

Technology Roadmapping

A Strategy for Success

APEC Center for Technology Foresight
Geoff Nimmo, Industry Canada

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agenda

Wednesday, September 10, 2003

08:30

Registration

09:00

Opening remarks

09:15

» Introduction to the Workshop and Participants (Slides 1-7)

10:15

Coffee Break

10:30

Session 1

» Technology Roadmaps in Canada (Slides 8-29)

- Intended results
- Description of a TRM

12:00

Lunch

13:30

Session 2

» Best Practices (Slides 30-49)

- Marine and Ocean Technologies TRM
- Canada's progress to date
- What have we learned

15:00

Refreshment Break

15:30

Session 3

» Examples from Industry Canada of recent Roadmaps (Slides 50-58)

16:30

Conclusion of the first day

Thursday, September 11, 2003

09:00

Session 4

» Reprise of Day 1 and the development of a Roadmap (Slides 59-74)

- Questions and comments on Day 1
- The TRM process
- Preliminary Activities
- Development of a Roadmap
- Follow-up Activity

10:30

Coffee Break

10:45

Session 5

» Workshop Exercises (Slides 75-82)

- Purpose
- Explanation and Background
- First Exercise Question (Product and Champions)

12:00

Lunch

13:30

Session 6

» Workshop Exercises (Slides 83-84)

- Second Exercise Question (Technologies needed)
- Third Exercise Question (Parameters and Prioritization for Technologies)

15:30

Refreshment Break

15:45

Session 7

» Feedback from the exercise (Slide 85)

16:30

Conclusion for the second day

Friday, September 12, 2003

09:00

Session 8

» Evaluating the TRM Exercise and TRMs in different jurisdictions (Slides 86-89)

- What did we learn?
- What could have been improved with this exercise?
- Other countries' examples of TRMs

10:30

Coffee Break

10:45

Session 9

» TRMs from participant's countries

» Conclusion and Wrap-up of Workshop (Slide 90)

11:50

Closing Remarks

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Technology Roadmapping: A Strategy for Success

Organized by: APEC Center for
Technology Foresight
Facilitator: Geoff Nimmo, Industry Canada

Introduction

- Purpose of the Session
- Structure of the Session
- Introductions and expectations

Purpose of the Session

- To share useful information, background, and past experiences related to Canada's experience with Technology Roadmaps (TRMs)
- To provide examples and current thinking on developing TRMs in Canada
- To work interactively with participants in developing elements of a Roadmap

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Structure for the Session

Day 1:

Morning

- Introduction
- Overview of Technology Roadmaps in Canada
 - Definition of a Technology Roadmap
 - Intended Results
 - Elements of a Technology Roadmap
 - Marine and Ocean Technology Roadmap

Afternoon

- Best Practices
- Examples of different Roadmaps

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Structure for the Session (CONTINUED)

Day 2:

Morning

- Reprise of Day 1
- Steps in Developing a Technology Roadmap

Afternoon

- Workshop to develop a Roadmap

Day 3:

- Feedback and Discussion
- Other countries' experiences with Technology Roadmaps
- Conclusion

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Introductions

- Your name and the organization that you represent. Are you with a company, the government or academia?
- What you are working on that relates or could relate to technology development in your country.
- How familiar are you with the concepts of Technology Roadmaps?
- What you hope to get out of this session?
- Do you have any expectations from undertaking a Technology Roadmap?

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Overview - Technology Roadmaps in Canada

- Definition
- Intended Results – What Canada is trying to achieve
- The Elements of a Technology Roadmap
- Marine and Ocean Technologies

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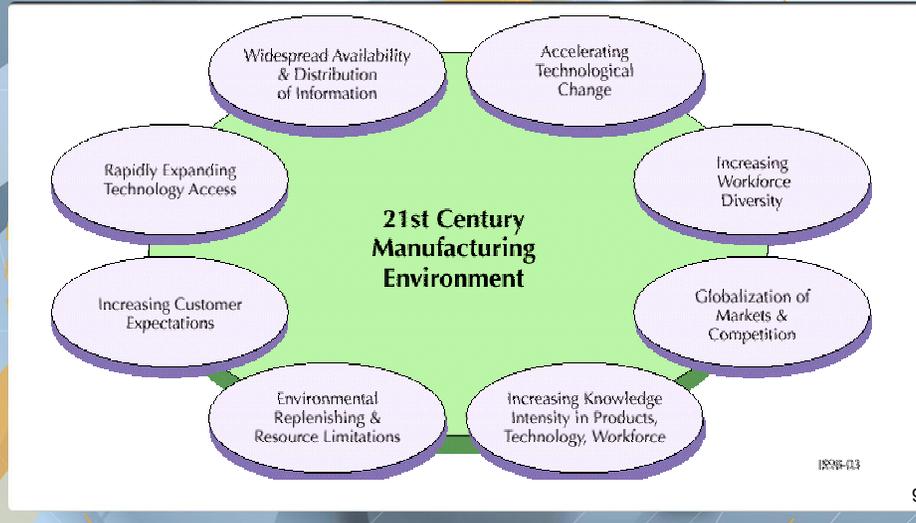
Canada's interest in Roadmaps

- High level of interest in technology development
- Federal government wants to make a positive contribution
- Technology and markets are changing rapidly
- Industry needs solutions that address the demands of today and anticipate future market goals
- Solutions are sometimes beyond the scope of one firm - TRMs can help

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Canada's interest in Roadmaps

- manufacturing environment increasingly complex



What is a Technology Roadmap? A Canadian Definition

A TRM is a **process tool** to help identify the key technologies that an industry/sector/company needs to succeed in the future and the projects/steps required to get those technologies developed and implemented by Canadian industry

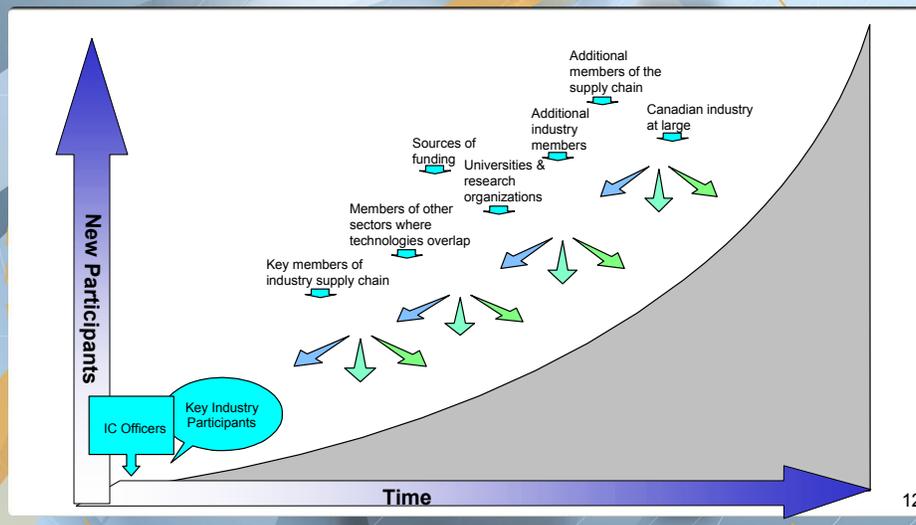
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What is a Technology Roadmap? Who is involved?

