Industry Canada

Technology Roadmaps

Progress Report and Contribution to Canada's Innovation Strategy

CENTRE FOR PUBLIC MANAGEMENT

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This document reports on the status of nine Technology Roadmaps (TRMs) underway during the winter of 2003, and the potential contribution of these TRMs to the elements of Canada's Innovation Strategy.

This study was conducted for Industry Canada's Industry Sector. However, the nine TRMs involved several other federal departments, including Natural Resources Canada (NRCan), the National Research Council (NRC), and others.

1.0 Overview of Technology Roadmaps

Technology Roadmaps (TRMs) are a process tool to help Canadian industries, or sectors within an industry, identify and address the technology challenges that are critical to their future. Developing and implementing a TRM involves a three-phase process, as follows:

Phase 1: Developing a formal TRM for an industry, a sector, or common areas of interest. Results from this developmental phase are captured in a formal Technology Roadmap Report, which is an important deliverable from Phase 1 of a TRM initiative. A Technology Roadmap Report typically captures the following information that was developed during the Phase 1 process:

1) The technologies that are critical to future competitiveness of an industry or of related industries, based on the TRM participants' knowledge and analysis of future requirements.
2) Technological requirements and opportunities for the industry's supply chain, and
3) Recommendations for action on how multiple organizations from industry, academic institutions, research organizations, and governments can work together to crack those technologies.

Phase 2: Selecting and undertaking projects set out in the TRM to "crack" the identified critical technology challenges.

Phase 3: The adoption by an industry, a sector, and/or others of a "culture of collaborative technology development" as part of their normal method of operation.

The lifecycle of all three phases of a TRM will most often cover a period of several years.

A key characteristic of TRMs is that they are "industry-led." This approach ensures that the concerned industries "buy into" the results, and is the major factor in ensuring that the initiative proceeds through all three phases, ultimately leading to new technology development.

The process for developing a TRM typically involves several companies from one or more industrial sectors that come together to identify the technologies that are critical to their collective future, and to establish a collaborative approach to developing those technologies. The key objectives of a TRM initiative are to provide a mechanism to enable organizations within an industry or a sector to achieve a collective decision on future technology development, and to establish a commitment to work together in addressing the related technological challenges.

Some of the key intended results from TRMs are the following:

- New enabling technological solutions are developed
- R&D funding has been reconsidered and/or redirected
- New products or utilization of new products have been developed
- New exports, new export markets of the enabling technology have been identified and exploited
- Barriers to development and transfer of critical technologies are better understood and overcome
- The flows of information related to technology development and inter-firm projects are better understood and used
- Formal technology development projects and/or less formal spin-off projects are undertaken
    - Some industry-wide
    - Some between a small number of companies
    - Some may be on an individual basis
    - New, additional related roadmaps were initiated/created
- Other industries have become interested in undertaking TRMs.

2.0 Progress of the Nine TRMs Underway

This report presents first a description of key characteristics of nine TRMs that were at various stages of development during the period of January to March 2003. The key characteristics discussed are those that are considered by Industry Canada to be important to a TRM's success in achieving desired results, described above.

The nine TRMs and the state of their progress is set out in the following table.

Technology Roadmap Name	Stage of Development
Bioproducts	Pre-workshop phase - Planning
Biopharmaceuticals	Study workshops/groups are underway (report complete/ not yet released)
Clean Coal	Study workshops/groups are underway
CO_2 Sequestration	Pre-workshop phase - Planning
Fuel Cells	Report is complete (released April 15, 2003)
Intelligent Buildings	Report is complete (projects being scoped)
Language Industry	Preliminary report is complete
Lean Logistics	Study workshops/groups are underway
Marine and Ocean	Report and web site are published.

It is noteworthy that the characteristics of the industries involved varied considerably based on economic profile, company sizes and regulatory environment. This supports the view that the TRM process can be applied to a wide variety of industries, or sectors within an industry.

2.1 Facilitation of the TRM Process

Facilitators are considered to be an essential element to the continued progress of a TRM initiative. Past evaluations of TRMs have found that a facilitator was an essential element to ensure progress of a TRM process.

The facilitators for the nine TRMs come from several organizations:

- Four TRMs were facilitated by Industry Canada Officers,
- One by an NRC officer,
- Two by NRCan officers, and
- Two by consulting firms.

