Circum Network inc.
management and research consulting

74 Val Perché Street
Gatineau, Québec J8Z 2A6
(819)770-2423, 🖷 (819)770-5196
service@circum.com
http://circum.com

rigour – transparency – creativity – relevance

Joint Evaluation of Research Tools and Instruments Grants (RTI) and Major Facilities Access Grants (MFA)

Final evaluation report

Prepared for

Evaluation
Natural Sciences and Engineering Research Council of Canada
350 Albert Street
Ottawa, Ontario K1A 1H5

August 7, 2007

⌘ This text is formatted for back-to-back reproduction.

Table of contents

STUDY TEAM

Consulting team

Benoît Gauthier, principal investigator
Heather MacDonald, co-investigator
Amanda McIntyre, key informant interviews and case studies
Steven Lum, key informant interviews
Andrew Hough, survey management

Natural Sciences and Engineering Research Council of Canada

Élaine Gauthier, scientific authority and project manager

EXECUTIVE SUMMARY

The Natural Sciences and Engineering Research Council (NSERC) is a national research-granting agency that funds the direct costs of research. It assists in buying or developing research equipment and in accessing regional or national research facilities via two main programs: the Research Tools and Instruments (RTI) program and the Major Facilities Access (MFA) program. This report presents the findings of the Joint Evaluation of RTI and MFA.

During the course of the present evaluation, the Major Facilities Access program was replaced by the Major Resources Support program. While observations presented in this report may apply to the new program, the descriptions and analyses are geared toward MFA.

Evaluation methodology

The evaluation process included the following methodologies:

- a survey of university department heads: between January and March 2006, 256 heads of natural sciences and engineering university departments (representing one third of all such departments) completed a Web-based questionnaire focused on the state of research equipment and the financing of operations and maintenance of research equipment;

- a survey of program applicants: between January and March 2006, 1,664 program applicants from the 2001 to 2005 competition years (41% of the population) completed a Web-based questionnaire on the impacts of obtaining or not obtaining an RTI or an MFA grant, as well as on various other themes related to the place of research equipment in the research environment;

- key informant interviews: 36 interviews were conducted with individuals whose position or experience allowed them to offer informed opinions on the programs;

- a document and administrative data review: a variety of documents and data sets were accessed to profile the use of the programs and the environment in which they operate; they included: Internal notes, annual reports of Major Facilities Access grant selection committees, NAMIS records, MFA applications, *ad hoc* data sets produced by NSERC for this evaluation, NSERC's *Facts and Figures* publication;

- a review of experiences in foreign countries: a brief overview of comparable international funding initiatives was conducted; representatives from seven countries were approached after information was collected from the relevant Web sites: Sweden, Korea, United States, Germany, Netherlands, United Kingdom and Australia.

- a series of case studies: case studies of five MFA projects were conducted which included a review of documentation, site visits and additional interviews.

Research Tools and Instruments Grants (RTI)

With average annual expenses of $32 million between 2001 and 2005, RTI is the core NSERC program for equipment acquisition. Over the same period, 82% of program funding was expended on equipment valued between $7,001 and $150,000; the balance went to equipment of higher cost, for projects in subatomic physics.[1] Still between 2001 and 2005, some 1,450 requests for funding were received annually on average and some 500 grants were awarded.

Program performance

RTI's objectives are to foster and enhance the discovery, innovation and training capability of university researchers in the natural sciences and engineering by supporting the purchase of research equipment and installations.

1 RTI Grant applications are divided into three categories according to the total cost of the equipment. The three categories are: RTI-1 (for equipment valued between $7,001 and $150,000); RTI-2 ($150,001 to $325,000) and RTI-3 (more than $325,000). A moratorium on Categories 2 and 3 has been in effect since 2003 (except for projects in subatomic physics).

RTI funding leads to more, faster and more in-depth research as well as better trained HQP; the absence of RTI funding translated into delayed, more superficial research and weakened research teams and HQP training programs. These impacts were felt across the spectrum of disciplines, in all regions and in large and small institutions. Small institutions tended to report benefiting more from RTI funding than larger institutions — as long as they were able to secure such funding since data have shown that the probability of funding was less for small institutions than for medium-size and large institutions. These observations support the notion that RTI is working toward the achievement of its objectives to enhance the discovery, innovation and training capability of university researchers.

RTI-1 funding

NSERC and CFI programming have made significant contributions to improving the state of university research equipment over the past decade or so. Yet, a little more than half of existing equipment is in very good or adequate condition, while a little less than half is in poor condition or inoperative. Also, while one laboratory in ten is inadequate for research purposes, half of the rest can support simple research applications and the other half, cutting-edge research.

Three messages come out loud and clear from this evaluation study:

- a significant proportion of the existing equipment infrastructure will require replacement over the coming five years — between one quarter and one third (about $1.5 billion) of the value of existing equipment is at play;
- about 20% of existing equipment (worth about $1 billion) will require major maintenance over the coming five years and funds are scarce for this need;
- it is difficult for researchers to find funding for small equipment.

The average annual need to replace obsolete equipment amounts to approximately $300 million. The current level of funding of RTI (about $32 million annually over the past 5 years for all three RTI sub-programs) will allow it to address only a small portion (about 10%) of the need for replacement of existing equipment in the coming years, not to mention the need for acquisition of entirely new equipment. Yet, the amount and quality of research equipment is one of the most important factors affecting research productivity and the quality of HQP training. Note that RTI is not the only player in the game of funding research equipment — although one major proponent, CFI, is not heavily involved in the financing of replacement equipment.

While CFI plays a pivotal role in the funding of acquisitions of state-of-the-art research equipment, NSERC is also a key player in this field. NSERC's annual budget for research equipment acquisition is much lower than that of CFI, but NSERC has been involved in such funding for a long time — such that its cumulative influence ranks it in second place as an equipment purchase funding source. Therefore, any modification to NSERC's priorities and strategies in this area will have profound consequences on the university research system.

Recommendation 1: increase and stabilize the funding of RTI-1.

RTI-2/RTI-3 moratorium

RTI Grant applications are divided into three categories according to the total cost of the equipment. The three categories are: RTI-1 (for equipment valued between $7,001 and $150,000); RTI-2 ($150,001 to $325,000) and RTI-3 (more than $325,000). A moratorium on Categories 2 and 3 has been in effect since 2003 (except for projects in subatomic physics).

Absence of overlap between RTI and CFI. Between 1998 and 2005, RTI has spent upwards of 77% of its budget on RTI-1 projects; projects of similar value represent 1% of CFI project awards. CFI spent 10¢ in projects with values in the range of RTI-1 for every dollar spent by RTI. Conversely, CFI spent respectively $12 and $42 in RTI-2 and RTI-3 grade projects for each dollar invested by RTI in projects of these sizes. Therefore, there is currently little overlap between the CFI and RTI programs. In fact, constraints to usage of CFI (large-scale, state-of-the-art projects within university strategic priorities) make unlikely a dramatic overlap in financial support with RTI/MFA projects.

Existence of a gap between RTI and CFI. The same constraints to usage of CFI programs may create gaps in funding availability, in particular for large scale projects outside of university strategic priorities.

A significant increase in RTI-2/RTI-3 activity could produce a movement of projects away from CFI, towards RTI, thereby bridging the gap between the two sources of funding, producing an overlap between the two programs and creating pressure on RTI funding. A reactivation of RTI-2 and RTI-3 would likely have some negative effects (reduction of RTI-1 funds, overlap with CFI) and some positive effects (reduction of the funding gap for projects too large for RTI-1 but outside the CFI program territory).

Effects of the moratorium. The RTI-2/RTI-3 moratorium has made it more difficult for researchers to obtain funding for mid-range to expensive pieces of equipment. The effect has not been catastrophic, however, as it has been compensated in part by the use of CFI funds and because RTI has continued providing an average of $5.7 million annually to RTI-2 and RTI-3 projects, albeit only in the area of subatomic physics.

Still, one third of the departments were left in need of equipment without funding to acquire any of them. Also, where laboratories have been unable to acquire major equipment they considered they needed, it is possible that their ability to conduct cutting-edge research has been impaired. Moreover, the latest round of CFI competition has reportedly been more fierce than previous ones, with more applications turned down; it appears to become more difficult than before to access CFI funds. Close monitoring of this situation is in order to avoid deterioration without reaction.

The moratorium allowed NSERC to concentrate its research equipment purchase funds on RTI-1 level grants; lifting the RTI-2/RTI-3 moratorium would presumably adversely affect the sums available for RTI-1, unless new funding is secured for more expensive equipment.

During the moratorium on RTI-2/RTI-3, a significant portion of the need for equipment worth more than $150,000 was satisfied using CFI funds. This suggests that the reinstatement of RTI-2/RTI-3 would create a funding overlap between the programs of the two organizations. Of course, the situation will be totally different if CFI programs disappear once they reach their sunset clause.

Allowance for equipment worth more than $150,000. Since 2004, NSERC has accepted applications under RTI-1 for equipment that costs up to $250,000 as long as the applicant is able to secure funding from other sources to bring the amount requested from NSERC to $150,000 or less. The program data systems are not set up to provide information on the incidence of such applications or on their rate of success. Considering that this allowance serves a certain need and that it has little to no impact on the rest of the program, it is recommended that it be maintained.

Recommendation 2: maintain the RTI-2/RTI-3 moratorium as long as CFI programs are active in this area.

Access to RTI

A large group of key informants believed that larger, well-funded institutions are advantaged. They believed that smaller, newer and more remote universities have more difficulty obtaining funding from RTI. This view is supported by data on success rates and funding rates. Between 2001 and 2006, small universities have had a success rate of 28% in RTI applications compared to 37% for medium-size universities and 40% for large universities. Their funding rate for the same period was 22% compared to 32% and 34% for the medium-size and large universities.

Recommendation 3: study the reasons for the lower success and funding rates of small universities in RTI-1.

Major Facilities Access Grants (MFA)

MFA grants support researchers' access to facilities or research resources that are significant in size, value or importance and that are not routinely available in Canadian universities. MFA grants provide funding for maintenance costs such as the salaries of technical and professional research support staff employed to provide support to users, or to maintain and operate the facility, and for other direct costs such as materials, supplies and small equipment essential to the maintenance and operation of the facility.

Between 2001 and 2005, 241 requests for funding were received by MFA and 149 grants were awarded — typically for a period of 3 years. Between FY 2000-2001 and FY 2004-2005, the program expended $62 million, or about $12 million annually.

Program performance

MFA aims to support researchers' access to major regional or national research facilities by assisting these facilities to remain in a state of readiness for researchers to use. Note that this objective is expressed at the level of activities (i.e., support access) rather than at the level of outcomes (e.g., enhance discovery).

The key impacts of MFA were identified as better use of the facilities, increased collaboration among researchers and improved international competitiveness of Canadian researchers. Effects of a grant appear more intense for MFA projects than for RTI projects — be they the positive effects of obtaining a grant or the negative effects of not obtaining it.

Increased collaboration among researchers and organizations as well as attraction and retention of faculty are much more prominent effects for MFA than RTI. The effects documented in this evaluation study seem to take place beyond the immediate objectives of the program (i.e., increased collaboration, attraction and retention may be a consequence of maintaining a state of readiness); this may be due to the measurement tools used or it may be that program applicants and key informants take facility readiness for granted and look beyond that point for the effects of MFA.

Recommendation 4: restate MFA objectives in terms of results instead of activities and adjust reporting requirements accordingly.

Funding of operations and maintenance expenses

The value of annual operating and maintenance costs for the coming years was estimated at about 4% of the original purchase cost of the equipment, based on the subsidies recently added to the CFI grants. If the university research equipment infrastructure is worth $5.2 billion, the O&M bill should be about $208 million annually and it will likely increase as CFI continues to support the addition of state-of-the-art equipment. Therefore, the $12 million invested annually by MFA for major facilities probably represents a little more than 6% of the need for O&M funding.

Considering the pace at which new equipment is added to the research infrastructure, via CFI programs in particular, the university research system is likely to face a serious problem funding the operations of the equipment as well as its maintenance.

Recommendation 5: augment funding for operations and maintenance expenses.

NSERC is second only to universities themselves among sources of funding with regard to operating and maintenance funds. CFI, other federal government funds, provincial funds and user fees each account for about half as much as NSERC. The role of CFI has been significant albeit short-term in this area with regard to the equipment it has subsidized since 2001.

Current MFA evaluation criteria do not accommodate facilities initially funded by CFI which may not fit the criteria of national or regional stature but have run out of operating and maintenance funding. Whether MFA should make room for these facilities is an open question.

Recommendation 6: coordinate with CFI to avoid under-investment in O&M.

The consensus appears to be that MFA evaluation criteria are appropriate in principle but unclear in practice. Of particular concern are the definition of the uniqueness and the definition of the regional stature of a research facility/resource — one of the gateways to MFA funding. This could be a communication issue or the expression of a structural problem. First, the definition of uniqueness of the facilities at the regional or national level was perceived to be unclear and difficult to demonstrate. Researchers do not understand the concept of a regional facility. For researchers, most facilities could be viewed as "regional" in nature as long as researchers from other institutions are not barred from using them. Second, there is concern that facilities located in small institutions have a harder time to secure funding. The presence of a few large applications, evaluated on the same footing as many small applications, also raises concerns.

In addition, access to regional and national facilities ranked lowest among the factors affecting research productivity and the quality of HQP training. This may lead to questioning the rationale for O&M support of regional and national facilities to the exclusion of local facilities and emphasize the need to support O&M efforts closer to research teams. Of course, a move in that direction runs the risk of spreading program resources too thin to have substantial effects.

Recommendation 7: The NSERC Council should revisit its decision to fund O&M costs for national and regional research infrastructures only. If a decision is made to maintain the current emphasis on regional/national resources, the definitions of uniqueness and of what constitutes a regional/national resource should be clarified.

