NRC·CNRC

SUMMARY REPORT

INDUSTRY CONSULTATIONS ON THE FUTURE OF MANUFACTURING

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Canada

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EXECUTIVE SUMMARY

For over 100 years, the National Research Council of Canada (NRC) has made immense contributions to industrial research and business innovation, support federal public policy, and advanced scientific knowledge. NRC's research ranges all the way from advancing the emerging science and technologies of tomorrow, through to applying our state-of-the-art knowledge and expertise to our clients' needs.

As we look to the future, the need for advanced manufacturing technologies to stimulate innovation, increase productivity, and assist Canadian companies to compete in the global marketplace now and for the future continues to grow. In the past year, the NRC has been consulting industry across the country to better define the advanced manufacturing landscape in Canada and to exchange ideas and explore opportunities for collaborations.

From February to June 2017, the NRC met with industry stakeholders in various locations across the country. Seven (7) workshops with participants from 131 organizations were held in the following locations: London, ON; Montréal, QC; Vaughan, ON; Kelowna, BC; Ottawa, ON; Winnipeg, MB, and Waterloo, ON. Discussions focused on four main topics: the vision for the future of manufacturing in Canada; the current situation (what is already under way and where there are gaps); the role that NRC should play in helping industry create the desired future; and who else should be involved. In addition to hosting these workshops, the NRC heard from 31 Industrial Research Assistance Program (IRAP) clients through a survey to gather additional input and feedback about advanced manufacturing technologies and applications in Canada. This report summarizes the combined findings from both avenues of consultation.

The vision for the future of manufacturing in Canada: Six different themes emerged consistently across the consultation: automation and robotics; changes in the supply chain; increased integration and collaboration; changes in the workforce; diversification, flexibility and mass customization; and disruption of traditional manufacturing. While there was some minor variation in the emphasis placed during the discussions, all predicted significant change requiring substantial adoption of new technologies and new ways of working.

The current situation: Generally speaking, the picture that emerged is of an industry that is taking early steps in adopting new technologies, but still relying fairly heavily on support from government and academia. Some industry networks and collaborative efforts are growing, and there are some factors in the broader Canadian context that are helping us move in the right direction. The gaps and challenges described by participants relate to government policy and regulations; the cost of doing business and competitiveness of the Canadian industry; education and training; technology adoption and commercialization; funding; knowledge and communication; and support for SMEs.

The role that NRC should play: Each workshop identified multiple ways in which the NRC might support the industry in creating a new and better future, generally falling under the following themes: building and sharing knowledge, including technology foresight, seminars, and online portals; supporting research and development; demonstrating and de-risking technology; intergovernmental advocacy and support; facilitating and encouraging collaboration; and providing advice and expertise.

Potential partnerships and who else should be involved: Participants supported broad involvement in moving forward together in building a strong future for manufacturing in Canada, including a variety of partnerships with stakeholders in banking and finance, industry, government, education, academia, and national research organizations in other countries. They identified a number of questions that they would like to see addressed related to Canada's vision for manufacturing, funding, the process of implementing new technologies, and the role and contribution of the NRC.

1. INTRODUCTION

BACKGROUND

As part of a strategic review of advanced manufacturing technologies and their applications in Canada, in early 2017, the National Research Council of Canada (NRC) consulted industry to discuss and export opportunities for collaboration in this growing field. The objectives of these consultations were to:

1. Reflect on the potential impacts of pervasive technology advancements and the challenges and opportunities that these present for Canadian Industry.
2. Identify what NRC can do now to assist in the development of novel technologies for Canada's leading-edge future factories and their supply chain.

From February to June 2017, the NRC met with industry stakeholders from across the country; seven (7) workshops in the following locations: London, ON, Montréal, QC, Vaughan, ON, Kelowna, BC, Ottawa, ON, Winnipeg, MB, and Waterloo, ON.

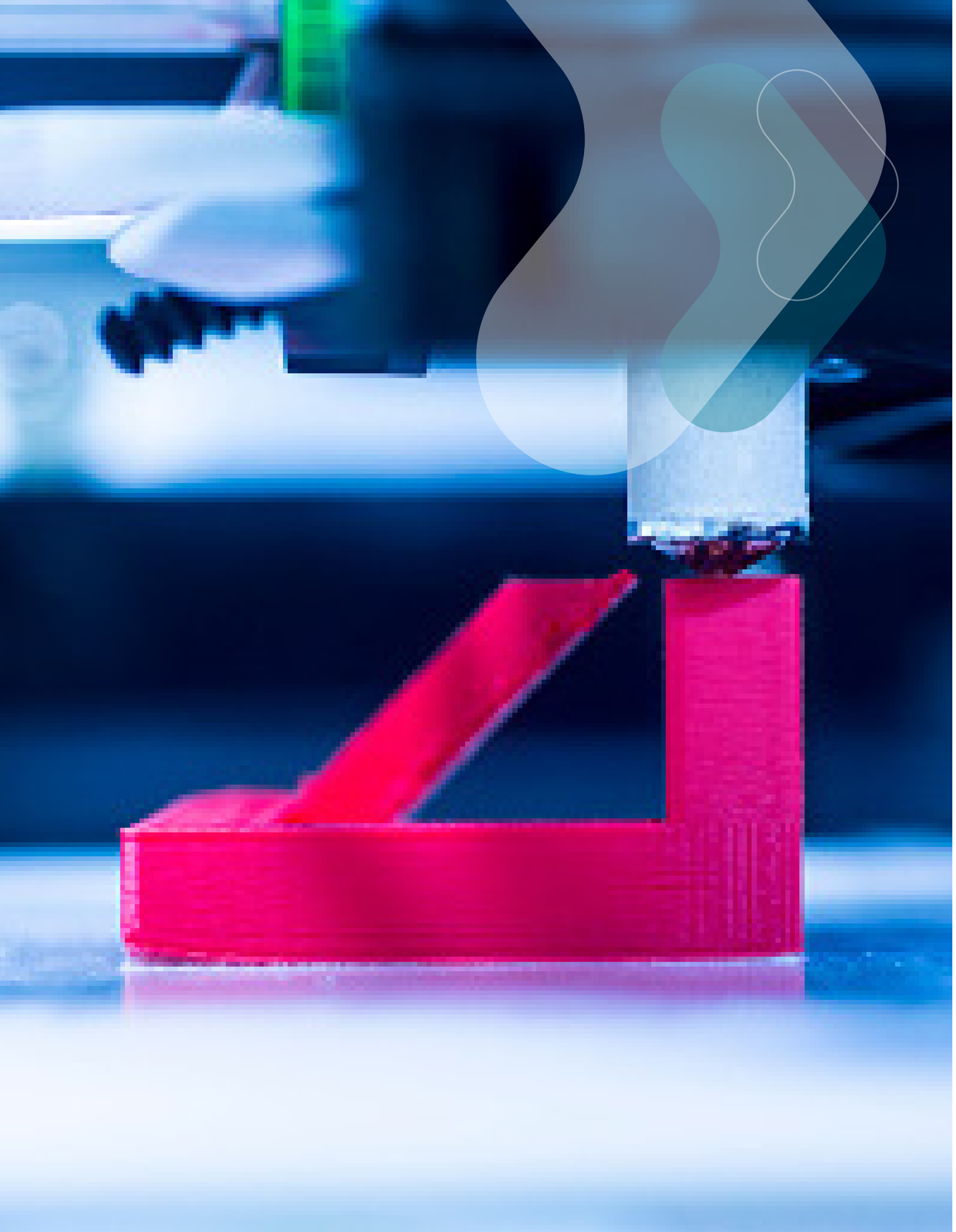
Participants in the workshops included representatives from a variety of industries, with automotive and aerospace most heavily represented, as well as representatives from government and academia. A list of all 131 participating organizations is provided in Appendix A.