In several of the TRMs, a participating industry member also contributed to facilitating the process.

The facilitators have performed and are performing many roles in the TRM process, from soliciting initial interest, ensuring steering committees are formed, educating participants about the process, structuring discussions and workshops, ensuring results are documented, and preparing reports. These observations indicate that the officers from the various federal organizations can play a variety

of roles to support the progress of a TRM. This finding is consistent with the findings of past evaluations of IC-facilitated TRMs[1].

2.2 Participation by Industry, Academia and Government

Participation by a diversity of participants that are knowledgeable of the industry and relevant technologies is an important factor in the success of a TRM. In general, there was broad participation in the nine TRMs studied. Good representation by the private sector increases the buy-in to the process and the potential for sustained effort. All nine TRMs included private sector participants. Participation by the academic sector appears to be more important for some industries, such as Bioproducts than it is in others, such as Intelligent Buildings. In two cases, Bioproducts and CO_2 Sequestration, the facilitation of an academic research network was an important preliminary step, and it helped to involve the academic community in the TRM process.

All nine TRMs have been successful in involving a full range of participants in the process.

2.3 Selection of the Areas for Study

Both the method used in a TRM process to choose areas of study, and the areas of study ultimately chosen can affect the level of participation, collaboration, and commitment to the process. A TRM will evoke more interest and commitment when the TRM's areas of discussion and analysis are directly relevant to participants of work groups. This is particularly the case for private sector participants who, to a varying extent, need to justify to their own organization their continued participation in the TRM because of other competing business priorities.

Furthermore, to enable collaboration, the TRM process needs to address the often-raised issue of industry participants concerning the disclosure of proprietary or competitive information. By selecting study areas and forming working groups carefully and thoughtfully, TRMs can overcome concerns about confidentiality and ensure that participants are fully engaged in the TRM analyses. The TRM process can be more successful by subtly managing the interaction of direct competitors and structuring sessions such that the discussions can be at a pre-competitive level.

The selection of areas of study for the nine TRMs has been mostly driven by steering committees. In some cases, the selection was further refined through a workshop process. Information provided on the TRMs indicated a good level of cooperation in working groups. For example, in the Marine & Ocean TRM, participants who originally thought their business activities were unrelated, realized there were indeed relationships between their businesses.

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[1] Synthesis of Six Technology Roadmaps Evaluations, Final Report, Industry Canada, March 2002

Furthermore, it appears that concerns over sharing information are being discussed and, for the TRMs that are well underway, successfully addressed. For example, this was a concern early in the Fuel Cell , Biopharmaceuticals and Intelligent Buildings TRMs, but was successfully addressed in both cases. The observations suggest that facilitators are finding effective methods for overcoming these concerns and fostering collaboration, even among competitors.

2.4 Involving Industry Champions

Industry champions can contribute many positive attributes to a TRM initiative, including credibility, substance, and a national presence/perspective. Champions are most often larger or prominent industry participants or industry leaders, and are recognized by participants as important contributors to the industry's current and future success. Industry champions' participation provides opportunities for forming new partnerships with other industry members. Champions can also help to ensure that a TRM's discussions of technology remain relevant to industry's realistic capabilities and interests.

Eight of the nine TRMs include well-recognized industry leaders. The remaining TRM, related to language industries, includes wide participation; however, the industry does not seem to have any recognized champions that would have necessarily strengthened the TRM process. The Language Industry TRM has facilitated alliances and acquisitions; the emergence of industry leaders is expected.

2.5 Commitment By Participants

A sustained commitment by participants is a good proxy measure for the relevance and usefulness of TRMs. In industries composed of a large proportion of SMEs, such as Biopharmaceuticals, time and resources for travel can be an issue. The findings indicate that commitment to the TRMs studied has been generally very good. Telephone and electronic collaboration have been used as vehicles to overcome time and financial constraints.

