usability laboratory to evaluate technology and software from the human perspective. The goal is to create more intuitive, safer devices used by health care professionals and the public at large.
- A virtual laboratory. In Canada where 8,000 to 10,000 people die annually because of medical errors, this laboratory explores HOW people make mistakes. It gives medical personnel and medical technology designers the opportunity to talk about mistakes and explore appropriate solutions.
- Remote controlled video cameras, microphones, and computer screen capture software, used to test and evaluate user ease and the possibility of error in technical devices.
- A virtual clinic that enables health professionals and patients to interact over the Internet and the telephone, avoiding unnecessary office visits and thus cutting travel costs, inconvenience and human suffering.
- Programs to provide diabetes and high blood pressure patient monitoring via cell pone technology; this arrangement helps to prevent "white coat readings" (a term used to describe unusually high values, due to stress, which may occur in doctor's offices). Patients are thus able to follow their own health monitoring – instead of waiting for a doctor or nurse to inform them – and may be more responsible for their own health care.
- A multi-tasking simulation laboratory designed exclusively for high-fidelity usability testing of eHealth innovations**.** Like a film set, it has movable walls, with furniture and props to simulate any health care environment (operating room, doctor's waiting room, post-surgery recovery room or a home bedroom). This environment creates natural conditions for performing health related tasks. Medical personnel, patients and actors participate in the simulations, providing feedback on how to improve devices, roles and workflows.
- A current experiment in at-home hemo-dialysis that could potentially cut the costs of this highly sophisticated service by 50%. Again, patient comfort with the technology is at the heart of this experimental process and the system has already been modified to

ease patient anxiety about dialysis hardware disconnecting while the user is sleeping at home.
- An operating room set-up that has been used to evaluate anaesthesia technology and simulate catastrophic events. This is used, once again, to develop technology so intuitive that tragedy can be averted.
- A mock-up of a doctor's waiting room, used to evaluate technologies useful in preparing patients for doctor/patient appointments. Studies indicate that doctors interrupt patients in less than a minute after consultation commences; this has lead to an exploration of methods to identify priority questions for patients, assessable via the Internet. For patients without Internet resources, coaches are being trained to assist those who do not read or write or for reasons of age, immigration or poverty cannot access the technology themselves.

In the words of eHealth's founding Director and project leader, Dr. Alejandro Jadad, "The world becomes our living laboratory."

And to create or improve technology for this to happen, Dr. Tony Easty, Chair of the Centre's Management Committee and Director of the Department of Medical Engineering at UHN, says, "We are user-centric. Technology has to make sense to people."

This collaboration between anaesthetist, Dr. Jadad, and engineer, Dr. Easty, and among many other committed innovators is to ensure that the RIGHT choice becomes the EASY choice.

◘ ◘ ◘

The Enhanced Oil Recovery Research Infrastructure (EORRI) at the University of Regina promises significant changes to the environmental impact of heavy oil recovery.
With EORRI technology, there will be no need to burn oil, with the danger of greenhouse gas emissions. Elaborate surface facilities are not necessary to this process either. Heavy oil recovery is accomplished by injecting a diluted solution of mainly alkalis, which will be recycled into underground reservoirs.

This infrastructure, funded by the CFI's **On-Going New Opportunities Fund**, has completed the Phase I conceptual study, Phase II laboratory tests and demonstrations and is now in Phase III, a field development program in collaboration with the Petroleum Technology Research Centre (PTRC). The field test site is near the Alberta/Saskatchewan border.

A Fluid-Rock Ultracentrifuge and a Spinning-Drop Interfacial Tensiometer are used in the process of injecting dilute alkaline solution to interact with heavy oil underground, creating very low or ultra-low interfacial tension. With this low oil/water interface tension, the heavy oil flows easier and the water is used to transport oil for recovery from a deep reservoir. This technology, called Dispersion-Alternating-Displacement Technique, increases recovery (15 to 20% in laboratory tests) over routine water recovery systems. If successful, this process could increase oil recovery efficiency, increase the recoverable oil reserves and increase production for the majority of Saskatchewan's heavy oil reservoirs and many heavy oil reservoirs in Alberta.