The NRC also collected input from 31 Industrial Research Assistance Program (IRAP) clients across Canada through a survey that gathered feedback about advanced manufacturing in Canada.

Discussions focused on four main topics:

1. The vision for the future of manufacturing in Canada.
2. The current situation (what is already under way and where there are gaps).
3. The role that NRC should play in helping industry create the desired future.
4. Who else should be involved.

This report combines the findings from all the workshops as well as the IRAP survey. It summarizes the themes that have emerged from each of the discussions on the four main topics listed and provides a comprehensive list of all the partnership opportunities, additional stakeholders to involve, and unanswered questions that were identified by workshop participants.



2. THE FUTURE OF MANUFACTURING

2.1 OVERVIEW OF KEY THEMES

Participants in the workshops were asked to share their perspectives on where the Canadian industrial future is going. This question was not asked in the IRAP survey.

In some sessions, the conversation was introduced by a presentation on Foresight and future scenarios developed by the NRC S&T Outlook group. In addition, in some locations presentations were provided by industry experts on the topic of the future of manufacturing. In other instances, participants drew mostly on their own knowledge to paint the picture of the future. Despite these variations, a number of common themes emerged across the different locations. These are summarized below.

2.2 DETAILS OF EACH THEME

Automation and Robotics

Workshop participants in all locations envisioned increased use of automation and robotics as key aspects of future manufacturing in Canada. They talked about increased reliance on robots to replace repetitive manual labour, and discussed the need to optimize the interaction of artificial intelligence with humans. They predicted increased resources devoted to developing and integrating technologies, and challenges related to remaining current with new technology, and with regard to capturing, storing, and protecting the data produced by robots.

Technology integration was more specifically identified in some locations, with ideas such as software that fits seamlessly into design, intelligence embedded into products, and IT solutions to help manage the supply chain. Some groups talked about the development of specialized services related to automation such as equipment or automation as a service, and financing for automation. Other suggested ideas were that smart sensors, data collection, and subsequent analyses will feed most technologies of the future as companies and their customers expect rapid results and actions. Participants identified that automation will have to be flexible and reconfigurable, with equipment moving to where the parts are, rather than parts moving to the equipment.

	Kelowna	London	Montreal	Ottawa	Vaughan	Waterloo	Winnipeg
Automation and robotics	●	●	●	●	●	●	●
Changes in the supply chain	●	●	●	●	●	●	●
Integration and collaboration	●	●	●	●	●	●	
Changes in the workforce	●	●		●	●	●	●
Diversification and flexibility, mass customization	●	●			●	●	●
Disruption of traditional manufacturing	●	●				●	●

Changes in the Supply Chain

At all the workshops, participants discussed various potential changes in the manufacturing supply chain of the future. There was general agreement that things will be different, but no common picture emerged of what the future will bring. The discussion included consideration of the following:

- The impact of 3D printing.
- Increased efficiencies with the replacement of person-to-person interactions with online and automated transactions.
- Changes to materials supply and economics which will push manufacturers to focus on added value.
- Whether a "50-km diet", as outlined in the scenario vignettes, will play out, or whether the trend will be to extend the supply chain from regional to continental. Cost of transportation was identified as a factor: could we, in Canada, take better advantage of the resources available locally in selecting materials? Customer expectations of rapid delivery could also play a role in shortening supply chains. On the other hand, platform limitations and IP considerations might constrain where some components are manufactured, such as is happening with smart phones. Canada might also be well positioned to manufacture niche products and export them globally.
- Increased communication and collaboration within OEM supply chains to reduce inefficiencies.
- Design for repair or rework, and the implications for the supply chain.
- Bringing in international experts to enhance the capacity of local supply chains.
- The value in creating a supply chain strategy, which might include clustering common capabilities (i.e., IT, standardization of resources and processes, and linking government, academia, and industry) to build a critical base of expertise.

Integration and Collaboration

Almost all groups predicted greater integration and collaboration at all levels of Canada's manufacturing landscape of the future. This could include targeted sharing of expertise, resources, facilities, and technology within groups such as supplier consortia or networks composed of manufacturers, academia, and government organizations. Industry could collaborate on funding, training, and supporting technology integrators to implement and distribute new technologies. Protection of intellectual property will become less important than figuring out the most efficient solution to a problem; while open platforms and the maintenance of standards will be increasingly more important.