Chapter 1

PROGRAMS

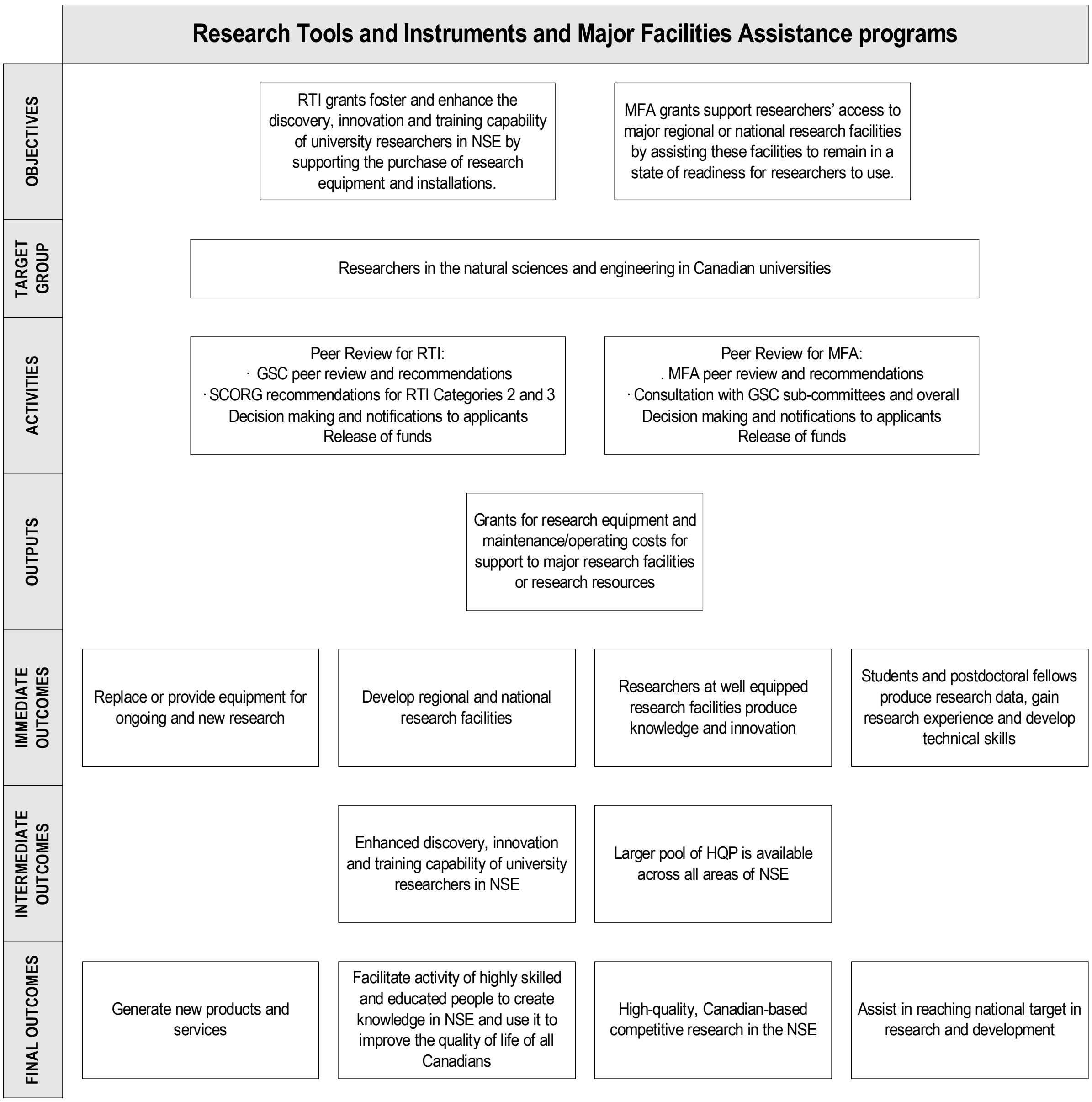
This report presents the findings of the Joint Evaluation of Natural Sciences and Engineering Research Council of Canada (NSERC) Research Tools and Instruments Grants (RTI) and Major Facilities Access Grants (MFA).

Chapter 2 presents the methodological information relative to the various sources of data. Chapter 3 addresses each evaluation issue one by one. Chapter 4 synthesizes the findings and offers recommendations.

1.1 Programs descriptions

The Natural Sciences and Engineering Research Council is a national research-granting agency that funds the direct costs of research. This agency uses two main programs that are administered by their Research Grants Division to assist in buying or developing research equipment and in accessing regional or national research facilities: the Research Tools and Instruments (RTI) program and the Major Facilities Access (MFA) program.

EXHIBIT 1.1 • Program logic model



Research Tools and Instruments program

The objectives of RTI are to foster and enhance the discovery, innovation and training capability of university researchers in the natural sciences and engineering (NSE) by supporting the purchase of research equipment and installations.

RTI grants are usually for one year. They provide assistance in buying or developing research equipment costing more than $7,000. RTI Grant applications are normally divided into three Categories according to the total cost of the equipment. The three categories are:

- RTI – Category 1: $7,001 to $150,000
- RTI – Category 2: $150,001 to $325,000
- RTI – Category 3: more than $325,000

A moratorium on Categories 2 and 3 has been in effect since 2003. However, since 2004, NSERC has accepted applications under Category 1 for equipment that costs up to $250,000 (before tax, shipping and handling) as long as the applicant is able to secure funding from other sources to bring the amount requested from NSERC to $150,000 or less. Grants in categories 2 and 3 can be multi-year in exceptional circumstances.

The moratorium does not apply to applications in subatomic physics, as the funding mechanism for Subatomic Physics differs from other disciplines. RTI applications in subatomic physics are evaluated within a separate Subatomic Physics budgetary envelope, which includes funds for both Discovery Grants and RTI, where the grant selection committee accepts applications in Categories 2 and 3. In fact, Subatomic Physics (SAP) puts their discovery and equipment grants money together and then decides globally what they will fund — even if it includes equipment that costs more than $150,000. That is to say, SAP applications for equipment are submitted without making the distinction between RTI 2 and RTI 3.

NSERC only accepts applications for equipment that has not yet been purchased, or that has been purchased within the one-year period immediately prior to the current deadline for receipt of applications. All applications are reviewed on a competitive basis and there is no guarantee of funding, even if the equipment has already been purchased.

Between 2001 and 2005 (Exhibits 1.2 and 1.3), 2,463 of the 7,239 requests (34%) were awarded a total of $158 million or about $32 million per year (29% of the requested amount).

EXHIBIT 1.2
RTI activity from 2001 to 2005

	Requests	Awards	Success rate[1]	Funding rate[2]
2001[3]	1618	642	40%	34%
2002[3]	1402	430	31%	26%
2003	1487	325	22%	20%
2004	1325	471	36%	29%
2005	1407	595	42%	37%
2001-2005	7239	2463	34%	29%

Note: these data include the subatomic physics activity.
[1] Proportions of requests leading to awards.
[2] Proportion of the funds requested actually awarded.
[3] Former Equipment Grants, Major Equipment Grants and Major Installation Grants programs

EXHIBIT 1.3
RTI awards from 2001 to 2005

	RTI 1		RTI 2		RTI 3	
	Awards	Awarded	Awards	Awarded	Awards	Awarded
2001	635	$31.3M	11	$2.5M	9	$7.7M
2002	414	$20.9M	10	$1.8M	7	$2.4M
2003	320	$17.9M	—	—	5	$12.3M
2004	470	$24.9M	1	$0.2M	—	—
2005	595	$35.1M	—	—	2	$1.5M
2001-2005	2434	$130.1M	22	$4.5M	23	$23.9M

Note: these data include the sub-atomic physics (SAP) activity.

EXHIBIT 1.4 • RTI-1 requests by grant selection committee and by competition year

GSC #	Grant selection committee	2002-2004	2002	2003	2004
All grant selection committees		**100%**	**1357**	**1487**	**1325**
	Life Sciences	**19%**	**469**	**479**	**419**
32	Cell Biology	3%	78	72	56
18	Evolution and Ecology	4%	96	103	98
1011	Integrative Animal Biology	4%	92	98	84
21	Interdisciplinary	1%	13	14	14
33	Molecular & Developmental Genetics	2%	47	38	40
3	Plant Biology and Food Science	4%	98	110	73
12	Psychology: Brain, Behaviour and Cognitive Science	2%	45	44	54
	Physical Sciences	**18%**	**438**	**447**	**377**
24/26	Inorganic-Organic Chemistry / Analytical-Physical Chemistry	9%	216	222	187
28	Condensed Matter Physics	2%	47	64	48
9	Environmental Earth Sciences	3%	86	74	65
29	General Physics	1%	20	22	23
8	Solid Earth Sciences	2%	38	42	32
17	Space and Astronomy	0%	12	12	9
19	Subatomic Physics	1%	19	11	13
	Mathematical and Computational Sciences	**4%**	**81**	**96**	**74**
330/331	Computing & Information Science – A & B	3%	54	73	64
336/337	Pure & Applied Mathematics – A & B	0%	16	10	3
14	Statistical Sciences	0%	11	13	7
	Engineering	**18%**	**369**	**465**	**455**
4	Chemical & Metallurgical Engineering	6%	135	147	138
6	Civil Engineering	4%	93	96	94
334	Communications, Computers & Components Engineering	2%	21	47	56
335	Electromagnetics & Electrical Systems Engineering	2%	41	47	32
20	Industrial Engineering	1%	12	15	16
13	Mechanical Engineering	4%	67	113	119

Source: NSERC Business Object Reports

Over the 2002-2004 competition years, 4,126 grant requests were received for RTI-1 (Exhibit 1.4). Life sciences, physical sciences and engineering contributed almost equal numbers of requests (hovering between 30% and 33%), while mathematical and computational sciences supplied 6% of them.

Major Facilities Access

During the course of the present evaluation, the Major Facilities Access program was replaced by the Major Resources Support program[1]. While observations presented in this report may apply to the new program, the descriptions and analyses are geared toward MFA.

MFA grants are generally awarded for three years. They support researchers' access to major regional or national research facilities by assisting these facilities to remain in a state of readiness for researchers to use.

MFA grants are not intended to maintain facilities that are standard in a discipline and present in many institutions. They support researchers' access to facilities or research resources that are significant in size, value or importance and that are not routinely available in Canadian universities. The facilities are used by researchers from a number of institutions, including universities, government laboratories and companies within a

1 The Major Resources Support (MRS) program replaced the Major Facilities Access (MFA) program after the 2006 competition. The MRS program builds on its predecessor. The following additions were made in the new program: (i) addressing the specific needs of the thematic research resources, such as institutes, alongside those of the experimental resources; (ii) formalizing the support to consortia of Canadian researchers in accessing major resources located abroad and without equivalent in Canada; (iii) re-focusing and expanding the selection criteria; (iv) offering up to five year grants (three in the past); (v) articulating explicit eligible and ineligible costs; (vi) implementing a screening step at the level of the Letter of Intent (to be effective for the 2008 competition); and (vii) implementing new reporting requirements for grants of $500,000/year and higher.

According to the program description, "The objective of the Major Resources Support (MRS) program is to facilitate the effective access of Canadian academic researchers to major regional, national, or international (based in Canada) experimental or thematic research resources by financially assisting these resources to remain in a state of readiness for researchers to use. MRS grants are not intended to support resources that are standard in a discipline or commonly available in Canadian universities. The MRS program also aims to facilitate the access by Canadian researchers to major international resources located outside Canada, excluding any direct financial support towards the operating and maintenance costs of such resources."

region or across the country. These resources cannot be entirely supported from sources such as user fees and research grants. They may include large special items of research equipment, specialized experimental facilities, or a core of highly skilled technical or professional research support staff essential to the research activities of a group.

MFA grants provide funding for maintenance costs such as the salaries of technical and professional research support staff employed to provide support to users, or to maintain and operate the facility, and for other direct costs such as materials, supplies and small equipment essential to the maintenance and operation of the facility. These grants may not be used to support graduate students or postdoctoral fellows or to pay any of the indirect costs of research. The costs of maintaining and operating a resource should be split into two major components: maintenance costs and recoverable costs. Only maintenance costs are eligible for MFA support.

EXHIBIT 1.5
MFA activity from 2001 to 2005
(annual competition funding)

	Requests	Awards	Success rate[1]	Amount awarded[2]	Funding rate[3]	Amount expended[4]	
2001	16	12	75%	$1.7M	71%	$7.8M	2000-2001
2002	50	34	68%	$4.5M	49%	$9.0M	2001-2002
2003	60	42	70%	$4.9M	52%	$9.9M	2002-2003
2004	51	29	57%	$3.8M	60%	$14.5M	2003-2004
2005	64	32	50%	$5.6M	63%	$20.7M	2004-2005
2001-2005	241	149	62%	$20.5M	57%	$61.9M	2000-2005

Note: these data include the sub-atomic physics (SAP) activity.
[1] Proportions of requests leading to awards.
[2] Typically awarded for three consecutive years.
[3] Proportion of the funds requested actually awarded.
[4] NSERC, *Facts and Figures 2004-2005*

1.2 Evaluation context

Given that the RTI program has been functioning since 1982 and the MFA program since 1996, in one form or another[1], the programs have been in place long enough to expect that some results have been achieved. NSERC considers that at this stage, an evaluation focused on the rationale and the impacts of the programs (i.e., a summative evaluation as opposed to a formative evaluation centred on program processes and possible improvements) is appropriate. Summative evaluations of the programs' previous incarnations were in fact conducted in the 1980s and 1990s.[2] The focus of the proposed summative evaluation is on the medium and long-term impacts of the program on the target populations.

In the summer of 2005, NSERC prepared an *Evaluation Framework* in which relevant evaluation question indicators and data sources were identified. The framework was developed based on a literature review of past evaluations and interviews conducted with program managers, the group chairs of Grant Selection Committees, and representatives of external organizations within the NSERC environment. Key informants were again consulted to determine the relative priority of each evaluation issue (low, medium, high) relating to program relevance, program impact/results and program design/alternative delivery. The *Evaluation Framework* proposed indicators and data sources/data collection methods for issues that were ranked as medium or high priority by key informants. The *Evaluation Framework* presented a profile of the programs, including their respective objectives and program deliveries, a logic model (linking the two programs) highlighting the intended outputs and results, evaluation questions by issue, and a detailed evaluation strategy.

The objective of the Joint Evaluation of Research Tools and Instruments Grants (RTI) and Major Facilities Access Grants (MFA) is to address the

1 RTI was established in 2003 and replaced Equipment Grants, Major Equipment Grants, Major Installation Grants. MFA was established in 1996 and replaced Infrastructure Grants.

2 Evaluations were conducted in 1984 for the Infrastructure program, and 1990 for the Equipment Grants program.

evaluation issues and questions presented in the *Evaluation Framework*. The evaluation issues are:

Rationale

1. What is the state of existing research equipment/infrastructure in Canadian universities (description, assessment, technical support, needs)?

2. What sources of funding are available for equipment and operating and maintenance costs in Canada?

3. What is the extent of the overlap, if any, between CFI programs and NSERC's RTI and MFA programs?

Impacts/Results

4. To what extent are the objectives of these programs being achieved? What have been the results of the programs? What have been some of their unintended impacts? What has been the effect of RTI funding on the discovery, innovation and training capability of university researchers? What has been the effect of MFA support on access to major regional or national research facilities? What has MFA funding been used for? What is the impact of major installations on university infrastructures (by discipline)?

5. What is the relationship between equipment/infrastructure and the research productivity and the training capability of university researchers? How much additional training/publications have been made possible by having new equipment/facilities? What was the impact on the quality and nature of the training provided to HQP?

6. Have institutions managed the major research facilities, and the sharing of these facilities regionally and nationally, optimally? How interdisciplinary / multidisciplinary are the installations and their users?

7. What has been the impact of the RTI 2-3 moratorium on the state of a) equipment b) research productivity? c) training of HQP? What are the ways

of coping without the requested equipment or facilities? What is the effect of not being funded?

Design/Alternative Delivery[1]

8. What is the best way to deliver equipment/infrastructure funding to the research community? What mechanisms are currently used by other organizations (both Canadian and foreign) to fund equipment and maintenance and operating costs for research facilities in science and engineering?

9. Are new or established researchers advantaged or disadvantaged by the current RTI selection process? Are new MFA applications or renewal applications advantaged or disadvantaged by the current selection process?

10. Are MFA objectives and evaluation criteria appropriate for all disciplines and all types of applications (regional facilities / national facilities / large research institutes)?

1 One evaluation issue was rated a low priority and was discarded from the evaluation process. It read: "Is the duration of MFA grants adequate? Under what conditions should the three-year period be extended?"

Chapter 2

METHODOLOGY

The evaluation process included the following methodologies:

- a survey of university department heads;
- a survey of program applicants;
- key informant interviews;
- a document and administrative data review;
- a review of experiences in foreign countries;
- a series of case studies.

2.1 Survey of department heads

Questionnaire design and pretest

The department heads questionnaire was developed as part of the design phase of the Joint Evaluation of RTI and MFA.

It addresses seven evaluation issues. The alignment between the evaluation questions and the questionnaire is presented in the design report. This questionnaire was designed primarily for Web data collection and was complemented with telephone contacts where required to improve the response rate.

As recommended in the *Evaluation Framework*, the survey was modelled in part and where appropriate on the questionnaire used for the evaluation of the former NSERC Equipment Program (1990).

The questionnaire was translated and 25 department heads were invited to complete it between January 5 and January 11, 2006. Motivational telephone calls were made on January 6. Five department heads completed the pretest questionnaire. Very few comments were made by the participants. The list of types of equipment did not cause problems and no additions were suggested. Since the changes made following the pretest were minor, the pretest responses were maintained in the final data set.

