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## Canada Looking Forward S+T 21C

Foresight Brief No. 46

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### Purpose

The NRC or National Research Council of Canada undertook a foresight exercise with a time horizon of 2020 to initiate planning for its strategic and organizational renewal. The exercise provided a global perspective and critical insights on the future and impact of S+T in Canada, and on opportunities for the NRC to address national challenges as part of Canadian National System of Innovation.

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### NRC - Science at Work for Canada

The NRC is the Government of Canada's highest body for national research and development. It stimulates community-based innovation and is an active player in international research collaboration that helps to extend Canada's knowledge creation networks and influence in vital sectors on a domestic and global level. The mandate of the NRC is to foster the scientific development of Canadian industry in response to Canadian needs, and for the extension and expansion of Canadian trade both at home and abroad.

#### The Drivers of the NRC

The renewal project intended to identify opportunities and to address a number of fundamental pressures and strategic issues that have emerged in the evolution of the NRC. In particular it sought opportunities to enhance the impact of NRC activities on Canadian socio-economic well-being and stimulate transformative changes within the National System of Innovation. This requires the NRC to re-assess its key roles and extend its core capabilities to further enable commercialization and align NRC resources and investments with Federal Government priorities.

### The 'Renewal Project'

The 'Renewal Project' is composed of four distinct phases:

- **Phase I:** Environmental Scan
- **Phase II:** Strategic Direction
- **Phase III:** Strategy Development
- **Phase IV:** Strategy Implementation

Phases I and II are now completed and Phase III will soon to be finalized. The environmental scan involved identifying global issues that were societal, economic or scientific in nature, industry needs and government priorities as well as S+T trends that will shape research and science in Canada over the coming years. It included an assessment of NRC core competencies, an analysis of the Canadian national system of innovation, and interviews with selected Canadian and foreign government S&T organizations on needs in relation to organizational capabilities. More specifically, five teams composed of internal researchers and external consultants were formed to conduct the environmental scan and the core competency assessment of NRC. A variety of techniques were used such as organization-wide participatory actions, extensive literature search, brainstorming and consultations, surveys, interviews, S+T foresight workshops and scenario-building exercises. The



process also involved consultation with internal and external stakeholders. A consolidation exercise was followed by an exploration of possible futures and impacts via a scenario-building exercise. A 'Strategy and Priorities Committee' led by a senior executive oversaw and guided the iterative process, while a project management team structured what was in effect a complex and rather novel initiative for the NRC.

## Findings of the Environmental Scan

The main findings are as follows:

- **Changes in Cultural Identity:** By 2025 it is expected that roughly 22% of the Canadian population will be aged 65 and over. By then Canada's population is expected to be around 35 million with visible minorities accounting for 19% to 23% of the total. Between 6.3 and 8.5 million citizens will reflect cultures, values and religions that are quite different from those upon which the country was founded. Demographic change will have economic and social impact in terms of a smaller workforce, lower productivity, pension payment liability, changing consumer expectations and increased demands on natural resources.
- **Worldwide Decline of the Nation State:** Although democracy is on the rise there is also a growing number of failed nation-states. The nation-state is seen to be losing ground to trade and religious groupings as the primary source of identity and Canada's place in the world will decline.
- **Loss of Leadership by Western Society:** In the 20<sup>th</sup> century it was widely assumed that the future would be owned and defined by western industrial cultures, technologies, economies and world views. Shifts in the way we think about the world contribute to a loss of confidence in institutions and leadership in western society.
- **Demand for Greater Security:** Rapidly increasing global interdependence brings new threats and vulnerabilities. The ability of the state to deal with the privatization of conflict weakens. To some extent 'security' drives how we perceive the world and how we react within it.

From this backdrop several challenges of critical importance for Canada and the world have been identified.

**Chronic Diseases and an Aging Population:** Chronic disease is the most common and costly health problem worldwide. Chronic diseases must be addressed to ensure quality of life for an aging population. Opportunities exist in the area of early diagnosis, monitoring and cures for many of these diseases based on Canadian strengths in genomics, proteomics, biosensors, biomaterials and nanotechnology areas.

