Canada Foundation for Innovation
Fondation canadienne pour l'innovation

PROGRESS REPORT OF CFI-FUNDED PROJECTS 2003-04

AN ANALYSIS OF ANNUAL INSTITUTIONAL AND PROJECT REPORTS SUBMITTED—JUNE 2004

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Executive Summary

This Report includes information for the period April 2003 to March 2004 on the status of 2,322 projects at 86 institutions which have received funding through a number of CFI programs. There was great variety in the size, type, and complexity of projects, with, for example, more than half the projects supported under the Innovation Fund (IF) receiving more than $1 million from the CFI, and three quarters of the projects supported under the New Opportunities Fund (NOF) receiving less than $200,000.

The budgets for these projects were finalized between April 1999 and March 2004 and the projects were in varying stages of development, with slightly more than half fully developed and operational by the end of the reporting period.

The infrastructure acquired by the institutions is of high quality. Almost 40 percent of the project leaders considered their infrastructure to be comparable to the best in the world, and an additional 50 percent considered it to be among the best in Canada.

The infrastructure acquired through these projects is enabling Canadian researchers to tackle research at the internationally competitive level (56 percent of projects) and even to lead the world in certain fields (14 percent of projects). The project leaders considered that three quarters of their projects were instrumental to their success in attracting research funding from international sources.

Over 20,000 researchers from academic institutions benefited from these projects last year, with an average of 22 academic users for each IF project. Over 80 percent of the project leaders were involved in international collaborations last year and felt that the infrastructure had helped foster 90 percent of these collaborations. More than 2,200 researchers from the private and public sectors used the infrastructure to work collaboratively with the project teams.

The projects are helping to build Canada's cadre of leading researchers. In 2003-04, 3,170 new faculty were recruited with the assistance of these projects, with 705 from the U.S. and 538 from other countries. The infrastructure also played a role in retaining over 4,000 faculty, or almost two per project. The projects attracted 3,801 postdoctoral fellows last year, including almost 2,000 from other countries.

The training milieu for more than 24,000 graduate students and 4,000 other trainees was enhanced by these projects last year, helping to build the pool of highly qualified people needed for Canada to compete in the global economy.

CFI-funded projects served to set the conditions for the translation of research into tangible social and economic benefits for Canadians. Last year, more than 160 projects produced intellectual property with over 270 instances of invention disclosures, patent applications, provisional patents, patents issued, licenses, and software copyrights. Over 40 project leaders credit their infrastructure with a significant role in launching a new spin-off company last year. Numerous anecdotes show how private and public sector partners translated the research enabled by the infrastructure into new products, processes and services, and improvements to health, the environment, quality of life, and public policies.

Projects which finalized their budgets in 1999 were least likely to be rated “the best” and it was deduced that the useful lifespan of projects may be exhausted after five years.

Institutions continue to find ongoing Operations and Maintenance of their infrastructure a challenge with 18 percent of projects having difficulty in securing adequate O&M funds. For projects which used funds from the CFI’s Infrastructure Operating Fund (IOF) the rate of reported difficulty was significantly reduced, to 11 percent. It appears that the IOF is helping institutions to meet this challenge.

It can be concluded that investments in infrastructure are having a very positive impact on building Canada’s capacity for innovation. Canada has become a research destination of choice. It is now important to sustain and capitalize on the achievements to date.

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1. Introduction

The Canada Foundation for Innovation (CFI) is an independent corporation created by the Government of Canada to fund research infrastructure. The CFI's mandate is to strengthen the ability of Canadian universities, colleges, research hospitals, and non-profit research institutions to carry out world-class research and technology development that benefits Canadians.

The CFI invests in research infrastructure at Canadian institutions through programs that are designed to:

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

The research enabled by the CFI also creates the necessary conditions for sustainable, long-term economic growth—including the creation of spin-off ventures and the commercialization of discoveries, as well as better health, improvements to the environment, and enhanced public policy. On average, the CFI contributes 40 percent of the cost of the infrastructure projects; the remainder must come from the institution itself or from its partners, typically provincial governments and the private sector.

The CFI distinguishes three broad categories of eligible institutions that may receive CFI funding for research infrastructure, recognizing that their research programs and priorities will differ markedly in scope, complexity, and nature.

- Larger universities receiving more than 1 percent of federal granting agency funding; hospitals; non-profit research organizations.
- Smaller universities receiving less than 1 percent of federal granting agency funding.
- Colleges that do not confer degrees.

The CFI invests the majority of its funding in projects that serve broad communities of researchers at institutional, regional or national levels through the following funds: the University Research Development Fund, the College Research Development Fund, the Innovation Fund, the International Joint Ventures Fund, and the International Access Fund. Initially, the Innovation Fund was designed to respond only to the needs of larger research institutions, that is, those having received the bulk of the sponsored research funding for the 1994-96 period. Two separate funds were created for smaller universities and colleges. However, since 2001, all eligible institutions submit their proposals to the Innovation Fund.

- The **University Research Development Fund (URDF)** was designed to strengthen the research infrastructure of smaller universities that received, during the 1994-96 period, less than 1 percent of total sponsored research funding in Canadian universities. The CFI invested $35.1 million under this fund.

- The **College Research Development Fund (CRDF)** was designed to help Canadian colleges, institutes, and their affiliated research centres develop and strengthen their research infrastructure in areas identified in their strategic research plan. Colleges could submit proposals for projects totalling up to $2 million in eligible costs with a maximum contribution of $800,000 from the CFI. The CFI invested $15.9 million under this fund.

- The **Innovation Fund (IF)** enables eligible institutions, individually or in partnerships, to strengthen their research infrastructure in the priority areas identified in their strategic research plans. The fund promotes multidisciplinary and inter-institutional approaches, and enables Canadian researchers to tackle groundbreaking projects. To March 31, 2004, the CFI had invested $1.77 billion under this fund.

- The **International Joint Ventures Fund (IJVF**) established three high-profile research infrastructure projects in Canada aimed at taking advantage of unique research opportunities with other countries. The CFI invested $87.4 million under this fund.

- The **International Access Fund (IAF)** helps Canadian institutions and researchers to access major international collaborative programs and facilities in other countries. The CFI invested $71 million under this fund.

The CFI also supports the infrastructure needs of individual researchers recruited by institutions according to their institutionally identified priorities. It does so through the following funds:

- The **New Opportunities Fund (NOF)** provides infrastructure support to newly recruited academic staff. The fund helps universities attract world-class faculty members in areas that are essential to the institutions' research objectives. To March 31, 2004, the CFI had invested $264.1 million under this fund.

- The **Canada Research Chairs Infrastructure Fund (CRCIF)** provides infrastructure support to Canada Research Chair holders. To March 31, 2004, the CFI had invested $136.3 million under this fund:

- The **CFI Career Awards** was established through a partnership with federal granting agencies. These awards recognize and support outstanding researchers by providing institutions with the infrastructure that is essential for their research programs. To March 31, 2004, the CFI had invested $3.9 million under this fund.

In addition to the infrastructure programs mentioned above, through the **Infrastructure Operating Fund (IOF)** the CFI contributes to the incremental operating and maintenance costs associated with infrastructure projects funded by the CFI. Unlike other CFI awards, there are no requirements for partner funds. Each eligible institution receives an IOF allocation representing 30 percent of the finalized CFI contribution for projects approved between July 2001 and

December 2005 under either the **Innovation Fund** or the **New Opportunities Fund**. The institution is able to manage the allocation by distributing the funds among the eligible projects according to its own strategic needs, rather than proportionately by project. To March 31, 2004, the CFI had invested $356.9 million under this fund.

As of March 31, 2004, the CFI had invested $2.7 billion to 3,456 research infrastructure projects in 118 institutions through its various funds.

2. Methodological Notes

2.1 Report format and content

In order to assess the impact of its investment, the CFI requires that institutions and project leaders provide yearly reports. This analysis summarizes information covering the period of April 2003 to March 2004 in annual reports received by the reporting deadline of June 15, 2004[1]. This information was provided by 86 institutions (78 percent of the 111 institutions for which a report was required) on the status of 2,322 projects received within the reporting deadline (91 percent of the projects for which a report was required).