2.6 Senior Management Participation

Participation by company executives in a TRM is another important indicator of relevance. TRMs are intended to encourage technology-focused collaboration. Participation by company executives from industry improves the likelihood of "information trading" and reaching agreements to work together, even outside the formal TRM exercise. Senior company officers tend to know more about their company and its strategic business directions, and are more likely to recognize opportunities for beneficial strategic partnerships. Furthermore, executives have a better understanding of what company information can be shared with others, whereas others in their organizations may avoid all information sharing for fear of divulging too much. Finally, the presence of executives will attract other

executives, and will add credibility to the overall TRM initiative. Therefore, several benefits arise from executive participation.

The TRMs that were underway included CEOs, Presidents, Vice-Presidents, Directors of Research Centres, Government Directors and staff at all levels. In the Intelligent Building TRM, senior management elected to delegate to company representatives and report back on their findings, and this approach was considered to be suitable to the industry.

Overall, this finding provides a strong indication that the TRM exercises are seen as credible, that they add value, and that they are achieving intended results.

2.7 Clear List of Technologies and Projects

TRMs proceed more deliberately into the Phase 2 implementation stage if Phase 1 provides good guidance for future technology development projects. Specifically, decisions to undertake Phase 2 projects are better supported by Phase 1 work if a) criteria have been developed in Phase 1 to help decide technology attributes that are important to the Canadian industry, b) alternative technologies have been discussed and analyzed to determine whether they meet the criteria and c) a list of higher-priority technologies is developed to help guide future project selection decisions.

Five of the roadmaps studied were at or past the stage of having a Phase 1 report approved by their steering committee. All of these reports contain technology goals. Some also contain policy recommendations that strive to make the industry environment more receptive to technology innovation, for example, related to funding/financing, design, and partnerships. Two of the TRMs – Fuel Cells and Biopharmaceuticals – focused more on commercialization of developed technologies in order to accrue more of the benefits in Canada. The Phase 1 reports for those two TRMs are expected to contain recommendations on production, market users, market drivers, including measures which would shorten product introduction,, and access to capital

Overall, of the five approved reports, almost all have identified projects/undertakings for participants to focus on after completion of Phase 1.

2.8 Industry Characteristics

An industry's business characteristics can have an impact on the relative value added of a TRM exercise. Even though focusing on critical technologies is important to virtually all industries all the time, the timing and the design of a TRM initiative can affect participants' involvement and the initiative's success. For example, key industry characteristics that should be taken into consideration when considering undertaking a TRM are: economic profile, regulatory environment and rate of technology advancement.

The findings indicate that all the TRMs were timely. As indicated earlier, the high added value of the TRMs was confirmed by the participation of many industry

participants and the presence of many industry executives. In fact, four of the TRMs – Bioproducts, Clean Coal, CO_2 Sequestration, and Fuel Cells – were particularly timely with the government's recognition of the Kyoto Protocol. Also, changes in border regulations were a significant factor contributing to the support of the Lean Logistics TRM.

Therefore, all nine TRMs appear to be well timed to add value to their respective industries.

2.9 Partnerships Formed

An important indicator of the added-value of a TRM is the formation or strengthening of technology-oriented arrangements or partnerships. The findings indicated that some new arrangements were created through the TRMs, and that some pre-existing ones may have been strengthened. For example, the Language Industry TRM is reported to have contributed to the formation of the Canadian Language Industry Network. The Marine and Oceans TRM was reported to have contributed to the formation of the National Ocean Technology Network, a partnership between Technopole Maritime du Québec (TMQ), Canadian Centre for Marine Communications (CCMC) and the BC Co-operative Ocean Information Network (BC-COIN). Furthermore, TRMs provided an opportunity for networks and associations on Bioproducts, Clean Coal Power, CO_2 Sequestration to come together respectively to discuss technology issues.

The findings indicate that some TRMs generated new arrangements, and that others, such as the Biopharmaceuticals, strengthened arrangements that already existed.

2.10 Conclusion on the TRMs' Characteristics

Overall, the findings indicate that the nine TRMs underway during the winter of 2003 reflected most of the characteristics that contribute to the success of a TRMs. Specifically:

- All nine TRMs have been successful in involving a full range of participants in the process,
- Facilitators are finding effective methods for fostering collaboration, even among competitors,
- Eight of the nine TRMs include well-recognized industry leaders, and the ninth is facilitating the emergence of industry leaders.
- The TRMs that were underway included representatives from senior management,
- Of the four approved reports, almost all have identified projects/undertakings for participants to focus on after completion of Phase 1,

- All nine TRMs appear to be well timed to add value to their respective industries, and
- Some TRMs generated new arrangements, and others are strengthening arrangements that already existed.

