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FINAL REPORT

Portfolio Evaluation of the NRC Technology Cluster Initiatives

September 2009

National Research Council Canada
Conseil national de recherches Canada

Canada

Prepared by:
Planning and Performance Management Directorate
Strategy and Development Branch
Corporate Services

Approval:
This Report was approved by NRC's President on September 25, 2009.

Additional information and a summary of this report are available on the National Research Council's website at:
http://www.nrc-cnrc.gc.ca/aboutUs/evaluation_e.html

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EXECUTIVE SUMMARY

This report presents the findings from an evaluation of the National Research Council (NRC) technology cluster initiatives (CIs). The CIs represent the contributions of NRC to the development and growth of technological clusters across Canada. The CIs, located in eleven Canadian communities, "*integrate industry, government and university resources through new partnership models that create the technological and entrepreneurial advantage for Canadian businesses to innovate and compete in the global marketplace*".[1]

An evaluation of the CIs was undertaken to provide information in support of the renewal process for the initiatives in 2009-2010. The study was led by NRC's evaluation function with the Planning and Performance Management Directorate, with support from private sector evaluators, as needed. The evaluation team also secured academic support for the literature review conducted as part of the evaluation.

The selection of evaluation issues used to guide the study was based on the Treasury Board Secretariat's Policy on Evaluation (2009), as well as the Results-based Management and Accountability Framework prepared for the Technology Cluster Initiatives. The issues identified include relevance, effectiveness and performance and leverage (efficiency and cost-effectiveness).

Evaluation Scope

The evaluation focuses on examining relevance and performance achieved with the resources provided to NRC from 2000-01 to 2007-08 (Round I), 2002-2003 to 2007-08 (Round II), and 2003-04 to 2007-08 (Round III). This was necessary as the evaluation was conducted in late 2008-09 and concluded in early 2009-10.

Evaluation Methodology

The methodology developed for this evaluation included multiple lines of evidence, as is standard practice in evaluation. The following methods were used to address the evaluation issues:

- administrative and performance data review;
- document and literature reviews;
- cluster community discussion groups (n=11);
- internal staff discussion groups (n=11);
- cluster initiatives leverage analysis;
- case studies (n=6), and
- targeted interviews (n=52).

Summary of Evaluation Findings

The following provides a summary of key findings stemming from the evaluation.

Relevance

The role of the federal government in clustering is supported by the approaches taken in other OECD countries. Many countries, including members of the G8 and Asia, have put in place nation-wide cluster policies. In some instances, approaches have been adopted to stimulate laggard regions, to reinforce highly performing ones, and to diversify older industrial areas into higher technology ones. Almost all of

[1] http://www.nrc-cnrc.gc.ca/eng/reports/technology-cluster-opportunities.html

these approaches involve some type of partnership between academia and government R&D laboratories, which supports the role of NRC in clustering.

All eleven cluster initiatives were found to be aligned with one of the four priority areas outlined in the Knowledge Advantage component of the Government of Canada's Science and Technology Strategy (2007). Further, a number of sub-priorities identified by the Science, Innovation and Technology Council (STIC) were found to be closely linked to the technological focus of the CIs. In several instances, the initiatives are also aligned with provincial or municipal strategies and investments (e.g., Nanotechnology, Nutrisciences and Health, Fuel Cell and Hydrogen Technologies).

Most of the technology areas at the heart of the cluster initiatives were found to be consistent with stakeholder needs and their vision for their region. They are also often consistent with the choices made by other industrialized nations in terms of technological development and public sector investment (e.g., nanotechnology and photonics). However, a few initiatives were identified in the evaluation as having a focus or orientation that may warrant closer examination in the future. These include Fuel Cell and Hydrogen Technology, Life Sciences, and Plants for Health and Wellness.

Effectiveness of Program Delivery and Governance

A recurrent theme raised by evaluation participants was the effect of five-year funding for what is intended to be a long-term activity – regional technology or knowledge-based cluster development. This cycle and its associated requirements (e.g., performance reporting, evaluation, Memoranda to Cabinet, etc.) were identified by both internal and external stakeholders as hindrances to optimizing the results to be achieved by the investment. Further, the short-term funding was found to hinder the attraction and retention of highly qualified personnel in the cluster initiatives, and increases the risk to the ongoing maintenance of new infrastructure funded through the CIs.

The integration of cluster initiatives activities to existing Institutes was also found to lead to program delivery issues, especially in those cases where the technological foci of the cluster initiative and the Institute are identical. In these instances, it has been difficult and time-consuming for the Institutes to report separately on cluster initiative and core activities, investments, and outcomes.

Effectiveness and Performance in Delivering Cluster Support Mechanisms

Overall, stakeholders consulted for the evaluation felt that there had been a positive change in the extent to which business support services have been made available to firms since the start of cluster funding and partially attributed this change to NRC. The role of NRC-IRAP in funding organizations was identified as an important enabler to clustering. These organizations work to support the innovative capacity of firms, or of a region delivering programming related to such areas as mentorship, business planning, regional planning (roadmapping and strategy development) and networking (conferences or networking, including participation in international missions).

The activities of NRC-CISTI in the CIs have evolved in various forms over the years and are highly valued by stakeholders. Despite a lack of direct funding in Rounds II and III of the cluster initiatives, NRC-CISTI has been able to provide Information Services and Competitive Technical Intelligence (CTI) products to nine of the eleven initiatives. The CTI services, in particular, are delivered through arrangements with NRC-IRAP and focus directly on the needs of its Industrial Technology Advisors (ITAs) and their client firms. In some instances, CTI services are covered by cluster initiative funding allocated to Institutes. The complexity of these arrangements, coupled with results from NRC's recent Strategic Review, leave questions as to how NRC will proceed in the future in terms of the provision of these services.

Industry Partnership Facilities (IPFs) are one of the ways in which NRC contributes to the development of firms. These facilities are generally designed to offer firms the opportunity to co-locate with NRC staff and serve a variety of purposes, such as providing tenants with access to NRC equipment and expertise, IT

infrastructure, meetings rooms, and, in some cases, business services. Seven new IPFs were established using cluster initiative funding. The key strengths of the IPFs, in the view of tenants, are that the NRC brand provides credibility to cluster firms, that tenants have access to highly specialized equipment not available elsewhere, and that firms benefit from knowledge or technology transfer from NRC. The study also noted that the programming offered by IPFs across the cluster initiatives varies substantially, and that IPFs do not only house firms that are working in a cluster-related technology area.

Effectiveness and Performance in Developing Specialized Infrastructure

One of the most significant ways in which the CIs contribute to the development of clusters is through the provision of facilities and equipment to cluster stakeholders. Six CIs have contributed to the development or expansion of new facilities owned by NRC totaling over 425,000 square feet of new space in the cluster regions. Leased space is also an important component of the NRC presence across the country, with new space leased in six regions. Overall, these are seen as a positive contribution to cluster development and in many cases, speak to the unique role of NRC within the cluster regions. The NRC facilities are often considered a focal point in cluster regions and help to generate awareness of the presence of the federal government in these areas. The use of cluster funding, in some cases, to ensure ongoing maintenance of the new buildings was raised as a concern in the study due to the added risk this poses to the organization in the long-term.

Effectiveness and Performance in Supporting the Development of Highly Qualified Personnel

The cluster initiatives were found to support the development of highly skilled personnel (HQP) through the attraction and retention of individuals to the cluster regions and through the contributions of NRC staff to training in other organizations. CI funding was used in several instances to hire research officers, technical officers, students, and other individuals to work on cluster-related projects. In total, 490 individuals were hired by NRC between the fiscal years 2001-02 and 2007-08. The split between continuing positions and term positions is approximately even for this period. In 2007-08, the positions funded out of the cluster initiatives represented approximately 7.5 percent of all NRC positions.

The initiatives also contributed in an important way to the training of students in the cluster regions. A total of 235 students received direct funding from the cluster initiatives to conduct research work at NRC in various capacities (summer students, graduate theses, etc). This is a conservative figure, given that many students receive grants from other organizations to pursue thesis research in NRC laboratories or may receive funding from the Institutes' core budgets. By providing students with access to its laboratories and expertise, NRC exposes students to multi-disciplinary research teams and facilitates their transition to industry once their studies are complete. In addition to the knowledge transfer that occurs when HQP participate in NRC projects, NRC researchers are also heavily involved in their respective cluster communities in terms of training the next generation of scientists through cross-appointments at universities, where they teach courses and sit on thesis committees.

Finally, one of the ways in which the cluster initiatives also have been able to attract HQP is through the Visiting Workers Program, which allows Institutes to host scientists for a pre-determined period of time. Visiting workers may be university or industry researchers on sabbatical leave, industrial collaborators engaged under the terms of a collaborative agreement, retired NRC staff, or students. Up until 2007-08, NRC has hosted 404 individuals in relation with its cluster initiatives. The consideration of Visiting Workers is particularly important when studying the impacts of cluster initiative funding, since the influx of these workers increases the research capacity of NRC in the cluster region.

Effectiveness and Performance in Developing Leading-Edge Knowledge

Although scientific excellence was not specifically assessed in the evaluation due to the large breadth of science areas represented by the cluster initiatives, evidence pertaining to leading-edge scientific activities conducted within the scope of the initiatives was nonetheless identified through stakeholder consultations and other methods. Overall, the funding provided through the CIs has enabled the

creation of new NRC initiatives in advanced fields such as photonics and nanotechnology, and has supported leading-edge research activities in existing areas of competence, such as plant biotechnology, ocean technology, and biodiagnostics. In many of these cases, the research conducted at NRC was found to be complementary and aligned to the research priorities of other cluster partners.

One of the ways in which NRC generates leading-edge knowledge in the clusters is through collaborative agreements with other partners, such as universities, firms, and other government organizations. In total, the cluster initiatives reported 151 collaborative agreements signed over the evaluation period. Even though the initiatives report collaborative activities with the private sector, one of the potential barriers to success raised by stakeholders is the lack of receptor capacity for the results of advanced research. Further work is required to better align the research activities that take place in many cluster Institutes with the needs of the industrial community.

Effectiveness and Performance in Fostering the Development of Innovative Firms

The extent to which the cluster initiatives have contributed to the development of innovative firms and industries depends largely on the stage of development of the cluster itself. With a number of clusters assessed as being in emerging or developing stages of evolution, expectations regarding firms should remain realistic. Further, some initiatives have been launched in regions that have different sizes, economic bases, and infrastructure. In many cases, the development of firms tends to occur once the impacts and outcomes described previously have been achieved, at least in part. However, direct and longer-term support to firms is provided primarily through the collaborative research undertaken by NRC and firms, the services and access to equipment provided by NRC Institutes, as well as support provided for R&D activities by NRC-IRAP.

Despite NRC's efforts, a number of challenges remain in the sustainable development of firms located in clusters. These include a lack of investment capital, a lack of incubation space, and the high cost of technology.

Effectiveness and Performance in Fostering Networks and Alliances

The development of networks and alliances between organizations is at the very core of cluster success. In general, the evaluation findings point to an increase or maintenance in the relationships developed between cluster actors over the entire CI funding period. The nature of these relationships, as well as the forms they may take in clustering, varies between the different cluster initiatives. The evaluation found that all CIs are involved in some way in networking activities, which tend to aim for the establishment of relationships between organizations at a general level. Most initiatives are also cooperating with key partners, undertaking projects or other activities that have finite objectives and separate tasks. Some initiatives have been able to move beyond these relationships and establish collaborative relationships with other cluster actors, where resources are shared to address common issues and a formal communication system has been established. Finally, a few initiatives are looking beyond their own geographic region and are involved in "*cluster twinning*" activities, where relationships are developed between clusters from different jurisdictions sharing similar technological foci.

Leverage and Efficient Use of Resources

In order to determine whether cluster initiative resources were used efficiently, the evaluation sought to determine the extent to which other parallel investments were made in support of the cluster initiatives, both in tangible (i.e., financial) and less tangible (i.e., social) areas. In particular, an attempt was made to determine the extent to which there had been 'leverage' in that NRC investment had resulted in subsequent investments by other levels of government, the academic community and the private sector.

Overall, available data suggest that NRC's direct regional investment in the CIs from the years 2000-01 to 2007-08, totaling $342M, has resulted in the leverage of $330M additional dollars in investment over this

same period. Therefore, for every dollar spent in the CIs, almost an equivalent amount has been invested by other cluster actors in everything from infrastructure to research and development.

The significant finding is that in all cases the NRC investment in technology clustering has resulted in investment from other sources in support of the chosen technology area. The greatest degree of leverage has occurred in nanotechnology in Edmonton where the largest investments from partners have been made. The CI with the lowest level of total levered funds is Life Sciences, with roughly $6M levered against a $32M investment.

Sizeable investments have been made by provincial governments in six of the initiatives with smaller investments in a number of others. Other parts of the federal government are also shown to have been major contributors, such as in the Saguenay, where $25M was provided to help build the new Aluminium Technology Centre.

Although the evaluation did not attempt to assess the full investment in R&D by all cluster firms, it was able to determine the financial and in-kind contribution that is being made by firms in projects in which they are engaging with NRC. On average, 17 percent ($50M) of current leverage activity has emanated from the private sector. The Aluminium Transformation CI has the highest amount of levered funds from firms at $16M. The fuel cells and hydrogen technologies cluster also has a high proportion of firm-invested R&D, in keeping with the stage of development of the cluster.

When looking overall at research projects with the Institutes, on average for every dollar invested by NRC, collaborators have invested $4.40. In the case of NRC-IRAP, the investments made are estimated to have a leverage effect of engaging firms in investing at least 8 times the NRC contribution.

The investments being made by NRC in technology clusters across Canada are closely intertwined, not only with its other regular A-base activities, but with investments being made by other levels of government, as well as universities, NGOs and municipalities. As firms begin or continue to interact with NRC, and early stage government support for infrastructure development tapers, the proportion of leveraged activities from firms will likely grow.

Conclusion and Recommendations

Ongoing work on NRC's clustering activities is supported by the findings of the evaluation. Without exception, community-based participants in the evaluation study expressed a desire to see investments continue. However, given the complexity of clustering and the level of investment required to support cluster development and growth, support by multiple players must be consistent, focused and long-term. Failure to engage over a 15 to 20-year period, with a reasonable level of resources, will not generate growth. Early results from this portfolio evaluation have identified that the investments made by NRC in its technology cluster initiatives have served to distribute research capacity and innovation opportunity more broadly across Canada. The variety of research areas being targeted, the range of activities supported, and the size of the communities hosting such initiatives demonstrate the applicability of clustering strategies and initiatives to a wide range of conditions.

NRC's role in support of regional clusters NRC has revolved around its infrastructure, people and brand. NRC has demonstrated an ability to play a 'broker' and 'catalyst' role, while still allowing communities to self-direct. A future challenge for the organization will be to balance its clustering strategy with other national priorities.

Five recommendations were put forward as a result of the evaluation study with NRC management responses and proposed actions as follows:

> ***Recommendation 1:*** *In light of evolving conditions and any apparent constraints (e.g., changing regional priorities, evolving scientific priorities, regulatory environment, etc.), it is proposed that NRC review and either reaffirm or modify the focus of its initiatives in the following areas: fuel*

cell and hydrogen technologies; life sciences, and plants for health and wellness. Timeline: March 2009 - April 2010.

NRC Management Response Action Plan: Accepted. NRC will review the focus of the initiatives in the areas mentioned to ensure that their alignment is consistent with the needs of the cluster and the community. Timeline: March 2009 - April 2010.

Recommendation 2: *In light of the five year funding underlying this substantive investment for NRC (greater than 10% of total expenditures and affecting 11 of NRC's 19 Institutes), it is recommended that NRC assess, as part of any planned funding renewal, the risk associated with this investment. Strategies proposed as a result of this assessment should attempt to position relevant CIs as long-term activities and address issues such as staffing and capital assets.*

NRC Management Response Action Plan: Accepted. The risks associated with the five-year funding period are well-understood and recognized by NRC. In order to mitigate those risks, the funding renewal exercise will include every possible argument in favour of obtaining A-base funding for the clusters. For any ongoing B-base funding, I/P/Bs will be asked to include a specific view of cluster risks in their business plan. Timeline: March 2009 - April 2010.

Recommendation 3: *It is suggested that the management of technology cluster initiatives by NRC be undertaken in a more holistic and integrated approach across Institutes and Programs. It is recognized that in many instances, NRC cluster initiative activities are incremental to existing activities being undertaken by NRC. This is particularly the case for NRC-IOT, NRC-IMB, NRC-IBD, NRC-PBI and NRC-IFCI, and extends practically to all other delivery Institutes or programs, including NRC-IRAP and NRC-CISTI.*

An ideal state would be to integrate the strategy, planning, and oversight of any cluster development progress into regular ongoing NRC processes (e.g., NRC strategy development, business planning, evaluation plan, etc). These would continue to report on and monitor contributions in support of planned objectives.

NRC Management Response Action Plan: Accepted. NRC will work to integrate cluster activities into Institutes' and Programs' business plans and performance reports, recognizing the necessity of also reporting and monitoring the contributions specific to cluster initiatives. Timeline: Fall 2010.

Recommendation 4: *Review with NRC-IRAP and NRC Institutes engaged in clustering activities strategies for addressing the ongoing need for Information and Intelligence Services (IIS) (i.e., NICs and CTI products) in support of their regional cluster objectives given the impact of decisions surrounding the Strategic Review process.*

NRC Management Response Action Plan: Accepted. Given that as a result of the 2008 NRC Strategic Review decisions, the Competitive Technical Intelligence services formerly provided by NRC-CISTI will be concluded. The decision to acquire any information research and analysis services for the individual cluster initiatives will rest with the lead cluster initiative NRC Institute. Timeline: April 2010.

Recommendation 5: *Provide NRC researchers with the opportunity to learn about the purposes and goals associated with clustering. Adopt strategies that recognize and place value on interactions and projects with cluster firms or firms that are engaged in activities that are relevant to the technology focus of the cluster.*

NRC Management Response Action Plan: Accepted. NRC will examine ways of raising the awareness and understanding of cluster initiatives with employees. Also, when reviewing its formal incentive programs, NRC will give proper consideration to the issues surrounding awareness and understanding of clustering activities. Timeline: March 2011.

1.0 Introduction

1.1 Rationale for the Evaluation

An evaluation of the National Research Council's (NRC) technology cluster initiatives (CIs) is required to be completed prior to NRC's renewal of funding to support these investments. As the funding for the initiatives expires in fiscal year 2009-10, NRC's Senior Executive Committee approved the conduct of a Portfolio Evaluation of the NRC technology cluster initiatives in 2008-09.[2]

The evaluation was carried out in accordance with NRC's approved evaluation plan for 2008-09 and Treasury Board Secretariat (TBS) policies. The primary reasons for conducting an evaluation of the CIs include:

- To understand and assess the current relevance, impact and value-for money of the CIs;
- To provide NRC senior executives and managers with information that may contribute to improved results achievement in the future; and
- To provide input to decisions related to the overall CI portfolio and future strategy and investment.

As NRC approaches a renewal process for its initiatives in 2009-10, the Planning and Performance Management (PPM) Directorate, which houses NRC's evaluation function, was asked to conduct an evaluation of the consolidated cluster investment (i.e., the cluster initiative portfolio). The study was led by NRC's Planning and Performance Management Directorate. The work of the internal team was supplemented by key contributions by consultants from EKOS Research Associates, the Centre for Public Management, and Goss Gilroy Incorporated. The evaluation team also received academic support for the literature review conducted as part of the evaluation.

Although the initiatives were launched in three different phases, a decision was made by NRC to align the three rounds of funding to NRC's technology cluster initiatives under the same funding cycle. This, it was felt, would enable the Government of Canada to consider a consolidated national cluster program.

1.1.1 Overview of Previous Evaluation Activity

To date, evaluations of each of the original 12 initiatives have been conducted. Those evaluations focused on the first four to five years of program activity where the initiatives were intent on putting in place the infrastructure, people and relationships necessary to move to full delivery. The evaluation reports were approved and provided to Treasury Board as follows:

- Atlantic Initiatives (Round I) – 2004;
- Central and Western Initiatives (Round II) – 2006; and
- Sustainable Infrastructure and Nutrisciences and Health (Round III) – 2007.

1.1.2 Overview of Evaluation Scope

The evaluation focuses on examining relevance and performance achieved with the resources provided to NRC to support its cluster initiatives. These resources were first allocated in 2000-01 and will be

[2] The Terms of Reference for the Portfolio Evaluation of the NRC Technology Cluster Initiatives were approved by NRC's Senior Executive Committee on September 10, 2008.

provided until 2009-10. However, due to the timing of the evaluation, which was conducted in the fall and winter of 2008-09, the evaluation only addresses activities and performance from 2000-01 to 2007-08. As a result, all reporting of information, including financial, administrative and performance data, is for that period only. Further, as some initiatives began later than 2000-01, there is variability in the length of time for which data are reported by some of these. The evaluation scope for each of the initiatives covered by the evaluation is shown in Table 1, below.

Table 1: Period of Investment Covered by the Evaluation

Cluster Initiative Round	Cluster Initiative	Evaluation Data Scope
(Round I) Atlantic Initiatives	▪ Ocean Technology ▪ Wireless Systems* ▪ Life Sciences ▪ Information Technology/e-Business	2000-01 – 2007-08
(Round II) Central and Western Initiatives	▪ Aluminium Transformation ▪ Photonics ▪ Biomedical Technologies ▪ Plants for Health and Wellness ▪ Nanotechnology ▪ Fuel Cell and Hydrogen Technologies	2002-03 – 2007-08
(Round III)	▪ Sustainable Infrastructure ▪ Nutrisciences and Health	2003-04 – 2007-08

* Funded in Phase 1 only. No data available.

1.1.3 Overview of Evaluation Issues

Overarching evaluation issues are predicated largely by the Treasury Board (TB) Evaluation Policy. The evaluation of the CI portfolio is also framed by the expectations of the federal government's current Science and Technology Strategy, *Mobilizing Science and Technology to Canada's Advantage*.[3] Contributions by the cluster initiatives to the elements of the S&T Strategy were assessed. Additionally, results were assessed against NRC's own strategy, *Science at Work for Canada: A Strategy for the National Research Council*[4], as well as the framework within which the program functions, the *NRC Technology Cluster Initiatives: National Strategy for 2010* (Draft).[5] The key elements within each of the strategies pertinent for the evaluation are outlined in more detail in section 4.0 – Relevance of the NRC cluster initiatives.

Also contributing to the formulation of evaluation issues was the content of the Umbrella Results-based Management and Accountability Framework (RMAF), feedback from meetings with Directors General and the CI Network[6], and comments from members of the NRC Senior Executive Committee. Further, recent information provided by TBS on "*Core Issues in Assessing Value for Money in Evaluations*", as well as the 2008 Strategic Review Reporting Template, were used as reference points in identifying the evaluation issues. The core evaluation issues, which help to define the scope of the data to be collected and, ultimately, the areas where conclusions and recommendations will be presented, are outlined below.

Table 2: Core Evaluation Issues

Core Evaluation Issues
Relevance
R-1.0 Do the activities of the CI Portfolio align with government priorities? ▪ R-1.1 Do the Portfolio's activities align with the federal S&T Strategy?

[3] http://www.ic.gc.ca/epic/site/ic1.nsf/en/h_0085e.html
[4] http://www.nrc-cnrc.gc.ca/aboutUs/corporatereports/strategy/strategy_e.html
[5] NRC Technology Cluster Initiatives: National Strategy to 2010 (Draft). NRC Corporate Policy and Strategy. November 2007.
[6] The CI Network is a made up of representatives from each of the CIs, and includes institutes, NRC-IRAP and NRC-CISTI, as well as Technology Cluster Secretariat staff and representatives from NRC's Strategy Development Branch.

Core Evaluation Issues
R-2.0 Is delivery of the CIs by NRC consistent with Federal roles and responsibilities? ▪ R-2.1 Has NRC's role evolved?
R-3.0 Is there a continued need for cluster initiatives support? ▪ R-3.1 What have been the core strengths and weaknesses of NRC's CI Portfolio? ▪ R-3.2 What opportunities exist for NRC and government going forward? (Recommendations)
Impact Performance
IP-1.0 Have expected CI portfolio outcomes been achieved? ▪ IP1.1 Are the CIs developing along the cluster lifecycle[7]?
Impact Performance - Immediate Outcomes
▪ IPIO-1.2Have the CIs supported the development of leading-edge knowledge?
▪ IPIO-1.3 Have the CIs supported the development of Highly Qualified Personnel?
▪ IPIO-1.4 Have the CIs supported the development of specialized infrastructure?
▪ IPIO-1.5 Have the CIs supported the development of innovative firms and industries?
▪ IPIO-1.6 Have the CIs fostered the development of cluster support services?
▪ IPIO-1.7 Have the CIs supported cluster networking and integration?
▪ IPIO-1.8 Have the CIs resulted in community commitment to cluster development?
Value for Money
VFM-1.0 Have CI resources been used in an economic manner?
▪ VFM-1.1 What resources have been contributed to support cluster growth?
▪ VFM-2.0 Have CI Portfolio outcomes been achieved in an efficient manner?
▪ VFM-2.1 What measures has NRC taken to reduce the costs of delivering the CIs?

1.2 Summary of the Methodology

The methodology developed for this evaluation included multiple lines of evidence, as is standard practice in evaluation, and was based on the specific evaluation issues identified previously. Two important issues were taken into consideration in the evaluation design. First, a number of the initiatives have recently been the subject of both a measurement study and an evaluation. There was a desire to limit the burden placed on cluster initiatives where feasible and not to repeat evaluative research already completed.

Secondly, although the evaluation would normally focus on impact, or summative issues, it is generally recognized that cluster building is a long-term process. With only two to three years of activities stemming beyond the implementation phase, impact expectations need to be tempered with the reality that seeing results in terms of cluster development requires time and an appropriate mix of enabling factors that facilitate cluster growth.

The evaluation methods used to address the issues are the following:

- **Financial, administrative and performance data review:** The portfolio evaluation included a review of NRC financial, administrative and performance data, as well as the collection and use of other secondary data available from external sources. For instance, a complete financial profile of the NRC cluster initiative investments was produced and updated at the end of 2008-09. Further, CIs participated in a data collection exercise focusing on program outputs from approximately 2000-01 to 2007-08, depending upon the start date of the initiative. Refer to Section 1.3.2 below for information

[7] See model proposed by Andersson et al. 2004 and adapted model developed by Hickling, Arthurs, and low (HAL) AL in Cluster Studies for NRC Technology Cluster Initiatives, August 23, 2006.

on the limitations of these data. This information was used to both assess the CI portfolio's achievement of planned immediate and intermediate outcomes and, to the extent feasible, to assess changes within individual clusters at various stages of development.

- **Document and other reviews:** As part of any evaluation, internal and external document review remains a primary means of obtaining information. Documents reviewed included Cabinet and Treasury Board documents pertaining to the CIs, performance measurement frameworks, previously completed evaluation reports, CI business cases, and other documents. In addition to this general review, two specific review activities were also undertaken as part of the evaluation:

  - *Review of the Role of Public Sector R&D Organizations in Clusters and Cluster Policy:* This review examined the appropriateness of the role of organizations similar to NRC in cluster policies and initiatives in a selection of countries. This study was completed both through document and literature reviews, as well as a limited number of interviews. Interviews were conducted with policy makers or the authors of studies who have examined similar issues in their country.

  - *Review of the Factors that Influence the Growth of Knowledge-Based Clusters:* This literature review involved approximately 40 documents published between 1998 and 2008 and identified the twelve most prevalent factors thought to influence the growth of knowledge-based clusters.

- **Cluster community discussion groups:** The views of external stakeholders were captured in part through the use of discussion groups held in all eleven communities where CIs were implemented. The purpose of these sessions was to generate discussion on the outcomes achieved in each cluster and to identify the contribution of NRC to these outcomes. These discussions were supplemented by a brief qualitative instrument completed on-site by the participants. The sessions were moderated by external consultants and attended by one evaluation team member. In total, 95 individuals participated in the discussion groups, with the highest proportion (37 percent) affiliated with industry. Other participants represented community associations, other government departments and agencies, universities, and other stakeholder groups.

- **Internal discussion groups:** In order to reach as many CI staff members as possible, internal discussion sessions were also held in each of the eleven regions. In total 99 individuals from NRC participated in these sessions.

- **Cluster initiatives leverage analysis:** NRC was asked by central agencies (i.e., Finance Canada, TBS) to define the *leverage effects* of NRC's investment in technology clustering and assess the contributions made by other cluster actors to the clustering effort, in addition to resources expended by the private sector and other organizations in support of scientific innovation. The purpose of the leverage analysis was therefore to address issues of value for money and overall progress of the CIs. The work consisted primarily of identifying direct and indirect investments made to NRC or the technology area being addressed by the cluster. These might have been made by partner organizations, firms or universities and others participating in collaborative research, firms in NRC-IRAP supported R&D, etc. The analysis also tried to identify and account for external investments made that support cluster growth, including investments made to universities to support the technology area, investments in provincial or regional strategies, etc.

- **Case studies:** Six case studies were conducted in order to capture the essence of some of the impacts of the work of various CIs and illustrate these through concrete examples. The themes for the cases were derived from the evaluation issues noted in Table 2, above, as well as from the RMAF. Themes included: the development of leading-edge knowledge; the development of highly qualified people (HQP); the development of specialized infrastructure; the development of innovative firms and

industries; the development of cluster support services; the cluster networking and integration, and community commitment to cluster development.

- The development of each case study involved a review of relevant documents (including the analysis of administrative data) as well as a number of key informant interviews.

- **Targeted interviews:** Fifty-two interviews were conducted with both internal (32) and external stakeholders (20) to supplement the data collected through the other lines of evidence. The interviews were conducted following the group discussion sessions and focused on similar issues as those raised in these sessions.

An in-depth presentation of each of the evaluation methods as well as copies of all the data collection instruments used in this study are available in the Technical Report prepared for the evaluation.

1.3 Evaluation Limitations and Challenges

Although in some instances, each method and sub-project identified as part of the Portfolio Evaluation presents its own unique set of challenges and opportunities, the overall evaluation faced certain limitations as outlined below.

1.3.1 Challenges and Limitations Due to the Nature of Innovation Systems

- **Attribution of changes within the cluster to the CI** – NRC's clustering activities are generally only one component of a series of activities or efforts that have been implemented to support the development of a cluster in a community or region. Given that there are no instances where clusters develop in isolation of their environment, there are limits to the level of control or degree of impact that NRC has on a cluster's development, particularly as time passes or the area of impact is more distant from NRC activities. In an ideal situation, an evaluation would be able to measure a number of changes in the innovation system, particularly changes at the firm level, and attribute these to NRC's funding. This ideal exceeds the capacity of NRC at this time.

- **Variability in the evolution and development of industries and economic sectors** – It is recognized that the evolution of any potential cluster will likely vary in relation to the type of industry or sector (and therefore technology) that is being targeted. Some of the areas in which NRC has invested (e.g., life sciences in Nova Scotia) have a relatively long commercialization timeline due to regulatory requirements and other aspects of the research work, whereas in other cases, such as information technology, the commercialization timeline tends to be shorter. Similarly, given that in the area of photonics NRC is working with firms who are closer to the end of the innovation spectrum (pre-commercial to commercial levels), expectations in terms of results achieved over the cluster funding period vary between initiatives.

1.3.2 Challenges and Limitations Due to the Scope of Elements Being Evaluated

- **Evaluating eleven relatively distinct initiatives –** For the most part, the funding size and nature of the cluster initiatives are highly variable. For instance, the NRC Canadian Photonics Fabrication Centre (NRC-CPFC) supports many different types of firms and the academic community on a fee-for-service basis. Conversely, the NRC Institute for Biodiagnostics (NRC-IBD) used its clustering resources to support the construction of an Industrial Partnership Facility, known as the Centre for the Commercialization of Biomedical Technology (NRC-CCBT). Other investments have been used to establish at least a portion of full-fledged research Institutes (i.e., the National Institute for Nanotechnology and the NRC Institute for Information Technology). The variability in type of initiative is supported by variability in funding, where amounts provided range from $2M/year to $12M/year.

- **Variable funding periods and stages of development –** With three phases of funding starting at different periods in time and the variability in the nature and size of initiatives, presenting evaluation results that are responsive to all of these variables is challenging. Particularly, as cluster development is long-term (estimated in the literature at 15 to 20 years), and the evaluation is occurring at a still early stage for most of the initiatives (the longest funding period at the time of evaluation will be approximately eight years and the shortest five), the potential of observing even intermediate level outcomes is limited.

- **Data and measurement –** Measurement has been an evolving process for the CIs and the capacity to provide information has improved. However early, and even current, data are difficult for some initiatives to segregate and report. Further, with such a variety of initiatives, funded over different years and lengths of time, aligning available data poses certain challenges. Although the evaluation is not meant as a comparative study, some contrasting is necessary. As a result, the approach taken has been to align, in some cases, data according to 'years of implementation' rather than calendar year. This allows the CIs to be more easily contrasted, although it does not address other issues such as the scope and size of investment in the initiatives. These issues are addressed contextually throughout the evaluation report as needed.

  To ensure consistency, much of the analysis done in the report is based upon figures up to and including 2007-08 only. These were the most recent data available at the time of the evaluation fieldwork and analysis.

- **Cluster 'ring' delimitations –** Defining what constitutes the geographic elements of the cluster, as well as simply whether all of these initiatives should be measured in terms of ongoing geographic impact, are issues that NRC and the initiatives continue to debate. Some initiatives consider their cluster impact parameters to extend beyond the geography of their census metropolitan area to encompass an entire province or region. In some instances, initiatives question whether they should pursue relationships with firms and organizations outside of their general cluster vicinity, or whether credit will be given to these efforts.

1.3.3 General Challenges and Limitations to the Evaluation Project

- **Purpose of the evaluation –** The evaluation follows on the footsteps of a series of early stage evaluations already conducted on each initiative. The current work seeks to summarize, for the complete investment of approximately $550M, its performance against stated objectives. This represents a fairly significant task given the complexities of evaluating cluster evolution based on program intervention. Examples of such types of evaluation are limited.

