

Refereed Paper

**Measuring the National Research Council's
Technology Cluster Initiatives**

Erin Cassidy
Planning and Performance Management
National Research Council of Canada

Charles Davis
Radio and Television Arts
Ryerson University

David Arthurs
Hickling Arthurs Low Corporation

David Wolfe
Political Science
University of Toronto

Principal Author:
Erin Cassidy
National Research Council Canada
Planning and Performance Management
M-58, 1200 Montreal Road, Ottawa, Ontario
Canada, K1A 0R6
Email: Erin.Cassidy@nrc-cnrc.gc.ca
Phone: 613.990.9272
Fax: 613. 941.0986

Erin Cassidy is an evaluation officer in the Planning and Performance Management group with the National Research Council. Her education includes a B.Mus. from the University of Ottawa. Her career in the Government of Canada has spanned several departments where her work as a senior analyst has focused on evaluation and policies for industrial development, science and technology, commercialization, regional economics and the Canadian music industry.

Charles Davis is a Senior Associate with HAL and a Professor at Ryerson University. Charles' educational background is in science and technology policy and management at the doctoral level, in history and philosophy of science at the Master's level, and in biology at the undergraduate level. He has more than twenty years of work experience as a policy researcher, analyst, research program and project manager, and university teacher and researcher.

David Arthurs is the President of Hickling Arthurs Low (HAL) Corporation, a consultancy specializing in technology management, strategy, and economics for science-based public sector organizations. His education includes a B.A.Sc. in engineering from the University of Waterloo, an MBA from the University of Ottawa, and a Ph.D. from Queen's University where his studies focused on the economics of technological innovation.

David Wolfe is a Senior Associate with HAL and Professor of Political Science at the University of Toronto, where he is Co-Director of the Program on Globalization and Regional Innovation Systems. David is also the National Coordinator of the Innovation Systems Research Network, which is investigating the role of local and regional clusters in Canada. David holds a B.A. and an M.A. in Political Science from Carleton University and a Ph.D. from the University of Toronto.

Measuring the National Research Council's Technology Cluster Initiatives

Abstract

The National Research Council (NRC) is the Government of Canada's primary public section research institution, composed of 20 institutes located across Canada with research and development programs spanning a variety of disciplines and offering an array of services.

In recent years, NRC has launched a series of cluster building initiatives intended to stimulate the growth of globally competitive knowledge-based regional economies that build on existing local strengths. These initiatives build on the Government of Canada's vision for innovation and economic development.

NRC has an active commitment to performance management and evaluation of its initiatives to support performance reporting requirements, to assist in program planning and management, and to aid communications with stakeholders within the clusters, the provinces, and the federal government.

This paper presents the approach NRC is taking to develop baseline measures of clusters in which NRC is involved. The project consists of a model, methodology, and execution plan for cluster measurement which NRC is implementing in two pilot studies: the National Institute for Nanotechnology within the Edmonton, Alberta nanotechnology cluster, and the Aluminium Technology Centre within the Saguenay, Quebec aluminium cluster.

Key words: cluster initiatives, regional development, evaluation, performance measurement, public research institutions.

Measuring the National Research Council's Technology Cluster Initiatives

Introduction

While economic theories of industrial agglomeration and regional specialization have existed for well over a century (e.g. Marshall), their practical impact accelerated with the adoption of 'cluster theory' within public policy beginning in the early 1990s. The notion was skilfully popularized by Michael Porter (1990, 2003) and embraced by practitioners in the public, private, and academic sectors. Governments at all levels were quick to adopt the concept as a tool for promoting national, regional, and local competitiveness, innovation, and growth (OECD, 1999, 2001). The development of clusters promised a seemingly easy answer to the challenges created by increased international competition and the growing importance of innovation in the knowledge economy – particularly for smaller regions tied to traditional industries. Policy analysts, academics, and industry were happy to follow as it simplified their task of explaining and promoting regional development economics. This enthusiasm was further fuelled by the significant amounts of public money that flowed to cluster development initiatives.

However, the cluster concept is becoming the focus of sober second thought. Martin and Sunley (2003) articulate that scepticism, stating "clusters have gate-crashed the economic policy arena" and that "the cluster concept should carry a public policy health warning". A workshop on government cluster intervention concluded that "ultimately, cluster initiatives have become a sort of 'magic recipe' to meet the challenges of the new economy, to the point that they have become dangerously fashionable" (Andersson et al, 2004).