Sampling

The survey of department heads comprised all available individuals. A total of 757 department unit heads from the 73 eligible university institutions in Canada were approached.

Protocol

Respondents were asked to complete the questionnaire on-line, in one or more sitting. After the initial phase of the survey was completed, we offered non-respondents the opportunity to complete the survey over the telephone. The on-line Web survey was designed so that respondents can print out a copy of the full survey to complete in pen prior to inputting their responses into the Web-based form.

Respondents were given a key identifier number on the introduction letter and e-mail message (in both official languages) along with instructions and a Web address to complete the survey. This number allowed respondents to complete the survey at their convenience and was used as a security feature so that only targeted respondents could access the survey. This number also allowed the project team to track the number of completions and to determine which individuals had or had not completed the survey. A second follow-up letter or e-mail (in both official languages) was sent to individuals who had not completed the survey some time after receiving the first letter. In addition, the project team contacted individuals by phone if they have not completed the survey after receiving the second letter.

Data collection operations

The data collection was initiated on January 5, 2006 and closed on March 7, 2006. The field operations were carried out in accordance with quality standards and procedures that are described in a separate document.[1]

During that period, 256 questionnaires were completed, for a raw response rate of 34% — which does not take into account various reasons for sample mortality like incorrect addresses or out of date information.

Data weighting

The data from this survey were weighted in order to obtain descriptive statistics[2] that are representative of the population of department heads. All of the estimates are adjusted for region and institution size. Weights were calculated as follows: each department was categorized in a region and an institution size, thereby leading to counts of the population of departments these groups as well as counts of responding departments. The weights were calculated as the ratio of the population in each cell to the size of the respondent pool for the same cell. For example, departments in large universities located in Ontario account for 22.5% of all departments and 23.4% of departments in the sample of respondents; therefore, the weight associated with that group is 0.962 (0.225 / 0.234).

1 See ***Circum*** *Network Inc.*, *Assessing Survey Research, a principled approach*, 2003. Available at http://circum.com/cgi/documents.cgi?lang=an&doc=T028

2 All of the descriptive statistics have been weighted; the inferential statistics have not.

Data processing

Survey data were managed using VoxCo's StatXP software. Data were edited to ensure conformity to the established response categories and to limit the distributions of unbound variables within reasonable values. Filtering logic instructions were developed to ensure that the reported data conform to the skip logic of the questionnaire.

Data analysis

Data analysis was done using basic stubs-and-banners crosstabs developed in StatXP. Percentage-based differences were tested on a percentage-versus-complement basis using two-tailed binomial distributions. Differences between means were tested using two-tailed t-tests.

Based on the full sample of 256 responses, the maximum sampling error is estimated at ±5.0 percentage points in the worst, complete-sample case (for a proportion of 50%, at a confidence level of 95%, with correction for finite population). Sampling errors are wider for sub-samples.

2.2 Survey of program applicants

Questionnaire design and pretest

The program applicant questionnaire was developed as part of the design phase of the Joint Evaluation of RTI and MFA.

The survey of program recipients and non-recipients addresses eight evaluation issues. The alignment between the evaluation questions and the questionnaire is presented in the design report.

The questionnaire was translated and 75 researchers were invited to complete it between January 5 and January 11, 2006: 25 MFA applicants, 25 RTI-funded applicants and 25 RTI applicants who were not funded. Motivational telephone calls were made on January 6. Seventeen researchers completed the pretest questionnaire. Several comments were made on-line by the participants. Changes were made to a few questions to clarify their purpose. Since the changes made following the pretest were minor, the pretest responses were maintained in the final data set.

Sampling

All MFA and RTI applicants from the past five years are within the population. A single application was sampled for each applicant (some applicants may have presented more than one application between 2001 and 2005) — the questionnaire focuses on this one (sometimes successful, sometimes not successful) application.

Defining recipients and non-recipients is not straightforward when individuals may have seen some of their applications rejected and others accepted. Non-recipients were defined as those who have applied but received no funding between 2001 and 2005; recipients were defined as anyone who has received funding over the same period (whether or not they were also turned down on other applications). Program data was attached to the survey data to document more precisely the funding history of individual researchers and, possibly, identify other participant and control groups.

All members of the population (4,096 individuals) were retained in the study sample. However, a subgroup of 2,781 RTI applicants was randomly selected to be given a lighter data collection treatment than the main sample — more on this in the next section.

Protocol

Respondents were asked to complete the questionnaire on-line, in one or more sitting. After the initial phase of the survey was completed, we offered non-respondents the opportunity to complete the survey over the telephone. The on-line Web survey was designed so that respondents could print out a copy of the full survey to complete in pen prior to inputting their responses into the Web-based form.

Respondents were given a key identifier number on the introduction letter and e-mail message (in both official languages) along with instructions and a Web address to complete the survey. This number allowed respondents to complete the survey at their convenience and was used as a security feature so that only targeted respondents can access the survey. This number also allowed the project team to track the number of completions and to determine which individuals had or had not completed the survey. A second follow-up letter or e-mail (in both official languages) was sent to individuals who had not completed the survey some time after receiving the first letter. In addition, the project team contacted individuals by phone if they had not completed the survey after receiving the second letter.

A group of 1,236 researchers constituted the primary sample which received e-mail and regular mail invitations to participate in the survey and who were the subject of call-backs during the field work. The rest of the population of RTI program applicants for the 2001-2005 period made up a secondary sample of 2,781 units who were only approached by e-mail. This additional group serves as a test of the effectiveness of regular mail contacts and telephone reminders.

Data collection operations

The data collection was initiated on January 5, 2006 and closed on March 14, 2006. The field operations were carried out in accordance with quality standards and procedures that are described in a separate document.[1]

During that period, 1,664 questionnaires were completed, for a raw response rate of 41% — which does not take into account various reasons for sample mortality like incorrect addresses or out of date information.

The response rate varied significantly according to whether the applicant was awarded a grant and according to the field work protocol. Exhibit 2.1 summarises the results.

1 See ***Circum*** *Network Inc.*, *Assessing Survey Research, a principled approach*, 2003. Available at http://circum.com/cgi/documents.cgi?lang=an&doc=T028

Data weighting

The data from this survey were weighted in order to obtain descriptive statistics[1] that are representative of the population of program applicants. Estimates for MFA were adjusted for grant award status. RTI estimates were adjusted for region, institution size and grant award status.

EXHIBIT 2.1
Field results for the survey of program applicants

			Population	Respon-dents	Response rate	Weight
MFA	Grant awarded		114	81	71%	1.003
	Grant rejected		53	38	72%	0.994
RTI	Awarded	Full protocol	375	216	58%	0.705
		Electronic	1555	633	41%	0.998
	Rejected	Full protocol	725	322	44%	0.915
		Electronic	1274	374	29%	1.384
TOTAL			4096	1664	41%	—

Data processing

Survey data were managed using VoxCo's StatXP software. Data were edited to ensure conformity to the established response categories and to limit the distributions of unbound variables within reasonable values. Filtering logic instructions were developed to ensure that the reported data conform to the skip logic of the questionnaire.

1 All of the descriptive statistics have been weighted; the inferential statistics have not.

Data analysis

Data analysis was done using basic stubs-and-banners crosstabs developed in StatXP. Percentage-based differences were tested on a percentage-versus-complement basis using two-tailed binomial distributions. Differences between means were tested using two-tailed t-tests.

Based on the full sample of 1,664 responses, the maximum sampling error is estimated at ±1.9 percentage points in the worst, complete-sample case (for a proportion of 50%, at a confidence level of 95%, with correction for finite population). Sampling errors are wider for sub-samples.

2.3 Key informant interviews

Key informant interviews address all evaluation issues but one. Key informants were recruited in the following groups:

- group chairs;
- MFA Grant Selection Committee members;
- vice-presidents of research in eligible Canadian universities;
- key informants from federal institutions (e.g., CFI).

Key informants received an advance introduction letter signed by an NSERC official explaining the context of the study and informing the individual that a member of the study team would be contacting them to schedule an interview.

We completed 36 key informant interviews.

2.4 Document and administrative data review

The file review clarified the official descriptions of various programs and lined up their objectives, audiences, eligibility rules and features so as to demonstrate the commonalities and differences among programs.

Internal notes were processed to lift analyses and opinions which have been expressed about various issues, such as the potential overlap between CFI activities and RTI/MFA. Annual reports of Major Facilities Access grant selection committees contain numerous insights into the issue of the appropriateness of the MFA evaluation criteria — and some on the adequacy of the program objectives. As part of the file review, the study team identified and documented these points of view.

Secondary data analysis contributed to the analysis of several evaluation issues. Data were extracted from NAMIS. Also, a sample of 50 successful MFA applications was drawn and studied in-depth. Data from a file lining up CFI funding with funding from RTI and MFA (created by the NSERC evaluation group based on RTI and MFA program data and CFI funding information) were analysed to ascertain the level of joint use of the programs. NSERC's *Facts and Figures* publication was also used.

2.5 Review of experiences in foreign countries

A brief overview of international funding initiatives within other countries that may be considered "comparable" to NSERC's RTI and MFA grants (i.e., funding initiatives to assist in buying or developing research equipment, and in maintaining access to regional or national research facilities) was conducted. The main objectives of this overview are:

- to help place the RTI and MFA programs into the international context of programs designed to support research equipment acquisition and maintenance and operating costs for research facilities; and,
- to help provide context to interpret the results of the evaluation, and provide important comparisons with respect to target populations, eligibility criteria, selection procedures and evaluation criteria, service delivery models, eligible costs/eligible projects, average level of funding awarded, success rates, and general strengths and weaknesses.

Seven countries were identified as having programs relevant to the international review:

- Sweden, Swedish Research Council;
- Korea, Korea Science and Engineering Council (KOSEF);
- United States, National Science Foundation (NSF);
- Germany, Deutsche Forschungsgemeinschaft (DFG);
- Netherlands, Netherlands Organisation for Scientific Research (NWO);
- United Kingdom, Engineering and Physical Sciences Research Council (EPSRC) and Particle Physics and Astronomy Research Council (PPARC);
- Australia, Australian Research Council (ARC).

A review was conducted of the funding initiatives described in the Web site of each of the organizations identified. Key informants were contacted by e-mail, in which the study was described and information on the relevant programs at their organization was requested. In some cases, telephone follow-up calls were made for further inquiries or clarification.

2.6 Case studies

The case studies are intended to address the following issues:

- Description of the state of the existing research equipment/infrastructure
- Management of the research infrastructure:
    - Sources of funding available for purchase of equipment, as well as for operation and maintenance costs
    - Impact of MFA/RTI funding on the infrastructure, including impacts on research programs, use of facility, research community generally, and training
    - Unintended impacts of MFA/RTI funding
    - Impact of CFI funding on research infrastructure
- Management of research equipment:
    - Experience with respect to maintaining stock of equipment
    - Impact of the moratorium on RTI 2 and RTI 3 (including whether alternative sources of funding were found by the facility)

  - Availability of funding for operations, maintenance and equipment, including the impact of funding gaps, where applicable
- Current Design and Alternative Delivery Models, including consideration of the following aspects of the RTI/MFA programs:
  - MFA Selection criteria
  - RTI 1 Ceiling ($7,000 to $150,000)
  - Moratorium on RTI 2 and RTI 3
  - Criterion of uniqueness of the facility at the regional or national level
- Other issues such as objectives of the programs, evaluation criteria, eligible expenses, etc.

Research facilities were selected by the scientific authority to reflect a range of funding histories, funding sources, extent to which facilities are shared regionally/nationally, and facility types.

Case study research was completed in April 2006 with the following facilities:

- Forêt d'enseignement et de recherche du Lac Du Parquet, Université du Québec à Montréal (UQAM) (representing field stations and collections);
- Canadian Neutron Beam Laboratory, McGill University (representing large grants, multi-institutional, at a government laboratory);
- Pacific Center for Advanced Materials and Microstructures, University of British Columbia (representing large facilities with extensive CFI investment);
- Trent University Water Quality Centre, Trent University (representing small, regional facilities with CFI investment and RTI grants);
- Navire interuniversitaire de recherche océanographique, Université du Québec à Rimouski (representing research vessels).

Chapter 3

RESULTS BY ISSUE

This chapter describes findings from each source as they pertain to the ten evaluation issues.

3.1 Issue 1, existing infrastructure

Issue number 1 reads as follows: *What is the state of existing research equipment/infrastructure in Canadian universities (description, assessment, technical support, needs)?* Evidence can be brought to bear from the following sources: the survey of department heads, key informant interviews and administrative data.

The state of the existing equipment infrastructure can be described using several indicators.

General working condition. Department heads classified the pieces of equipment owned by their department with regard to the general working condition. While the majority (55%, see Exhibit 3.1) of the pieces of equipment were in very good or adequate working condition, almost half (46%) were in poor condition or were inoperative over the previous year.

This observation applies across all disciplines, sizes of institution and regions although equipment appears in slightly worse condition in physical sciences departments. The main reasons mentioned for the poor condition of equipment was sheer obsolescence (particularly in the case of computer equipment which has a shorter useful life than most other types of equipment) or the fact of having bought inferior equipment to start with because of lack of funds.

EXHIBIT 3.1 • Subjective state of existing equipment

Working condition of equipment[1]		**Overall quality of equipment**[2]	
Working condition	% of the number of existing pieces of equipment	Overall quality	% of departments
Very good	28%	Adequate for cutting-edge research	43%
Adequate	27%	Adequate for simple research applications	43%
Poor	30%	Adequate for teaching, insufficient otherwise	7%
Inoperative for the entire year	16%	Insufficient even for teaching	3%

[1] Department head survey, question 7, "Please estimate the percentage of the number of research equipment items housed in your department that falls within each of the following categories of general working condition"; these figures are not weighted according to the number of pieces of existing equipment; they are standardized to 100%.
[2] Department head survey, question 9: "Which of the following categories best describes the overall quality of the laboratory equipment in your department?"; 5% could not answer.

Overall quality of equipment. Globally, 10% of department heads (see Exhibit 3.1) indicated that the overall quality of the laboratory equipment in their department was insufficient for simple research applications. This proportion approached 20% in small institutions but neighboured 5% in large institutions. At the other end of the spectrum, more than four in ten (43%) department heads classified their departmental laboratory as adequate for cutting-edge research. This was less frequent in engineering (30%) and small institutions (25%) but more frequent in large institutions (50%). Note that there is no inconsistency between this indicator and the previous one: 16% of pieces of equipment were inoperative in the previous year, but 10% of laboratories were insufficiently equipped for research applications.

State of equipment at case study locations

Since they are relatively new installations, the quality of the research equipment at both the Forêt d'enseignement et de recherche du Lac Du Parquet (FERLD) and the Navire interuniversitaire de recherche océanographique research facilities was deemed very good by the researchers interviewed. The current state of the equipment at the Canadian Neutron Beam Laboratory (CNBL) appears to be satisfactory to the researchers interviewed. This facility is said to be well-supported financially by the user community and by the National Research Council of Canada and are therefore better able to maintain a state-of-the-art research facility.

Although there have been significant improvements with respect to the quality of the equipment available at the Trent Water Quality Centre (WQC), several researchers felt that there is much room for improvement on the current state of the equipment. For instance, two spectrometers are broken and out of use and the facility would benefit greatly if it could obtain a centrifuge, which it has not been able to purchase due to lack of funding. The quality of equipment at the Pacific Centre for Advanced Materials and Microstructures (PCAMM) varied, as some equipment had been recently purchased and some equipment at PCAMM had been inherited from previous researchers who were no longer at the institution.