Dr. Mingzhe Dong, EORRI's Project Leader, says, "Saskatchewan accounts for 62% of Canada's heavy oil resource, including 1.7 billion cubic meters (m3) of proven and 3.7 billion m3 of probable reserves." He goes on to say, "New non-thermal enhanced oil recovery (EOR) techniques developed by the EORRI will maximize the recovery potential and profitability of these heavy oil reservoirs and potentially recover 85 million m3 more heavy oil in Saskatchewan if only an incremental recovery of 5% initial oil-in-place is achieved in field implementation of the process."

Clearly, increased oil recovery without environmental damage is important for Canada's economy and environmental well-being.

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The **Centre for Studies in Autobiography, Gender and Age (SAGA)** at the University of British Columbia, funded by CFI's **Innovation Fund**, is the first of a pan-Canadian network of comparable projects. Similar centres are now at Wilfred Laurier University in Waterloo, Ontario and Concordia University in Montreal. Inter-disciplinary from its inception, SAGA grew out of a collaborative project on Narratives of Disease, Disability and Trauma involving UBC colleagues from the Social Sciences, Health Sciences and Humanities. It has now expanded its mandate to include racialisation as a central element in life experience, in addition to gender and age.

"We have realized that we need to integrate ethnicity and race. Our connections to health have broadened to consider various types of intergenerational cultural transmission through religion and customs, even cooking," says Valerie Raoul, founding Director of SAGA.

Dr. Raoul adds, "The study of life stories in relation to gender doesn't exclude men, but looks at relationships."

The SAGA Centre exists to foster research in "auto-bio-graphy" (spelling format is SAGA's) in its broadest interpretation, including written, oral or visual forms. SAGA's space at UBC's Koerner Library has 15 work stations with internet access, digital recording equipment, voice recognition and desk-top publishing software, and video-editing equipment. There is also access to a growing database of archival materials; for example, a pilot study digitalized diaries and photographs stored in UBC archives.

Beyond its use as a database, the facility has evolved into a resource for community groups and international visiting scholars. The SAGA Centre has developed close ties with several universities in India and links to institutions in China, Australia and many universities in Europe. International visitors, staying for a month to a year, have come from a dozen countries around the world.

Examples of SAGA's activities over the past year include:

- A one-day event held as part of the World Peace Forum (June 2006) where women from 10 countries told their stories of life in combat zones. This provided the opportunity to create new connections among academics, NGOs and other international organizations, with a focus on women in conflict zones.
- Work on the use of oral history in a community-based Women's Studies course at the Philippine Women's Centre in Vancouver.
- Workshops on video-interviewing and editing.
- A student-led discussion group on methods of analysis of life-writing.
- Editing interviews with 20 female UBC faculty members on their careers as feminist academics.
- Organization of a film series comparing visual autobiographical accounts, produced by directors from Canada, Europe and Asia.

SAGA is connected to local, national and international networks. Work through this centre is original and innovative in efforts to cross the university-community divide and remove disciplinary boundaries.

"We want to build bridges between the theoretical or academic and hands-on, community-based approaches," says Dr. Raoul.

◘ ◘ ◘

Infrastructure for Memorial University's **Cellular Signaling Mechanisms in Growth, Development and Disease** has facilitated collaboration and bridge-building across disciplines, the nation and national borders. State-of-the-art equipment, funded by CFI's **On-going New Opportunities Fund**, includes proteomics instrumentation for gene expression studies, cellular protein imaging, laser micro-dissection, mass spectrometry based protein bioinformatics and analysis of protein-protein interactions in cell signaling mechanisms.

This equipment is used primarily to understand how cancer develops; it is used to image proteins, visualize them, measure their levels and measure the differences between cancer cells and normal cells. Project leader, Dr. Robert Gendron, says, "If we figure out new ways to block a cancer cell from growing, eventually we will find new drugs and treatment."

The infrastructure is networked via the Web and is fully functional from many sites at Memorial. Staff and students at this campus and other institutions in Atlantic Canada have been trained to use this infrastructure and already students have seamlessly moved on to other similar facilities in Toronto and Germany.

Collaborations embrace:

- Interdisciplinary researchers at Memorial, who are working to evaluate molecular signaling events corresponding to recovery from stroke. Work is also being done to study the role of stress proteins in pre-term delivery;
- Memorial and University of Toronto researchers, who are studying the regulation of proteins specific to ovarian cancer;
- Researchers from Memorial University, Stanford University, University of Cincinnati and University of Michigan who have worked collectively to define the role of Tubedown, a novel protein, in blindness and pediatric cancer; and
- Potential Industry partners for technology and drug development to treat Tubedown 1 in vision loss due to diabetes mellitus, age related macular degeneration and retinopathy of pre-maturity. Discoveries may also lead to partnerships oriented to cancer treatment.