- **Timelines and resources to conduct the study –** The evaluation had to be completed in a short timeframe (approximately 8 months) in order for delivery to NRC Council and for consideration by NRC as part of its renewal process for the cluster initiatives. The timeline represents a very tight turnaround for such a complex and significant investment by NRC where performance is judged not only on the activities and outputs by NRC, but also on the incremental impact that these have on a particular technology area in a geographic region.

1.4 Organization of the Report

The next two sections provide background for this evaluation. Section 2.0 provides an overview of clustering and cluster theory. This is important contextual information for the evaluation. Section 3.0 then profiles NRC's investments and activities in technology clustering. The next four sections focus on the major evaluation issues. Section 4.0 addresses issues of program relevance, by considering alignment with government priorities and the appropriateness of a publicly funded organization, such as NRC, in cluster development.

Issues of program effectiveness of delivery and governance, as well as effectiveness and performance with respect to predetermined RMAF objectives are examined in section 5.0. The ‘leverage’ effects of the cluster initiatives are discussed in section 6.0, following by a summary of the effectiveness and performance of individual cluster initiatives in section 7.0. General evaluation conclusions are outlined in section 8.0 with the management response in section 9.0.

Throughout the report are found numerous tables that include information on the eleven CIs. In these tables, CIs are listed geographically, from east to west with NRC-CISTI and NRC-IRAP listed at the end if appropriate.

2.0 Cluster Theory Overview

Before delving into the results of the evaluation, the complexity of the subject of clusters, cluster policies and strategies, and cluster development and the factors that affect it, bear some discussion. Some background on cluster and related concepts are provided, followed by an overview of cluster evolution and growth theory.

2.1 Cluster Concepts and Evolution

The regional agglomerations of industrial firms have been characterized using numerous concepts. Industrial districts and growth poles were among the first to capture the imagination of scientists and policymakers. It was in the 1920's that Alfred Marshall, a social scientist, noticed the geographical agglomeration of companies operating in the same industry. He attributed the phenomenon to the accumulation of knowledge in the area, the formation of a specialized labour pool, as well as to the attraction of support and supplier industries. He coined the term "*industrial district*" to refer to such geographical concentrations of firms and related industries.[8]

A later concept, one of growth poles, was introduced in France in the 1970s in reference to geographical agglomerations of industry that take place through the activities of one or a few large companies. These companies may be large system integrators that attract suppliers of parts and components, or producers of essential inputs. The concept was widely adopted in Western Europe where governments tried to build automobile, chemical or aerospace poles by attracting - often by subsidizing - large corporations to specific regions. In such poles, firms were linked together by the regional trade of parts, materials and components.

In the 1990s, an interest in the geographic component of industry was revived. Nobel Prize recipient Paul Krugman wrote that *"the geographic concentration of production is clear evidence of the pervasive influence of some kind of increasing returns."*[9] Under such conditions, regions may be interested in implementing policies that nurture increasing returns industries in specific locations. Krugman's analysis provided theoretical justification for regional science, technology and innovation (STI) policies.

The discussion on economic development took a new path when it was suggested that institutions were the key factor of economic growth. Some argued that property institutions and the rule of law were particularly important in this growth, while others suggested that only science, technology and innovation institutions mattered for economic development. It was suggested that what really mattered for economic development was the quality of institutions such as universities, government R&D laboratories, and STI policies that produce human capital, create demand for such capital, generate new scientific and technical knowledge, and modify the behaviour of private firms in order to insufflate innovative activities in them through R&D incentives. This thinking produced the concept of national systems of innovation (NSI), defined as *"the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies."*[10]

The NSI has helped to incubate the concept of regional systems of innovation (RSI). An RSI is a set of companies and institutions that interact in the production of science and technology in particular industries.

[8] Marshall, A. Principles of Economics, London, Macmillan (Eighth edition). 1920.
[9] Krugman, P. Geography and Trade, Cambridge, MIT Press. 1991.
[10] Freeman, C. Technology Policy and Economic Performance, London, Pinter. 1987.

> *Regions which possess the full panoply of innovation organizations set in an institutional milieu, where systemic linkage and interactive communication among the innovation actors is normal, approach the designation of regional innovation systems. (Cooke and Morgan, 1998: 71)*

It has been suggested that such systems are not homogeneous and that their geographic contour is often vague. An RSI is usually a set of interrelated clusters, where public research institutions and organizations play a key role. Regional innovation systems are thus more easily found in metropolitan areas rather than in smaller, more specialized cities.

Michael Porter jumped on this new current in the late 1980's and early 1990s. His definition of industrial clusters resembles the earlier noted industrial districts. According to Porter, clusters are:

> *Geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions… in particular fields that compete but also cooperate.*[11]

Porter suggested that clusters enhance productivity by attracting or creating common support industries, training programs, infrastructure and business services. Local rivalry also contributes to increase productivity. Clusters make it simpler to compare performance among competitors, to monitor supplier costs, and to attract specialized labour.

The role of government, in Porter's theory, is one of networking, support provider and facilitator. In his view, governments do not choose clusters nor start them from scratch. In a report titled *Clusters of Innovation*, he acknowledges that government centres have a role in clusters but does not elaborate further on the specifics of such a role.

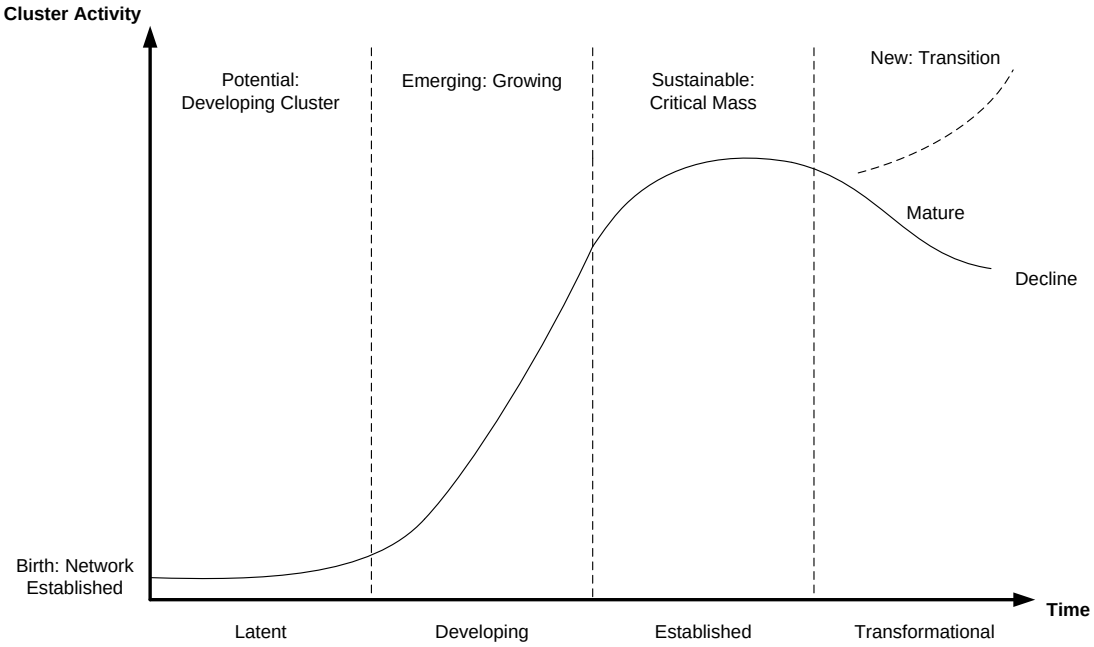
2.1.1 Cluster Lifecycle Theory

In 2004, as part of its first set of formative evaluations of technology clusters in Atlantic Canada, NRC adopted the use of a Technology Cluster Lifecycle Model.[12] The use of such a model is helpful in pinpointing the stage at which a cluster is believed to be functioning. An evolved model, shown below, details the generation, development, and implementation of ideas as interactive processes that evolve as an S-curve over time. Cluster development begins with a slow early-stage gestation period, accelerates as the number of firms grows and interactions strengthen, and then levels off as the technology matures (indicating that renewal is needed to avoid decline). This pattern, or lifecycle, is observed at the level of the cluster as well as at the level of the firm.

The cluster lifecycle model adopted by NRC identifies four stages of cluster development, which are identified in Figure 1, below.

[11] Porter, M. E., Cluster and Competition: New Agendas for Companies, Governments, and Institutions, 1998, p. 3.
[12] White, Kenneth and P. Gunther, *Knowledge Intensive Clusters: The Problematic*, Industry Canada, 2003.

Figure 1: Cluster Life Cycle Model



The lifecycle presented here can be described using the following stages:

- **Latent –** Characterized by a small number of firms and other actors within a given region that begin to cooperate around a core activity/focus and realize common opportunities through largely local and informal linkages. The dynamic of the cluster is often triggered by one or more actors with a lasting vision for a new local technological path, and the on-going support of champions. Typically, a critical mass of firms does not yet exist, and cluster funding is primarily drawn from public sources. Emphasis at this stage is on knowledge creation and diffusion among actors within the cluster. Firms are not yet generating substantial commercial results, or accessing private capital.

- **Developing –** Clusters are stimulated by an increase in entrepreneurial activity which attracts new actors from within or outside the region. New collaborations emerge through open and flexible formal and informal networks. Cluster organizations are established, new firms are created through spin-offs or start-ups, and there is labour mobility within the cluster. The cluster is dependent on the continued existence of a pool of skilled workers, as well as access to incubator and innovation assistance in order to support the growth of firms. Emphasis at this stage is on the transformation of knowledge into products/processes, which is supported by a balance between public and private R&D funding. An increasingly international focus on markets and commercialization emerges, as may a label and common promotional activities for the region.

- **Established –** Characterized by an internal dynamic of new firm creation resulting in continued growth in number of firms and employees, which arrives at a certain critical mass, then slows, declines or consolidates as the cluster matures. Networks become more formalized and strategic, and relations outside of the cluster are strengthened, which brings in new knowledge and keeps the networks open. Labour mobility within the cluster continues, and the thematic boundaries of the cluster adjust as new technologies are added. The cluster is primarily supported by private R&D investments (e.g., banks, IPO), as well as its own returns, and the focus at this stage is on economic success and market expansion.

- **Transformational –** Clusters are beginning to change with their markets, technologies and processes. Transformation may be through changes in the products and methods, or firms may move out and form new clusters focused on new activities. The cluster is characterized by a decreasing number of firms and employment, and its renewal is dependent on continued development and mobilization of HQP, continued renewal and expansion of cluster networks, the creation of new modes of interaction and integration of external knowledge, and the ability to adapt its technological trajectory to knowledge and market shifts as well as technological discontinuities. The cluster is still primarily supported by private R&D investments, and its commercial margins are shrinking. The focus at this stage is on survival and renewal, which may involve the intervention of government.

2.2 Factors Affecting Cluster Growth

It is understood that the evaluation of the impact of clustering policies, strategies or initiatives (i.e., a set of activities implemented in order to support cluster development and growth) requires some 'grounding' in terms of the precepts upon which a 'successful' initiative can be identified. It is hypothesized that an NRC cluster initiative would support the development of a technology community along the cluster lifecycle.

In support of this grounding, an extensive literature review was undertaken to help identify the main factors in place when a cluster was deemed to be successful and progressing along the cluster lifecycle. Following a review of approximately 40 documents published between 1998 and 2008, the most prevalent factors that influence knowledge-based cluster growth were identified. According to the literature, the 12 factors presented below are deemed as being fundamental to the growth of knowledge-based clusters. Although the literature identifies additional factors, the ones presented here are those that are most frequently cited. These are thought to be the factors that must normally be present in order for a cluster to exist and to progress over time.

- **Skilled workforce –** A highly talented, specialized and skilled workforce represents a key source of knowledge and innovation. Successful clusters are able to access and nurture a strong skills base both at the level of management and of specialized labour, which is a key factor in attraction and retention of firms as well as their continued development within the cluster.

- **Specialized training and educational infrastructure –** The availability of a steady supply of highly skilled workers is tied to the existence of post-secondary institutions, R&D laboratories and other knowledge infrastructure and expertise within the region. Such infrastructure serves to build and attract talent and companies, helps drive innovation, and acts as a magnet around which clusters form.

- **Innovative technology and technological transfer –** Innovation maintains the cluster at the forefront of the market. While a strong R&D base provides for ideas/products and helps foster commercialization, clusters by their very nature create environments conducive to the technology and people-based transfer of innovation and knowledge critical to the success of dynamic clusters.

- **Networking –** Open, flexible and purposeful networks sustain the flows of knowledge and information that help support strong interdependence, collective learning and competitive performance of the cluster. Successful networks are supported by close social interactions and by the encouragement of trust and informal relationships among actors. The capacity of firms to form, manage and maintain such linkages and to build and sustain their social capital is fundamental to cluster success.

- **Cluster animator –** Individual champions, community-level associations/institutions and public organizations can serve to facilitate and animate the development of the cluster. Amongst other things, they can facilitate co-operation, collaboration and networking among cluster actors; act as cluster "*drivers*" or network brokers between sectors and individual interests; support the mobilization

of cluster resources; facilitate the recruitment of companies into the region; lobby on behalf of business interests; etc.

- **External knowledge sources (global pipeline) –** The ability of clusters to extend beyond their internal knowledge channels following the early stages of cluster development helps safeguard against insularity and the inability to respond to new ideas/innovations. Successful clusters foster high-performing networks and effectively adapt their networking strategies from local to global connectivity, and/or heighten their critical mass through consolidation with proximal clusters.

- **Business support services –** These specialized legal, accounting, financial and other business services facilitate the performance of firms and can also support the successful development of the cluster. Services can include support for new business start-ups and spin-outs; ICT support or grant assistance; management and production advice; business planning; marketing and market intelligence; networking assistance; etc.

- **Leadership –** While the quality and nature of leadership within a firm helps differentiate it from its competition, the scope and influence of leadership at the cluster and/or community level supports the collective interests and needs across firms – fostering a collaborative advantage through stakeholder interaction, mutual awareness and shared vision at the local level. Amongst other things, leaders help overcome obstacles, enhance collaboration, develop vision and champion strategies. Private sector leadership, coupled with active government participation, is noted as a success factor for cluster development.

- **Anchor organization –** Anchor organizations play an important role in the emergence, growth and further development of clusters. Such organizations can act as local magnets, attracting firms and talent to a region. In addition, anchor organizations support the development of the early talent base and the steady flow of trained personnel and experienced managers. They also act as repositories of technology, markets and expertise, and support the strong network of knowledge and technology exchange that are critical to cluster success.

- **Risk capital –** The availability of continuing R&D investment is an important factor in the successful growth and expansion of cluster-related activities. The ability of firms and clusters to access such funding, the proximity to financial institutions and intermediaries, and the ability to build informal or formal relationships with the investment community are seen as positive factors in the development of clusters.

- **Government support –** Provincial and national policies, institutional frameworks, regulations, and various forms of R&D support play an important role in the success of clusters. Governments play a leading role in building the knowledge infrastructure (universities, colleges, government laboratories, etc.) that supports clusters in producing technology assets for regions. A stable macro-economic environment at the national level is also seen as a positive factor in the development of clusters.

- **Cluster brand –** A clear brand is noted as being a critical factor in strengthening the competitiveness of a cluster. A brand serves to strengthen the ability of the cluster to attract investments, venture capital, skilled workers, etc. A brand can also help cluster actors to come together under a shared vision, purpose and identity. A cluster brand can be supported by public sector involvement whereby the brand is communicated to a wider audience.

These factors have been taken into consideration when drawing conclusions about the impact of NRC's activities in support of cluster growth, as well as the overall strength of a given cluster. An assessment of the current strength of the clusters in which the CIs have been launched is provided in section 8.0.

3.0 PROFILE OF THE NRC TECHNOLOGY CLUSTER INITIATIVES

3.1 NRC Cluster Portfolio Program Profile

Following on the thinking of Porter and others espousing clusters as a means of regional and economic development, in 2000-01 NRC began a series of investments in what it then called Regional Innovation Initiatives. These Initiatives were identified as being ones that would support the establishment of regionally-based innovation clusters, with NRC's participation and investment, along with those of collaborating organizations, acting as a catalyst towards the longer-term growth of technology clusters in selected regions and technologies.

Figure 2: Elements of Cluster Success

At the time, the conceptual model adopted by NRC positioned firms clearly as the major beneficiary of various coordinated elements. Figure 2, to the right, shows the elements recognized as being key to cluster success. NRC felt that it could play a role in almost all of these areas, with the one exception perhaps being policy and regulation.

The general objectives for NRC's technology clustering activities have been outlined in a variety of documents. A number of results-based management and accountability frameworks (RMAFs), which detail the initiatives' objectives, have been drafted, with a most recent framework having been agreed to in 2008. This Umbrella RMAF forms the basis upon which the current understanding of the activities and outputs, and immediate, intermediate and long-term outcomes is drawn. The logic model contained in that RMAF is provided in Figure 3. The emergence of "*Globally competitive Canadian clusters of technology based companies*" is identified as the strategic vision for these initiatives.

The development of clusters occurs over a number of years, typically taking from 15 to 20 years for a cluster to reach its full potential. Supporting organizations, such as NRC, play various roles by focusing on a variety of activities throughout the development of a cluster. The various roles are also detailed in the logic model.

Each NRC cluster initiative is led by an NRC Institute that may work with NRC-IRAP, NRC-CISTI and other actors to facilitate technology cluster development. The NRC Industrial Research Assistance Program (NRC-IRAP) and the Canada Institute for Scientific and Technical Information (NRC-CISTI) support technology cluster development through the provision of support and access to specialized knowledge and information.

NRC-IRAP supports cluster networking and the development of cluster capacity (e.g., it supports organizations that provide services in support of firms and also supports delivery of competitive technical intelligence by NRC-CISTI), and it provides technical and business advice as well as financing to SMEs to increase their innovation capabilities.

Figure 3: **Cluster Initiative Logic Model**

Outcomes	Planned Results
Proposed Strategic Vision	*Globally competitive Canadian clusters of technology based companies.*
Long term Outcomes	▪ Canadians reap the benefits of competitive industries ▪ Canadian firms in the clusters develop and export world leading products / processes / services ▪ International recognition among peers ('Silicon Valley North')
Intermediate Outcomes	▪ Increased investment in strategic R&D / increased community research activity with NRC ▪ Canadian firms develop and commercialize advanced technology solutions that address national priorities and issues ▪ Improved standards, regulatory climate and policies ▪ Attraction of national and international investment (capital and HQP)
Immediate Outcomes	*Supporting the development of leading-edge knowledge, people, and specialized infrastructure* ▪ Increase in supply of HQP from colleges, universities and technical institutes. ▪ Development of HQP (training, graduates, Post Doctoral Fellows) ▪ Greater use of NRC research facilities, technology platforms, expertise, knowledge and information transfer tools by cluster members *Supporting the development of innovative firms and industries* ▪ Growing presence of innovative firms in the cluster regions ▪ Growing use of technology / commercial development (e.g., effective technology transfer/new products and services on the market, increase in marketable IP that is used by Canadian companies, highly visible demonstrations of cluster technology) *Fostering the development of cluster support services* ▪ Growing presence of business support services / suppliers ▪ Improved tech transfer support climate and access to technology knowledge and information transfer tools *Supporting cluster networking and integration* ▪ Regional jurisdictional engagement (provincial, municipal, etc.) in community cluster development ▪ Increased cooperation / collaboration among cluster members ▪ Recognition and understanding of the roles of NRC and its partners in the cluster ▪ Community commitment to cluster development
NRC Programs **Activities and Outputs** (NRC Control)	▪ Provide access to research / testing facilities ▪ Undertake R&D, testing, demonstration ▪ Attract / hire / train HQP (NRC HQP and HQP from universities, industry, colleges) ▪ Provide entrepreneurship support ▪ Liaise / network with cluster members, national and international organizations and networks ▪ Provide advice, mentoring support, cluster capacity support and seed funding (e.g., NRC-IRAP) ▪ Delivery of information and competitive intelligence services and digital content (e.g., NRC-CISTI) ▪ MOUs, agreements for collaboration and joint initiatives, R&D and related contracts, funding agreements (IRAP), CTI reports, licenses to occupy space ▪ Publications, patents, licences, technologies, technical reports ▪ Strategies, plans, roadmaps etc that reflect knowledge of the cluster
Resources:	Resources used: dollars spent, number and types of staff involved, dedicated time. Stable, long-term resourcing.

NRC-CISTI's role varies among the initiatives but it has developed a role whereby it delivers to cluster stakeholders a variety of information and intelligence services.

The ultimate primary and direct clients, based on both intermediate and long-term outcomes for NRC's activities, are Canadian small and medium enterprises (SMEs). However, indirectly, the CIs' activities

may be directed at a wide variety of other client groups with the long-term objective of positively affecting firms. These groups include:

- Researchers (both internal and external to NRC);
- Students;
- Universities, colleges and other learning institutions;
- Other government departments;
- Investment organizations; and
- Business support organizations.

The initiatives in which NRC has made investments are outlined in Table 3, below and on the following page. At least one initiative was launched in each of Canada's ten provinces.

Table 3: Overview of the NRC Technology Cluster Initiatives

Regional Cluster Focus	Cluster Focus Core Initiative Investment Activity	Initiative Location	Lead Delivery Institute/ Organizations
Ocean Technology	Construction of an IPF and expansion of core research programs at NRC-IOT in the area of ocean technologies.	St. John's, Newfoundland	Institute for Ocean Technology (NRC-IOT)
Wireless Systems	Establishment of research capacity to support the development of wireless technologies.	Sydney (Cape Breton), Nova Scotia)	Institute for Information Technology (NRC-IIT)
Biosciences	Establishment of the Institute for Nutrisciences and Health (NRC-INH).	Charlottetown, Prince-Edward Island	Institute for Marine Biosciences (NRC-IMB)
Life Sciences	Expansion of scientific activities at NRC-IMB in the area of genomics, proteomics, bioinformatics and advanced imaging. Additional IPF facilities.	Halifax, Nova Scotia	Institute for Marine Biosciences (NRC-IMB) Institute for Biodiagnostics (NRC-IBD)
Information Technology/ e-Business	Construction of a new NRC research facility and Industry Partnership Facility (IPF). Establishment of research capacity in the areas of human web; internet logic; and e-government/e-citizen; e-learning; and e-health.	Fredericton, Moncton and Saint John, New Brunswick	Institute for Information Technology (NRC-IIT)
Aluminum	Construction of the Aluminum Technology Centre (NRC-ATC) and establishment of research programs.	Chicoutimi (Saguenay Region),Quebec	Industrial Materials Institute (NRC-IMI)
Photonics	Construction of the Canadian Photonics Fabrication Centre (NRC-CPFC).	Ottawa, Ontario	Institute for Microstructural Sciences (NRC-IMS)
Biomedical	Construction of an IPF and creation of the Centre for the Commercialization of Biomedical Technology (NRC-CCBT).	Winnipeg, Manitoba	Institute for Biodiagnostics (NRC-IBD)
Sustainable Infrastructure	Establishment of the Centre for Sustainable Infrastructure Research (NRC-CSIR).	Regina, Saskatchewan	Institute for Research in Construction (NRC-IRC)
Functional Foods and Nutraceuticals	Initiation of the Crops for Enhanced Human Health research program (CEHH). Later renamed Plants for Health and Wellness.	Saskatoon, Saskatchewan	Plant Biotechnology Institute (NRC-PBI)
Nanotechnology	Creation of the National Institute for Nanotechnology (NINT)	Edmonton, Alberta	NRC, University of Alberta and the Government of Alberta
Fuel Cell and Hydrogen Technologies	Reorientation of the NRC Innovation Centre and creation of the Institute for Fuel Cell Innovation (NRC-IFCI).	Vancouver, British Columbia	Institute for Fuel Cell Innovation (NRC-IFCI)

3.1.1 Rationale for the Introduction of Cluster Initiatives at NRC

As described in section 2.0, research and literature on growth theory and regional innovation systems, spurred on by the writings of Michael Porter, gained increasing attention throughout the 1990s as economies looked for the next generation of means to retain global competitive advantage. Following through on these 'cluster' concepts, NRC proposed to the Canadian government the introduction of cluster oriented initiatives as a means of developing regionally based technology innovation hubs in order to better help Canada participate in the knowledge-based economy. This supported the overall goals of developing a highly skilled Canadian workforce, diversifying the Canadian economy and improving the ability of Canadian firms to innovate and thus compete on an international scale.

A focus on regional innovation system building in the US, and increasingly in Europe and Southeast Asia, had proven successful for these countries. The suggestion was made to government that there were means to jump start and accelerate regional innovation system development, and address Canada's widening productivity gap, through focused public interventions in R&D. NRC proposed that it was well positioned to deliver such interventions. The Council also based its positioning on the achievements of some of its pre-existing Institutes, such as the Plant Biotechnology Institute (NRC-PBI) in Saskatoon, which had already been recognized as a pivotal institution in the development of the ag-bio/ bio-science cluster in that city, and the work of the NRC Biotechnology Research Institute (NRC-BRI) in Montreal, which has had a long-standing history of supporting the biotechnology/life sciences sector in the region.

NRC's positioning was also based on the fact that it had a national reach through its R&D presence in most provinces (with the exception of New Brunswick, Prince Edward Island and Alberta), and a presence in 80 communities under NRC-IRAP. It also argued that it had extensive linkages with other government departments (OGDs) and universities, and that it had existing ties to industry and understood the business of technology development and transfer, which the cluster initiatives enable further.

3.1.2 Cluster Focus and Technological Orientation

Despite the optimism underlying cluster theory, one of the tasks faced by NRC was to identify potential technology areas for targeted regions. For some of these, full-fledged clusters with a substantive private sector presence were not present, or were in a latent stage. In others, there was a conglomerate of firms where there was either a fully recognized cluster, or the cluster was unorganized or experiencing a period of transition.

Initiatives were first launched in Atlantic Canada in 2000-01 following regional consultations on priority areas. As a result, the following foci were determined:

- **St. John's, Newfoundland –** With an existing NRC presence through NRC-IOT with a focus on ocean engineering and ocean resources, ocean technology was identified by stakeholders as a natural orientation. A good number of firms were already engaged in related activities.

- **Halifax, Nova Scotia –** NRC's activities in Halifax were limited to NRC-IMB prior to the launch of a cluster initiative in 2000-01. At the time the Institute was focused on aquaculture and genomics. However, with a focus on life sciences by the Halifax community, NRC-IMB reoriented its activities to support local directions. Further, NRC increased its presence in the region through NRC-IBD's establishment of a satellite laboratory in support of the Brain Repair Centre in Halifax. The Centre supports neurological research, also identified as a regional priority.

- **Fredericton, Moncton and St. John, New Brunswick –** Looking to diversify its economy, New Brunswick (NB) had begun to invest in information and communication technologies (ICT) in the late 1980's. The Province and firms such as NBTel had spearheaded this activity. By 2000, an estimated 200 small and locally owned ICT-oriented firms could be identified. For NB, which had prided itself as being at the leading edge of ICT adoption through its 'first to the post' government on-line initiatives, a focus on e-business and information technology was a natural fit.

- **Sydney (Cape Breton), Nova Scotia –** With a serious need for development support, Cape Breton looked at a variety of opportunities for economic enhancement. Out of consultations emerged a focus on wireless technologies, perhaps aligned to a regional economic development focus on information technology. No substantive base of firms or technology was present at the time and as a result the initiative was terminated in 2005.

A second series of investments were proposed with funding beginning in 2002-03. Under the rubric of Regional Innovation/National Innovation Infrastructure Initiatives, six technology cluster orientations are relevant to the evaluation.

- **Chicoutimi (Saguenay), Quebec –** Although a world leader in the production of aluminium, Canada's performance and competitiveness in its transformation into value-added products is weak. With Alcan positioned in the Saguenay and facing political pressure to sustain regional employment, and a range of smaller firms engaged in activities related to aluminium production, opportunities were sought to enhance regional potential. Aluminium transformation was selected as a cluster orientation.

- **Ottawa, Ontario –** On the strength of the already internationally recognized ICT cluster based in Ottawa, a need was identified for precise support to the related and emergent area of photonics. (Note that NRC was already present and undertaking activities in support of the local cluster via NRC-IIT and NRC-IMS).

- **Winnipeg, Manitoba –** With NRC already present in the community (NRC-IBD), a focus by the community on the life sciences and biotechnology, and a selection of firms located in Winnipeg, NRC reiterated biomedical technologies as its established technological focus.

- **Saskatoon, Saskatchewan –** The region has a long-standing history in agricultural and biotechnology sciences and an existing concentration of research activity and firms focused on related research areas. The decision to add incremental funding to NRC-PBI in support of functional foods and nutraceuticals was based on opportunities for growth and expansion by the existing cluster into this area.

- **Edmonton, Alberta –** With a healthy economy, the government of Alberta was looking to diversify its economic focus by using its resources to support leading-edge investments in R&D. Nanotechnology was identified as a gap for Canada, with many other nations already having launched strategies and research activities in this emergent area. Although a transformational technology with applications across many sectors, the decision to focus on this technology was done in the absence of any substantive number of firms working in nanotechnology in the Edmonton area or in Alberta. NRC did not have a presence in the area at the time.

- **Vancouver, British Columbia –** When looking to reorient NRC's Vancouver-based Innovation Centre, consultations with community representatives led to a focus on the fuel cells and hydrogen innovations taking place. With Ballard Power Systems leading as an anchor organization in this area, a decision was made to expand NRC activity in support of related research.

A final set of investments in cluster initiatives was made beginning in 2003-04. Their orientations were determined as follows:

- **Regina, Saskatchewan –** The concept of a sustainable infrastructure cluster germinated when NRC-IRAP and the City of Regina collaborated on a demonstration project in 1999. Two years later, a number of interested parties converged to spearhead the launch of an initiative that would support the development of a cluster focused on sustainable infrastructure. NRC had no formal research

presence in the region. Even though firms were not immediately involved in the creation of the cluster, the municipality positioned the city as a 'living laboratory' in which to conduct research.

- **Charlottetown, Prince Edward Island –** Based on a regional roadmapping exercise, Prince Edward Island identified an interest and opportunity in the area of nutrisciences. With local interest led by PEI BioAlliance and a small number of firms already working in the area, as well as support from the university and provincial government, a case was built for an investment by NRC in a province where it did not yet have a research presence.

3.1.3 Resources and Investments

Support for the CIs has come primarily in the form of five-year, B-base (sunsetting funding) from the federal government. Table 4 outlines the approximate annual B-base investment in each CI, and the sum total investment over their full funding period.

Table 4: B-base Financial Resources in Support of Technology Cluster Initiative Delivery[13]

NRC Cluster Initiative	Period of Investment	Planned Annual B-base Funding (2007-08) (Millions $)	Total Direct Planned B-base Funding Over Investment Period (Millions $)
Ocean Technology	10 years	3.2	31.3
Wireless Systems	5 years	0.0	5.0
Nutrisciences and Health	7 years	4.0	31.0
Life Sciences	10 years	3.8[14]	40.5
Information Technology/ e-Business	10 years	9.9	74.6
Aluminum Transformation	10 years	8.6	52.4
Photonics	8 years	6.9	51.1
Biomedical Technologies	8 years	1.1	14.0
Sustainable Infrastructure	7 years	2.0	14.0
Plants for Health and Wellness	8 years	1.0	13.2
Nanotechnology	8 years	11.3	94.6
Fuel Cell and Hydrogen Technologies	8 years	3.7	31.5
NRC industrial Research Assistance Program	10 years	4.2	29.0
NRC Canada Institute for Scientific and Technical Information	10 years	1.7	16.0
Support Services[15]	10 years	5.3	56.0
Total			554.2

3.1.3.1 NRC B-base Resources

Total B-base resources received by NRC in support of the CIs amount to $554.2M, and in the last three years have averaged planned expenditures of approximately $68M per year. Of the total amount

[13] Figures may not sum due to rounding.
[14] The Life Sciences Cluster Initiative in Halifax includes the genomics portion delivered by NRC-IMB, and the Brain Repair Centre portion delivered by NRC-IBD.
[15] Includes: overhead and property taxes; human resources branch, corporate functions; co-ordination office; Senior Executive Offices, Cluster Technology Secretariat.

received, approximately $498.2M, or 90 percent, was directed to individual CIs, with the balance, $56.0M (ten percent) being applied to NRC functions that support initiative design, implementation, delivery and oversight.[16] These resources have all been received for five, three or two year time horizons.[17]

Considering all initiative and overall allocations, the largest proportion ($229.0M or 41 percent) was allocated for operating expenses, followed closely by salary and benefits at $210.5M or 40 percent. Planned capital expenditures represent 19 percent ($104.0M) and grants and contributions round out these figures with the remaining two percent, or $10.6M.

3.1.3.2 NRC A-base Resources

Although B-base resources constitute the direct investment in the CIs by the federal government, it will become apparent in this report that NRC's existing A-base resources also constitute important, if not necessary and parallel, investments in support of the technology areas focused on by both NRC and communities. This is because in all instances, the lead Institute or its additional resources, are also undertaking activities that support clustering objectives.

3.1.3.3 External Direct Investment to the NRC Technology Cluster Initiatives

In some instances, other federal departments or agencies, and other levels of government, have made direct contributions to NRC's CI activities, most notably in support of infrastructure. These are discussed in some detail throughout the report, including in section 6.0.

3.1.3.4 Human Resources

Part of the cluster initiatives' activities included the hiring of research, managerial and other staff to deliver on planned activities. Through CI funding, some 325 people could be identified in 2007-08 as being employed as a result of CI resources.[18] This represents about seven and a half percent of NRC's full staff complement which is now reported at 4 343. More about human resources and highly qualified people in general can be found in Section 5.4 – Effectiveness and Performance in Supporting the Development of Highly Qualified Personnel.

[16] Support services include: program launch and coordination (Round I Co-ordination Office and current Technology Cluster Secretariat); funding to corporate functions (HR, etc.); overhead and property taxes; and senior management support.
[17] The 3 and 2 year funding periods for Round II and III initiatives are a function of NRC's desire to align funding renewal for all initiatives in 2010, thus truncating them from a full 5-year term.
[18] NRC cluster initiative performance data reported for 2007-08.