For the fiscal year ending on March 31, 2004, institutions were asked to submit a brief report (maximum of five pages) on the impact in the past year of all CFI investments (both infrastructure and operating funds), in accomplishing the objectives of their strategic research development plan. The individual institutional reports are available on the CFI website. Institutions were also asked to report on challenges they faced in the acquisition, development or implementation of infrastructure. In addition, they were asked to note challenges in operation or maintenance of the infrastructure, and how the IOF had helped to address them. The present analysis uses selected comments gleaned from institutional reports to interpret findings on the impact of CFI investments on institutions and their researchers.

The CFI requires institutions to submit a status and impact report on each project, each year for the first five years following finalization of the budget. The project leaders normally prepare these reports. The information expected in project reports is in three sections and the data are limited to results obtained within the past year.

Part A, to be completed for all projects, regardless of their implementation status, consists of information on the implementation of the infrastructure and on the impact of the project on the attraction and retention of researchers, and on the attraction of trainees. 2,322 project leaders responded to these questions.

Part B is to be completed for projects that were fully or partly operational during the period covered by the report (April 1, 2003 to March 31, 2004). It consists of information on the status of the infrastructure and its impact on research activities and funding, collaborations and training,

[1] The CFI follows up on reports not submitted by the deadline. Further CFI funding is withheld until the institution provides the required reports.

and the social and economic benefits to Canada that have ensued from the research supported by the infrastructure. A total of 2,158 project leaders responded to Part B.

Part C is an optional narrative attachment to provide fuller explanations on (1) project implementation and management challenges; (2) social and economic benefits of the research to Canada; and (3) other significant project benefits, over the past year. Over 80 percent of project leaders completed part C of their reports.

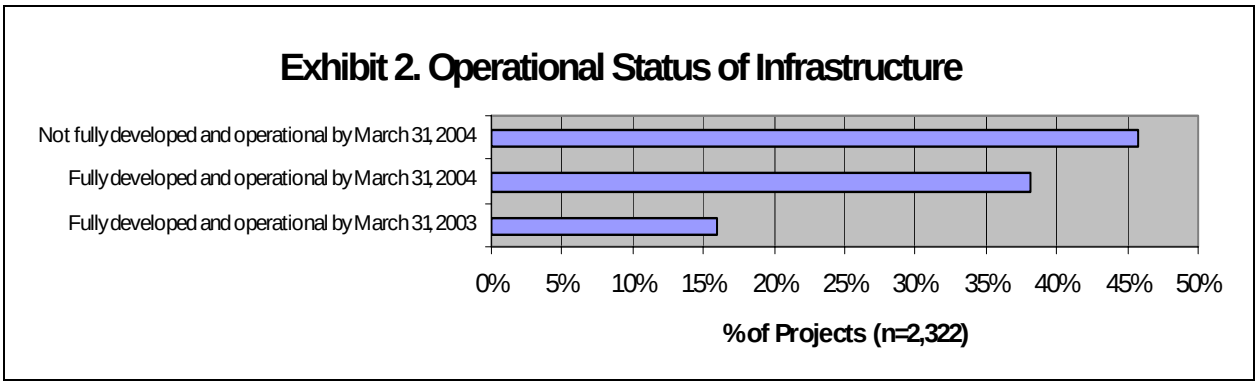
2.2 Profile of projects included in the analysis

There is great variety in the size, type, and complexity of projects that have been funded and finalized so far and for which the reports were received in time to be included in this analysis. The results observed in this diverse array of projects are similarly complex.

Exhibit 1. CFI Award

Funds	<$200,000	$200K-$1M	$1M-$4M	$4M-$10M	$10M-$20M	>$20M	TOTAL
URDF	51	33	6	0	0	0	90
CRDF	8	15	0	0	0	0	23
IF	64	149	170	69	14	6	472
IJVF	0	0	0	0	0	2	2
IAF	0	0	0	0	2	1	3
NOF	796	295	1	0	0	0	1,092
CRCIF	526	105	1	0	0	0	632
Career Awards	4	4	0	0	0	0	8
TOTAL	1,449	601	178	69	16	9	2,322

Exhibit 1 shows the number of project reports for the various funds, as well by size of the CFI award. Three quarters of the CRCIF and NOF awards are less than $200,000, and there are virtually no awards greater than $1 million. In contrast, about 55 percent of IF awards are greater than $1million, and almost 20 percent are greater than $4 million. Clearly, infrastructure projects receiving large CFI awards (more than $1 million) are more complex, and have greater potential impact because they serve a greater diversity of researchers. Where applicable, the analysis highlights the results that differ from fund to fund. For some programs, the number of project reports is very small, and the program impact cannot be assessed separately in the analysis (IJVF, IAF, Career Awards). However, the data for these projects have been included wherever an overall result is reported.



This analysis includes projects for which the budgets were finalized between April 1999, and March 2004 and thus were in various stages of development during the reporting period. Slightly more than half of the infrastructure projects were fully developed and operational by the end of the reporting period, with 16 percent of projects achieving this at the beginning of the reporting year, and an additional 38 percent reaching this state by March 31, 2004 (Exhibit 2). The remaining 46 percent of projects were still under development throughout the reporting period. Implementation status was similar across all funds except the URDF and CRDF, where the last awards were approved in 2001; 82 percent of these projects are now fully developed. Not surprisingly, the projects for which the budgets were finalized in 1999 were more likely to be fully operational than those finalized in 2004. Many indicators of impact are affected by the status of development of the infrastructure and this has been noted where applicable in the subsequent analysis.

The institutions eligible to apply for CFI funding, colleges, smaller, and larger universities, have vastly different missions and consequently the nature of their research activities and the stage of development of their research programs are quite varied. For example, CFI awards in the health area are made for the most part in 16 universities which are affiliated with research hospitals. The research undertaken in colleges tends to be more applied. College researchers are not generally eligible to apply for grants from the federal granting agencies, to hold Canada Research Chairs and access the associated CRCIF fund, or to apply for NOF awards. Some of the questions in the project report questionnaire only apply to projects in universities (for example, recruitment of graduate students and post-doctoral fellows). Data from all institutions are included in the following tables with a note made where there is a distinctive finding for one of the groups.

2.3 Interpretation of data

Much of the data used in this analysis relies on subjective assessments by project leaders, who are asked to estimate the impacts of a specific infrastructure project when they may be involved in several projects, and to differentiate the infrastructure contribution from the influence of other highly important factors, including research funding, the expertise of their colleagues, and institutional support. The institutions exercise quality control on the reports by reviewing them before they are submitted to the CFI, and the CFI does not further verify the information. Thus, some small error rate must be expected. In situations where two different project leaders each attribute a particular effect to their own project, and indeed, both projects could be playing a role, the result will show up as “double counting.” To balance this, there will inevitably be some under-reporting of impacts for projects shared by several institutions, where the institution managing the infrastructure project attempts to collect information from all the partners. To enhance confidence in the project report data, the CFI is introducing a program of site visits to completed projects, during which the impacts can be assessed and verified in a more objective manner by independent reviewers.

3. Results

The results of the analysis clearly demonstrate that the investment in research infrastructure is having a profound impact on research across the country and on Canada's international profile, and is beginning to yield economic and social benefits for Canadians. This portion of the analysis summarizes the information obtained from the project reports. The institutional perspective, gleaned from the institutional reports, has been incorporated where it provides a context for the findings.

3.1 Strengthening Canada's capacity for innovation

A country's research capacity and productivity is a cornerstone of its system for innovation. This, in turn, is dependent on several factors including the availability of high-quality research infrastructure that enables Canadian researchers to undertake leading-edge research.

The quality of infrastructure projects obtained with CFI funds is considered high in most instances by researchers.