Projected state of existing equipment. Thinking in terms of the overall value of the research equipment owned by their department, department heads indicated that almost half (46%, see Exhibit 3.2) of the equipment would still be usable in five years with only minor maintenance and 20% more would require major maintenance. More importantly, research equipment corresponding to 29% of the existing value will require replacement over the next five years. This need will be even more evident in math and computer sciences departments where some 55% of the equipment value will become obsolete; the need will be somewhat less important in earth sciences departments (about 15%).

The next section estimates the worth of the university research equipment infrastructure at $5.2 billion. This means that, within 5 years, the estimated cost of replacement of obsolete equipment will be about $1.5 billion (29% of the total). If this number is valid, it indicates that the$32 million invested annually by NSERC via RTI (approximately, for the three RTI sub-programs) would address about 10% of the need for replacement of obsolete equipment, with no additional equipment funded.

Using a similar logic, we can estimate the value of required operating and maintenance costs for the coming years based on the subsidies recently added to the CFI grants.[1] CFI adds 30% to its infrastructure grants (which typically represents 40% of the total project cost) to defray the costs of operation and maintenance for the first three years of operation of the equipment; these funds are not tagged for this purpose, universities can use them as they wish. Presumably, operation and maintenance costs are lower in the early years than in the final few years of useful life of the equipment, so using this value as a reference should not lead to an overestimation. If 30% of 40% the value of the equipment covers 3 years of O&M[2], the annual cost of O&M would be about 4% of the original cost of the equipment. If the university research equipment infrastructure is worth $5.2 billion, the O&M bill should be about $208 million annually and it will likely increase as CFI continues to support the addition of state-of-the-art equipment. Therefore, the $12 million invested annually by MFA for major facilities probably represents a little more than 6% of the need for O&M funding.

EXHIBIT 3.2 • Projected state of existing equipment

States	% of the value of equipment[1]
% value of items usable for the next five years with minor modification / maintenance	46%
% value of items usable for the next five years with major modification / maintenance	20%
% value of items that will become obsolete within the next five years and require replacement	29%
% value of items that will become obsolete within the next five years and will not require replacement	5%

[1] Department head survey, question 8; these figures are not weighted according to the value of existing equipment because of the detrimental effect that missing data would have on the calculation; they are standardized to 100%.

State of types of equipment. The condition of the research equipment varies significantly according to the type of equipment. Exhibit 3.3 indicates the proportion of equipment which is in at least adequate condition.

1 Arguably, CFI did not establish its percent contribution to O&M based on research aimed at quantifying this need. It appears to have reversed engineered its percent contribution based on funds it had available for this purpose and funds available for capital expenses. The CFI O&M contribution is generally seen as a low estimation of the need.

2 Based on interviews with CFI representatives.

- Among analytical, characterization and detection instruments, various types of equipment are at least adequate 85% of the time, including microscopes which are owned by 66% of departments. At the other end of the spectrum, about six scintillation or gamma radiation counters or detectors in ten (64%) are in adequate condition, while being held by one third of departments.
- In the data and imaging equipment category, computers are owned by virtually all departments and are most likely to be adequate (93%), whereas data recorders have a 74% chance of being in adequate condition.
- Similarly, in other equipment categories, the condition of equipment varies from more than 80% adequate to less than 70%.

EXHIBIT 3.3 • State of types of research equipment

n = 256; weighted n = 757	At least adequate[1]	Years of useful life left[2]	Within department[1]
Analytical, Characterization, and Detection Instruments			
Subatomic Particle Detectors	89%	6	3%
NMR and Regular Mass Spectrometers	89%	12	28%
Electrophoresis Systems	88%	6	32%
Elemental or Carbon Analyzers	85%	7	24%
Microscopes (optical, fluorescence, other non-electron)	85%	8	66%
X-Ray Diffractometers	83%	9	24%
Other Spectrometers	81%	7	41%
Temperature/Pressure Control/Measurement Equipment	81%	7	47%
Chromatographs	79%	6	42%
Microscopes (electron - all types)	78%	8	33%
Fluorometers	77%	7	29%
Particle Sizers and Analyzers	73%	7	21%
Calorimeters and Thermal Analyzers	71%	7	29%
Other	68%	8	69%
Velocimetry Equipment	68%	7	12%
Scintillation/Gamma Radiation/Counters/Detectors	64%	7	33%
Data and Imaging Equipment			
Computers, Workstations, Servers, Software and Accessories	93%	3	97%
Other	87%	6	76%
Communications Equipment	78%	4	56%
Imaging, Video, Camera and Motion Tracking Equipment	76%	4	75%
Data Recorders, Loggers and Data Acquisition Equipment	74%	4	74%
Materials Handling and Processing			
DNA/Protein Synthesizers/Sequencers/Analyzers/PCRs	81%	5	25%
Growth and Environmental Chambers/Incubators/Bioreactors	75%	8	39%
Other	75%	7	72%
Glove and Dry Boxes/Fume Hoods/Safety Cabinets Centrifuges	70%	9	66%
Miscellaneous			
Other	85%	5	73%
Lasers and Optical Equipment	76%	5	42%
Animal Housing and Tracking Equipment	73%	8	20%
Astronomical Equipment	71%	8	6%
Transportation Equipment (Vehicles/Trucks/Boats)	69%	5	25%
Robotic Equipment	69%	5	26%
Mechanical Testing Equipment	67%	8	26%

[1] Department head survey, question 1; categories were "inoperative", "poor", "adequate", "very good".
[2] Department head survey, question 2

Exhibit 3.3 also documents the years of useful life left to existing equipment. Globally, it varies between four and seven years with the exception of computers (three years) and regular mass spectrometers (12 years).

Point of view of key informants. Questioned on the current state of research equipment in Canadian universities, a large number of respondents focused on how much the situation has improved in recent years and emphasized the contribution of the Canada Foundation for Innovation (CFI) to explain this improvement. Key informants consider that current state of the research equipment facilitates the research effort as well as training of highly qualified personnel (HQP).

Two caveats were noted. First, one black cloud identified by key informants is what they consider to be insufficient funding for operating and maintenance (O&M) budgets. In recent years, the focus has gone to the acquisition of equipment but limited budgetary effort has been made to address the maintenance requirements of existing equipment and the operation and maintenance needs of all of these new pieces of equipment added to the research environment. Limited investment in O&M translates into underused equipment and increased down time. Let's quote one of the key informants: "The lack of support means that the required maintenance of equipment is not being done as often as it should be. In turn, universities are not getting the full use of the capital cost research equipment. For example, we have not used one piece of equipment at our university for some time because it requires maintenance and we do not have room in the budget to do so."

A second qualification to the overall judgment concerns insufficient funding to make small and basic equipment purchases. We heard repeatedly that researchers and laboratories have very limited budgets to acquire small and basic equipment and to maintain existing equipment. Some have argued that such needs should be addressed by universities using their general research funding as well as funds provided by the Indirect Cost Program (ICP). As documented in the 2005 ICP evaluation report, funds from this program are typically assigned to some general budget category by universities, making it difficult to track their actual utilization. They may or may not be used to address the needs for small and basic equipment and maintenance expressed during this study.

Conclusion: existing infrastructure

There is a consensus that CFI and NSERC programming — but particularly the former considering its sheer size — have made significant contributions to improving the state of university research equipment over the past decade or so. Yet, a little more than half of existing equipment is in very good or adequate condition, while a little less than half is in poor condition or inoperative. Also, while one laboratory in ten is inadequate for research purposes, half of the rest can support simple research applications and the other half, cutting-edge research.

Drawing a conclusion from these data requires comparing the state of equipment with the expectations Canada places on university researchers: if cutting-edge world-class research is expected of them, then about half of the research infrastructure is not up to par (since 57% of labs are not state-of-the-art); if it is acknowledged that not every university researcher is involved in cutting-edge research, then it is possible that the current state of research equipment mirrors the needs of the research community. The message heard from key informants is that, on the whole, the situation is much more liveable now than it was two decades ago and that the key upcoming issue is not so much the acquisition of new equipment as it is the maintenance of existing ones.

Three messages come out loud and clear from this evaluation study:

- a significant proportion of the existing equipment infrastructure will require replacement over the coming five years — between one quarter and one third of the value of existing equipment is at play;
- about 20% of existing equipment will require major maintenance over the coming five years and funds are scarce for this need;
- it is difficult for researchers to find funding for small equipment.

3.2 Issue 2, sources of funding

Issue number 2 reads as follows: *What sources of funding are available for equipment and operating and maintenance costs in Canada?* Evidence can be brought to bear from the following sources: the survey of department heads, the survey of program applicants and key informant interviews.

Department heads indicated that NSERC came second as a source of funding for existing departmental research equipment (Exhibit 3.5). They estimated that 23% of the purchase value of existing equipment was funded by NSERC versus 29% by CFI, 13% by provincial governments and 13% by universities. Industry funds were a minor but still important source of funding with 6% of the total, while user fees amounted to 2% of the value of equipment.

NSERC is also second among sources of funding with regard to operating and maintenance funds: 18% of O&M funding is from NSERC according to departmental heads, while universities contribute 42% of O&M expenses. CFI, other federal government funds, provincial funds and user fees each account for 8% to 10% of O&M expenses.

While department heads are in a position to comment on funding for the entire research equipment infrastructure, individual researchers are able to document sources of funding for specific pieces of equipment (for RTI applicants) and O&M expenses (for MFA applicants) for applications they presented to NSERC. Not surprisingly, NSERC ranks first as a source of funding for projects funded by the program: 83% of the funding for the purchase of equipment in these projects came from NSERC; CFI and universities were secondary actors with the provision of about 10% of the funding. On the O&M front for MFA projects, NSERC leads with 28% of the funding followed by user fees which represent 21% of O&M expenses; universities (15%) and other federal funds (11%) follow.

EXHIBIT 3.5 • Sources of funding

Sources	Department heads		Program applicants		
			% of the total purchase value of the equipment sought[3]		
	% of the total purchase value of existing equipment[1]	% of the O&M spent[2]	Successful RTI applicants	Unsuccessful applicants who purchased the equipment	% of the O&M spent[4] (MFA applicants only)
NSERC	23%	18%	83%	9%	28%
CFI funds	29%	10%	4%	27%	6%
Other federal gov. funds	9%	8%	1%	11%	11%
Provincial gov. funds	13%	8%	2%	17%	7%
University funds	13%	42%	6%	17%	15%
Industry funds	6%	5%	2%	9%	8%
Private foundation funds	2%	0%	0%	1%	1%
User fees	2%	8%	0%	0%	21%
Other	3%	2%	1%	8%	3%

[1] Department head survey, question 4; these figures are not weighted according to the value of existing equipment in each department although, arguably, they should be. This is because of the detrimental effect that missing data would have on the calculation. Values are standardized to 100%.
[2] Department head survey, question 17; these figures are not weighted according to expenses on O&M because of the detrimental effect that missing data would have on the calculation; they are standardized to 100%.
[3] Applicant survey, question 6; these figures are not weighted according to the value of the equipment because of the detrimental effect that missing data would have on the calculation; they are standardized to 100%.
[4] Applicant survey, question 16; these figures are not weighted according to expenses on O&M because of the detrimental effect that missing data would have on the calculation; they are standardized to 100%.

In the case of 26% of unsuccessful RTI applications, the equipment is purchased anyway.[1] In these cases, CFI becomes the prime funding source (27%) followed by universities (17%) and provincial governments (17%). That left 71% of departments whose RTI application was unsuccessful without the coveted equipment.

The prominent position occupied by CFI in equipment acquisition does not come as a surprise: CFI has injected 1.5 billion dollars[2] between 1998 and

1 According to answers to question 5 in the Applicant questionnaire.

2 According to CFI annual financial statements included in annual reports for 1997-1998 to 2004-2005.

March 2005 to support the acquisition of state-of-the-art research equipment aimed at university strategic priorities. This very goal, though, is its main weakness according to key informants who commented on the issue: CFI funds have been used by institutions to support large visionary projects according to institutional strategic development priorities which leaves other research equipment needs out of its scope — in particular, basic equipment and low-cost equipment as well as the replacement and upgrade of existing equipment, some of the targets of RTI and MFA.[1] Of course, there is no doubt that CFI grants are applied in part to the acquisition of basic and low-cost equipment in the context of setting up large projects.

As an aside, assuming that the estimate of 29% of the total value of existing equipment being attributable to CFI is reliable, we can calculate the purchase value of university research equipment by dividing the sum expended by CFI to date by 0.29. Based on CFI expenditures of $1.5 billion for natural sciences and engineering, we estimate that the value of the university research infrastructure is 5.2 billion dollars. Similar calculations cannot be performed using NSERC data because of the absence of a reliable estimate of NSERC's total equipment funding due to a much longer funding history and a variety of programs which could fund equipment purchases.

Regarding O&M funding, key informants have noted that CFI's involvement is short-term ("It lasts only three to five years" indicated one informant), leaving universities with the burden of heavy O&M costs when equipment starts deteriorating.

Provincial funding of equipment acquisition is almost always limited to matching funds provided by CFI. Therefore the focus identified for CFI (and its limitations) is replicated by provincial funding.

1 We will offer evidence later that CFI has also supported smaller projects within university research priorities.

Conclusion: sources of funding

While CFI plays a pivotal role in the funding of acquisitions of state-of-the-art research equipment, NSERC is also a key player in this field. NSERC's annual budget for research equipment acquisition is much lower than that of CFI, but NSERC has been involved in such funding for a long time — such that its cumulative influence ranks it in second place as an equipment purchase funding source. Therefore, any modification to NSERC's priorities and strategies in this area will have profound consequences on the university research system.

The same is true of operating and maintenance expenses where NSERC comes second only to universities in its financial involvement. The role of CFI has been significant albeit short-term in this area with regard to the equipment it has subsidized since 2001.

3.3 Issue 3, relationship with CFI

Issue number 3 reads as follows: *What is the extent of the overlap, if any, between CFI programs and NSERC's RTI and MFA programs?* Evidence can be brought to bear from the following sources: the survey of department heads, the survey of program applicants, administrative data and the document review.

Exhibit 3.6 summarises the views of department heads and program applicants on possible overlaps and gaps between RTI/MFA and CFI as well as potential complementarity among these programs. What comes out of this table is that there is no consensus on either one of these possibilities. The levels of uncertainty are high as measured by the proportion of the respondents who could not answer the questions. Also, respondents are spread across the four categories of answers: significant (if not equal) groups of people think that there is little to no overlap, gap or complementarity between RTI/MFA and CFI and significant groups perceive that there is moderate to extensive overlap, gap or complementarity. All in all, this is inconclusive evidence.

EXHIBIT 3.6 • Views on the relationship between RTI/MFA and CFI

	Department heads[1]					Program applicants[2]				
	None	Small	Mode-rate	Exten-sive	Don't know	None	Small	Mode-rate	Exten-sive	Don't know
How much ***overlap*** (that is, instances of programs aiming at the same targets using the same tools) do you feel there is, if any, between the programs of...										
RTI category 1 and CFI?	19%	32%	16%	7%	26%	28%	32%	17%	6%	17%
RTI categories 2 and 3 and CFI?	4%	15%	32%	20%	29%	6%	15%	29%	23%	27%
MFA and CFI	9%	12%	19%	21%	39%	12%	11%	15%	16%	46%
How much of a ***gap*** (that is, instances of neither program addressing an important need within their mandate) do you feel there is, if any, between the programs of...										
RTI category 1 and CFI?	9%	15%	22%	17%	38%	14%	17%	21%	18%	30%
RTI categories 2 and 3 and CFI?	10%	18%	21%	10%	40%	16%	19%	18%	7%	41%
MFA and CFI	11%	18%	14%	9%	48%	11%	14%	11%	8%	57%
How much ***complementarity*** (that is, instances where program collaborate to attain common goals) do you feel there is, if any, between the programs of...										
RTI category 1 and CFI?	18%	21%	21%	7%	33%	18%	20%	23%	13%	26%
RTI categories 2 and 3 and CFI?	10%	20%	26%	5%	38%	12%	20%	22%	8%	38%
MFA and CFI	9%	17%	19%	10%	44%	10%	13%	15%	9%	54%

[1] Department head survey, question 35
[2] Applicant survey, question 33

By design, RTI/MFA and CFI present areas of possible overlap and complementarity. The following program design features could produce overlaps:

- all programs target the same community, that of university researchers albeit CFI's target is wider as it stretches beyond the science and engineering community;
- RTI and CFI fund the purchase of equipment; MFA as well as CFI fund operating and maintenance expenses — the latter as a proportion of the capital cost rather than on their own.