Changes in the Workforce

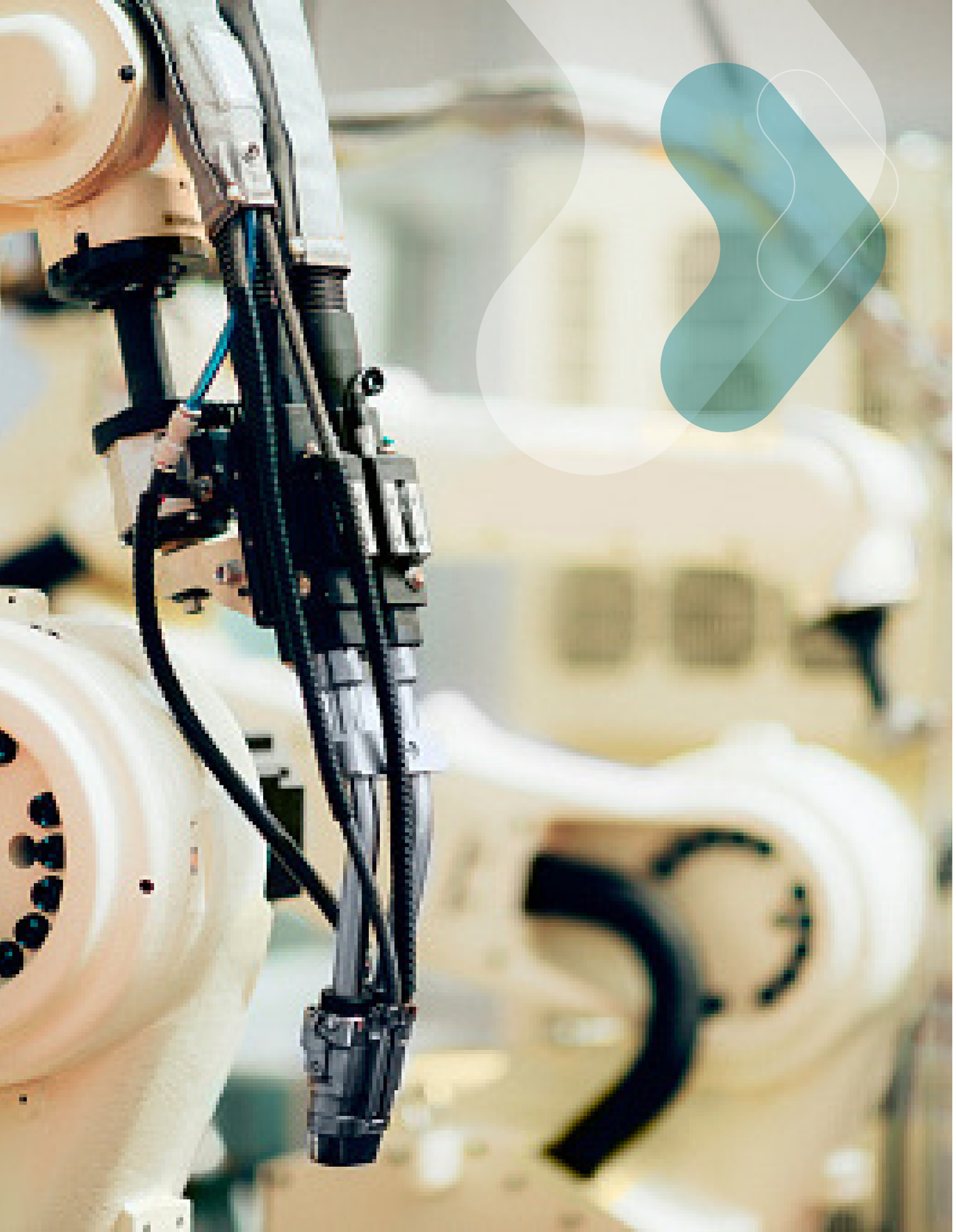
This discussion focused a lot on the impacts of automation and robotics, but also extended further into other changes in the Canadian workforce. There were numerous comments about needing new skill sets and expertise as work shifts from manual production to oversight and maintenance of automated production. This will force changes not only to what we teach children and students, but how we teach them, and who we teach, with more emphasis on learning how to learn, and on retraining and reskilling existing workers throughout their career. In future, what a company does will depend more closely on the available workforce and what skills they bring; Canadian manufacturers may face increasing talent shortages unless they can adapt to the expectations and demands of newer generations of workers. One topic of debate was whether the workforce of the future will be more global: Some felt that "techno-gypsies", i.e., a highly mobile workforce, will be the way of the future, whereas others suggested that companies will make efforts to keep the workforce that they have invested in training.

Diversification, Flexibility and Mass Customization

A number of discussions focused on the increasing importance of being able to adapt quickly to changing customer needs. Manufacturers will have to invest in technology and more complex facilities where more models or different versions of a same product can be produced, and at different scales, ramping up or down based on demand. Platforms will be more flexible, new materials will play an important role, and we will likely see lower inventories and more agile and Just-In-Time (JIT) manufacturing. As one group put it, this industrial future will see roles reversed, where customers will be looking for specific products as opposed to products looking for customers, and they will want them produced quickly.

Disruption of Traditional Manufacturing

In four of the seven locations (see table in section 2.1), groups also discussed other types of disruptions to traditional manufacturing, for example those resulting from changes in market demand. Some went so far as to predict the disappearance of the current primary industry; others talked about manufacturing new components, and changes in energy supply, maintenance, and infrastructure. There were suggestions that sustainability and renewable resources (green focus) could be the direction of manufacturing evolution, or that manufacturing may get more heavily into food production. Smaller, more dispersed manufacturing plants – "micro-factories" – may significantly change the Canadian manufacturing landscape, especially with new advances in 3D printing. Specific industries mentioned in these discussions included the automotive industry, aerospace, and even healthcare and the production of medical devices. The possibility was raised that augmented reality would become more common on shop floors in Maintenance, Repair and Overhaul (MRO) operations.



3. THE CURRENT SITUATION IN CANADA

Having considered the future possibilities, the groups were then invited to focus on the current situation in Canada, looking at what is already under way to create the desired future, and what gaps might need to be filled. This section provides a summary of key themes for each of these questions, starting with what is currently under way.

3.1 WHAT IS ALREADY UNDER WAY

Overview

As can be seen in the table below, there were some themes that were present through all the discussions, and a few that showed some differences in emphasis in the discussion of what is already under way in Canada to prepare for the envisioned future.

Technology Innovation / Implementation of New Technologies

All groups provided examples where new technologies are being tested and adopted. For the most part, this technology adoption seems to be happening in pockets and not yet generalized across industries or geographies. In Kelowna, participants talked about companies engaging in mass customization and adapting their processes to achieve innovation unique to the market. The London workshop generated examples of engineering and technology companies doing work in advanced manufacturing, but with limited awareness and consolidation.

In Montreal, it was noted that some companies invest in new technology because it is novel, but may not know how to best leverage that technology. Reference was also made to an additive manufacturing material database being developed for sharing within a consortium. In Ottawa and Vaughan, conversations centered on what industry has been doing to build awareness and learn about new technologies; in Ottawa in particular, there was much discussion on the benefits of learning from abroad, for example the Hanover Fair in Germany. Waterloo participants stressed the strength of Canadian manufacturing in Artificial Intelligence (AI) specifically, especially given the AI centers in Kitchener-Waterloo, Montreal, and Vancouver. Winnipeg participants also spoke of AI applications, and also referenced interesting new developments in additive manufacturing and autonomous vehicles. They specifically noted the Canada Makes network, which acts mostly as an advocacy group for the additive manufacturing industry in Canada, and Canada's strength in metal additive technologies. Also noted were mass customization applications and considerable momentum in usage of big data. All of these developments were mentioned by the IRAP survey respondents, in addition to developments in advanced manufacturing such as the use of machine assisted assembly, growth in robotics and automation, and developments in lean manufacturing and CADCAM technologies for machining and fabrication that are helping to drive change.