Exhibit 3. Comparability of Projects to Similar Infrastructure

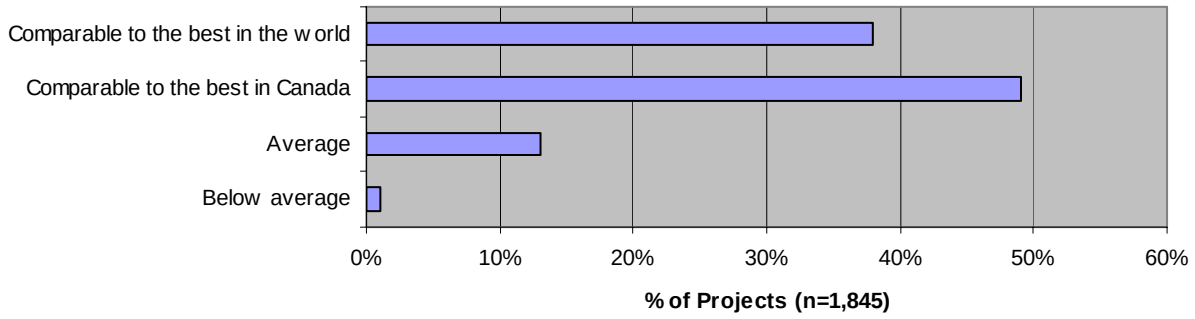


Exhibit 3 illustrates the responses of project leaders who considered their projects sufficiently developed last year to make a comparison with similar infrastructure at other research centres. Almost half of the project leaders considered their infrastructure to be among the best in Canada and almost 40 percent considered it to be comparable to the best in the world. Given their different ambitions, there are understandable differences between the categories of institutions, with the research intensive universities rating over 40 percent of their projects at the international level, versus 23 percent for smaller universities, and 13 percent for colleges.

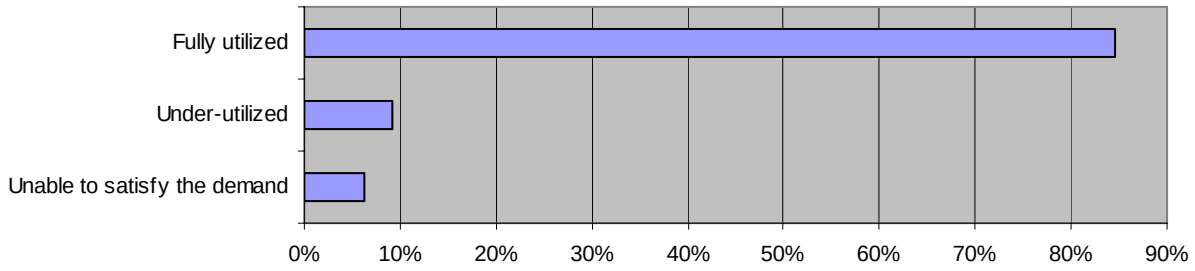
> **T**he new scanner is the first PET scanner to use a dual layer LSO/LYSO detector to achieve depth of interaction, a process that allows higher resolution than possible with a single detector system. The experiments carried out during the commissioning of the scanner proved that the performance of the system exceeded all design specifications. It is currently the most advanced PET scanner for brain research.
> —***Centre for Addiction and Mental Health***

> **O**ur lab has been used by […], the probe manufacturer, as their North American demonstration lab over the last couple of years (seven demonstrations to date). As a result, our facility is arguably tops in North America. We receive requests for consultation from all over the world.—***University of Calgary***

An estimated 1 percent of respondents considered their projects to be below the average for comparable infrastructure; however, the budgets for many of these projects were finalized four or five years ago. It was deduced that, over time, infrastructure may need renewal in order to remain state of the art.

An indirect measure of the quality of the infrastructure is the extent to which it is valued and used by researchers. As shown in Exhibit 4, among the respondents to the question who considered their project to be sufficiently developed to judge, 85 percent reported that the infrastructure was fully utilized in the past year and 6 percent reported that the infrastructure was barely able to satisfy demand. Only 9 percent of respondents considered that their projects were underutilized over the past year.

Exhibit 4. Utilization of the Infrastructure



Patterns were generally similar across the different funds. However, it was noted that 6 of the 22 CRDF project leaders (37 percent) reported under-utilization of the infrastructure.

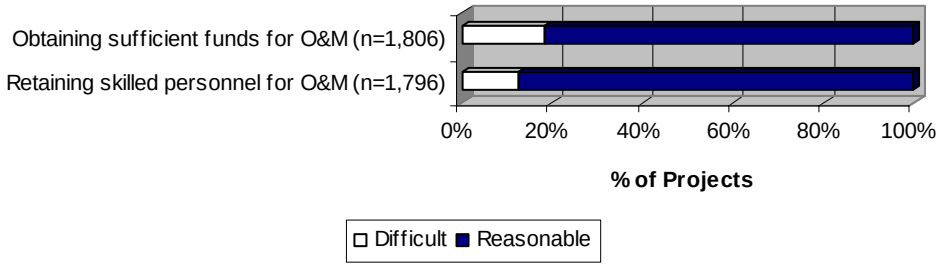
> **B**ecause of the uncertainty of long-term financial support and limited operating funds, we have not been able to hire a technologist. Our operation in essence relies on co-op students. With regular and frequent rotation of these students back to the classroom on their non-working terms, it is an ongoing challenge to ensure efficient and smooth operation. It is imperative that a designated technologist be hired.—***College Project***

While the difference is small, there was a time trend with the projects which finalized their budgets in 1999 being less likely to be rated "the best" in Canada or the world and more likely to be "unable to satisfy demand." This suggests that the useful lifespan of projects may be exhausted after five years, at least in some fields.

> **T**he infrastructure is currently over-subscribed. A second comparable microscopy workstation is necessary but it is very difficult to secure funding for it.—***Large University***

Explanations for under-utilization were given in the narrative section of the reports. Lack of funds and technical personnel for ongoing operations and maintenance were by far the most important factors determining the success of institutions and project leaders in using the infrastructure to support their research. Of the projects that were advanced enough for operations and maintenance to be an issue, 18 percent reported difficulty in securing O&M funds, and 13 percent in finding skilled personnel for O&M (see Exhibit 5). 20 percent of projects experiencing these difficulties were considered under-utilized, compared to the general under-utilization rate of 9 percent.

Exhibit 5. Operation & Maintenance (O&M) Challenges



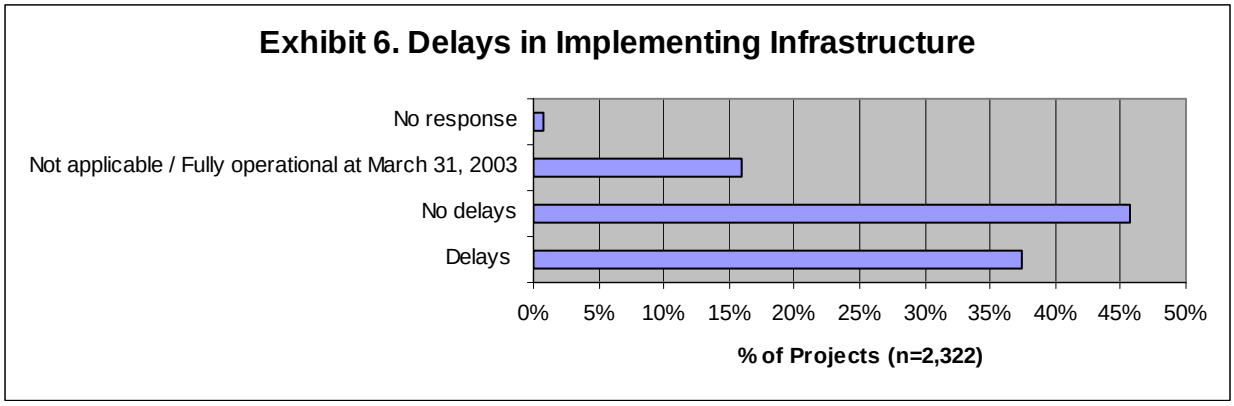
As mentioned in the Introduction, through the IOF, the CFI has contributed to the O&M costs of IF and NOF projects approved after July 2001. This analysis included 355 projects which had the benefit of funds from their institution's IOF allocation. Using additional CFI records, it was estimated that the institutions will spend about $85 million of their IOF on these projects. Interestingly, 11 percent of these projects reported concerns about obtaining sufficient O&M funds, compared to the overall rate of 18 percent. It is concluded that the IOF is helping, although it is not the complete solution.