Ultimately however, whether the cluster concept is useful, whether cluster development is possible, or whether government intervention is warranted, are matters for evaluation. The cluster concept is not being discredited, but faith is not enough. As with any investment, particularly involving public funds, there is a need for accurate and ongoing measures of success - evidence that the investment is having, or will have, net positive benefits. Unfortunately, there is a scarcity of comprehensive evaluations of clusters, and cluster benefits are still often taken for granted rather than systematically documented (Nauwelaers, 2005; Andersson et al, 2004).

This paper begins by presenting NRC's cluster initiatives. Second, we discuss the impetus for NRC's cluster baseline study and some of the issues associated with cluster measurement. Third, we propose an approach that consists of a model which builds on the Porter Diamond, a process for evaluation and planning, and tools to measure cluster development. Fourth, we examine the role of public research institutions such as NRC and their influence in clusters according to the model. Finally we introduce our next steps in this project.

NRC's cluster initiatives

Through the National Research Council of Canada (NRC), the Government of Canada has made a series of investments in clusters. Recognizing that innovation can be encouraged as part of a deliberate strategy to improve productivity growth and Canadians' standard of living, in 2002 the Government of Canada launched a national Innovation Strategy.¹ The Strategy included an assessment of Canada's innovation performance, proposed national targets to guide stakeholder efforts, and identified where the government could act to improve the nation's innovation. A key element of this strategy was the National Research Council of Canada's goal of contributing to the development of at least 10 internationally recognized clusters by 2010. Between 2000 and the present, NRC has received over \$300 million in four rounds of funding to establish and reinforce cluster initiatives across the country.

NRC cluster initiatives have focused on building science and technology based innovation capacity in areas of local and regional strength to foster economic growth and improve quality of life. The process involves: engaging in community consultation; providing specialized research infrastructure and highly qualified personnel; supporting the creation, growth, and attraction of firms; facilitating the development of external linkages; and supporting the cluster in attracting new resources.

Currently, NRC's cluster initiatives include: ocean technologies, e-business, information technologies and life sciences in Atlantic Canada; nanotechnology, nutraceuticals, biodiagnostics and fuel cells in Western Canada; photonics in Ontario; and aerospace, biotechnology, and aluminium transformation in Quebec.

NRC has a strong commitment to evaluation and performance measurement, and is systematically evaluating its cluster initiatives. This paper presents the results of a project that has developed a framework and methodology to establish baseline studies of technology clusters in which the NRC has invested, and which is implementing this approach in two pilot studies: the National Institute for Nanotechnology (NINT) within the Edmonton nanotechnology cluster; and the Aluminium Technology Centre (ATC) within the Saguenay aluminium cluster. NRC will explore applying the approach to its ensemble of clusters initiatives in the future. The resulting longitudinal study of cluster development will support periodic evaluations of NRC cluster initiatives.

Cluster measurement

Many descriptive and qualitative case studies of clusters have been conducted and some research is available that compares clusters across industries or regions. These efforts have generated significant information on cluster components, structures, linkages, governance, and interactive processes. More recently, a body of literature has emerged on the policy experiences of governments with respect to cluster development and management. While this descriptive and qualitative material provides interesting insights into the dynamics of individual clusters, its usefulness for policymakers seeking to foster innovation-based economic development is more limited. Martin and Sunley (2003) note that the rush to employ cluster ideas has run ahead of many conceptual, theoretical, and empirical issues.

¹ www.innovation.gc.ca

While NRC draws on fundamental elements of cluster theory (stimulating knowledge based opportunities for growth; building pools of highly educated people; and fostering networking and collaboration in communities and regions to drive overall national competitiveness), NRC is concerned primarily with empirical issues such as the ability to measure the development of clusters in which it has invested to track results, and to identify the most appropriate role for NRC on an ongoing basis.

The formative evaluation of NRC's first cluster initiatives,² completed in 2004, highlighted the lack of quantitative data on cluster development and recommended the development of baseline measures to facilitate performance measurement over time. NRC committed to addressing this issue, but soon found that while many different methods and techniques have been proposed in the literature (Padmore, & Gibson, 1998), no standardized approach has emerged, and numerous challenges have been identified.

For NRC, the first challenge was the availability of appropriate cluster models. The most widely known, Porter's Diamond, overlooked the role of firms in clusters, lacked dependent variables such as outcomes, and contained variables that are only broadly defined (Davies & Ellis, 2000; Martin & Sunley, 2003).