4.0 Relevance of the NRC Technology Cluster Initiatives

Relevance represents a fundamental issue to be addressed in a program evaluation. In this section, the evaluation considers the alignment of the portfolio of CIs to the priorities of government, both in terms of the relevance of clustering as a publicly supported strategy for economic development and in terms of the relevance of the various activities supported by cluster funding (e.g., research and development, contributions to firms, competitive technical intelligence, firm development through incubation and related services, etc.). Attention is also paid to the relevance of the investments in the various technology areas supported by these initiatives, as well as the regions in which they are positioned. A thorough scientific review of the performance of NRC in these areas was not performed.

4.1 Roles of Government in Clustering

→ *Is delivery of the CIs by NRC consistent with federal roles and responsibilities?*

A review undertaken as part of the evaluation sought to determine whether governments outside of Canada have supported cluster policies, strategies and initiatives as a means of addressing their competitive positioning. This type of review was meant to help ascertain the role of government, particularly publicly funded science-based entities, in cluster-building efforts.

The results of the review indicate that many countries, including members of the G8 and Asia, although notably not the United States, have put in place nation-wide cluster policies (although some US states have their own clustering policies in place).[19] Their aims and the particular instruments and procedures used vary substantially from one country to another and, the review suggests, there are "*no adequate and comprehensive typologies common to all of them*."[20] Notwithstanding this, cluster-related policies and activities implemented around the world are generally designed to address systemic and market failures such as the inefficient functioning of markets, informational failures, limited interaction between actors in innovation systems, institutional mismatches between public knowledge infrastructure and market needs, and government failure. The numerous differences observed amongst OECD countries for instance, in terms of cluster policies and activities, are illustrative of the types of approaches that have been taken with regards to clustering internationally.

In some instances, approaches have been adopted to stimulate laggard regions, to reinforce highly performing ones, and to diversify older industrial areas into higher technology ones. The types of clustering activities implemented include:

- Competition policy and regulatory reform;
- Provision of platforms for constructive dialogue;
- Facilitating cooperation in networks;
- Joint industry-research centres of excellence;
- Human capital development, and
- Public consultancy.

In OECD countries, almost all cluster activities involve some type of partnership between academia and government R&D laboratories. They often include plans for either attracting external resources (human capital, private direct investment or R&D funding) or creating new ones through training, incubation of spin-off companies or R&D.[21]

[19] Cluster programs and initiatives were examined in countries such as France, the United Kingdom, Japan, Taiwan and the United States.
[20] Niosi. p. 14-15.
[21] Ibid, p. 29-30.

The review suggests that the implementation of a clustering strategy by the Canadian federal government is consistent with the roles of other national governments worldwide. It is an appropriate role for the federal government given its involvement in regional development and industry support.

4.1.1 Appropriateness of NRC's Role in Clustering

A literature review on the role of government laboratories in clustering addressed the appropriateness of NRC's role in clustering. The literature review identified two main roles for government laboratories in clustering. One approach developed by Michael Porter places government laboratories in a networking role. The clusters are primarily led by industry and emerge from existing capabilities within specific regional boundaries. The second approach favours government as an active promoter of the creation of new sectors. In this perspective, government laboratories and their university partners represent the 'anchor tenants' of these new sectors and provide both technology and new entrepreneurs.

The NRC CIs were found to represent either one of the two approaches identified in the review, which indicates that NRC is playing an appropriate role in clustering given its organizational mandate and expertise. Some of the initiatives were implemented in regions where clusters were already in existence, such as Newfoundland, the Saguenay, Saskatoon[22] and Vancouver, while others were created in regions with a very limited presence related to technology activity, such as Regina and Edmonton. Even though both approaches are legitimate, the expectations in terms of outcomes and cluster development would naturally be different for these alternating scenarios.

The actual activities undertaken by government laboratories in cluster policies around the world can be summarized in four main categories:

- **Support to industrial extension:** Government laboratories can supply basic industrial knowledge to private firms, particularly SMEs, such as certification, metrology, quality control, just-in-time systems, technological and strategic foresight, and other managerial practices linked with the adoption of technology. In Canada, the Alberta Research Council and Quebec's Centre de recherche industrielle du Québec (CRIQ) are examples of organizations that conduct this type of activity.

- **Creation of advanced R&D:** Public R&D laboratories can conduct contract R&D for existing firms, as well as transfer technology that stems from their internal R&D projects, not based on contracts for private firms. VTT Technical Research Centre laboratories in Finland and National Institute of Health (NIH) laboratories in Maryland provide examples of such a role.

- **Networking:** The laboratories can participate in the building of networks, and creating trust and cooperation within the cluster. The Finnish technology centres, namely VTT, include global networking among their missions. British centres have a similar mandate.

- **Spinning-off of firms:** Public laboratories may actually give rise to a cluster by spinning off new technology-based firms out of their own R&D activities and personnel. Taiwan's Industrial Technology Research Institute (ITRI) is a typical case of this type of contribution.

Interviews conducted as part of the literature review with cluster representatives from several countries indicate that in most countries, government laboratories provide one or two of these services to private firms and the cluster economy. A few laboratories, such as Taiwan's ITRI, are active in all four areas.[23]

The four activities identified above are consistent with those undertaken in the various NRC cluster initiatives and all contribute to risk reduction for SMEs. The findings of the review therefore indicate that the activities undertaken by the cluster initiatives are appropriate for a government laboratory.

[22] Pre-existence of an ag-bio/bioscience cluster.
[23] Niosi, p. 34.

The appropriateness of the role of NRC in creating and maintaining the CIs can also be considered within a broader context. This was discussed with external stakeholders through the community discussion sessions. A number of different players (provincial governments, other federal government organizations, cluster and industrial organizations, universities, private sector firms, etc.) are involved in the activities undertaken within each cluster. Each of these players has its own goals, vision, and approach to clustering. Important differences in terms of cohesion, funding levels, and anchoring were found between the eleven CIs, based on the activities and outcomes attained by other contributing organizations.

Although NRC is highly esteemed as a partner within this broader context, it cannot and should not always fulfill the duties of a cluster animator nor be held solely accountable for cluster development. The roles of other players within the cluster, especially those of the federal government (through its regional development agencies, granting councils and other departments), should be further examined to determine whether the coordination of inter-departmental activities would be beneficial in terms of ensuring greater cohesion within each cluster, and to deal with potential overlap between the work done by NRC and other federal organizations. In the future, NRC may need to identify the most appropriate ways for each of its CIs to contribute to the development of their respective clusters, based on the actions of other cluster actors and the stage of development of each cluster and its firms. This may involve a greater emphasis on technology development for some CIs, and a stronger focus on business development for others.

4.2 Alignment with Government Priorities

→ *Do the activities of the CI Portfolio align with government priorities?*

The relevance issues addressed in this evaluation are largely framed by the expectations of the Federal government's current Science and Technology Strategy, *Mobilizing Science and Technology to Canada's Advantage*.[24] The alignment of the cluster initiatives to the Strategy and other federal priorities is outlined below, followed by a review of the alignment of the cluster initiatives to the priorities of other levels of government.

4.2.1 Alignment with the Priorities of the Federal Government

→ *Do the portfolio's activities align with the federal S&T Strategy and other key priorities?*

The S&T Strategy identifies a number of priorities with which NRC's cluster initiatives are aligned. The Strategy focuses first on private sector research and innovation through its 'Entrepreneurial Advantage' and articulates policy commitments around enabling private R&D investments, advanced technologies, and skilled workers, as well as increasing the application and commercialization of research. An important component of this entrepreneurial focus is encouraging private, academic and public research partnerships, which are at the very foundation of cluster theory. In particular, the strategy states that *"…we must continue to explore and develop new models for S&T collaboration between federal departments and agencies and other sectors".* Clustering provides one of the means through which this can be achieved.

Direct mention of NRC in the Strategy occurs in the case of NRC-IRAP, where reference is made to the Program's role in supporting the 'Entrepreneurial Advantage' and the capacity of firms to innovate.

The 'Knowledge Advantage' identified in the Strategy outlines the need to focus on specific areas of priority through strategic or targeted research. The alignment of each of the CIs to targeted S&T areas and sub-priorities are outlined in Table 5 below.

[24] http://www.ic.gc.ca/epic/site/ic1.nsf/en/h_0085e.html

Table 5: Alignment of NRC Cluster Initiatives to S&T Strategy Priority Areas and Sub Priorities

Cluster Initiative	S&T Strategy S&T Areas	S&T Strategy Sub-Priorities
Ocean Technology	Natural Resources and Energy Environmental Science and Technologies	Arctic Resource Production, Monitoring
Nutrisciences and Health	Health and Related Life Science and Technologies	Health in an Aging Population Neurosciences
Life Sciences	Health and Related Life Sciences and Technologies	Neuroscience; Health in an Aging Population; Biomedical Engineering and Medical Technologies
Information Technology/ e-business	Information and Communications Technologies	Medical Technologies[25] New Media, Animation and Games
Aluminium Transformation	Natural Resources and Energy	
Photonics	Transformative Technology (Applicable to a range of areas)	
Biomedical Technologies	Health and Related Life Sciences and Technologies	Biomedical Engineering and Medical Technologies
Sustainable Infrastructure	Environmental Science and Technologies	Water (Health, Energy, Security)
Plants for Health and Wellness	Health and Related Life Sciences and Technologies	Health in an Aging Population
Nanotechnology	Transformative Technology (Applicable to a range of areas)	
Fuel Cell and Hydrogen Technologies	Natural Resources and Energy	Fuel Cells and Nuclear Energy

All of the cluster initiatives can demonstrate alignment to at least one of the key areas identified in the S&T Strategy. The focus on nanotechnology by NINT and photonics by NRC-CPFC represent a focus on what STIC refers to as 'transformative' technologies. As a result, these initiatives have linkages to a number of strategic areas and are therefore not linked to any one specifically. Eight of the eleven initiatives can also show alignment to sub-priority areas of the Strategy identified by STIC, suggesting even higher levels of relevance.

The 'People Advantage' identified in the Strategy focuses on the development of future generations of scientists and entrepreneurs. The NRC CIs also align well with this strategic focus, given the involvement of cluster researchers in university teaching and the supervision of graduate students in NRC labs, as well as the development of collaborative research opportunities with universities and the private sector.

Another notable component of the federal government's science and technology approach is the *Innovation Road Map*[26] developed in 2006 by the Science, Technology, and Innovation Council of Canada (STIC). The Road Map outlines various dynamic elements of the innovation process. Key areas identified in the Road Map include outcomes directly aligned with those of the cluster initiatives, such as:

- Attracting and developing talent;
- Supporting world-leading research;
- Commercialization;
- Creation of new firms;
- Incubators; and
- Shared infrastructure such as labs, equipment and facilities.

[25] Sub priority identified under Health and Related Life Science Technologies.
[26] http://www.stic-csti.ca/eic/site/stic-csti.nsf/eng/h_00010.html

In addition, the Canada Economic Action Plan put forth by the government in January 2009 provides support to specific sectors, regions and communities across Canada. This includes funding for clean energy as well as an additional $200M over two years to NRC-IRAP.

4.2.2 Alignment with the Strategies of Other Levels of Government

Given the nature of clustering and the extent to which the federal government is able to provide funding to the cluster initiatives, financial and strategic support by other levels of government is paramount for regional success and speaks to the relevance of the technology areas selected by NRC for its initiatives.

The evaluation identified significant examples of alignment between the CIs and the priorities of provincial governments, particularly in Alberta, Prince Edward Island and British Columbia. In these provinces, strategies have been launched with planned commitments to support the technology focus. In Alberta, the launch of the Alberta Nanotechnology Strategy, with a planned investment in the magnitude of $130M, currently stands out as the most significant provincial commitment to a cluster technology, notwithstanding the investment already made in NINT of $60M by the Province and the University of Alberta.

Second in scope is the Government of PEI's announcement of its $200M, five-year strategy called the Island Prosperity Plan. The Plan names bioscience as one of its four key economic sectors and priorities. Part of the Plan includes a $30M investment in an Island BioCommons Research Park, to be located in Charlottetown. According to the Province, it will serve as a national centre of excellence in natural product development for health applications.

In British Columbia, the provincial government launched strategies such as the BC Hydrogen and Fuel Cell Strategy (2004) and later the BC Energy Plan (2007). Both of these initiatives include support to deployment and demonstration projects related to fuel cell and hydrogen technologies. For instance, support has been provided for the Hydrogen Highway and the Vancouver Fuel Cell Vehicle Program. In the case of the Hydrogen Highway, investments in this initiative have been derived not only from the province and local levels of government, but also from other parts of the federal government and the private sector.

In some of the earlier CIs, provincial commitments were made to support infrastructure and related activities. For instance, the Ontario government provided approximately $13M to support both the fit-up of the NRC-CPFC as well as a training component to be delivered by Carleton University. In New Brunswick, resources were provided under a Regional Economic Development Agreement (a joint agreement between the Province and the federal government) to support the establishment of an NRC presence in Saint John and Moncton, in addition to Fredericton.

Provinces have also complemented federal investments with additional research infrastructure such as:

- The Centre Universitaire de Recherche en Aluminium (CURAL) in the Saguenay, where the Quebec government invested $9.4M to construct a research facility on the Université du Quebec Campus near NRC-ATC.

- At Dalhousie University in Halifax, construction is currently underway on The Life Sciences Research Institute (LSRI), which will house an incubator and will serve as a hub for the delivery of business services. Funding for the project is being provided by the Province and other sources.

With much of the initial infrastructure investment complete, commitments by other levels of government now come largely in the form of strategy orientation or priority setting. In some cases, priorities continue to be aligned, but in others, commitment, due to many factors, may be oriented elsewhere or may not have been renewed because commitments were first made in support of infrastructure. In New Brunswick for instance, commitments from the province under the Regional Economic Development Agreement

(REDA), resulted in investments being made by NRC in Saint John and Moncton, in addition to Fredericton. When REDA funding ended, NRC made the decision to close the Saint John satellite site and consolidate staff in Moncton. Since then, the provincial contributions to cluster growth have focused on funding specific activities or entities, such as fora and showcases.

4.3 Relevance of the Technology Areas Addressed by the Cluster Initiatives

One of the issues raised with external stakeholders is the relevance of the technology areas that are the focus of each of the initiatives. As clusters develop and mature, a reorientation of the technological focus can sometimes occur due to changing market forces or new scientific discoveries.

The evaluation findings indicate that NRC has demonstrated an ability to react to changing circumstances in the technology areas represented by the CIs. For example, in 2005, a formative evaluation of the CIs identified a lack of alignment of wireless technologies to Cape Breton. Although there had been some community aspiration that the introduction of R&D capacity on the island with a focus on this area might prove fruitful, a number of conditions, including the lack of any relevant firm presence, a lack of synergy between local actors, and a small investment of only $1M per year, led to a decision by NRC to discontinue the initiative.

With the remaining eleven initiatives, most of the technology areas were found to be consistent with stakeholder needs and their vision for their region. They are also often consistent with the choices made by other industrialized nations in terms of technological development and public sector investment (e.g., nanotechnology and photonics).

However, a few initiatives were identified in the evaluation as having a focus or orientation that may warrant closer examination in the future:

- **Fuel Cell and Hydrogen Technologies cluster initiative:** There is interest in seeing an expansion of scope into clean energy in British Columbia. The Government of British Columbia is showing an increasing interest in the broader field of clean energy, as demonstrated by recent commitments to establish a $25M Clean Energy Fund to help commercialize technologies that contribute to climate change solutions. At the same time, changes in investment priorities have been observed at a global level in some areas of research and development such as automotive applications of fuel cell technologies. These changes, which have been witnessed both in the public and private sector, may provide the Institute with the latitude to refocus in new areas of interest and importance, while continuing to support work in promising niche areas (e.g., stationary, portable and specialty vehicle applications).

- **Life Sciences cluster initiative:** The Greater Halifax Partnership has identified life sciences as one of the growth sectors for the region, particularly due to the significant healthcare facilities located in Halifax as well as the continued investment towards expanding the available infrastructure. Some stakeholders feel that life sciences is too broad a sector for the cluster and that a more precise focus should be identified, although others feel that life sciences is an appropriate focus. A number of different mapping exercises have been undertaken since the implementation of the cluster initiative, with mitigated results. BioNova, the industry association for the life sciences community in Nova Scotia, is currently undertaking several studies, including the development of a roadmap, which may support the identification of a clearer focus for the life sciences community.

- **Plants for Health and Wellness cluster initiative:** The focus of the cluster initiative on functional foods, nutraceuticals and natural health products (FFN) was found to be limiting to cluster growth. Because this sector is highly fragmented, it is difficult to coordinate clustering activities across the region and to effectively respond to firm needs through research. There is some dissension among cluster members in terms of its focus. Most stakeholders consulted for the evaluation felt that a

broader focus would be of benefit to the industry, although those organizations more closely involved with FFN felt that this might threaten their ability to market and sell their products. Currently, NRC-PBI is leading efforts in expanding the technological scope of the cluster (through its research and networking activities) while reducing its geographic area.

Given the discussion of the three initiatives provided here, a recommendation pertaining to the examination of the technological areas of these initiatives is presented:

> ***Recommendation 1:*** *In light of evolving conditions and any apparent constraints (e.g., changing regional priorities, evolving scientific priorities, regulatory environment, etc.), it is proposed that NRC review and either reaffirm or modify the focus of its initiatives in the following areas: fuel cell and hydrogen technologies; life sciences, and plants for health and wellness.*

4.4 Summary of Findings

Overall, the evidence gathered through the evaluation indicates that the NRC cluster initiatives continue to be relevant and appropriate given the role of national governments in clustering and that of public laboratories in particular. A focus on cluster strategies or policies similar to the CIs was identified in other countries. These strategies and policies represent viable mechanisms for supporting economic growth. The undertaking of cluster initiatives supports the Government of Canada's overall objectives and scientific priorities, and supports the ability of firms to innovate through programs such as NRC-IRAP and collaborative research with NRC Institutes. Further, relevance is attested to in many instances by the fact that the investments by NRC were made in partnership with those of other parts of government, both federal and provincial; and for the most part, the technology orientations chosen are aligned to regional interests. However, a few cases emerge where a review of focus has been recommended.

5.0 Effectiveness and Performance of the NRC Technology Cluster Initiatives

5.1 Effectiveness of Program Delivery and Governance

This section addresses issues related to the design, delivery and governance of the CIs. The effectiveness of each of these elements is highly relevant to the overall performance and achievements of the CIs.

→ *What are the core strengths and weaknesses relating to the design, delivery and governance of the cluster initiatives?*

5.1.1 Cluster Initiative Program Elements

The initial 12 cluster initiatives were launched over a four-year period in separate blocks of funding (four Atlantic Initiatives began in 2000-01, six central and western initiatives began in 2002-03 and the two remaining in 2003-04) and therefore represent a highly varied and diffuse set of activities. Only the Atlantic Initiatives were launched by NRC with a concise and planned coordinating process, under an NRC Coordination Office. This was due to the fact that they were all launched in the Atlantic region under a common federal action plan. Later initiatives were not launched in such a coordinated fashion.

NRC-IRAP and NRC-CISTI have always been identified as core assets that NRC could apply to support regional dynamism and cluster growth. As part of the Atlantic Initiatives, NRC's earliest set of funded CIs, NRC-IRAP and NRC-CISTI were identified as core delivery components – as attested to by the fact that they received funding in that initial round. However, the subsequent two rounds of funded initiatives (eight in total) did not include resources specifically for NRC-IRAP or NRC-CISTI. Although they continued to play a role in many of these CIs, NRC-IRAP and NRC-CISTI management expressed that the lack of dedicated resources limited their contribution. NRC-IRAP was then allocated CI grant and contribution (G&C) funds to support the second five-year phase of the central and western initiatives (Round II). It did not receive additional funds, particularly grant and contribution funds, for Sustainable Infrastructure or Nutrisciences and Health (Round III initiatives). NRC-CISTI also did not directly receive additional funds beyond its Atlantic funding. Instead, NRC-IRAP and NRC-CISTI were directed to work in an integrated fashion with the lead NRC Institute for each CI in order to secure resources (e.g., to support the delivery of NRC-CISTI services for instance).

5.1.1.1 Cluster Initiative Coordination and Governance

The overall coordination of the activities common to all CIs, such as the development of business cases and performance reporting, is now provided by the Technology Cluster Secretariat (TCS), housed within the Strategy and Development Branch of NRC's Corporate Services. The Secretariat currently counts four positions, namely a Director, two substantive positions, and a half time support person.

The TCS became active in 2006 following an evaluation recommendation that pointed to a lack of a coordinated strategy for the CIs, despite a growing accountability requirement to report on progress achieved in each initiative. Prior to this, no formal coordination mechanism or strategy was in place across all of the CIs.[27] The Directors General (DGs) responsible for the Atlantic Initiatives, out of a desire for coordination, met periodically to discuss implementation measurement issues. They used their respective CI resources to support these meetings.

Since its introduction, TCS has focused its activities on cluster strategy development, business planning, performance measurement, program coordination and outreach. Feedback obtained through interviews

[27] The Co-ordination office referred to earlier in Section 5.1.1.1 ceased to function following successful implementation of the Atlantic Initiatives.

with key internal stakeholders revealed that, overall, the work of TCS is highly regarded and considered beneficial. It has played a substantial role in raising the level of knowledge within the organization about the activities of the CIs, and has played an advocacy role for them. It has established a CI Network, with representatives from each Institute and NRC-IRAP region engaged in initiative delivery, and coordinated visits and knowledge exchange – all activities that are exemplary of cluster principles around networking and knowledge sharing.

The Secretariat does not constitute, however, a governance mechanism for the CIs, nor should it. No overall governance structure is in place as the CIs are not a formal program at NRC.[28] Rather, as the CI investments represent, in most cases, incremental investments for existing Institutes and NRC program activities[29], the governance of each initiative is left with DGs (reporting in turn to their respective Vice President). The DGs work in collaboration with NRC-IRAP and NRC-CISTI to develop coordinated approaches for their cluster activities in their regions. This has been an evolving process and is appropriate. Initially, NRC Institutes and Programs did not work in this coordinated fashion. Over time, Institutes, NRC-IRAP and NRC-CISTI (I/Ps) have been called on to work together more closely. Evidence of this includes co-location, the transfer of financial resources between I/Ps, increased levels of dialogue and communication, and integrated business planning. Evaluation findings indicate that the TCS has played a positive role in this regard.

Directors General involved in the delivery of the CIs also now come together periodically, as part of a DG Cluster Committee, in a forum of exchange and dialogue. Much of this activity has been driven by accountability and funding renewal requirements, soliciting a substantial level of effort on their part. They work in partnership with their respective Vice President to set priorities and an orientation for the activities undertaken by the Institute or Program in alignment with cluster priorities.

An area where the functioning of a CI is unique is in the Life Sciences CI in Halifax. Here, investments are made by two Institutes, namely NRC-IMB and NRC-IBD. Although both contribute to life sciences, they have generally delivered separate activities, in part as a result of their diversity (one focused on bioanalytical chemistry, functional genomics and marine bioactives and the other on neuroscience, particularly magnetic resonance technology). While there is some common ground between the two Institutes, they have fairly distinct collaborators and research activities. Reflective of the fact that the Life Sciences CI constitutes, to at least some extent, two separate programs is the fact that NRC-IMB and NRC-IBD had traditionally submitted separate business cases for their planned activities. Separate planning activities suggest there may have been some weaknesses in the overall strategy to contribute to the growth of life sciences in Halifax. Future activities and interactions will demonstrate the extent to which this is addressed, with both Institutes, at the time of the evaluation, indicating that they would engage in more integrated planning in the future.

Having noted the above, however, it is important to note that there have been instances in which NRC-IMB and NRC-IBD have worked in concert in planning their support to the life sciences sector. For example, the two Institutes partnered with the IWK Hospital to open the Biomedical MRI Research Laboratory in an effort to address a community need for an animal MRI facility. Also, NRC-IBD (Atlantic) partnered with NRC-IMB and Dalhousie University to establish a new NMR facility in Halifax.

5.1.1.2 Cluster Initiative Funding Cycle

A recurrent theme raised by evaluation participants was the effect of five-year funding for what is intended to be a long-term activity – regional technology or knowledge-based cluster development. This cycle and its associated requirements (e.g., performance reporting, evaluation, Memoranda to Cabinet, etc.) were identified by both internal and external stakeholders as hindrances to optimizing the results to be achieved by the investment. They suggested that it was inefficient to have to spend significant amounts of

[28] Cluster initiatives are not identified on NRC's Program Activity Architecture as Program Activities.
[29] See 2010-11 TBS approved Program Activity Architecture.

time undertaking activities related to funding renewal, especially when combined with other processes such as Strategic Review, business planning and performance reporting.

In the majority of the discussion groups held, it was made clear that stakeholders felt that investments should be long-term or renewed. This is not an uncommon finding in public sector evaluations.

The issue of the impact of short-term funding on the attraction and retention of HQP has been raised in previous evaluation reports focusing on the CIs. In the earlier years of implementation, some employees were hired into term positions to mitigate the risk of a loss of funding. However, current data show that 57 percent of CI funded staff are in continuing positions, indicating that this has not had an effect on the type of positions offered to people over the long term. It is nonetheless recognized that the need to renew funding may hamper the overall efficiency of the organization in maintaining and attracting leading-edge talent to NRC. It is not known whether there are positions that are vacant, or not being actively filled, given the current climate of uncertainty.

Another area affected by the fact that such a substantial level of funding is provided on a short-term basis relates to the fact that NRC has used these resources to put in place permanent new infrastructure (i.e., new buildings and equipment). In the absence of cluster initiative funding, such infrastructure would nonetheless have to be maintained. Section 5.2 of the report outlines the new infrastructure added and identifies the associated risks to NRC.

In addition, another example of the impacts of short-term funding was identified in NRC's ability to maintain partner engagement. With a short period of only two years since the last renewal of funding for the Sustainable Infrastructure cluster initiative in Regina, the work undertaken as part of the evaluation revealed that cluster partners have deferred a decision to invest in the region's technology animator, Communities of Tomorrow, while they wait to learn about future funding from NRC. The clear result, according to evaluation participants, is that the potential of the investment to leverage the input of others or gain momentum is seriously diminished.

A positive outcome of the five-year renewal cycle is that it has contributed to an increase in NRC's level of accountability and due diligence with respect to its use of the CI resources received. These renewal exercises, involving evaluation and business case development, where CIs have been oriented to work more cohesively with their component parts (Institutes, Programs and Branches), have driven NRC towards higher levels of accountability, responsibility and coordination.

> ***Recommendation 2:*** *In light of the five year funding underlying this substantive investment for NRC (greater than 10% of total expenditures and affecting 11 of NRC's 19 Institutes), it is recommended that NRC assess, as part of any planned funding renewal, the risk associated with this investment. Strategies proposed as a result of this assessment should attempt to position relevant CIs as long-term activities and address issues such as staffing and capital assets.*

5.1.2 Institute Delivery of Cluster Initiatives

As stated previously, a good portion of CI funding was provided to NRC Institutes that already had A-base funding. Such cases include NRC-IOT, NRC-IMB, NRC-IBD, NRC-PBI and NRC-IFCI. For these Institutes, CI funding represents between 7 percent and 45 percent of the institutes' total funding.[30] Because much of their A-base activities are related to the same, if not highly associated technology or science areas, it has often been difficult for many of these to report their CI activities separately.[31]

[30] Figures derived from the Financial Profile of the NRC Technology Cluster Initiatives. SDB-PPM. Draft v.7. May 6, 2009.
[31] For NRC-PBI, reporting on CI activities has remained more feasible due to resources being used primarily to support a specific program at the Institute, namely Plant Products for Health and Wellness.

In the cases above, CI activities leverage the regular, ongoing work undertaken by Institute staff and the funding provided is used to support the technology orientation of each Institute. Although this integration has had a positive impact in terms of outcomes achievement (it is not argued by NRC that its A-base funded activities do not support cluster development), it does create numerous difficulties in terms of resource administration, reporting and accountability. In earlier periods, when NRC was engaged in catalyzing cluster activity by many stakeholders through specific investments or activities, it made sense to report on progress on specific resources. However, as time passes and funding is accessed for cluster development, a more holistic approach should be taken to reflect the reality that any and all of NRC's activities in a region have the potential to legitimately contribute to cluster growth.

> ***Recommendation 3:*** *It is suggested that the management of technology cluster initiatives by NRC be undertaken in a more holistic and integrated approach across Institutes and Programs. It is recognized that in many instances, NRC cluster initiative activities are incremental to existing activities being undertaken by NRC. This is particularly the case for NRC-IOT, NRC-IMB, NRC-IBD, NRC-PBI and NRC-IFCI, and extends practically to all other delivery Institutes or programs, including NRC-IRAP and NRC-CISTI.*
>
> *An ideal state would be to integrate the strategy, planning, and oversight of any cluster development progress into regular ongoing NRC processes (e.g., NRC strategy development, business planning, evaluation plan, etc). These would continue to report on and monitor contributions in support of planned objectives.*

5.1.3 Summary of Findings: Program Delivery and Governance

The Technology Cluster Secretariat was created in 2006 in response to a recommendation made in a previous evaluation study and was found to be highly regarded by internal stakeholders. Beyond the coordinating function of TCS, however, no formal governance mechanism for the initiatives is in place, leaving the responsibility for each initiative to individual Directors General.

A recurrent theme raised by evaluation participants was the effect of five-year funding for what is intended to be a long-term activity. This cycle and its associated requirements were identified by both internal and external stakeholders as hindrances to optimizing the results to be achieved by the initiatives. A recommendation focusing on assessing the risk associated with the five-year investment cycle was brought forward to address this issue. In addition, the evaluation recommends that instead of separating the reporting and accountability requirements for each CI from its associated Institute, a more holistic approach to the management of the cluster initiatives be adopted by integrating the strategy, planning, and oversight of the CIs into regular NRC processes.

5.2 Effectiveness and Performance in Delivering Cluster Support Mechanisms and Services

→ *Have the CIs fostered the development of cluster support mechanisms and services?*

The activities conducted by NRC with respect to the delivery of cluster support mechanisms and services is outlined in the sections that follow. Where possible, ancillary activity in the cluster is discussed as examples of catalyzed or leveraged activity and investment.

5.2.1 Organizations Funded by the NRC Industrial Research Assistance Program

The mandate of NRC-IRAP includes the provision of funding not only to firms, but also to organizations, for the purpose of supporting Canada's innovation system. It does so with the objectives of:

- supporting organizations in building and integrating the innovation capacity in Canada for the benefit of Canadian firms, primarily SMEs; and

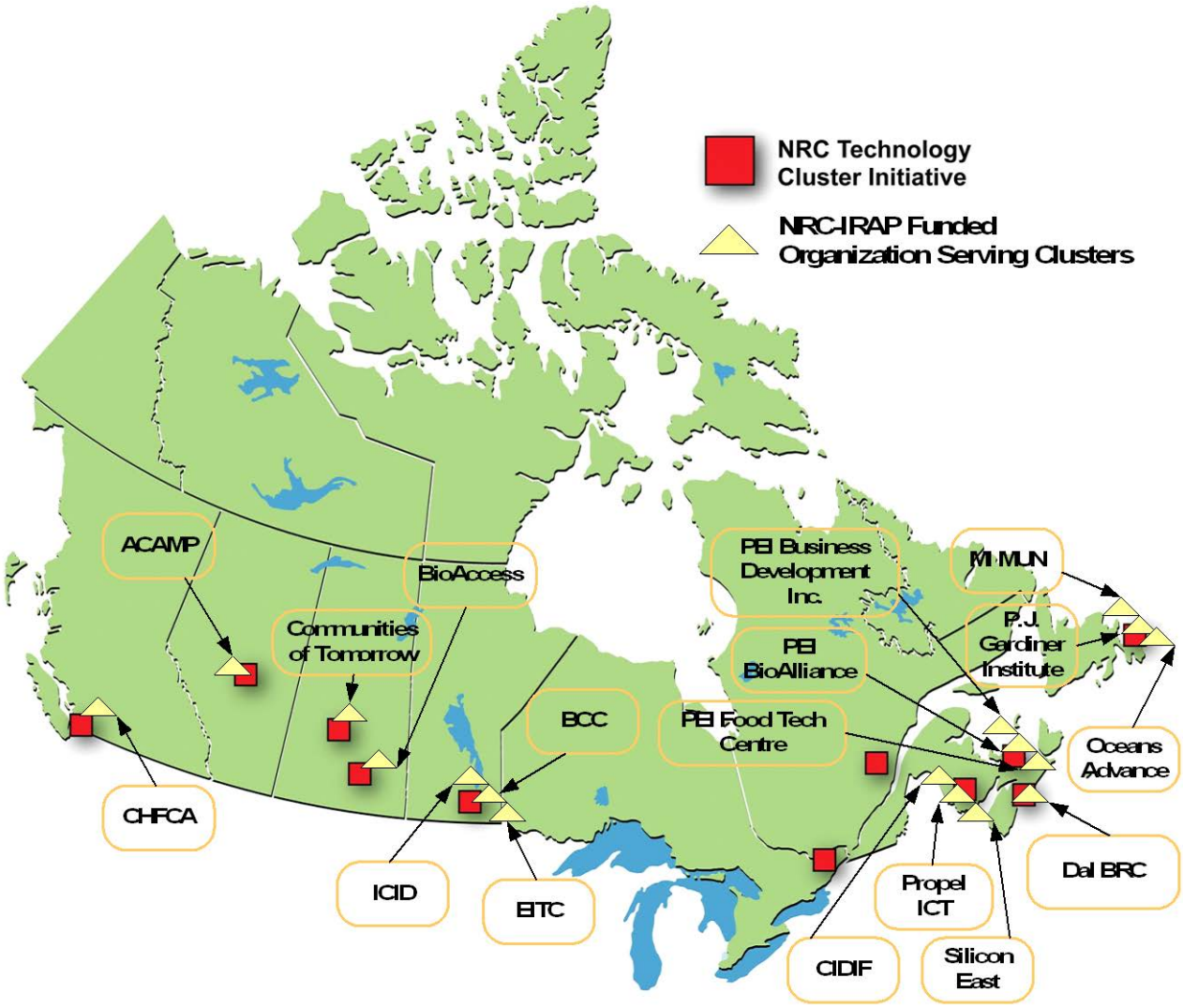
- supporting organizations in providing innovation assistance services to Canadian SMEs.

