



**THE STATE OF ADVANCED
MANUFACTURING IN NEWFOUNDLAND
AND LABRADOR: BARRIERS,
CONSTRAINTS AND OPPORTUNITIES**

September 2021

WHO WE ARE

ABOUT CANADIAN MANUFACTURERS & EXPORTERS

Since 1871, we have made a difference for Canada's manufacturing and exporting communities. Fighting for their future. Saving them money. Helping manufacturers grow.

The association directly represents more than 2,500 leading companies nationwide. More than 85 per cent of CME's members are small and medium-sized enterprises. As Canada's leading business network, CME, through various initiatives including the establishment of the Canadian Manufacturing Coalition, touches more than 100,000 companies from coast to coast, engaged in manufacturing, global business, and service-related industries.

CME's membership network accounts for an estimated 82 per cent of total manufacturing production and 90 per cent of Canada's exports.

ACKNOWLEDGEMENTS

This report was prepared by David Haire, Vice President, NL Division, Erwin Matusoc, Technology Champion, and Alan Arcand, Chief Economist at CME, and Bruce Gilbert, Principal at Bruce C. Gilbert Consulting.

This research was made possible through funding provided by NGen. NGen is the industry-led non-profit organization leading Canada's Advanced Manufacturing Supercluster (i.e., one of five national networks supported by Canada's ambitious Innovation Superclusters Initiative). NGen is founded on the principle that digital transformation in advanced manufacturing will enrich the lives of Canadians, delivering better products and good jobs while generating the economic growth essential to a better future.

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EXECUTIVE SUMMARY

In spring 2021 CME-NL worked closely with NGen (Next Generation Supercluster) to develop an applied research initiative that aimed to illuminate new ways for CME-NL and others to further improve the NL manufacturing and processing sector with emphasis on advanced manufacturing (AM) adoption. The study aimed to contribute to the growing body of knowledge emerging from across Canada related to best ways to help accelerate the growth of AM. Specifically, the project sought to improve understanding of the barriers and constraints to AM (hindering factors) and AM accelerants (helping factors) facing or available to NL manufacturers and processors. It also sought to illuminate new and different ways in which NL manufacturers and processors could be better supported to adopt AM, to lay the groundwork for the development of an NL AM cluster, and ultimately to help to educate and inform decisionmakers and other stakeholders as to the overall importance of AM to the success of NL's manufacturing sector and provincial economy. The hypotheses underpinning the project were: some of the factors that impact AM adoption in NL are to some degree different from those relevant to other jurisdictions; and practical actions can be taken to support companies interested in AM in NL and thus improve the overall NL rate of AM adoption. The project used qualitative research approaches and methods. Open-ended interviews allowed a variety of interrelated questions to be asked in a flexible, semi-structured, and conversational manner. Twenty-eight individuals associated with 28 manufacturers and processors of various types and sizes and with varying degrees of AM experience were interviewed.

What Interviewees Said

Eight interrelated themes emerged from the interviews:

- 1) For successful adoption, the identification of a clear need, purpose, or goal for the AM is essential
- 2) Costs associated with AM, concerns about overall affordability, and anticipated difficulties related to finding investors/borrowing money can dampen appetite for adopting AM
- 3) Knowledge and awareness of AM is a prerequisite for successful adoption
- 4) The 'right type' of workers/employees are needed for successful AM adoption
- 5) NL's geography/weather are important considerations for those interested in AM
- 6) Certain cultural/social characteristics of the NL population may negatively and/or positively impact NL's adoption of AM
- 7) Support and properly resourced support-agencies are essential for the successful adoption of AM in NL
- 8) Collaboration/networking are essential for the successful adoption of AM in NL.

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Several general conclusions were also drawn from the 28 interviews: AM barriers, constraints and accelerants exist in NL; hindering factors can ‘stack up’ and result in a negative confluence of factors in NL; there is no shortage of possible interventions that can be taken to try and stimulate or advance AM in NL, but commitment and resources are required; there is still a lot we do not know regarding why companies choose to adopt or not adopt AM suggesting that more investigation is required.