The second challenge was with regards to existing quantitative data. National statistical agency data presents a number of significant limitations that severely constrain its usefulness for NRC:

- This data is gathered using surveys of firms organized by established industrial sectors (NAICS codes) that exclude emerging technology areas (e.g. nanotechnology, fuel cells) that are the focus of NRC cluster interventions.
- Even where NRC initiatives focus on existing technology areas (e.g. aluminium) data is often not sufficiently refined to capture particular industrial categories (e.g. secondary and tertiary transformation of aluminium).
- Data is subject to confidentiality rules that limit its availability at regional or metropolitan levels.

The proposed approach

We have developed an approach to measuring cluster development that builds on the previous work of Porter and the Innovation Systems Research Network (ISRN)³ and that is tailored to NRC needs. Our approach consists of a *model*, a *process*, and *tools*, and addresses some of the challenges of cluster measurement discussed above.

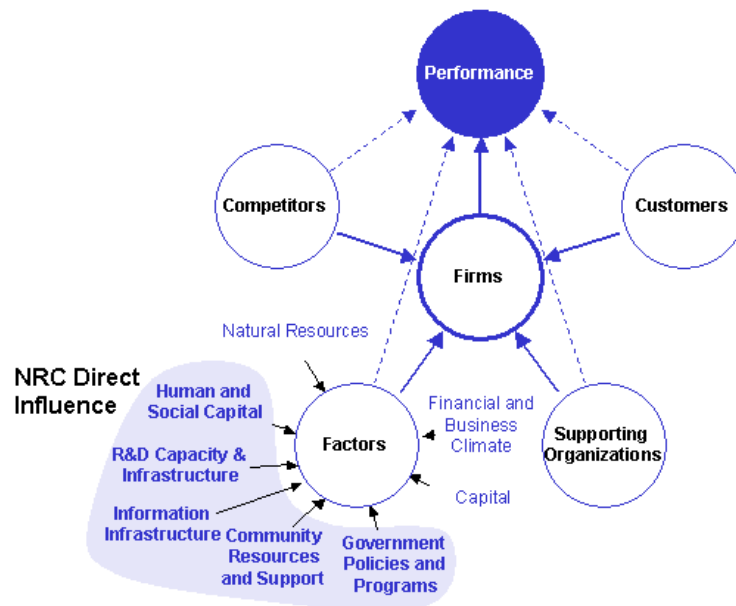
² NRC has undertaken three series of cluster initiatives, details of which are available at http://www.nrc-cnrc.gc.ca/clusters/initiatives_e.html. The evaluation report is available at: http://www.nrc-cnrc.gc.ca/aboutUs/audit_e.html.

³ The Innovation Systems Research Network (ISRN) is a group of Canadian researchers funded by federal research granting councils and NRC to research and disseminate results on Canada's diverse regional systems of innovation and develop policy responses for the various levels of government.

Model

Our model is illustrated in Figure 1. At the centre of the model are cluster firms. The success of these firms is influenced by the conditions of their environment. The performance of the cluster as a whole is dependent on the success of the individual firms and moderated by the cluster conditions.

Figure 1: Cluster model



This model has important differences from the Porter Diamond. First, cluster firms and their capabilities are explicitly included in the model. Second, the model has a dependent variable - cluster performance - that allows us to measure how changes in cluster conditions, resulting from the activities of cluster actors, have impact over time. Third, we have expanded the definition of Porter’s ‘Related and Supporting Industry’ to include public and non-profit organizations that support cluster development, and re-labelled it ‘Supporting Organizations’. Fourth, we explicitly identify those factors that are influenced by NRC.

In Table 1, we operationalize the broader concepts by breaking down cluster conditions and cluster performance into a hierarchy of constructs, sub-constructs, and indicators. We have drawn these from the broad range of characteristics considered important to clustering in the literature. Our measures include the cluster's business characteristics, internal and external linkages, use of public innovation infrastructure, innovative behaviour, and market orientation.