It is anticipated that outcomes from such funding will include: the development of alliances with local, regional, and national innovation players to extend the Program's reach and increase the number of innovation services available to SMEs; the extension of its network to international players to improve access by SMEs to foreign knowledge; the creation of joint initiatives to enhance SME participation in clusters; and the establishment of partnerships with publicly funded R&D organizations to facilitate the transfer of technologies to the private sector.

Over the course of NRC's involvement in the funded CIs, NRC-IRAP has provided at least $6.3M[32] in funding to organizations that are focused specifically on supporting a cluster technology area, as illustrated in the figure below. Funding to organizations, compared to firms, represents about 70 percent of the grant and contribution (G&C) investments that NRC-IRAP has made in clusters.

[32] NRC-IRAP investments in organizations were drawn from both B-base cluster funding and existing A-base and Commercialization funds.

Figure 4: NRC-IRAP Investments in Key Organizations Supporting Clusters



A brief synopsis of key investments, particularly to organizations that are working in direct support of the cluster's focal technology, is provided below:

- **Ocean Technologies, St. John's –** NRC-IRAP has provided funding in support of three organizations. Support was provided to: Oceans Advance, essentially the cluster animator in Newfoundland; the Fisheries and Marine Institute at Memorial University to support advice and services for firms; and the Young Entrepreneurs' Program delivered by the PJ Gardner Institute for Enterprise and Entrepreneurship.

- **Biosciences, Charlottetown –** In PEI, NRC-IRAP has provided support to PEI BioAlliance ($185K), Prince Edward Island Business Development Inc. (BDI) ($270K) and the PEI Food Technology Centre (FTC) ($55K) in support of the cluster's development. The PEI BioAlliance outlines that it is a *"cluster of individuals and organizations dedicated to building the bioscience-based economic sector in PEI, with an emphasis on collaborative initiatives in research, business, education, and supporting*

infrastructure." PEI Business Development Inc. provides support intended to lead to business creation on the Island and the PEI FTC provides technical support to the food processing sector on the Island.

- **Life Sciences, Halifax –** In this region, an $86K contribution was made in 2005-06 by NRC-IRAP to support the commercialization activities of the Dalhousie University Brain Repair Centre.

- **Information Technology/E-Business, Fredericton/Moncton –** In New Brunswick, NRC-IRAP has supported the work of the Centre international pour le développement de l'inforoute en français (CIDIF), PropelSJ Inc. and Silicon East Inc. From 2005-06 to 2007-08 contributions to these organizations have totaled approximately $273K. The investments have helped to support services offered to SMEs, including mentorship, and to support roadmapping and business strategy development work (e.g., e-business strategy).

- **Biomedical Technologies, Winnipeg –** Biomedical Commercialization Canada (BCC) is a not-for-profit business incubation organization housed in NRC-CCBT in Winnipeg. Support from NRC-IRAP first began in 2003-04 and is currently ongoing. From 2003-04 to 2007-08 just under $2.3M have been provided to BCC by NRC-IRAP in support of its mentoring and coaching activities. This is NRC-IRAP's most substantive funding to a CI-oriented organization. The organization is currently working with firms in the NRC-CCBT as well as in other locations, with a general emphasis on biomedical technology. Some of the tenants of the NRC-CCBT housed by BCC are support firms who provide services (e.g., IT infrastructure, law, etc.) to the core clients of BCC. Currently, some of the BCC-leased space within NRC-CCBT is still available for new firms interested in using the services of this organization.

  NRC-IRAP has also provided funding in support of BioMed City planning and strategy development through the International Centre for Infectious Diseases (ICID) and the Economic Innovation and Technology Council (EITC). Approximately $200K were provided to both of these between 2005-06 and 2007-08. The current status of BioMed City is uncertain – there appears to be a lack of appetite within the community to pursue this project at the present time.

- **Plants for Health and Wellness, Saskatoon –** In support of this cluster, NRC-IRAP has provided approximately $1.3M in funding since 2006-07 to Presagio Technology Group Inc., a Saskatoon-based company that helped to create the BioAccess Commercialization Centre located in the IPF at NRC-PBI. Early funding helped to support functional foods and nutraceutical industry consultations, roadmapping and planning. BioAccess now provides SMEs in Western Canada's functional foods, nutraceuticals and natural health products (FFNHP) industry with access to information and specialized advice. At this time, it is still early to comment on the outcomes achieved by BioAccess. Some of the issues that may influence this organization's ability to achieve concrete outcomes in this community are competing organizations within the cluster and an inability to properly establish the scope and geographic boundaries of the FFN cluster.

  NRC-IRAP has also provided funding to Wellness West, a partnership that works to support the FFNHP cluster in Western Canada by linking together federal and provincial government organizations. With funding of approximately $278K from NRC-IRAP between 2004-05 and 2006-07, Wellness West provides information on technology and market trends for its members, and acts as a convener of interest among key government departments across Canada's west. This organization is generally well-regarded within the cluster, although its reach is somewhat limited by its mandate.

- **Sustainable Infrastructure, Regina –** NRC-IRAP has more recently supported the delivery of market intelligence by Communities of Tomorrow (CT) with a planned contribution of approximately $65K by the end of 2008-09 in support of a market information officer. The organization was created

to "*become the catalyst for the development of a cluster of companies, researchers, municipalities, and investors in the field of innovative infrastructure*" in Saskatchewan.[33]

- **Nanotechnology, Edmonton –** NRC-IRAP has provided approximately $117K in funding to support the Alberta Centre for Advanced MNT Products (ACAMP), a not-for-profit organization that provides specialized business services to MNT clients. The centre's services are designed to help bring together researchers, small start-up companies and established firms that have a potentially viable product and need help in order to bring it to a level of profitability. It provides access to equipment and facilities, such as a class 100 clean room for product package assembly and testing, and related equipment, all necessary for the handling of microsystems and nanotechnology products.

- **Fuel Cell and Hydrogen Technology, Vancouver –** $23K was provided in 2007-08 to Hydrogen and Fuel Cells Canada to support the May 2009 International Hydrogen and Fuel Cell Conference.

In conclusion, the evaluation findings point to the fact that the funding applied by NRC-IRAP has provided support to organizations across most of the CIs. These organizations supporting the innovative capacity of firms or of a region, delivering programming related to such areas as mentorship, business planning, regional planning (roadmapping and strategy development) and networking (conferences or networking, including participation in international missions).

In a few instances, NRC-IRAP is playing an important role in supporting organizations that are intended to focus on a cluster network, firms and technology development. Most substantive is the multi-year support provided to BCC and the BioAccess Commercialization Centre. In these two cases, NRC is the major financial contributor to an organization focused on supporting the development of firms.

5.2.2 Services Delivered by the NRC Canada Institute for Scientific and Technical Information

From early documents outlining NRC's approach to technology clustering, the NRC Canada Institute for Scientific and Technical Information (NRC-CISTI) has always been positioned, at least operationally, as a component of the capability that NRC could put forward in support of cluster development.

NRC-CISTI's contribution to clustering is not reflected by the funding that it received in the various rounds of CI funding. The Institute's portion represents only 3 percent, or $16M of total CI funds, and was provided in support of the Atlantic Initiatives only. This specific investment in Atlantic Canada by NRC allowed NRC-CISTI to expand the services delivered by NRC Information Centres (NICs) in St. John's, Halifax and Charlottetown. For instance, NICs expanded their collections in line with cluster orientations. The investment also allowed NRC-CISTI to pilot a new service offering called Competitive Technical Intelligence (CTI). This service offers a set of specialized services that deliver "*business sensitive information about scientific or technical threats, opportunities, or developments that have the potential to affect an organization's competitive situation*."[34] Through arrangements with NRC-IRAP, NRC-CISTI began to deliver a series of services focused directly on the needs of the Industrial Technology Advisors (ITAs) and their client firms.

With developed products and a CTI network established in the Atlantic Region and then Quebec, NRC-CISTI found itself engaged with other NRC Institutes, newly established CI facilities (e.g., NRC-ATC and NRC-CPFC), and NRC-IRAP to expand the CTI offering. Thus, through a process of integrated planning with Round II and Round III cluster initiatives, the Institute has expanded its presence across NRC's CIs and now provides CTI services to nine of the eleven initiatives. The two exceptions are at NINT in Edmonton and in NRC-CSIR in Regina, where there is no NRC-CISTI presence. In the case of NINT, the services of the University of Alberta are used and in Regina, NRC staff access the Ottawa-based library and information services provided by NRC-IRC. The absence of CTI services is perhaps explained by the fact that there are a small number of firms in these regions, resulting in limited immediate demand.

[33] http://www.communitiesoftomorrow.ca/Home/tabid/55/Default.aspx
[34] http://zone.nrc-cnrc.gc.ca/news/2003/20030317_intelligence_e.html

Alternately, the lack of demand could be the result of the unavailability of such services in the region. Instead, at least in Regina, some form of CTI is delivered by Communities of Tomorrow, under NRC-IRAP funding.

Most of the support for the delivery of CTI has come from transferred funds from NRC-IRAP, presumably as a result of the value placed on the service by ITAs and/or Institutes.

In some instances, the additional CTI services are not NRC-IRAP funded, but rather are covered by CI funds received by an Institute. Such is the case in the Saguenay, where NRC-CISTI staff are paid for by CI funds, and in Ottawa where NRC-CPFC pays for the salary of a Technical Business Analyst (TBA) to deliver CTI in response to the needs of the Centre.

As NRC-CISTI's expanded service offerings were put in place over varying time frames, trend analysis of changes in usage of services is difficult to accomplish. The data indicate some differences in usage levels in the areas where NICs were already present, as some communities use NRC-CISTI more than others. For example, the highest usage level of Search Services is reported in St. John's, a community that also vehemently expressed concern in the discussion group over planned cuts to NRC-CISTI stemming from NRC's Strategic Review exercise.

In some locations, the data provided show an increase in the use of NIC Search Services in the CI funding period. This has occurred in Ocean Technology (St. John's), Aluminium Transformation (Saguenay), and Nutrisciences and Health (Charlottetown).[35] The NIC in the Saguenay is seeing an increase in usage, with Search Service delivery equivalent to or surpassing more established sites. This seems to have occurred despite NRC-ATC facing some staffing challenges for the Centre a few years ago.

As for CTI, its offering has slowly been expanded. Its offering began in the Atlantic region in 2003-04 and has slowly expanded, with the most recent addition occurring in Vancouver in 2007-08. The value of the three key products delivered to the CIs (Information Report, CTI Assessment and CTI Insight) can be inferred from the increase observed in requests for these products. Data submitted by NRC-CISTI identify approximately 220 CTI products having been delivered as of 2007-08. These might best be described as 'premium' products, recognizing that their development, while highly valued, requires anywhere from ten to 120 hours to produce.

From a qualitative perspective, users of NRC-CISTI services clearly articulated the high value they place on the products provided, whether they be NIC delivered access, search or monitoring services, or the more specific CTI offerings. The comments provided in the context of this evaluation were consistent with those articulated in previous NRC evaluations of both the CIs and other programs.[36] Firm and university evaluation participants suggested that NRC-CISTI's resources had supported them in such things as grant application efforts, the identification of grey literature or unpublished work for research purposes, and with firm investment decisions based on patent searches. Competitive Technical Intelligence products, such as CTI Assessments, were identified as providing valuable market information. Even within NRC, staff praised the CTI services by substantiating the high quality of the deliverables. It was suggested that they had not realized the value added of the NRC-CISTI CTI offering until they were exposed directly to the work of Technical Business Analysts.

In terms of weaknesses, some perceived that the work of NRC-CISTI was not sufficiently visible within some clusters, but positioned more as a 'background' element. According to participants, these visibility problems translate into a difficulty for some in accessing its services as well as a perception that NRC-CISTI has a limited impact on the development of the cluster. As said by one evaluation participant about

[35] Note that complete data on services provided was not available for all NICs where a CI investment has been made.
[36] See Formative Evaluation of the Atlantic Initiatives, NRC-PPM, October 27, 2004 and NRC-IRAP Impact Evaluation Report, December 2007.

NRC-CISTI*: "…they are brilliant with the market, but they are not marketing themselves."* Another evaluation participant synthesized at least one community's perception by stating: *"… they are the best kept secret around."*

As part of NRC's recent Strategic Review exercise, the NRC-CISTI Information and Intelligence Services (IIS) program, from which NIC and CTI are delivered, may transform to a new delivery model allowing privatization of program services, or may be terminated, around 2010. With rather complicated funding mechanisms having evolved for the delivery of NRC-CISTI services to the CIs over the past 8 years (the majority of funding to CTI coming from NRC-IRAP or CI Institute funding, as opposed to direct NRC-CISTI funds), it is currently unclear how NRC will proceed in the future.

> ***Recommendation 4:*** *Review with NRC-IRAP and NRC Institutes engaged in clustering activities strategies for addressing the ongoing need for Information and Intelligence Services (IIS) (i.e., NICs and CTI products) in support of their regional cluster objectives given the impact of decisions surrounding the Strategic Review process.*

5.2.3 Industry Partnership Facilities

Resources were sought by NRC as part of the cluster initiatives to construct industry partnership facilities (IPFs) in a number of locations. New facilities were added in seven of the eleven CI locations, namely: St. John's; Halifax; Charlottetown; Fredericton; Winnipeg; Edmonton, and Vancouver. In other locations, an IPF either already existed (Ottawa and Saskatoon) or was not established (Saguenay and Regina). For the purposes of this report, emphasis is placed on the activities of the IPFs funded through the cluster initiatives. However, it is recognized that two Institutes focused on cluster development, namely NRC-PBI and NRC-IMS, also house IPFs. In both of these cases it was found that the IPF serves cluster firms and contributes to cluster growth and development regardless of its funding status.

Industry partnership facilities established by NRC are generally designed to offer firms the opportunity to co-locate with NRC staff and serve a variety of purposes, including access to specialized facilities and equipment, technical support services, business support services, and networking. For the most part, the IPFs function as 'research incubators', allowing firms to benefit from their proximity to research activities, and potentially other nearby located services. In a few cases, the IPFs have also entrenched the delivery of business development services, giving them the added dimension of reflecting a 'business incubator'.

The activity and performance of each of the CI funded IPFs is summarized below. Further, any related business development activity in the region is identified.

- **St. John's (NRC-IOT):** The IPF opened in 2003 and includes office space for new and established companies, conference rooms, and the expanded NRC-CISTI NRC Information Centre. The offices of NRC-IRAP and Oceans Advance (the local cluster animator) are now integrated into the new building, which is attached to the existing NRC-IOT facility. Along with the IPF, NRC-IOT inaugurated the Ocean Technology Enterprise Centre (OTEC), which is a combination of two programs available to companies.

  The OTEC is part of a 'campus incubation consortium', where the resources of NRC are combined with those of others to support innovation and entrepreneurship. Other elements of this consortium include: The Genesis Centre (which provides mentorship and investor 'readiness' support); the P.J. Gardiner Institute (an SME and student/faculty business consulting Centre at Memorial University of Newfoundland); the Enterprise and Entrepreneurship Gateway (a resource centre for entrepreneurs); the Inco Innovation Centre and MUN itself via the Faculty of Engineering and Applied Science. The presence and integration of multiple resources represents a strength in any cluster development effort.

Specifically, OTEC's mission is to promote the development of ocean technology business in Newfoundland by providing a supportive environment to assist the growth and development of new ventures in ocean technology and by providing co-location facilities to assist collaborative activities between NRC researchers and ocean technology companies and organizations.

In support of these objectives, the OTEC supports the delivery of two programs, namely the Young Entrepreneurs Program, or YEP (in receipt of contribution support from NRC-IRAP) and the Ocean Technology Co-location Program. The YEP is directed at new graduates of engineering, science or technology programs who are starting or contemplating starting new ocean technology enterprises. The Ocean Technology Co-location Program is directed towards ocean technology companies that can benefit from co-location with NRC-IOT. These companies are either engaged in collaborative activities with NRC-IOT or use NRC-IOT facilities and expertise in the development of their technology or conduct of their business.

OTEC houses two mainstays of the cluster: Oceans Advance and Oceanic. While these are not incubating firms, they are nevertheless key components of the Ocean Technology cluster initiative, as well as of the cluster itself. The former provides networking impetus and animation for the cluster while the latter does fee-for-service work using NRC-IOT equipment and expertise, and also attracts and helps to train HQP. Other tenants are firms at various levels of technological and business development. As of 2007-08, nine SMEs were located in the IPF, using up the facility's available capacity.

When asked what value being located in the IPF at NRC-IOT had, one firm commented that it has most benefited from the ability to leverage the NRC brand. By being able to demonstrate a linkage to NRC, the firm has experienced increased success internationally, which it directly attributed to NRC.

Although the presence of an IPF is most often thought to influence the firms or organizations amongst its walls, the proximate nature of firms also influences the research community by exposing researchers and academics to private sector activities and interests. One researcher commented that following the introduction of a cluster orientation at NRC-IOT, they were more apt to collaborate with the private sector.

- **Halifax (NRC-IMB):** Using $4.2M of CI funding, NRC-IMB built a 30,000 ft^2 IPF. The facility has housed ten firms and one provincial organization since 2001. In addition to space, the IPF offers services to firms, including access to equipment and training. Three of the tenants in the IPF have accessed these services, as have eight organizations who have not leased IPF space. Firms currently located in the IPF felt that the services offered through the facility differentiated it from other rental facilities available in Halifax.

  Other incubation activity in the area includes the construction of the Life Sciences Research Institute (LSRI). Planned for completion in 2011, it will include an incubator and also be located on the campus of Dalhousie University. Its focus will be on business services, including those offered by InNOVACorp, as opposed to the research support NRC-IMB offers. They are seen as being distinct and complementary, but not duplicative.

- **Charlottetown (NRC-INH):** The IPF at NRC-INH can house up to six firms and is presently fully occupied. Given the pace at which the IPF was filled, several evaluation participants indicated that NRC-INH could have a greater impact if more space were available. According to these individuals, the IPF space was filled faster than had originally been anticipated and additional firms have expressed an interest in gaining access to this space. However, this is not currently possible, given that the original tenants have not yet 'graduated' from the IPF. Since opening in 2006 the INH IPF has generated in $380K in rental and fit up revenues.

The firms that currently occupy space in the IPF have expressed that they have benefited from the research space, as well as access to both specialized equipment and research expertise for reasonable costs. Had NRC-INH not offered these services, evaluation participants indicated that it would have been difficult for some firms to afford either the equipment or researcher time.

Overall, NRC-INH orients its activities to support firms' research needs, as opposed to business support services. To support broader business support requirements, PEI has announced an investment in a new business support facility, BioCommons. This facility would serve a variety of purposes including allowing firms graduating from the NRC-INH IPF to relocate in order to continue the process of putting a product on the market.

- **Fredericton (NRC-IIT):** The IPF offers start-up companies up to three years of co-location with NRC and other SMEs, as well as access to IT expertise, laboratory and network resources. There are currently ten tenants in the IPF encompassing public and private sector entities. There is one government tenant (Department of Foreign Affairs and International Trade), two councils, one non-profit institute, and six companies. The services provided by the Institute to its IPF tenants include access to CA*net4, Canada's high-speed research network, voice-over IP, and access to highly-specialized NRC facilities and laboratories. Because they are located within the Institute, IPF tenants are also able to access the expertise of NRC researchers, NRC-CISTI (for CTI services) and NRC-IRAP.

  Leveraging the IPF

  A former NRC-IIT IPF tenant "went from zero to $1.25M" in revenues with the help of the Institute. Tenancy in the IPF enabled this company to attract highly qualified personnel and conduct research with the proper tools.

  Tenants interviewed as part of the evaluation study emphasized the benefits accrued to their companies through their exposure to NRC services and expertise and attribute their success in recruiting high quality personnel and attracting venture capital in part to these contributions. According to an analysis conducted by the Institute, IPF tenants have been able to raise $24M in capital over the course of the evaluation period.

- **Winnipeg (NRC-IBD):** In Winnipeg, the CI funds have been primarily used to construct and operate the IPF, officially named the NRC Centre for the Commercialization of Biomedical Technology (NRC-CCBT). As a result of funding provided by NRC-IRAP, the Centre is able to offer business support services delivered through Biomedical Commercialization Canada (BCC). The new facility extends IPF space previously available at NRC-IBD, where cluster firms are also found. The model in place at NRC-CCBT, where BCC is a tenant and brings in its own clients as tenants, is considered to be unique by cluster stakeholders. NRC-IBD, its IPF and the BCC are thought by many to be inseparable components of one large initiative, regardless of the specific source of funding. The advantages of this model are the linkages created between the tenants of the facility and NRC-IBD researchers, as well as NRC-CISTI and NRC-IRAP. The combination of scientific and technical expertise, along with business and market expertise, and the access to laboratories and machine shops is not found elsewhere in Manitoba and provides added value to both the tenants of the IPF and other cluster firms not situated in the Centre.

  Although some of the NRC-CCBT tenants are clearly linked to the cluster's mandate, such as the International Centre for Infectious Diseases (ICID) and MRI-Tech Canada, many other tenants provide services on behalf of BCC (e.g., IT infrastructure, law services, etc.) but are not specifically identified as such. NRC-IBD should further document the linkages between its tenants and the biomedical cluster in order to clarify its choice of tenants and receive due credit for those firms and organizations that are directly connected to the cluster technology area.

- **Edmonton (NINT):** In September of 2007 NINT officially opened the NINT Innovation Centre to support technology transfer and partnership. The facility consists primarily of office and laboratory space with tenants gaining access to some NINT equipment. At the time of its official opening, there were five companies and a research group from the NINT-XEROX Canada industrial research partnership occupying a portion of the 15 rental units of combined office and laboratory space. More recent data indicate that occupancy has grown slightly, with seven firms being reported on site as of July 2008 and another initiative using space. The Centre is currently running at an approximate 50 percent to 60 percent occupancy rate and has generated about $190,000 in rental revenues.[37]

  To those in the region, the Centre is still in its infancy in terms of capacity and the contribution it is making. Regional leaders profile the presence of a public-private research partnership between Xerox Canada, Alberta Advanced Education and Technology and NRC at the Centre as a success. With this co-location, investments are being made and additional researchers are expected to be hired.

  The region also counts other incubation or business support services, some of which are more recent additions in support of advances in Nanotechnology. Such entities include the Alberta Centre for Advanced MNT Products (ACAMP), which became operational in 2007 (supported by Western Economic Diversification and Alberta Advanced Education and Technology) and TEC Edmonton, (University of Alberta and the Edmonton Economic Development Corporation (EEDC), reinvented in 2006.

- **Vancouver (NRC-IFCI):** As of July 2008, the IPF hosted nine individual organizations (private or other). The design of NRC-IFCI's building allows for a certain level of flexibility with respect to the office and laboratory space available for the purpose of the IPF. As such, the available space is determined periodically according to the level of research activity of the Institute. Given these circumstances, it was not possible for the Institute to establish the percentage of available space in the IPF. However, the relevance of this facility in support of the development of cluster firms has been demonstrated by the interest of some tenants to rent additional space.

  An example of a firm achieving success following incubation in the NRC-IFCI IPF is Cellex Power Products, purchased in 2008 by US-based Power Plug Inc. Cellex was the first tenant of NRC-IFCI. While at the Institute, the company was able to gain access to high-grade offices, machine shops, hydrogen-safe laboratories for testing its prototypes, as well as gas procurement, information technology and administrative support. Cellex also gained crucial networking opportunities and the credibility to attract investors.

Data provided by the Institutes operating these new IPF facilities at NRC indicate that local firms have, in most locations, embraced the opportunity to work in an NRC facility. As of 2007-08, 54 firms were housed in the CI-funded IPFs. If all nine NRC cluster initiative IPFs are considered, this number rises to 76. In both cases, firms represent 85 percent of occupancy, with an average of six to eight firms per facility. Other tenants include not-for-profit organizations (e.g., Oceans Advance in St. John's, the New Brunswick Business Council in Fredericton, the International Centre for Infectious Diseases in Winnipeg, and Hydrogen and Fuel Cells Canada in Vancouver) and other government departments (e.g., NRCan in Vancouver). New space added as a result of a newly constructed IPF has, in some cases, also allowed NRC to house NRC-IRAP offices, NRC-CISTI (e.g., a NRC Information Centre) and, in some instances, NRC staff.

The mix of tenants in the IPF adds value not only by facilitating access by residents to services, but by potentially creating an innovative forum for exchange, simply by the relationships formed.

In a few cases, NRC has entered into reasonably significant arrangements with third party organizations to deliver business support services to IPF tenants and external firms. The most significant examples are

[37] Estimated revenues report as of end of March 31, 2009.

BCC (Winnipeg) and BioAccess (Saskatoon).The services offered include marketing, regulatory consulting, financial management, and IT support. These organizations as well as other peripheral service organizations (e.g., law firms) are working to help the technology firms "*graduate*" from the IPF as viable businesses.

Some of the key strengths offered by NRC in attracting firms to work from its premises include:

- **The NRC brand:** It gives credibility to firms who work with a national laboratory.
- **The infrastructure:** Being in the IPF allows firms to be close to advanced facilities for testing and research purposes (e.g., Ottawa-based Cyrium Technologies in the NRC-IMS IPF has accessed NRC-CPFC).
- **The people:** Being near NRC researchers supports knowledge transfer and innovation (e.g., Xerox has established a presence at the NINT Innovation Centre for the purposes of interacting more fully with NINT researchers).

Although the evaluation did not allow for a detailed review of IPFs and their performance, it is nonetheless observed that in some cases the level of programming supporting an IPF is not well defined or developed. Certainly it is variable across the CIs. This may explain why IPFs sometimes house firms or organizations that do not appear to have a direct relationship to the cluster technology. It may also explain why there are instances where, beyond the strength of the NRC brand, it is not clear whether NRC has optimized the results that such a facility might achieve. NRC has, by choice, generally refrained from suggesting that the IPFs are business incubators. Not all IPFs offer an official suite of business support services beyond access to general tenancy services and meeting space.

5.2.4 Summary of Findings: Delivery of Cluster Support Mechanisms

Overall, stakeholders consulted for the evaluation felt that there had been a positive change in the extent to which business support services have been made available to cluster actors since the start of cluster funding and partially attributed this change to NRC.[38] NRC-IRAP was found to support cluster organizations across most of the CIs. NRC-IRAP has provided at least $6.3M in funding to organizations that are focused specifically on supporting a cluster technology area, which represents about 70 percent of the grant and contribution investments that NRC-IRAP has made in the clusters. The contributions made by NRC-CISTI to the cluster initiatives were identified by stakeholders as having a high value but not a high level of visibility in the cluster communities. The funding of the services provided by NRC-CISTI was also found to vary considerably between initiatives, with some CI funding complemented by Institute and NRC-IRAP funds. A recommendation focusing on a review of the ongoing need for the services provided by NRC-CISTI in the cluster initiatives was made in the evaluation.

Industrial partnership facilities were also identified as a key mechanism used by NRC for supporting cluster development. New facilities were added in seven of the eleven CI locations and since the last round of evaluations the presence of firms in these facilities has grown markedly. The key strengths offered by NRC in attracting firms to work from its premises include the NRC brand, infrastructure, and people.

5.3 Effectiveness and Performance in Developing Specialized Infrastructure

→ *Have the CIs supported the development of specialized infrastructure?*

The development of specialized infrastructure symbolizes NRC's presence across Canada. The expansion of existing facilities, the construction of new buildings, and additional leased space have all

[38] Based on a qualitative questionnaire administered to discussion group participants.

contributed to making NRC more visible in cluster communities. In addition to these, specialized equipment purchases have been made by NRC on behalf of the clusters and serve the needs of firms and other cluster actors.

5.3.1 Expansion of Existing Facilities and Construction of New Buildings

The incremental nature of the CI funding has made it possible for a number of Institutes to expand their existing facilities to better serve the needs of cluster firms and other actors. This also included the construction of new facilities geared towards cluster activities.

A comparison of the space added to NRC facilities (through expansions, new constructions, and new leases) since the start of cluster funding provides a sense of the impact of the CIs on the presence of NRC across Canada. CI-related additions represent approximately ten percent of total NRC floor space, owned and leased. The replacement cost of NRC-owned facilities added as part of the cluster initiatives was estimated by NRC-ASPM[39] to be about $89M, which represents approximately six percent of the total replacement cost of all NRC facilities (established at $1.37B). Table 6 presents a summary of the infrastructure investments that have been made since the start of cluster funding.

Expanding the Reach of NRC

- CI-related investments in major capital have added over 425,000 square feet of new space across 7 of the 11 cluster initiatives.
- External investments made towards the construction of these facilities total $38.2M, or 33 percent of the total cost of construction.

Table 6: Infrastructure Investments[40]

Cluster Initiative	Description of Construction	Additional Square Footage	Total Square Footage in Region	Financial Contribution (NRC vs. External Investments)	Replacement Cost Estimate (current value of facilities)
Ocean Technology	Expansion of building to house new IPF	37 673	653 864	NRC: $6.5M[41]	$7.5M[42]
Life Sciences (NRC-IMB)	Expansion of building to house new IPF and parkade	42 954	129 163	NRC:$4.2M	$3.97M
Information Technology/ e-Business	New office and laboratory space, including IPF	59 815	59 815	NRC:$10.5M	$9.9M
Aluminium Transformation	New office and laboratory space	91 869	91 869	External: $25M	$21.1M
Photonics	New facility adjoined to NRC-IMS	66 594	3 347 608 (incl. NRC-IMS)	NRC: $30M[43] External: $10M	$18.5M
Biomedical Technologies	New IPF	54 994	271 001	NRC:$10M External: $3.2M	$12M

[39] NRC Administrative Services and Property Management Branch
[40] Data on square footage and replacement cost estimates provided by NRC-ASPM; these do not include minor capital or scientific equipment.
[41] $4.65M were used in the expansion of the building from cluster funding and the remainder was provided through NRC-IOT core funds.
[42] Replacement cost for the IPF component of the facility was estimated based on the total cost of replacement of NRC-IOT facilities and the square footage of the expansion.
[43] This includes investments in equipment.

All of the cases identified in the table refer to the use of CI funding for the development of infrastructure. A key consideration when reviewing this information, however, is that existing facilities also contribute greatly to cluster development and growth. For example, as mentioned previously, IPFs may have existed in some Institutes and are incubating cluster firms. Therefore, the numbers reported represent a minimum in terms of the contribution of NRC in infrastructure to cluster development.

NRC-IFCI is not included in the table even though NRC owns the building in which the Institute is located. This is due to the fact that the NRC-IFCI building was purchased using funds from the sale of another NRC building situated on UBC land and thus was not constructed using cluster funds. NRC spent $19M on the new building, which currently has an estimated replacement value of $16M. NINT is also a particular case: NRC invested $8M in the construction of the $48M facility, and is leasing almost 140,000 square feet of space in this building.

Some of the initiatives are leasing space from other cluster partners as appropriate. In many cases, the Institutes in place are also leasing the land on which the NRC facilities have been built, usually from local universities or hospitals. Decisions underlying whether NRC builds a facility or leases space in an existing facility are generally made on a case-by-case basis, depending on contextual factors. The table below summarizes the space leased by NRC as part of its cluster initiatives.

Table 7: Leased Space

Cluster Initiative	Description of Leased Space	Duration of Lease	Square Footage	Owner of Property
Ocean Technology	Land	1981-2081	Not applicable	Memorial University
Nutrisciences and Health	Office and laboratory space, including IPF	NA	34 895	UPEI
Life Sciences (NRC-IMB)	Land	1966-2065	Not applicable	Dalhousie University
Life Sciences (NRC-IBD)	Office and laboratory space in two locations	No specific end date	10 000	Hospitals: QEII and IWK
Information Technology/ E-business (Moncton)	Office and laboratory space	2006-10	5 455	Université de Moncton
Information Technology (Fredericton)	Land	2003-43 with 40 yr renewal period	Not applicable	University of New Brunswick
Aluminium Transformation	Land	2002-11	Not applicable	UQAC
Sustainable Infrastructure	Office and laboratory space	2004-09	6 856	University of Regina
Plants for Health and Wellness	Land	1945-2008	Not applicable	University of Saskatchewan
Nanotechnology	Office and laboratory space	2006-11 with nine five year renewal periods	139 945	University of Alberta
Fuel Cell and Hydrogen Technologies	Land	NA	Not applicable	University of British Columbia

The administration of real property in cluster regions is based on a federated model. The Administrative Services and Property Management Branch (NRC-ASPM) is responsible for most of the NRC infrastructure (excluding scientific equipment) located in the National Capital Region, but currently does not have a national mandate. As a result, the Directors General of regional Institutes have additional responsibilities to those of Ottawa-based DGs. For instance, regional Institutes are responsible for

ensuring building maintenance and security. NRC-ASPM provides consultative services in some areas, for example in Occupational Safety and Health and for issues related to procurement. NRC-ASPM also coordinates networks of professionals in some of these areas to ensure information sharing across the organization.

One area in which NRC-ASPM is involved regionally is in space leasing. All leases and licenses to occupy space (used in leases of IPF space) must be signed by the Director General of NRC-ASPM. However, property managers in the regions are responsible for leasing activities and report directly to the Institute DG. Some coordination is required to ensure that these activities are aligned and efficient. Overall, this arrangement is thought to be effective by internal stakeholders.

Aside from their administrative responsibilities, regional Institutes also ensure the longer-term financial responsibility for their facilities. Ongoing maintenance costs related to personnel, equipment purchases, land leases, payments in lieu of taxes (PILT), and utilities are currently covered by CI funding. The use of renewable, cluster funding to cover these costs represents a significant risk in the long term, both for the Institutes and for NRC overall, if this funding is not renewed.

5.3.2 Provision of Laboratory and Scientific Equipment

One of the contributions of NRC to the clusters is the provision of equipment for use by other cluster actors, whether by universities, the private sector, or other R&D organizations. A total of 13 equipment rental agreements have been signed with cluster firms or other organizations since 2001-02, for an approximate value of $94K in rental income. Beyond these, cluster actors also have access to equipment and expertise through collaborative agreements and fee-for-service arrangements. Stakeholders cited the reduction of their own R&D costs as the main advantage of the availability of equipment and services at NRC. Contributions to the purchase of equipment were made by external organizations in a number of initiatives, including Photonics and Fuel Cell and Hydrogen technologies.