3.0 Contribution of TRMs to Canada's Innovation Strategy

This study is also intended to discuss the actual and potential contribution of TRMs to Canada's Innovation Strategy. The Innovation Strategy includes three principal areas, which each include specific goals, targets and priorities. The three principal areas and their related goals are the following:

Knowledge Performance Challenge

- Vastly increase public and private investments in knowledge infrastructure to improve Canada's R&D performance.
- Ensure that a growing number of firms benefit from the commercial application of knowledge.

Skills Challenge Innovation

- Develop the most skilled and talented labour force in the world.
- Ensure that Canada continues to attract the skilled immigrants it needs and helps immigrants achieve their full potential in the Canadian labour market and society.

Environment Challenge

- Address potential public and business confidence challenges before they develop.
- Ensure that Canada's stewardship regimes and marketplace framework policies are world-class.
- Improve incentives for innovation.
- Ensure that Canada is recognized as a leading innovative country.

In addition, a fourth topic area provided goals related to clusters:

Sources of Competitive Advantage Are Localized

- Governments need to work together to stimulate the creation of more clusters of innovation at the community level.
- Federal, provincial/territorial and municipal governments need to cooperate and supplement their current efforts to unleash the full innovation potential of communities across Canada. Efforts must be guided by community-based assessments of local strengths, weaknesses and opportunities.

This section of the report discusses the relationship between the TRMs and goals in each of these four areas of the Innovation Strategy.

3.1 Knowledge Performance Challenge

-- Vastly increase public and private investments in knowledge infrastructure

This goal is focused on increasing investment in research and development, more strategic alliances and improved access to risk capital.

As indicated earlier in this report, TRMs are designed deliberately to encourage the private sector to identify, develop and share technologies that are key to their future success. TRMs, including all nine studied, focus clearly on encouraging the private sector to develop and adopt technologies. Also, as indicated above, successful TRMs result in the creation of strategic technology alliances or partnerships – a key component of Canada's knowledge infrastructure. For example, in preparation for both the Bioproducts and the CO_2 Capture and Storage TRMs, the formation of a research network was an essential first step, which allowed stakeholders to become engaged in the TRM process.

TRMs do not necessarily increase the private sector's investment in R&D; however, they do provide a vehicle for maximizing the collective results generated from R&D investments.

This analysis indicates that TRMs can contribute clearly to the achievement of this goal of Canada's Innovation Strategy.

-- Ensure that a growing number of firms benefit from the commercial application of knowledge

This goal involves encouraging the private sector in Canada to develop more aggressively its capacity to commercialize and adopt technologies to remain competitive. TRMs align strongly to this Innovation Strategy goal in two ways:

- They assist the transfer of knowledge from publicly funded research organizations to industry and vice versa; and
- They can help to develop collective strategies on the ways that existing technologies can be commercialized.

The nine TRMs provided several examples where they contributed to this goal. Specifically,

- The Biopharmaceutical TRM is exploring strategies for maximizing the commercialization of the R&D investment that companies are making and

identifying the technology platforms in which Canada may demonstrate global leadership;

- The Fuel Cells TRM is developing strategies for stimulating market demand, improving quality and reducing cost, financing, creating infrastructure, meeting the demands of key drivers and users and product introduction timelines;
- The Bioproducts TRM is investigating mechanisms for transferring the knowledge and expertise of universities to industry;
- The Intelligent Buildings TRM hopes to stimulate the market by releasing a Best-Practices guide and by developing standards for inter-operability;
- The Lean Logistics TRM intends to bring the latest technologies to SMEs so that the industry can become more integrated. The TRM is intended to provide SMEs with tools to help make technology decisions; and
- The Clean Coal TRM will examine a number of emerging technologies and pilot projects to decide which technology pathways are suitable to meet the upcoming Kyoto greenhouse gas mitigation requirements.

Overall, the analysis indicates that TRMs contribute strongly to the achievement of this Innovation Strategy goal.