Table 1: Cluster model constructs

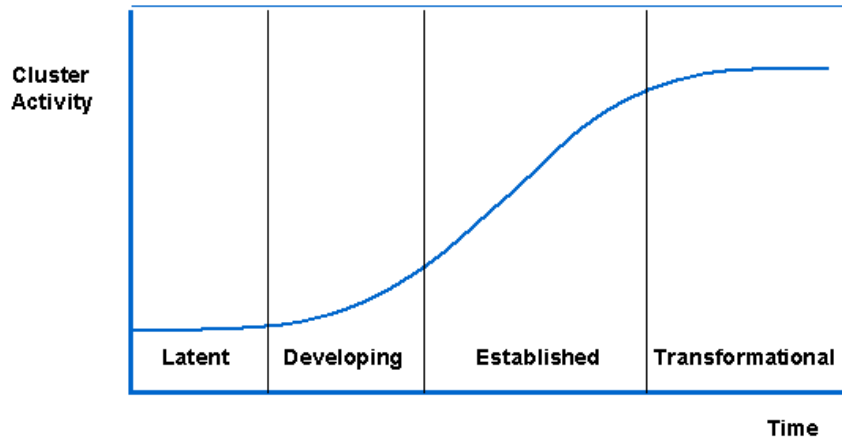
Concepts	Constructs	Sub-Constructs*	Indicators	
Current Conditions	Factors	Human Resources	Access to qualified personnel	
			Sources of qualified personnel	
			Distance of qualified personnel sources	
		Transportation	Quality of local transportation infrastructure	
			Connections to national / international transportation systems	
			Business Climate	
		Supporting Organizations	Innovation	Quality of local lifestyle
				Business costs relative to competing regions
			Innovativeness relative to competing regions	
	Community		Contribution of NRC to ideas, knowledge and innovation	
			Contribution of local institutions to ideas, knowledge, and innovation	
	Suppliers		Adequacy of regional development support	
	Services		Local availability of materials and equipment	
Financial	Local availability of business services			
Competitors	Local availability of capital			
Customers	Distance of most important competitors			
Current Performance	Significance	Diversity	Distance of most important customers	
		Size	Number of cluster firms	
		Responsibility	Size of cluster firms (employees and revenue)	
		Reach	Scope of responsibilities of cluster firms (strategy, research, production, sales)	
	Interaction	Identity	Export orientation	
			Internal awareness by cluster members	
		Linkages	External recognition by others	
			Partnerships and alliances	
	Innovation	Inputs	Involvement in local clustering activities	
			Linkages within the cluster network	
			R&D spending	
		Outputs	Business development capabilities	
	Dynamism	Product development capabilities		
	Revenue from new products and services			
	New firms within the cluster			

* Shaded boxes indicate areas in which NRC has an influence

Process

NRC recognizes that cluster development is a long-term process and that mobilizing the key stakeholders in the community is critical to success. NRC is establishing an approach to cluster development that builds on community involvement and recognizes that clusters evolve throughout their lifecycle. We define four stages: latent, developing, established, and transformation, as shown in Figure 2. A latent cluster has few firms and is only beginning to recognize the benefits of clustering. It becomes a developing cluster as the rate of growth increases. A cluster is considered established when both its size and rate of growth are significant and sustainable. It enters the transformational stage when its growth rate slows and it must reconsider its technology focus.

Figure 2: Cluster lifecycle



NRC's process is situated within the broader government process of budget priorities and funding allocation, and within NRC's own planning and performance management framework. This includes the following steps:

- **Strategic Decision Making** – a gap is defined that NRC can most appropriately fill. NRC identifies stakeholders it can engage with to stimulate cluster development and funding is secured to implement the initiative. Ideally at this stage, the key immediate, regional, and national outcomes of the NRC initiative within the cluster are identified.
- **Implementation** – NRC focuses on building and staffing facilities, developing research and technology programs, and engaging firms and other stakeholders to develop and implement a strategic plan.
- **Baseline** – NRC establishes an operational definition of the scope and extent of the cluster based on the cluster's self-awareness (how do members of the cluster view themselves?), external recognition (how do others view the cluster?), and comparison (what definition will permit comparisons with similar clusters?). The current conditions and performance of the cluster are then measured, eventually allowing the current conditions and performance of the cluster to be compared to its past performance.
- **Evaluation** – Using a variety of methodologies (peer review, interviews, impact analysis), NRC examines the performance of the initiative against intended outcomes and ongoing relevance, and makes recommendations to improve future performance.
- **Renewal** – NRC engages the community to collectively determine the appropriate future course of action, to determine stakeholder roles in the context of the cluster's

stage of development, to mobilize resources and to develop an action plan to move forward.

As the cluster evolves over time, its focus may also change – in reaction to external forces, a cluster may re-invent itself; sub-clusters may form and acquire their own identity; or sub-clusters may become redundant and coalesce. NRC recognizes that the evolutionary nature of clusters presents a challenge in efforts to measure the progress of the cluster since the subject being measured may have transformed itself into something quite different in the future.