> **W**ith all CFI projects, operating funding continues to be a major concern. While CFI is to be commended for their efforts in establishing the IOF, supporting operating funding for a portion of the projects, there are still major gaps in operating support which threaten the long-term operating plan.—***University Health Network***

> **T**he introduction of a percentage funding for operating costs has helped to resolve the challenge of having infrastructure support without corresponding support for people and administration. Colleges are particularly vulnerable in this area, since they are not usually eligible for staffing and student support from other federal funding agencies.
> —***Nova Scotia Community College***

Given the complexity and scope of these projects, it is not surprising that institutions were not always able to complete the acquisition and development of their infrastructure within their planned time frames.[2]

[2] The CFI provides its funding as universities incur actual expenditures and adjusts its payment schedules to accommodate delays.



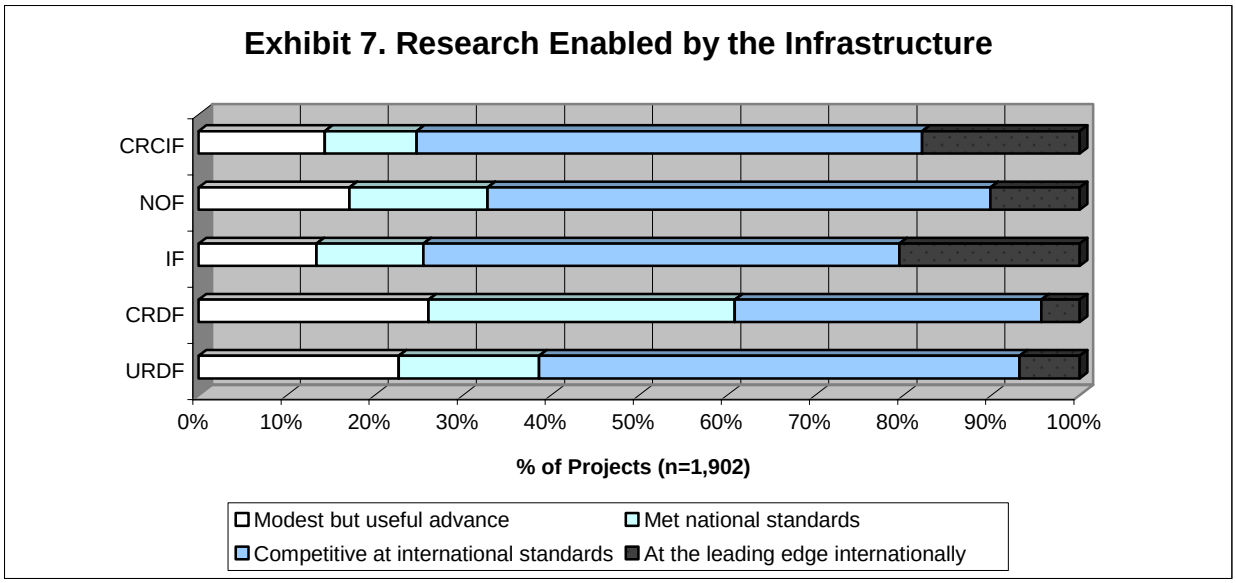
As indicated in Exhibit 6, approximately 37 percent of project leaders reported some delay in the implementation of their project during the past year. Delays were relatively more prevalent for IF projects, which almost always involve construction, in contrast to less complex NOF and CRCIF projects. Delays are more likely to occur in the first two years following budget finalization.

The narrative comments indicate that delays were due to equipment development challenges, lengthy construction times, and other unanticipated difficulties, in roughly equal proportions. Delays in obtaining the latest complex technology, or dealing with a shortfall in partner funding, for example, tended to be resolved relatively quickly. Delays related to construction were lengthier and occurred across all programs. In some cases, the construction phase of the project itself was delayed. However, even for equipment acquisition projects under the NOF or CRCIF, there were cases where the researcher's lab was destined to be located in a new building, and the project was on hold until the building was ready for occupancy.[3]

In general, the institutional reports echoed the enthusiasm about the infrastructure they have acquired with assistance from the CFI, but also the concern about the long-term sustainability of projects. Although the IOF assists with operations and maintenance, institutions remain concerned about the viability of the projects that do not qualify for support under this fund. Further, if Canadian research infrastructure is to remain state-of-the-art, infrastructure renewal, particularly in areas where technical developments are extremely rapid, is an issue that will need attention in the future.

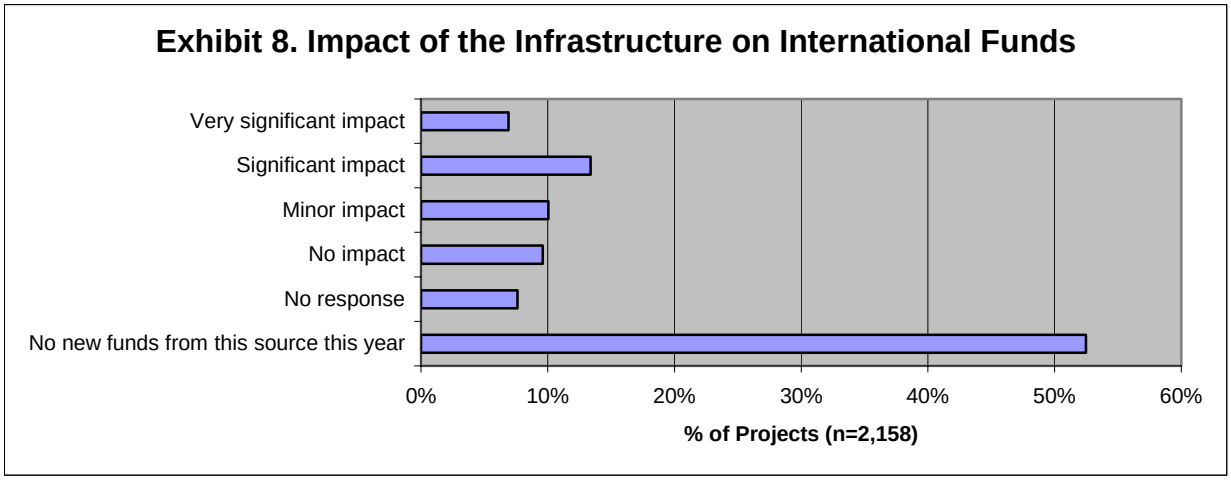
Project leaders were not only very positive about the quality of their infrastructure, they were equally enthusiastic about the research that they and their teams were able to tackle.

[3] In an effort to encourage institutions to plan more realistically for new construction, in 2003 the CFI imposed an 18 month time limit for construction to commence.



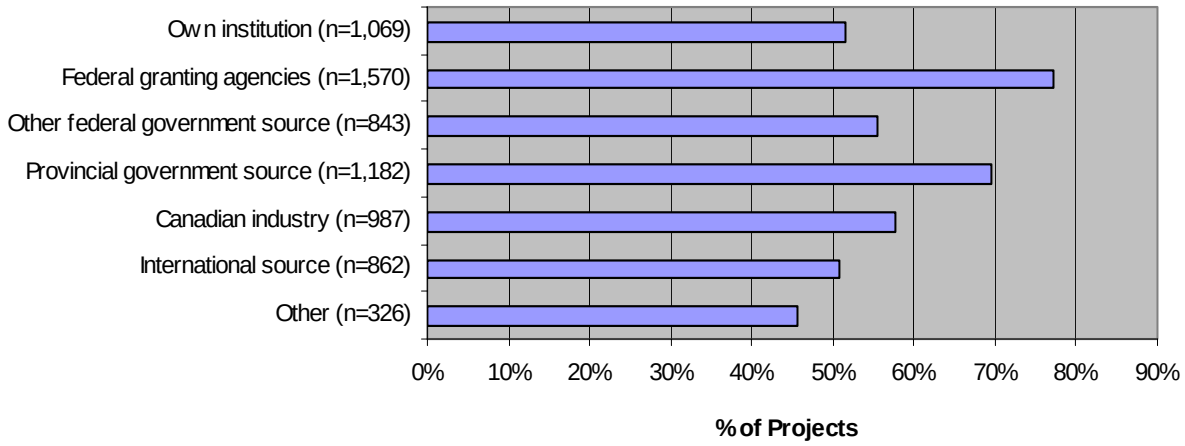
Overall, 14 percent of project leaders rated the research enabled by the infrastructure to be at the leading edge. An additional 56 percent considered their research to be internationally competitive. As estimated 16 percent of project leaders rated their research progress over the last year as modest; the majority of these were the more recent projects, many of which are not yet fully operational. As shown in Exhibit 7, the CFI's major investments through the IF, and support for recruiting excellent faculty through the NOF and CRCIF programs, have clearly promoted internationally leading research.

