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Nanotechnology Subsector Study: Canada's Evolving Nanotechnology Industry and Future Implications for the ICT Labour Force

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Doyletech Corporation Project Team:
Dennis Senik, Denzil Doyle, Glenn McDougall, and Jeffrey Doyle

Doyletech Corporation
Suite 201, 28 Thorncliff Place
Ottawa, Ontario, Canada K2H 6L2
Tel: 613.226.8900
www.doyletechcorp.com

1.0 Executive Summary

The objective of this exploratory scan is to examine the potential impacts of recent and expected developments in nanotechnology on Canada's ICT labour market. Change is expected to be significant because currently, the industry's centre of gravity is in research and development (R&D). It will shift toward product design and process engineering as markets take shape.

The following are the **major findings**:

Nanotechnology Market

- While Statistics Canada (SC) cooperates with international organizations such as the Organization for Economic Co-operation and Development (OECD) in developing statistical frameworks on nanotechnologies, published data is very limited. In 2005, SC conducted a landmark pilot study that provided various Canadian nano industry data, but no updates are available. A list of industry codes (presumably North American Industry Classification System "NAICS" codes) has been developed to facilitate the monitoring of actual or possible nanotechnology activity.

- The main sources of international nanotechnology data are private consulting firms and various ad-hoc, or one-off studies that have been conducted. In Canada, there have been a few surveys conducted on Alberta's nanotechnology industry.

- While the SC pilot study indicated there were 88 Canadian nano firms in 2005, it is likely the current number is in excess of 135 (since this is the number of firms identified by industry observer Victor Jones back in 2009).[1] The Canadian industry is highly concentrated in Alberta, British Columbia, Ontario, and Quebec. We believe that the number of Alberta nano firms is increasing as a proportion of the Canadian total.

- Nanotechnology R&D expenditure data is not available from SC. However, more than 60 countries now have national nanotechnology programmes and studies indicate that global R&D spending by government is increasing rapidly.

- Examples of Canadian firms *believed to be involved* in nanotechnology R&D include Integran, Magna, Hydro-Quebec, Angstrom Engineering, Imperial Oil, Suncor Energy, Syncrude Canada, Xerox Research Centre of Canada, NOVA Chemicals, DALSA Corporation, IntelligentNano, Com Dev, Westport Innovations, Cyrium, D-Wave Systems, Lumerical Solutions, Applied Nanotools, FPInnovations, Quantium Technologies, Purifiner, and Raymor Industries, among many others.

- The Alberta Government has made major investments in nanotechnology R&D and education, as well as a range of developmental activities, with the intent that Alberta will become one of the world's leading nanotechnology regions. The *Alberta Nanotechnology Strategy* states that: "*By 2020, Alberta will achieve a two per cent share of the global nanotechnology market – generating an estimated $20 billion of new economic activity*".[2]

- Currently, there is no Canadian technology cluster in the top 20 internationally in terms of nanotechnology patenting and there are few large Canadian corporate R&D performers of international scale.

- There have been a myriad of nanotechnology market forecasts over the past decade, some of which have received criticism for being too unrealistic. There are obvious issues about how to define nanotechnology using various industry groupings, codes and

[1] Nanotech BC Scoop: Part 2 Interview with Victor Jones. (2009) http://www.frogheart.ca/?p=214.
[2] Alberta Nanotechnology Strategy: Unleashing Alberta's Potential.

statistical constructs. Some of the most optimistic forecasts consider the total market value of all end products that embody a nanotechnology component, rather than the value of end-products that can be directly attributed to this component. While market forecasts must be interpreted with great care, they do at the very least suggest a growing economic impact of nanotechnology.

- Europe has a leading position in nanotechnology in terms of chemistry and medicine/pharmacy. The United States leads in nanostructuring and Asia is strong in nanoelectronics. Canada is strong in nanotechnology research and development (R&D) and educational initiatives, as are the United Kingdom, France and Germany.