- TRMs are developed by a group of collaborators who are knowledgeable about an industry/sector and its relevant technologies
- **These collaborators:**
 - identify the key future technologies
 - create the roadmap that will lead to their development
 - implement the roadmap's projects/steps

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What is a Technology Roadmap? Participation in TRMs increases over time



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The expected benefits of a TRM

- helps an industry/company predict future technology and product needs
- defines the "road" that must be taken to compete successfully in tomorrow's markets
- guides technology R&D decisions
- increases collaboration, shared knowledge and new partnerships
- reduces the risk of costly investment in technology
- helps the industry/company seize future marketing opportunities

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Intended Results What we are trying to achieve

- Industry Canada and the entire Canadian federal government have been focusing on achieving and measuring the results from their policies and initiatives
- The primary intended results of Industry Canada's involvement in TRM are the following...

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Intended Results

Industry participation:

- A commitment has been made by a wide variety of industries to proceed with development of a TRM
- A large number and variety of participants have become involved in each TRM

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Intended Results

Industry and other stakeholders working together:

- Industry has become fully committed to the TRM process of collaboration to address key technology issues
- A culture of partnering has become more acceptable to industry members

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Intended Results

- New technological solutions
- Reconsideration and redirection of R&D funds
- New products
- New exports, new export markets
- New jobs
- Barriers to development and transfer of critical technologies are better understood and overcome
- Improved understanding and use of the flows of information related to technology development and inter-firm projects

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Intended Results

- Improved competitiveness
- New financing sources
- Spin-off projects
 - Some industry-wide
 - Some between fewer companies
 - Some on an individual basis
- New, related roadmaps being initiated/created
- Other industries becoming interested

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The Elements of a Canadian TRM

The Canadian approach has three cornerstone principles:

1. **Industry Led:** Helps to ensure relevance and ongoing commitment to implementation
2. **Planning Element:** Varies from industry to industry (timing, industry dynamic). Not a standard approach
3. **Highly Collaborative Approach:** Industry members and other stakeholders working together on new technological challenges

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The Elements of a Canadian TRM

- In Canada, we have designed TRMs as a sequential, three-phase process
- Each phase builds on the earlier one and has distinct characteristics, participants, activities, and results

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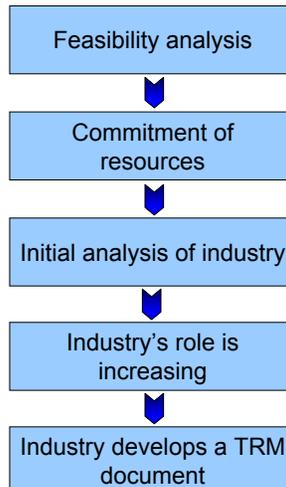
The Elements of a Canadian TRM

- **Phase 1 – Industry embraces TRM concept and develops its roadmap**
- **Phase 2 – Industry implementation of the TRM**
- **Phase 3 – Generating knowledge-based, self-sustaining future iterations**

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Phase 1 -- Main elements

Industry embraces the concept and develops a TRM



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The government role

The Canadian government officers' role:

- The “custodian” of the TRM concept
- Catalyst/facilitator for the process
 - Defines the industry/sector
 - Targets and engages potential participants
 - Shepherds the process, timing, and contribution of participants
 - Keeps the focus on the desired strategies, outputs, results, and outcomes

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How to prioritize sectors?

• Selecting an industry or sector

- Examples of feasibility questions:
 - Are there opportunities to converge on the development of technologies?
 - How important is technology to the future success of the industry?
 - Are there issues that may prevent industry participation in a TRM at this time?
 - Are there structural reasons why industry members are not able to collaborate on technology?
 - What is the market potential for the industry if it were successful in developing critical technological solutions?
 - How capable is the industry to take advantage of technological advances and translate these into marketplace success?

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Industry participation

Identify participants and industry champion:

- Who are potential champions?
- Who should participate to ensure a cross-section?
- What role can be played by associations, unions and other representative groups?
- What public sector organizations should become involved?
- Which participants should become involved at what points as the initiative progresses?

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Phase 2 – Main elements

Industry's implementation of a "first" TRM iteration

Projects are defined and initiated



Projects are monitored and managed



Technologies are developed and commercialized; technology is transferred



Planning for subsequent iterations of the TRM

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Phase 3 – Main elements

Generating knowledge-based, self-sustaining future iterations

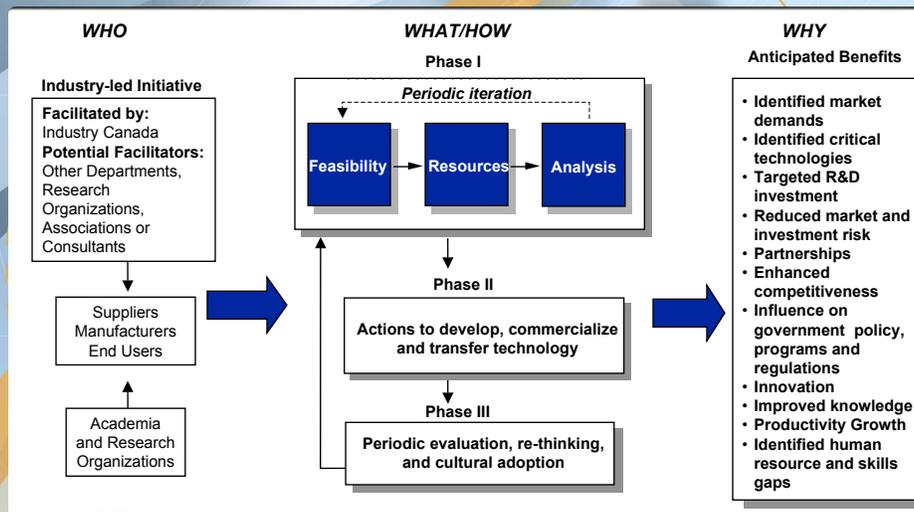
TRMs evolve and become self-sustaining



Results are systematically monitored and measured

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A Graphical Presentation



A Practical Canadian Example – Marine and Ocean Technologies

- 1. What does the “industry” look like?**
- 2. Who was involved?**
- 3. Major activities, milestones**
- 4. Results**
- 5. Next steps**

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The Marine and Ocean Technologies TRM *“Thinking Beyond Our Shoreline”*

What the “industry” looks like:

- Shipbuilding, Offshore Oil and Gas, Marine Operations, Fishing and Aquaculture, Ocean Technologies
- Marine and ocean technologies cover a wide range of disciplines including communications, navigation systems, sensors, underwater vehicles, acoustics, engineering, biotechnology, nanotechnology, meteorology, optics, radar
- 350,000 part-time and full-time jobs
- Rapidly changing economic dynamics

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Why a Technology Roadmap?