Tools

We have developed a number of tools to assist in collecting and analyzing measures of cluster development that combine the strengths of qualitative and quantitative approaches:

- Statistics Canada provides data of a general nature on the economic context of the region.
- A survey of firms provides data that is tailored to NRC needs and that can be used for quantitative analysis.
- Qualitative interviews with supporting organizations provide insight into the internal dynamics and workings of the cluster.
- Social network analysis provides information on the nature, extent and quality of ties and interactions between actors in the cluster.

The role of public sector research organizations

The past decade has seen a growing reliance on public sector research in innovation policy in many OECD countries. Public research institutions, such as NRC, and institutions of higher education have become centerpieces of innovation policies.

Public research institutions appear to be quite common in clusters. ISRN³ has produced two-dozen case studies of Canadian clusters, and public research institutions are seen to play a role in almost all of them. However, the literature on clusters has relatively little to say on this topic. These institutions are generally regarded as one part of the regional innovation support infrastructure – part of the organizational environment through which government can exercise policy (Andersson et al, 2004; OECD, 1999, 2001).

The traditional rationale for establishing public research institutions was to contribute to the development of scientific knowledge in areas where other elements of the innovation system, such as research universities or corporate research laboratories, lacked the required competence. Increasingly, public research institutions are expected to generate more applied knowledge of greater relevance to industry, to diffuse knowledge, provide technical support to industry, and actively participate in the fostering of new commercial activity. This ever more complex innovation system has been described as a triple helix of university-industry-government relations (Etzkowitz & Leydesdorff, 1996).

Public research institutions exist in a variety of institutional models focused on different primary tasks and research outputs, as can be seen in the typologies proposed by Callon, Larédo, & Mustar (1995, 2000), Miller & Manseau (1996), and Crow & Bozeman (1998). However, despite the range of structures of national research facilities and the varied research fields in which they operate, the reasons for their establishment and the roles they perform within their respective innovation systems are similar. By way of example, NRC's roles include:

1. *Research and Technology Development* – NRC institutes focus on research areas that will form the foundations for commercial development.
2. *Training and knowledge development* – NRC's research activities contribute to the national supply of highly skilled researchers and contribute to Canada's capacity to absorb scientific research conducted elsewhere.
3. *Facilities and personnel* – NRC provides Canadian companies access to specialized equipment and major engineering facilities – resources that most companies cannot afford – offering a competitive edge in developing products and technologies.
4. *Technology business development and information diffusion* – NRC's Industrial Partnership Facilities (incubators) and Industrial Research Assistance Program (IRAP) support NRC researchers and emerging technology firms in commercialization and firm growth, and build links to industry and other government agencies across the country. The NRC Canada Institute for Scientific and Technical Information (CISTI) is a leading provider and publisher of papers of scientific and technical information.
5. *Forming networks and facilitating interaction* – NRC cluster initiatives, described previously, IRAP, and other NRC-supported initiatives build innovation capacity by fostering linkages and collaboration in areas of local and regional strength.
6. *Testing, codes and standards* – NRC institutes provide major facilities and specialized equipment for technology assessment, calibration, measurement, and performance analysis. NRC standards institutes ensure precise measurements and uniformity to meet international market requirements that are essential for reciprocal trade in advanced technologies.
7. *Representing Canadian science and technology* – NRC represents Canadian scientific and engineering communities in a broad range of international science and technology organizations. NRC facilitates interaction between Canada's innovation system and those of other countries, and with institutions that operate at the supra-national level. It has reciprocal standards with other international organizations, and through initiatives such as IRAP trade missions, facilitates access by Canadian firms to other markets.

Table 2 shows how each category of output of a public research institution can be expected to affect each of the four primary actors in a cluster: firms, supporting organizations, competition, and customers. Public research institutions primarily affect cluster development through their effects on cluster firms and, to a lesser extent,

supporting organizations. Often, competitors and customers are not located locally, or even nationally, limiting the effect of public research institutes.

Table 2: Cluster actors and the impact of public research institutions

Public Research Institution Outputs	Cluster Actors			
	Firms	Supporting Organizations	Competition	Customers
Research and technology development	R&D capacity and support	Indirect effects	Indirect effects	Contributions to customer solutions
Facilities and personnel	Technical support services			Technical implementation support
Training and knowledge development	Availability of highly qualified personnel	Improved understanding of cluster needs		Acceptance of cluster products and services
Technology and information diffusion	Access to new knowledge and techniques			More informed purchase decisions
Networks and Interaction	Cluster planning and facilitation of concerted action leading to increased opportunities			
Codes and standards	Interoperability among complementary products and services			
Representing Canadian science and technology	Branding, visibility, and credibility	Branding, visibility, and credibility	Opportunities for collaboration	Knowledge of Canadian capabilities

As noted above, NRC has adopted an approach to cluster development that is based on a cluster lifecycle model. Over a period of time, we would expect that a public research institute's R&D and cluster-building activities will evolve as the cluster itself evolves. NRC has proposed a framework for the key efforts of a public research institution at each stage of a cluster that are outlined in Table 3.