List of Recommendations and Next Steps

Improving NL’s AM adoption rate starts with manufacturers. The ultimate responsibility for keeping pace with technology and forging a path to success lies with them. CME-NL is there to lead and partner with the province’s manufacturers to enhance their competitiveness by building their knowledge and helping them work on their business, including by helping them identify and deploy ideal technology solutions. But governments and policymakers also have an important role to play in encouraging faster AM technology adoption. It is especially incumbent on them to implement effective policies that create a supportive investment environment and allow manufacturers to grow and achieve scale.

Against this backdrop, CME-NL proposes the following recommendations and next steps to further increase understanding of AM in NL and to help manufacturers overcome the common barriers of advanced technology adoption:

1. Develop AM education and awareness programs and technology testing opportunities

This project revealed that education about and awareness-building related to AM and its potential for NL is sorely needed. Awareness about AM could be raised through technology demonstration tours and site visits that showcase cutting-edge technology to NL manufacturers. Similarly, the creation of testing hubs, placed at strategic locations across the province, could be another way to raise awareness about AM.

2. Develop an online technology adoption roadmap

There are other ways in which governments could work with industry partners to help manufacturers accelerate the adoption of AM technologies. One effective strategy would involve the development of an online technology adoption roadmap.

3. Promote networking and collaboration across the sector

All those interviewed as part of this project noted that better communication, cooperation and collaboration could help to support the adoption of AM within NL. Governments, along with other key stakeholders, have a role to play in encouraging greater collaboration.

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4. Provide mentoring and direct support for adopters

The need for trained and experienced people who can guide, coach and/or mentor potential new AM adopters as they begin their respective AM journeys was regularly raised within and across the interviews. While some organizations currently undertake such work, more could and should be done to support mentoring activities although new resources will be required.

5. Encourage AM adoption by matching the Atlantic Investment Tax Credit

The high cost associated with advanced technology was also identified as a key barrier to its adoption, particularly for small businesses that are often cash flow constrained. The simplest way for governments to stimulate business investment in new technologies is through the tax system. To encourage more capital investment, the NL government should consider matching the federal government's 10 per cent Atlantic Investment Tax Credit, thus creating a shared 20 per cent tax credit.

6. Ensure education and training programs are a good match for the skills that manufacturers need and will need in the future

Interviewees made it clear that NL's acute labour and skilled worker shortage is a major barrier to technology adoption in the manufacturing sector. Without access to a skilled, innovative workforce, the economic case for investing in technology adoption evaporates. Therefore, governments should work with industry and post-secondary institutions to ensure that education and training programs are a good match for the skills that manufacturers currently need and will need in the future.

7. Increase investments in trade-related infrastructure

NL's unique geography has the effect of increasing shipping costs, identified as another key barrier to advanced technology adoption. This indicates that governments should invest more in infrastructure that facilitates trade and lowers shipping costs.

8. Support additional research related to AM in NL

Finally, the need for additional research related to AM in NL has been illuminated by this effort. This project itself was limited in scope and scale – as such more needs to be known about why some manufacturers opt to move forward with AM while others do not, how urban and rural contexts affect the adoption of AM, and which types of companies are in most need of mentoring and support.

INTRODUCTION

For over 34 years, the Newfoundland and Labrador (NL) division of Canadian Manufacturers & Exporters (CME-NL) has provided important programs and services to manufacturers and processors in NL to help them to achieve their unique and shared corporate goals. Through these support efforts, CME-NL has helped NL manufacturers and processors to improve their bottom lines. It has also positively contributed to the economic performance of this province.

In keeping with this proven leadership track record, in spring 2021 CME-NL worked closely with NGen (Next Generation Supercluster) to conceptualize and develop an applied research initiative that broadly aimed to illuminate new ways for CME-NL and others to further improve the NL manufacturing and processing sector with emphasis on advanced manufacturing (AM) adoption. It also aimed to contribute to the growing body of knowledge emerging from across Canada related to and about best ways to help accelerate the growth of AM overall. With the support of NGen, CME-NL developed and implemented a focused and modest qualitative research project that specifically sought to:

1. Improve understanding of the barriers and constraints (hindering factors) and potential accelerants (helping factors) facing/available to NL manufacturers and processors when it comes to the successful adoption of AM
2. Illuminate new and different ways in which NL manufacturers and processors could be better supported to increase adoption of AM
3. Lay the groundwork for the potential development of an NL AM cluster and
4. Help to educate and inform decisionmakers, policymakers, the media, and the general public as to the overall importance of advanced manufacturing to the future success of NL's manufacturing sector and overall economy