Ocean technology industry

- small to medium-sized companies
- geographically dispersed
- limited infrastructure capability for expanding and growing markets
- needed a Canadian platform from which to market ocean technology products and services
- Needed a national industry voice and a recognized “brand”

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Broad participation

Who was involved in the TRM:

- Equipment Manufacturers
- Consulting organizations
- Research institutes
- Labour unions
- Associations
- Federal government departments and agencies
- Provincial government departments and agencies

Steering committee included 30 members

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Chronology of the Roadmap

Major activities/milestones:

- Started in November 2001
- Steering committee formed in June 2002
- Working committees were assembled and formed into internal sub-sector committees such as shipbuilding and aquaculture and to address various coordinating functions
- Regional workshops and information sessions were held at which over 1200 specific technologies relevant to the industries were discussed
- Phase 1 TRM report published in Spring 2003

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Potential impact of the Roadmap

Identified focused research opportunities:

- Great Lakes Seaway Fleet
- Vessel Technologies
- Shipbuilding Pathways
- Extended Year Seaway Scenario
- Advance Material and Composite Technologies for Shipbuilding
- Shipboard Waste Management
- Subsea Smartwell Processes
- Offshore Waste Management Disposal
- Aquaculture Waste Disposal
- Aquaculture Pen Design Technologies
- EEZ Technologies
- Automation Technologies
- Marine Sensors Technologies
- Ice Technologies
- AUV Technologies

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The Marine and Ocean Technologies TRM

- **Phase 1 has been completed**
- **The TRM identified a number of specific projects to be undertaken by industry segment and by timeframe (short-, medium-, and long-term)**
- **Industry members will next select the projects based on their capabilities, needs, and expected opportunities**

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Technology Roadmaps in Canada – Best Practices

- **Canada's progress to date**
- **What we've learned so far**

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Canada's Progress To Date

- **First explored TRMs in 1995**
- **Launched 7 pilot TRMs in Spring of 1996**
- **13 TRMs are in post Phase 1 status**
- **Another 8 are at Phase 1 stage**

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Canada's Progress To Date

Technology Roadmaps Past Phase 1

- Aircraft Design, Manufacturing, Repair and Overhaul
- Aluminum
- Canadian Electric Power
- Canadian Metalcasting
- Forestry Operations
- Fuel Cells
- Geomatics
- Logistics and Supply Chain
- Lumber and Value-Added Wood Products
- Marine & Ocean Technologies
- Medical Imaging
- Wood-Based Panel Products
- Intelligent Buildings

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Canada's Progress To Date

Currently in Phase I

- Biopharmaceuticals
- Aerospace Competitive Intelligence
- Clean Coal
- Carbon Dioxide Capture and Geological Storage
- Oil Sands
- Biofuels from Biomass
- Language Industries

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What Canada Learned

- Evaluations conducted on almost all TRMs
- Evaluations provided a formal mechanism to see what results were achieved
- Extensive interviews with stakeholders involved in developing the TRMs
- The evaluations revealed:
 - What participants experienced
 - Specific factors that contributed to the success of TRMs

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What Canada Learned

- **The feasibility study in Phase 1 is critical so that the “right” industries/sectors are selected for the TRM exercise**
 - Is industry receptive?
 - Is the timing right?

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What Canada Learned

- **Industry leadership essential**
 - Ensures buy-in and relevance
 - Industry champion key element to ensure credibility of the process
 - Government can be an effective catalyst

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What Canada Learned

- **The journey is as important as the destination**
 - Bringing interested stakeholders together is an important feature
 - Provides opportunities for establishing formal and informal networks and partnerships
 - Opportunities for improving understanding on all sides (small and large companies/academia/government)

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What Canada Learned

- **Government is a good catalyst**
 - Companies are not likely to do it on their own
 - Are primarily preoccupied with profitability
 - Have concerns over intellectual property
 - The concept needs to be promoted by an independent, credible group such as a federal government organization

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What Canada Learned

Benefits of the TRM are often difficult to identify and measure

- Results are likely to occur over a long timeframe, thereby making them hard to track
- Collaborations might be established outside the TRM framework. These are not always attributed to the TRM effort
- Technology advances are sometimes not readily identifiable or measurable

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What Canada Learned

Flexibility in approach is essential

- Each industry and sector has unique characteristics. Therefore, a standard approach will not work
- The “coordinator/facilitator” needs to be creative in adjusting the approach

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What Canada Learned

Focus on all three phases of the TRM

- There is a natural tendency to focus on the development of TRM documents. It is essential to encourage momentum toward Phases 2 and 3

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What Canada Learned

TRMs don't necessarily require significant financial resources

- Phase 1 efforts have ranged in cost between C\$25,000 and C\$200,000
- Well-selected participants recognize the potential benefits of the TRM and are willing to contribute resources

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Eight Canadian TRM Short Stories

- **Bio-Products**
- **Biopharmaceuticals**
- **Clean Coal**
- **Carbon Dioxide Capture and Storage**
- **Fuel Cells**
- **Intelligent Buildings**
- **Language Industries**
- **Lean Logistics**

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Short Story – Bio-Products

- Bioenergy firms, bioresource processors, chemical producers and specialty products firms
- Produce fuels, chemicals, materials, and specialty products using biological feedstocks and bioprocesses
- Steering committee and seven technical workshops
- Industry, academia, not-for-profit, and government (over 100 organizations from industry)
- Canadian Green Chemistry Network was formed

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Short Story – Biopharmaceuticals

- The industry: firms usually formed by a core group of university scientists; traditional pharmaceutical companies; specialized firms serving both the pharmaceutical and biopharmaceutical industries with platform technologies
- Biopharmaceuticals are complex macromolecules derived from recombinant DNA technology, cell fusion or genetic manipulation
- Steering committee: 30 biopharmaceutical companies
- Kicked off with an industry focus day

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Short Story – Clean coal

- Clean coal technologies provide energy from coal while minimizing unwanted emissions
- Focus is on removing Carbon Dioxide from emissions, in addition to Sulphur Oxide and Nitrogen Oxide and particulate matter
- Participants include major coal producers and coal energy companies; government; academic and research institutions
- Introductory workshop held in March 2003 (more than 85 participants) where presentations were made on issues facing the industry, the TRM process, various clean coal technologies and the technology pathways

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Short Story – Carbon Dioxide Capture and Storage

- Kyoto ratification has made greenhouse gas mitigation technologies a critical factor for Canadian companies
- Carbon Dioxide capture and storage involves a series of technologies including the separation of Carbon Dioxide from large point sources; the transportation of Carbon Dioxide by pipeline; and the storage of Carbon Dioxide in depleted oil and gas wells, deep aquifers or deep coal seams
- Could allow Canada to continue to use its fossil fuels