However, the following program features reduce the risk of overlaps and increase the likelihood of complementarity between RTI/MFA and CFI:

- RTI is targeted at individual researchers, while CFI deals with institutions and institutional research priorities;

- RTI defrays 100% of the cost of the equipment while CFI covers 40% of the cost;
- RTI addresses the need for basic and less expensive equipment, while CFI predominantly focuses on large and state-of-the-art facilities. This distinction is clear with regard to RTI-1 but fuzzier with regard to RTI-2 and RTI-3;
- RTI and MFA are open to all research streams, whereas CFI funding is limited to university strategic priorities;
- CFI funding of O&M is limited to projects approved since 2001; MFA selection criteria do not exclude older facilities.

The average CFI project funding level (including CFI awards and other sources of funding) is $1.4 million in sciences and engineering, which is much higher than the average RTI grant. However, based on the brackets of values financed by the three components of RTI, another way to look at the possibility of overlap between RTI and CFI is to analyse the number of projects funded by CFI which fall into the same value groups. Exhibits 3.7 and 3.8 present this evidence.

Program statistics indicate that CFI is indeed present in the RTI-1 funding level territory, but at a low rate: RTI-1 level funding represents 7% of CFI projects (199/2,821) and 1% of the value of its funding (22M/3,699M). CFI has funded 20 times fewer projects in this funding bracket (199 for CFI vs 4,038 for RTI-1) for one tenth the project value ($22 million vs $198 million). These numbers indicate that there is some overlap between RTI-1 and CFI in terms of project size but that the focus of the two budget envelopes are clearly different: most CFI projects correspond to the RTI-3 bracket, while RTI has been restricted within the RTI-1 territory for several years now — by program decision. This is true throughout the 1998-2005 period.

Exhibit 3.7 • RTI and CFI funding statistics for NSE, 1998-2005

	RTI activity according to the total value of the grants				CFI activity[1] according to the total value of the grants				
	RTI-1 eq.[2]	**RTI-2 eq.[3]**	**RTI-3 eq.[4]**	**TOTAL**	**RTI-1 eq.[2]**	**RTI-2 eq.t[3]**	**RTI-3 eq.t[4]**	**Beyond RTI-3[5]**	**TOTAL**
Number of projects									
1998-1999[6]	812	36	19	867	28	61	199	5	293
1999-2000[6]	802	23	12	837	13	43	93	18	167
2000-2001[6]	630	9	10	649	17	66	229	17	329
2001-2002[6]	410	14	12	436	21	147	323	38	529
2002-2003	215	5	9	229	32	141	242	7	422
2003-2004	458	0	5	463	51	214	364	31	660
2004-2005	711	3	4	718	37	144	237	3	421
1998-2005	**4038**	**90**	**71**	**4199**	**199**	**816**	**1687**	**119**	**2821**
Total project value in million $									
1998-1999[6]	32.6	7.1	11.3	51.1	3.0	15.6	248.6	218.9	486.1
1999-2000[6]	37.5	5.5	7.6	50.6	1.4	10.4	100.6	326.6	439.0
2000-2001[6]	30.8	1.8	7.5	40.1	2.0	17.6	300.9	246.8	567.4
2001-2002[6]	20.2	2.4	5.0	27.6	2.4	38.6	383.4	659.0	1083.4
2002-2003	10.9	0.9	3.5	15.3	3.2	37.5	154.3	179.7	374.7
2003-2004	24.7	0.0	2.8	27.4	5.7	56.0	354.0	0.0	415.8
2004-2005	40.9	0.6	2.6	44.1	4.3	36.0	137.4	155.0	332.7
1998-2005	**197.6**	**18.3**	**40.3**	**256.1**	**22.1**	**211.6**	**1679.3**	**1786.1**	**3699.1**

Source: administrative data supplied by CFI, based on total project value; NSERC administrative data.
[1] CFI projects were defined as Natural Science and Engineering as per the primary research discipline code selected by the project leader. The awards are not necessarily disbursed yet. Includes all CFI funds.
[2] RTI-1 equivalent, i.e., up to a project value of $150,000.
[3] RTI-2 equivalent, i.e., from $150,001 to $325,000.
[4] RTI-3 equivalent, i.e., from $325,001 to $8,063,000, the value of the largest RTI grant ever awarded.
[5] Project value in excess of the largest RTI grant ever.
[6] Before the moratorium.

Exhibit 3.8 • RTI and CFI funding statistics for NSE (indices)

	Proportion that CFI represents of RTI			
	RTI-1 eq.[1]	RTI-2 eq.[2]	RTI-3 eq.[3]	TOTAL[4]
Number of CFI projects funded for one RTI-funded project				
1998-1999	0.03	1.7	10.5	0.3
1999-2000	0.02	1.9	7.8	0.2
2000-2001	0.03	7.3	22.9	0.5
2001-2002	0.05	10.5	26.9	1.2
2002-2003	0.15	28.2	26.9	1.8
2003-2004	0.11	—	72.8	1.4
2004-2005	0.05	48.0	59.3	0.6
1998-2005	**0.05**	**9.1**	**23.8**	**0.7**
Amount spent by CFI for $1 spent by RTI in the same category				
1998-1999	0.1	2.2	21.9	9.5
1999-2000	0.0	1.9	13.2	8.7
2000-2001	0.1	9.8	40.1	14.1
2001-2002	0.1	16.1	77.4	39.3
2002-2003	0.3	43.9	44.4	24.6
2003-2004	0.2	—	127.9	15.2
2004-2005	0.1	58.2	52.4	7.5
TOTAL	**0.1**	**11.6**	**41.7**	**14.4**

Source: Exhibit 3.7
[1] RTI-1 equivalent, i.e., up to a project value of $150,000.
[2] RTI-2 equivalent, i.e., from $150,001 to $325,000.
[3] RTI-3 equivalent, i.e., from $325,001 to $8,063,000, the value of the largest RTI grant ever awarded.
[4] Ratios for all RTI projects versus all CFI projects, including those exceeding $8,063,000.

Exhibit 3.8 gives another view of the same phenomenon. For each RTI-1 project funded by NSERC, CFI has funded 0.05 project in the same value bracket. Meanwhile, CFI has funded 9 projects of a value similar to RTI-2 for each RTI-2 project funded by NSERC and 24 projects in the RTI-3 range for each RTI-3 project. Looking at it from the total project value perspective, CFI has put 10¢ in RTI-1 grade projects when NSERC has but $1, but the relationship is opposite for RTI-2 ($12 from CFI for $1 from NSERC) and RTI-3 grade projects ($42 from CFI for $1 from NSERC). Of course, one larger CFI project could encompass several RTI-1 type equipment.

The circumstances of a given research project can be described in many ways: it can be small or large, short-term or long-term, equipment-heavy or not, etc. Depending on circumstances, a research project is more or less likely to get funding from RTI/MFA or CFI. In the analysis of overlaps, gaps and complementarity of RTI/MFA and CFI, seven contextual dimensions of research projects were considered important. They are presented in Exhibit 3.9.

Exhibit 3.9 • Factors affecting possible overlaps or gaps

Circumstances of the research project	More likely to get RTI	More likely to get MFA	More likely to get CFI
Need	Equipment	O&M	Equipment (with ensuing O&M)
Researcher career	New and mature researchers	Unrelated	New and mature researchers[1]
Project size/value	Smaller grants	Whole range	Larger projects
Nature of the equipment	New equipment[2] or renewal Basic equipment	—	New equipment[2] only State-of-the-art equipment
University strategic plan	Unrelated	Unrelated	Must be within plans
Matching funds	No requirement	No requirement	Matching funds available
Uniqueness	No requirement	Unique nationally or regionally	Often unique nationally or regionally

[1] Key informants generally thought that new researchers were favoured by CFI; CFI representatives indicated that the new Leading Edge Fund corrects this situation.
[2] "New" equipment as opposed to the acquisition of equipment to replace existing equipment which may have become obsolete.

Exhibit 3.9 does not evidence many overlaps between RTI/MFA and CFI. It does serve as a tool to identify gaps, however. For example, the following types of projects would have difficulty finding funding:

- a large project based on less than state-of-the art equipment[1];
- a project using more than low-cost equipment outside the university's strategic plans;

[1] CFI representatives argue that basic equipment could be part of a CFI grant, as long as it is used in an innovative way. While this is the case from the point of view of the funding agency, this is not the take that universities and researchers have on this issue.

- an innovative project without matching funds;
- equipment requiring repairs to maintain a basic university lab running.

Gaps between programs are related to the constraints imposed on the action of each program; the more constraints, the more difficult it is to make the programs work to fill all relevant needs. While they have wider disciplinary reach, CFI programs come with more constraints to funding equipment purchases than RTI.

Conclusion: relationship with CFI

The data reported in this section support the general notion that NSERC's RTI and MFA programs do not duplicate CFI efforts:

- MFA is focused on O&M, while CFI only provides O&M in conjunction with infrastructure awards:
- between 1998 and 2005, RTI has spent almost 80% of its budget on RTI-1 projects, whereas CFI has expended 1% of its funds on projects of similar value;
- CFI has funded many more RTI-2 and RTI-3 level projects than RTI has in the last five years (of course, the moratorium on RTI-2/RTI-3 explains this in good part).

Meanwhile, many CFI projects require funding of the RTI-2 and RTI-3 level. Ending the RTI-2/RTI-3 moratorium could produce a movement of projects away from CFI, towards RTI, thereby bridging the gap between the two sources of funding, producing an overlap between the two programs and creating pressure on RTI funding. A reactivation of RTI-2 and RTI-3 would likely have some negative effects (reduction of RTI-1 funds, overlap with CFI) and some positive effects (reduction of the funding gap for projects too large for RTI-1 but outside the CFI program territory).

Constraints to usage of CFI (large-scale, state-of-the-art projects within university strategic priorities) make unlikely a dramatic overlap in financial support with RTI/MFA projects but may create gaps in funding availability, in particular for large scale projects outside university strategic priorities.

3.4 *Issue 4, objective achievement*

Issue number 4 reads as follows: *To what extent are the objectives of these programs being achieved? What have been the results of the programs? What have been some of their unintended impacts? What has been the effect of RTI funding on the discovery, innovation and training capability of university researchers? What has been the effect of MFA support on access to major regional or national research facilities?* Evidence can be brought to bear from the following sources: the survey of department heads, the survey of program applicants and key informant interviews.

RTI carries an implicit assumption that program funding is required to acquire the coveted equipment. This is confirmed by the fact that 71% of unsuccessful RTI applicants indicated that they did not eventually acquire the equipment without NSERC funding — 26% did make an acquisition without RTI assistance.

Asked how the RTI or MFA grant they received had impacted their research effort and their research environment, successful program applicants were most likely to indicate that it accelerated their research effort, that it improved the quality of training of graduate students and postdoctoral fellows, that it increased the depth of the research effort and that it increased their ability to launch research efforts (Exhibit 3.10). Therefore, such funding makes for more, faster and more in-depth research as well as better trained HQP. The logical corollary is also supported by the responses of unsuccessful applicants: the main impacts of not obtaining a grant are delayed, more superficial research and weakened research teams and HQP training programs.

Rarer impacts of RTI/MFA grants include the attraction of new faculty, the retention of existing faculty, inter-institutional collaboration and obtaining tenure or promotions. Note that the rejection of an RTI/MFA grant application does not affect these areas either — which appear impermeable to equipment grant attribution.

Impacts of the case study facilities

Researchers from five academic disciplines made use of each MFA facility in case studies. The Forêt d'enseignement et de Recherche du Lac Duparquet (FERLD) facility accommodated the largest number of disciplines, ranging from the social sciences to physiology. Four of the five facilities accommodated researchers from both the social sciences as well as natural sciences and engineering disciplines.

Researchers reported that research collaborations had occurred as a result of contacts made through the facility. For instance, a researcher at the FERLD reported that their facility had "built up a database of information [...] (ECO-NET). Now researchers can do follow-up work and use the research precedents of others". Another researcher from the Navire de Recherche Océanographique reported that "the synergy between the researchers was surprising." The principal of the CNBL reported that as a result of the facility and the equipment, researchers are more inclined to work in teams to share their knowledge and expertise.

The presence of external (non-academic) facility users contributed to collaborations between the private sector and researchers. Such collaborations were cited at PCAMM and CNBL. International collaborations were also reported by researchers at the facilities profiled. According to the CNBL Web site, "In the last three years the lab has engaged in collaborative research with over 100 institutions in 19 countries from the developed and developing world." Researchers at the TWQC reported that "most of the researchers at Trent have some international collaborative research projects and this is a direct result of the research center."

Researchers reported that a number of research projects conducted, publications, and grants obtained were possible due to the facility. For instance, the CNBL was used for 143 experiments in 2004/2005 (15 proprietary, 128 in the public domain). Researchers at both the FERLD and the Navire de Recherche Océanographique research facilities stated that the number of research grants received from external agencies had increased as a result of the facility and that new partnerships that have emerged as a result. For example, the Navire de Recherche Océanographique receives students from the Institut Maritime du Québec at its facility for training purposes.

Finally, institution research programs have been impacted by the MFA-supported facilities through the recruitment of new faculty. Eight new faculty members have contributed to an expanded research program at UBC; these researchers were recruited to the institution as a result of the PCAMM facility. The TWQC also, has attracted new faculty members to the university as a result of the research facility.

These effects were observed in all disciplines, all regions and all sizes of institution. However, overall, researchers from life sciences were somewhat ***less*** likely to report the various effects of obtaining the grant, whereas those located in smaller institutions were ***more*** likely to report that the grant had produced positive impacts.

MFA applicants score the positive impacts of obtaining a grant and the negative impacts of not getting a grant higher than RTI applicants. Effects on collaboration among researchers and organizations, and effects on attraction and retention of faculty are rated much stronger by MFA applicants than by RTI applicants.

EXHIBIT 3.10 ● Impacts of obtaining a grant or not

Impacts	Impacts of obtaining the grant[1]		Impacts of not obtaining the grant[1]	
	RTI	MFA	RTI	MFA
Acceleration of the research effort | Delay in the research effort	88	82*	77	81
Better quality training of graduate students and postdocs | Reduced [...]	87	84	68	79*
Increase in the depth of the research effort | Decrease [...]	86	81	73	80
Increased ability to launch research efforts | Cancellation of the research effort	84	82	37	53*
Increased competitiveness of the research team | Reduced [...]	80[2]	82	69	79*
Increased complexity of the research issues tackled | Simplification [...]	80[3]	78	63	64
Increase in the uniqueness or originality of the research effort | Reduction [...]	79[4]	79	63	76*
Increased ability to carry out ground breaking research | Reduced [...]	78[5]	81	70	76
Investigation of new research directions | Lack of [...]	74[6]	73	62	67
More publications | Fewer [...]	72	76	60	64
Improved professional reputation for your research team | Deteriorated [...]	70[7]	86*	36	42
More collaboration among researchers | Less [...]	67[8]	80*	51	82*
Increased ability to attract graduate students and postdocs | Difficulty attracting [...]	65[9]	75*	47	54
More research grants | Fewer [...]	57	63	49	56
Retention of graduate students and postdocs | Loss [...]	51	67*	23	20
Substantial change in the research area	48[10]	51	43	47
More collaboration among organizations | Less [...]	44[11]	75*	41	79*
Obtaining of tenure and promotions | Loss of [...]	41	45	10	11
Retention of faculty | Loss [...]	32	59*	8	13
Increased ability to attract new faculty | Difficulty attracting [...]	28	65*	22	48*
n	769	81	696	38

Source: Applicant questionnaire, question 10
[1] Entries are weighted averages where "no such effect" has a value of zero, "small effect", 33, "moderate effect", 67, and "intense effect", 100.
[2] Less so in life sciences but more so in physical sciences.
[3] Less so in life sciences.
[4] Less so in life sciences but more so in engineering and life sciences.
[5] Less so in life sciences but more so in physical sciences and interdisciplinary fields.
[6] Less so in life sciences but more so in interdisciplinary fields.
[7] Less so in life sciences but more so in engineering.
[8] Less so in life sciences but more so in engineering.
[9] Less so in life sciences.
[10] More so in engineering.
[11] Less so in life sciences and physical sciences but more so in engineering and earth sciences.
* The difference between the scores provided by RTI and MFA applicants is statistically significant at least at the 95% level.