This project was considered relevant because anecdotal evidence emerging from within and across NL has raised the prospect that barriers/constraints to the adoption of AM in NL (hindering factors), and those factors or preconditions that may help to make AM adoption possible here, may not be the same as those identified by other national and regional initiatives/studies¹ exploring factors that help or hinder AM adoption

¹ Some examples of other initiatives/studies are:

- [Advanced Manufacturing: The sector today & opportunities for tomorrow, Interim Report](#) (Canada's Economic Strategy Tables, 2017)
- [Industrie 2023: A National Strategy for Canadian Manufacturing in the Digital Age](#) (CME, 2016)
- [2020 Management Issues Survey & Economic Outlook \(Atlantic Canada\)](#) (CME, March 2021)

more broadly. Simply put, it was thought important to know if AM tends to unfold differently in NL and if so, how and why does it unfold this way - because CME-NL wants to ensure its future support interventions related to AM in NL remain and are focused, relevant, timely, appropriate, and robust.

The report is organized as follows. The first section outlines the project hypothesis, the study's utility and limitations, and interview methods. Section two defines advanced manufacturing, explains the importance of advanced technology adoption in the manufacturing sector, and conducts a data analysis to highlight the current state of advanced manufacturing in Canada and Atlantic Canada. The next section summarizes the results of the interviews and identifies common themes and findings. The fourth section provides an overview of the study's main findings, while section five outlines the action steps needed to build on the research of this study, and to increase the adoption of advanced technology in NL's manufacturing sector.

RESEARCH QUESTION AND METHODOLOGY

Hypotheses

The hypotheses underpinning this project are:

- Some of the helping and hindering factors that impact AM adoption in NL are to some degree different from those relevant to other jurisdictions; and
- Practical actions can be taken to support companies involved with/interested in AM in NL and improve the overall rate of AM adoption here.

With these hypotheses in mind, and notwithstanding that the Interview Guide (see Appendix B) contains numerous probing questions seeking to explore interviewee experiences, perceptions, and insights about AM adoption, this initiative's core research questions are:

- What factors help/have helped NL-based companies succeed with their AM efforts or hinder/have hindered them from succeeding?
- Is there anything unique about the NL reality/context that can explain how NL has/has not adopted AM?
- Who could/should do what to help to improve the rate of AM adoption in this province (and what could/should they do)?

Project Utility and Limitations

This study's results should be of interest to those attempting to advance AM and manufacturing more generally within and across NL including: manufacturers (i.e., owners; operators; leaders; innovators), CME-

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NL and other related industry associations, government decisionmakers and policymakers, and funding-agency representatives. People currently engaged in attempting to understand better the helping and hindering factors underpinning successful adoption of AM regardless of context or location may also find this research of interest.

While this report contains findings that should/may be of interest to others, the size, scale, limited geographic focus (NL), and modest budget supporting this research project ensures that it also has some limitations. These include that only a relatively small number of people were interviewed (28²), and that some responses of some interviewees were offered up only as ‘hunches’, ‘best guesses’, or opinions. As well, not everyone interviewed had the same understanding of the meaning of AM. Furthermore, the budget underpinning the project limited the amount of time that could be spent on pre-testing of the interview questions and on data analysis.

Moreover, making broad conclusions of relevance to others about a complex multi-factor topic (i.e., a chemistry of factors that may cause a company to adopt/not adopt AM) based on a limited number of relatively short conversations with a group of individuals from a single region is difficult no matter how compelling the findings appear to be. Clearly, broad and robust conclusions that could potentially be applied to other jurisdictions would likely require more rigorous scholarly investigation. Still, notwithstanding this reality, the insights emerging from this study are informative. They are certainly of use to those concerned with AM in the NL context, and they may also have some utility for those further afield.

Interview Methods

This project employed qualitative research approaches and methods. Open-ended interviews allowed a variety of interrelated questions to be asked in a flexible, semi-structured, and conversational manner. Twenty-eight individuals associated with 28 NL-based manufacturers and processors of various types and sizes - and with varying degrees of AM experience - were interviewed. Each interview lasted for approximately 60-75 minutes. An interview guide or protocol (see Appendix B) ensured that all interviewees were asked similar questions on common themes. Interviews were largely conducted so that general understanding of barriers/constraints (hindering factors) and positive accelerants/drivers (helping factors) to/of the adoption of AM in NL could be improved upon. Generally, the intent was to make a constructive contribution to the growing knowledge base about and related to AM in NL and to a lesser degree, Canada. It was hoped that findings would assist those agencies supporting or interested in growing AM within NL to become more

² According to Statistics Canada data, there were 370 manufacturing enterprises with employees in Newfoundland and Labrador in June 2021.

effective with their interventions. It was also understood that other research questions about AM worth pursuing would emerge from this project.