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Short Story – Fuel Cells

- A fuel cell is an electrochemical device that produces electricity without combustion by combining hydrogen and oxygen to produce water and heat
- The roadmap focuses on commercialization activities that will help make fuel cells cost competitive with internal combustion
- The steering committee identified five workgroup areas: Mobile, Stationary, Portable, Infrastructure and Skills. Each workgroup met three times from June to September 2002
- 45 organizations participated, including companies, all levels of government and non-governmental organizations

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Short Story – Intelligent Buildings

- An Intelligent Building is one equipped with the tele-communications infrastructure that enables it to continuously respond and adapt to changing conditions and includes:
 - heating, ventilation, air conditioning, fire safety, and security
- The TRM was published at the end of 2002. One section was re-opened by the industry due to technology advancements, showing that the TRM is in fact “evergreen” and “industry led”
- The steering committee’s 21 members included: builders, control systems suppliers, communications companies, energy companies and federal government departments and agencies
- Demonstration projects are being defined

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Short Story – Language Industries

- 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 industry is very fragmented so it is essential that smaller firms collaborate to compete with the global companies
- This roadmap supported the formation of a new industry association, the Canadian Language Industries Network
- The TRM is now focused on setting out “concrete measures to be taken by the industry to stimulate a second phase of growth”

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Short Story – Lean Logistics

- Logistics is the process of planning, implementing and controlling the flow and storage of goods and services and related information from point-of-origin to point-of-consumption
- The Steering Committee includes key players such as transportation companies, industry groups, academics, and retailers such as Wal-Mart
- The participation of Wal-Mart, the retail “channel master”, was key in validating the TRM process and attracting participants
- The Steering Committee decided to organize working committees by sector: Manufacturing, Transport/Logistics, Retail/Wholesale, and Pharmaceutical/Health Care
- Three key technology areas have been identified

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The TRM process

- **Preliminary Activity**
- **Development of the Technology Roadmap**
- **Follow-Up Activities**

* The TRM process section has been adapted from the “Fundamentals of Technology Road Mapping”, Sandia National Laboratories, New Mexico, U.S.

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day 2

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The TRM process

The process is important. A good process will ensure that :

- Industry will be committed and participate actively
- Convergence in views will be achieved through structured collaboration
- All possible technologies will be considered. That is, the best-known, most familiar technologies will not automatically be chosen as the preferred future direction

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The TRM process

Develop the Roadmap Steps

- Determine the governance structure
 - Steering committees, reporting frameworks
 - Review and “quality control”
- Determine approach for discussing and selecting technologies
 - Working groups, discussion groups, method for choosing/allocating participants
 - Analyses done through contracts
 - Protocol for allocating tasks
 - Define the expected outputs and deliverables
 - Set timelines

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The TRM process

Satisfy essential conditions

- perceived need for a TRM and collaborative agreement
- input and participation from several different groups
- participation from various parts of the organization
- must be needs-driven rather than solution-driven

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The TRM process

Define scope and boundaries of the TRM initiative

- What is the TRM's vision – what will it be striving to achieve?
- Is the initiative too broad? Should it be scoped to a specific sector within an industry?
- Is the vision supported by participants?
- To what extent will participants' expectations be met?
- What adjustments are required to the scope of the project to encourage maximum participation and benefit?

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The TRM process

Identify the “Product” that will be the focus of the TRM

- Participants must agree on the common product needs to be satisfied
- Agreement important for buy-in and acceptance of the Roadmap
- Scenario-based planning can help define the “product”

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The TRM process

Identify Critical Systems Requirements and their targets

- Provide the overall framework for TRM
- Requirements to which the technologies relate
- Derived from product needs by assessing customer requirements and product technologies

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The TRM process

Specify the major technology areas

- Which technologies can assist?
- What are the barriers and challenges to the technologies?

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The TRM process

Critical variables determining which technology alternatives are pursued

- What do you want the technologies to do?
- What are the cost and environmental implications?
- What progress has been made to date toward solving the technology problem?
- What collaborations can be established?

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The TRM process

Identify technology alternatives and their timelines

- Which technology alternative can meet the target? (or multiple technologies)
- If several pursued, when to choose the winner?

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The TRM process

Recommend technology alternatives to be pursued

- Variables include cost schedule and performance

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The TRM process

Develop a report on the technologies to address through the TRM

- Establish a short list with some indication of relative priorities
- Provide a sense of the scope of the technology development project and a discussion of any important challenges/issues

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The TRM process

Disseminate the TRM strategy

- Relatively few people in a company or a sector are involved in developing a TRM
- The TRM strategy/document needs to be critiqued, validated, and accepted by as many industry participants as possible
- Wide discussion and acceptance will assist in planning and undertaking the implementation phase

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The TRM process

Launch implementation phase

- Identify the priority technology projects and the project parameters
- Collectively decide on the project participants
- Establish a technology transfer policy and mechanism for sharing TRM-related technological advances

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The TRM process

Review and Update

- A TRM report should be an evergreen document
- Every few years, under the leadership of industry, the report should be reviewed and updated to reflect technological progress
- This discipline will contribute to achieving the goal of making the TRM a self-sustaining collaboration to address key technological challenges

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The TRM process

Evaluating TRMs

- Evaluation is a key ingredient to determine the achievement of intended results
- Each evaluation provides knowledge to improve the success of that TRM and others
- Evaluations can be completed at the end of the development stage and implementation stage

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Group Workshop Exercise

Material for this exercise was kindly made available by the Cambridge Centre for Technology Management, within the Institute for Manufacturing, at the University of Cambridge, the United Kingdom.

Workshop exercises - purpose

- To discuss and experience the types of issues involved in TRMs
- To experience the diversity of directions and views
- To recognize the potential of TRMs

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Workshop exercises - process

- Each table will discuss a TRM “strategy question” concerning a common “case”
- Each table chooses a member to be a note-taker/spokesperson
- Spokespersons to report back to the room on the discussion

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Workshop exercises – the discussion case

Biko: the bicycle of the future



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Biko: An Introduction

- Biko, a small traditional but well regarded bicycle manufacturer, has just been taken over by a large sports equipment and clothing manufacturer, Sportco
- The new owner has requested a technology roadmap outlining how Biko proposes to develop its market offering over the next 10 years, and if convinced by their business case, is willing to make a significant investment
- Biko traditionally strong at frame design and logistics, but not so strong on aesthetics, comfort and customization
- Biko has a good engineering reputation in gears and brakes, but needs to improve understanding of advanced materials and electronics

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Biko: An Introduction

Market analysis has revealed:

- Young and old people have significantly more income
- Fashion industry emphasizes fitness and accessories
- Working hours reduced; leisure time more important
- Regeneration of inner cities, pressure to reduce cars due to pollution, increased fuel tax
- Increase in number and quality of bicycle paths for commuting and leisure activities
- Sports more important in motivating purchases
- Electronics and information technology to have increasing impact on all products