	IRAP	Kelowna	London	Montreal	Ottawa	Vaughan	Waterloo	Winnipeg
Technology Innovation / Implementation	●	●	●	●	●	●	●	●
Government support	●	●	●	●	●	●	●	
Academic sector / Education	●	●	●		●	●	●	●
Industry collaboration and networking		●			●		●	●
Broader Canadian context			●			●	●	

Government Support

Most of the comments under this theme referred to the work being done by the NRC, for example the IRAP program and its Concierge Service, as well as the National Science Library and various research initiatives such as the work on additive manufacturing and the Advanced Manufacturing program. Participants also mentioned recent budget allocations by the federal government and various programs and departments or agencies funding research and development. For example:

- The Scientific Research and Experimental Development Tax Incentive Program (SRED)
- The Technology Demonstration Program (TDP) of the Industrial Technologies Office (ITO)
- The Business Development Bank of Canada (BDC)
- Government funding for collaborative research such as OCE and CARIC
- Export programs.

Finally, it was noted that there has been a lot of financial support in Canada for skills development and training, including the recently announced Superclusters Initiative which is an industry-led program.

Academic Sector / Education

The investments in skills development and training have resulted in a variety of initiatives and new developments. Participants mentioned support in colleges and universities for emerging technologies such as 3D printing and robotics/automation. It was noted that the University of Toronto, University of Alberta, and University of Montreal are leaders in AI and graduates from these institutions are highly sought after. A joint program between Germany's Fraunhofer Institute and the University of Western Ontario on composite manufacturing was also mentioned, as were initiatives in colleges like Sheridan College, the Red River College Skilled Trades and Technology Centre, and the Red River College Materials Institute to incorporate additive and advanced manufacturing into their curriculum. Efforts to try to stimulate interest in industry and students include youth Internship programs to hire post graduate employees, co-op programs, and other initiatives such as one focused on teaching school children to code. It was noted that schools are producing good, technically skilled candidates.

Industry Networks

A number of different industry networks and collaborations were mentioned in the workshops, some also involving government and/or academia, including the following:

- Provincial industry consortia
- Toronto Global, an amalgamation of Toronto area jobs, interfaced with multinational and local market opportunities targeted to new and established businesses alike
- Canada Makes, a network of academic, public, and private organizations focused on advanced and additive manufacturing
- Organizations like Communitech that facilitate partnerships within the tech industry
- Superclusters across Canada
- The Canadian Urban Transit Research & Innovation Consortium (CUTRIC)
- The Consortium for Aerospace Research and Innovation in Canada (CARIC)
- CANARIE and Canada's National Research and Education Network

Broader Canadian Context

Aspects of the broader Canadian context that support or drive progress toward the envisioned future can be seen at multiple levels. Canada is perceived as a strong country to partner with; we are politically stable, and our focus on open borders and new trade agreements can support more opportunities and cross investments to reverse the trend of opening manufacturing facilities abroad instead of in Canada. We have significant access to talent and expertise, both through our educational system and immigration policies. The decision to declare Internet an essential service will help spread connectivity across the country. And finally, there are signs of growth in the manufacturing sector and some work coming back into Canada from overseas, particularly for complex parts and assemblies.

3.2 GAPS AND CHALLENGES

Overview

Although what is currently underway is presented separately from the gaps and challenges, both were often voiced in the same breath: "we have this, but we need/we lack that...". The gaps and challenges identified can be clustered into seven major themes, as noted below.

Groups varied somewhat in the gaps or challenges on which they focused, although in some cases it may simply be a matter of framing similar or related issues differently.

Government Policy and Regulations

Participants commented on different aspects of government policy and regulations, which they felt are either not adapted to the new vision of manufacturing or impede movement in that direction. At the broadest level, they mentioned CPP deductions and carbon pricing as barriers to profitability. Barriers to free trade within Canada were also mentioned, as was a lack of tax incentives for advanced manufacturing or for greener technologies and manufacturing processes. The challenge mentioned most often was related to regulations: their complexity, in some cases rigidity, and the difficulty inherent in working through the federal, provincial, and municipal layers of regulation. Environmental regulations were specifically mentioned. It was suggested that regulations must not only make it easier for manufacturers to adapt and change, but also that the regulations themselves must adapt more quickly to the changing context. Aerospace, drones, driverless trains, and equipment used in the production of nuclear energy were specifically named as being overly regulated. With regard to NRC policies, there were suggestions to revise the IP policy to make it easier to share and transfer IP; to re-examine the current system of certification; and to relook at how its services are priced to make them more accessible to small businesses. A gap in private-public partnerships (too few) was also mentioned. Interestingly, although immigration policy was mentioned as something that helped bring in skilled labour, it was also mentioned as a barrier.

Cost of Doing Business / Competitiveness

Government policies and regulations affect the industry's competitiveness and increase the cost of doing business, but this is only one aspect. Participants argued that Canada is not very competitive on the world stage, at least in part because Canadian companies are smaller and often our manufacturing plants are branch plants controlled by foreign head offices. In some locations, they stated that overhead costs, including wages, rent, and manufacturing equipment, are too high, resulting in

	IRAP	Kelowna	London	Montreal	Ottawa	Vaughan	Waterloo	Winnipeg
Government policy and regulations	●	●	●	●	●	●	●	
Education & training	●	●	●		●	●	●	●
Technology adoption and commercialization	●		●	●	●		●	●
Cost of doing business, competitiveness	●	●	●			●		●
Funding	●	●		●			●	●
Knowledge and communication	●	●		●	●			●
SME Support	●	●			●	●		●

manufacturing plants and offices being set up in other, larger volume markets either in the US or abroad. Canadian business culture was noted as a challenge, with a lack of aggressiveness and self-promotion and not enough risk-taking; we do not have a Team Canada approach to marketing ourselves, nor do we have a national marketing strategy that would help identify our key strengths, and capabilities, that will support our global marketing efforts.

