



Industry Canada

Synthesis of Six Technology Roadmap Evaluations

Final Report

**The Strategic Review Group
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Industry Canada

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Industry Canada

Synthesis of Six Technology Roadmaps Evaluations Final Report Executive Summary

This document sets out a synthesis of the findings and conclusions from the evaluations of the following six Technology Roadmap (TRM) initiatives undertaken by Industry Canada (IC):

- Canadian Aircraft Design, Manufacturing, Repair and Overhaul (Aircraft Manufacturing)
- Electrical Power
- Medical Imaging
- Geomatics
- Wood Based Panel Board
- Forestry Operations.

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.

Conclusions From the Synthesis

Overall, TRMs were viewed as worthwhile exercises. Evaluation findings suggested that industry members recognized the potential value of Technology Roadmaps, and believe that Industry Canada provided a very important contribution to the initiatives. These factors contributed to participants' staying committed to the Phase 1 TRM process until completion.

The progress of a TRM appears to be influenced by a number of factors. It appears that having a facilitator is essential to a TRM and that the TRM collaborative approach adds significant value. Also, assessing an industry's readiness for a TRM is important, particularly the importance of industry-wide issues, an industry's ability to converge on a set of critical technologies, and the speed of an industry's technology development.

Lessons Learned

Emphasizing the following success factors will optimize future TRMs' added value to participants and to the concerned industry:

- 1) TRM's benefit from having a facilitator to help provide direction, momentum, enabling mechanisms, and overall secretariat services.
- 2) TRM initiatives should include a diversity of participants that are knowledgeable about the industry concerned, and the private sector should be well represented.

- 3) TRM initiatives should be designed and implemented so that they include industry champions that are, and are perceived as industry leaders.
- 4) TRMs should maintain their collaborative approach of bringing together and/or consulting with a wide variety of concerned industry stakeholders.
- 5) TRMs are more likely to encourage information exchange and partnership opportunities if company executives participate actively in the initiative. Executives will also attract other executives, and will increase the credibility and practical usefulness of the TRM.
- 6) TRM initiatives will progress more deliberately if Phase 1 generates a clear list of key technologies and a series of related future technology development projects.
- 7) The timing and design of a TRM initiative should take into consideration the industry's other macro-level business priorities and participants' potential to converge on the industry's critical technologies.

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Synthesis of Six Technology Roadmaps Evaluations Final Report

This document sets out a synthesis of the findings and conclusions from the evaluations of six Technology Roadmap (TRM) initiatives undertaken by Industry Canada (IC).

1.0 Introduction and Methodology

Using the findings and conclusions from six evaluations, this synthesis analysis identified a number of success factors that can be used to guide future TRM exercises. The six evaluated TRMs discussed in this report are:

1. Canadian Aircraft Design, Manufacturing, Repair and Overhaul (Aircraft Manufacturing)
2. Electrical Power
3. Medical Imaging
4. Geomatics
5. Wood Based Panel Board
6. Forestry Operations

The methodology for this synthesis involved reviewing the evaluations of the above six TRMs and analyzing the findings and conclusions on common topics and issues. The similarities and differences in these findings and conclusions were examined to identify the attributes that appeared to contribute most to a TRM's positive outcome. Also, the consulting firm conducting this synthesis had undertaken some of the above TRM evaluations and were able to contribute to the synthesis exercise from first hand knowledge from interviews with TRM participants.

2.0 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.

3.0 Findings From the Synthesis

The synthesis analysis revealed there are key success factors that enhance the usefulness of, and impact from TRM initiatives. The following sub-sections set out the key success factors that influenced six TRMs conducted by IC since 1996.

It is essential to note that the above-noted six TRM exercises had only undertaken Phase 1 activities. As a result, this synthesis only considers findings and conclusions from Phase 1 TRM activities.

3.1 A facilitator is essential

The synthesis found that a facilitator was an essential element to the continued progress of a TRM initiative.