The ability to attract research funding from foreign sources is a strong indicator of the international competitiveness of these projects. Over the past year, 40 percent of project leaders reported success in obtaining research funds from international sources, and 76 percent of these reported that their infrastructure projects had an impact on their ability to attract these funds (see Exhibit 8).



In general, project leaders considered their projects to be instrumental in attracting research funds from many sources, not just international. In Exhibit 9, data are shown only for projects where the research team successfully obtained funding from each source. It is important to restrict the data in this way, as most research grants cover several years, and therefore, in any specific year, the project team may not be in a position to apply for new funds from every source. From these data, and the comments in the narrative section of the reports, it is clear that the infrastructure enabled research at the highest competitive level. In turn, the significant amount of research funding received ensured that the infrastructure was exploited for research to its full capacity.

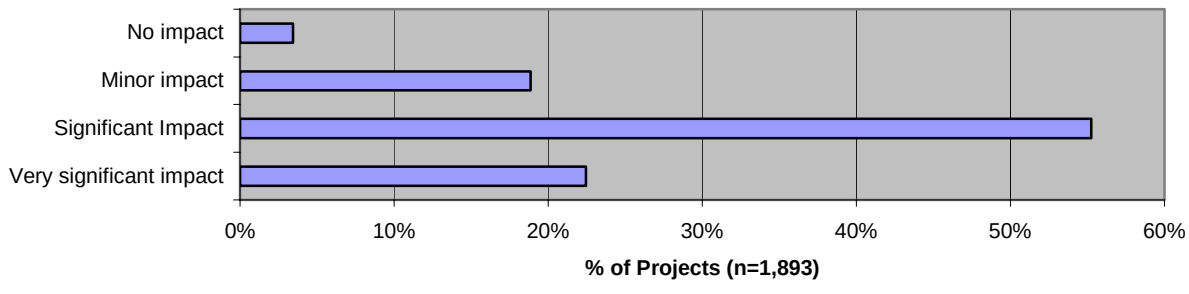
Exhibit 9. Significant Impact of Infrastructure on Attracting the Research Funding from Each Source



3.2 Multidisciplinarity, collaboration, and partnerships

Finding innovative solutions to today's major societal problems often requires a multidisciplinary collaborative approach, and indeed, 90 percent of the project leaders had been involved in multidisciplinary endeavours last year. Of these, fully 96 percent considered that their infrastructure had enhanced their opportunities to work this way (see Exhibit 10). IF projects were most often rated as having a very significant impact, as might be expected from these large and broad based projects.

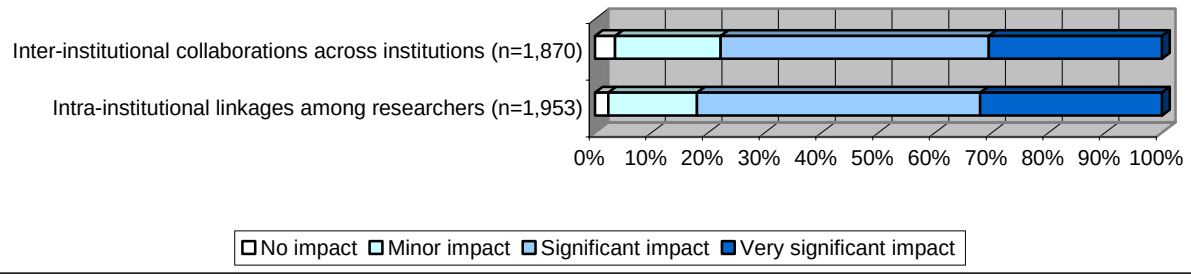
Exhibit 10. Impact of the Infrastructure on Enhancing Opportunities for Multidisciplinary Research



A similar result was found when examining the impact of infrastructure on collaborations among researchers within their own, or across different Canadian academic institutions (see Exhibit 11). Again, about 90 percent of project leaders reported such collaborations, and in virtually all cases, the infrastructure had played a role. IF projects were again shown to be very significant in strengthening collaborations among researchers. In some cases, the project leaders were able to carry out their part of a collaborative effort because they now have the infrastructure needed to do so. In other cases, the shared use of the infrastructure brought together researchers who, until then, had not appreciated their common interests.

> **T**he availability of the infrastructure made it possible to collaborate this past winter with internationally recognized leaders in the field of exercise physiology on a major expedition to northern Greenland to study how the body adapts to exercise.—***Concordia University***
>
> **T**he CFI has had a major impact on the research infrastructure at the University of Saskatchewan, both in physical structure and equipment. The common instrumentation and space hope to capture the benefits of daily contact with other disciplines. The sharing of facilities provides a natural venue for collaborations and partnerships.
> —***University of Saskatchewan***

Exhibit 11. Impact of the Infrastructure on Creating, Maintaining, or Strengthening Collaborations



As might be expected, the projects that had been underway the longest were more influential in building collaborations—it takes time for information about the opportunities afforded by the infrastructure to circulate. The CRDF projects were the least likely to have a major impact on academic collaborations. This may reflect the local orientation and single research project focus of many of the infrastructure awards under this Fund.

Another way to assess the potential of these projects to foster collaborative research is to look at the researchers who are using the infrastructure to advance their research. Over 12,000 researchers within the project leaders' institutions, and over 8,000 researchers from other academic institutions benefited from these 2,158 projects, or an average of nine researchers per project per year.

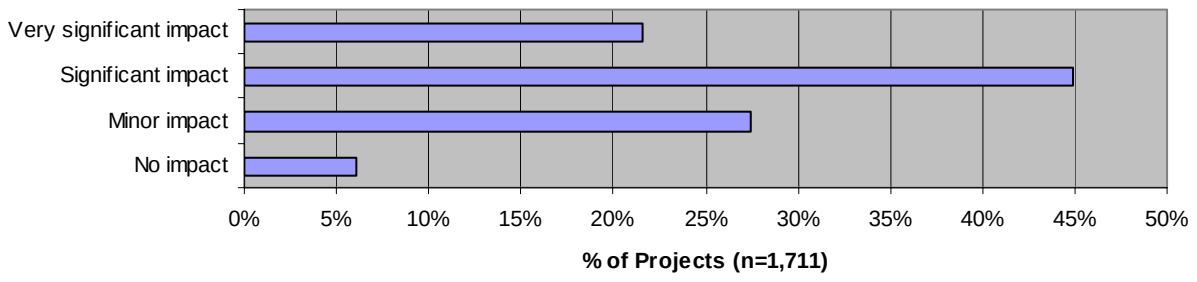
Exhibit 12. Researchers Using the Infrastructure Project to Advance their Research

		Researchers from academia						Researchers from outside Canada	
Fund	# of projects	From within the institution	From another institution	Total from academia	# per project	U.S.	Others	From outside Canada	# per project
All	2,158	12,438	8,043	20,481	9.5	1,546	2,150	3,696	1.7
URDF	88	511	161	672	7.6	29	31	60	0.7
CRDF	23	110	38	148	6.4	3	4	7	0.3
IF	445	6,220	3,663	9,883	22.2	578	670	1,248	2.8
NOF	1,005	3,222	1,617	4,839	4.8	341	374	715	0.7
CRCIF	590	2,315	2,526	4,841	8.2	581	1,044	1,625	2.8

On this measure, there were marked differences among the funds, as shown in Exhibit 12. IF projects with 22 academic users per year offered the most opportunities for building collaborations. Interestingly, CRCIF projects, with over eight users involved on average, compared favourably with NOF projects, with less than five users per year. Although both these funds support the research of one faculty member,[4] CRCIF recipients are generally at a more advanced stage of their careers, and more likely to attract collaborators.