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Researchers at the **Centre for Nanostructured Polymeric and Inorganic Materials** at the University of Toronto work, in the words of Project Leader Mitch Winnik, to "Provide knowledge that helps people in industry become better inventors".

Interdisciplinary research teams work on projects that vary from understanding the process of how paint dries (to help find alternatives to volatile organic compounds in paint) to tissue regeneration, including spinal cord and bone tissue repair.

Infrastructure, funded in part by the CFI's **Innovation Fund**, is utilized to explore new and advanced polymer, inorganic and hybrid nanostructured materials.
In lay terms, these state-of-the-art facilities help researchers make new things, identify and characterize what is made and then understand possible applications. And in technical terms: this infrastructure enables researchers to synthesize and characterize at the molecular level, fabricate and characterize at the nanometer and micrometer length scales and process on the millimeter and centimeter scale. To put this in perspective, it may be noted that a human hair

is 80,000 nanometers wide and work in these laboratories involves looking at structures as small as 50 nanometers.

Above ground laboratories contain instruments to synthesize, fabricate and characterize materials. Below ground is a warren of laboratories specifically designed to minimize vibration from the hubbub of downtown Toronto. This secure bunker houses equipment for transmission electron microscopy, optical microscopy, scanning electron microscopy and laser confocal fluorescent microscopy as well as all the supporting paraphernalia.

This infrastructure is used by a broad spectrum of researchers within the University (from the Departments of Chemistry, Physics, Mechanical Engineering, Electrical Engineering and Chemical Engineering). It is also used in collaboration with local (University Health Network) and international (Harvard, Max Planck Institute) researchers. The Centre has a number of formal and informal collaborations with industry, including: ICI Paints, NICAN/National Starch, 3M, Xerox, ExxonMobil, Nortel and DuPont. The equipment is also made available (under supervision) to industry.

The paint and tissue repair projects are explained:

- **Interfaces in Polymer Blends**
  The infrastructure is used to understand how the films formed from latex nanospheres work, different types of particles are blended in water, allowed to dry and examined using fluorescence techniques, particularly flourescence decay measurements. This work is useful for the development of new types of paint, both for household use and for plastics.

- **Polymeric Materials for Spinal Cord Repair**
  The infrastructure is used to understand the interface between polymer design, synthesis and the creation of scaffolds (pathways) for biomedical applications. These scaffolds are intended to promote and guide cell growth and so far, this research has been successful in creating open structures of the right size and shape for cells to grow. As well, biostable and biodegradable polymers are being investigated for drug delivery, among other uses.

Dr Winnick says that this infrastructure has enabled researchers in nanoscience and nanotechnology to "address some of the big and riskier questions of our time"; questions (and answers) in the field of health, communication and energy.

◘ ◘ ◘

Researchers at the **Brain Tumour Initiative at the Montreal Neurological Institute**, McGill University, have helped to contribute to the first major breakthrough in 30 years in the study and treatment of brain tumours. This work is funded, in part, by CFI's **Innovation Fund**.

Primary brain tumours rarely spread cancer to other parts of the body, but instead invade other parts of the brain. In the past, surgery to remove a brain tumour may fail to prevent recurrence, sometimes on the other side of the brain.

"Most brain tumours develop from supporting cells, rather than in the cells involved in thought processes. Research has attempted to understand why tumour cells detach and travel long distances in the brain," says Dr. Rolando Del Maestro, project leader.

The first thing to understand, says Del Maestro, is to understand why the cells detach and invade the brain and then why they stop moving and grow somewhere else. Time-lapse video microscopy has allowed researchers to watch cells move in model systems and determine which cells move the most and which divide the most.

Studies looking at the biochemical mechanism of the drug Temodal (Temozolomide) and its effectiveness are also being conducted. This drug, given during and after radiation therapy, increased brain tumour patient survival rate at two years from 10% to 26%. "The question is: Is there a subgroup of patients for whom this drug is very effective, and why?" says Dr. Del Maestro. New research is being conducted into the effectiveness of Temodal given two weeks before surgery.