The evaluations indicated that the facilitation role included leading the TRM process, helping to define the structure and roles of steering committees and work groups, coordinating interaction among participants, compiling analyses, and guiding the report writing. For some TRM's, the facilitators established communication mechanisms, for example using the Internet.

The facilitators for the six TRMs were either Industry Canada, the Forest Engineering Research Institute of Canada (FERIC), or Forintek Canada Corporation (Forintek). As facilitators, Industry Canada, FERIC and Forintek knew the TRM process, knew the TRM participants, understood the respective industry's environment and context, interacted with participants frequently, and kept the process moving despite participants' other competing time commitments. Furthermore, as facilitators they were the "steward" of the TRM process and provided guidance, coordination, enabling mechanisms (such as communication vehicles), and an overall secretariat function. For all TRMs, Industry Canada played a pivotal role in launching and managing the progress of the exercises. For the Forestry Operations and the Wood Based Panel Board TRMs, Industry Canada played a central role, since it defined and let the respective contracts to FERIC and Forintek.

The evaluations indicated that, without the facilitators, the TRM initiatives would not have progressed. In fact, the findings indicated that the lack of impetus in recent years to proceed to Phase 2 has been largely caused by the lack of a central facilitation/coordination role for next steps.

It is noteworthy that the evaluations determined that Industry Canada performed the facilitation role very well. Some participants indicated that, if not for IC's successful performance as facilitator, their TRM would not have progressed. Many said that, without IC, there would "not have been a TRM at all." Others indicated that it was beneficial to have an IC representative since they were respected by, and familiar with the industry, thereby enabling them to encourage industry participation.

Overall, the evaluations indicated that a facilitator contributes significantly to influencing the progress and direction of a TRM initiative. The findings also suggested that the effort and innovation provided by the facilitator affects the success of the process and the outcomes from the exercise.

Key Success Factor

- 1) TRM's benefit from having a facilitator to help provide direction, momentum, enabling mechanisms, and overall secretariat services.

3.2 Choosing TRM participants

The synthesis analysis suggests that the approach used to select TRM participants can affect the usefulness of the TRM exercise.

The six TRM initiatives used different practices to select their participants. The expert organizations leading the Forestry Operations and Wood Based Panel Board TRM's – FERIC and Forintek – involved industry stakeholders in different ways: one conducted Canada-wide consultations and the other interviewed mostly major industry associations. Aircraft Manufacturing involved mostly participants from the manufacturing sector; Electric Power, Geomatics, and Medical Imaging involved a diversity of participants from the private and public sectors and from academia.

Participants in the Aircraft Manufacturing, Electric Power, Geomatics, and Medical Imaging TRMs were invited to participate by Industry Canada. IC specifically targeted some participants because of their prominence or special contribution to their specific industry. Industry Canada invited participants with a view to representing a cross section of concerned stakeholders – private and public sectors and academia. Some individuals were asked to participate by other industry members because their views were considered to be important. Some participants became involved simply because Industry Canada had asked them, or because they wanted to establish a closer relationship with the Department.

The six evaluations indicated that participants had differing views about their role and contribution to their respective TRM. Some indicated that the TRM discussions and analyses were directly relevant to them and their company's current or future role in the industry. On the other hand, some found that the direction taken by their respective exercise did not relate to the activities, product focus, or future priorities of their own company, even though they may have recognized the potential value of the TRM exercise. These participants indicated that it became increasingly difficult to justify to their own organization their continued participation in the TRM because of other competing business priorities. For example, some participants in the Electric Power TRM, which was focused primarily on the Utilities sector, felt that the TRM's direction was not relevant to their own area of expertise or concern. As discussed later, these individuals fulfilled their obligations for the exercise, but would be wary of involving themselves in a similar exercise again.

Other participants indicated that it is important that TRMs involve many representatives from the private sector. They indicated that such a strategy seems reasonable, given that a TRM is expected to be industry-led, with a high level of industry buy-in. Furthermore, such an approach would ensure that all working groups for a TRM would have sufficient private sector members to ensure that the discussions reflect the practical views of the industry's manufacturers.