**Pandemics and Infectious Diseases:** Bacteria and viruses are able to develop resistance to essentially all antimicrobial and antiviral agents marketed to date. With population movement at an all-time high, conditions are ideal for the global transmission of infection. There is need for quick identification of infectious agents, for the creation of a robust, innovative production capacity for vaccines. Traditionally the vaccine mar-

ket was unattractive to investors but the economics of vaccines may be improving, particularly with countries now scrambling to stockpile vaccines. Canada has responded with the creation of the 'Public Health Agency of Canada' and is viewed as one of the countries better prepared for a pandemic.

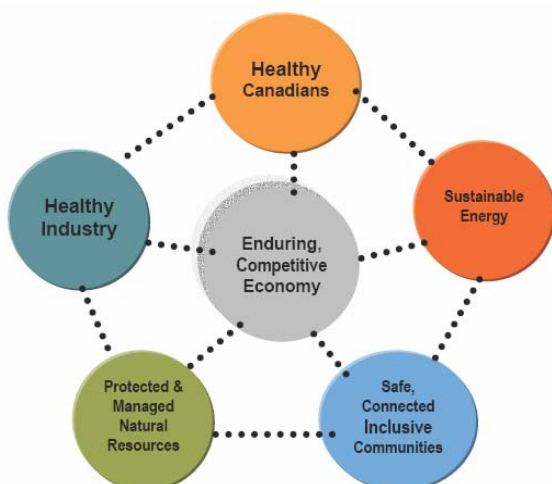
**Natural Resource R&D:** In all challenges that were examined, the Canadian resource sectors, including agri-food, forests, energy, minerals and metals, as well as related industries are some of the largest contributors to our GDP. While there are many S&T players involved in these sectors, they, for the most part, concentrate on the early stages of the value chain and on development of markets; the goals are primarily sustainability, efficiency and marketability. This is one of the sectors in which there is clearly an urgent need for R&D, particularly in innovative value-added opportunities such as **Agri-food**, where it is likely that developed countries will achieve the goal of producing sufficient quantities and qualities of value-added agri-food products to have a significant positive impact on their economies within the next 10 years. In the area of **Forestry** Canada has proven its ability to be innovative and with the right combination of R&D and policy frameworks it should not only maintain its global position but improve upon it. The **Mining and Minerals** industry is well positioned to transform S+T advances into commercial activity. It fully appreciates both the commercial and environmental imperatives for its leadership role in sustainable development. The likelihood of achieving significant benefits is therefore very high. Canada is rich in **fresh water resources** whereas freshwater is becoming increasingly scarce around the world. Canada should seize the challenge and become a world leader in all related domains - purification, desalination, transportation of water; and safe water management through the application of technology.

**Environmentally Sound Technologies:** The emerging global market for environmental technologies presents a significant economic opportunity for Canada. This refers to all technologies to manage pollution through control, remediation, avoidance and monitoring. According to OECD findings **bio-based technologies** will provide both economic and environmental benefits that include cost savings of 10-50%, a reduction of CO<sub>2</sub> emissions by 10- 80%, water savings of 20-50% and a significant reduction in pollution and toxic substances. In Canada, a combination of abundant biomass resources, a strong science base for industrial bioproducts and bioenergy, and federal priorities in favour of biotechnology, are creating a favourable climate for the development of a **new bioproducts and bioprocessing industry**. Canada is recognized as a **world leader in bio-fuel**. Reducing the cost of technologies and systems for biomass harvesting and conversion into bioproducts and bioenergy is therefore a major R&D target.

**Sustainable Energy and Economic Growth:** Access to adequate supplies of energy is both an opportunity and a prerequisite for growth. Although the potential benefits of **hydrogen and fuel cells** are significant, many challenges remain before they will offer a competitive energy alternative. Cost