Key impacts of MFA. Among key informants, the most commonly cited impact of MFA is to support personnel to ensure better use of facilities. MFA is also claimed to allow collaboration and to allow Canadian researchers to be more competitive in relation to foreign researchers. MFA is seen as in a league of its own as, outside university funding, few if any other sources of funding exist for the costs of operating and maintaining a research facility.

Among the five cases which were studied in more depth, there was a consensus that MFA funding is a key input, which allows for the provision of critical infrastructure resources. Almost all informants felt that the facility would be severely disabled without the provision of MFA funding. MFA funding allowed researchers to better run the facilities and provide better maintenance on the equipment through the hiring of additional staff members (administrative assistants, technicians, etc.). It also allowed researchers to purchase or replace equipment that was out of use.

Every research facility profiled as part of the case studies has a multi disciplinary mandate. Researchers interviewed at all five facilities reported that research collaborations had occurred as a result of researchers from diverse disciplines coming into contact at the facility. The presence of external (non-academic) facility users contributed to collaborations between the private sector and researchers. International collaborations were also reported by researchers at the facilities profiled.

Unintended impacts of MFA. As part of case studies, informants were asked to share whether they had observed other, unintended impacts that are associated with the MFA program. Some unintended impacts of the MFA program that were observed include a larger global impact of the research facility on the community, such as the development of tourism or economic impacts. In the case of the Corialis research vessel, researchers indicated that the facility attracts a large number of foreign students because of its uniqueness.

Conclusion: objective achievement

RTI's objectives are to foster and enhance the discovery, innovation and training capability of university researchers in the natural sciences and engineering by supporting the purchase of research equipment and installations.

Based on the input gathered from program applicants and various key informants, we conclude that RTI funding leads to more, faster and more in-depth research as well as better trained HQP; the absence of RTI funding translated into delayed, more superficial research and weakened research teams and HQP training programs. These impacts were felt across the spectrum of disciplines, in all regions and in large and small institutions. Small institutions tended to report benefiting more from RTI funding than larger institutions. These observations support the notion that RTI is working toward the achievement of its objectives to enhance the discovery, innovation and training capability of university researchers.

MFA aims to support researchers' access to major regional or national research facilities by assisting these facilities to remain in a state of readiness for researchers to use.

The key impacts of MFA were identified as better use of the facilities, increased collaboration among researchers and improved international competitiveness of Canadian researchers.

Effects of a grant appear more intense for MFA projects than for RTI projects — be they the positive effects of obtaining a grant or the negative effects of not obtaining it. Increased collaboration among researchers and organizations as well as attraction and retention of faculty are much more prominent effects for MFA than RTI. The effects documented in this evaluation study seem to take place beyond the immediate objectives of the program (i.e., increased collaboration, attraction and retention may be a consequence of maintaining a state of readiness); this may be due to the measurement tools used or it may be that program applicants and key informants take facility readiness for granted and look beyond that point for the effects of MFA.

Note that the MFA objectives are stated in terms of activities (i.e., support to ensure availability) rather than in terms of results (e.g., more research, more collaboration, etc.). Consequently, reporting requirements, if they existed, would focus on activities, which does not shed light on the value of the program.

3.5 Issue 5, research productivity and training capability

Issue number 5 reads as follows: *What is the relationship between equipment/infrastructure and the research productivity and the training capability of university researchers? How much additional training/ publications have been made possible by having new equipment/facilities? What was the impact on the quality and nature of the training provided to HQP?* Evidence can be brought to bear from the following sources: the survey of department heads and the survey of program applicants.

Department heads and program applicants were asked to rate the relationship between research productivity (in their department or in their own case, respectively) and a variety of conditions in their research environment — several of which were related to the equipment infrastructure. Exhibit 3.11 summarizes their answers.

EXHIBIT 3.11 ● Importance of factors affecting productivity

	According to department heads[1]		According to applicants[2]	
Factors	Research productivity[3]	Quality of training[3]	Research productivity[3]	Quality of training[3]
Faculty and staff in your department	98	98	71	85
Financial support for graduate students or postdocs	95	93	96	93
Graduate students or postdocs in your discipline who are in your department	95	91	94	90
Amount or quality of research equipment	91	90	95	93
Funds or staff available for operations and maintenance of the equipment	84	81	83	80
Accessibility of research equipment within the department	82	82	83	84
Time required by faculty for teaching and administration	82	82	82	81
Degree of access to other facilities within the institution	65	63	69	68
Degree of access to other, regional or national facilities	58	56	56	55

[1] Department head questionnaire, questions 20 and 21
[2] Applicant questionnaire, questions 21 and 22
[3] Entries are weighted averages where "not at all important" has a value of zero, "slightly important", 33, "moderately important", 67, and "very important", 100.

Heads and applicants (i.e., individual researchers) generally agreed on these relationships, with the exception of the one factor rated of highest importance by department heads: the latter consider that the most potent influence on their department's research productivity is the faculty and staff in the department, whereas researchers place this towards the bottom of their list as it relates to their own research productivity.

Second comes a cluster of three factors affecting research productivity: financial support for graduate students or postdocs, graduate students or postdocs in the discipline who are in the department and the amount or quality of research equipment. RTI's number one target (research equipment) appears in this list of top factors affecting research productivity (tier 1), but it is not alone. This suggests that a global strategy to improve research productivity would have to include actions targeted at the other key factors which revolve around graduate students and postdoctoral fellows.

A second tier of three factors was identified as impacting on research productivity: funds or staff available for operations and maintenance of the equipment, accessibility of research equipment within the department and time required by faculty for teaching and administration. The MFA program targets are among these second tier factors (O&M and facility accessibility).

Closing the list of environmental factors important in determining research productivity are access to other research facilities within the institution and elsewhere. Department heads and individual researchers attribute generally significantly less importance to these types of accessibility dimensions. It is not clear whether informants reach this conclusion because of limited exposure to other facilities or because of limited need to access these facilities.

According to the same department heads and individual researchers, the factors affecting the quality of training at the advanced level are essentially the same as those affecting research productivity.

Another way to look at the impact of the programs on research productivity is to determine how many researchers have used the MFA facilities and the RTI equipments. Exhibit 3.12 indicates that, in the previous year, 57 graduate students used each MFA facility on average, while more than 7 used each piece of RTI equipment on average. University researchers come second followed by private sector and government researchers and then postdoctoral fellows.

Each MFA facility is reported as used by 10 universities on average and 7 departments within the institution itself — a significant level of co-operation.

EXHIBIT 3.12
Average number of actual users for MFA recipients facilities and RTI equipment

Types of users	MFA	RTI
Graduate students	57.1	7.5
University researchers	41.5	4.3
Private sector and government researchers	20.5	0.6
Postdocs	14.4	1.8
Private sector companies	10.1	0.4
Universities	9.8	1.3
Departments in your organization	6.7	1.6
Government entities	3.8	0.3
Source: Applicant questionnaire, question 11		

In total, focussing on the categories of Exhibit 3.12 referring to individuals rather than organizations, an MFA facility services an average of 133 researchers or graduate students per year and a piece of RTI equipment is used by 14 individuals per year.

With regard to the specific issue of training capacity, note that only 1% to 2% of MFA funds are reportedly spent on undergraduate and graduate student support (from Exhibit 3.15 later). However, according to Exhibit 3.12, MFA facilities accommodate 57 graduate students on average as well as 14 post-doctoral fellows — that totals 71 researchers of 164 or 43% of all researchers serviced by MFA facilities.

Conclusion: research productivity and training capacity

The quality and the amount of research equipment is among the top tier of factors affecting research productivity and the quality of advanced training — along with the availability of graduate students and postdoctoral fellows. This reinforces the rationale for RTI action but also highlights the importance of other environmental conditions.

MFA action targets (operations and maintenance costs and the accessibility of research equipment) are among the second tier factors affecting research productivity and the quality of training. However, access to regional and national facilities located outside one's institution rates low overall in terms of impact on research productivity; this could be because of researchers not needing such access or because of a strong preference for locally owned equipment. This observation could lead to questioning the rationale for MFA support.

The data suggest that each MFA facility is used by 133 researchers, 10 universities and 7 departments within the university, yearly, on average. A piece of RTI equipment is used by 14 researchers and graduate students per year on average.

3.6 Issue 6, management of major facilities

Issue number 6 reads as follows: *Have institutions managed the major research facilities, and the sharing of these facilities regionally and nationally, optimally? How interdisciplinary/multidisciplinary are the installations and their users?* Evidence can be brought to bear from the following sources: the survey of program applicants and key informant interviews. The evaluation study collected only limited information pertaining to this issue.

The MFA selection of projects for awards is based in part on facility management criteria. They are: effectiveness of the management structure, administration and allocation of access to the resource to different users (internal and external, from universities, government, or industry), plan and budget for the maintenance and operation of the resource, and plan of the resource to keep abreast of scientific and technical advances, as well as to sustain well-coordinated and leading-edge research activities.

Generally, the management of regional and national facilities by MFA was well rated by key informants. Some informants noted that formal management systems are employed and free researchers from time-consuming administrative tasks.

Measures have been implemented to ease access to facilities. Other measures that were frequently mentioned were frequent meetings, announcements and the Internet. Few informants had concerns about accessibility, but some thought that there needed to be more promotion or that equipment could be more accessible. Exhibit 3.12 indicates that MFA facilities service a variety of types of users from various horizons (universities, private sector, government).

Based on responses from successful MFA applicants, we established that users of MFA facilities are as likely to be from physical sciences and from life sciences (Exhibit 3.13). Earth sciences and engineering are also almost equally present, followed by "other" fields and mathematics.

EXHIBIT 3.13 • Distribution of MFA users by discipline

Disciplines	% of users
Physical sciences	26%
Life sciences	26%
Earth sciences	18%
Engineering	15%
Multidisciplinary and other disciplines	11%
Mathematics and computer sciences	4%

Source: Applicant questionnaire, data for MFA recipients only, question 12; n = 81; the figures are standardized to 100%.

One very limited indicator of the quality of MFA facility management is the proportion of O&M expenditures that is financed via user fees; it has limited value because reliance on user fees depends upon much more than the quality of facility management. It currently stands at 21% (Exhibit 3.5). Unfortunately, no comparative data are available to provide context to this information. According to facility managers, 40% of the users' fees are paid by users housed within the facility (Exhibit 3.14) and an additional 27%, by other users from universities.

EXHIBIT 3.14 • Distribution of MFA user fees by source

Sources	% of user fee revenues
Users from within your facility	40%
External users from universities	27%
External users from the private sector	18%
External users from government	7%
Other	8%

Source: Applicant questionnaire, data for MFA recipients only, question 20; n = 74; the figures are standardized to 100%.

As seen in the previous section, MFA facilities service a significant number of researchers and graduate students — an average of 133 per year, per facility.

Use of MFA funds. Form 300 data were used to profile the utilization made of MFA funds. This analysis was limited by the availability of data: Statement of Account data for the fiscal year 2005-2006 were not available at the time of this analysis; data from fiscal years 2003-2004 and 2004-2005 were used. The 2004-2005 expenditures were concentrated on salaries (65%) and materials (26%) (Exhibit 3.15).

EXHIBIT 3.15
MFA expenditures according to Statements of Account

	2003-2004	2004-2005
Undergraduate Students	0.5%	0.5%
Master's/Doctoral Students	0.3%	0.3%
Postdoctoral Fellows	1.1%	0.4%
Salaries	70.2%	64.7%
Equipment	3.6%	5.3%
Materials	22.7%	26.4%
Travel	1.7%	2.4%
Total	100.0%	100.0%

Source: NSERC administrative data, Form 300.

Exhibit 3.15 indicates that about one quarter of the MFA funds are devoted to "materials" and, therefore, likely to work toward the third management criterion (plan and budget for the maintenance and operation of the resource).

The same exhibit documents that about 2% of MFA funds are devoted to travel expenses, showing that this is not a priority in most MFA facilities or that methods other than travelling are used toward that goal. Performance of MFA facilities with regard to keeping abreast of scientific and technical advances was not brought forward by key informants — as if this were not forefront in the thinking of key informants about MFA.

Conclusion: management of major facilities

The data assembled here does not raise significant issues with the management of MFA facilities, nor does it supply clear evidence of outstanding performance (because indicators of such are not easily found).

MFA facilities appear to open their doors to researchers from a variety of disciplines and origins (universities, private sector, government). They collect about one fifth of their revenues from users. They devote most of their funds to salaries, then to materials, which is consistent with the management criteria which are set for them.

3.7 *Issue 7, RTI 2-RTI 3 moratorium*

Issue number 7 reads as follows: *What has been the impact of the RTI 2-3 moratorium on the state of a) equipment b) research productivity? c) training of HQP? What are the ways of coping without the requested equipment or facilities? What is the effect of not being funded?* Evidence can be brought to bear from the following sources: the survey of department heads, the survey of program applicants and key informant interviews.

RTI grant applications are divided into three categories according to the total cost of the equipment. The three categories are:

- RTI – 1: $7,001 to $150,000
- RTI – 2: $150,001 to $325,000
- RTI – 3: more than $325,000

A moratorium on Categories 2 and 3 has been in effect since the inception of the program in 2003.[1] The moratorium does not apply to applications in subatomic physics. The evaluation issue is: what have been the effects of the moratorium?

Almost two department heads in three (62%) indicated that their department had needed to acquire equipment worth more than $150,000 over the previous three years and half of them (52% of the 62% above) did in fact acquire some of this equipment, mainly using CFI funds and provincial government funds (totalling 65% of the sources mentioned) (Exhibit 3.16). This has left about one third of departments (62% x 48% = 30%) in need of such equipment without funding to acquire any of them.

1 However, since 2004, NSERC has accepted applications under Category 1 for equipment that costs up to $250,000 (before tax, shipping and handling) as long as the applicant is able to secure funding from other sources to bring the amount requested from NSERC to $150,000 or less.

EXHIBIT 3.16 ● Effects of moratorium

	According to department heads	According to applicants
% who needed to acquire equipment worth more than $150,000[1]	62%	37%
% who made at least some of the purchases among those who had the need[2]	52%	40%
Sources of funding for these purchases[3]:		
NSERC	4%	6%
CFI funds	44%	40%
Other federal gov. funds	6%	6%
Provincial gov. funds	21%	25%
University funds	11%	10%
Industry funds	7%	9%
Private foundation funds	2%	1%
User fees	2%	0%
Other	2%	2%

[1] Department head questionnaire, question 22 (n=256); RTI applicant questionnaire, questions 23 (n=1545)
[2] Department head questionnaire, question 25 (n=158); RTI applicant questionnaire, questions 23 (n=580)
[3] Department head questionnaire, question 27 (n=83); RTI applicant questionnaire, questions 28 (n=226); the figures are standardized to 100%

It is possible to get a sense of the effect of the moratorium on departments unable to acquire major equipment they considered they needed by contrasting the current (self-defined) state of their laboratories (Exhibit 3.17). A majority (60%) of departments which were able to make major purchased in the past three years self-classified as owning laboratory equipment adequate for cutting-edge research, while one-third fewer (40%) did so among departments which were unable to acquire major equipment in the past three years. These data could suggest that 20% of departments which could not make major purchased in the past three years slipped away from being able to carry out cutting-edge research. That translates to 6% of all departments (20% x 30%).