The synthesis findings suggest that TRM's do benefit from having participants from a cross-section of concerned areas. Furthermore, a variety of participants

ensures that a diversity of expertise is reflected in the exercise. The approach of having Industry Canada select participants had a positive result inasmuch as the people involved were willing to participate and they knew their area of the industry.

The synthesis analysis suggests that those who participated in TRMs were considered to have provided a positive contribution. Furthermore, inviting a wide variety of participants to contribute to the TRMs added value in that it provided a diversity of expertise, perspective, and experience. Furthermore, it appears to be reasonable to include in a TRM as many private sector participants as practicable.

Key Success Factor

- 2) TRM initiatives should include a diversity of participants that are knowledgeable about the industry concerned, and the private sector should be well represented.

3.3 An industry champion increases the likelihood of success

The synthesis analysis suggested that the participation of industry champions in the TRM process increases the potential for agreeing on key technologies.

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.

The six evaluations indicated that four of the TRM initiatives had participants who performed the role of industry champion. Specifically, the Forestry Operations and Wood Based Paneling TRMs involved the respective industry's national research and development organizations; Aircraft Manufacturing included top executives from 66 industry members; and Electric Power included major utility companies. It was less clear whether the Geomatics and Medical Imaging TRMs included participants who acted as industry champions.

It is not clear whether the involvement of champions had a direct impact on the results achieved during these six TRMs. However, interviewees from TRM initiatives indicated that industry champions perform a leadership.

The analysis indicated that participants viewed a TRM initiative as being more worthwhile and credible if one or more participants act as industry champions. This suggests that TRMs should to the extent practicable, include champions, and that the initiatives could be designed to maximize the contribution of these champions. This approach would increase the buy-in of industry and help to enable TRMs to become industry led.

Key Success Factor

- 3) TRM initiatives should be designed and implemented so that they include industry champions that are, and are perceived as industry leaders.

3.4 A collaborative approach is important to TRMs

Participants in TRMs have benefited from collaboration with other participating firms.

One of the objectives of a TRM is to bring together a variety of stakeholders associated within a specific industry to discuss and identify key technologies that the industry will need to “crack.” Four of the six TRM’s created collaborative fora for discussion by establishing working groups and discussion groups based on areas of common interest. These groups included participants from the private, public and academic sectors. The Wood Based Panel Board and Forest Products TRMs did not involve the same type of collaborative working groups as did the other four TRMs. However, they did involve significant consultation with a variety of organizations involved with the industry. For example, an Electric Power TRM participant said, “As a smaller company, the networking helps, and also gives us a better understanding of what our customer’ needs are.” An Aircraft Manufacturing TRM participant said that the collaborative approach led to subsequent technology partnerships.

The evaluations indicated that the collaborative aspect of the TRMs was useful since it provided an opportunity to bring multiple stakeholders together to discuss views on the relative importance to the industry of specific technologies and key obstacles that needed to be overcome. Discussion groups were considered to be excellent media to bring concerned parties together to discuss current and future interests. Even participants who were less directly affected by the directions that their respective TRM eventually took benefited from the discussions on technology issues with other industry members.

The evaluations also suggested that many participating companies became less concerned with issues of confidentiality as the TRM progressed. This finding may indicate that companies participating in a TRM can overcome concerns that their own intellectual property or business strategies would be compromised in a TRM exercise.

The synthesis analysis determined that the collaborative nature of TRM initiatives provides a significant benefit to participants. Even when the outcomes of the TRMs do not apply to some participants, the TRM provides an opportunity for interaction and sharing information.

Key Success Factor

- 4) TRMs should maintain their collaborative approach of bringing together and/or consulting with a wide variety of concerned industry stakeholders.

3.5 Level of commitment to the TRM

In the TRM exercises evaluated, there was a high degree of commitment by all the participants to see the exercise through to the completion of Phase 1.