Education and Training

Gaps and challenges identified in the area of education and training touched both on existing skill sets and on broader challenges in the education system. Curriculum gaps were identified in Canadian university engineering programs, including:

- Phased product development processes,
- Design control processes and management systems
- 3D printing
- Internet of Things (IoT)
- Collaborative robots and connectivity
- Effective and focused apprenticeship programs

Some explanations for these gaps focused on how curriculum is set in universities, while others mentioned insufficient connection between the research that is being done and the education system. Participants flagged a national and global trade gap, and insufficient enrollment in Canada in science, technology, engineering, and mathematics (STEM) fields at both the university and college levels. Participants also suggested that there is more education and training needed for leaders of Canadian manufacturing companies on the new manufacturing technology solutions that are available and how they can best be applied. They identified a gap in retraining programs for existing workers, for example supporting employees during sabbaticals to acquire new skills. The way education and training are delivered was also identified as a challenge, with insufficient hands-on, practical experience. Finally, some argued that there is a gap in public education about manufacturing and, more specifically, about the benefits of automation.

Technology Adoption and Commercialization

Participants identified a number of different gaps and challenges under the theme of technology adoption and commercialization, ranging from general process or capacity issues to specific technologies that may be under-developed. They noted that many of the owners of existing SMEs are older and less open to innovation and new technologies, and new start-ups need more support to transition to existing manufacturers and to commercialize their work. They stated that there are not enough spaces where industry can test out their ideas and work out practical details in preparation for implementation. The technologies that were mentioned as needing more resources and focus included the following:

- Software development and implementation, especially in areas of Canadian expertise such as mining, communications and engineering.
- Automation, robotics, machine-assisted assembly, machine learning, artificial intelligence (AI).
- Integration and interoperability of technologies;
- Adoption of digital technologies such as manufacturing resource planning, CADCAM and real-time inventory control.
- Big data.
- Addressing issues with additive manufacturing.

It was suggested that Canada lacks an overall roadmap for the future of manufacturing, something to guide efforts and investment and against which to measure our progress. Questions were also raised about our ability to adapt to the pace of technology change in a sustainable manner, whether in terms of moving students through the system more rapidly, repurposing obsolete equipment and technology, or upgrading software on physical equipment with a 20-30 year lifespan.

Funding

Several gaps and challenges were identified in the way Canada in general, and the NRC specifically, fund innovation and research and development of new technologies, and particularly funding for commercialization. Gaps mentioned included: getting from a higher TRL to commercialization; purchase of machinery; rental of industrial space for the first year of production; certification; and more direct funding. Participants also mentioned incentives to attend trade shows or conferences that would support partnerships and possibly spur consortiums, and subsidies for low volume injection molding for start-up hardware companies. Timing was mentioned as a challenge, either in terms of when manufacturers can apply or receive funds, or in terms of the amount of time it takes to be accepted. The complexity of the application process was noted as a challenge, particularly for SMEs. The lack of national strategy tying all the programs together and ensuring coordination and continuity of funding was identified as a gap. Other challenges related to funding included the lack of venture capital in Canada, the low risk tolerance in existing programs, and insufficient flexibility for R&D support.

Knowledge and Communication

This theme focused on gaps and challenges in acquiring and sharing information and knowledge about advanced manufacturing technologies and innovative practices. Participants stated that there is a gap in availability of useful, relevant, and forward-thinking information for manufacturers; this is partly caused by competitive pressures and companies trying to protect their business. There is a lack of safe forums for collaboration and information-sharing between manufacturing companies, and between these companies and the Canadian Do-It-Yourself community. One group noted the absence of a comprehensive process for small companies with new ideas to communicate their ideas to the NRC. Participants talked about the need for integration, for breaking down silos, and for clusters of supply chain players.

SME Support

The need for additional support for SMEs was a common thread through other conversations, and it was also named specifically. Particular SME challenges that were mentioned included limited access to specialised knowledge; the high cost of certain software; the lack of resources for developing new technology, and for writing and submitting applications to programs that might help; the lack of space to test applications and prototypes; and the prohibitive cost of patents.

4. THE ROLE OR CONTRIBUTION OF THE NRC

Having identified gaps in preparing for the future of manufacturing, participants were then invited to identify the role that they would like to see the NRC play, who else might be involved, what partnerships might be created, and what questions still need to be answered before we can make progress. Themes from each of these topics are provided in this section.

4.1 OVERVIEW OF KEY THEMES

The following table summarizes the themes that emerged in the discussions at each location. Checkmarks indicate that a theme was mentioned, whereas stars indicate those that were identified as the highest priorities. The question of top priorities was not included in the IRAP survey and was added to the workshop agenda after the first two workshops in London and Montreal.

In addition to the themes mentioned above, general recommendations were made that the NRC clarify its mandate, more clearly outline what it can do for industry, and improve the way it measures and communicates performance. Some participants argued that the NRC fee-for-service programs and revenue generation activities interfere with its role as a funding agency, and create potential for conflict of interest. Another topic in this vein was related to the way the NRC handles intellectual property (IP), with suggestions that this needs to be reviewed.

4.2 DETAILS OF EACH THEME

Building and Sharing Knowledge

This was a strong theme in all the workshops and in the IRAP survey. The industry looks to the NRC to gather information about new developments in Canada and abroad, and to share that knowledge effectively and efficiently with manufacturers. Specific suggestions under this theme included the following:

- Setting up and maintaining portals and databases of information such as trends, best practices, new technologies, new materials, cybersecurity, etc.
- Publishing foresight reports.
- Creating and disseminating short videos on key topics.
- Hosting in-person meetings, seminars, and conferences.
- Organizing and hosting webinars.
- Establishing and maintaining networks of contacts.
- Creating a 360-degree assessment tool which will look in more detail at the non-technical aspects of a manufacturing business.
- Translating academic knowledge into potential applications, particularly for mid-tier TRL.
- Developing and delivering training programs.

	IRAP	Kelowna	London	Montreal	Ottawa	Vaughan	Waterloo	Winnipeg
Building and sharing knowledge	●	*	●	●	*	●	*	●
Supporting Research & Development	●	*	●	●	●	●	●	*
De-Risking Technology	●	●	●	●	*	*	●	*
Intergovernmental advocacy and support	●	●	●	●	*		*	●
Facilitating and encouraging collaboration		●	●		*	*	●	*
Providing advice and expertise	●	●				●	*	●

Supporting Research and Development

When it comes to supporting research and development, the types of support that participants said they expected from the NRC include the following:

- Be the 'go-to' R&D partner for industry, by acting as the extension of organizations; for example, SMEs could use the NRC as their R&D arm.
- Focus research efforts in areas identified by industry, including collaborative research that is pre-competitive, applied research, and fundamental research with a capacity for technology development that has industry identified projects.
- Conduct and support research on specific technologies, acting as first adopter, and offering an opinion as to the Technology Readiness Level (TRL) and Manufacturing Readiness Level (MRL), to save time for Canadian companies in continuing to research equipment; specific areas of research that were mentioned included:
  - Joining technology/processes that can fast join dissimilar materials; examples include, arc welding, resistance welding, solid state welding, ultrasonic welding, adhesive bonding, and mechanical fastening.
  - Fast combination additive/subtractive manufacturing for engineering materials (outside prototype or "home-made" plastic AM).
  - New coatings for corrosion and wear resistance whose application is environmentally friendly.
  - Textile joining methods that could replace sewing, gluing, and welding especially for "smart" textiles.
  - RFID tags to help with the availability of RFID tags suitable for the wood industry.
  - Security software tools and solutions.