Examples of the types of equipment available through such arrangements include, but are not limited to:

- MRI (Halifax, Winnipeg);
- NMR (Charlottetown, Halifax, Saskatoon, Edmonton);
- Mass spectrometry facilities (Charlottetown, Halifax, Saskatoon);
- Electron microscopy (Saguenay, Edmonton);
- Model workshops and model ice tanks (St. John's);
- Microarray scanners (Charlottetown, Saskatoon);
- Computer and informatics laboratories (Fredericton);
- Aluminium forming equipment (Saguenay);
- Plant growth facilities (Saskatoon);
- Pilot drinking water distribution system facility (Regina);
- Water quality laboratory and field equipment (Regina);
- Non-destructive testing/analyzing equipment (Regina);
- Focused ion beam (Edmonton)
- Nanoimprint lithography (Edmonton)
- Hydrogen Environmental Chamber (Vancouver); and,
- Membrane electrode assembly facility (Vancouver).

Recommissioning Components

One of the three MRI scanners currently available to cluster actors in Halifax (IBD) was built using a magnet owned by NRC and no longer used. This enabled the cluster community to have access to this MRI even though it had been unable to raise sufficient funds to purchase a new machine.

In most cases, NRC researchers or technicians operate the specialized equipment, although in some instances, the equipment is operated directly by its clients. One example of this is the friction stir welding equipment in the Saguenay which is currently housed in a private sector firm.

The issue of complementarity between equipment owned by NRC and other cluster actors was mentioned in several regions. Efforts are made in all regions to ensure that equipment purchases do not

duplicate what is owned by other local organizations. One example of this is the synergy between NRC-ATC and the Centre Universitaire de Recherche en Aluminium (CURAL), where both parties work closely to ensure that investments are complementary. Further examples include the communication and consultation process between the various organizations involved in the biosciences cluster (the broader description for the cluster in which NRC-INH operates) ensures there is no duplication between purchases, as well as the agreement between NRC-INH, AAFC and UPEI through which purchased equipment housed in the NRC-INH building may be accessed by key stakeholders, as well as firms in the region. Similarly, NRC-INH was specifically designed without animal modeling facilities as there are such facilities at the Atlantic Veterinary College that are accessible to NRC-INH researchers.

Although many stakeholders consulted indicated that NRC equipment and facilities are used extensively in particular communities, a few exceptions were noted. For example, the Hydrogen Environmental Chamber in Vancouver, valued at $2.13M (to which NRC contributed $1.64M) and requested by the community, has been used approximately 100 days in three years, despite a marketing study conducted in 2007-08. Efforts are currently underway to recruit individuals responsible for leasing this infrastructure to firms and other cluster actors.

Finally, it should be noted that in instances where NRC Institutes receive both core (A-base) funding as well as cluster initiative funding, resources are sometimes pooled to acquire equipment of use to NRC researchers as well as other cluster actors. Even though these purchases are not outlined in detail here, they are a noteworthy example of the way in which Institutes work towards the achievement of their clustering goals.

5.3.3 Contribution of Infrastructure to Cluster Development

As described previously, the CIs have had a significant impact in terms of increasing NRC's presence across Canada. Currently, the distribution of NRC research space in the National Capital Region as opposed to that in other parts of Canada is just above 50 percent[44]. Even though not all of NRC's regional facilities are associated with the CIs, they nonetheless constitute a major contribution to the development of NRC activity in ten Canadian provinces. The added investment by NRC in this infrastructure, notwithstanding NRC-IRAP's existing national presence, reflects a coming of age of the organization as a truly national entity able to more widely serve the needs of Canada, particularly Canadian industry.

Beyond the physical space that the NRC facilities provide in cluster regions, one of the key impacts of this infrastructure on the cluster communities is the branding that these buildings provide for the region, both for NRC and for the cluster in general. These facilities are often considered to be the focal point of the cluster and increase awareness of the federal government's presence in these regions.

The presence of NRC in the regions is seen by stakeholders as highly positive and necessary in ensuring continued cluster development. In fact, the extent to which external organizations were willing to invest in NRC infrastructure demonstrates a considerable level of stakeholder support for the investments made by NRC in infrastructure and the value of these facilities to the clusters. One example of the value of the equipment made available by NRC was expressed by one respondent in the Life Sciences cluster initiative: *"I don't think we could have brought those instruments here without NRC."*

In the words of some industrial stakeholders working in the fuel cells and hydrogen cluster:

> *(…) from [name of the company] perspective, three years ago we wouldn't even contemplate doing something outside of our laboratory. We have a very significant infrastructure and capability. But NRC has found a way to find these niche applications, if you will, in terms of their environmental chamber where we now, to many degrees, rely on that facility. I know many other smaller companies who don't have the infrastructure capabilities there, they found the right niche to do that.*

[44] Figure provided by NRC-ASPM.

NRC-IFCI is a facility that any one company by itself would be unable to build, but that many companies have a need for.

Attraction and Retention of HQP

CI funding was used in Saskatoon to hire individuals to work on the Plants for Health and Wellness program using term positions associated with specific research projects. This enabled the Institute to hire individuals with the skills and expertise required for each project. Some of these individuals have since been hired on a continuing basis by the Institute using revenue funds.

5.3.4 Summary of Findings: Development of Specialized Infrastructure

One of the most significant ways in which the CIs contribute to the development of their respective clusters is through the provision of facilities and equipment to cluster stakeholders. A number of the CIs have supported the development of specialized infrastructure through the establishment or expansion of facilities as well as the procurement of specialized equipment that is used by other cluster actors. Overall, these are seen as a positive contribution to cluster development and in many cases, speak to the unique role of NRC within the cluster regions.[45] The NRC facilities are often considered a focal point in cluster regions, and help to generate awareness of the presence of the federal government in these areas. However, certain issues should be addressed by NRC to ensure long-term maintenance and sustainability of the facilities.

5.4 Effectiveness and Performance in Supporting the Development of Highly Qualified Personnel

→ *Have the CIs supported the development of highly qualified people?*

The cluster initiatives have been instrumental in attracting new personnel to NRC as well as students and visiting workers interested in working on cluster-related projects. NRC researchers have also played an important role in training students, either through teaching activities or through thesis supervision at local universities. The specific role of the cluster initiatives in supporting the development of highly qualified personnel is described in more detail in the sections that follow.

5.4.1 Attraction of New Staff to NRC

CI funding was used in several instances to hire research officers, technical officers, students, and other individuals to work on cluster-related projects. In total, 490 individuals were hired by NRC between the fiscal years 2001-02 and 2007-08. Of these, 283 were hired on a continuing basis while 207 were funded for a shorter term.[46]

The use of term and continuing positions to recruit initiative staff is shown in Figure 5. The figure shows that when the Atlantic Initiatives were first launched, a greater number of continuing positions were created and staffed; over time, this has changed to a point where, although the numbers of continuing and term positions are now relatively similar, recent years have seen a higher number of term positions filled. This trend may indicate that some Institute positions related to the cluster initiatives were filled initially on a continuing basis, and more temporary positions have been filled recently to fill gaps identified by the cluster initiatives as they fulfill their mandates.

[45] Ibid.
[46] Thirty-three positions were unidentified in the performance data submitted by the initiatives.

Figure 5: Comparison of New Hires in Term and Continuing Positions per Fiscal Year

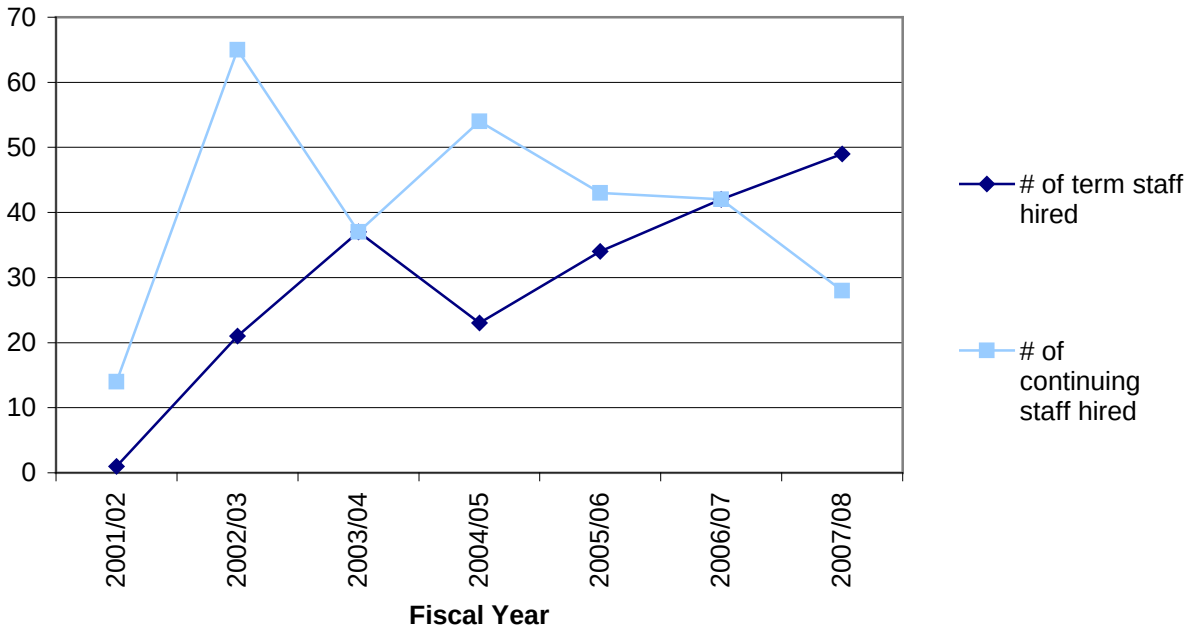
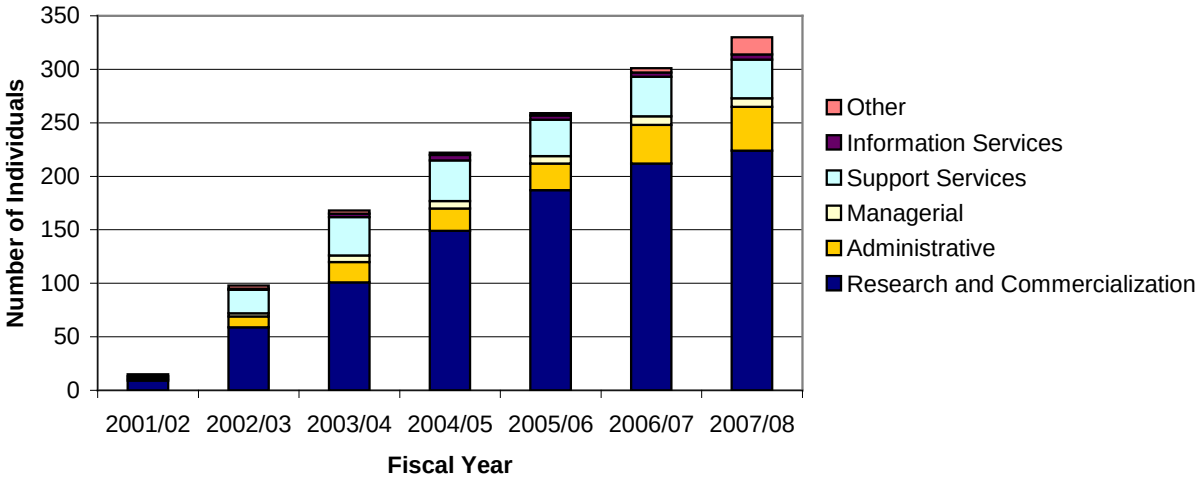


Figure 6 presents the new cluster initiative NRC hires (in a cumulative model) up to fiscal year 2007-08. The categories used in the figure summarize the classification groups used by the Human Resources Branch. In some categories, classifications with similar activities were grouped together to present a clearer picture of the different types of positions filled using cluster funds. The greatest proportion of the new positions created is found among staff classified as Research Officers, Research Council Officers, Research Associates, and Technical Officers[47].

[47] The Research and Commercialization category includes the RO, RA, TO and RCO classifications. Research Council Officers can be involved in research, commercialization, or other work within NRC. Specific divisions within this classification group were not available based on the data collected.

Figure 6: Types of Positions Created Through the Cluster Initiatives[48]



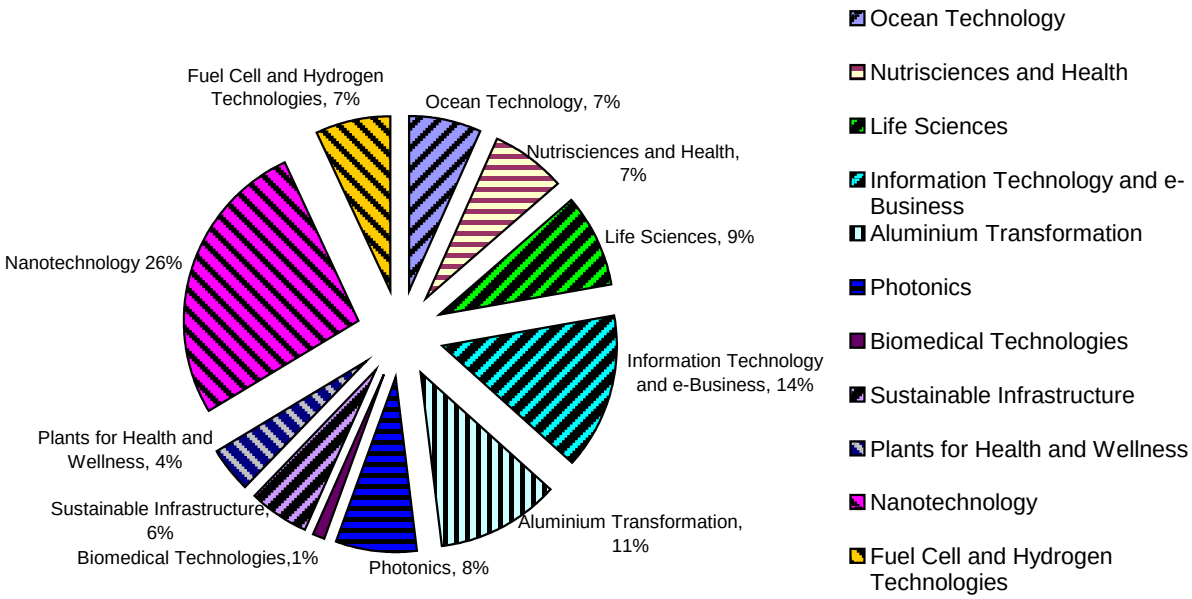
In 2007-08, the positions funded through the cluster initiatives represented approximately 7.5 percent of all NRC positions. The greatest proportion of these was found in the Research Officer group, with 10.9 percent of NRC positions in this classification, followed closely by the Research Associate group at 10.8 percent. The lowest proportions were found in the Library Services classification, at 1.3 percent and the Information Services positions, at 3.6 percent. Management positions created using cluster initiative funds accounted for 5.6 percent of all NRC management positions. Figure 7 displays a snapshot of the 2007-08 cluster-funded positions by initiative. The greatest proportion of new hires was found to have occurred in the Nanotechnology cluster initiative (26 percent), Information Technology cluster initiative (14 percent), and Aluminium Transformation (11 percent). None of the regions associated with these initiatives had an existing NRC facility in place, so it is reasonable to expect that these CIs would have made the largest investment in human resources. Although these data do not represent a cumulative view of individuals hired over the course of the cluster initiative funding, this one-year slice provides a general sense of NRC activities in this area.

Hiring Practices Across Cluster Initiatives

- *Nutrisciences and Health:* All of the individuals hired to work at NRC-INH had previous experience in the private sector, which has facilitated linkages between NRC and industry.
- *Life Sciences:* NRC-IMB consulted private sector stakeholders when developing new cluster-focused positions, to ensure that the individuals hired would be able to meet industry needs.
- *Information Technology/e-business:* A number of researchers, including some referred to as 'rising stars' were attracted to work at NRC-IIT early on. The initiative has also served to repatriate individuals to the province.
- *Nanotechnology:* NINT focused on attracting and recruiting international experts, both from Canada as well as other countries. Some researchers brought students with them to NINT or were able to attract excellent

[48] The categories outlining the different types of positions are based on groupings of NRC classifications.

Figure 7: Distribution of New Hires by Initiative for FY 2007-08



In general, the initiatives do not currently report significant problems in recruiting new staff to NRC, although earlier evaluations had identified some challenges in recruiting in particular regions or specializations (e.g., NINT Director of Research). Stakeholders involved in Charlottetown and Halifax reported that the cluster initiatives have enabled the communities to repatriate some local scientists who were living out-of-province because of their work or their studies. This is seen as a major contribution to the economic development of the Atlantic Provinces; it is believed that the repatriated individuals are not likely to leave the province again due to their personal and professional ties to their respective regions. Another example of the ways in which the CIs have enabled individuals to stay within their home community or to return to it can be found in Ottawa, where many of the NRC-CPFC hires come from Ottawa-based firms caught in the economic downturn of the ICT sector. In fact, increasing demand for the services of NRC-CPFC has resulted in the addition of a second shift, contributing even further to the ability of the Centre to retain local talent.

Two exceptions to this trend are the Saguenay and Regina-based cluster initiatives, where attraction and recruitment have been more difficult due to specific regional features. In the Saguenay region, local cluster attributes (e.g., language requirements, distance to main urban centres, etc.) may have decreased the size of the potential pool of HQP specialized in aluminium transformation. In Regina, significant difficulties were experienced in terms of attracting human resources already established in the region due to the fact that the University of Regina does not have a Faculty of Civil Engineering from which students and researchers might have been recruited (although the university offers connected engineering programs in environmental systems, electronic systems, computer systems and industrial systems and the University of Saskatchewan has a large and well-established civil engineering program that serves the entire province). Other issues raised by stakeholders included the fact that sustainable infrastructure is a relatively new technological area, and that there currently is a strong demand for engineers in the energy sector. In the words of one respondent, *"The HQP in the region are focused on other areas of research. Our objective is to make them change their focus or to use their talent differently."* The difficulty associated with attraction and recruitment of personnel is demonstrated by the fact that the initiative was unable to utilize a large portion of its available CI funding to undertake all of its planned operations and staffing activities in its first few years. Both initiatives are becoming more stable, however, as efforts continue to attract and retain HQP in their respective regions.

5.4.2 Visiting Workers

One of the ways in which the cluster initiatives also have been able to attract HQP is through NRC's Visiting Worker Program, which allows Institutes to host scientists for a pre-determined period of time. Visiting workers may be university or industry researchers on sabbatical leave, industrial collaborators engaged under the terms of a collaborative agreement, retired NRC staff, or students. Over the course of the evaluation period, NRC has hosted 404 individuals in relation with its cluster initiatives. The consideration of Visiting Workers is particularly important when studying the impacts of the cluster initiative funding, since the influx of these workers increases the research capacity of NRC in the cluster areas. Indeed, some stakeholders referred some these workers as the best scientists in their fields and as 'magnets' for other HQP. This speaks to the relevance of the technology areas selected for the cluster initiatives and the engagement of the community in the research aspect of clustering.

5.4.3 Involvement of Other NRC Staff (Not Funded Through the Cluster Initiatives)

In addition to the positions funded through the cluster initiatives, some of the positions funded with Institute budgets have also contributed to cluster-related activities. A total of 129 full-time equivalent (FTE) positions have been dedicated to clustering since 2001-02. Data provided by the Institutes show that an increasing amount of staff time funded through the A-base (core) budget is spent on activities associated with the cluster initiatives.[49]

It should be noted here that in several cases, the involvement of staff funded through the A-base budget is not specifically included in the performance data submitted for the cluster initiatives. In cases where the Institute is closely integrated with the initiative, the activities of many, if not all A-base staff members have the potential to contribute to the development of the cluster. The case of NRC-IMS can be offered as an example. As described by an evaluation participant about the role of NRC-IMS in relation to NRC-CPFC, "*IMS represents basically the 'brain trust' where an awful lot of the ideas are.*" This individual went on to say:

> *To me, the ability for CPFC and actually some of the companies to make the turns that they have in the last five to seven years…to some extent has a path that leads through CPFC to their larger group of friends inside IMS because of the knowledge base.*

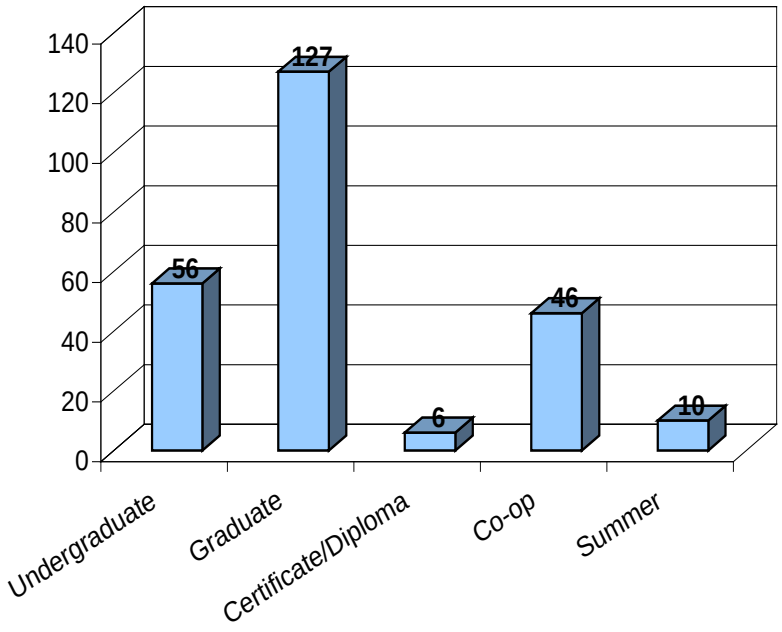
Given the ideas expressed above, and the general understanding that all of what NRC has to offer to a region can contribute to overall cluster growth, the estimate of 129 FTEs does not likely due justice to the real contribution of the greater part of the Institutes.

5.4.4 Contributions to Student Training

In general, NRC was perceived as a magnet for HQP in the cluster regions. Students and visiting workers, in particular, enable knowledge transfer from NRC to cluster firms and other organizations. By providing students with access to NRC laboratories and expertise, students have the opportunity to develop in a broader context and to get more exposure to a variety of scientific problems. Overall, 245 student positions were funded through the cluster initiatives, with most students spending more than one year at NRC.[50] Figure 8 displays the breakdown of students funded by level.

[49] The data used in the chart do not include NINT, because it did not use A-base funding to support positions, nor does it include Plants for Health and Wellness and Oceans Technology due to the unavailability of data in this area.
[50] Only students who received funding directly from the cluster initiatives are included in this calculation. Other students, who may receive funding from the institutes, granting councils, or other sources, are not included here even though they may contribute to cluster-related research activities.

Figure 8: Student Positions Funded Through the Cluster Initiatives



Interviews conducted with students as part of the evaluation identified a number of advantages to students working or studying at NRC: Students explained that conducting their research work at NRC provides them with access to equipment they would not have at the university, exposes them to multi-disciplinary research teams focused on common goals, and gives them access to networking and training opportunities held on NRC grounds, such as seminars presented by NRC researchers. In some cases, students spoke highly of the opportunity to work in cluster firms or hospitals through various NRC agreements. Another advantage cited by students which speaks to the unique experience provided by NRC is that their experience allows them to develop skills valued by industry, and thus facilitates their transition from academia once they complete their studies. As stated by one professor, *"And so I think that the environment they're in is actually richer than the one we provide..."*

In addition to the knowledge transfer that occurs when HQP participate in NRC projects (whether they do so as students, visiting workers or other temporary staff), NRC researchers are also heavily involved in their respective cluster communities in terms of training the next generation of scientists. In all eleven initiatives, NRC research officers were found to contribute to student training in local universities, where they are involved in teaching courses and/or supervising student theses. One case study conducted as part of the evaluation focused specifically on student training by NRC researchers in New Brunswick. The case study, detailed elsewhere, highlights the contributions of NRC-IIT researchers involved with local universities. In general, NRC researchers have obtained the status of adjunct professors at the universities and are heavily involved in student supervision as well as teaching courses or seminars. Several researchers were professors in these universities before joining NRC and have maintained close relationships with their former organizations through this mechanism. The amount of time spent by NRC researchers on teaching or student supervision varies by individual: some have estimated it to range from ten to 20 percent of their total work time.

Training the Next Generation of MRI Technicians

In response to the increasing focus on biomedical devices, including Magnetic Resonance Imaging technology, the Winnipeg-based Red River College has developed a special program to train MRI technicians. NRC-IBD researchers teach the courses in this program and thus make a contribution to the training of HQP in their region that goes beyond the more typical university course.

The case study identified significant benefits to NRC, the students and the universities: NRC is able to identify and recruit new hires from the student base and take advantage of funding opportunities available to university researchers; the universities increase their pool of available course offerings and thus gain a competitive advantage over other schools; students gain access to NRC-IIT laboratories and are exposed to new areas of research. Some of the challenges that have been encountered in these arrangements include cultural differences between organizations, which can pose communications issues between parties, and a moderate research capacity in some universities. These challenges, however, have been overcome in recent years.

Various models are in use currently to compensate NRC for the time spent by researchers on teaching or supervisory duties. There is no NRC-wide policy on adjunct professorships or cross-appointments; decisions are made at the Branch or Institute level. Given the extent to which NRC research officers are involved in university life, it may be beneficial for NRC to consider putting in place some general guidelines identifying the maximum proportion of time to be spent on these activities as well as the proper compensation models (for the individuals and for NRC).

5.4.5 Influence on Cluster Research Capacity

The influence of NRC extends beyond its own walls into the cluster community. The evaluation found that in many instances, the NRC cluster initiative provided the impetus for other organizations to mobilize their resources in the technological area of the CI. Some examples of these activities include the following:

- Holland College has launched a bioscience technology diploma program to train technicians to meet the needs of local firms and organizations in the biosciences cluster;
- The Marine Institute of Memorial University established a School of Ocean Technology in 2007 with $1M in funding support from the provincial government;
- Carleton University in Ottawa received $3.125M from the Province of Ontario for a photonics training program; and,
- CMC Microsystems, housed on NRC grounds, provides access to the NRC-CPFC for university researchers and students who otherwise would not be able to obtain services from the facility.

These examples reinforce the relevance of the technological areas of the cluster and can be considered an indicator of continued need for HQP in these areas. In addition to this, the evaluation found evidence that the presence of NRC itself in a cluster region had an impact on the ability of universities to attract HQP. One stakeholder in the Fuel Cells and Hydrogen CI described it in the following way: "*At [university], it is hard to attract good high level PhD students. The presence of NRC-IFCI facilitates the recruiting*." This was also found to the be the case at NINT, where stakeholders stated that: *"There is no doubt that having this cluster here brought some high-powered talent to the University of Alberta that would not have come here"* . Interviewees also raised the importance of the infrastructure NRC brings to the region in ensuring high quality researchers are attracted to NRC as well as to other organizations and firms in the region. *"The… people don't come and stay in areas where they can't do interesting, cutting-edge research and without these instruments we wouldn't have some people here."*

5.4.6 Summary of Findings: Development of Highly Qualified Personnel

The cluster initiatives were found to support the development of highly qualified personnel (HQP) through retention and attraction of personnel to the cluster regions and through the contributions of NRC staff to training in other organizations. CI funds were used to support continuing and term positions, and NRC researchers were found in all eleven initiatives to contribute to student training in local universities, where they teach courses and supervise graduate students.

5.5 Effectiveness and Performance in Developing Leading-Edge Knowledge

→ *Have the CIs supported the development of leading-edge knowledge?*

The cluster initiatives support the development of leading-edge knowledge in a variety of ways. Most notably, the scientific activities conducted by NRC researchers contribute to this outcome area, as well as collaborative research activities undertaken with cluster partners. These two mechanisms are explored further in this section.

5.5.1 Leading-Edge Scientific Activities

Although scientific excellence was not specifically assessed in this evaluation study, evidence pertaining to leading-edge scientific activities conducted within the scope of the cluster initiatives was nonetheless identified through stakeholder consultations and other methods. The funding provided through the CIs has enabled the creation of new NRC initiatives in advanced fields such as photonics and nanotechnology, and has supported leading-edge research activities in existing areas of competence, such as plant biotechnology, ocean technology, and biodiagnostics. In the words of one respondent from the biosciences cluster, *"I think what this place represented [for the] province [was] a kind of industry-related, high level world-class research. It hadn't existed in the past."*

One particularly salient example of how the CIs contribute to leading-edge scientific activities is found at NINT. One of its research groups, focusing on Molecular Scale Devices (MSD) was highlighted in a case study conducted for the evaluation.[51] The goal of the group is to enable the fabrication of molecular devices, primarily hybrid structures made from organic molecules on the surface of silicon. To build these devices, the group focuses on understanding the fundamental processes that influence their construction and operation. The group also uses tools that allow imaging and manipulation of individual atoms and molecules on silicon, such as the scanning-tunneling microscope (STM).

IT for Cancer Research

NRC-IIT has developed powerful algorithms to help in the analysis of tumor types for the detection of prostate cancer. The project, conducted in collaboration with a cancer research organization, has resulted in the development of new data mining tools that are useful for classification of multiple tumor types using gene expression generated from DNA microarray data.

The researchers within the MSD group were attracted to NINT for different reasons. For many of them, the opportunity to work in an Institute where researchers from different disciplines (e.g., computational chemistry, surface chemistry, physics, engineering, etc.), are working towards the same goals was particularly attractive. In the words of one researcher, "*The opportunity to work with different people who are doing different but related things is very exciting, both within the MSD group, but also in the Institute as a whole*". The researchers also have numerous international linkages, both individually and as a group. Formal linkages are in place with organizations in the Netherlands, Japan, and the United States, and informal collaborations are ongoing with researchers in Poland, Italy, as well as Japan and the United States.

[51] Ekos Research Associates, 2009. Note that the Principal Investigator responsible for the MSD group was unavailable for a phone interview during the development of the case study. The information reported here is based on interviews conducted with the other members of the group.

Although the scientific horizon for this technology is long-term, some short-term successes related to commercialization have already been experienced by the group. Specifically, the group's effort to refine the STM's imaging has resulted in a new and improved microscope, through the development of a tip that improves the quality of the imaging. The tip was originally developed in an effort to further the group's research, but it was quickly realized that microscopy using highly focused electron sources has broader applications.

One important indicator of scientific excellence is the support of NRC research activities by other organizations. Peer-reviewed research grants, in particular, demonstrate the relevance and value of the work conducted by NRC researchers, often in collaboration with other partners. Grants reported by the initiatives total $10.4M since the beginning of cluster funding. In most cases, grants were obtained for collaborative research activities with other cluster stakeholders. The extent to which the cluster initiatives contributed to the development of these collaborations is discussed in a later section.

Beyond the data reported directly by the cluster initiatives, further evidence of grants was obtained for NINT as part of the evaluation process. NINT researchers and their collaborators have received an $8.3M grant from the National Institute of Bioimaging and Bioengineering (NIBIB) of the United States National Institutes of Health (NIH) under its Bioengineering Research Partnership program. The five-year grant will help develop new molecular analysis tools using Raman flow cytometry. These new tools, which will measure the quantity, modification, and function of proteins while flowing in a liquid stream, are considered to have potential for pharmaceutical and biomedical research, including the detection and treatment of microbial pathogens.

More Affordable Solar Panel Cells

In March of 2009 NINT announced advancement in their pursuit of developing a model for cheap and easily manufactured plastic solar panel cells. A team of researchers looked at ways of making solar cells with less expensive materials and in a way that is also much less expensive. Unlike the silicon cells that are currently used in production, a plastic version could be available at lower cost.

5.5.2 Alignment of Research Activities with Cluster Priorities

Aside from the quality and recognition of the scientific activities conducted by NRC researchers, the cluster initiatives should by nature contribute to the creation of leading-edge knowledge that is considered to be relevant to industry. One of the ways in which NRC can ensure industrial relevance is by targeting its research activities to meet the needs of cluster firms or to advance the state of knowledge in a particular technology area deemed important by a cluster. This alignment between NRC research and cluster technology is particularly evident in a number of initiatives. Examples include, but are not limited to:

- **Ocean Technology:** The research conducted at the Institute is increasingly focusing on arctic research. This ties in with government priorities in this area.
- **Life Sciences:** In 2007, NRC-IMB undertook a reorientation of its core research areas based on the Atlantic Initiative Phase II business plan, after consultation with regional stakeholders. This allowed the Institute to better align its program activities and resources to the priorities of cluster companies.
- **Information Technology and e-Business:** NRC-IIT developed its research programs in New Brunswick based in part on provincial priorities in Advanced Learning Technologies and e-Health.
- **Fuel Cell and Hydrogen Technologies:** NRC-IFCI built considerable research capacity in the area of fuel cells in a relatively short time to meet the needs of industry in this sector.

This alignment, however, is not without challenges, especially in cases where NRC researchers are involved in collaborative research activities with other stakeholders, such as NINT. In the words of one respondent, *"We are trying to get researchers within the U of A…to align themselves more with industry*

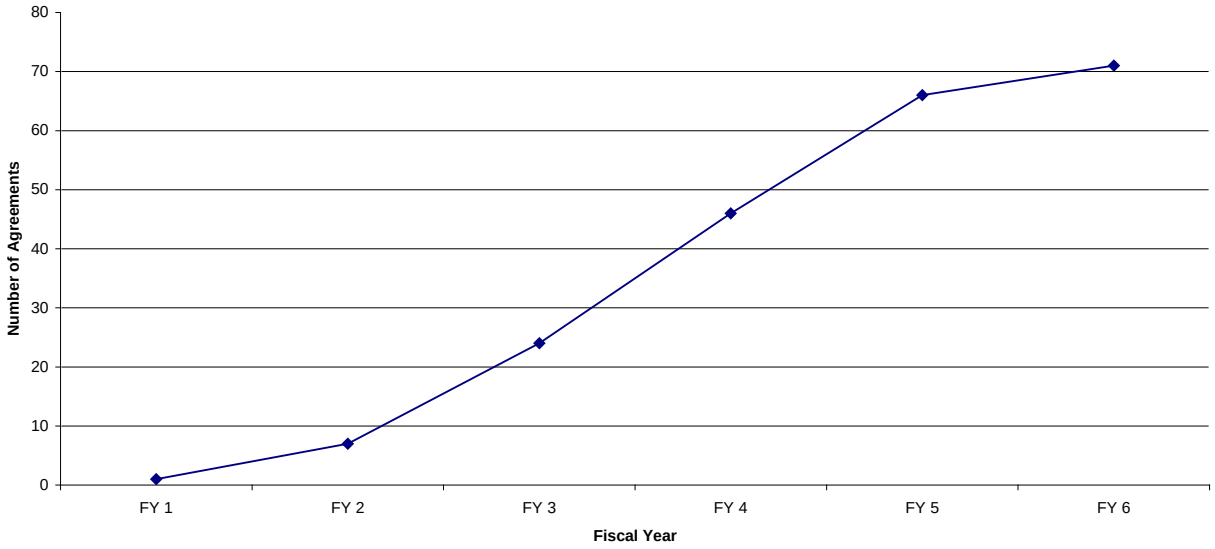
needs that don't necessarily compromise their primary fields of investigation and compromise their ability to decide what they investigate. And that is quite a juggling act."