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Biko: An Introduction

Opportunities and Threats

- Product
 - City populations ageing so older people become more important
 - Cheaper insurance for regular bike users expected soon
 - Recent survey of bicycle users showed security and comfort key concerns
- Technology
 - Competition working on concepts such as the “intelligent bike” and “puncture proof” tires
 - Electronic “add-ons” increasingly popular
 - New materials could make bikes much lighter

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Workshop exercises

First exercise question:

- Brainstorm what motivates customers to make a purchase
- Group customer motivators into themes
- Identify key market segments and prioritize the importance of purchase motivators for one or more of these
- Take 40 minutes to discuss this question with colleagues at your table. Don't forget to choose a note-taker/ spokesperson

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Workshop exercises

Second exercise question:

- Brainstorm product performance, features and attributes
- Develop product brochure for the future
- Group performance, features and attributes into themes, and decide which would be the most important for Biko to succeed
- Take 40 minutes to discuss this question with colleagues at your table. If you wish, you may change the note-taker/ spokesperson

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Workshop exercises

Third exercise questions:

- Brainstorm potential technology solutions for the product needs. Which two or three technology areas would you give the highest priority for specific projects?
- What would be the major parameters of those projects?
 - i.e., participants? timelines? interaction/ collaboration? technology transfer mechanisms? or others
- Take 40 minutes to discuss this question with colleagues at your table. Again, if you wish, you may change the note-taker/ spokesperson

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Discussion and Feedback

- **Key questions**
- **Discussions about technology development experiences in different countries**
- **What would be the strongest points about TRMs in your own country?**
- **What do you see as the most significant barriers to undertaking TRMs in your country?**

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Comparison to TRM practices of other countries

The Canadian approach has emphasized:

- Industry leadership
- Broad participation
- To provide a catalyst for:
 - encouraging R&D collaboration
 - adjusting future R&D decision-making

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day 3

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Comparison to TRM practices of other countries – the U.S.

- U.S. has extensive history of TRMs
- Since 1990, U.S. has over 200 government-initiated Roadmaps, and over 1,000 by companies
- Many Roadmaps and subsequent projects have been government funded. Department of Energy (DOE) and Department of Defence are key proponents
- In U.S. model, governments facilitate the process, leverage government resources, share project costs with industry, and provide access to government laboratories
- Companies compete for government funding of projects identified in the TRM

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Comparison to TRM practices of other countries – the U.S.

The DOE Roadmapping Process

- Visioning: Executive forums, where industry leaders for a sector develop a unified vision of where the sector wants to be in 20 years
- Roadmapping: Larger group of representatives meet in workshops to develop a strategy for achieving the goals established in the vision
- Implementation: Once roadmap is complete, it becomes the basis for cooperative research, development and the deployment of R&D activities

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Comparison to TRM practices of other countries – Australia

- A relative newcomer to technology roadmapping
- Based its approach on an examination of best practices in other countries
- Focus on better understanding a firm's markets and making informed technology investment decisions
- Focus on collaboration and sharing of knowledge. Results in reduced risk in technology investments

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Conclusions and wrap-up

- **The Canadian view of Technology Roadmaps**
- **The Canadian experience with TRMs**
- **Observations about the workshop session**
- **Comments, conclusions**
- **Keeping in touch**

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a p p e n d i c e s

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**INDUSTRY CANADA – TECHNOLOGY ROADMAPS INITIATIVE
AN EVALUATION TEMPLATE
PHASE 1 - INDUSTRY EMBRACES TRM CONCEPT AND DEVELOPS THEIR ROADMAP**

	INPUTS	ACTIVITIES	OUTPUTS	INTENDED RESULTS
Feasibility analysis	<ul style="list-style-type: none"> ◆ Some initial sense by IC that TRMs would apply to and be feasible for a particular industry ◆ Preliminary criteria to determine whether a TRM is feasible for an industry 	<ul style="list-style-type: none"> ◆ IC: Learn the TRM concept and its application to a particular industry ◆ IC: Develop a preliminary plan of what the TRM process may be for the specific industry (e.g., segmented, serial, parallel, other) 	<ul style="list-style-type: none"> ◆ Concept of what a TRM might look like for a particular industry ◆ Possible industry knowledge of TRM ◆ Communication strategy on the part of IC 	<ul style="list-style-type: none"> ◆ IC's level of awareness of the TRM initiative has been raised (what it is and the value it has) ◆ IC has developed an interest in pursuing a TRM for a specific industry, and has developed an initial approach for contacting and involving industry
Commitment of resources	<ul style="list-style-type: none"> ◆ IC: Branch management commitment of resources, a defined budget for a specific industry TRM initiative 	<ul style="list-style-type: none"> ◆ IC: Engage Branch human resources and funds to: <ul style="list-style-type: none"> ◆ foster and build industry awareness and understanding of TRM ◆ foster and build industry's trust in TRM process ◆ IC: Set out communications strategy to stimulate industry participation and buy-in 	<ul style="list-style-type: none"> ◆ Information, communications strategies ◆ Industry's knowledge and understanding of TRM 	<ul style="list-style-type: none"> ◆ Industry has developed an awareness, understanding (what it is and the value it has) and positive attitude towards TRM concept ◆ Industry views the TRM initiative as a positive opportunity ◆ IC understands that the TRM initiative is a continuing priority for the government
Initial analysis of industry	<ul style="list-style-type: none"> ◆ Background information on key industry elements, e.g., <ul style="list-style-type: none"> ◆ industry supply-chain ◆ key industry stakeholders ◆ national associations ◆ market drivers and their interrelationships ◆ other government initiatives/programs which may contribute to or support this initiative ◆ other similar initiatives (int'l) ◆ Time and funding by IC and industry members 	<ul style="list-style-type: none"> ◆ IC: Involve industry in the initiative ◆ IC: Develop communications tools ◆ IC analysis may include: <ul style="list-style-type: none"> ◆ Research and present alternative scenarios of industry's market ◆ Explore existing industry contacts ◆ Analysis/evaluation of what technology development initiatives currently exist ◆ Analysis/evaluation of current literature and other sources of information on TRM initiatives to identify possible approaches that could be used for the industry 	<ul style="list-style-type: none"> ◆ Components of the TRM analysis are being developed, including: <ul style="list-style-type: none"> ◆ Components of the supply-chain ◆ market outlook scenarios ◆ Increasing participation by industry ◆ Communications strategies refined to reflect analyses 	<ul style="list-style-type: none"> ◆ A commitment has been made by the industry to proceed with development of a TRM document
Industry's Role is Increasing	<ul style="list-style-type: none"> ◆ Additional time and effort by IC and industry members 	<ul style="list-style-type: none"> ◆ IC: Encourage momentum of initiative ◆ IC: Provide forum for key stakeholders to meet and discuss the TRM ◆ IC: Help to identify TRM roles for industry members ◆ IC: Information and communications tools are refined and promulgated 	<ul style="list-style-type: none"> ◆ Elements of TRM document are beginning to be developed and refined ◆ Formal and informal industry networks ◆ Refined Information and Communications tools for that industry's needs 	<ul style="list-style-type: none"> ◆ Industry involvement/leadership has increased ◆ An industry champion/leader may have been identified ◆ Industry stakeholders are more accepting of the benefits of working with one another