BACKGROUND ON ADVANCED MANUFACTURING

What is Advanced Manufacturing?

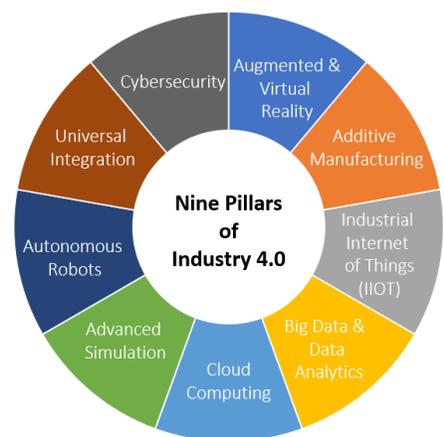
Advanced Manufacturing (AM) is defined as the adoption of fourth industrial revolution (Industry 4.0) technologies to existing processes, equipment, approaches that bring enhanced capabilities to manufacturing, product development, and supply chains. It is driven by the ever-increasing pressure to shorten time-to-market (TTM), increase flexibility, and achieve greater asset efficiency and higher levels of customer satisfaction.

The term **Industry 4.0** originates from the high-tech strategy of the German government, which sought to re-define the role of manufacturing following the global financial crisis (GFC). It suggests that we are on the cusp of the Fourth Industrial Revolution, a cyber physical age. It is an age in which materials and machines are interconnected through the internet of things (IoT), where all objects have network connectivity that allow them to send and receive data to each other.

Figure 1
The Nine Pillars of Industry 4.0

The Nine Pillars of Industry 4.0 are, Augmented & Virtual Reality, Additive Manufacturing Simulation, Industrial Internet of Things (IIoT), Big Data & Data Analytics, Cloud Computing, Advanced Simulation, Autonomous Robots, Universal Integration and Cybersecurity

Source: CME.



Nine AM Technology Pillars and their Benefits to Manufacturing

There are nine technology pillars of Industry 4.0³, as illustrated in Figure 1 and explained in more detail below.

1. Augmented & Virtual Reality (AR/VR)

Only a few short years ago, virtual reality technology was mainly used for flight simulators to train pilots. But today, remote repair instructions can be sent to literally any location on earth with internet access, helping technicians to enhance their skills by practicing high-end repairs and maintenance using AR/VR technology.

2. Additive Manufacturing

Additive manufacturing technologies like 3D printing are already playing an important role in enabling innovative solutions in manufacturing in the following three areas:

- Design: Design teams can experiment with creating more complex geometric shapes and structures due to the flexibility of 3D printing technology
- Prototyping: 3D printing is often used for prototyping, accelerating design cycles and reducing costs. Companies are free to fail fast in a controlled environment and explore multiple models before deciding on final designs
- Low-Volume Production: When only a small amount of a product is needed, 3D printing is the fastest and most economical production method

3. Industrial Internet of Things

The Internet of Things refers to the networking and connectivity of smart devices. When you think of the IoT, devices such as smartphones, wearables, tablets, and laptops are usually top of mind. However, the IoT also applies to any machine, equipment or device used in manufacturing that is internet capable. Through Industrial Internet of Things (IIoT) applications, manufacturers can automate manual tasks, gain real-time visibility of operations, and establish better command and control.

4. Big Data and Data Analytics

Data analysis, once only an Information Technology (IT) application, has penetrated the manufacturing and supply chain, and is being used to reduce downtime and waste.

³ Rüßmann et al., "Industry 4.0."

5. Cloud Computing

Cloud computing is the practice of using a network of remote computers hosted on the internet to store, manage, and process data rather than on a local server or computer. Cloud computing can help make manufacturing operations more productive, cost and energy-efficient, and streamlined.

6. Advanced Simulation

Simulation makes it possible to visualize and optimize operations using computer-based models. It helps engineers better visualize designs and identify problems and obstacles early on.