The need for NRC to conduct research that meets the needs of the various clusters will be revisited throughout the remainder of this section.

5.5.3 Collaborative Research

NRC is engaged in collaborative research agreements in cluster regions as it is in other Institutes not affiliated with a particular cluster initiative. Collaborative Agreements (CAs) are one of the ways in which NRC supports technology and knowledge transfer to the industrial sector. These agreements enable NRC researchers to help firms deal with particular scientific problems. The evaluation found that ten of the eleven CIs are involved in collaborative research with cluster firms (with the exception of NRC-CPFC which enters into fee-for-service agreements only). In total the CIs reported 151 collaborative agreements being signed over the course of the evaluation period.[52] Figure 9 displays the number of 'active' agreements, meaning in progress, for all initiatives combined, per year of cluster funding.[53]

Figure 9: Active Collaborative Agreements



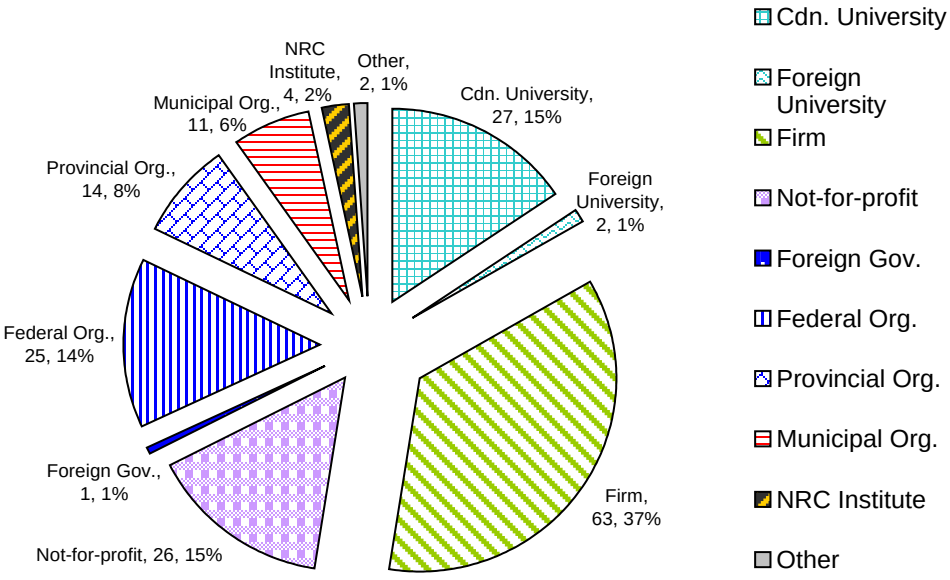
The information presented in the chart shows that collaborative agreements tend to be developed a few years after the initial year of funding, or early implementation of an initiative. This is consistent with the time required to develop new relationships where relevant, and to identify areas of common interest. The type of collaborators most often found in these projects can also be identified from the performance data. Figure 10 presents the percentage of project collaborators for the cluster initiatives by type. The two types of collaborators that NRC most often works with are firms (37 percent) and Canadian universities (15 percent), followed by non-profit organizations (15 percent) and other federal government and provincial government organizations (14 percent each). Few NRC Institutes are typically involved in one another's cluster-funded projects, which may be explained by the diversity found in the technological areas covered by the cluster initiatives. Some examples of interaction between NRC Institutes can be

[52] NRC cluster initiatives were asked to report collaborative agreements supported by CI funds, or associated with relevant cluster activities only. This figure likely under-represents relevant cluster activity by not accounting for other projects undertaken by the A-base portion of an Institute delivering a CI, or other parts of NRC that undertake work in support of a cluster technology area.
[53] Data is shown by fiscal year of implementation rather than by calendar year in order to account for the fact that cluster initiatives began in three separate years (2000-01, 2002-03 and 2003-04). The decision to portray the data in this way is thought to provide a better overall reflection of change in activity over time.

found in the Atlantic Provinces, where NRC-IIT has entered into collaborative agreements with NRC-IMB and NRC-IOT.

Examples of collaborative activities were derived from stakeholder consultations and documents reviewed as part of the evaluation. One example of how NRC has developed a framework to make collaboration more effective is the Collaborative Research and Development Agreement, or CRADA. This document outlines the terms of cooperation between NRC-INH, AAFC and UPEI and may avoid future challenges and allow more efficient and effective collaborations. In Halifax, collaboration between researchers from different organizations is facilitated through the associate professor status conferred upon researchers in the life sciences cluster initiative by Dalhousie University and the affiliated scientist status given to NRC-IBD (Atlantic) researchers by the two regional hospitals. These enable NRC researchers to access resources within collaborating organizations.

Figure 10: Collaborators by Type



Even though the cluster initiatives report collaborative activity with the private sector, one of the main issues identified by stakeholders is the receptor capacity of cluster firms to use research results generated by NRC researchers. In several instances, external and internal stakeholders saw a lack of capacity as an important barrier to cluster development. The research conducted at NRC tends to be seen as highly advanced, and not always directly applicable to the technological problems encountered by small start-up firms. Efforts to engage SMEs in collaborative research continue, with a number of different service offerings that may be more suitable to the needs of these firms.

In addition to the lack of receptor capacity found in some clusters, one of the potential barriers to success in the area of collaborative research involves the ongoing evolution of NRC's research culture in some instances. In the past, the contributions that were traditionally rewarded by NRC focused on high-quality research work disseminated through standard mechanisms such as scientific journals and monographs. While this does not prevent NRC researchers from working with industry, the types of scientific problems often experienced by SMEs do not always translate to the traditional, rewarded means of knowledge production and dissemination. The culture has begun to change in some areas, where changes to the role of the NRC researchers are gradually occurring through a variety of mechanisms, such as the use of Research Council Officer designations for some new cluster research positions (e.g., NRC-IOT), and the

development of alternate programs that enable NRC researchers to spend time working with SMEs on specific, short-term projects (e.g., the Researcher-in-Residence program currently being piloted at NRC-IBD).

> ***Recommendation 5:*** *Provide NRC researchers with the opportunity to learn about the purposes and goals associated with clustering. Adopt strategies that recognize and place value on interactions and projects with cluster firms or firms that are engaged in activities that are relevant to the technology focus of the cluster.*

5.5.4 Intellectual Property

A cross-cutting issue that underpins the development of leading-edge knowledge is that of the management of intellectual property (IP) generated through NRC research. The cluster initiatives were created in part to support the development of leading-edge knowledge at NRC and in other cluster organizations. The ownership or rights to the IP produced are of significant importance to both the Crown and the private sector. For the private sector, the maintenance of IP represents a significant asset for the company.

In total, 35 patent applications have been filed and six patents were obtained since the start of cluster funding. Eleven license agreements have been signed in four of the cluster initiatives and $331K were received in royalties stemming from these agreements. According to the performance data provided by the initiatives, Plants for Health and Wellness was the highest producer of Intellectual Property, with 15 patent applications and two licenses. A close second was Information Technology and e-Business, with ten patent applications and three licenses.[54] The latter is particularly interesting given the findings of a recent New Brunswick-based asset map exercise in Information Technology, which identified IP as a major barrier to the development of firms in this sector.

The current NRC IP Policy is typically regarded by cluster stakeholders as a barrier to the development and dissemination of leading-edge knowledge. According to some individuals, the policy limits the potential of technology transfer by focusing on licenses rather than on spin-offs, which may be a more natural means of dissemination for some technology areas. The IP Policy is also perceived as a barrier to the development of IP agreements with large companies who contribute considerable human and financial resources to collaborative research agreements with NRC. This was particularly raised as an issue in the Saguenay, where NRC-ATC works closely with companies such as GM and Alcan. Some stakeholders have expressed a preference for using fee-for-service agreements as opposed to collaborative agreements because of their perceptions of the IP Policy. One respondent outlined how, in general, stakeholders recognize the importance of working with NRC, but highlights the need for changes in the IP Policy as well as other agreements:

> *I think a challenge for the NRC, particularly the executive NRC, is to meet some of those new challenges that are being presented by the types of collaboration that are occurring. There is no longer the traditional NRC anymore, right? So with a mandate to support industry, a lot of the IP and agreement types of requirements have to change. And I think they can still go a lot, a lot further, but I think universities, and I think the NRC are a lot more willing to, I guess to cooperate or to make changes to make things happen in the sector.*

A case study conducted at NRC-INH as part of the evaluation describes the IP Policy of the Government of Canada and illustrates the potential impacts of the policy on industry:

> The Government of Canada's current IP policy is complex. It also provides significant scope for interpretation. Over the years and in various circumstances some have interpreted the policy to mean that any IP that is developed in partnership with NRC researchers becomes the property of

[54] The extent to which each patent or license is directly associated with the cluster funding was assessed by the reporting Institute.

> the Crown. Licensing and royalty agreements can also form part of collaboration agreements between NRC and other parties. It seems that while it is possible to design collaboration agreements to the satisfaction of all parties involved, success on this front has a great deal to do with the skill and knowledge of the person who negotiates agreements on behalf of NRC. In the case of the NRC-INH industry partnership facility, a number of mutually satisfactory agreements have been reached. There was strong agreement among the NRC-INH's IPF client representatives that participated in the development of this case study, however, that the federal government's IP policy could be a significant obstacle to future private sector-NRC collaboration, because of the way some companies perceived favouring the Crown to the detriment of companies. There was strong agreement that the policy should be reviewed and modernized, particularly with respect to the non-exclusivity on IP licensing agreement: *"I know some business people who say they would never work with NRC because of the IP ownership rules."*[55]

The issue of the IP Policy was raised in previous evaluations of the cluster initiatives, as well as other evaluation studies. NRC is currently in the process of implementing a revised policy. Under this proposed revised IP policy, NRC may have more discretionary power to make decisions about IP ownership. Further, NRC and the client(s) may share costs and may both have personnel working on the same project. Finally, licensing or ownership terms would be negotiable by the parties involved with a variety of potential arrangements at their disposal.

5.5.5 Summary of Findings: Development of Leading-Edge Knowledge

The CIs support the development of leading-edge knowledge in a variety of ways. In general, evaluation stakeholders agreed that there had been a positive change over the length of cluster initiative funding in terms of technological development and transfer, and partially attributed this change to NRC.[56] However, the extent to which the CIs support the development of leading-edge knowledge was found to vary across initiatives, given the lack of receptor capacity found in several regions and the specific technological focus of each cluster. Another issue raised in some initiatives focused on the research culture of some initiatives, where a focus on the needs of SMEs has not yet clearly been established. A recommendation to provide NRC researchers with the opportunity to learn about the purposes and goals of clustering was made to address this issue. An update to the NRC Intellectual Property Policy may give NRC more flexibility in dealing with the private sector over collaborative agreements.

5.6 Effectiveness and Performance in Fostering the Development of Innovative Firms

→ *Have the CIs supported the development of innovative firms and industries?*

The importance of the private sector to the ongoing economic development of Canada is highlighted in the 2007 federal Science and Technology Strategy, which states:

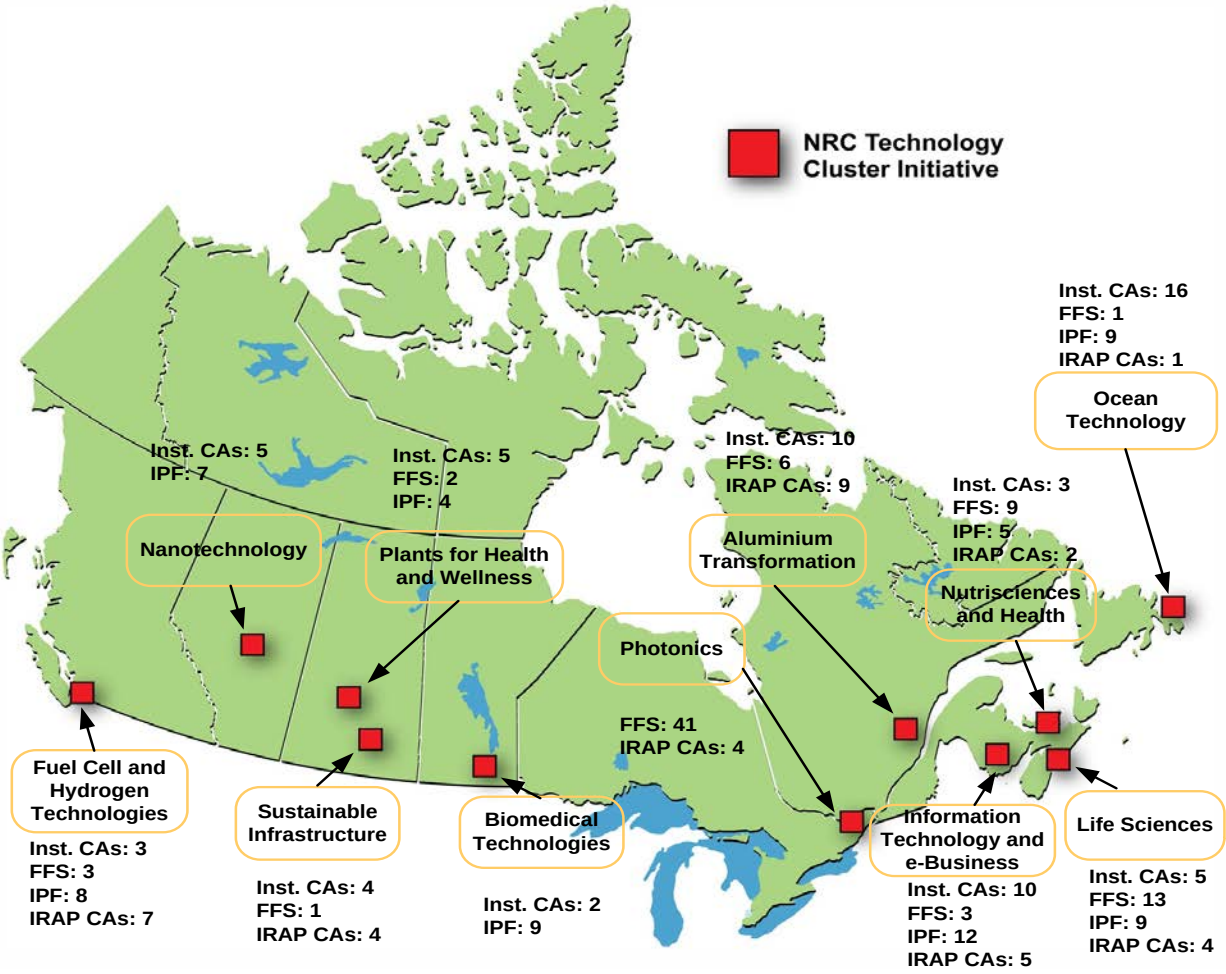
> The for-profit private sector plays the central role of translating knowledge into goods, services, and technologies for domestic and global markets. Firms invest in R&D to generate new products, services, and process improvements. And it is the private sector that builds the innovative and competitive companies that win on the world stage. Their ability to bring innovations to market requires foresight, risk-taking, and creativity in the adoption and use of advanced technologies.[57]

All of the previous sections of this report dealing with effectiveness and performance touch on areas of NRC activity that are meant to support the private sector in achieving success. However, direct and longer-term support to firms comes primarily via the collaborative research undertaken by NRC Institutes

[55] Ekos Research and Associates, NRC Technology Clusters Evaluation Case Studies.
[56] Based on qualitative questionnaire administered during discussion groups.
[57] Mobilizing S&T to Canada's Advantage, p. 35.

in partnership with them, via the interactions between these firms and NRC via tenancy in an IPF, or via support for R&D provided by NRC-IRAP. Based on information provided, Figure 11 provides a sense of the number of firms that have accessed these different mechanisms up until 2007-08. This information is provided in relation to cluster resources only for NRC Institutes and does not necessarily capture their broader reach as a result of contributed A-base resources, which represent a substantial additional investment in the identified technology areas.

Figure 11: Level of Firm Interaction with Cluster Initiative Resources



Inst. CAs – Institute Collaborative Agreements
FFS – Fee For Services and Service Agreements
IPF – Industry Partnership Facility
IRAP CAs – NRC-IRAP Contribution Agreements

It is worth remembering that NRC was not present or active in selected technology areas in a number of communities prior to 2000-01 (Fredericton/Moncton – Information Technology and e-Business); 2003-04 (The Saguenay region – Aluminium Transformation; Ottawa – Photonics; Vancouver – Fuel Cells and Hydrogen Technologies); and 2004-05 (Regina – Sustainable Infrastructure and Charlottetown, Nutrisciences and Health). Further, most initiatives required two to three years to become fully operational due to construction and resourcing requirements.

The particular ways in which NRC Institutes and NRC-IRAP contribute to cluster objectives are highlighted in the sections that follow.

5.6.1 Contributions to Firm Development – NRC Institutes

Firms are typically seen as being the end users or key targets of the NRC cluster initiatives. Most activities undertaken as part of the CIs, in fact, can be traced back to specific firm needs, whether this is infrastructure, support services, HQP, or leading-edge knowledge. Beyond these outcomes, however, the CIs contribute to firm development in various ways. For instance:

- The services provided by NRC are often not available from other private-sector suppliers;
- NRC helps firms obtain permits (e.g., in the area of fuel cell and hydrogen technologies);
- Technical officers provide training on the use of specialized scientific instruments (e.g., nanotechnology);
- Scientific staff assist firms in interpreting the results of analyses conducted at NRC or elsewhere;
- NRC researchers may mentor firm staff as part of collaborative agreements; and,
- Business development officers often work with firms on licensing or commercialization.

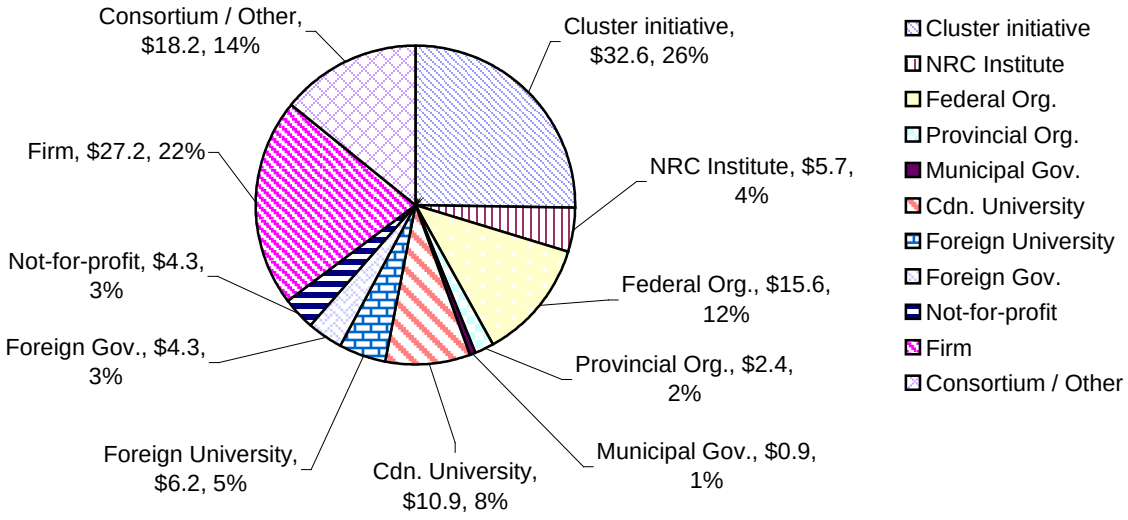
The main ways in which NRC Institutes contribute to the development of innovative firms are the provision of specialized technical services and research collaborations. Although collaborative agreements are addressed in the discussion focusing on leading-edge research (See section 5.4), they also constitute an important mechanism through which NRC Institutes are able to support firm development. Figure 11 on the previous page provides an overview of the extent to which the various initiatives have used their cluster resources to engage in these types of agreements with firms.

Fee-for-service agreements constitute another mechanism for interacting with companies. Data submitted suggest that the Canadian Photonics Fabrication Centre (NRC-CPFC) is the greatest user of this mechanism with over 40 separate service agreements with firms. Specialized services provided to cluster firms on a fee-for-service basis enable them to benefit from the equipment available in NRC facilities as well as the expertise of NRC staff on targeted scientific problems. The NRC-CPFC, by virtue of its prototyping and low volume manufacturing resources in Ottawa, supports clients in their innovation objectives. NRC provides access to advanced technology, which individual companies could not purchase or maintain on their own.

Analysis of data provided on the reach of the cluster initiatives in terms of the number of distinct clients engaging in fee-for-service agreements with NRC indicates that the Photonics cluster initiative has the broadest reach in terms of the number of different clients that it serves, which is a key feature of its mandate and purpose. This is in contrast to the Ocean Technology cluster initiative, which also has a high number of fee-for-service agreements, but which tends to work with the same clients on multiple agreements.

The extent to which different stakeholders contribute to collaborative agreements is shown in Figure 12. It shows that, after NRC, firms are the largest contributor to these agreements. This suggests that these organizations value their collaborative activities with NRC researchers and are willing to invest in the potential outcomes of the research. As shown in the figure, firms have contributed over $27M to collaborative research activities with NRC as one of the collaborators since 2001.

Figure 12: Collaborative Agreement Contributions ($M)



The services and research collaborations through which NRC supports the technical development of cluster firms also have an impact on the ability of these firms to commercialize their products. Stakeholders in the Nutrisciences and Health initiative, in particular, felt that NRC's presence gives credibility to the research being done and that as a result, the firms are more successful in accessing financing: *"…the fact that companies are able to connect with and improve the quality of their product development program by connecting with these scientists makes a huge difference in accessing capital. It kind of moves it from, you know, 'that's interesting' to you know, 'you've got a really, really strong product plan'".*

NRC Institutes also contribute to this aspect of firm development in other ways, described in other sections of this report:

- **Ocean Technology:** Young entrepreneurs program co-delivered with Memorial University; Oceanic contributes to firm development through its fee-for-service activities;
- **Biomedical Technologies:** Biomedical Commercialization Canada (BCC) programming available in the NRC-CCBT; this programming is devoted to firm growth and development and makes use of NRC scientific resources;
- **Plants for Health and Wellness:** BioAccess Commercialization Centre, situated in the IPF and focused on the functional foods and the nutraceuticals sector.
- **Fuel Cell and Hydrogen Technologies:** Testing and evaluation of products; modeling and numerical simulation; prototyping and system testing; sensing and diagnostics.

The support of NRC Institutes in the development of innovative firms was exemplified through one of the case studies conducted as part of the evaluation.[58] This case focused on Marport Deep Sea

[58] Case study developed by Ekos Research Associates, Inc., 2009.

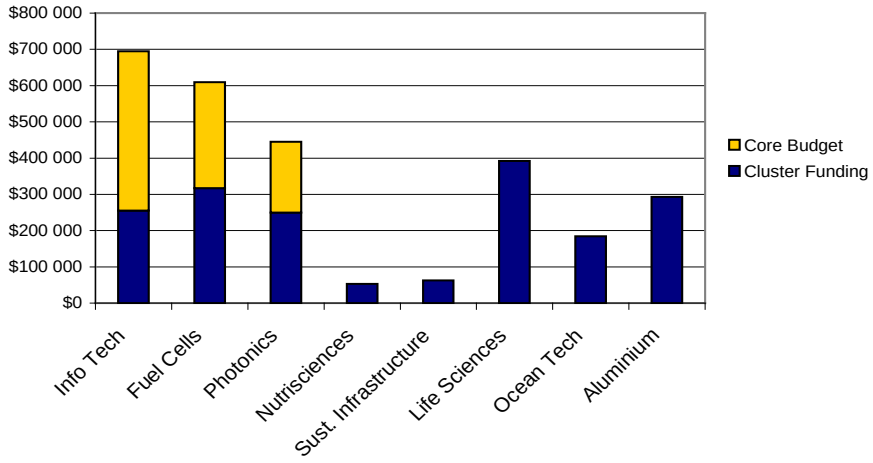
Technologies Inc., a widely held private company headquartered in St. John's, Newfoundland. The company has been in operation since the mid 1990s and specializes in Software Defined Sonar technology and projects for a wide variety of underwater sensing and communications applications. As part of its growth and renewal process, Marport identified a new opportunity to extend its work into the area of Automated Underwater Vehicles (AUV), but did not possess the in-house capacity, experience, and expertise to develop such a product on its own. It sought the assistance of NRC-IOT researchers as well as Memorial University to complement its own strengths. A three-year agreement was signed between the three organizations in April 2008, with a total cost estimated at approximately $1M for the project. The project team was fully integrated, where Marport engineers were able to work alongside a group of world-class experts in underwater robotics. Team members participated in weekly meetings to review progress and address challenges. Design decisions were made collectively and the development process often involves engineers and technicians from the three organizations.

Case study participants expressed confidence that the development of a successful AUV will generate revenue, mainly in the form of clients/sales and licensing agreements. A major US firm has already expressed interest in learning more about the project, and this could lead to a variety of positive outcomes, including sales, joint venture and/or investment. Although it is still too early to gauge the economic success of this new product, Marport representatives commented on the value of what they called the "*intangible*" project benefits, such as the development of a sizeable network of valuable contacts and the synergy and camaraderie that comes from working as a team with people from different organizations.

5.6.2 Contributions to Firm Development – NRC-IRAP

In addition to NRC Institutes, NRC-IRAP has supported the development of innovative firms within the clusters through its core budget as well as cluster initiative funding. The contributions of NRC-IRAP, both financial and otherwise, are generally considered to be critically important to the sustainability of small firms and start-ups, especially at a time where risk capital is difficult to secure. The total contribution of NRC-IRAP to firms has amounted to $2.27M, with $1.28M (or 56 percent) allocated from CI funds and $989K (or 44 percent) allocated from the core NRC-IRAP budget. The breakdown of total funds awarded to each of the initiatives is provided in Figure 13 below.

Figure 13: NRC-IRAP Funding Directed to Cluster Firms



The figure shows that NRC-IRAP provided funding to firms considered to be cluster actors in eight of the eleven initiatives. All eight of these received cluster funding, while firms associated with the Information Technology and e-Business, Fuel Cell and Hydrogen Technologies, and Photonics initiatives also received funds from the NRC-IRAP core budget.[59] The level of investment made in support of firms in a region is both a function of demand, opportunity and available resources.

OneChip Photonics

OneChip Photonics, which has not only benefited from NRC-IRAP funding but which has also used the services of the NRC-CPFC, has achieved particular success with a recent announcement of an investment of $19.5M in venture capital financing. This privately owned company, headquartered in Ottawa, develops and manufactures low-cost, high-performance optical transceivers for access networks and other mass-market broadband applications.

A case study illustrating the impact of NRC-IRAP support on the development of a cluster firm was conducted as part of the evaluation. This case focuses on DPoint Technologies, a privately held Vancouver-based company specializing in the development and supply of heat and humidity exchangers for Fuel Cell Systems and Energy Recovery Ventilation (ERV). In 2006, DPoint entered into a long-term license agreement with Ballard Power Systems, under which DPoint acquired the rights to Ballard's humidification patents and humidifier designs.

Since its inception, DPoint Technologies has received approximately one-quarter of its NRC-IRAP funding through cluster funds, and the remainder of the Program's contribution was provided through its core budget. The NRC-IRAP funding supported the hiring of additional staff and technical expertise. In fact, since 2004, DPoint has grown from a three-person company to currently employing 13 engineers. In addition to the financial support provided by NRC-IRAP, the Program's Industrial Technology Advisors (ITAs) helped to ensure that DPoint had the proper business strategies in place, and have put the company in contact with other experts in the areas of fuel cell and ERV market intelligence and intellectual property.

5.6.3 Main Barriers to the Development of Firms

Even though the NRC cluster initiatives have contributed to the development of innovative Canadian firms, significant barriers have been encountered by NRC and firms in this area. One of the most important barriers pertains to the receptor capacity of SMEs for NRC-developed research and technology.

[59] NRC-IRAP reported data based on allocated funding. It is likely that the data reported here underrepresent the extent to which the Program has contributed to the development of cluster firms, due to cluster funding being only provided to NRC-IRAP in Round 2, Phase 2 of the initiatives.

This point is addressed in section 5.5 of the report. In addition to this, other barriers identified by stakeholders include the following:

- **Lack of investment capital**: The consequences of low investment levels in SMEs are exemplified in some of the comments made by one stakeholder of the life sciences CI*: "I think there's a lot of good work that maybe doesn't get done as quickly as we would like to see, especially in terms of commercialization because there are gaps in funding along that line."* This is particularly relevant to firms that are too small to qualify for venture capital, but require continued funding to survive, or firms that are in areas characterized by slow development periods due to regulatory processes (e.g., biomedical devices and functional foods and nutraceuticals).

Saponin Inc.

This company was built using technology developed at NRC-PBI and has applications in the areas of cosmetics, food and beverages, drugs, and others. It received $2.2M in venture capital in 2006 and at one time, employed 13 individuals in its laboratories and offices situated in the NRC-PBI Industrial Partnership Facility. Although the company has recently suffered in the wake of the economic downturn, the contributions of NRC to its development were highlighted by one company executive: *"NRC can take credit for the fact that Saponin would not have existed at all without this program having done research in some of the different species of plants that could be hosts for molecular farming".*

- **Disconnect between the state of development and needs of firms and the work of NRC:** In some instances, SMEs are simply not at a stage of development, or do not have an identified need that is aligned to the interests and priorities of NRC and its researchers. It is not always feasible to ensure a match between SME requirements, which are varied, and the technology offerings of an Institute.

- **Lack of incubation space**: Identified by NRC-INH, this point refers to the fact that the IPF at the Institute is already full and there are no business incubators for the firms who may otherwise be able to move out of the IPF to free up space for new firms.

- **Lack of firms**: In the Sustainable Infrastructure CI, firms are not NRC's key clients. The municipality is the main recipient and user of NRC-developed technology. Firms that are situated in the cluster are mostly in the consulting business, and do not usually engage in collaborations with NRC. In Alberta, with the cluster being described as being in a nascent stage only, there are currently but a handful of companies that engage in relevant activity.

- **Cost of technology**: The high cost of technology development was raised as one of the barriers to the growth of firms in the fuel cells and hydrogen technologies initiative. This includes the cost of the materials used in new products as well as the expenses related to the use of equipment.

5.6.4 Summary of Findings: Development of Innovative Firms

The extent to which the CIs have contributed to the development of innovative firms and industries depends largely on the stage of development of the cluster. With a number of clusters assessed as being in emerging or developing stages of cluster development, expectations in terms of firm development should remain realistic. Further, some initiatives have been launched in regions that are much smaller than others (e.g., the Saguenay vs. Vancouver) with very different economic bases and infrastructure. Nonetheless, specific contributions to firm development are identified in an effort to demonstrate the different ways in which NRC interacts with firms in support of cluster development. In many cases, the contributions and performance outlined here stem from the results identified in other sections as clustering activities are fundamentally focused on economic growth and wealth creation.

5.7 Effectiveness and Performance in Fostering Networks and Alliances

→ *What have been the core strengths and weaknesses of NRC's CI Portfolio?*

The nature of cooperation, as well as the forms it takes in clustering, varies according to a number of factors. Collaboration, defined as alliance-building (rather than the previously used definition of conjoint research activities) is seen both as an activity in which key stakeholders are engaged with one another, and as an outcome of the clustering process. In her work on the evaluation of organizational collaboration, Gadja[60] proposes that collaboration can be conceptualized as a continuum with five levels of integration: networking, cooperating, partnering, merging, and unifying. Although the cluster initiatives are not expected to reach the highest level of integration (unifying), which implies a formal structure, defined leadership, and the relinquishment of autonomy to support one surviving organization, the first four stages of the continuum provide a useful framework with which to measure the extent to which all eleven NRC cluster initiatives are engaged in and have resulted in, inter-organizational collaboration.

Table 8 below provides an adapted version of Gadja's collaboration assessment tool. Specific examples from the eleven cluster initiatives will be used to illustrate the various levels of achievement in collaborative activities.

Table 8: Adaptation of the Strategic Alliance Formative Assessment Rubric [61]

Level of Integration	Purpose	Strategies and Tasks	Leadership and Decision-Making	Communication
Networking	▪ Initiate communication ▪ Identify and create a base of support ▪ Explore interests	▪ Loose or no structure ▪ Flexible, roles not defined ▪ Few if any defined tasks	▪ Non-hierarchical ▪ Minimal or no group decision-making	▪ Communication among all members infrequent
Cooperating	▪ Complete specific tasks ▪ Leverage or raise money ▪ Identify mutual needs, but maintain separate identities	▪ Member links are advisory ▪ Minimal structure ▪ Some strategies and tasks defined	▪ Non-hierarchical, decisions tend to be low stakes ▪ Facilitative leaders, usually voluntary ▪ Several people form "*go-to*" hub	▪ Communication among members clear, but may be informal
Collaborating	▪ Share resources to address common issues ▪ Organizations remain autonomous but support something new ▪ To reach mutual goals together	▪ Strategies and tasks are developed and maintained ▪ Central body of people have specific tasks	▪ Alliance members share equally in the decision-making ▪ Decision-making mechanisms are in place	▪ Communication system and formal information channels developed ▪ Evidence of problem solving and productivity
Merging	▪ Merge resources to create or support something new ▪ Extract money from existing systems or members	▪ Formal structure to support strategies and tasks is apparent ▪ Specific and complex strategies and tasks identified	▪ Strong, visible leadership ▪ Sharing and delegation of roles and responsibilities ▪ Leadership capitalizes upon	▪ High degree of commitment and investment ▪ Communication is clear, frequent and prioritized ▪ High degree of problem solving

[60] R. Gadja (2004). Utilizing collaboration theory to evaluate strategic alliances. American Journal of Evaluation, 25 (1), 65-77.
[61] Ibid, p. 71

Level of Integration	Purpose	Strategies and Tasks	Leadership and Decision-Making	Communication
	▪ Commitment for a long period of time to achieve short and long-term outcomes	▪ Committees and sub-committees formed	diversity and organizational strengths	and productivity

5.7.1 Networking

As the most basic level of collaborative activity, networking involves the exploration of common interests through non-formal outreach mechanisms. Examples of this type of activity found in the cluster initiatives include seminars delivered by NRC researchers (e.g., Biomedical Technologies, NINT) and networking sessions with presentations (e.g., Nutrisciences and Health, Information Technology). Overall, fora or seminars were the events organized most often, closely followed by presentations and workshops.