Demand and Supply of Nanotechnology Workers

- Perhaps the most cited nano forecast in the world is the (2001) estimate by the National Science Foundation in the U.S. that about two million nanotechnology workers will be needed worldwide by 2015 (including around 800,000 to 900,000 in the United States).[3]

- We did not find any source of data on the current or forecasted demand for (and supply of) nanotechnology workers in Canada. There is no SC data on nanotechnology enrollment or placement.

- OECD research suggests that eighteen member countries have or will soon introduce measures to attract nanotechnology workers. While Canada does not appear to have an explicit strategy for attracting nanotechnology workers, the activities of the National Research Council Canada – National Institute for Nanotechnology (NRC-NINT) and the *Canada Research Chairs Program* is certainly helping to do so (among other organizations and programs).

- In terms of the supply of workers, Canada appears to be doing a good job of developing nanotechnology talent. There are approximately fifteen university programs in nanotechnology and nanoscience. Most programs offer co-op opportunities and appear to be closely aligned with industry. Nanotechnology-related degrees granted in Canada tend to be a *Bachelor of Science* or *Bachelor of Applied Science*, with a few *Bachelor of Engineering* degrees.

- The first Canadian diploma program in nanotechnology was recently launched by the Northern Alberta Institute of Technology (NAIT) to graduate nano technicians and technologists.

- There are few education outreach or awareness programs in nanotechnology at the primary and secondary school levels in Canada (especially when compared to the United States, which appears to be a world leader in this area).

Skill and Education Requirements of Industry

- Canadian industry expects nanotechnology workers to have a strong combination of technical and soft skills such as communications skills. Given its interdisciplinary nature, nanotechnology often requires team work, which means workers must be able to effectively communicate and critically think about their own and others' work.

[3] Roco, M.C. & Bainbridge, W. (eds.) Societal Implications of Nanoscience and Nanotechnology (National Science Foundation, Arlington, VA, 2001).

- Our interviews with industry and academia (as presented in Sections 5, 8, and 9) suggest the following soft skills are desired:
    - Working in teams / team building skills;
    - Intercultural skills;
    - Communication and presentation skills;
    - Self management skills; and
    - Analytical / critical thinking skills.

- It appears that industry is generally of the view that Canada's workers have excellent science and engineering skills, however what is often lacking are entrepreneurial and business skills, namely the ability to integrate science, business, and technology for maximum wealth creation. The view is that a risk adverse business culture, compounded by several barriers such as a lack of risk or expansion capital, is contributing to this situation.

We see the biggest **opportunity for Canada** as being:

> ***Leveraging Canada's already significant nanotechnology R&D and education expenditures into a stronger Canadian nanotechnology industry.***

The comments from industry (as presented in Section 9) are clear: Canada does not have an R&D or training challenge with respect to nanotechnology at this time, but rather a larger developmental challenge. The investment being made by Canada's federal and provincial governments (and a range of other funding organizations) represents a significant opportunity for Canada. However, if the views of industry are correct, the benefits of that investment could be minimal unless the various barriers to new firm creation and business expansion are addressed.

We see the **major challenges** as being:

> **Nationally:** ***developing appropriate mechanisms which will lead to a stronger Canadian private sector and innovation system.***
>
> **For Nanotechnology:** ***the immediate challenge is to help the current Canadian industry transition to product and distribution activities from its current R&D focus. There is a significant human resources (HR) component to this transition.***

These challenges go beyond the mission of ICTC. However, it is a clear message that industry is sending: nanotechnology HR development cannot be considered in a vacuum. In order to commercialize the technology that is being developed by Canada's R&D activity, expertise will have to be developed in activities other than R&D, specifically engineering prototyping and production engineering. Because such expertise is in short supply in Canada, much of it is likely to be acquired from the ranks of the R&D personnel. Making that transition will be a major challenge for the technical personnel involved as well as their managers.

Based on this exploratory scan, we propose the following **recommendations** (as presented in Section 10):

- ***Identify and Track the Data and Information Gaps;***
- ***Develop a Nanotechnology Transition Program and Training;***
- ***Develop a National Strategy to Complement Regional Competencies;***
- ***Be Prepared to Address Age, Gender, and Diversity Considerations; and***
- ***Champion Education and Outreach Programs at the Pre-University Levels.***