"We have our foot in the door as we begin to improve patient survival, now we have to open the door further," says Dr. Del Maestro.

Researchers at the Brain Tumour Research Centre collaborate with researchers in the United States and Norway and new collaborations are developing in China and Saudi Arabia.

◘ ◘ ◘

The Virtual Manufacturing Centre at the University of Manitoba is far from "virtual" in its applications. Funded by **CFI's On-Going New Opportunities Fund**, this world-class Virtual Reality (VR) infrastructure can simulate real manufacturing processes, including design, detail design and prototypes. It can simulate product assembly processes and the layout of equipment in order to generate a virtual workshop. By examining these details before construction, industry may be assured of efficient, safe assembly plants.

The facility has been used to help Manitoba Hydro develop technology to test ice build up in their power transportation lines. If the temperature is hovering around freezing, too much weight can crash power lines, resulting in blackouts. The VR infrastructure has been used for the development of a tool using image processing to monitor ice 24 hours a day, seven days a week. This technology replaces the use of manpower to monitor ice buildup.

This VR infrastructure has also been used to assist the Health Sciences Centre (managed by the Winnipeg Regional Health Authority) to improve efficiency in their operating rooms. Two graduate students have collected data on the physical layout of an operating room and how it is currently used by doctors, nurses and patients. Until the current process is more thoroughly understood, the VR infrastructure is used to "play" with this model. In collaboration with hospital authorities, recommendations will be made to rearrange resources in the operating room and situate personnel more effectively.

With GPS information, a virtual model of the University of Manitoba campus has been created. In collaboration with the Faculty of Architecture, renovation of the Engineering building was thoroughly modelled with VR before work began. The shift from 2D architectural plans to 3D imaging provides an entirely new perspective in architecture.

Researchers from the faculties of Nursing, Dentistry and Civil Engineering have also used this infrastructure. One Civil Engineering graduate student used the VR infrastructure to create models of roads with timed traffic lights in order to research traffic accidents involving large trucks. Testing this model under varying road conditions, it was discovered that truck drivers do not have enough time to stop in certain circumstances.

Beyond academia, industry and health care, Imbibio Inc., a small art design company in Winnipeg, uses the 3D laser scanner to develop cost-effective methods to build decorative human statues.

According to the Centre's project leader, Dr. Qingping Peng, "Virtual Reality has a lot of applications. The next step is to promote these applications cost-effectively."

4. Conclusion

The investments that the CFI and other partners have made in Canada's institutions to equip them for their role as foundation stones of the Canadian knowledge economy are showing signs of a positive path. This analysis of annual progress reports submitted to the CFI, covering the highest ever number of such reports submitted to the organization to date, reveals trends that are at play.

Research infrastructure at Canada's universities, colleges, research hospitals and non-profit research organizations continue to attract researchers and students in significant numbers. Collaborative and multidisciplinary research is ongoing and substantial, at local, regional, national and international levels. Some 40,000 researchers are engaged in research, in Canada, using infrastructure funded by the CFI and other partners. Substantial training has proceeded on the latest infrastructure, and many of the graduates are now moving into other sectors of the economy to contribute their new-found skills to a range of different employers. Other students are in pursuit of further training, to contribute to Canada's long-term future and frontiers of exploration – from black holes to nanotechnology.

Research enabled by the infrastructure is contributing to knowledge production, and many linkages are being formed with the private and public sectors to ensure its effective translation into social and economic benefits for Canadians. Canada is clearly on the path to a knowledge economy, and all the more dependent on the specialized skills of R&D that safeguards the country in areas such as food safety, epidemics and sustainable energy. Likewise, R&D enabled by research infrastructure underpins the products and services that we increasingly count on and sometimes take for granted – wireless communications, vaccines and air traffic control.

Research infrastructure is a basic cornerstone around which researchers from different disciplines, sectors and countries may come together to address complex R&D issues and problems. To assure that the cutting edge performance in R&D and training continues at Canadian institutions, for the benefit of all Canadians, it must be sustained.

Appendix 1

(Sample Project Report Form follows.)