The extent to which the various initiatives engage in the organization of events for the community varies significantly. In some cases, such as the Biomedical Technologies cluster initiative, the Institute already had established relationships in the region and the presence of other clustering organizations, such as Biomedical Commercialization Canada, meant that there was not a pressing need for NRC to become involved in the organization of networking events. This is in contrast to the information technology cluster in New Brunswick, where the presence of a clustering organization who would take charge of networking activities has not yet been established.

In general, discussion group participants felt that there had been a change in the extent to which they were involved in networking activities since the start of cluster funding, and attributed this change to the presence of NRC in the region.[62] One of the key advantages for stakeholders of these activities is the chance to meet other actors in order to know whom they should contact if and when interesting opportunities arise. In the words of one respondent in the biomedical cluster, *"It's not that you need to work with everybody, but if you do need something, there's always someone you can phone who will know where you can get something done".*

5.7.2 Cooperating

The next level of integration between organizations involves a more deliberate effort in terms of identifying specific tasks to be done and leveraging funds to accomplish this. This level is characterized by a loose coalition of a relatively small group of individuals or organizations with informal and irregular contacts. An example of this type of activity found in the cluster initiatives is the development of a technology roadmap, which is typically led by one organization but steered by a committee of representatives from a few key cluster or sector members. Concrete examples of roadmapping or other types of consultative activities undertaken within the clusters include the following:

- BioFutures roadmapping exercise undertaken by BioAccess in the Western Canadian Functional Foods and Nutraceuticals cluster (2009).
- Building a Health/Life Sciences Information Technologies Asset Map of New Brunswick (2008)
- Advanced Learning Technologies (ALT) Asset Map for New Brunswick (2009)
- Community-led Innovation Round Table, hosted by NRC and the Greater Halifax Partnership (2000)
- Nova Scotia Life Sciences asset map (completed in 2007).
- Canadian Aluminium Transformation Technology Roadmap (updated in 2006).

[62] Based on qualitative questionnaire administered to the discussion group participants.

- Roadmapping in PEI (2000).
- Newfoundland and Labrador Ocean Technology Cluster Map (2008).
- Canadian Fuel Cell Commercialization Roadmap (2003) and Roadmap (updated in 2008).

The evaluation findings point to the ability of NRC to enter into relationships with other organizations fairly easily through either Letters of Intent or Memoranda of Understanding (MOU). These agreements state the interest of both organizations to work together toward common goals, without necessarily exchanging financial resources or in-kind contributions. NRC is generally seen as a strong ally in the cluster communities, and tends to be part of the small groups of organizations that consult one another before undertaking significant work in the technology areas represented by the cluster initiatives (e.g., Wellness West in the Plants for Health and Wellness CI). In this way, NRC is able to assert its leadership where warranted and mobilize organizations that have a similar vision to its own.

In terms of quantitative information, the Information Technology and e-Business cluster initiative leads the initiatives by reporting the most MOUs signed at 66, with 49 distinct organizations. The Fuel Cell and Hydrogen cluster initiative reported 21 MOUs signed with 20 distinct organizations. All other initiatives have signed between zero and six MOUs.

5.7.3 Collaborating

This level of integration is defined by the more formal process that is undertaken to bring organizations together towards a specific common goal. Even though the organizations remain autonomous at this level, specific individuals may be dispatched or seconded to work on common projects from each collaborating organization. This is often the case for collaborative agreements signed between NRC and cluster firms to conduct research that is relevant to specific industrial needs. The extent to which the NRC cluster initiatives are involved in collaborative research is described in section 5.4.3.

The initiatives thought to have reached this level of integration within the cluster are those in which NRC has established long-term, ongoing relationships with a number of different partners and is continuously engaged in pursuing common goals with these organizations. For most of the initiatives, this level represents the ultimate outcome that is to be reached in terms of networking and outreach. It is also one of the ways in which NRC can best influence the direction taken by the cluster as well as its growth. Cluster initiatives that have reached this level include:

- **Photonics cluster initiative:** Of all of the funded initiatives, the activities of the NRC-CPFC place it at the highest ranks in terms of its collaborative activity. NRC-CPFC has been involved in numerous networks, organizations, consortia and fora. Recognized as a support to numerous photonics ‘clusters’, the Centre played an active role in the establishment of the International Photonics Alliance (IPCA), for which NRC received $350K in funding from the Enhanced Representation Initiative (ERI) to support Canada-US interaction and outreach in this area. NRC-CPFC and NRC-IRAP staff also participate in photonics conferences where both NRC-IRAP and ERI funding has helped to fund networking by Canadian firms with international photonics interests.

- **Fuel Cell and Hydrogen Technologies cluster initiative:** In a few years, NRC-IFCI has developed the required research capacity to position itself as a leading authority in Canada in the area of fuel cells and hydrogen. By working with its private sector and university-based partners, it has increasingly been able to mobilize the community and move its activities in new directions. The Institute’s leadership has been successful in establishing these relationships and obtaining support for its own activities.

- **Nutrisciences and Health cluster initiative:** The integration of NRC, AAFC and UPEI in the same building offers the opportunity to share ongoing progress, leverage available resources and

coordinate efforts, as does the proximity of these organizations to the Atlantic Veterinary College (AVC). The provincial government is also highly involved in cluster-related activities and has developed a component of its innovation strategy based on the technological area of the cluster. PEI BioAlliance, the community networking organization, has played a role in developing relationships within the cluster through both informal and formal networking opportunities such as organizing speakers to present at networking lunches. In addition, PEI BioAlliance has coordinated efforts within the cluster to establish links outside of PEI to develop national and international linkages with organizations and firms working in biosciences.

- **Biomedical Technologies cluster initiative:** A great degree of integration is evident from the interactions that occur between cluster actors (both in the private and public sectors). The federal government, provincial government, the private sector and the industry association coordinate their activities and efforts and are represented in all major events. The Director General of the Institute, in particular, has been successful in establishing linkages with other cluster organizations through committee work and other high-profile activities.

- **Aluminium Transformation cluster initiative:** The aluminium transformation cluster is characterized by a high level of representation by various industrial associations, local universities and colleges, the provincial government, and other federal government departments and agencies. The geographic proximity of these parties provides the concrete structure upon which these relationships rest

- **Sustainable Infrastructure cluster initiative:** The integration of NRC, the City of Regina and the University of Regina into a formal networking organization called Communities of Tomorrow (instead of sharing office and laboratory space) offers both challenges and opportunities. There are challenges due to not having the opportunity to share available physical infrastructure and human resources due to immediate proximity. However, without expenditures on a building structure and extensive laboratory space, the limited financial resources allocated to the Regina CI were focused on networking, needs assessment, high-value R&D and developing collaborative projects and pre-competitive technology groups.

- **Information Technology/e-Business cluster initiative:** NRC-IIT has developed close relationships with a number of cluster actors in various technological areas, including advanced learning technologies and e-health. The leadership of the Institute played a critical role in mobilizing stakeholders in the early years of the initiative. The cluster initiative is involved in developing relationships with other information technology clusters and provides opportunities for firms to participate in international missions (e.g., via NRC-IRAP).

- **Ocean Technologies cluster initiative:** NRC-IOT has developed a working relationship with Memorial University over a number of years. The relationship between the two organizations is maintained on several fronts, such as the co-delivery of the Young Entrepreneurs Program, linked to NRC-IOT's IPF, organizing joint research teams involving NRC-IOT, Memorial and a private company, or having NRC-IOT personnel teaching at the University. The Institute also has close relationships with the not-for-profit organization OceansAdvance, with which it shares networking and cluster development responsibilities, and Oceanic Consulting, which undertakes the bulk of fee-for-service work at NRC-IOT, renting the facilities and hiring expertise from the Institute. Both of those organizations are located within NRC-IOT as tenants.

- **Plants for Health and Wellness cluster initiative:** NRC-PBI is the catalyst of NAPGEN, a consortium composed of universities and other research organizations (see inset box below). NRC-PBI, NRC-INH and NRC-IMB have recently formed an NRC Bioactives Working Group to complement and leverage each Institute's capabilities.

- **Life Sciences cluster initiative:** NRC-IBD (Atlantic) is partnering with the Capital District Health Authority as well as the IWK Hospital in Halifax, where the Institute has two research laboratories. Institute researchers collaborate regularly with hospital staff members. NRC-IMB has a multi-partner arrangement for a new NMR facility located within its building.

- **Nanotechnology cluster initiative:** NINT has been closely working with other federal agencies and the Government of Alberta, which is also involved in a provincial "*NanoStrategy*" initiative, to attract and collaborate with multinationals in the field of nanotechnology, with the ultimate goal of commercializing technologies and developing a nanotechnology-based economy in Alberta. Such collaborations take different forms, from conducting technology development projects to the creation of a high-technology products centre.

A New Model for Collaboration

One of the key components of the plants for health and wellness cluster initiative is the creation and maintenance of **NAPGEN**, or the Natural Products Genomics Resource. This consortium of government organizations and universities focuses on the generation of genetic resources that will be employed in the development of new nutraceutical plant varieties to provide industry with a plant platform to develop new products. In addition to NRC, current participants include the Universities of Saskatchewan, Alberta, Victoria, Calgary, Western Ontario, Brock University, the Alberta Research Council, and AAFC. So far, 1.1M Expressed Sequence Tags from 32 species have been generated by the partners and continues to grow.

5.7.4 Merging

This level shows an increased integration between two or more organizations, to the point where a new entity might emerge that is somewhat independent from its organizational sources. This is characterized by a formal management or leadership structure and formal communication processes, much like those found in separate organizations. Although this is not the ultimate goal of many of the CIs, one that might conceptually be expected to achieve this level is NINT, where NRC and the University of Alberta are to be closely integrated. Mechanisms such as cross appointments and project secondments are meant to support a merged state, as is the governance model of the Institute. However, NINT has not yet completely emerged from the fact that both its resources (federal and provincial) and organizational cultures (public R&D vs. university) derive from different sources with diverse priorities and ways of doing business.

5.7.5 Cluster Partnerships

Technology clusters are increasingly involved in partnering with other clusters that have similar mandates and interests. These activities allow clusters to look beyond their own jurisdiction and to access new markets, new potential partners, and complementary research. Examples of these partnerships include the following:

- The PEI bioscience cluster, with leadership from PEI BioAlliance, is currently investigating international relationships and cluster twinning opportunities with bioscience clusters in the United States.

- The fuel cell cluster has been involved, with significant participation and leadership from NRC-IFCI, in developing relationships with other fuel cells and hydrogen clusters in the United States (e.g., throughout New England, New York and along the southern west coast of the US, Europe, Brazil, China, and Taiwan.

- The Winnipeg biomedical cluster has been involved, with significant participation and leadership from NRC-IBD, in developing relationships with other biomedical clusters in the US, New Zealand and

Australia. The main cluster partner currently is Minneapolis, both for geographical reasons and because both clusters share important similarities in terms of expertise and mandate.

- In photonics, the Ottawa-based cluster (Ottawa Photonics Cluster or OPC), is part of an Ontario-based network of clusters all operating under the provincial umbrella of the Ontario Photonics Industry Network (OPIN), which is a member of the Canadian Photonics Consortium (CPC). For its part, the CPC links in not only Ontario but Quebec (Reseau Photonique du Quebec) and British Columbia (British Columbia Photonics Industry Association).

- The New Brunswick information technology cluster has developed a relationship with Stuttgart, Germany, through various missions and activities. NRC-IIT has been closely involved in organizing such events and is currently investigating the development of a MOU with a German company, MFG, to explore potential collaboration opportunities.

5.7.6 Summary of Findings: Fostering Networks and Alliances

The development of networks and alliances between organizations is at the very core of cluster success. In technology development as in other areas of the economy, these activities enable organizations to achieve a vision otherwise not possible when independent entities work on their own. In general, the evaluation findings point to an increase or maintenance in the relationships developed between cluster actors over the evaluation period.

6.0 NRC Technology Cluster Initiative Leverage

One of the key interests of government is that resources provide value for money to Canadians. Canadians should receive good value for their tax dollars and resources should be well utilized, programs delivered in an affordable manner and the costs of achieving outcomes should be minimized.

This section of the report examines the extent to which NRC's investment in technology clustering has played a role in bringing about added partner investment. These added investments may serve to complement and add value to initial activities.

6.1 Use of Resources

→ *Have CI resources been used in an economic manner?*

One strategy for looking at the use of resources, particularly in the case of technology clustering, is to consider the extent to which other parallel investments are being made, both in tangible (i.e., financial) and less tangible (social) areas. In particular, there has been interest expressed in determining the *leverage* of NRC's investment in technology clustering and to assess the contributions made by other cluster members to the clustering effort, in addition to resources expended by the private sector and other organizations in support of scientific innovation.

Reviewing leverage is fundamental when looking at clustering. Despite its importance, very little has been done empirically to assess leverage impacts due to cluster strategies, policies or initiatives.[63] At the nearest, work done by countries such as Finland, in the area of input additionality, have elaborated models that seek to measure the additional investments made by firms subsequent to an initial injection of public funding. The application of similar principles to the larger cluster, including input additionality by both private and public entities, has not been addressed.

As a result, the evaluation sought to establish a model for assessing cluster inputs not only by NRC, but by other sources also, with a view to determining the overall leverage into the cluster initiatives that is focused on growth of their respective technology. The goal was to attempt to qualify and quantify the leverage generated by the CIs. The work was also intended to complement the descriptive portions of the cluster initiative evaluation, with a level of rigour and consistency that would also recognize the differences between the clusters and NRC's CIs. The assessment stopped short however of being able to ascertain broader cluster leverage for each community given the time and resource constraints of the evaluation.

6.1.1 Definitions

The definition of leverage used in the evaluation and its calculation have been informed by the Technology Cluster Secretariat's RMAF data collection process, as well as a review of concepts with a small panel of experts. From this work it is recognized that leverage forces include financial investment, physical capital, human capital, and social capital. The RMAF data collection process defined the CI contribution ratio as: *The ratio of cash and in-kind contributions from cluster actors leveraged against the NRC CI initial and ongoing investments.*

For the purposes of this work, no attempt was made to place a value on the intangible leveraged effects of the cluster initiatives. Instead, the content in the previous sections serves to provide information on

[63] A discussion with a small panel of cluster experts and a literature review revealed that little work has been done to define and measure the leverage effects of clusters.

these aspects. However, where there were calculable investments made, an attempt was made to measure these.

In an interpretation of the RMAF data in a leverage context, CI cluster actors are defined as:

- private sector firms;
- non-governmental organizations (NGOs) including non-profit organizations;
- academic institutions;
- other federal departments; and/or
- provincial and municipal governments.

Cash and in-kind investment from these actors may be in the form of contributions to CI collaborative agreements (CAs), contributions by firms to NRC-IRAP funded projects, or investments into physical, social, or human capital. For the purpose of calculating an overall leverage ratio, in-kind contributions have been translated into an equivalent monetary value and added to cash contributions. The described investments are then assessed against CI investments, which are defined as the summation of NRC CI planned allocations for 2000-01 to 2007-08[64] (including NRC-IRAP) for the same period.

6.1.2 Assumptions and Limitations

Given the nature of the analysis, some assumptions and limitations are worth noting:

- Results of the analysis are heavily dependent on the quality of information gathered through the RMAF data collection process, web/documentation reviews, interviews, and community discussion group sessions. In the event that Institutes or Programs have been unable to provide information on the requested data, or that this was not identified in the community, an impact on the calculated ratios will have occurred.

- Leverage estimates are conservative at best, as they do not capture the full extent of private investment in terms of R&D expenditure, venture and angel investment, or the current value of spin-offs. Nor do they capture the full extent of public sector investments, particularly investments made by granting councils and funding agencies (such as NSERC, CFI or even provincial programs), nor the full investments made by regional economic development agencies such as the Atlantic Canada Opportunities Agency (ACOA) and or Canada Economic Development for Quebec Regions (CED-Q).

- Rather than actual expenditures, planned expenditure values were used as an input to the CI investment value calculation. Variations between planned and actual CI investments would have an impact on the leverage ratios calculated through this analysis.

- The calculations do not take into account the incremental A-base investment made by NRC in almost all of the Institutes delivering CIs (NINT being the only exception as 100% of its cluster funding comes from B-base cluster funding). The estimated value of this A-base investment, excluding internal services, ranges up to $110M/year.[65] The importance of this is that NRC's cluster related activities are likely underestimated.

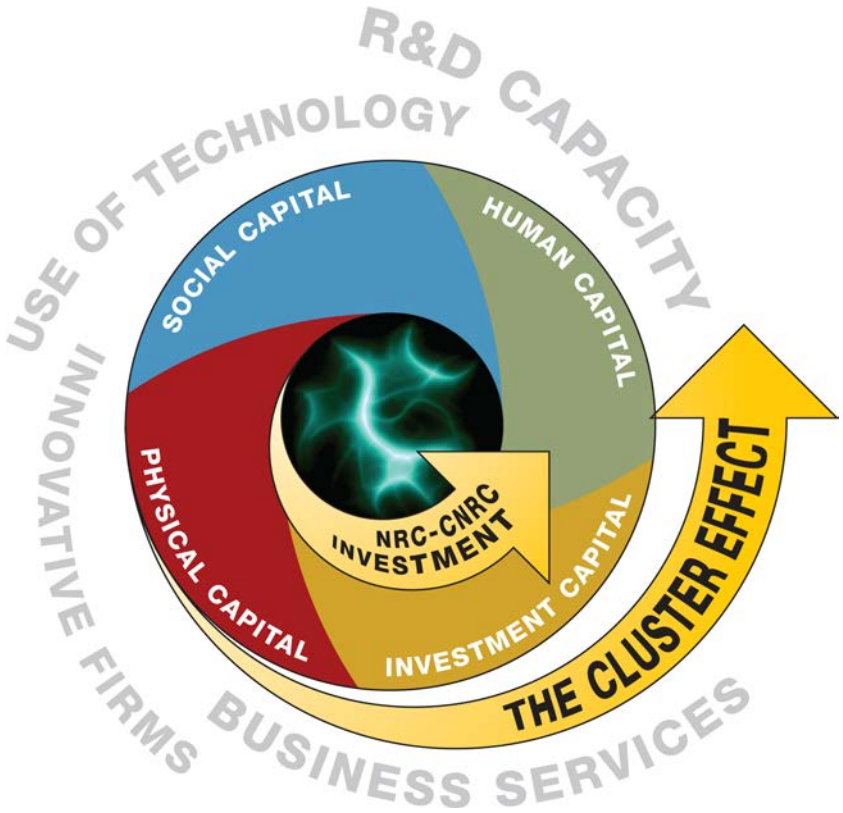
6.1.3 Cluster Effects and Leverage

NRC's regional investments, combined with various forms of local 'capital' interact to achieve expected stakeholder outcomes.

[64] 2008-09 was chosen at the end data as it corresponds to the last calendar year for which performance data was available.
[65] Estimate based on NRC Utilization data for NRC institutes delivering initiatives where CI funding is discounted.

In the context of this evaluation, NRC's investment in the cluster initiatives may have a leveraging effect, with a series of investments in infrastructure, people, knowledge, and collaboration, all branded with the identity of Canada's National Research Council, interacting with locally present capital to generate a larger cluster effect. Figure 14, below, illustrates these interactions.

Figure 14: Cluster Effects and Leverage



These combined elements, resulting in leverage forces of business services, use of technology, R&D capacity and innovative firms, may exist within a cluster at its nascent or early state or throughout its existence.

The local forces include:

- **Investment capital:** Incremental investments made by other federal departments, provincial/municipal governments, academic institutions, firms, non-profit organizations, and industry associations to support cluster activity;
- **Human capital:** Investment in and the development of highly qualified people;
- **Physical capital:** Investment in facilities and specialized equipment; and
- **Social capital:** Investments in networks/alliances and institutions as forums for collaboration and dialogue.

NRC investments in the cluster initiatives, when acting in concert with local capital, result in a series of leverage effects, namely:

- The attraction of regional/national/international investment, defined as the change or velocity of change in investment, physical social and/or human capital;
- The growing use of technology in the form of: sales; exports; commercialization; product lines and licensing;
- A growing capacity for conducting R&D, as demoted by R&D expenditures;
- The growing presence of innovative firms, including the number of innovative firms and the growth of innovative firms; and
- The growing presence of business support services/suppliers, both in terms of number and absolute growth.

Based upon the above conceptual model, the evaluation sought to ascertain the approximate value of the leveraged investments into communities or regions that have cluster initiatives, including not only NRC investments, but those of other collaborators (e.g., other government departments or levels of government), and actors (e.g., organizations, firms).

6.1.4 Observations

An illustration of the ability to apply the model is given in the text box below.

Leverage in Aluminium Transformation

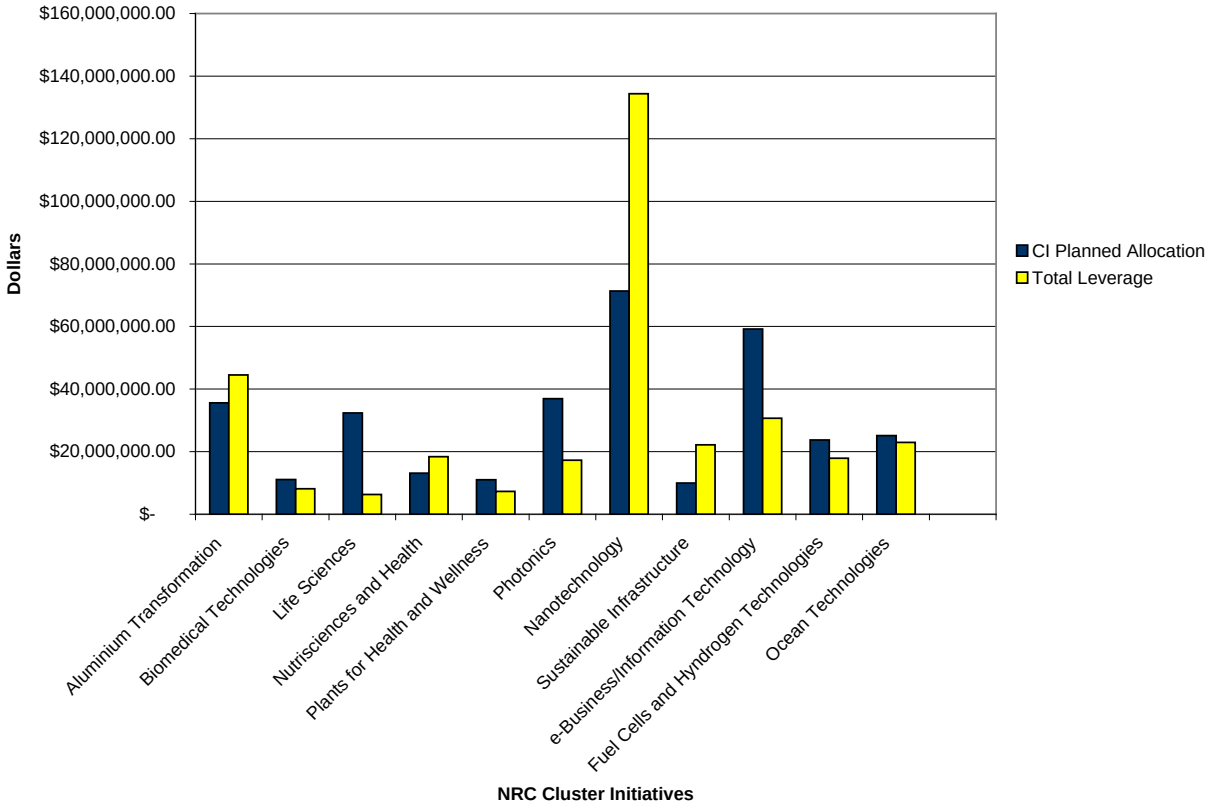
- **Pre-CI Context:** Due to hydroelectric resource abundance and its accessibility via the St. Lawrence Seaway and Saguenay Fjord, as well as proximity to major markets, most Canadian aluminium smelting activities have historically been located in Quebec, the Saguenay Lac-St-Jean region in particular. The CI focuses on the development of secondary and tertiary production of aluminium products.
- **NRC Investment:** The most pivotal element within NRC-ATC is its infrastructure (specialized equipment). Currently, NRC-ATC has specialized equipment on site worth approximately $7M, and on average purchases equipment for $1M annually. Human resources also constitute an important investment by NRC.
- **Leverage Force:** Through six MOUs and 18 collaborative agreements, the CI has tapped into and partnered with the existing human and investment capital in the region, across the country, and around the world.
- **Leverage Effect:** Through the leverage forces outlined above there is evidence of an enhancement in social capital, and collaboration and partnering within the cluster.

6.1.5 Analytical Findings

The analysis of the level of leverage for the various cluster initiatives is provided in Figure 15, below. Again, the concept of leverage compares two main elements: NRC's cluster initiative investment[66] and total levered funds. When looking at this information and analysis, it is very important to keep in mind that it is based directly on reported activity associated with CI dedicated funds and, in many instances, does not capture the full effect of NRC's broader activities in the Institutes (i.e., totaling approximately an additional $110M in investment per year).

[66] CI planned allocations are sourced from the Financial Profile of the NRC Technology Cluster Initiatives. Draft v. 7. May 6, 2009. Figure reported is for 2007-08 in order to compare to 2007-08 performance.

Figure 15: Planned Allocations and Leveraged Funds[67]



Overall, available data indicate that NRC's direct regional investment in the CIs (including NRC-IRAP contribution agreements) from the years 2000-01 to 2007-08 and totaling $342M[68], has resulted in the leverage of more than $330M additional dollars in investment over this same period. Therefore, for every dollar spent in the CIs, almost an equivalent amount has been invested by other cluster actors in everything from infrastructure to research and development.

Data in Figure 15, above, suggest that the greatest degree of leverage has occurred in nanotechnology in Edmonton where the largest investments from partners have been made. Following an investment by the federal government of approximately $71M, roughly $134M has been levered. These funds came in part from the University of Alberta and the Province of Alberta.

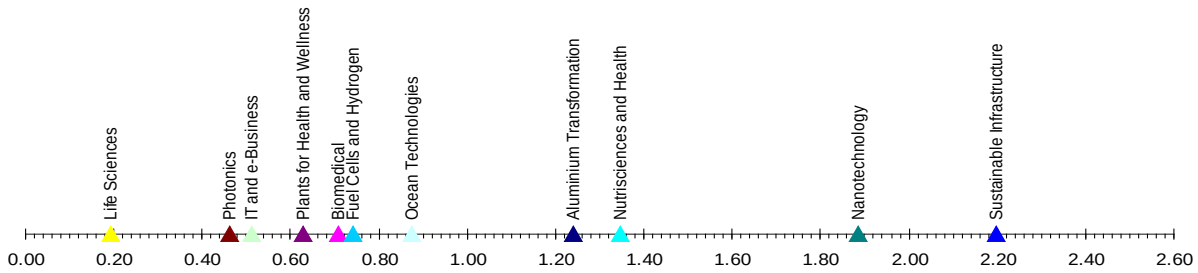
The CI with the lowest level of total levered funds is Life Sciences, with roughly $6M levered against a $32M investment. In the case of Life Sciences, the initiative did not benefit from large infusions of partner resources the way some other initiatives did. This was in part due to the established nature of the Institute at the time of CI launch with already existing infrastructure and people in place.
Another initiative with a low total amount of leverage is Photonics. Notwithstanding its success in attracting business to the NRC-CPFC, these interactions, undertaken as service agreements, mean that

[67] The data for the Life Sciences cluster initiative do likely underestimate the leveraged resources by NRC-IBD Atlantic as RMAF data for its activities was not available for the evaluation. Future efforts will attempt to capture these fully.
[68] This figure includes NRC-IRAP planned expenditures but excludes all expenditures by NRC for Support Services (e.g., Human Resources Branch, Co-ordination Office, Technology Cluster Secretariat, SEC Offices, Overhead, Corporate Functions, Overhead and Property Taxes)

no calculated financial or in-kind contributions are identified.[69] Having noted this, it should be recognized that firms engaging in service agreements or fee for service activity are investing in project activity, although the precise level of investment could not be obtained for this study. The calculation does however take into consideration the support obtained by the Ontario Government for early ramp-up of the NRC-CPFC, funding provided to Carleton University for funding of research projects, other federal funding provided to enhance outreach and international networking, and NRC-IRAP activities.

Based on the data in Figure 15, above, are calculated the following leverage ratios for each the eleven cluster initiatives.

Figure 16: Distribution of Cluster Initiative Leverage Ratios



The significant finding is that in all cases the NRC investment in technology clustering has resulted in investment from other sources in support of the chosen technology area, generally through partnerships or direct activity by firms, academia and other levels of government. Ratios vary from 0.19 in the case of the Life Sciences CI and 0.46 for the Photonics CI (both discussed earlier), to 2.20 for the Sustainable Infrastructure CI.

Sustainable Infrastructure's higher leverage ratio is a function of the relatively low investment point for this initiative (approximately $10M over the five year analysis period of 2003-04 to 2007-08) in relation to the number and high value of community investments being made. For instance, the partnership around Communities of Tomorrow leveraged $20M from the City of Regina, the University of Regina, Western Economic Diversification (WD) and the province of Saskatchewan. Second, NRC-CSIR leveraged resources through its vigorous involvement in collaborative R&D projects with cluster partners and industry. As a result, from 2003-04 to 2007-08, NRC-CSIR established 22 collaborative projects under MOUs that saw investments, both financial and in-kind, reach a value of approximately $4.8M.

The Nanotechnology cluster initiative has a high ratio as a function of the investments being made by the Province of Alberta. The Government of Alberta and the University of Alberta have contributed substantially to nanotechnology in the province.

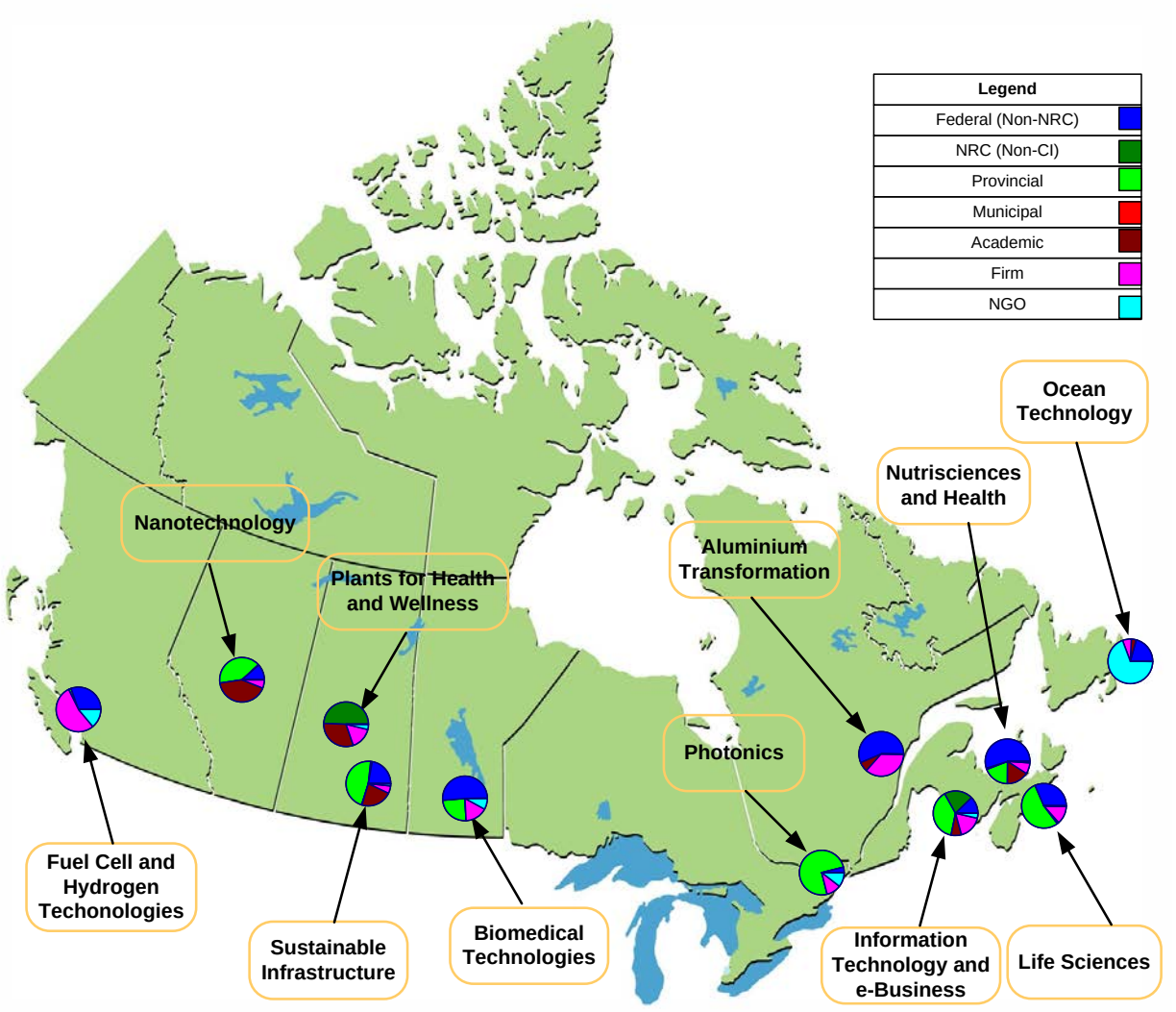
The ratio of the Nutrisciences and Health CI is a function of the investments being made by other partner organizations in the initiative, specifically towards infrastructure. For instance, The Atlantic Canada Opportunities Agency (ACOA) and the Province of PEI invested $8.0M and the University of Prince Edward Island (UPEI) invested $3.5M into the construction of the NRC-INH facility. Agriculture Canada also contributed $2.0M to major capital and UPEI made a $181K contribution to NRC-INH research

[69] Note that fee for service agreements and service agreements, which make up the majority of activity of the NRC-CPFC, were deemed to be excluded as leveraged activity.

equipment. Finally, to date, the CI has signed 11 collaborative agreements, which have contributed a total of close to $5M in activity.