Participants' commitment to their respective TRM initiative involved primarily staying involved with the exercise until it was finished. Commitment to a TRM seemed to be based on a) a participant's desire to finish what they had started, b) their expectation that the results would be useful to them (or their organization), and/or c) their belief that the TRM would be beneficial to their industry.

According to the evaluations, the six TRMs did not necessarily meet the expectations of all their participants. Even so, the evaluations' interviewees indicated that they remained involved in the process until the end because they had indicated that they would do so. Some interviewees remained involved in their TRM even though they were receiving pressure from their own organization to withdraw from the exercise due to other organizational priorities. Some also said that they remained committed to the exercise to be "good corporate citizens" or because they recognized the potential benefit to their industry and recognized the value of what they called "strategic thinking" on technology issues.

Therefore, the synthesis determined that, even if the TRMs did not meet the needs or expectations of all participants, the participants remained committed to the process. Some did so because they saw the potential benefits from the TRM initiative, and others to fulfill their obligation to stay with the project until it was completed. These findings suggest that, once TRM exercises are started, they are likely to build momentum and continue to receive the support of participants.

3.6 Senior management participation adds value

TRMs that included more participation from senior company managers were seen to more successful at actively transferring knowledge and establishing linkages.

TRMs are intended to encourage technology-focused collaboration. The evaluations indicated that participation by company executives from industry improved the likelihood of better "information trading" and reaching agreements to work together, even outside the formal TRM exercise. The studies' findings suggested that several factors contributed to these positive results. First, senior company officers tend to know more about their company and its strategic business directions. Therefore, they 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.

Of the TRMs examined, the Aircraft Manufacturing and Medical Imaging exercises included senior company officials. In fact, the Aircraft Manufacturing evaluation was the only one where interviewed participants indicated that partnerships *were* formed as a result of the TRM.

The Wood Based Panel Board and Forestry Operations TRMs were led by the respective industry's technology research organization and, therefore, did not result in more technology collaboration or partnerships than would have occurred otherwise. It was not clear whether company executives participated in the Geomatics or Electric Power TRMs; however, interviewees from the Electric Power exercise indicated that more executive involvement would have been beneficial.

Therefore, if TRM exercises include the active participation of industry executives, they are more likely to generate partnerships and the exchange of technology and business information, which are important intended results.

Key Success Factor

- 5) TRMs are more likely to encourage information exchange and partnership opportunities if company executives participate actively in the initiative. Executives will also attract other executives, and will increase the credibility and practical usefulness of the TRM.

3.7 Few of the TRMs are ready to proceed to Phase 2

Phase 2 of a TRM involves establishing projects to “crack” new important technologies. Only two of the six evaluations examined were ready to proceed toward Phase 2.

Phase 1 of a TRM is intended to provide an analytical foundation for undertaking technology projects. Decisions to undertake projects are better supported if a) criteria have been developed 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.

The synthesis analysis determined that only two of the examined TRM exercises had developed a list of higher-priority technologies. Specifically, the Aircraft Manufacturing and Forestry Operations TRMs produced lists of specific technologies that were considered to be important to their respective industry's future success. Even though these two initiatives have not yet proceeded to

Phase 2, because a list of key technologies has been developed, these two industries are better prepared to establish clearly focused technology development projects.

The other four TRMs produced less-focused information. The Wood Based Panel Board TRM identified technology areas that could be improved immediately, and a range of broad technologies that would be required in the future for specific industry areas; the Medical Imaging TRM identified technology areas that could be improved; and the Electric Power TRM identified areas where the industry needed to develop technology solutions. The TRM reports from these four exercises did not provide sufficient information to enable the industry to undertake specific technology-development projects.

Some evaluations indicated that TRM participants expected more of a *focused* result from their TRM initiative and that, when a useful list of technologies was not developed, they expected that more work would be done until a clearer direction was developed. Other evaluations, such as the ones for the Medical Imaging and Wood Based Panel Board indicated that those TRM exercises were not intended to produce a list of future projects. Therefore, at least some TRM participants expected that the TRM exercise would lead to a clear direction for future technology development. Furthermore, a list of future projects would be an important output to enable progress to Phase 2 of a TRM.