 <p>Industry codifies TRM document</p>	<ul style="list-style-type: none"> ◆ Additional time and effort by IC and industry members 	<ul style="list-style-type: none"> ◆ IC: Provides assistance/guidance for developing criteria for critical technologies ◆ Industry: Develop criteria to identify what constitutes a critical technology (risk, cost, key for future competitiveness) ◆ Industry: Develop prioritized list of the technologies that are critical to their industry 	<ul style="list-style-type: none"> ◆ Criteria for technologies that reflect, to the extent practicable, the priorities, policies, strategies and directions of IC (e.g., environmental sustainability) ◆ A consensus on roadmap document for the industry ◆ TRM document that identifies opportunities, critical technologies 	<ul style="list-style-type: none"> ◆ Core group of key stakeholders committed to the TRM initiative and their role in the TRM process is increasing (and may evolve) ◆ Industry is well positioned to proceed with the first iteration of its TRM
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**INDUSTRY CANADA – TECHNOLOGY ROADMAPS INITIATIVE
AN EVALUATION TEMPLATE
PHASE 2 – INDUSTRY’S IMPLEMENTATION OF THE FIRST TRM**

INPUTS	ACTIVITIES	OUTPUTS	INTENDED RESULTS
<ul style="list-style-type: none"> ◆ TRM document ◆ Industry commitment ◆ Resources ◆ New formal/informal networks 	<ul style="list-style-type: none"> ◆ IC: Provides guidance and information ◆ Industry: <ul style="list-style-type: none"> ◆ Develop criteria for prioritizing list of critical technologies ◆ Refines the list to a short list of technologies to be developed ◆ Identify projects to address the selected technologies <ul style="list-style-type: none"> ◆ Time, resources, responsibilities ◆ Identify and contact additional stakeholder groups required to implement the defined projects ◆ Involve additional members of the industry where required 	<ul style="list-style-type: none"> ◆ Selection criteria for priority critical technologies ◆ Projects and action plans for each technology ◆ Additional stakeholders involved in the TRM, e.g., <ul style="list-style-type: none"> ◆ Universities, research institutes ◆ Sources of funding ◆ Other sectors (where industry technologies may complement) 	<ul style="list-style-type: none"> ◆ Culture of partnering has become more acceptable to industry members ◆ Industry has committed to action related to the TRM ◆ Other stakeholders have become involved/committed – directly/indirectly, formally/informally (Canadian industry at large) <ul style="list-style-type: none"> ◆ Eg, as a result of the communications strategy, IC has stimulated demand for and implementation of TRMs* ◆ Priorities for projects reflect IC's policies, priorities, and directions and link with departmental horizontal issues

Projects are defined and initiated

Projects are monitored and managed	<ul style="list-style-type: none"> ◆ Action plans ◆ Resources 	<ul style="list-style-type: none"> ◆ Industry: Taking actions set out in plans, and monitoring and managing progress ◆ IC: <ul style="list-style-type: none"> ◆ Assisting with coordination ◆ Assisting with developing the processes, practices to monitor/measure results and other achievements ◆ Assisting with monitoring ◆ Facilitating the projects, ◆ Analyzing the potential for broadening the TRM across the sector ◆ Exchanging information with other areas in IC for use by other industries 	<ul style="list-style-type: none"> ◆ Knowledge about the industry's TRM, selected priorities ◆ Outputs and results from individual projects: <ul style="list-style-type: none"> ◆ Solutions <ul style="list-style-type: none"> ◆ E.g., technologies identified as critical have been developed, and are in place and in use ◆ Strategic alliances – formal or informal <ul style="list-style-type: none"> ◆ New R&D partnerships ◆ New supply partnerships ◆ New production partnerships ◆ Identified barriers to implementation of key technologies ◆ Other linkages, including inter-sector ◆ Processes and practices for monitoring and measuring results 	<ul style="list-style-type: none"> ◆ Industry is deriving benefits from projects/initiatives and learning more about the TRM and its potential ◆ Basic TRM Initiative management systems have been developed and implemented ◆ The TRM process was well received by industry ◆ The following results may occur, but are not necessarily expected from the first iteration: <ul style="list-style-type: none"> ◆ New enabling technological solutions ◆ Reconsideration, redirection of R&D funds ◆ New products or new utilization of products ◆ New exports, new export markets of the enabling technologies ◆ Barriers to development and transfer of critical technologies are better understood and overcome ◆ Improved understanding and use of the flows of information related to technology development and inter-firm projects ◆ Formal projects and/or less formal spin-off projects are undertaken <ul style="list-style-type: none"> ◆ Some industry-wide ◆ Some between fewer companies ◆ Some may be on an individual basis ◆ New, additional related roadmaps were initiated/created ◆ Other industries have become interested ◆ Industry has become fully committed to the TRM ◆ Government has been responsive to results of TRM process <ul style="list-style-type: none"> ◆ New/revised policy ◆ New/revised regulations ◆ TRM has become an integral part of policy and other government initiatives
Planning for subsequent iterations of the TRM	<ul style="list-style-type: none"> ◆ Results from first projects, plans 	<ul style="list-style-type: none"> ◆ IC, Industry and other stakeholders: <ul style="list-style-type: none"> ◆ Develop strategy for ensuring the self-sustainability of the TRM for the industry ◆ Apply lessons learned from the first iteration and from other industries' TRMs ◆ IC: <ul style="list-style-type: none"> ◆ Market and communicate to those already involved in the TRM process, other components of the sector and to others <ul style="list-style-type: none"> ◆ Develop information and communication tools ◆ Identify target organizations ◆ Encourage actions required for subsequent iterations 		<ul style="list-style-type: none"> ◆ Branch has reduced its overall level of participation and/or has reconsidered its role/function, and the critical role of the Industry Sector in getting the TRM off the ground and implemented is recognized'

**INDUSTRY CANADA – TECHNOLOGY ROADMAPS INITIATIVE
AN EVALUATION TEMPLATE
PHASE 3 – GENERATING KNOWLEDGE-BASED, SELF-SUSTAINING FUTURE ITERATIONS**