3.2 The Skills Challenge

-- Develop the most skilled and talented labour force in the world

Even though TRMs are intended to be primarily focused on the identification of key technologies, in practice they have also helped to identify issues related to skills and learning.

The analysis of the nine TRMs revealed that discussions related to skills and learning came up frequently throughout several of the TRM processes. For example:

- The Fuel Cells TRM is developing a manpower strategy, and training policies and criteria;
- The Intelligent Buildings TRM intends to raise awareness of new Intelligent Buildings technologies among designers and builders and in the education system;
- The Lean Logistics TRM identified the need for more specialized programs at the post-secondary level and an analysis of the P.Log professional certification;

- The Language Industries TRM identified the need for modernization of education at the post-secondary level and internship programs in language industries; and
- The Bioproducts TRM is expected to identify skills needed to support a bio-based economy.
- The Biopharmaceutical TRM supports recommendations which will encourage measures which attract foreign managers into Canadian firms

Furthermore, the Intelligent Buildings and the Marine & Ocean TRMs identified actions that could be taken by unions to provide education on, and raise awareness of new technologies, and transfer technology related skills to younger workers.

The analysis of the nine TRMs strongly indicates that, even though it was not explicitly intended to do so, the TRM process has provided a good vehicle for identifying skills-related issues and opportunities, and strategies and policies for training. This conclusion reinforces what appears to be an important benefit of the TRM process: when knowledgeable and committed individuals from diverse stakeholder groups come together to discuss a *common and relevant* area of opportunity, it appears that they will stretch the scope of the discussion to include all areas that relate to maximizing that opportunity.

The analysis indicates that the TRM process supports well the achievement of this goal of the Innovation Strategy.

-- Ensure that Canada continues to attract the skilled immigrants it needs and helps immigrants achieve their full potential in the Canadian labour market and society

The analysis of the nine TRMs does not provide a clear and explicit linkage between the TRM process and this skills-related goal. However, the achievement of this goal could be linked to the TRM skills and learning opportunities discussed in the previous sub-section.

3.3 The Innovation Environment Challenge

-- Address potential public and business confidence challenges before they develop

The TRM process appears to be an effective vehicle by which a diverse or fragmented industry can combine resources to develop a strategy for success. Therefore, the process could be used to both identify emerging confidence challenges and engage stakeholders in developing strategies for increasing confidence. The analysis provided specific examples of this type of result:

- The Language Industry TRM is unifying a somewhat fragmented industry. Through the TRM process, participants are finding areas of capability to focus on and researching global trends and opportunities for technology development;
- The Marine and Ocean TRM provides a very diverse industry with a vehicle for "re-grouping" and cooperating locally so that industry members can collectively compete globally in niche markets;
- The Biopharmaceuticals TRM is exploring ways for Canadian companies to retain the industry in Canada and retain greater economic benefits to Canada. TRM participants are discussing possible approaches, as well as the potential of promoting benefits of increased manufacturing capability in Canada; and
- The Lean Logistics TRM is developing strategies for SMEs to be current with the latest supply-chain-management technology, thereby enabling them to interface with the large North American "channel masters".

These examples illustrate that TRMs can provide a forum for discussing and addressing challenges that can affect the confidence of Canadian industry and communities.

-- Ensure that Canada's stewardship regimes and marketplace framework policies are world-class

As discussed above, the TRM process provides participants with opportunities to identify and discuss areas of concern that are important to an industry or sector within an industry and to make recommendations on policies to improve the environment for technology development and commercialization. For example, the Bioproducts roadmap will make recommendations on fuel taxation with the goal of leveling the playing-field for biodiesel. As discussed in section 2.0, other TRMs provided recommendations related to such issues as maintaining industries in Canada and funding/financing and regulatory changes.

TRMs can contribute to the achievement of this goal, although indirectly.

-- Improve incentives for innovation

TRMs are explicitly intended to foster innovation. The discussion above illustrates that TRMs are an effective incentive to innovation: they foster technological innovation, and they also provide a vehicle for addressing other issues that affect the future success of an industry. The above-mentioned achievements of the nine TRMs studied illustrate that well-chosen and well-managed non-financial incentives can contribute to technological innovation.