Funding support was also mentioned, and the comments mirrored those identified in the gaps/challenges portion of the discussion.

De-Risking Technology

While de-risking technology could be considered a form of applied research, it was mentioned specifically as a separate role that the consultation participants would like to see NRC take on. The suggestions made most often included:

- Provide access to technology or services that are not accessible elsewhere, including:
  - Spaces where various digital technologies are tested and evaluated by the NRC as a neutral third party. What is ultimately needed is an environment for technology being developed, tailored in such a way that when the technology is introduced to a factory floor it is ready to go, not something that needs to be modified.
  - A subsidized prototyping/low volume manufacturing facility that provides start-ups access to first articles.
  - A central repository of loaner demo models for technologies like 3D scanners and 3D printing.
  - Large footprint buildings out of which multiple small manufacturers can operate.
  - Incubators with industrial-scale equipment to prototype and build things for certain types of equipment.
  - Demonstration sites for smaller players wanting to showcase their equipment and technology.
  - Host the creation of a supercluster of the resources available, meaning education, testing, industry resources, into one large package to avoid duplication and allow groups to focus on their key area of expertise and increase the leverage of funding available.
- Create and publish end-to-end guides to design, manufacturing, qualification, and service.
- Simulation: support process modeling platforms for manufacturing problems. This could be achieved through:
  - System analysis
  - Stress modelling
  - Process and automation simulation
  - N-defector design
  - Self-diagnostic inspection methods
  - Process integration
  - Post-processing algorithms
  - Prediction technologies
- For low Technology Readiness Levels (TRL), demonstrate the potential of emerging technologies, and for medium TRL, share the performance of existing technology and disclose existing incubators, and be relevant for industry in all stages of technology maturation and adoption.

Intergovernmental Advocacy and Support

Participants mentioned a number of roles or activities that had to do with connecting industry to other government agencies and departments, and influencing them to better coordinate policies and programs and adapt them to industry needs. They mentioned the following:

- Lobbying the federal government to stabilize government policies and reduce government regulations that stifle manufacturers; acting as a liaison between industry and government regulators to remove obstacles and delays that currently exist.
- Working with other federal government departments to ensure manufacturers can connect with other government departments and crown corporations like ISED and Via Rail.
- Working with educational institutions, in conjunction with industry, to help influence education priorities, update curriculums, and make programs in educational institutions more relevant to industry.
- Producing better understanding of existing technology risks and use that to influence regulation and make regulations less rigid (e.g., regulations are the limiting factor to innovation in the nuclear industry).
- Playing a role in creating a Canadian industrial culture which attracts and retains tech talent.
- Acting as the liaison between companies and federal funding sources. For example, industry groups can depend on the NRC by contacting it to reach funding from other government programs.

Facilitating and Encouraging Collaboration

Consultation participants felt that the NRC is well positioned to convene stakeholders and create spaces where collaboration can thrive. They mentioned collaboration between educational institutions and industry in particular. They also talked about the NRC taking on the role of information broker to facilitate the sharing of information between companies that are otherwise in competition; this would likely involve sharing concepts but not specific technologies. A specific collaboration that was mentioned a number of times was the development of an industry roadmap that will move industry towards the future. Other strategies mentioned by participants included aligning the needs of various players and tying them into a project or program; developing collaborative technology networks; and acting as liaison between companies to develop partnerships.

Providing Advice and Expertise

A final role identified for the NRC by participants was that of an expert advisor, providing guidance and expertise. There is a link between this role and the support for research and development, but this section has a broader focus than research. Participants indicated that they would value expert advice from the NRC in:

- CNC programming, to outsource programming services cost effectively to manufacturers across Canada to advance their manufacturing machines and environments on an ongoing basis.
- Robotic automation and configuration, to assist manufacturers in designing small robotic cells, assist with robot system selection, and assist with robotic programming services. In addition, provide services to custom design machine-assisted processes.
- Operational excellence and lean manufacturing.
- Developing effective metrics management processes which will ensure that they focus on the correct activities and are able to course-correct swiftly and effectively.
- Developing effective and flexible supply chain strategies and processes; many companies are tied to Asian suppliers and sacrifice working capital and total product cycle time for the elusive advantage of high volume component supplies.
- The benefits of RFID for manufacturers and their customers.
- Creating a company roadmap to get their concepts moved along into a working model.
- Helping companies figure out what it means to do their business.

One suggestion was for the NRC to provide advisors to fill gaps in expertise and resources on an as-needed basis, such as the "Ask an Expert" service offered by Small Business BC in British Columbia.

There was also a request for the NRC to enable onsite visits by NRC scientists: The current NRC structure is not supportive of scientist going onsite because it is too costly, yet enabling these meetings would provide avenues for NRC scientists to interact with other scientists and industry partners.

5. MOVING FORWARD TOGETHER

Conversations about moving forward focused on identifying potential partnerships, other stakeholders to involve, and questions that have yet to be answered.

5.1 OPPORTUNITIES FOR PARTNERSHIPS

Opportunities for partnerships were identified at different levels: some groups provided very general answers about types of partnerships that would be helpful, while others described specific partnership opportunities. The ideas put forward are listed below.