The investments made in these initiatives, and early evidence of investment by firms, universities and others in research activities, are outlined for each of the cluster initiatives in Figure 18, below.

Figure 17: Sources of Estimated Leveraged Investment



Sizeable investments have been made by provincial governments in six of the initiatives with smaller investments in a number of others. Other parts of the federal government are also shown to have been major contributors, such as in the Saguenay, where $25M was provided to help build the new Aluminium Technology Centre.

One of the areas of interest is the investment being made by firms in R&D. The federal government's Science and Technology Strategy highlights the fact that the private sector must offer leadership in S&T:

> *Prosperity requires wealth creation, and wealth creation is the business of business. … In the knowledge-based economy, value is added when knowledge is embedded in new or improved products (goods or services), and that is done through R&D.*[70]

One means of assessing this investment is to consider the level of resources being dedicated by firms to R&D and collaborative research activity. Although the evaluation did not assess the full investment in R&D by all cluster firms, it was able to determine the financial and in-kind contribution that is being made by firms in projects in which they are engaging with NRC.[71] This level of activity is portrayed in the table below.

Table 9: Leverage Contribution by Firms[72]

Cluster Initiative	Leverage Contribution by Firms ($M)	% of Total Levered Funds for the CI
Ocean Technology	1.5	6%
Nutrisciences and Health	1.5	8%
Life Sciences	2.6	42%
E-Business/Information Technology	5.3	17%
Aluminium Transformation	16.1	36%
Photonics	1.6	11%
Biomedical Technologies	1.3	16%
Plants for Health and Wellness	1.2	16%
Sustainable Infrastructure	1.2	5%
Nanotechnology	8.2	6%
Fuel Cell and Hydrogen Technologies	9.6	54%

On average, 20 percent of current leverage activity within the CIs has emanated from firms. The Aluminium Transformation cluster initiative has the highest amount of levered funds from firms at $16.1M. This is likely by virtue of a large scale commitment by Rio Tinto Alcan Inc. to support promising research projects. It is followed by the Fuel Cell and Hydrogen Technologies CI, which has seen an estimated $9.6M in collaborative or funded private sector activity with NRC. The fuel cells and hydrogen technologies cluster has a high proportion of firm invested R&D, in keeping with the stage of development of the cluster.

The lowest percentage of levered funds from firms occurs in Regina in the Sustainable Infrastructure CI where only 5% of funds come into the cluster initiative from firms. As discussed previously, NRC-CSIR has identified municipalities as the primary end-users of technologies and solutions produced and/or commercialized by firms. Hence, municipalities are considered as partners in NRC projects, since early adopters can help develop better products and solutions. Further, investment by firms is being made via Communities of Tomorrow, rather than with NRC directly, which had an effect on the calculations. In terms of total firm leverage, Sustainable Infrastructure, Plants for Health and Wellness and Biomedical Technologies have approximately the same level of investment by firms at just over $1M each.

NRC-IRAP also serves as a mechanism facilitating investment in R&D by companies. Based on information provided by the Program, approximately 36 CAs have been signed with cluster firms. NRC-IRAP's investment in these CAs has totaled $2.3M, with firms estimated to be contributing $19.1M.[73] This results in an overall leverage of 8.3 by NRC-IRAP.

[70] Mobilizing Science and Technology to Canada's Advantage. 2007.
[71] Again, this is limited to interactions related to cluster funding only.
[72] Estimates based on the inclusion of both cash and in-kind contributions to NRC collaborative agreements, and NRC and firm contributions to NRC-IRAP funded projects.
[73] NRC-IRAP firm estimates, or *total project costs* are based on a sum of the *NRC-IRAP CA contribution* and the total project costs to the firm. *Total project costs to the firm* are determined to be two times the *NRC-IRAP CA contribution* plus *other project costs*

When looking at research projects overall with the Institutes, on the sum of investments made by all collaborators in research activity, they have on average invested $4.40 for every $1 invested by NRC.[74]

In summary, the investments being made by NRC in technology clusters across Canada are closely intertwined not only with its other regular A-base activities, but with investments being made by other levels of both federal and provincial governments, as well as universities, NGOs and municipalities. As firms begin or continue to interact with NRC, and early stage government support for infrastructure development tapers, the proportion of leveraged activities from firms will likely grow and represent a much higher value of investment in the CIs than is currently the case.

6.2 Cost Savings and Efficiencies

→ *Have CI Portfolio outcomes been achieved in an efficient manner?*
- *What measures has NRC taken to reduce the costs of delivering the CIs?*

A few examples of cost-saving measures and efficiencies were identified in the evaluation. Most of these focus on the reduction of the costs associated with building maintenance and operations. The most prevalent examples are outlined below:

- Initiatives have engaged in consultation with other cluster stakeholders before major equipment purchases to ensure complementarity rather than duplication or to propose a cost-sharing option. Evidence was found, for instance, that such initiatives as Sustainable Infrastructure, Nutrisciences and Health, Aluminium Transformation, Fuel Cell and Hydrogen, Information Technology/e-Business and Life Sciences all coordinate with local, regional or extended cluster partners to ensure that resources do not overlap.

- Retooling of equipment represents an additional means of efficiently using resources. In the Photonics, Fuel Cell and Hydrogen Technologies, and Life Sciences cluster initiatives, examples of recommissioning or reuse of equipment already owned by NRC were found.

- The living laboratory concept in use in Regina, allowing the use of real life infrastructure for research purposes, represents another novel means of cost savings for research activities and for the municipality involved.

- Co-location of equipment, as a form of leverage, represents a cost-saving and efficient approach for all involved. As an example, the Life Sciences and the Nutrisciences and Health cluster initiatives employed novel models for their new facilities. NRC-IBD (Atlantic) has two laboratories in two different health centres in Halifax, where the health centres provide the space and NRC-IBD provides the equipment and researchers. NRC-INH is co-located in a new UPEI-owned building along with both UPEI and AAFC researchers and equipment.

Further cost savings were identified in the design or improvement of infrastructure either funded through the CIs, or associated with their implementation (i.e., the construction of NRC-IFCI). For instance, new buildings in the Saguenay, Edmonton and Vancouver have all obtained the LEED certification for their facilities under the Energy and Environmental Design program run by the US Green Building Council. This designation recognizes that the building has been designed to meet rigorous environmental and safety standards as attested to by a third party review. LEED-certified buildings should:

- have lower operating costs and increased asset value;

(representing 20% of the *total project costs*). *Other project costs* may include materials, equipment, travel, and additional labour not supported by NRC-IRAP.

[74] Source: Ratio of collaborator investment to NRC investment in collaborative projects (by FY signed) averaged from 2001-02 to 2007-08.

- reduce waste sent to landfills;
- conserve energy and water;
- result in a healthier and safer environment for occupants;
- reduce harmful greenhouse gas emissions; and
- demonstrate the owner's, in this case the Canadian government, commitment to environmental stewardship and social responsibility.[75]

It is worth noting that the support service costs associated with the delivery of cluster initiatives at NRC have absorbed a minimum of 10% of total allocated expenditures ($56M). These are the resources that have been absorbed by NRC at a corporate level to help manage and deliver on the expanded activity. The figure does not take into account the administrative requirements of each of the Institutes or NRC-IRAP in the delivery of their activities at a local level.

It has already been outlined in the report that five-year funding for such a vast and varied number of initiatives at NRC (a number of which represent incremental funding to Institutes for expanded programming), results in almost doubling the level of accountability and planning tasks for institutes. Evaluation participants stated that these efforts detract from regular business activities within their regions. Further discussion on the impact of five-year funding on the administration of cluster initiatives, and their overall efficiency, was discussed earlier in section 5.1.1.2.

6.3 Summary of Findings

In order to determine whether cluster initiative resources were used efficiently, the evaluation sought to determine the extent to which other parallel investments were made in support of the cluster initiatives, both in tangible (i.e., financial) and less tangible (social) areas. In particular, an attempt was made to determine the extent to which there had been 'leverage' in that NRC investment had resulted in subsequent investments by other levels of government, the academic community and the private sector.

Overall, information collected through the evaluation shows a positive correlation between the investment made by NRC as well as those of cluster partners and firms. Data suggests that in the early phase of cluster initiative implementation, for every dollar invested, an equivalent investment has been made beyond NRC. Further, collaborators are actively investing in R&D projects with NRC, generally contributing four times the NRC investment. The most significant finding stemming from this component of the evaluation is that in all cases the NRC investment in technology clustering has resulted in investment from other sources in support of the chosen technology area.

[75] See US Green Building Council at http://www.usgbc.org.

7.0 Effectiveness and Performance of Individual Cluster Initiatives

7.1 Summary of Findings for Individual Cluster Initiatives

→ *Are the cluster initiatives developing along the cluster lifecycle?*

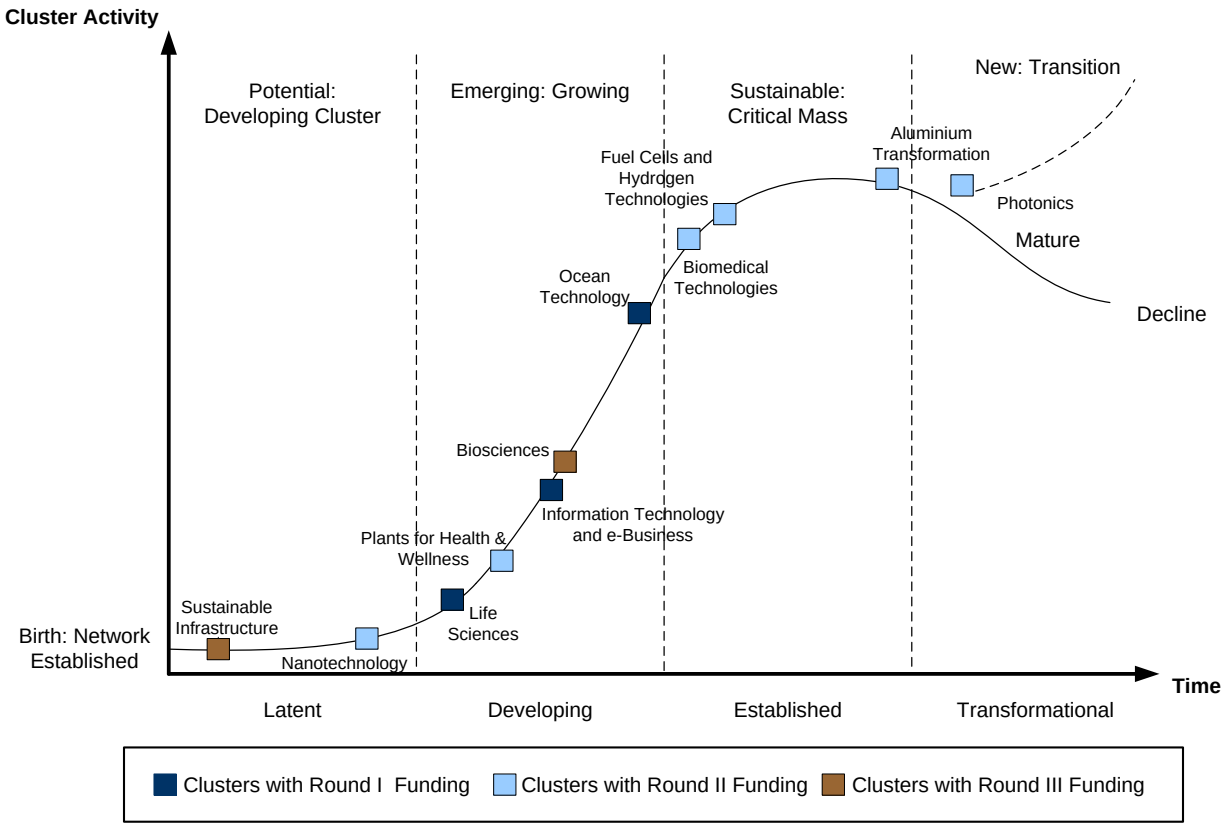
As described previously, cluster theory indicates that the development of technology clusters is a long-term process that often takes up to 15 to 20 years to reach an 'established' stage. In general, there has been a small evolution of the clusters where NRC is involved since the various initiatives were launched. NRC's arrival and presence in and of itself constituted a fairly significant event in many locations, particularly in Edmonton (Nanotechnology), Vancouver (Fuel Cell and Hydrogen Technologies), the Saguenay (Aluminium Transformation), Ottawa (Photonics) and Fredericton/Moncton (Information Technology). In other cases, cluster funding and associated activities were much less visible, such as in Saskatoon (Plants for Health and Wellness) and Halifax (Life Sciences).

Clusters were in existence in certain communities prior to NRC's arrival (e.g., Ocean Technologies, Fuel Cell and Hydrogen Technologies, Biosciences (PEI), Aluminium Transformation and Biomedical Technologies), whereas in other communities, existing relationships or critical mass were not sufficient enough to apply a cluster label (e.g., Sustainable Infrastructure, Nanotechnology and Functional Foods and Nutraceuticals).

Figure 18, below, details the approximate evolutionary phase of each of the regional clusters along the cluster lifecycle. This positioning was based on feedback obtained from evaluation participants in each of the clusters and represents their general view of the status of their cluster.[76] For the most part, clusters have remained within similar phases of evolution along the development path as when earlier NRC evaluations were completed. This is not to say that NRC's initiatives have not had an impact on the clusters. These impacts have already been articulated and can be found mostly in the area of added infrastructure, HQP and networking. Increasingly, knowledge generation and transfer are occurring. Indeed, cluster development is a long-term activity and significant changes in cluster status are not expected for those initiatives that are new or that have been evaluated in recent years.

[76] Note that no comparison of clusters is intended. Evaluation participant comments are to be contextualized in terms of the performance of their own community and not those of others.

Figure 18: Positioning of the Regional Technology Clusters



Recognizing the various stages at which clusters appear to exist, and the strength and weaknesses of the NRC initiatives working to support their evolution, the following summaries on the effectiveness and performance for each of NRC's cluster initiatives are offered. These summaries consider all information available to the evaluation team collected as part of the evaluation process from the multiple lines of evidence used in the study.

- **Ocean Technologies (Cluster and Cluster Initiative) –** There is a well established, although small ocean technologies cluster in and around St. John's. The cluster in St. John's was originally centered on marine supply and service and was transformed in 2002 to focus on ocean technology. The Institute contributes to cluster development through the advancement of knowledge and the development of new technological applications in traditional areas of strengths, such as marine safety. Over time, NRC-IOT has adapted its priorities to the evolving needs of the community. For instance, research formerly geared to the fisheries industry is now focused on the needs of the offshore oil and gas industry as well as arctic navigation. NRC-IOT has an active IPF that hosts a number of SMEs as well as Oceans Advance, the local cluster animator, and Oceanic Consulting. NRC-IOT has also established a close working relationship with Memorial University in terms of collaborative research and HQP development.

  The announcement of Canada's Ocean Action Plan in 2004 has placed added pressure on organizations such as NRC-IOT to support the Plan's key pillars. NRC-IOT is being directed to

support not only activities in Newfoundland, but those in other marine and ocean 'clusters' in such locations as Victoria, Rimouski and Halifax.

- **Nutrisciences and Health (Cluster and Cluster Initiative) –** The biosciences cluster in which NRC-INH operates can be considered to be in the 'developing' phase of the cluster lifecycle. Firms in the region include newly formed SMEs as well as existing firms being drawn to the cluster, which has been attributed in part to NRC's presence and the credibility it offers the research underway in the community. The IPF in place at NRC-INH is currently at capacity, as are the NRC research laboratories. In the minds of stakeholders, this could be an impediment to the further development of the initiative, as well as the ability of NRC to meet high expectations (both internal and external to NRC). At this time, the cooperation between the federal and provincial governments, the University of Prince Edward Island and other cluster stakeholder is seen as critical to supporting private sector members of the cluster and attracting new companies to the cluster.

  NRC-INH is perceived as being directly aligned with the needs of the community, as well as the priorities of the provincial government. It is complementary to the competencies offered by other organizations, including UPEI and Agriculture and Agri-Food Canada (AAFC). The personnel and facilities available through NRC-INH are seen as being of value to firms and other organizations, and their cost would make them inaccessible to firms without NRC-INH's involvement.

- **Life Sciences (Cluster and Cluster Initiative) –** Various activities to identify the focus of the life sciences sector in Halifax and reorient the major stakeholders towards a new focus have been ongoing for some time. Although the life sciences initiative was one of the earliest cluster initiatives funded, the first few years were said to have been driven by the priorities of large organizations involved in the region as opposed to those of local firms.

  Since 2004-05, the cluster is seen to have shifted from being organization to industry-driven, and the NRC Institute for Marine Biosciences was reoriented to be more closely linked with the priorities and focus of the initiative. Since then, the Institute and initiative have been seen as well-aligned to the needs of the community, although there continue to be mapping activities by the cluster community itself, currently led by BioNova, in order to identify cluster priorities. This ongoing activity suggests a continued need to find focus. The Life Sciences cluster initiative will need to remain responsive to those needs as they are articulated by the community. NRC should continue to be proactive in searching out new opportunities for collaboration and engagement with firms in the community.

  The infrastructure and personnel brought to the region by NRC-IMB and NRC-IBD have been highly regarded both in terms of responsiveness to the needs of the community as well as the quality of researchers and equipment available. NRC-IBD's co-location in the health centres allows the NRC-IBD infrastructure to be more widely used than would likely be the case if it were located in the NRC-IMB facility.

- **e-Business/Information Technology (Cluster and Cluster Initiative) –** The e-Business/Information Technology cluster initiative was launched in large part to build on the foundation laid by successive New Brunswick governments in the ICT sector. Indeed, at the start of the initiative, the Regional Economic Development Agreement (REDA), a joint ACOA and provincial government partnership, provided $12M over five years for NRC-IIT to open offices in Saint John and Moncton. In pursuing its mandate, NRC-IIT has developed strong collaborative relationships with ACOA, the Province, universities, the Canadian Forces, and a number of other research organizations. It concentrates on two sectors of interest to the province, ICT-health and advanced learning technologies (ALT). NRC-IIT is active in HQP development, particularly through collaboration with New Brunswick's three universities. One facet of this collaboration is the appointment of a number of researchers as adjunct professors at the universities. It also has had some success in developing some SMEs through its IPF.

However, a number of challenges remain for this cluster as it develops. There is as yet no evidence of a cluster anchor or a cluster animator. Also, it is interesting to note that while NRC talks of an IT or ICT cluster, the province defines its clusters according to the application that is made of ICT, such as e-health and ALT. Moreover, the Province has not contributed to the cluster initiative after its initial five-year period. Through its involvement in the health and learning sectors, NRC-IIT is more inclined to deal with public sector organizations.

- **Aluminium Transformation (Cluster and Cluster Initiative) –** The Saguenay aluminium cluster is generally thoughts to have reached a certain level of maturity and to be well established. This is due in large part to the presence of Rio Tinto Alcan (RTA) in the region. RTA's presence was the main element in bringing NRC-ATC to the region and it remains the single largest private sector stakeholder in the cluster. NRC-ATC's presence and impact in the region are very much appreciated by stakeholders. The Centre is viewed as an important element attracting HQP to the region, acting in a synergistic fashion with RTA, UQAC, and several other public, private and not-for-profit bodies in the region. NRC-ATC has negotiated a sizeable number of collaborative research agreements with private firms. Through its attraction of HQP and cooperation with other bodies in the region it has contributed to the development of a critical mass of researchers in the Saguenay.

  One challenge for NRC-ATC is trying to match its services to the needs of small and medium firms in the region. This is linked to the state of development of SMEs in the aluminium transformation sector. The Centre has a large number of collaborative agreements with medium and larger firms and several SMEs have access to the Centre's facilities. However, according to some SMEs, the Centre is better suited to deal with medium to long-term research projects than quick turnaround enquiries related to production issues. There may be a need for a more adapted interface with smaller firms in need of a rapid response to technical challenges.

- **Photonics (Cluster and Cluster Initiative) –** The NRC-CPFC, which constitutes the major investment by NRC in support of a photonics cluster in Ottawa, is serving a cluster currently operating in a transformative stage. More broadly however, the NRC-CPFC does by no means maintain an Ottawa-only focus. Although very important to the region according to stakeholders, particularly in maintaining Ottawa's position as a leader in ICT and optoelectronic technologies, the Centre is very much focused nationally and even internationally in building its networks, reputation and client reach. It has proven to be a high quality offering, attracting international clients. It has increased its capacity in response to this demand by hiring more staff and adding an additional work shift.

  There are a few challenges for the NRC-CPFC in the medium to long-term. One is reported to relate to skills maintenance and development, and thus its reputed private sector focus. Its employees come largely from the private sector and some will approach retirement in the near term. There is concern as to how to ensure a future generation of HQP within the Centre. Another is related to the highly competitive nature of this developing area, and the need for NRC-CPFC to remain an attractive and competitive service offering. This requires ongoing investments in new equipment and infrastructure. Currently, revenues are used to address new requirements.

- **Biomedical Technologies (Cluster and Cluster Initiative) –** The biomedical cluster initiative focused primarily on the construction of a new Industrial Partnership Facility, given the demands on existing infrastructure. The initiative was instrumental not only in providing the infrastructure, but in guiding the creation of Biomedical Commercialization Canada, a non-profit organization housed within the IPF providing business development services to cluster firms. The model governing the relationships between these organizations is thought to be unique in Canada, and shows promise in terms of facilitating the commercialization of biomedical devices.

NRC-IBD has developed solid relationships with other cluster actors, as evidenced by its involvement in various cluster activities. These relationships should enable the Institute to take full advantage of its new facility in the future and ensure that the firms housed in the IPF are linked directly to the cluster technology area – these linkages are not yet obvious from the mix of tenants currently housed in the facility.

- **Plants for Health and Wellness (Cluster and Cluster Initiative) –** This initiative, which first began as the Crops for Enhanced Human Health Initiative, represents an expansion of the research work done at NRC-PBI. It has mainly focused on research activities and the recruitment of HQP to work on specific projects. One important contribution of this initiative has been the creation of NAPGEN, a consortium of universities and government departments focusing on the generation of genetic resources that will be employed in the development of new nutraceutical plant varieties to provide industry with a plant platform to develop new products. The cluster initiative has also been instrumental in a successful bid by a cluster firm in obtaining venture capital, even if only for a short time, and has been heavily involved in the creation of the BioAccess Commercialization Centre, which offers business development services to firms in the Functional Foods and Nutraceuticals sector.

  At this time, the FFN cluster is fragmented and distributed over a much wider geographic area than had been previously anticipated. Disagreements between cluster organizations over mandate and geography have made the coordination of activities difficult. Although seven years is still considered to be early in the development of any technology-based cluster, more progress could reasonably be expected compared to what has been achieved in terms of cluster growth and development. At this junction, NRC must consider whether the cluster initiative funding should continue to be targeted specifically in Saskatoon, and whether it should continue to focus on the FFN sector rather than the broader Ag-bio cluster to which NRC-PBI has been and continues to be an important contributor. Recent efforts to bring together NRC Institutes involved in research on BioActives have the potential to increase the activity level in the Ag-bio sector across Canada.

- **Sustainable Infrastructure (Cluster and Cluster Initiative) –** Although the initiative faced some challenges at the offset, including the recruitment of HQP, the inability to expend available resources, and a lack of clear community vision as to direction, it has been able to establish a research team and build a research infrastructure to support the development of the cluster. The support of other cluster partners like the City of Regina, Communities of Tomorrow and the University of Regina are resulting in the generation of new knowledge that is being applied by local municipalities. The 'living lab' concept applied by the initiative, which allows it to leverage the resources of local municipal infrastructure, is a novel and potentially efficient means of undertaking research. However, several challenges, like long-term commitment of key partners and the engagement of firms, will have to be surmounted before a nascent cluster state is surpassed.

  More specifically, the limited resources of NRC-IRAP and NRC-CSIR in the cluster with respect to the development of innovative firms combined with NRC-CSIR's strategic decision to orient its R&D activities toward the needs of municipalities raises some legitimate questions about the fundamental nature of this initiative. In comparison with a national research program, a cluster initiative normally presents many distinct characteristics, including the development of innovative firms, which is considered to be a crucial component of the NRC clustering approach. In this context, the main challenge for NRC-CSIR going forward is to ensure that the R&D that it conducts in collaboration with municipalities generates technologies or innovative solutions that can be absorbed and commercialized by the private sector.

- **Nanotechnology (Cluster and Cluster Initiative) –** The concept of a nanotechnology cluster in Edmonton is, at present, but a concept. Stakeholders described it as a 'protocluster' at the most. However, the Alberta government has made the most substantive commitments to supporting the

development of a chosen cluster technology of any other NRC partner or contributor. Since the last evaluation, it has launched programs to support its goal of generating $20B in revenues for the province in nanotechnology by 2020. Although not defined as a cluster by all regional actors, the objectives established by the province in particular speak clearly to its desire to create an internationally recognized hub for nanotechnology, with the associated economic impacts that it could generate. These principles are highly aligned to what would eventually be recognized as a world leading cluster, if successful.

From an NRC standpoint, the purported strengths of the NINT model, being a joint initiative between two levels of government, also contribute to its weaknesses. There is a sense that the Institute is not adequately focused on commercial benefit, bringing some people in the region to question whether NINT can adequately respond to expectations in this regard.

- **Fuel Cell and Hydrogen Technologies (Cluster and Cluster Initiative) –**The transformation of the NRC Innovation Centre into NRC-IFCI in an established cluster where the community, including the universities and Ballard Power Systems, already possessed strong R&D capacity was an ambitious challenge for the organization. In seven years, it appears that NRC-IFCI was successful at building state-of-the-art infrastructure, developing core competencies in the area of fuel cells as well as implementing cluster support services (e.g. testing and validation services) that are strongly valued by the industry. The skills and research capacity of the Institute are starting to attract the attention of the major players in this field of research at the local, national and international scale as demonstrated by the numerous alliances, networks and research collaborations that were established over the years. Most evaluation participants profiled NRC-IFCI as the 'focal point' of the cluster.

  When asked what direction the Institute should take in order to better support the cluster, evaluation participants unanimously said that it should "*stay the course*" and raised the possibility of expanding its scope to the clean energy industry. Finally, although the fuel cell experts that were consulted during the evaluation process agreed that the research that is being conducted in the area of fuel cell and hydrogen technologies can provide valuable solutions to other clean energy systems, most of them believe that this will require additional resources for the Institute.

- **NRC Industrial Research Assistance Program –** NRC-IRAP is recognized to play a very relevant role in Canada's innovation system. The Program and its ITAs play significant roles in linking firms to resources that support firms, including information and financial assistance. In the CIs, NRC-IRAP's role has grown more integral as NRC moves from early implementation to seeking greater levels of performance in supporting firm development. The Program has adequately been able to expend its resources in most regions, and in others has expended beyond its allocations. NRC-IRAP is also supporting organizations that support clusters in most of the CI regions.

  If firm activity grows in such areas as nanotechnology in Edmonton, biomedical technologies in Winnipeg and functional foods and nutraceuticals in Western Canada, the Program will likely have the opportunity to play a more significant role in offering assistance to companies.

- **NRC Canada Institute for Scientific and Technical Information –** The core strengths of NRC-CISTI are demonstrated by the fact that the Institute's presence and service offerings have been expanded across NRC as a result of the CIs, even in the absence of direct funding in eight of the eleven sites. NRC Institutes and NRC-IRAP have given the Institute added relevance by funding its activities in most of the CIs. Unfortunately, the manner in which the funding before expansion has occurred, particularly with Competitive Technical Intelligence, but also with the NRC Information Centres, has left NRC-CISTI with a complex delivery structure that lacks homogeneity. Components of the Information and Intelligence Services program must rely on funding from various parts of NRC to support their operations.

8.0 CONCLUSION

8.1 Ongoing Need for the NRC Technology Cluster Initiatives

→ *Is there a continued need for cluster initiative support?*

Ongoing work on NRC's clustering activities is supported by the findings of the evaluation. Without exception, community-based participants in the evaluation expressed a desire to see federal investments continue and are hopeful that these will bear local returns. However, given the complexity of clustering and level of investment required to encourage cluster growth, support by multiple players needs to be consistent, focused and long-term. Failure to engage over a 15 to 20 year period, with a reasonable level of resources, will not generate growth. Even with such commitment, cluster growth is not guaranteed.

It is difficult to gauge growth in all areas, with so many factors at play. However, early indications are that the investments by NRC in technology clustering have served to distribute research capacity and innovation opportunity more broadly across Canada, and have expanded and strengthened it in certain regions. The variety of research areas being targeted, the range of activities supported, and the size of the communities hosting cluster initiatives demonstrate the applicability of clustering strategies and initiatives to a wide range of conditions.

Cluster development requires the presence of a series of growth factors, as outlined in the report. Each of the clusters currently demonstrates various degrees of strength in these areas. NRC has played a documented role in contributing to the strength of many of these communities, particularly through its infrastructure, people and brand. NRC has demonstrated an ability to play a 'broker' and 'catalyst' role, while still allowing communities to self-direct.

One of the challenges facing NRC is the adoption of promising strategies for Canada in support of wealth generation and prosperity. Clustering was adopted close to ten years ago a mechanism to support the development of regional innovation systems. The communities involved in these initiatives generally wholeheartedly embraced the clustering concept.[77] Currently, NRC's approach has broadened to include an emphasis on national strategies and specific key sectors. It has launched some horizontal initiatives (e.g., NRC Fuel Cell and Hydrogen Program) and considered others (e.g., a national nanotechnology program) as a means of leveraging its resources and broadening its reach in order to support advances in these areas. These strategies are also aligned to current government priorities. The value of the cluster initiatives within this new policy environment will need to be assessed in the future, as these national programs and key sectors become more established.

[77] Wireless Systems remains the notable exception. It was concluded in 2005.

9.0 Management Response

The following Management Response Action Plan was proposed by NRC's Senior Executive Committee in response to the recommendations included in the report.

Recommendations	Response and Planned Action(s)	Responsibilities	Timelines	Measure(s) of Achievement
Recommendation 1: In light of evolving conditions and any apparent constraints (e.g., changing regional priorities, evolving scientific priorities, regulatory environment, etc.), it is proposed that NRC review and either reaffirm or modify the focus of its initiatives in the following areas: fuel cell and hydrogen technologies; life sciences, and plants for health and wellness.	Accepted. NRC will review the focus of the initiatives in the areas mentioned to ensure that their alignment is consistent with the needs of the cluster and the community.	Vice-presidents	March 2009 - April 2010	Having cluster plans that reflect the appropriate changes in focus.
Recommendation 2: In light of the five year funding underlying this substantive investment for NRC (greater than 10% of total expenditures and affecting 11 of NRC's 19 Institutes), it is recommended that NRC assess, as part of any planned funding renewal, the risk associated with this investment. Strategies proposed as a result of this assessment should attempt to position relevant CIs as long-term activities and address issues such as staffing and capital assets.	Accepted. The risks associated with the five-year funding period are well-understood and recognized by NRC. In order to mitigate those risks, the funding renewal exercise will include every possible argument in favour of obtaining A-base funding for the clusters. For any ongoing B-base funding, I/P/Bs will be asked to include a specific view of cluster risks in their business plan.	President	March 2009 - April 2010	Obtaining A-Base financing for some of the clusters. Assessment of CI risk within the context of the I/P/B business planning process.

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Recommendation 3: It is suggested that the management of technology cluster initiatives by NRC be undertaken in a more holistic and integrated approach across Institutes and Programs. It is recognized that in many instances, NRC cluster initiative activities are incremental to existing activities being undertaken by NRC. This is particularly the case for NRC-IOT, NRC-IMB, NRC-IBD, NRC-PBI and NRC-IFCI, and extends practically to all other delivery Institutes or Programs, including NRC-IRAP and NRC-CISTI. An ideal state would be to integrate the strategy, planning, and oversight of any cluster development progress into regular ongoing NRC processes (e.g., NRC strategy development, business planning, evaluation plan, etc). These would continue to report on and monitor contributions in support of planned objectives.	Accepted. NRC will work to integrate cluster activities into Institutes' and Programs' business plans and performance reports, recognizing the necessity of also reporting and monitoring the contributions specific to cluster initiatives.	Vice-presidents	To be implemented for the next round of business plans i.e. Fall 2011.	The development of business planning guidance that addresses the integration of CIs within I/P/B business planning. Visibility of CI performance and planned activities within I/P/B business plans. The integration of CI performance measurement into overall NRC performance measurement.
Recommendation 4: Review with NRC-IRAP and NRC Institutes engaged in clustering activities strategies for addressing the ongoing need for Information and Intelligence Services (IIS) (i.e., NICs and CTI products) in support of their regional cluster objectives given the impact of decisions surrounding the Strategic Review process.	Accepted. Given that as a result of the 2008 NRC Strategic Review decisions, the Competitive Technical Intelligence services formerly provided by NRC-CISTI will be concluded. The decision to acquire any information research and analysis services for the individual cluster initiatives will rest with the	Vice-Presidents	April 2010	Cluster funding is allocated to the lead CI NRC Institute for CTI products.

Recommendations	Response and Planned Action(s)	Responsibilities	Timelines	Measure(s) of Achievement
	lead cluster initiative NRC Institute.			
Recommendation 5: Provide NRC researchers with the opportunity to learn about the purposes and goals associated with clustering. Adopt strategies that recognize and place value on interactions and projects with cluster firms or firms that are engaged in activities that are relevant to the technology focus of the cluster.	Accepted. NRC will examine ways of raising the awareness and understanding of cluster initiatives with employees. Also, when reviewing its formal incentive programs, NRC will give proper consideration to the issues surrounding awareness and understanding of clustering activities.	Vice-Presidents	March 2011	Ongoing communications. Incentive programs having been revised to address awareness and understanding of clustering.