EXHIBIT 3.17
Overall quality of equipment according to need for major equipment

	Need for equipment worth more than $150,000, in the last 3 years [2]		
Overall quality of research equipment[1]	**No need to acquire such equipment**	**Have had such need and have made the acquisition**	**Have had such need and have not made the acquisition**
Adequate for cutting-edge research	34%	60%	40%
Adequate for simple research applications	52%	34%	51%
Insufficient even for simple research applications	15%	6%	9%
n	76	81	71

[1] Department head questionnaire, question 9.
[2] Department head questionnaire, questions 22 and 25.

Asked what the effect of the moratorium had been on their department in terms of the quality of research equipment, research productivity and the quality of training of graduate students and postdoctoral fellows, department heads settled on something less than "somewhat negative" — in fact, about half way between "somewhat negative" and "no effect" (Exhibit 3.18). Differences in perceived impact of the moratorium by university size did not reach statistical significance. Overall though, physical sciences departments seem to have suffered most from the moratorium (in particular, analytical-physical chemistry, inorganic chemistry and biochemistry as well as civil, structural and environmental engineering) and math and computer sciences, least.

EXHIBIT 3.18 ● Effects of moratorium on departments

Effect of the moratorium[1]	According to department heads	According to applicants
On the quality of research equipment	-29[2]	-18[3]
On research productivity	-24[4]	-16[5]
On the quality of training for graduate students and postdocs	-26[4]	-18[5]

[1] Department head questionnaire, question 28 (n=256); RTI applicant questionnaire, questions 29 (n=1545); averages based on responses coded -100 for "very negative impact" to 100 for "very positive impact".
[2] Less of an impact in math and computer sciences.
[3] Less of an impact in math and computer sciences but more of an impact in physical sciences — particularly in analytical-physical chemistry, inorganic chemistry and biochemistry as well as civil, structural and environmental engineering.
[4] Less of an impact in math and computer sciences but more of an impact in physical sciences.
[5] Less of an impact in math and computer sciences but more of an impact in physical sciences — particularly in analytical-physical chemistry and inorganic chemistry and biochemistry.

Individual researchers were less likely than whole departments to have needed equipment worth in excess of $150,000 (37%) but they were also less likely to have been able to acquire some without RTI assistance (40%). Individual researchers' assessment of the impacts of the moratorium were somewhat less negative than that of department heads. Variations by university size and discipline were the same for researchers as in the case of department heads.

According to key informants, impacts of the moratorium revolve around two issues. First, existing equipment in mid-range price was said to be out of date or inaccessible due to the moratorium. Second, researchers not benefiting from CFI funding appear to suffer more than other from the moratorium.

When they indicated that the moratorium exerted impacts on research productivity, key informants focused on lower research activity or a delay due to searching for other funding. A minority of key informants were of the view that such effect of the moratorium was minimal though.

A majority of informants indicated that training of HQP is generally unaffected by the moratorium. Minority views included that the moratorium led to a lack of modern facilities and to a need to find equipment at other institutions — two situations which were thought to affect the training of HQP.

In 2003, RTI program management conveyed[1] concerns from the natural science and engineering community in the following terms:

> The scientific and engineering communities, in their various interactions with NSERC staff have indicated that they see a role for NSERC's RTI 2-3 programs for new emerging areas that are not directly linked to the institution's strategic plan, and for those needs where 60% in matching funds cannot be found. This concern is often raised by researchers or administrators in Eastern Canada. Also, another concern often raised is the difficulties linked with CFI's application process and with institutions to which they apply to get the matching funds. The Physics and Chemistry Grant Selection Committees specifically asked that NSERC re-instate the programs.

1 Note from the Director, Physical and Mathematical Sciences, to the Committee on Research Grants dated April 11, 2003.

Conclusion: RTI-2 and RTI-3 moratoriums

It is clear that the RTI-2/RTI-3 moratorium has made it more difficult for researchers to obtain funding for mid-range to expensive pieces of equipment. The effect has not been catastrophic, however, as it has been compensated in part by the use of CFI funds; physical science's departments (where the effects of the moratorium have been felt more intensely) may be an exception to this conclusion. Still, one third of the departments were left in need of equipment without funding to acquire any of them. Also, where laboratories have been unable to acquire major equipment they considered they needed, it is possible that their ability to conduct cutting-edge research has been impaired. Moreover, the latest round of CFI competition has reportedly been more fierce than previous ones, with more applications turned down; it appears to become more difficult than before to access CFI funds.

The moratorium allowed NSERC to concentrate its research equipment purchase funds on RTI-1 level grants; lifting the RTI-2/RTI-3 moratorium would presumably adversely affect the sums available for RTI-1, unless new funding is secured for more expensive equipment.

During the moratorium on RTI-2/RTI-3, a significant portion of the need for equipment worth more than $150,000 was satisfied using CFI funds. This suggests that the reinstatement of RTI-2/RTI-3 would create a funding overlap between the programs of the two organizations. Of course, the situation will be totally different if CFI programs disappear once they reach their sunset clause.

3.8 Issue 8, program delivery

Issue number 8 reads as follows: *What mechanisms are currently used by other organizations (both Canadian and foreign) to fund equipment and maintenance and operating costs for research facilities in science and engineering?* Evidence can be brought to bear from the international review of experiences in foreign countries.

A review of research equipment funding programs was conducted in seven countries: Australia, Germany, Korea, Netherlands, Sweden, United Kingdom and the United States. The next exhibit provides a summary of the observations made.

EXHIBIT 3.19 ● Comparison of RTI and MFA with program in other countries

Aspect	Observations in other countries	Situation in Canada
Funding target	Target individual researchers as much as universities.	RTI targets individual researchers, and MFA, facilities. CFI targets universities.
Funding level	Target mid-range to expensive equipment and, in most cases, stay away from equipment worth less than $100,000, leaving such requirements to universities. It is not possible to ascertain whether key informants reached in each country and the country's agency Web site simply did not mention programs aimed at lower-cost equipment or if these programs really don't exist in these countries.	RTI funds acquisitions from $7,000; there is a moratorium on RTI funding of equipment worth more than $150,000 (except in sub-atomic physics). CFI funds larger projects.
Breadth of funding	Emphasize infrastructure development *in toto* rather than equipment purchases in a piecemeal fashion.	RTI funds individual equipment purchases ,while MFA deals with the O&M needs of facilities. CFI funds complete projects.
Research collaboration	Explicitly value researcher collaboration and the sharing of infrastructures.	RTI does not raise the issue of collaboration and sharing of equipment. RTI program applicants do not assign much value to collaboration and sharing. MFA is built on the premise of sharing facility services. CFI supports infrastructures which are expected to be used by researchers from various institutional origins.
Selection criteria	Peer review is the fundamental selection tool used in all countries and programs. Sometimes, peer review is used to rank applications rather than select them.	Peer review is the key selection mechanism.
Selection focus	Focus selection on research quality. Of the programs with available evaluation criteria, most show a clear concern for the end results of the research based on the requirement for long-term plans and objectives, broader impacts of the research, social relevance, contribution to society or government policy, advances in knowledge or contribution to the national interest. A requirement for equipment or infrastructure to be of a clear national interest was evident in three countries' programs: Sweden, Netherlands and Australia.	The review criteria for the RTI are: excellence of the applicant(s); merit of the proposed research program(s); need and urgency for the equipment, including availability of and access to similar equipment; suitability of the proposed equipment for the proposed research program(s); and importance of the equipment for the training of HQP. In the case of MFA: uniqueness of the facility at the regional or national level; need for access to the facility for the research programs; merit of the research programs that rely on access to the facility and excellence of the user community; demonstrated need for support through an MFA grant; management of the facility; contribution of the facility to the training of HQP; and synergy.
Cost sharing	Cost sharing requirements are rare.	RTI has no cost-sharing requirements. MFA assumes that the facility receives other funding. CFI has explicit cost-sharing requirements. Cost-sharing appears to cause disproportionate problems in Eastern Canada and among small universities.

EXHIBIT 3.19 • Comparison of RTI and MFA with program in other countries

Aspect	Observations in other countries	Situation in Canada
O&M costs	Often include provisions for operating and maintenance costs of the equipment acquired.	RTI includes no provision for O&M costs. MFA offers essentially O&M support. CFI adds 30% of the acquisition cost to cover O&M for a period of three to five years.

Conclusion: program delivery

Foreign countries appear to have decided to assist larger infrastructures and to support them with acquisition funds as well as funds aimed at operating and maintaining the infrastructure. In comparison, RTI focuses on individual pieces of equipment, MFA specializes in O&M for large facilities and CFI supports strategic plans of universities with limited commitment for the long term. An emphasis on total project needs (observed abroad) may lead to a more coherent development of the research infrastructure.

3.9 Issue 9, selection process

Issue number 9 reads as follows: *Are new or established researchers advantaged or disadvantaged by the current RTI selection process? Are new MFA applications or renewal applications advantaged or disadvantaged by the current selection process?* Evidence can be brought to bear from the following sources: the survey of department heads, the survey of program applicants and key informant interviews.

Individual researchers and department heads share common views on the RTI and MFA selection processes — although researchers tend to be somewhat more intense in their judgments. RTI is seen as favouring new researchers at about the same rate as it is seen favouring established researchers (Exhibit 3.20). Few individuals indicated that they saw RTI as favouring certain disciplines or certain types of equipment.

Both groups support favour being given by RTI to new researchers and new applications, and they tend to think that disciplines and types of equipment should not be the subject of particular selection priority.

Regarding the MFA selection process, department heads and individual researchers perceive that the selection process favours established researchers, national facilities and regional facilities. The perceptions of individual researchers are much more intrenched than those of department heads in this regard, though. If they had their say, department heads and individual researchers would lean more toward new researchers, new applications and, particularly, small yet unique facilities in selecting MFA projects.

Physical sciences departments have a stronger perception than others that RTI favours new researchers, while engineering departments and small universities perceive a leaning toward established researchers. These same groups are also of the view that these emphases are appropriate.

EXHIBIT 3.20 • Views on the selection process

	According to department heads		According to applicants	
	Currently favours[1]	Should favour[2]	Currently favours[3]	Should favour[4]
RTI				
new researchers	41%	63%	44%	61%
new applications	34%	51%	30%	49%
established researchers	39%	46%	39%	36%
renewal applications	21%	34%	19%	33%
certain disciplines	17%	12%	15%	13%
certain types of equipment	9%	9%	12%	16%
MFA				
new researchers	9%	31%	15%	34%
new applications	9%	34%	16%	34%
established researchers	43%	46%	57%	57%
renewal applications	28%	36%	54%	63%
certain disciplines	9%	7%	17%	18%
regional facilities	31%	45%	56%	65%
national facilities	36%	35%	68%	67%
large facilities	34%	29%	60%	48%
small yet unique facilities	12%	43%	28%	69%

Note: Entries are percentages indicating that the program does/should moderately or strongly favour; percentages include "Don't know" answers and are thus representative of the entire populations.
[1] Refers to the program currently favouring; Department head questionnaire, questions 29 and 31 (n=256)
[2] The program should favour; Department head questionnaire, questions 30 and 32 (n=256)
[3] Refers to the program currently favouring; Applicant questionnaire, question 30 (RTI n=1545, MFA n=119)
[4] The program should favour; Applicant questionnaire, question 31 (RTI n=1545, MFA n=119)

A large group of key informants believed that larger, well-funded institutions are more advantaged due to the design or delivery of RTI and MFA. They believed that smaller, newer and more remote universities have more difficulty obtaining funding from RTI and MFA. "The MFA disadvantages smaller facilities because they do not have the same concentration of research infrastructure as larger universities. Unless, smaller institutions have an established centre or facilities then they are less likely to receive MFA funding." indicated one key informant.

The RTI program was also criticized for being better suited for larger institutions; the reasoning was that NSERC would not view research supported by smaller institutions as "major" research.

When asked about strengths and weaknesses of RTI and MFA in general, the most frequent comment was that the programs have limited funding or lack funding. With respect to MFA in particular, several informants stated that it was essential to facilities and encouraged collaboration between researchers.

When asked about the impact of the need for the facilities to possess a regional or national attraction, informants most often commented that there is more of an international focus than a regional or national one in facilities and the MFA may not necessarily recognize this.

Comments made by informants with regards to the advantages or disadvantages to researchers, programmes or disciplines due to the design or delivery of the programs were varied. The most commonly mentioned opinion was that funding or support is given to established, larger institutions. However, just as many held the opinion that there were no disadvantages or advantages. Another commonly mentioned disadvantage was that disciplines that are not as well established do not receive enough funding or equipment; as many informants also mentioned that the programs advantaged mature disciplines requiring more expensive equipment.

The general views of key informants regarding small institutions being disadvantaged in the RTI selection process appear supported by data on success rates and funding rates. Between 2001 and 2006, small universities have had a success rate of 28% in RTI applications compared to 37% for medium-size universities and 40% for large universities. Their funding rate for the same period was 22% compared to 32% and 34% for the medium-size and large universities. These differences are statistically significant, while those between medium-size universities and large universities are not, which singles out small universities as the most disadvantaged. Note that small universities fared particularly poorly compared to the two other groups early and late in the 2000-2006 period.

EXHIBIT 3.21 • Success rates and funding rates by university size

	Success rates			Funding rates		
	Small	**Medium size**	**Large**	**Small**	**Medium size**	**Large**
2000	**35%*#**	52%	52%	**26%*#**	43%	43%
2001	**30%#**	40%	42%	26%	35%	35%
2002	23%	32%	32%	**17%#**	22%	28%
2003	18%	24%	23%	13%	21%	21%
2004	29%	29%	38%	**19%#**	27%	32%
2005	34%	42%	44%	30%	39%	39%
2006	**24%*#**	39%	47%	**22%#**	33%	41%
2001-2006	**28%*#**	37%	40%	**22%*#**	32%	34%

Source: NSERC administrative data.
* The difference with the medium-size university score is statistically significant at least at the 95% level.
# The difference with the large-university score is statistically significant at least at the 95% level.

Conclusion: selection process

All in all, some groups of researchers or types of applications are perceived as receiving preferential treatment by either RTI or MFA, but these emphases are understood and accepted, even desired.

One exception to this overall conclusion is small yet unique facilities on which department heads and researchers (even more so the latter) would like to see a priority established for MFA funding.

Program data also demonstrates that small universities achieve significantly lower success and funding rates in their RTI applications.

3.10 Issue 10, MFA objectives and evaluation criteria

Issue number 10 reads as follows: *Are MFA objectives and evaluation criteria appropriate for all disciplines and all types of applications (regional facilities / national facilities / large research institutes)?* Evidence can be brought to bear from the following sources: the survey of department heads, key informant interviews and the document review.

Selection committee reports are informative.

- In the 2001 competition, the selection committee noted that there was continuing pressure to support local facilities — some of which received CFI funding, while being excluded from MFA funding.
- In 2004, MFA received two proposals with funding requests exceeding $1 million. The committee felt that the gap between the large national requests and the applications from small facilities made selection difficult, and it recommended that large national facilities be evaluated in a separate competition with its own budget.
- In 2006, NSERC's Committee on Grants and Scholarships reported that "the substantial investments made by CFI continue to drive numerous applications to the MFA program. An analysis of the applications in this year's competition demonstrated that 59% (46 applications) of all the facilities requesting MFA support received CFI funding for at least part of their facilities."