and storage are the biggest challenges. Research is needed to develop storage technologies using materials such as metal hydrides and carbon nanostructures. **Solar and wind** are renewable energy sources that offer more than just a solution to meet our growing energy needs and address oil depletion and climate change problems. They also create new opportunities for economic growth and provide security benefits. Solar and wind energy will also accelerate the transition to reliance upon domestically available clean energy technologies. There is a renewed interest in **nuclear power** as an emission-free energy source and as a natural hedge against the environmental costs of fossil fuels. Uranium is one of the world's most important energy minerals, but is notable for its very low energy efficiency. Less than 1% of the resource is extracted as energy and the rest is stored as 'waste'. At this rate, Canadian uranium resources, about 14% of world total, will be exhausted within 50 years. R&D is required to make that technology 10 to 50 times more efficient. The **oceans** contain a huge amount of power that can be exploited for generating useful energy. Developed conversion systems concern tidal energy, thermal energy, marine currents and ocean waves. Canada is particularly rich in tidal current and wave energy resources.

**Connected Communities** both from a physical and virtual perspective will create new opportunities for many sectors of society, including transportation, trade, education, research, healthcare as well as security and government services. Connecting communities requires physical infrastructure for transportation, transportation technologies, network infrastructure, computational power, bandwidth, as well as software and hardware technologies to address the challenge. This connectivity is essential to support the new knowledge economy. While the Canadian economy is generally quite sound with growth maintained at roughly 2.7% in 2005 and forecast growth of 3.1% and increased employment for 2006, some factors of **Canadian competitiveness** are a cause for concern. Canada has dropped in economic performance and global competitiveness, productivity is lagging and the global balance of economic power is shifting to emerging giants such as China and India.



The previous graphic highlights S&T opportunity themes identified from the foresight study and validated with extensive consultations. These themes are interconnected and progress in one theme will almost certainly affect others. Most importantly these themes take into account the economy, society and the environment in an integrated way that provides the foundation for sustainable development.

### Strategic Direction

Armed with the consolidated findings and insights from the environmental scan several activities took place in Phase II. A series of 26 workshops was held with NRC staff across the country from August to October 2005. Staff was asked for input on the key opportunities and challenges identified for NRC. The objective of these consultations was to build a shared understanding of the S+T opportunities and challenges for Canada from the perspective of the year 2020, and assess whether a strong role can be played by NRC.

Opportunities highlighted by staff were consistent with those identified in the foresight phase as key national issues: energy, natural resources, and health. These are summarised in the table below:

Protected and Managed Natural Resources	<ul style="list-style-type: none"> <li>- Protection</li> <li>- Management</li> <li>- Conservation and</li> <li>- Modelling for</li> <li>- Water</li> <li>- Minerals</li> <li>- Oceans and</li> <li>- Forests</li> </ul>
Healthy Canadians	<ul style="list-style-type: none"> <li>- Wellness</li> <li>- Public Health</li> <li>- Prevention and</li> <li>- Diagnosis as well as</li> <li>- Drugs &amp; Therapies for</li> <li>- Age Related Diseases</li> <li>- Chronic Diseases and</li> <li>- Individualised Medicine</li> </ul>
Sustainable Energy	<ul style="list-style-type: none"> <li>- Efficiency</li> <li>- Clean energy</li> <li>- Conservation</li> <li>- Alternatives</li> <li>- Distribution</li> </ul>
Healthy Industry	<ul style="list-style-type: none"> <li>- Materials</li> <li>- Manufacturing</li> <li>- Commercialisation</li> <li>- Productivity</li> <li>- Efficiency</li> </ul>
Connected, Safe, Inclusive Communities	<ul style="list-style-type: none"> <li>- Transportation</li> <li>- Emergency Preparedness</li> <li>- Connectivity &amp; Communications</li> <li>- Security</li> <li>- Housing</li> <li>- The e-Economy</li> </ul>

In September and October 2005 7 cross-country workshops were conducted with close to 300 key external stakeholders from industry and universities as well as from provincial and municipal government organizations. Challenges thrown up in the course of the consultation were also identified and these are summarised in the following table:

<b>Governance</b>	<ul style="list-style-type: none"> <li>- Link National S&amp;T Policy to the Economy</li> <li>- Align Government Priorities</li> <li>- Improve Collaboration between Government, Academia and Industry</li> <li>- Demonstrate Leadership</li> </ul>
<b>Infrastructure</b>	<ul style="list-style-type: none"> <li>- Focus on Regional Strengths</li> <li>- Execute Smart Regulations</li> <li>- Increase Private Sector Research and Absorbive Capacity</li> <li>- Become more Adaptive, Agile and Responsive</li> </ul>
<b>Knowledge &amp; IP Management</b>	<ul style="list-style-type: none"> <li>- Support Knowledge Sharing, Management and Dissemination</li> <li>- Access International Knowledge</li> <li>- Add Value to Products before Export</li> <li>- Protect IP for Canada</li> </ul>
<b>Education</b>	<ul style="list-style-type: none"> <li>- Develop and Improve Cross-Disciplinary Education</li> <li>- Engage Aboriginal Youth</li> <li>- Develop Professors with Industry Experience</li> <li>- Link Immigration Policy to Educational Needs</li> </ul>
<b>HQP</b>	<ul style="list-style-type: none"> <li>Develop the ability to:</li> <li>- Attract and Retain Top Talent</li> <li>- Grow Internal Talent</li> <li>- Absorb Talent into Industry</li> <li>- Link Immigration Policy to Employment Opportunities</li> </ul>

The consultation process was critical because the selection of strategic directions for the NRC should rest in a large part on

### Impact and Policy Implications

As a result of these foresight studies and consultations on challenges, opportunities and disruptive technologies, the Senior Executive and members of the Strategy and Priorities

its ability to engage its key stakeholders. On the basis of these results a vision of potential future roles for NRC was derived.

### Disruptive-Technologies Workshop

In November 2005 over 40 scientists from across the NRC got together for a unique brainstorming session. The goal was to explore anticipated S+T challenges from now until 2020 and identify areas of likely to be transformed by breakthroughs in the next generation and in which the NRC should consider investing and developing new competencies. The results are summarised in the table below.

<b>Human Health</b>	<ul style="list-style-type: none"> <li>- Diagnostics</li> <li>- Therapeutics</li> <li>- Bio-System Interfaces</li> <li>- Food</li> </ul>
<b>Transportation</b>	<ul style="list-style-type: none"> <li>- Autonomous Vehicles</li> <li>- Micro-Vehicles</li> <li>- Sub-orbital Vehicles</li> </ul>
<b>Intelligent Systems</b>	<ul style="list-style-type: none"> <li>- Manufacturing</li> <li>- Monitoring Environments</li> <li>- Infrastructure</li> </ul>
<b>Quantum Technologies</b>	<ul style="list-style-type: none"> <li>- Cryptography and Computing</li> <li>- Photonics, Spintronics &amp; Molecular Electronics</li> <li>- Extreme Measurement and Control</li> </ul>
<b>ICT</b>	<ul style="list-style-type: none"> <li>- Mathematical Theory of Computation</li> <li>- Programming Languages</li> <li>- Software Engineering</li> <li>- Breakthrough Applications</li> <li>- New Software Authoring Communities</li> </ul>
<b>Sustainable Energy &amp; the Environment</b>	<ul style="list-style-type: none"> <li>- Generation</li> <li>- Storage and Distribution</li> <li>- Energy User Technologies</li> </ul>

Committee are working to develop a new strategy for the NRC, identifying its purpose, role, vision and goals to contribute to increasing Canada's social and economic competitiveness into the future.

### Sources and References

The consolidation report entitled 'Looking Forward: S&T for the 21<sup>st</sup> century' can be found at the following website:

[http://www.nrc-cnrc.gc.ca/docs/NRC-Foresight\\_Consolidation\\_Report\\_e.pdf](http://www.nrc-cnrc.gc.ca/docs/NRC-Foresight_Consolidation_Report_e.pdf)

About the EFMN: Policy Professionals dealing with RTD, Innovation and Economic Development increasingly recognize a need to base decisions on broadly based participative processes of deliberation and consultation with stakeholders. One of the most important tools they apply is FORESIGHT. The EFMN or European Foresight Monitoring Network supports policy professionals by monitoring and analyzing Foresight activities in the European Union, its neighbours and the world. The EFMN helps those involved in policy development to stay up to date on current practice in Foresight. It helps them to tap into a network of know-how and experience on issues related to the day to day design, management and execution of Foresight and Foresight related processes.