Project leaders were proud of the international recognition of their research which had been enabled by the infrastructure. On average, 80 percent of the project leaders were involved in international collaborations (ranging from 50 percent in CRDF projects to 90 percent in IF projects). Of these, over 90 percent of the project leaders felt that the infrastructure had helped foster the collaboration, having a very significant impact in more than 20 percent of the projects (Exhibit 13).

Exhibit 13. Impact of the Infrastructure on International Collaboration



[4] Only a small percentage of NOF and CRCIF awards are for a "cluster" of candidates.

> **T**he Toronto Centre for Phenogenomics (TCP), represents a major cooperative effort between Mount Sinai Hospital and other University of Toronto teaching hospitals to provide state-of-the-art production, housing, and phenotypic analysis facilities for genetically altered mice. In addition, the TCP is now part of an international consortium to assign function to all genes in the mouse.—***Mount Sinai Hospital***

Further evidence of the positive international reputation enjoyed by these projects was the number of researchers from the U.S. (1,546) and other countries (2,150) who came to use the infrastructure and work with the project teams. As shown in Exhibit 12, the IF projects lead on this measure, with 2.8 international research users per project. Interestingly, the CRCIF projects match this, showing that even smaller projects can support research at the international cutting edge.

> **A**s a result of these facilities we have been approached by researchers in Australia, United States, Germany, New Zealand, Uruguay, Spain, and Austria to perform analyses of their water samples. Some of these requests are leading to longer term international collaborations (e.g., the Arctic River Delta Experiment in 2004).—***Université Laval***

3.3 Building the cadre of highly skilled researchers

Canada must build its cadre of highly skilled researchers to carry out the innovative research needed to give the nation a competitive edge in the global economy. The CFI recognizes that state-of-the-art research facilities can be an important tool for institutions as they vie with other jurisdictions, especially the U.S., to attract and retain the best from Canada and around the world.

The project reports provide ample evidence that the CFI's investments in infrastructure are playing a major role in recruiting excellent researchers for Canada. Overall, 3,170 new faculty were recruited in 2003-04 with the assistance of these 2,322 projects, with over half the projects recording at least one new recruit. As shown in Exhibit 14, IF projects were markedly more successful with an average of 3.4 new recruits per project; the other funds were all similar in attracting approximately one new faculty per project last year.

Exhibit 14. New Faculty Recruited & Faculty Retained

Funds	# of projects	# of faculty recruited	per project	# of faculty retained	per project
All	2,322	3,170	1.4	4,104	1.8
URDF	90	104	1.2	166	1.8
CRDF	23	28	1.2	64	2.8
IF	472	1,616	3.4	2,134	4.5
NOF	1,092	801	0.7	1,035	0.9
CRCIF	632	603	1.0	688	1.1

Both the CRCIF and NOF programs are, of course, contributing to attraction and retention of the project leaders themselves. However, the potential for these smaller projects to sustain further recruitment is clearly less than the major facilities associated with the IF. It is interesting to

note that the operational status of the projects had no impact on their ability to attract faculty. It seems that the existence, or even the promise of future availability of high-quality infrastructure is sufficient incentive for recruitment.

Of the 3,170 newly recruited faculty, 705 were from the U.S. and 538 were from other countries, which speaks to the very positive image the Canadian research enterprise is able to project internationally, particularly for the larger facilities.

> "The lure of Canada Research Chairs and CFI funding for this project facilitated the relocation of an entire research group from the U.K. to the university."
> —***University of Alberta***

The majority, 87 percent, of the new faculty were drawn from academia. Interestingly, the smaller universities and colleges were relatively more likely to find new faculty in the private and public sectors (25 percent of their new recruits), which might be explained by closer links with their communities. In addition, projects with an engineering focus were twice as likely to recruit from the private sector compared to other fields.

While the factors influencing the retention of faculty are difficult to prove, more than half the project leaders reported that their infrastructure had played a role in retaining over 4,000 faculty (see Exhibit 14). The average number of faculty retained per project, 1.8, was similar across funds, with the usual prominence of IF projects, where 4.5 faculty per project factored the availability of the infrastructure into their decisions to stay. Not surprisingly, there was a time trend on this measure, with more recent projects showing less effect on retention; there has simply been insufficient elapsed time to observe the phenomenon of retention.

In the typical research team, intellectual leadership is provided by faculty researchers. However, much of the actual day-to-day research activities are performed by postdoctoral fellows—individuals who have completed their formal training, and are preparing to begin their own independent careers. To sustain a high level of groundbreaking research activity, Canadian universities must be able to attract highly skilled PDFs, again, in the face of competition from other jurisdictions.

Project leaders reported a very positive impact of their infrastructure on the attraction of these vital members of their research teams. The 2,322 projects attracted 3,801 PDFs last year, as shown in Exhibit 15, including almost 2,000 from other countries.

Exhibit 15. PDFs Attracted

Funds	# of projects	# of PDFs to join	Average per project
All	2,322	3,801	1.6
URDF	90	61	0.7
IF	472	1,793	3.8
NOF	1,092	929	0.9
CRCIF	632	984	1.6

IF projects, which tend to be more large-scale and complex, attract proportionately more PDFs than other infrastructure projects.

> **R**ecruiting efforts have gone very well over the last year. Two postdoctoral fellows were recruited, […including one…] from the State University of New York at Stoney Brook. Both of these researchers were experienced in the field of cold atom physics, and thus a great "catch." It speaks highly for the impact of the CFI funding that they were successfully recruited, since postdoctoral fellows with experience in cold atom physics are in *great demand* even at the best labs in the world.—***University of Toronto***

3.4 Strengthening research training of young Canadians

To compete in the global knowledge economy, Canada must increase the size and quality of its pool of highly qualified people. Key to this development are post-secondary research training programs of the highest calibre. The CFI recognizes that innovative research taking place in state-of-the-art facilities is essential to achieve this national goal. The project reports provide ample evidence of a large and positive impact on the training milieu for young Canadians.

Exhibit 16. Use of Infrastructure for Training Graduate Students and Other Trainees

	Graduate students	*Other trainees*
Joining the institution from Canada	8,915	
Joining the institution from other countries	2,926	
Joining the institution from all locations	11,841	
Receiving training on the infrastructure	24,218	4,776

As shown in Exhibit 16, almost 12,000 graduate students were influenced by the availability of the infrastructure to join the institutions to pursue their studies. An even greater number of trainees at all levels, almost 29,000, made use of the infrastructure available at their institutions, to enhance their training through research. As might be anticipated, the more mature projects (finalized earlier and currently fully operational) were more popular for these time-limited experiences.

> **G**iven the cross-discipline application of spatial analysis, the creation of MP_SpARC brings together researchers in three faculties and provides increased opportunities for collaborative research between the University, and partners in government and the private sector. The Centre also allows researchers to train students on state-of-the-art equipment by the availability of the infrastructure. —***Saint Mary's University***

> **T**he infrastructure has been of primary importance in the research training of 6 clinical residents/fellows, 12 graduate students, 6 postdoctoral fellows, and more then 20 undergraduate students. The access to state-of-the-art scientific equipment has allowed us to provide an advanced training environment in which trainees can gain experience with the latest scientific methodologies and tools. These experiences have allowed our trainees a competitive advantage within the scientific community.—***St. Michael's Hospital***

From these data and the narrative comments, it is evident that project leaders view their infrastructure as key to more relevant, more multidisciplinary, and more collaborative research training. The significant presence of PDFs and graduate students from other countries adds an important international dimension to training for Canadians, and augurs well for future international collaborative research efforts.