-- Ensure that Canada is recognized as a leading innovative country

The TRM process has the potential to raise the international recognition of Canadian industry's technological status. The process is semi-public since, even though the detailed discussions are private, the objectives, schedule, and reports are often available to the public and on the web. This provides both the industry and the public, inside and outside Canada, with the opportunity to recognize that a particular industry is making a significant effort to innovate by undertaking a TRM. This visibility may serve to maintain or promote the innovation profile of the industry within Canada and internationally.

The analysis of the nine TRMs provided examples where the TRM process contributed to the international profile of the Canadian industry:

- The CO_2 Sequestration TRM will receive significant research input from an international project for CO_2 transport and geological storage located in Weyburn, Saskatchewan. International delegations have visited the project and reported back to their national governments.
- The Intelligent Buildings TRM was the first on the subject in North America. This has attracted attention to the innovation efforts of the Canadian industry.
- The lead participant in the Lean Logistics TRM intends to present findings at a logistics conference this year in France.

Therefore, TRMs can increase Canada's recognition as a leading innovative country.

3.4 Sources of Competitive Advantage Are Localized

-- Governments need to work together to stimulate the creation of more clusters of innovation at the community level

TRMs are intended to increase collaboration across an industry. They can provide strong support for the formation of clusters at the community level by providing a networking environment that directly encourages the formation of innovation clusters. Section 2.9 above provides illustration of networks formed or strengthened through the TRM process.

TRMs can also provide recommendations on joint priorities for organizations located in cluster areas, such as research centres.

The TRMs discussed above provide examples of fostering cluster activities, including:

- The networking activities associated with the Marine and Ocean TRM resulted in a strategic partnership between the Canadian Centre for Marine Communications in Newfoundland, the Technopole Maritime de Québec and BC Co-operative Ocean Information Network; and
- One of the objectives of the Language Industries TRM is to provide guidance on the programs of a research institute, for which federal funding has recently been announced.
- The Biopharmaceutical TRM encourages the maximization of limited science resources for a country the size of Canada in order exercise its strengths of being a world leader in designated technology platforms
- Therefore, even though the TRM process does not limit the geographic region of participants, it does contribute to the networking that is essential to the formation of clusters.

-- Federal, provincial/territorial and municipal governments need to cooperate and supplement their current efforts to unleash the full innovation potential of communities across Canada. Efforts must be guided by community-based assessments of local strengths, weaknesses and opportunities.

This goal is directed at governments. Since TRMs primarily focus on technology development, as discussed above, some have produced policy recommendations for government. For example, though in early stages, the Bioproducts TRM is expected to provide policy-related recommendations. Furthermore, it has identified significant opportunities for rural/regional development, which will promote rural industry and at the same time be complementary to climate change objectives.

Therefore, since TRMs can generate recommendations directed toward government policies, they can stimulate action by governments that will encourage innovation.

3.5 Summary on the Linkages Between TRMs and Canada's Innovation Strategy

The analysis indicates that TRMs contribute significantly to almost all areas of Canada's Innovation Strategy. In particular:

- TRMs contribute directly to addressing the "Knowledge Performance Challenge" component of the Strategy because they provide a vehicle for maximizing the results from R&D investments, they assist in the transfer of

publicly funded R&D, and they contribute to the development of collective commercialization strategies;

- The analysis indicates that TRMs support the "Skills Challenge" component of the Strategy, but they do so more indirectly by providing a forum for identifying skills-related issues and solutions;
- TRMs contribute to addressing the "Innovation Environment Challenge" component of the Strategy. They do so because they are explicitly intended to foster innovation, and because they encourage concerned stakeholders to come together, thereby strengthening the innovation environment.
- Even though the TRM process does not limit the geographic region of participants, it does contribute to the networking that is essential to the formation of clusters.

Appendix: TRM Case Study Summaries

Bioproducts

The bioproducts industry includes firms that produce fuels, chemicals, materials and specialty products using biological feedstocks and bioprocesses. These include: bioenergy firms, bioresource processors, chemical producers and specialty products firms.

The TRM is currently entering the workshop phase with 7 workshops planned during the next 3 months.

The steering committee has developed a detailed implementation document for the workshop phase. The phase 1 report is expected to be final by Jan 2004.

There is excellent industry initiative and a balance of involvement from industry, research and government.