7. Autonomous Robots

Autonomous robots move raw materials and ready-made materials in a simpler, faster and smarter way. These robots are designed to work in ways like humans, with the added ability to monitor and transmit data.

8. Universal Integration (Vertical & Horizontal)

Horizontal integration ensures that machinery, IoT devices, and engineering processes work seamlessly together. Vertical integration ensures that production data are used at all organizational levels, including at the director and executive level when hiring, marketing, and other strategic decisions are made. In other words, through universal integration, manufacturers can quickly receive information from all levels of a business operation, including the extended supply chain, helping them to make better decisions about current operations and future initiatives.

9. Cybersecurity

As connectivity increases, the risk of a potential cyberattack grows alongside it. Any security breach could damage multiple areas of a business, from the supply chain to operations. Cybersecurity is a critical aspect of a company's technology infrastructure, implying that manufacturers must prepare and protect their information systems and production activities from growing cyber threats.

Why Adopting AM Is Important

Manufacturers around the world are facing substantial challenges due to ongoing environmental, social, economic, and technological changes. To meet these challenges, manufacturers of the future will need capabilities to manage their entire value chain in an agile and responsive manner. Companies will need virtual and physical structures that enable collaboration between machines, devices and people and continuous improvement during an entire product lifecycle from innovation to production and distribution. Firms across the globe are transitioning to AM through the adoption of Industry 4.0's nine technology pillars, transforming

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the world of manufacturing and helping them stay ahead of the competition in today's digitally connected world.

Clearly, countries that are world leaders in the adoption of advanced technologies are best prepared for the future of production, and this will give them a competitive edge over those that are lagging. This begs the question: what is Canada and the Atlantic region's track record on innovation and the adoption of new technologies?

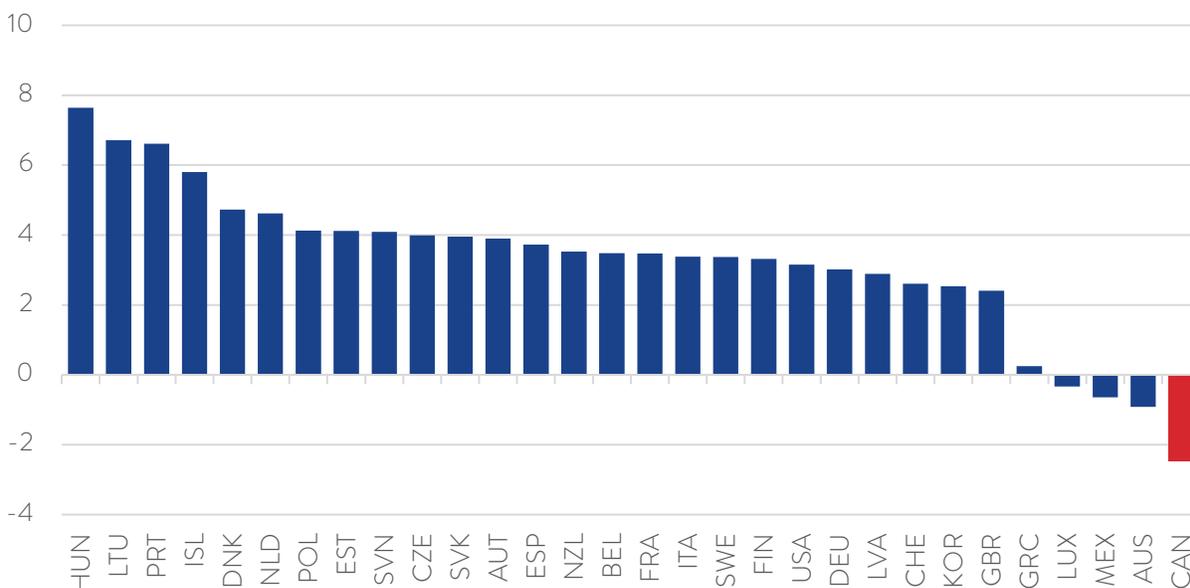
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Unfortunately, as detailed and documented by CME and other organizations including the Government of Canada, Canadian industry is a global laggard in technology adoption. This has hindered growth in the manufacturing sector and in the economy overall. Slow technology adoption has also resulted in sluggish labour productivity growth, the single most important determinant of a country's standard of living. Canada's poor technology adoption record directly limits our ability to compete for and win investment and jobs in the intensely competitive manufacturing sector.