Canada
Foundation
For Innovation

Project Report Form

Report for the year April 2005 to March 2006

Part A
(to be completed for all projects whether fully, partly, or not yet operational)

Background

Project Number:

Project Leader:

Date submitted:

Title project:

Institution:

CFI Fund:

CFI contribution:

Date of Approval:

Project Summary

Infrastructure Implementation

1) Which of the following statements best corresponds with the implementation status of your infrastructure project in the past year April 2005 - March 2006:

- ☐ The infrastructure was fully acquired/developed, operational and used for research throughout the year.
- ☐ Part of the infrastructure was acquired/developed and used for research throughout the year and/or the infrastructure was fully acquired/developed, operational and used for research for part of the year
- ☐ The infrastructure was not sufficiently developed for research use during the year.

Researchers, students and technical personnel

2) In the past year, was the availability (current or future) of the infrastructure an important factor in the decision of any researchers (faculty members, and other principal researchers, including yourself if applicable), but not trainees (e.g. PDFs, graduate or undergraduate students) to join the institution(s)?

Yes ____ No ____

If any, for how many researchers was this an important factor ________

a. Of these researchers, how many were recruited from:

i. Canada: ________
ii. the U.S.: ________
iii. other countries: ________

b. Of these researchers, how many were recruited from the:

i. academic/hospital sector: ________
ii. private sector: ________
iii. public/not-for-profit sector : ________

3) Since the beginning of the project (ie. when the award was finalized and CFI issued an Award Agreement, October 19, 2001 is your date of award finalization), including the past year, was the availability of the infrastructure an important factor in the decision of any researchers including yourself to join and stay at the institution(s)?

Yes ____ No ____

If any, for how many researchers was this an important factor ________

a. Of these researchers, how many were recruited from:

i. Canada: ________
ii. the U.S.: ________
iii. other countries: ________

b. Of these researchers, how many were recruited from the:

i. academic/hospital sector: ________
ii. private sector: ________
iii. public/not-for-profit sector : ________

4) In the past year, for how many PDF trainees and graduate students was the availability (current or future) of the infrastructure an important factor in their decision to join the institution? This question is directed at universities and research hospitals.

PDF trainees ______ Graduate Students ______

(Put "0" if none)

a. Of these PDF trainees, how many came from:

i. the institution(s): ______
ii other Canadian institutions: ______
iii U.S. institutions: ______
iv other foreign institutions: ______

b. Of these graduate students, how many came from:

i. the institution(s): ______
ii other Canadian institutions: ______
iii U.S. institutions: ______
iv other foreign institutions: ______

5) Since the beginning of the project, how many PDF trainees and graduate students have used the infrastructure as a key resource in their research projects?

(Put "0" if none) ______

6) Since the beginning of the project, how many of these PDF trainees and students have:

(Put "0" if none) ______

a. stayed at your institution as trainees? ______
b. stayed at your institution as employees/contractors? ______
c. joined another academic institution, college or research hospital? ______
d. joined the Canadian private business sector? ______
e. joined the Canadian public sector? ______
f. joined the private, not-for-profit sector? ______
g. pursued further training in Canada? ______
h. pursued further training abroad? ______

7) Since the beginning of the project, how many technical personnel have been trained on the use and maintenance on the infrastructure?

(Put "0" if none) ______

a. Of these, how many have:

i. stayed at your institution? ______
ii. joined another academic institution, college or research hospital? ______
iii. joined the Canadian private business sector? ______
iv. joined the Canadian public sector? ______
v. joined the private, not-for-profit sector? ______
vi. pursued further training in Canada? ______
vii. pursued further training abroad? ______

Further comment is invited in the box below on the recruitment and retention of researchers, enrichment of the training environment and employment of trainees.

Maximum 4000 characters (about 1 page)

Infrastructure Status During the Past Year

8) In the past year, how did the infrastructure that was operational compare to similar infrastructure in other research institutions in Canada and around the world? (Select which best applies).

- ☐ Infrastructure was not sufficiently developed to permit a comparison.
- ☐ It was below average compared to other labs. (Explain why in the space provided below)
- ☐ It was average compared to other labs.
- ☐ It was comparable to the best in Canada.
- ☐ It was comparable to the best in the world.

Maximum 1000 characters (about 1/4 page)

9) In the past year, which of the following best characterizes the utilization of the infrastructure?

- ☐ Infrastructure was not sufficiently developed to judge.
- ☐ The infrastructure was underutilized. (Explain below)
- ☐ The infrastructure was fully utilized.
- ☐ The infrastructure was unable to satisfy the demand of researchers wanting to use it. (Explain)

Maximum 1000 characters (about 1/4 page)

Infrastructure Status During the Past Year

10) In the past year, how easy or difficult has it been to obtain sufficient funds for Operations and Maintenance of your project?