TRMs evolve and become self-sustaining

INPUTS	ACTIVITIES	OUTPUTS	INTENDED RESULTS
<ul style="list-style-type: none"> ◆ Knowledge, information, lessons learned, and results from actions from first iteration – formal or informal, with or without the involvement of IC-Branch ◆ Knowledge/understanding of TRM process and dynamic ◆ Relationships already developed 	<ul style="list-style-type: none"> ◆ IC/Industry: <ul style="list-style-type: none"> ◆ Establish process/discipline to re-examine at defined milestone the criteria for technology and project selection ◆ Define steady-state roles and responsibilities ◆ Establish process that will reconsider directions and projects at defined milestones ◆ Monitor implementation ◆ Monitor environment for new information ◆ IC: <ul style="list-style-type: none"> ◆ continue to promote TRM initiative and broaden involvement across the industry ◆ Continue to facilitate and coordinate efforts of industry and to promote IC's policies, priorities and directions 	<ul style="list-style-type: none"> ◆ New/additional TRMs or subsequent iterations of existing TRMs ◆ Processes and disciplines to encourage future iterations ◆ Additional strategies, projects, plans for future iterations ◆ Adjustments to process for developing a TRM ◆ Improving information flow between industry and government funded R&D 	<ul style="list-style-type: none"> ◆ Industry has continued to refine the TRM based on results and other information from the first iteration of projects and plans ◆ The TRM document has been updated to remain relevant, or increase relevance ◆ New directions, projects, stakeholders have been added to the TRM initiative ◆ The TRM process has evolved to ensure self-sustainment ◆ Industry champions/custodians of the TRM have been firmly established ◆ New/additional benefits are derived from projects/initiatives - same as from Phase 2 + the following: <ul style="list-style-type: none"> ◆ New enabling technological solutions ◆ Reconsideration, redirection of R&D funds ◆ New products or new utilization of products ◆ New exports, new export markets of the enabling technology ◆ Barriers to development and transfer of critical technologies are better understood and overcome ◆ Improved understanding and use of the flows of information related to technology development and inter-firm projects ◆ Formal projects and/or less formal spin-off projects are undertaken <ul style="list-style-type: none"> ◆ Some industry-wide ◆ Some between fewer companies ◆ Some may be on an individual basis ◆ New, additional related roadmaps were initiated/created ◆ Other industries have become interested ◆ Industry has become fully committed to the TRM ◆ Governments have become more responsive to the needs of the TRM initiative <ul style="list-style-type: none"> ◆ New/revised policies ◆ New/revised regulations ◆ TRM has become an integral part of policy development and other government initiatives

Results are systematically monitored and measured

<ul style="list-style-type: none"> ◆ Data, information related to TRM projects, relationships, related activities <ul style="list-style-type: none"> ◆ Quantifiable, measurable data/information collected systematically over time ◆ Qualitative data/information 	<ul style="list-style-type: none"> ◆ IC/Industry: <ul style="list-style-type: none"> ◆ Establish processes and practices to collect data and information on a systematic basis ◆ Analyze data: results achieved, successful practices, what worked well and what did not ◆ A set of activities which occur throughout the TRM process which are highlighted in this phase: <ul style="list-style-type: none"> ◆ Disseminate information about results, lessons, processes ◆ Encourage utilization of results and other information to improve TRM directions/projects and/or develop subsequent iterations of TRMs strategies and actions 	<ul style="list-style-type: none"> ◆ Information, case studies ◆ Communication tools, approaches 	<ul style="list-style-type: none"> ◆ Results from TRMs are being measured and the information is being used by Industry in the development of subsequent Roadmap/projects/plans
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INDUSTRY CANADA – TECHNOLOGY ROADMAPS INITIATIVE

PHASE 2 – INDUSTRY'S IMPLEMENTATION OF THE FIRST TRM

Projects are defined and initiated

INTENDED RESULTS	MEASURES OF THOSE RESULTS
<ul style="list-style-type: none"> ◆ Culture of partnering has become more acceptable to industry members ◆ Industry has committed to action related to the TRM ◆ Other stakeholders have become involved/committed – directly/indirectly, formally/informally (Canadian industry at large)² <ul style="list-style-type: none"> ◆ Eg., as a result of the communications strategy, IC² has stimulated demand for and implementation of TRMs² ◆ Priorities for projects reflect IC's policies, priorities, and directions and links with departmental horizontal issues² 	<ul style="list-style-type: none"> ◆ Evidence that industry members are establishing or pursuing strategic alliances: discussions between companies [individual companies & associations] ◆ Number of formal or informal strategic alliances established [individual companies & associations] ◆ Number of projects and action plans established [individual companies & associations] ◆ Number/level of industry resources allocated to TRM projects, actions [individual companies] ◆ Number of new industry participants or others in the projects, plans [individual companies] ◆ Evidence of linkage between project selection criteria and IC policies and priorities: key themes, linkages to indicators [sectors]

INDUSTRY CANADA – TECHNOLOGY ROADMAPS INITIATIVE

PHASE 2 – INDUSTRY'S IMPLEMENTATION OF THE FIRST TRM

INTENDED RESULTS	MEASURES OF THOSE RESULTS
<div style="background-color: black; color: white; padding: 5px; writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold;">Projects are defined and initiated</div> <ul style="list-style-type: none"> ◆ Culture of partnering has become more acceptable to industry members ◆ Industry has committed to action related to the TRM ◆ Other stakeholders have become involved/committed – directly/indirectly, formally/informally (Canadian industry at large)² <ul style="list-style-type: none"> ◆ Eg., as a result of the communications strategy, IC² has stimulated demand for and implementation of TRMs² ◆ Priorities for projects reflect IC's policies, priorities, and directions and links with departmental horizontal issues² 	<ul style="list-style-type: none"> ◆ Evidence that industry members are establishing or pursuing strategic alliances: discussions between companies [individual companies & associations] ◆ Number of formal or informal strategic alliances established [individual companies & associations] ◆ Number of projects and action plans established [individual companies & associations] ◆ Number/level of industry resources allocated to TRM projects, actions [individual companies] ◆ Number of new industry participants or others in the projects, plans [individual companies] ◆ Evidence of linkage between project selection criteria and IC policies and priorities: key themes, linkages to indicators [sectors]

PHASE 2 – INDUSTRY CANADA’S IMPLEMENTATION OF THE FIRST TRM (Continued)