Canada is a recognized leader in this sector due to both our expertise in the area and our resource supply of biomass, such as feedstock.

Biopharmaceuticals

Biopharmaceuticals are complex macromolecules derived from recombinant DNA technology, cell fusion, or processes involving genetic manipulation. They include recombinant proteins, genetically engineered vaccines; therapeutic monoclonal antibodies; and nucleic acid based therapeutics, including gene therapy vectors. Unlike orally delivered small molecule drugs that underpin the traditional pharmaceutical industry, biopharmaceuticals are usually given by injection.

The biopharmaceutical industry consists of three key segments: firms usually formed by a core group of university scientists; traditional pharmaceutical companies which finance and market biopharmaceuticals developed by biotechnology firms; and a specialized group of firms serving both the pharmaceutical and biopharmaceutical industries with platform technologies that can, for instance, improve protein drug delivery or speed up the drug discovery process.

Following the industry focus day, held in March 2002, a workshop held in April 2003 focused on commercialization. Access to capital is critical due to the high cost of drug development and length of time it takes to get a product approved. Most firms do not have products on the market to generate cash flow, and are therefore dependent on funds from venture capital, public equity markets, and strategic alliances used to share development costs and to spread the risk. The industry predominantly consists of research-oriented, royalty-based companies. Product rights are usually licensed at an early stage with multinational pharmaceutical partners gaining most of the commercial benefits.

The final TRM report is expected in 2003. Canadian innovation in this sector ranks third internationally, with other international players rapidly entering the market, the challenge is to maintain Canada's profile in this area, and ensure the maximization of benefits accrued from Canada's investment in research and development.

Clean Coal

Clean coal technologies provide energy from coal while minimizing unwanted emissions. In the past few decades, clean coal technologies have focused on the removal of SOx and NOx compounds and particulate matter from emissions of coal power plants. Currently the focus of clean coal technologies is on removing CO_2 from emissions, in addition to SOx and NOx and particulate matter.

The roadmap launch workshop was held March 20th and 21st, 2003 in Calgary. The workshop participation was excellent. Areas of study were identified for more detailed analysis in subsequent workshops. The major coal producers and coal energy companies are involved and are committed to the process.

The final report is targeted for November of 2004. This will position Canadian industry to be at the forefront for the installation of clean coal technologies in the 2010 to the 2020 time frame.

CO_2 Sequestration

Due to the ratification of Kyoto, greenhouse gas (GHG) mitigation technologies have become increasingly important, if not critical to Canadian resource and energy companies. NRCan sees the TRM process as a way for industry to meet the Kyoto challenge in the 2010 to 2020 timeframe.

CO_2 Capture and Storage is an attractive option to help Canada meet its Kyoto commitment. It allows Canada to continue to use its fossil fuel resources and also provides the necessary time needed to make the transition to lower-carbon intensive energy technologies.

CO_2 Capture and Storage involves a series of technologies including the separation of CO_2 from large point sources, the transportation of CO_2 by pipeline, and the storage of CO_2 in depleted oil and gas wells, deep aquifers, or deep coal seams. In addition, Canada's has synergistic opportunities where CO2 can be stored while used in conjunction with CO2 injection for enhanced oil recovery and coal bed methane production. Canadian researchers and companies are recognized internationally as leaders in this field.

Dr. Thambimuthu, who is the government lead for the CO_2 Capture and Storage TRM exercise, is also the government lead for the Clean Coal Technology Roadmap, Canada's CO_2 Capture and Storage Network, the IEA Greenhouse Gas R&D Program, and is Canada's participant in the United Nations Intergovernmental Panel on Climate Change CO_2 Capture and Storage initiative. Dr. Thambimuthu's cross cutting leadership will ensure Canada's TRM exercise will complement existing activities.

Although CO_2 capture from coal fired power plants is covered under the Clean Coal TRM, the scope of the CO_2 Capture and Storage TRM is to include capture of CO_2 from other large point source emitters and to address the transportation and storage of the all the collected CO_2 emissions.

The CO_2 Capture and Storage TRM started in February 2003. Activities to date include the ongoing development of a interactive web site, the identification of key stakeholders, the surveying of existing CO_2 Capture and Storage roadmaps and technology developments, survey of industry issues and technology needs, the synthesis of information and the development of a straw man technology pathways. This information will be presented to stakeholders at a planned June 2003 workshop.