3.5 Economic and social benefits to Canada

There is ample evidence in the project reports that CFI funding has served to set the conditions for the translation of innovative research into tangible economic and social benefits for Canadians. The CFI defines innovation as a process that begins with the creation of knowledge in research and continues through its applications, for the benefit of Canadian society. The availability of high-quality infrastructure and the research it supports are important enablers of innovation, but ultimately the research must be transferred to, and exploited by others to create social and economic benefits. Collaborative partnerships with the private and public sectors are key to the transfer of research results, as these companies and agencies are most likely to deliver the economic and societal improvements.

Two thirds of the project leaders reported inter-sectoral partnerships during the past year, and considered that two thirds of these were significantly strengthened by the infrastructure (see Exhibit 17). Another form of partnership that is especially important in the economic context is the "cluster." Slightly fewer examples were noted by the project leaders, but nevertheless, the infrastructure played a significant role in over half of these networks.

Exhibit 17. Linkages with the Private and Public Sectors

Fund	# of projects	# of researchers from private or public sector	# per project	% of projects significantly supporting inter-sectoral partnerships	% of projects significant for the creation of clusters/networks
All	2,158	2,215	1.0	66%	56%
URDF	88	103	1.2	68%	49%
CRDF	23	42	1.8	62%	38%
IF	445	1,026	2.3	73%	63%
NOF	1,005	415	0.4	63%	50%
CRCIF	590	605	1.0	63%	58%

One of the most direct ways of transferring, and ultimately applying, research results is to engage the user organization—company or service agency—in collaborative research using the infrastructure. Over 2,200 researchers from outside academia (in the private and public sectors) used the infrastructure to enhance their research and work collaboratively with the project teams.

> "The Applied Technologies for Healthy Aging Research Lab provided the necessary infrastructure for the development of a partnership between Fleming, Communications and Information Technology Ontario (CITO), and a private partner, Wireless Interactive Medicine. This partnership and related funding resulted in advancing research significantly in the area of ubiquitous location tracking over the past year. A licensing agreement among the partners was recently finalized.—***Sir Sanford Fleming College***"

Interestingly, almost half of the researchers from the private sector were involved in projects with an engineering focus, although such projects represent only 21 percent of the group under analysis. Taken together with the relatively greater recruitment of private sector researchers into engineering projects noted above, it appears that the linkages between engineering researchers in academia and industry are more readily forged.

Project leaders describe many examples of infrastructure and research that have laid the groundwork for innovative applications. Some researchers and institutions have successfully exploited results themselves with invention disclosures, patents, licenses, and even spin-off companies. Other project reports describe how public and private sector partnerships have helped to realize health, environment, and quality of life improvements based on the research output. The information provided below was gleaned from these narrative comments.

Economic Benefits

According to the project leaders, over the past year more than 160 projects have produced intellectual property in the form of invention disclosures, patent applications, provisional patents, patents issued, licenses, and software copyrights. While exact numbers were not given, there were at least 270 instances where such intellectual property was created. More than 40 project leaders also credit their infrastructure and research for playing a significant role in the launching of a new spin-off company last year. In addition, the project reports include numerous examples where private-sector partners have translated the research into improved products, processes, and services, in some cases with significant cost savings or job creation. These economic benefits for Canada are best illustrated in the words of the project leaders themselves.

> **T**he projects pursued thanks to the infrastructure we have acquired so far pertain mainly to process and product automation, development, or improvements. Thus, access to this infrastructure allows manufacturers, which are mostly SMEs, to increase their productivity and their competitiveness.—***Cégep de La Pocatière***

> **A** typical example is the partnership with […] under the Networks of Centres of Excellence in Microelectronics–(MICRONET). Indeed, thanks to our infrastructure's unique features we have been able to develop new thin films to meet the specific needs of […]. This work yielded intellectual property of direct benefit to our industrial partner.
> —***Institut national de la recherche scientifique***

> **A**s a result of the research and development activity of the Centre, there are also significant economic benefits to industry partners and the regional economy. For example, [Company] has reported direct sales to industry and research organizations in the United States and Ireland as a result of the Centre's research.
> —***Marine Institute-Memorial University of Newfoundland and Labrador***

The infrastructure continues to be instrumental in attracting a great deal of interest from Canadian content developers interested in exploring the use of HD digital cinema. We have attracted the attention of several new companies looking to expand commercial products in the HD field. The infrastructure has been used to help one Canadian manufacturer better compete in the North American market by making HD demo footage that would not otherwise be available. The same manufacturer is working with us to develop new HD products as well.—***Algonquin College***

The laboratory has generated data and models on asphaltene precipitation, and deposition that are useful for the design and operation of oilfield recovery, production, and processing schemes. It is difficult to quantify the benefit of this data, however, a number of companies are using it.—***University of Calgary***

The project to develop novel therapeutics to treat medical conditions affecting cartilage and bone has resulted in filing of two patents and two provisional applications. This project has also led directly to the establishment of a new start-up company at Western that will develop novel therapies for stimulating bone and cartilage growth.
—***University of Western Ontario***

Scientists have developed several devices important to the imaging of breast cancer, leading to the filing of a U.S. provisional patent, the creation of a spin-off company, and the training of people able to use this sophisticated equipment.
—***Sunnybrook and Women's Health Science Centre***

A patent has been filed in Canada and the U.S. on a series of small molecules that are presently being developed as drugs for the treatment of Alzheimer's disease. The patent has been licensed out to a private sector partner who is presently undergoing toxicology studies prior to the application for a IND, to proceed to clinical trials. Jobs have been created to manage the project, and to do the toxicology studies.—***University of Toronto***

The Microarray Centre (MAC) has been able to, as a result of the CFI infrastructure, build up a world-renowned reputation for making high-quality and affordable microarrays. As such, many labs have turned to the UHN microarray centre as their primary source of arrays. In 2003-2004, the MAC has sent arrays to over 300 labs around the world (20+ countries).—***University Health Network***

Photoacoustic devices were developed. A new company was formed for the manufacture of hand-held photoacoustic devices to test weld integrity in auto assembly.
—***University of Windsor***

A U.S. patent has been granted and we are awaiting a patent for the same invention from the Canadian Patent Office.—***Université du Québec à Trois-Rivières***

The infrastructure has indirectly led to the creation of a spin-off company. This company has signed non-exclusive license agreements with SAP, CGI, and Bell Canada.
—***École Polytechnique de Montréal***

A spin-off company has been formed to market custom infrared spectroscopic products to the Terahertz community. T-rays are recognized as an emerging field with many applications in the defence and remote sensing fields.—***University of Lethbridge***

In the past year, we completed a project on the use of lime mud residue from paper mills involving three pulp and paper mills in Northwestern Ontario. Benefits include a reduction in landfilling costs for paper mills, the preservation of land space resulting from decreased landfill usage and lower reclamation costs for contaminated mine sites.
—***Lakehead University***

[**C**ompany] was a spin-off created from the York GeoICT Lab. Two technologies were transferred to [Company] for commercialization and marketing.—***York University***

Over the last year, project researchers have worked closely with [Company] in developing a new motor drive product for various applications in petrochemical, paper/pulp, mining, iron/steel, power generation, and other industries. The new technologies are expected to generate at least $12.5 million in revenue per year for [Company]. In addition, a U.S. patent was granted in September 2003. [Company] is currently using this technology in their products, and estimates that the use of technology can reduce the manufacturing cost by $10,000 per drive and bring a total annual saving of $2 million.—***Ryerson University***

Previously developed technology licensed to a UBC spin-off company is now being used intensively for process development on the new [aircraft manufacturer] project.
—***University of British Columbia***

CFI-funded equipment is being used to support studies that are resulting in increased yields of important economic crops in Atlantic Canada. The research of the Wild Blueberry Research Centre has resulted in increases in production acreage, processing tonnage, the market share of wild blueberries, and has improved the competitiveness of these industries on the international market.—***Nova Scotia Agricultural College***

A patent has been issued and commercialization of the new device is now in progress. A spin-off Canadian company has been founded as a commercialization vehicle, with initial funding from Canadian investors. The company is negotiating a license for the technology from the University.—***Queen's University***

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Health, environment, social, and public policy improvements

Research can lead to improvements in all these areas. However, active participation by decision-makers and service providers is necessary for the translation of knowledge to occur and improvements to be implemented. That the research enhanced by the CFI program has already produced results in many areas is illustrated in the sampling of quotes below.