- Find a better way of partnering companies with university researchers, with a simpler process than the one currently in place with MITACS.
- The insertion of personnel from engineering and technology providers on a contract-basis into relevant NRC groups and departments, to help them become more advanced and rapidly expose NRC scientists to new methods, and act as “SWAT” teams to industry participants needing innovation-triage.
- NRC could partner and pay for multiple private entities to realize a subsidized prototyping/low volume manufacturing facility that provides start-ups access to first articles.
- Connecting software suppliers with manufactures to implement current technologies and realize new innovative ideas to support both sectors.
- Partnership between the NRC and industry associations to communicate their programs and to hear from industry the challenges being faced.
- Partnerships with private industry who are willing to close gaps and perhaps be mentors to those who still have a long way to go.
- A potential opportunity for partnerships would be between NRC and certain Canadian manufacturing companies that are deemed to be high potential adopters of new manufacturing technologies. This would accelerate advancement in Canadian manufacturing capabilities.
- Enable movement between industry and NRC, which will allow people to move and learn by going back and forth. More porous boundaries can transfer the understanding of needs across sectors. Professors who have spent time in industry are more likely to partner because they have a better knowledge, better insight into how to drive work more efficiently.
- Explore strengths of different national models. Interesting models to explore include:
  - Sheffield, a model which allows the sharing of ideas and deployment of technology.
  - The French model: in France, the relationship between universities and the CNRS is easy, they have put in place mechanisms to make it work well.
  - The US model used at DMDII, where different groups work together and still have access to results. There the key is sharing, again an issue that is related to IP.
  - European centers are good at developing consortiums, for example the Fraunhofer in Germany.
- Investing time, effort and money into public-private partnerships, deliberate collaboration between government, academia, and industry on a national and international level.
- Making connections at all levels, including plant managers: efforts must continue to provide opportunities to network and learn, although it is a challenge to reach the plant managers and get them out of their plants.
- Trade shows outside Canada bring in huge amounts of knowledge and networking opportunities. A local cluster could attend international conferences or trade shows (e.g., the Paris Air Show) for the benefit of the greater Canadian manufacturing industry, to see what is going on globally, get access to the content and then share what was learned in a session in Canada.
- A partnership between the NRC and the Federation of Canadian Municipalities, they have strong connections with federal, provincial, territorial, and municipal associations.
- Developing more technology parks, like the St-Laurent campus being developed by Technoparc Montreal.
- An Innovation, Science and Economic Development Canada (ISED) super-cluster on advanced manufacturing.
- Strategic use of / capitalization on the Industrial and Technology Benefits Policy (ITB).
- A model like the Robot Industry Association model in the US which brings people together via the internet and social media. They have an “Ask an Expert” service and an educational webinar series.
- Partner and work with other countries to develop strategies for Industry 4.0.
- Bring multinationals and SMEs together to collaborate on solving specific industry related problems.

5.2 WHO ELSE NEEDS TO BE INVOLVED? AND HOW?

Participants identified additional stakeholders in five broad categories: banking and finance, industry, foreign organizations like the NRC, government, and education/academia:

Banking and Finance

- The Business Development Bank of Canada
- Banking and finance
- Export Development Canada
- Crowd-sourcing
- Investors – for seed funding in particular, including start-up accelerators like Starburst
- The venture capital community because they need to be aware of the opportunities available

Industry and Industry Associations

- Former business leaders
- Industry and trade associations – both broad-based and industry-specific
- Professional associations, for example societies of manufacturing engineers
- Chambers of Commerce
- Superclusters
- More start-ups and entrepreneurs
- Private engineering firms
- Large, multinational OEMs (look at their long-term targets and strategies, rules, restrictions)

Foreign Organizations Similar to the NRC

- For example, the National Institute for Standards and Technology (US);

Government

- Provincial governments and their agencies
- Technical institutes and regional colleges
- Regional districts, municipalities, governments, native agencies
- Global partners – for information, including: all developed and developing countries – focus on global leaders and emerging leaders; Canada-Europe Trade Agreement; the TPP, EPA
- ISED
  - Export Development Canada
  - Global Affairs Canada

Public Works and Government Services Canada

- The Department of National Defence, Customs, Borders
- Canada Revenue Agency
- Funding agencies like MITECs, NSERC, etc.

Education / Academia

- The Learning Factory
- Universities and colleges
- School boards
- Business schools and community colleges to expose students to the future of manufacturing
- Industrial campuses to leverage partnerships into other industries
- Youth

5.3 WHAT QUESTIONS DO WE NEED TO ANSWER TO MOVE FORWARD?

The following questions were raised by participants as requiring answers to move forward:

Canada's Vision for Manufacturing

- Vision for manufacturing similar to the US, and we could benefit from evolving a vision for manufacturing in Canada. We must ask ourselves, what is our future desired state?
- What sectors are we all focusing on in Canada to move forward?
- Made in Canada is a good brand at the moment, how do we keep it up there? What investments can we do to keep this brand, like the Swiss and French have done for their respective industry strengths?
- Maybe a "Canadian Manufacturing Certification" – some kind of label of excellence?
- Something like what oil producers are doing – "this is good"
- How do we, as a country, figure out how we can be competitive?
- How can we develop the industry policy for advanced manufacturing that speaks to jobs for Canadians?
- What is the market and where is it going?
- What are the policy changes required to support the technology roadmap for advanced manufacturing?
- What products are we going to manufacture in Canada?
- What are our strategic priorities in Canada? Productivity for example.
- Does the government understand the critical importance of the country having some leading-edge companies that are important to a number of important clusters?
- Canada is more than capable of building (especially since we do all of the prototyping) so why can't IRAP get the collaboration and funding to create jobs here and bring back outsourced manufacturing?
- Who takes the lead? Manufacturing is the backbone of the country and we need a country-wide, all-sector conversation on what we are trying to achieve. Who is going to make this happen? NRC can play a significant role, but it also takes political will. E.g. Canadian Institute of Advanced Manufacturing Act.
- Should Canada invest in hosting "Smart Factory Conferences" similar to those hosted by other jurisdictions?
- Because manufacturing does not have the reputation it deserves, how can we sell ourselves better?
- What underlies our fall in the international rankings? Are others doing better, or are we declining? What are the success stories in international markets?
- What is the future state of our GDP dependency on natural resources?

Funding

- What will be done about the lack of funding?
- How is NRC funding helping Canadian manufacturing companies sustainably adopt world-class innovation to increase their competitiveness?
- Where is the scorecard that tracks this and the associated timeline?
- How do NRC-peer organizations in Japan, South Korea and Germany keep track of this?
- How does NRC compare to these organizations and their track record?
- How do we better fund commercialization?
- Participants said there is currently a lot of paperwork, which is very time consuming for little return. Industry wants to see a smart application process because they are tired of losing funding for arbitrary reasons.
- How much provincial funding can be made available for not-for-profit organizations that rely on government funding? The biggest challenge is getting longer term funding agreements that are non-political.

Implementing New Technologies

- Obviously, there is a lot of technology in manufacturing sectors like mining but what else do we have to offer?
- How can the risks of implementing new techniques be decreased and the benefits increased?
- How can the timing be reduced from opportunity identification to final implementation?
- Why can't we get better in outsourced areas of manufacturing to create jobs and give us products to build to help us increase our technology?
- What type of training to do we need in each sector for manufacturing i.e. what is the auto industry lacking etc.?
- How can we access some of these partnerships with the Learning Factory?
- How do we stay ahead of / keep up with technology obsolescence?
- What are all the areas of expertise that we could draw on or participate in?
- How can we benefit from all the research that is going on, how do we access it?
- What are we doing in terms of talent development within advanced manufacturing? Part of the challenge of colleges and universities is the slow process of program approval for new programs or changing the curriculum.