Projects are monitored and managed	<ul style="list-style-type: none"> ◆ Industry is deriving benefits from projects/initiatives and learning more about the TRM and its potential ◆ Basic TRM Initiative management systems have been developed and implemented ◆ The TRM process was well received by industry ◆ The following results may occur, but are not necessarily expected from the first iteration: <ul style="list-style-type: none"> ◆ New enabling technological solutions ◆ Reconsideration, redirection of R&D funds ◆ New products or new utilization of products ◆ New exports, new export markets of the enabling technology ◆ Barriers to development and transfer of critical technologies are better understood and overcome ◆ Improved understanding and use of the flows of information related to technology development and inter-firm projects ◆ Formal projects and/or less formal spin-off projects are undertaken <ul style="list-style-type: none"> ◆ Some industry-wide ◆ Some between fewer companies ◆ Some may be on an individual basis ◆ New, additional related roadmaps were initiated/created ◆ Other industries have become interested ◆ Industry has become fully committed to the TRM ◆ Government has become more responsive to the needs of the TRM initiative <ul style="list-style-type: none"> ◆ New/revised policy ◆ New/revised regulations ◆ TRM has become an integral part of policy and other government initiatives 	<ul style="list-style-type: none"> ◆ Evidence of changing behaviour of industry members: number and types of strategic alliances, number of new strategic alliances under consideration, importance of technologies that are being developed [sectors & individual companies] ◆ Extent of reported management practices in place: planning and discussion for agendas, minutes, reporting [sectors & individual companies] <ul style="list-style-type: none"> ◆ Methods, practices for transferring information between companies ◆ Increased commitment of resources to TRM Initiative on the part of Industry Canada [sectors] ◆ Increased commitment of funding to TRM projects and plans by industry [individual companies] ◆ Changes in R&D directions & R&D policies: new technologies, new approaches to R&D by industry and federal performers [federal R&D performers & individual companies] ◆ Number of references to TRMs in industry and IC communications [sectors & individual companies] ◆ Number and type technological solutions developed, implemented [individual companies] ◆ Number of potential marketing opportunities created/provided by TRM for technology suppliers [individual companies] ◆ Number of barriers to development, replication, commercialization overcome [individual companies] ◆ Influence on other industries: influenced the development of a TRM in another industry, initiated a TRM in a related industry [sectors] ◆ Possibly (attributable to some extent to the TRM projects/plans): [upstream & downstream companies] <ul style="list-style-type: none"> ◆ Number and types of new products or uses of products - enabling technologies ◆ New products exported – enabling technologies and/or a product roadmap ◆ Number of new markets ◆ Number and characteristics of spin-off projects
Planning for subsequent iterations	<ul style="list-style-type: none"> ◆ Branch has reduced its overall level of participation and/or has reconsidered its role/function, and the critical role of the Industry Sector in getting the TRM initiative off the ground and implemented is recognized 	

INDUSTRY CANADA – TECHNOLOGY ROADMAPS INITIATIVE

PHASE 3 – GENERATING KNOWLEDGE-BASED, SELF-SUSTAINING FUTURE ITERATIONS

INTENDED RESULTS	MEASURES OF THOSE RESULTS
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">TRMs evolve and become self-sustaining</p> <ul style="list-style-type: none"> ◆ Industry has continued to refine the TRM based on results and other information from the first iteration of projects and plans ◆ The TRM document has been updated to remain relevant, or increase relevance ◆ New directions, projects, stakeholders have been added to the TRM initiative ◆ The TRM process has evolved to ensure self-sustainment ◆ Industry champions/custodians of the TRM have been firmly established ◆ New/additional benefits are derived from projects/initiatives - same as from Phase 2 + the following: <ul style="list-style-type: none"> ◆ New enabling technological solutions ◆ Reconsideration, redirection of R&D funds ◆ New products or utilization of new products ◆ New exports, new export markets of the enabling technology ◆ Barriers to development and transfer of critical technologies are better understood and overcome ◆ Improved understanding and use of the flows of information related to technology development and inter-firm projects ◆ Formal projects and/or less formal spin-off projects are undertaken <ul style="list-style-type: none"> ◆ Some industry-wide ◆ Some between fewer companies ◆ Some may be on an individual basis ◆ New, additional related roadmaps were initiated/created ◆ Other industries have become interested ◆ Industry has become fully committed to the TRM ◆ Government has become more responsive to the needs of the TRM initiative <ul style="list-style-type: none"> ◆ New/revised policies ◆ New/revised regulations ◆ TRM has become an integral part of policy and other government initiatives 	<ul style="list-style-type: none"> ◆ Number and scope of subsequent TRM iterations, TRM projects and plans [individual companies, any strategic alliance] ◆ Number of segments of an industry affected by TRM projects [industry associations, any strategic alliance] ◆ Changes/improvements to project selection criteria [individual companies, any strategic alliance] ◆ Evidence of accomplishments from previous iterations - may be just anecdotes [industry associations, any strategic alliance] ◆ Increased commitment of funding to TRM projects and plans by industry members [industry associations, individual companies] ◆ Changes in R&D directions and R&D policy: new technologies, new approaches to R&D by industry and federal performers [individual companies and sectors] ◆ Number and types of new R&D partners [industry associations] ◆ Number of references to TRMs in industry and IC communications [sectors, individual companies, industry associations] ◆ Number and type technological solutions developed, implemented [individual companies] ◆ Number of barriers to development, replication, commercialization overcome [individual companies] ◆ Influence on other industries: influenced the development of a TRM in another industry, initiated a TRM in a related industry [sectors] ◆ Number and types of new products and new uses of products that can be attributed to a TRM initiative [individual companies, upstream & downstream] ◆ Volume of increased exports, that can be attributed to a TRM initiative [individual companies, upstream & downstream] ◆ Number of new markets that can be attributed to a TRM initiative [individual companies, upstream & downstream] ◆ Number and characteristics of spin-off projects [individual companies, upstream & downstream]

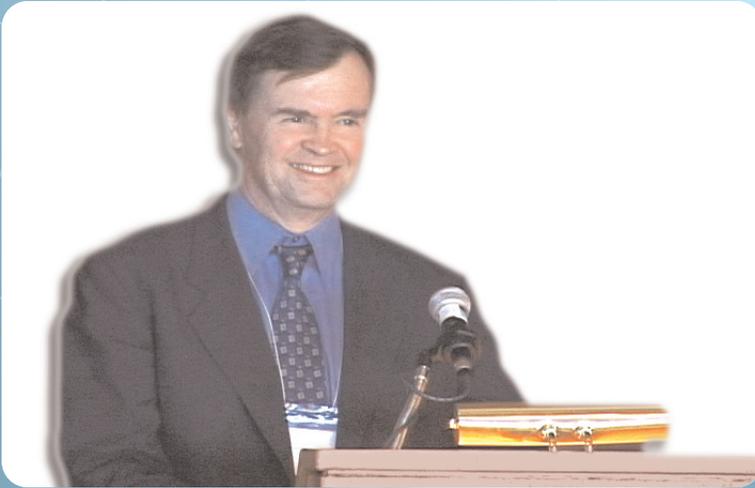
PHASE 3 – GENERATING KNOWLEDGE-BASED, SELF-SUSTAINING FUTURE ITERATIONS (Continued)

Results are systematically monitored and

◆ Results from TRMs are being measured and the information is being used by Industry in the development of subsequent Roadmap/projects/plans

◆ Evidence of use of TRM results are used: information is communicated between companies, increased references to TRM project results, recognition that results are from a TRM initiative, linkages between TRM projects [individual companies]

b i o



Geoffrey Nimmo

Mr. Nimmo graduated from the University of Victoria, in Victoria, Canada, with a BA in International Relations in 1979 and from Carleton University in Ottawa, Canada, with a Masters in International Relations in 1981. He has directed the Technology Roadmap Secretariat at Industry Canada for the past three years. During that time, a number of Technology Roadmaps (e.g., Intelligent Buildings, Fuel Cells, Lean Logistics) have been initiated by Industry Canada and completed by industry. In addition, publications explaining Industry Canada's approach to technology roadmapping have been developed:

- Technology Roadmapping:
A Strategy for Success
- Technology Roadmapping:
A Guide for Government Employees

Mr. Nimmo lives in Ottawa, and is married with two daughters.

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