- ☐ Infrastructure was not sufficiently advanced to require funds this past year
- ☐ Very difficult (Explain)
- ☐ Difficult (Explain)
- ☐ Reasonable
- ☐ Easy

Maximum 1000 characters (about 1/4 page)

11) How many years of useful life remain for the infrastructure in terms of addressing your research objectives. If desired, provide further explanation in the box below.

- ☐ >6
- ☐ 5-6
- ☐ 3-4
- ☐ 1-2

Maximum 1000 characters (about 1/4 page)

12) In the past year, how easy or difficult has it been to attract and retain skilled personnel (e.g. technicians) for operations and maintenance?

- ☐ Infrastructure was not sufficiently advanced to require personnel this past year
- ☐ Very difficult (Explain below)
- ☐ Difficult
- ☐ Reasonable
- ☐ Easy

Maximum 1000 characters (about 1/4 page)

13) In the past year, has your institution used funds from its allocation under the CFI Infrastructure Operating Fund to assist with the O&M for this project?

Yes____ No ____

Research Activities

14) In the past year, how many researchers at the institution(s), including yourself, faculty, and other principal researchers (but not including trainees) have advanced their research by using the infrastructure?

(Put "0" if none) 0

15) In the past year, how many researchers outside the institution(s) (not including trainees) have advanced their research by using the infrastructure?

(Put "0" if none) ______

a. If any, how many of these researchers are at institutions/organizations:

i. within the municipality ______
ii. elsewhere within the province: ______
iii. elsewhere in Canada: ______
iv. in the U.S.: ______
v. in other countries: ______

b. If any, how many of these researchers are at:

i. universities, colleges or hospitals: ______
ii. the private sector: ______
iii. the public sector: ______
iv. the not-for-profit sector: ______

16) Since the beginning of the project, has the availability of the infrastructure enhanced opportunities for multidisciplinary research?

☐ The research has not, to date, lent itself to a multidisciplinary approach.

☐ The research has benefited from a multidisciplinary approach but this is independent of the infrastructure.

☐ The research has benefited from a multidisciplinary approach and this has been enabled by the infrastructure. If so, the role of the infrastructure to draw together disciplines has been:

- ☐ Minor
- ☐ Significant
- ☐ Critical

(Explain below, giving details of the disciplines and how the infrastructure has assisted in the forging of linkages)

Maximum 2000 characters (about 1/2 page)

17) Since the beginning of the project, has the availability of the infrastructure enhanced opportunities for collaborative research across organizations/sectors?

- ☐ The research has not, to date, lent itself to a collaborative approach.
- ☐ The research has benefited from a collaborative approach but this is independent of the infrastructure.
- ☐ A collaborative approach is important to the research, and this has been enabled by the infrastructure. If so, the infrastructure has aided one or more of (check all that apply):
  - ☐ Intra-institutional collaboration(s)
  - ☐ Inter-institutional collaboration(s)
    - ☐ Within Canada
    - ☐ Outside Canada
  - ☐ Institutional government collaboration(s) within Canada
  - ☐ Institutional international public sector organizations (eg. UN)
  - ☐ Institutional private enterprise collaboration(s)
    - ☐ Within Canada
    - ☐ Outside Canada
  - ☐ Institutional private, non-profit
    - ☐ Within Canada
    - ☐ Outside Canada

18) Since the beginning of the project, and in an overall sense, provide your best estimate of the influence of the infrastructure in fostering international collaboration in terms of joint research, the mobility of students and technical personnel, and participation in international networks.

- [ ] Not relevant - no international collaboration
- [ ] No influence
- [ ] Minor influence
- [ ] Significant influence (Explain below)
- [ ] Critical influence (the collaboration would not have proceeded in its absence). (Explain)

Maximum 2000 characters (about 1/2 page)

19) Since the beginning of the project, and in an overall sense, provide your best estimate of the influence of the infrastructure in fostering local or regional collaboration in the formation of technology clusters or regional R&D-based initiatives in Canada

- ☐ Not relevant - research has a different target
- ☐ No influence
- ☐ Minor influence
- ☐ Significant influence (Explain below)
- ☐ Critical influence (the collaboration would not have occurred in its absence). (Explain).