Most key informants thought that the MFA evaluation criteria were appropriate, while several found them unclear. The definition of uniqueness of the facilities at the regional or national level was perceived by most to be unclear and difficult to demonstrate. All key informants who took a

MFA selection criteria assessed during case studies

Informants felt that the requirement that the facility have a national or regional nature is either unclear or irrelevant. Researchers at one location had mixed opinions about whether the objective of the program should be expanded to include local facilities. One researcher felt that with limited funds in the program, it is reasonable to prioritize funding to regional and national facilities. On the other hand, two other researchers felt that a facility that is local but with a significant impact should be funded nevertheless.

The principal at one location suggested that the primary consideration should be whether researchers at other universities, as well as other disciplines use the facilities. At another location, the principal proposed that evaluators should primarily consider whether the resources available at the facility are available elsewhere. At yet another facility, the principal felt that the outreach of the facility should be the point of focus, and not the regional aspect. The researcher proposed as criteria the user community and the openness of the facility to researchers not affiliated with the primary institution.

The uniqueness criterion appeared to be less clear to informants than the regional criteria. Most interpreted this as indicating whether the same capabilities exist elsewhere in Canada. As expressed by one participant: "This seems to imply that there should be a comparison with other research facilities. If this is the case, then it should be made clear." There was some confusion regarding whether the uniqueness criterion includes only the uniqueness of the equipment or also the uniqueness of the research approach and/or the methods used. This criterion also raised some concern over whether facilities that are considered "standard" yet ones that are necessary to the scientific community would not be funded.

stand on the clarity and appropriateness of the definition of a regional facility thought it was unclear.

Most informants thought that eligible expenses were appropriate and all commented positively on the appropriateness for demonstration of a need in order to obtain funding from MFA.

Several key informants indicated that the prime selection criterion should be the quality of the research conducted at the facility.

At page 26, we estimated that the annual need for operations and maintenance funding is upwards of $208 million and that MFA funds represent approximately 6% of this need. It is questionable, in this context, whether MFA can impact the university research system with such limited resources (see issue no. 1).

Department heads who expressed an opinion generally thought that MFA evaluation criteria were appropriate (Exhibit 3.22). The requirement for a demonstration of need for funding was not questioned and few criticized the appropriateness of the definition of uniqueness of facilities. Expense eligibility rules and the definition of the regional stature of facilities were the subject of more limited support. In particular, physical sciences department heads were more critical than others of the definition of regional stature.

EXHIBIT 3.22 • Appropriateness of MFA evaluation criteria

Appropriateness (entries are weighted averages)	Department heads
the requirement of a demonstration of need for funding	86
the definition of uniqueness of the facilities	72
the requirement that the facilities be of regional or national stature	67
the definition of regional stature	60
the expense eligibility rules	59
Source: Department head questionnaire, question 33; n = 256	

One issue which has come up repeatedly over the years, without solution, is that MFA applications comprise a large pool of small applications and a small number of large applications. This heterogeneity makes comparisons and selection difficult. Also, if a small number of large applications is selected, there is a risk that little funds will be left available for small applications.

Conclusion: MFA objectives and evaluation criteria

The consensus appears to be that MFA evaluation criteria are appropriate in principle but unclear in practice. Of particular concern is the definition of the regional stature of a research facility — one of the gateways to MFA funding.

Access to MFA funding is becoming increasingly difficult (the funding rate is decreasing; see the previous section). Additionally, the presence of a few large applications, evaluated on the same footing as many small applications, also raises concerns.

Finally, current MFA evaluation criteria do not necessarily accommodate facilities initially funded by CFI which may or may not fit the criteria of national or regional stature but have run out of operating and maintenance funding. Whether MFA should make room for these facilities is an open question.

MFA funds represent approximately 6% of the need for operations and maintenance funding. It is questionable, in this context, whether MFA can impact the university research system with such limited resources.

Chapter 4

SUMMARY AND RECOMMENDATIONS

This chapter summarises the evaluation approach, key findings and associated recommendations.

4.1 Evaluation methodology

The evaluation process included the following methodologies:

- a survey of university department heads: between January and March 2006, 256 heads of natural sciences and engineering university departments (representing one third of all such departments) completed a Web-based questionnaire focused on the state of research equipment and the financing of operations and maintenance of research equipment;
- a survey of program applicants: between January and March 2006, 1,664 program applicants from the 2001 to 2005 competition years (41% of the population) completed a Web-based questionnaire on the impacts of obtaining or not obtaining an RTI or an MFA grant, as

well as on various other themes related to the place of research equipment in the research environment;

- key informant interviews: 36 interviews were conducted with individuals whose position or experience allowed them to offer informed opinions on the programs;
- a document and administrative data review: a variety of documents and data sets were accessed to profile the use of the programs and the environment in which they operate; they included: Internal notes, annual reports of Major Facilities Access grant selection committees, NAMIS records, MFA applications, *ad hoc* data sets produced by NSERC for this evaluation, NSERC's *Facts and Figures* publication;
- a review of experiences in foreign countries: a brief overview of comparable international funding initiatives was conducted; representatives from seven countries were approached after information was collected from the relevant Web sites: Sweden, Korea, United States, Germany, Netherlands, United Kingdom and Australia.
- a series of case studies: case studies of five MFA projects were conducted which included a review of documentation, site visits and additional interviews.

4.2 Research Tools and Instruments Grants (RTI)

The program

With average annual expenses of $32 million between 2001 and 2005, RTI is the core NSERC program for equipment acquisition. Over the same period, 82% of program funding was expended on equipment valued between $7,001 and $150,000. Still between 2001 and 2005, some 1,450 requests for funding were received annually on average and some 500 grants were awarded.

Program performance

RTI's objectives are to foster and enhance the discovery, innovation and training capability of university researchers in the natural sciences and engineering by supporting the purchase of research equipment and installations.

RTI funding leads to more, faster and more in-depth research as well as better trained HQP; the absence of RTI funding translated into delayed, more superficial research and weakened research teams and HQP training programs. These impacts were felt across the spectrum of disciplines, in all regions and in large and small institutions. Small institutions tended to report benefiting more from RTI funding than larger institutions — as long as they were able to secure such funding since data have shown that the probability of funding was less for small institutions than for medium-size and large institutions. These observations support the notion that RTI is working toward the achievement of its objectives to enhance the discovery, innovation and training capability of university researchers.

RTI-1 funding

NSERC and CFI programming have made significant contributions to improving the state of university research equipment over the past decade or so. Yet, a little more than half of existing equipment is in very good or adequate condition, while a little less than half is in poor condition or inoperative. Also, while one laboratory in ten is inadequate for research purposes, half of the rest can support simple research applications and the other half, cutting-edge research.

Three messages come out loud and clear from this evaluation study:

- a significant proportion of the existing equipment infrastructure will require replacement over the coming five years — between one quarter and one third (about $1.5 billion) of the value of existing equipment is at play;
- about 20% of existing equipment (worth about $1 billion) will require major maintenance over the coming five years and funds are scarce for this need;
- it is difficult for researchers to find funding for small equipment.

If the need to replace obsolete equipment amounts to $1.5 billion over 5 years, the average annual need amounts to $300 million. The current level of funding of RTI (about $32 million annually over the past 5 years for all three RTI sub-programs) will allow it to address only a small portion (about 10%) of the need for replacement of existing equipment in the coming years, not to mention the need for acquisition of entirely new equipment. Yet, the amount and quality of research equipment is one of the most important factors affecting research productivity and the quality of HQP training. Note that RTI is not the only player in the game of funding research equipment — although one major proponent, CFI, is not heavily involved in the financing of replacement equipment.

While CFI plays a pivotal role in the funding of acquisitions of state-of-the-art research equipment, NSERC is also a key player in this field. NSERC's annual budget for research equipment acquisition is much lower than that of CFI, but NSERC has been involved in such funding for a long time — such that its cumulative influence ranks it in second place as an equipment purchase funding source. Therefore, any modification to NSERC's priorities and strategies in this area will have profound consequences on the university research system.

Recommendation 1: increase and stabilize the funding of RTI-1.

RTI-2/RTI-3 moratorium

Absence of overlap between RTI and CFI. Between 1998 and 2005, RTI has spent upwards of 77% of its budget on RTI-1 projects; projects of similar value represent 1% of CFI project awards. CFI spends 10¢ in projects with values in the range of RTI-1 for every dollar spent by RTI. Conversely, CFI spends respectively $12 and $42 in RTI-2 and RTI-3 grade projects for each dollar invested by RTI in projects of these sizes. Therefore, there is currently little overlap between the CFI and RTI programs. In fact, constraints to usage of CFI (large-scale, state-of-the-art projects within university strategic priorities) make unlikely a dramatic overlap in financial support with RTI/MFA projects.

Existence of a gap between RTI and CFI. The same constraints to usage of CFI programs may create gaps in funding availability, in particular for large scale projects outside university strategic priorities.

A significant increase in RTI-2/RTI-3 activity could produce a movement of projects away from CFI, towards RTI, thereby bridging the gap between the two sources of funding, producing an overlap between the two programs and creating pressure on RTI funding. A reactivation of RTI-2 and RTI-3 would likely have some negative effects (reduction of RTI-1 funds, overlap with CFI) and some positive effects (reduction of the funding gap for projects too large for RTI-1 but outside the CFI program territory).

Effects of the moratorium. The RTI-2/RTI-3 moratorium has made it more difficult for researchers to obtain funding for mid-range to expensive pieces of equipment. The effect has not been catastrophic, however, as it has been compensated in part by the use of CFI funds and because RTI has continued providing an average of $5.7 million annually to RTI-2 and RTI-3 projects, albeit only in the area of subatomic physics.

Still, one third of the departments were left in need of equipment without funding to acquire any of them. Also, where laboratories have been unable to acquire major equipment they considered they needed, it is possible that their ability to conduct cutting-edge research has been impaired. Moreover, the latest round of CFI competition has reportedly been more fierce than previous ones, with more applications turned down; it appears to become more difficult than before to access CFI funds. Close monitoring of this situation is in order to avoid deterioration without reaction.

The moratorium allowed NSERC to concentrate its research equipment purchase funds on RTI-1 level grants; lifting the RTI-2/RTI-3 moratorium would presumably adversely affect the sums available for RTI-1, unless new funding is secured for more expensive equipment.

During the moratorium on RTI-2/RTI-3, a significant portion of the need for equipment worth more than $150,000 was satisfied using CFI funds. This suggests that the reinstatement of RTI-2/RTI-3 would create a funding overlap between the programs of the two organizations. Of course, the situation will be totally different if CFI programs disappear once they reach their sunset clause.

Allowance for equipment worth more than $150,000. Since 2004, NSERC has accepted applications under RTI-1 for equipment that costs up to $250,000 as long as the applicant is able to secure funding from other sources to bring the amount requested from NSERC to $150,000 or less. The program data systems are not set up to provide information on the incidence of such applications or on their rate of success. Considering that this allowance serves a certain need and that it has little to no impact on the rest of the program, it is recommended that it be maintained.

Recommendation 2: maintain the RTI-2/RTI-3 moratorium as long as CFI programs are active in this area.

Access to RTI

A large group of key informants believed that larger, well-funded institutions are advantaged. They believed that smaller, newer and more remote universities have more difficulty obtaining funding from RTI. This view is supported by data on success rates and funding rates. Between 2001 and 2006, small universities have had a success rate of 28% in RTI applications compared to 37% for medium-size universities and 40% for large universities. Their funding rate for the same period was 22% compared to 32% and 34% for the medium-size and large universities.

Recommendation 3: study the reasons for the lower success and funding rates of small universities in RTI-1.

4.3 Major Facilities Access Grants (MFA)

The program

MFA grants support researchers' access to facilities or research resources that are significant in size, value or importance and that are not routinely available in Canadian universities. MFA grants provide funding for maintenance costs such as the salaries of technical and professional research support staff employed to provide support to users, or to maintain and operate the facility, and for other direct costs such as materials, supplies and small equipment essential to the maintenance and operation of the facility.

Between 2001 and 2005, 241 requests for funding were received by MFA and 149 grants were awarded — typically for a period of 3 years. Between FY 2000-2001 and FY 2004-2005, the program expended $62 million, or about $12 million annually.

Program performance

MFA aims to support researchers' access to major regional or national research facilities by assisting these facilities to remain in a state of readiness for researchers to use. Note that this objective is expressed at the level of activities (i.e., support access) rather than at the level of outcomes (e.g., enhance discovery).

The key impacts of MFA were identified as better use of the facilities, increased collaboration among researchers and improved international competitiveness of Canadian researchers. Effects of a grant appear more intense for MFA projects than for RTI projects — be they the positive effects of obtaining a grant or the negative effects of not obtaining it. Increased collaboration among researchers and organizations as well as attraction and retention of faculty are much more prominent effects for MFA than RTI. The effects documented in this evaluation study seem to take place beyond the immediate objectives of the program (i.e., increased collaboration, attraction and retention may be a consequence of maintaining a state of readiness); this may be due to the measurement tools used or it may be that program applicants and key informants take facility readiness for granted and look beyond that point for the effects of MFA.

Recommendation 4: restate MFA objectives in terms of results instead of activities and adjust reporting requirements accordingly.

Funding of operations and maintenance expenses

The value of annual operating and maintenance costs for the coming years was estimated at about 4% of the original purchase cost of the equipment, based on the subsidies recently added to the CFI grants. If the university research equipment infrastructure is worth $5.2 billion, the O&M bill should be about $208 million annually and it will likely increase as CFI continues to support the addition of state-of-the-art equipment. Therefore, the $12 million invested annually by MFA for major facilities probably represents a little more than 6% of the need for O&M funding.

Considering the pace at which new equipment is added to the research infrastructure, via CFI programs in particular, the university research system is likely to face a serious problem funding the operations of the equipment as well as its maintenance. This issue concerns not only universities and NSERC but CFI as well.

Recommendation 5: augment funding for operations and maintenance expenses.

NSERC is second only to universities themselves among sources of funding with regard to operating and maintenance funds. CFI, other federal government funds, provincial funds and user fees each account for about half as much as NSERC. The role of CFI has been significant albeit short-term in this area with regard to the equipment it has subsidized since 2001.

Current MFA evaluation criteria do not accommodate facilities initially funded by CFI which may not fit the criteria of national or regional stature but have run out of operating and maintenance funding. Whether MFA should make room for these facilities is an open question.

Recommendation 6: coordinate with CFI to avoid under-investment in O&M.

The consensus appears to be that MFA evaluation criteria are appropriate in principle but unclear in practice. Of particular concern are the definition of the uniqueness and the definition of the regional stature of a research facility/resource — one of the gateways to MFA funding. This could be a communication issue or the expression of a structural problem. First, the definition of uniqueness of the facilities at the regional or national level was perceived to be unclear and difficult to demonstrate. Researchers do not understand the concept of a regional facility. For researchers, most facilities could be viewed as "regional" in nature as long as researchers from other institutions are not barred from using them. Second, there is concern that facilities located in small institutions have a harder time to secure funding. The presence of a few large applications, evaluated on the same footing as many small applications, also raises concerns.

In addition, access to regional and national facilities ranked lowest among the factors affecting research productivity and the quality of HQP training. This may lead to questioning the rationale for O&M support of regional and national facilities to the exclusion of local facilities and emphasize the need to support O&M efforts closer to research teams. Of course, a move in that direction runs the risk of spreading program resources too thin to have substantial effects.

Recommendation 7: The NSERC Council should revisit its decision to fund O&M costs for national and regional research infrastructures only. If a decision is made to maintain the current emphasis on regional/national resources, the definitions of uniqueness and of what constitutes a regional/national resource should be clarified.