Health

One of the bench to bedside projects undertaken with the infrastructure has led to the development of a new clinical assessment tool for evaluating patients with bleeding problems.—***McMaster University***

One patent, previously reported, has been licensed to Bio-logic Systems Corp, a world-leader in neurodiagnostic medical devices. This MASTER (Multiple Auditory Steady-State Evoked Response) physiologic audiometer system is now FDA approved and is being marketed internationally.—***Baycrest Centre for Geriatric Care***

The results obtained with the infrastructure have enabled us to seek two patents, one of which is being adapted to the industrial scale in collaboration with a top Canadian company in the area of probiotics: a major niche in the area of functional foods and neutraceutics where Canada is a leader.—***Université Laval***

The benefits to Canada are palpable: children in this study susceptible to childhood cancer will be identified, monitored, and subsequently treated immediately if signs of cancer appear. Early treatment will lead to higher survival rates among children.
—***Hospital for Sick Children***

The impact of research conducted with the facility has culminated in the production of a significantly improved fire shelter that will undoubtedly save the lives of firefighters. This shelter, patent pending, is under contract with the USDA Forest Service and is also under consideration for acquisition by several jurisdictions in Canada.—***University of Alberta***

This collaborative project engages academic, private, and public sector scientists and will take full advantage of the multidisciplinary expertise of the investigators who together will create a research team that can be quickly recruited to address the next outbreak of infectious disease.—***University of Ottawa***

A Canadian patent was issued for the multi-drug resistance protein (MRP) gene developed in our lab. A licensing agreement was signed with [Company] for the company to use our technology to provide commercial screening devices, or to develop licensed products.
—***Queen's University***

Access to real-time PCR instrumentation has allowed us to develop assays for the detection of four major foodborne pathogens which can be completed in less than one hour.—***University of Guelph***

The Manitoba Centre for Health Policy was invited to appear before the Standing Committee on Health in relation to its major study on the situation of prescription drugs in Canada.—***University of Manitoba***

Last year, the infrastructure allowed the Genome Sequence Centre to play a lead role in sequencing the SARS genome.—***University of British Columbia***

Our discovery that chronic pain curtails learning over a year in children with severe impairments has provided stronger impetus to treat pain in this population. Our measure of post-operative pain in children is used in many settings around the world.
—***Dalhousie University***

The Centre's focus on novel therapeutics has already led to a number of innovative clinical trials that would not otherwise have been available to Canadian patients. These have come in some cases from our own technologies, from large pharmaceutical companies who sought our expertise, which is now concentrated in the Centre, as well as from smaller biotech companies in Canada.—***McGill University***

The quality of the platform enabled us to create major collaborations with industry, particularly for the development of new endovascular catheters, as well as with companies that develop contrast agents for vascular imaging and with makers of imaging equipment. Furthermore, our equipment enabled our team to develop experimental animal models. Based on the expertise developed with the platform, we have signed technology assessment contracts with several companies.
—***Université de Montréal***

Environment

The facility funded through the CFI was used for testing of a new product concept for drinking water disinfection equipment. This research led to the development of an improved UV reactor design for household applications. Also, two companies located in Ontario gained significant benefit from these resources.—***University of Toronto***

Benefits also included environmental and health improvements, including co-operation with the regional office of the MOE in monitoring time variations in particulate matter for the purpose of locating polluting sources.—***Fanshawe College***

The Atmospheric Monitoring Project is having immediate impact. Data collected on precipitation, humidity, solar radiation, etc. is made available to the public via JASCO Environmental Monitoring System or JEMS (JASCO Research Ltd) through the University. It is currently being used by the Victoria Capital Regional District in conjunction with data collected by the B.C. Ministry of Water Land and Air Protection and the National Air Pollution Surveillance Program of Environment Canada to assess regional air quality issues.—***Royal Roads University***

The project on Environmentally Friendly Products and Processes has led to the development of new technology for methane reforming. This Canadian-based technology will allow for the implementation of catalytic processes that will help this country meet its Kyoto obligations in future years. The project has also resulted in the formation of a new Western spin-off company, Recat Technologies, Inc., which will commercialize new technologies developed using the infrastructure.—***University of Western Ontario***

This facility with its analytical and modeling capabilities has been instrumental in setting-up a university spin-off company with four partners, which will provide unique and integrated tracking and management tools and solutions for water and watershed protection, and management.—***University of Victoria***

Public policy

“**T**he Maritime Data Centre for Aging and Policy Research is well established now. Results of the research are informing policy development related to caregiving for the aging population at many levels.—***Mount St. Vincent University***

Our work allowed us to identify forest exploitation levels (e.g. the proportion of lumber harvested) that corresponds to the tolerance level of several bird species associated with mature forests. Based on this work, the province has modified its quantitative goals in terms of forest structure.***—Université de Moncton***

Transport Canada uses our research to set regulation policies. Similarly, we input into a number of standards organizations such as the International Organization of Standardization.—***University of Calgary***

The project leader is responsible for evaluating, within the Anglophone sector, the effectiveness of the MEQ’s *New Approaches: New Solutions* project designed to combat high drop-out rates within Quebec schools.—***Concordia University***

Federal departments and agencies constantly ask us to perform analyses. In our view, we now have—thanks to the infrastructure—a unique capacity in Canada (and perhaps in North America) to monitor urban and regional economies in Canada, the United States, and (soon) Mexico.—***Institut national de la recherche scientifique***

A first edition of a comprehensive GIS-based tool for safety analysis of rural road networks was developed.—***Carleton University***

Research on seahorses led the Convention on International Trade in Endangered Species of Wild Fauna and Flora to add seahorses to its list of regulated species.
—***University of British Columbia***

The findings of this project have contributed to an enhanced quality of teacher professional development and teaching in Ontario. The Ontario College of Teachers recognized the value of the model developed based on our findings by granting 14 Professional Learning Credits for the seven modules submitted to them for certification. —***Seneca College***”

Institutions are equally enthusiastic about the opportunity to contribute to Canada’s economic and social well-being.

> **S**ince our last report, 16 patents have either been approved, applied for or have applications in preparation in diverse areas such as cardiovascular gene therapy, ICT wireless, positron emission tomography, and protective clothing research.
> —***University of Alberta***

It is evident from the foregoing that Canadian researchers are intent in transferring the knowledge acquired through their research and putting it to work for Canadians.

4. Conclusions

Canadian research institutions continue to take full advantage of CFI programs to advance towards their strategic research goals with enthusiasm and optimism. Despite some of the challenges encountered in the implementation of projects, the data provided in this report leave no doubt about the positive impact of investments in infrastructure on building Canada's capacity for innovation. By giving Canadian researchers the tools they need to undertake more innovative research at an internationally competitive level, CFI programs continue to enable enhanced research productivity and technology transfer to partners who can exploit the results and generate economic and social benefits for Canadians.

Of particular importance to Canada's long-term capacity for innovation is the power of infrastructure investments to build the pool of highly qualified researchers for today and the future, both in the private and public sectors. There is every indication that the projects are both playing a significant role in recruiting and retaining excellent faculty researchers, and providing Canadian trainees with an enhanced and exciting milieu in which to develop their skills.

The challenges encountered in the implementation of some projects, and the data suggesting that some infrastructure is now nearing the end of its useful life, suggest that more attention be paid in the future to operation, maintenance, performance enhancement and, where merited, replacement. Investments have been made in infrastructure for good effect—Canada has become a research destination of choice. It is now important to sustain and build on the achievements to date.