Key Success Factor

- 6) TRM initiatives will progress more deliberately if Phase 1 generates a clear list of key technologies and a series of related future technology development projects.

3.8 Industry business characteristics can affect the “success” of a TRM

The evaluations indicated that participants agreed that technology planning is always important. However, they also indicated that business factors can affect the relative success of a TRM initiative.

The evaluations indicated that three industry-related factors affected the relative success of the TRM initiatives: industry environment, industry maturity, and the pace of technology development.

The evaluation of the Electric Power TRM indicated that participants recognized the benefits of the initiative and fulfilled their commitment to complete the exercise. However, participants also indicated that, because the industry was adapting to a new deregulated environment, their company's priorities were not focused primarily on technology at the time of the TRM. The evaluation of this TRM indicated that the initiative likely did not receive the level of senior industry attention that it could have because executives were preoccupied with the very significant change to their business environment arising from deregulation. It

could be expected that significant changes in an entire industry's business environment would distract industry members' attention away from a TRM. As a result, future TRMs should determine whether potential industry-wide business issues could affect negatively participants ability to focus and allocate resources to a TRM initiative.

The evaluation of the Medical Imaging TRM suggested that the industry may not have been ready yet for a TRM. A number of participants in that TRM had indicated that the Medical Imaging industry was still relatively new, with a large proportion of smaller companies focusing on specialized areas of the market. These participants indicated that their industry was not yet ready to consider technology issues from an industry-wide perspective. It is noteworthy that this TRM exercise included a number of executives from small companies, which lends credibility to the argument. It could be argued that participants in an emerging industry need time to solidify and grow their own market position before being able to converge on industry-wide technology opportunities. On the other hand, perhaps a TRM would provide opportunities for strategic business partnering and helping to target future technology development. It is not clear whether industry maturity is indeed a factor that affects the potential success of a TRM. However, an industry's readiness to consider industry-wide technology issues would clearly affect the progress of a TRM.

Finally, the Geomatics TRM evaluation suggested that the TRM exercise may not have been appropriate to that industry at the time because of the rapid pace of technology development. Some findings from that evaluation suggested that the Canadian Geomatics industry and its technologies are evolving so fast, that the TRM approach to identifying *collectively* critical technologies was slower than the actual pace of the industry's own technology initiatives. That evaluation did not provide sufficient information to determine whether this viewpoint was fully supportable. However, the finding may suggest that the speed of technology evolution within an industry could diminish the relative added value of the TRM approach. Conversely, a TRM's approach could be adjusted to move more quickly and/or focus on a longer timeframe.

Overall, the evaluations indicated that 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.

Key Success Factor

- 7) The timing and design of a TRM initiative should take into consideration the industry's other macro-level business priorities and participants' potential to converge on the industry's critical technologies.

4.0 Conclusion

The synthesis analysis determined that the six TRMs were conducted very differently and that some of the exercises were more ready than others to proceed to Phase 2 of the TRM. Also, fewer business partnerships were developed through the TRM Phase 1 than were expected by participants.

Evaluation findings related to the six TRMs suggest that industry members recognize the potential value of Technology Roadmaps, and believe that Industry Canada provided a very important contribution to the initiatives. These factors contributed to participants' staying committed to the process until it was completed.

The progress of a TRM appears to be influenced by a number of factors. It appears that having a facilitator is essential to a TRM and that the TRM collaborative approach adds significant value. Also, assessing an industry's readiness for a TRM is important, particularly the importance of industry-wide issues (such as deregulation); an industry's ability to converge on a set of critical technologies (maturity); and the speed of an industry's technology development.

Selecting participants also influences a TRM. Specifically, TRMs benefit from:

- selecting participants from the private and public sectors and from academia,
- including participants who will act as industry champions, and
- encouraging companies' executives to participate.

Overall, TRMs are viewed as worthwhile exercises. Emphasizing the above success factors will optimize the initiatives' value added to participants and to the concerned industry.