Table 3: Stages of Cluster Evolution and the Role of Public Research Institutions

	Latent	Developing	Established	Transformational
Contributions	<ul style="list-style-type: none"> ▪ Regional S&T asset creation ▪ Technical expertise 	<ul style="list-style-type: none"> ▪ Partnering facilities 	<ul style="list-style-type: none"> ▪ HQP 	<ul style="list-style-type: none"> ▪ Scientific intelligence
Roles	<ul style="list-style-type: none"> ▪ Catalyst ▪ Technology Provider ▪ Talent management 	<ul style="list-style-type: none"> ▪ Champion for regional action plans at government level ▪ Credibility provider for R&D & new product innovation 	<ul style="list-style-type: none"> ▪ Initiator of technology foresight & search for next technology transformation ▪ R&D contractor 	
Activities	<ul style="list-style-type: none"> ▪ Identify potential technology platforms ▪ Provide technical expertise ▪ Initiate road mapping and roundtables ▪ Attract HQP with cross appointments ▪ Train next generation 	<ul style="list-style-type: none"> ▪ Business Development ▪ Incubation ▪ Encourage spin offs from labs ▪ Technology transfer ▪ Facilitate problem solving ▪ Contract with emerging industries 	<ul style="list-style-type: none"> ▪ Support public private partnerships ▪ Attract investment to region ▪ Provide product development assistance ▪ Support process innovation ▪ Incubate firms ▪ Launch new ventures ▪ Knowledge diffusion in focused technical areas ▪ Technology transfer 	<ul style="list-style-type: none"> ▪ Incubate firms ▪ Foster new firm formation ▪ Develop new technology capabilities ▪ Absorb HQP rendered redundant ▪ Implement technology platforms in collaboration with partners ▪ Invest
Relationships	<ul style="list-style-type: none"> ▪ Instigate networking with & within community ▪ Work with development agencies on market entry ▪ Bridging and collaboration with universities & other research organizations 	<ul style="list-style-type: none"> ▪ Network beyond the region ▪ Give way to private sector in social capital 	<ul style="list-style-type: none"> ▪ Encourage alliances between MNEs & SMEs ▪ Foster international networking ▪ Continue building social capital 	<ul style="list-style-type: none"> ▪ Develop alliances with MNEs ▪ Facilitate SME-MNE partnership ▪ Link to worldwide R&D ▪ Identify opportunities & new technologies ▪ Have a presence in local, national, international networks

Next Steps

The project team is currently implementing the approach outlined above in the form of pilot studies in two clusters in which NRC is involved: the nanotechnology cluster in Edmonton, where NRC, in partnership with the government of Alberta and the University of Alberta, has established a new NRC institute, the National Institute for Nanotechnology; and the aluminium cluster in the Saguenay region of Quebec where NRC, in partnership with the federal regional development agency, Canada Economic Development for Quebec Regions, and the University of Quebec in Chicoutimi, has established the Aluminum Technology Centre, a satellite of the NRC Industrial Materials Institute located in Boucherville, Quebec.

The two clusters were chosen because they offer several key contrasting features:

- An emerging technology area (nanotechnology) vs. an existing industry in transformation (aluminium);
- A nascent cluster (catalyzed by NRC involvement through the establishment of NINT) and an established cluster (which mobilized to ensure the establishment of an NRC presence – the ATC).

For the pilot studies, we are exploring the efficacy of a number of data collection tools including:

- Web vs. telephone firm surveys;
- In person vs. telephone qualitative interviews;
- An introductory meeting assembling all cluster stakeholders; and
- Contrasting social network analysis methodologies.

Based on an analysis of the methods used and the results obtained, NRC will be seeking to undertake baseline studies for the ensemble of clusters in which it is active. These studies will contribute to the evaluations planned and underway for our second and third round of cluster initiatives. It is the intention of NRC to then undertake subsequent studies to be able to measure the development of these clusters, and NRC's contribution to their growth, over time.

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