Role of the NRC

- How can the NRC help companies that are non-established corporations with revenue streams move forward with getting a new product that has been proven to be good technology to market when financial support is the issue?
- Who is the customer? The manufacturer? The technology providers?
- Who is the customer's customer? (e.g. multinationals)
- What do you want to do with this facility?
- What is the priority? (demonstration of latest technology, research, development)

› Who is willing to support with equipment, etc.?

› Who does NRC report to? And how does that inform their decision-making? In response to this question, it was clarified that the NRC has a dual reporting relationship to two ministers, the Minister of Innovation, Science and Economic Development, and the Minister of Science.

› How can IRAP make itself more accessible?

› In terms of the NRC facility being built in Winnipeg:

- There is a general expectation that funding will be allocated to support the facility once it is open but will there be capital put aside to fund projects, educate and share the technology?
- Will the companies outside the southern Manitoba perimeter be able to participate?
- There is an expectation from industry to provide funding for the new facility, what will the formula be?
- Since this facility is important, what can the individuals participating in this session do to press the province to support this project in a significant way?
- How is NRC planning on staffing the new facility with subject matter experts?
- Will we (industry) have the opportunity to review the building design to ensure it is built around the future programs?
- What does the NRC see the role of the province being?
- What will be the research bandwidth? University or college students? Where will researchers come from?

APPENDIX A · PARTICIPANT ORGANIZATIONS

IRAP SURVEY

Alberta

› Norseman Structures - Edmonton

British Columbia

› BioInteractive Technologies Inc. - Vancouver

› ExcelSense Technologies Corp. – Vancouver

Manitoba

› 3D Currax Solutions Inc. - Kelowna

› Solara Remote Data Delivery Inc. - Winnipeg

› Valley Acrylic Ltd. – Mission

Ontario

› AlphaKOR – Windsor

› Altair Canada – North York

› Burloak Technologies – Dundas

› Centerline limited – Windsor

› Crest Mold Inc. – Oldcastle

› Deep Trekker – Kitchener

› Gray Tools – Brampton

› Hibar Systems Ltd. - Richmond Hill

› Marlex Engineering – Ancaster

› Next Dimension Inc. - Windsor

› NIX Sensors - Hamilton

› Paytec/EMBP - Toronto

› Pollard Windows (Mike S. client) – Burlington

› Superior Radiant Products – Stoney Creek

› Tulmar - Hawkesbury

› Muskoka Cabinet Company – Ottawa

› Westbrook Floral – Grimsby

› Westlake Industries – Burlington

Québec

› UmanX – Québec

Saskatchewan

› Croatia Industries – Saskatoon

› Doepker Ind. – Saskatoon

› Eneray – Moose Jaw

› Lean Machine – Saskatoon

› Massload Technologies – Saskatoon

› Michel's Industries – St. George

IN-PERSON WORKSHOPS

151 Research Inc.

A

Accelerate the Journey
ABC Group
Access Precision Machining Ltd.
Additive Metal Manufacturing
AddUp/ Fives Michelin
Aéro Montréal
AeroPlus STM Services Inc.
AGS Automotive
Airport Technologies Inc.
Ajile Light Industries Inc.
AK Solutions
Angstrom Engineering
Anodyne Electronics Manufacturing Corp
Avcorp Industries

B

Bell Helicopter
Blaze King
Boeing Canada Winnipeg Division (BCW)
Bombardier Aéronautique
Bombardier Commercial Aircraft
BOS Innovations Inc.
Brave Control Solutions Inc.
Buhler Industries Inc.
Buhler Versatile Inc.

C

Campion
Canadian Manufacturers and Exporters (CME)
CARIC
Carl Zeiss Canada
Centre Technologique en Aérospatiale
City of Toronto, Economic Development and Culture
Claire Lasers Corporation
Composites Innovation Centre Manitoba Inc.
Concours Mold Inc.
CRIQ (Centre de recherche industrielle du Québec)
Custom Foam Systems
Customer Attraction

D

D&D Automation
Dajcor Aluminium Ltd
DataREalm Inc.
Drop
Dynaplas Ltd

E

Eclipse Automation
Economic Development Winnipeg
ElectroMotion Energy Corporation
Entelegis
Enviro-stewards
EnviroTrec

F

Fanuc Canada
Fenix Advanced Materials Inc.
Footage Tools Inc.
Fort Gary Fire Trucks

G

GE Aviation
GE Transportation
H
HERD North America Inc.
Héroux-Devtek
Hovey

I

Industrial Technology Centre
In-House Solutions
Innovation Science and Economic Development (ISED)
Institute for Diagnostic Imaging Research

J

Jayson Myers Public Affairs Inc.
JCA Electronics
JMP Engineering

K

Kamloops Precision Machining Ltd.
Kilmarnock Enterprise
KingFisher Welded Sportfishing Boats
KPMG

L

Letar
Linn Grove Ventures
Logicap Engineering Corp
Lynch Dynamics

M

MacDon Industries Ltd
MAEROSpace
Magellan Aerospace
Manitoba Aerospace
Motor Coach Industries (MCI)
MDA Corporation
MDA Robotics and Automation
MEMEX Inc.
Metalumen Manufacturing Inc.
MHI Canada Aerospace
Ministère de l'Économie, Science et Innovation (MESI)
Mitacs and Western Canadian Innovation Offices
Mohawk College – IDeaWORKS Main Office

N

New Flyer
Nicola Logworks
Nu-Tech Precision Metals Inc.

O

Octopuz
Ontario Aerospace Council
Ontario Ministry of Economic Development and Growth

P

Precision ADM
P&P Optica
Palliser
Passive Remediation Systems Ltd.
Performance Manufacturing
Pratt & Whitney Canada Corp.
Prolucid Technologies Inc.
Province of Manitoba

R

Radix Inc.
Red River College
Renishaw Canada
RidgeTech
Rockwell Automation

S

Safran Landing Systems Canada
Sandvik Mining
Siemens
Siemens Digital Factory
Sightline Innovation
Simulent Inc.
StandardAero
Structurlam Products
Systematix

T

Talius
TCA Technologies
TechBrew
Thalmic Labs
The Eastside Group of Companies
Transport Canada

U

Universal Packaging
University of British Columbia
University of Manitoba
USNR

V

Vari-Form
Vehicle Technology Centre (VTC)
Veriform Inc.
Vertex Precision

W

Wainbee
WestCaRD
Western Economic Diversification Canada
WESTEST

X

Xerox Research Centre of Canada


Intersol