Maximum 2000 characters (about 1/2 page)

20) Please select which one of the following statements best represents the research enabled by the infrastructure since the beginning of the project.

- ☐ the research has not yet produced any advances
- ☐ the research has produced modest but useful advances
- ☐ the research has met national standards, or was the best in an undeveloped field, and contained some innovative aspects (Give evidence in the box below)
- ☐ the research was competitive at international standards and innovative (Give evidence)
- ☐ the research has been at the leading edge internationally, and has been transformative. (Give evidence)

Maximum 2000 characters (about 1/2 page)

Funding in the Past Year

21) In the past year, has the infrastructure had an impact on the ability of its main users to attract new funds from the following sources? (Check which best applies for each source of funds this past year)

Funding Source	**No new Funds from this source this past year**	**No Impact**	**Minor Impact**	**Signi-ficant Impact**	**Very signi-ficant Impact**
Your/their institution					
Federal funding agencies					
Other federal government sources					
Provincial government sources					
Canadian industry					
International sources					
Other (specify)					

Benefits to Canada

22) Please comment on how CFI investments in infrastructure for your research have helped to generate social and economic benefits for Canada since the beginning of the project. Benefits may be generated directly by activities of researchers and trainees, by other users of the research infrastructure or the users of the research enabled by it. The following list provides some examples of social and economic benefits. Check those that apply, and provide further details in the box below.

- ☐ New or improved public policies and programs (eg. health, environment, education, social development, food security, communications, transport etc.)
- ☐ New or improved products, processes or services including cost savings
- ☐ Intellectual property rights (eg. provide number and type of applications for rights, or awarded rights, among: patents, copyrights, plant breeders rights, and industrial designs; plus number and nature of licensing agreements)
- ☐ Spin-off companies (provide number(s) and business line(s))
- ☐ Private or public sector jobs created
- ☐ Other

Appendix 2

CFI Analysis of Progress Reports 1999-2010 - Overview as of October 2006

Year	Nature of report produced	External Dead-line date	# (%) Project Reports [1,2,3]	# (%) Instit'n Reports [2,3]	Comment
1999	• Early impacts of 98/99 projects	Nov 5	365 (67%)	52 (73%)	
2000	• List of institutional reports • Analysis of institutional AND project reports	Oct 16	491 (65%)	56 (71%)	
2001	(No report - shift to electronic submission)				
2002	• List of institutional reports • Analysis of institutional AND project reports	Feb 15	796 (57%)	67 (73%)	• Numerical and text data are separate forms. Numerical data in a database
2003	• List of institutional reports • Analysis of project reports, with mention of institutional reports only	June 30	1833 (90%)	83 (83%)	
2004	• List of institutional reports • Analysis of project reports, with mention of institutional reports only	June 15	2,322 (91%)	86 (78%)	
2005	• List of institutional reports • Analysis of project reports • Provincial breakdown of data Selected institutional reports analysed for Outcome Assessment visits	June 15	2,805 (96%)	81 (72%)	• Numerical and text data are integrated in one electronic form, that is submitted to a database
2006	• List of institutional reports • Analysis of project reports • Provincial breakdown of data • Selected institutional reports analysed for Outcome Assessment Visits • Special study on O&M • Provision of data to SPR Associates for NOF Evaluation Implementation • Update of forms (TBD)	June 15	3,137 (97%)	90 (82%)	• Professional statistician hired to advise on methodology and nature of the data. • ATIP expert hired to advise on privacy considerations • Institutional focus group formed to advise on data collection at ground level
2007		June 15	Min ~ 2929	Min ~ 87	
2008		June 15	Min ~ 2294	Min ~ 75	
2009		June 15	Min ~ 1564	Min ~ 69	
2010		June 15	Min ~ 864	Min ~ 60	

<u>Notes</u>
1. Number received by the internal deadline date which exceeds the external deadline by a short grace period. Some reports arrive later, but are not included in the analysis.
2. Percentage (%) refers to % submission rate (i.e. the % of reports received vis-à-vis the number due).
3. Projections for 2007 – 2010 refer only to those projects already approved, and with award agreement finalized, by *September 2006.* A large number of additional awards are already budgeted for, but are omitted from these projections as they have not yet been awarded and finalized.