The target date for the TRM final report is January of 2005.

Fuel Cells

A fuel cell is an electrochemical device that produces electricity without combustion by combining hydrogen and oxygen to produce water and heat. Fuel cells can be used instead of internal combustion engines or batteries to power vehicles ranging in size from small mopeds to large transit buses and transport vehicles, or in small consumer devices such as laptops and wireless phones. Large fuel cells can replace existing

power plants to provide electricity for a large number of users, or in smaller, distributed power generation plants to supply the electrical needs of a factory, a neighbourhood, or an individual home.

After over a year of team effort, the final roadmap was released in April 2003.

The early consensus was that, technology issues being secondary, this roadmap should focus on commercialization of fuel cell technology.

The next steps for this roadmap are implementation by industry, government and academia; development of a strategy for collaboration and successful implementation.

This TRM contributes directly to the innovation strategy of ensuring that a growing number of firms benefit from the commercial application of knowledge.

Intelligent Buildings

An Intelligent Building is one equipped with the telecommunications infrastructure that enables it to continuously respond and adapt to changing conditions, allowing for a more efficient use of resources and increasing the comfort and security of its occupants. An Intelligent Building provides these benefits through automated control systems such as: heating, ventilation, and air-conditioning (HVAC); fire safety; security; and energy/lighting management. For example, in the case of a fire, the fire alarm communicates with the security system to unlock the doors.

Having its origins at the 1999 Federal Interdepartmental Forum on Construction Technology, the TRM was published at the end of 2002. A best practices guide was also developed and published. One section of the roadmap has been re-opened by the industry due to technology advancements, showing that the document is in fact "evergreen" and the roadmap is "industry led".

Fifteen specific recommendations were identified. The recommendations have been prioritized. Four or five task forces will begin to address these recommendations.

The TRM and Best Practices Guide are intended to raise the awareness level of designers and builders across the country while stimulating innovation.

Language Industry

The language industry encompasses the sectors that process natural language: translation, interpretation, terminology, localization, dubbing, language training, language technology, information management and speech processing.

The steering committee finalized the preliminary TRM report as of March 31, 2003. This TRM supported the formation of a new industry association, the Canadian Language Industries Network. Funding for a research centre has been announced. The steering committee is providing guidance on the establishment of the centre. After sub-committee work, the report is planned for 2004.

The industry, until now quite fragmented, is coming together to define future technology directions. The roadmap identifies skills issues to be addressed. Funding for a research centre has been announced and planning for this centre has begun.

Lean Logistics

Logistics is the process of planning, implementing and controlling the flow and storage of goods and services and related information from the point of origin to the point of consumption.

Four working committees met at a Toronto workshop in January. Key action items were identified in the areas of investment, technology, skills and diffusion of information.

The participation rate is excellent at 95% for the Toronto workshop. The workshop satisfaction rating was 4.4 out of 5. There is a strong collaborative relationship among the working committees due to the fact that direct competitors are not in the same groups. The participants are finding that more involvement of small / medium sized enterprises (SMEs) is needed in this industry TRM.

Final reports are expected following regional consultations in March 2003.

The contributions to Canada's Innovation Strategy are in the areas of process innovation and skills innovation, and connectedness.

Marine and Ocean

Marine and Ocean technologies include: shipbuilding technologies, offshore oil and gas structures, robotics, subsea vehicles, navigation, imaging equipment, oceanic sensors, marine information systems, communications equipment and electronics equipment frequently used in navigation.

The TRM was approved by the steering committee in December 2002. The report and the web site have been published.

The TRM identified critical technologies in each of the sub-sectors: Shipbuilding and Industrial Marine, The Offshore Oil and Gas Industry, Marine Operations, Fish Capture, Seafood Harvesting and Aquaculture, Ocean Technology and Services.

It identified the need for an aquaculture action plan, which has been initiated by Fisheries and Oceans Canada. The TRM further identified the need for an Ocean Technology action plan, which has been initiated by Industry Canada.

Through discussion, the participants concluded that the most promising approach for Canadian Marine and Ocean Technology industries is to find niche markets, collaborate in those specific areas and then solidify their international position in those niche markets.