Chart 1

Non-Residential Investment Among Selected OECD Countries

2015-19 (constant prices, national base year, compound annual growth rate, %)



Sources: OECD; CME.

Data from the OECD show that, in recent years, Canada has ranked at the bottom of advanced economies in terms of non-residential capital investment growth. From 2015 to 2019, Canadian non-residential gross fixed capital formation (GFCF) fell by an average of 2.5 per cent per year, the worst performance among 30

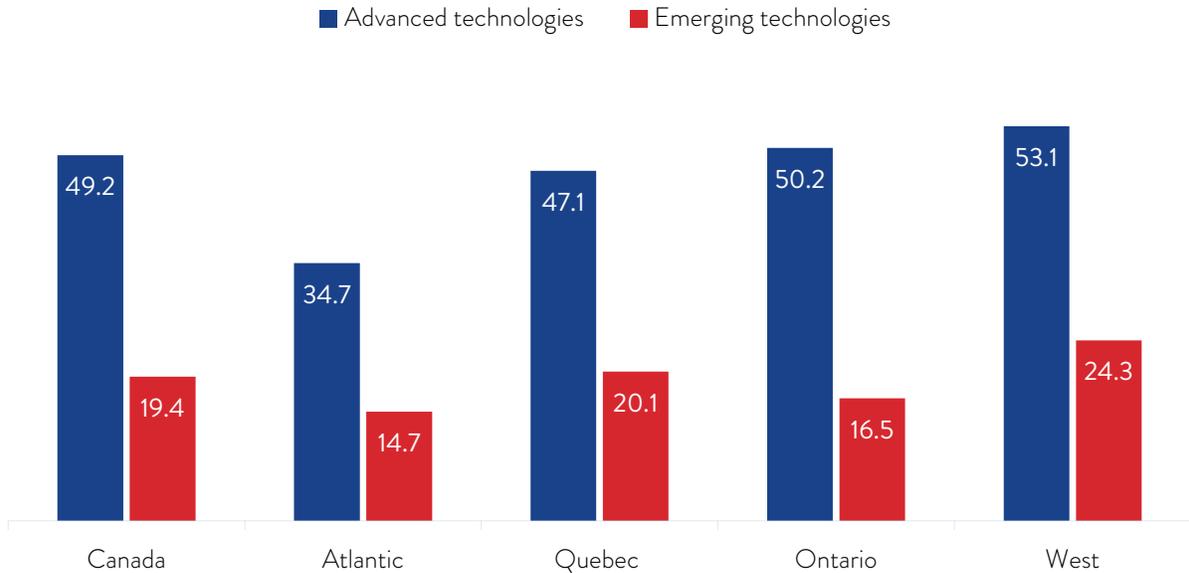
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OECD countries. (See Chart 1.) Over the same period, total non-residential investment in Newfoundland and Labrador declined at an even steeper 6.7 per cent average annual rate. While the oil and gas sector contributed the most to the declines in Canada and Newfoundland and Labrador, investment activity on the non-energy side, especially in manufacturing, was also disappointing.

Given Canadian businesses' reluctance to invest in their operations, it should not come as a surprise that advanced technology adoption in manufacturing is still more the exception than the rule. This is evident when reviewing the results of Statistics Canada's Survey of Innovation and Strategy. In this survey, Canadian companies are asked whether they use at least one type of advanced or emerging technology. Advanced technologies are defined as new technologies (equipment and software) that perform a new function or perform a function significantly better than the technologies commonly used in the industry or by competitors. The use of emerging technologies serves as an indicator of how innovative a business is.

In the 2019 survey, less than half (49.2 per cent) of Canadian manufacturers said they are using advanced technologies, while 19.4 per cent reported using emerging technologies. (See Chart 2.) For Atlantic Canada, the story is even more discouraging. Compared to their counterparts in Quebec, Ontario, and Western Canada, manufacturers in the Atlantic region have the lowest rates of advanced and emerging technology adoption. Specifically, 34.7 per cent and 14.7 per cent of Atlantic Canadian manufacturers said they are using advanced and manufacturing technologies, respectively, lower proportions than in all other regions of Canada.

Chart 2
Use of Advanced and Emerging Technologies in Manufacturing by Region
2019 (% of companies)

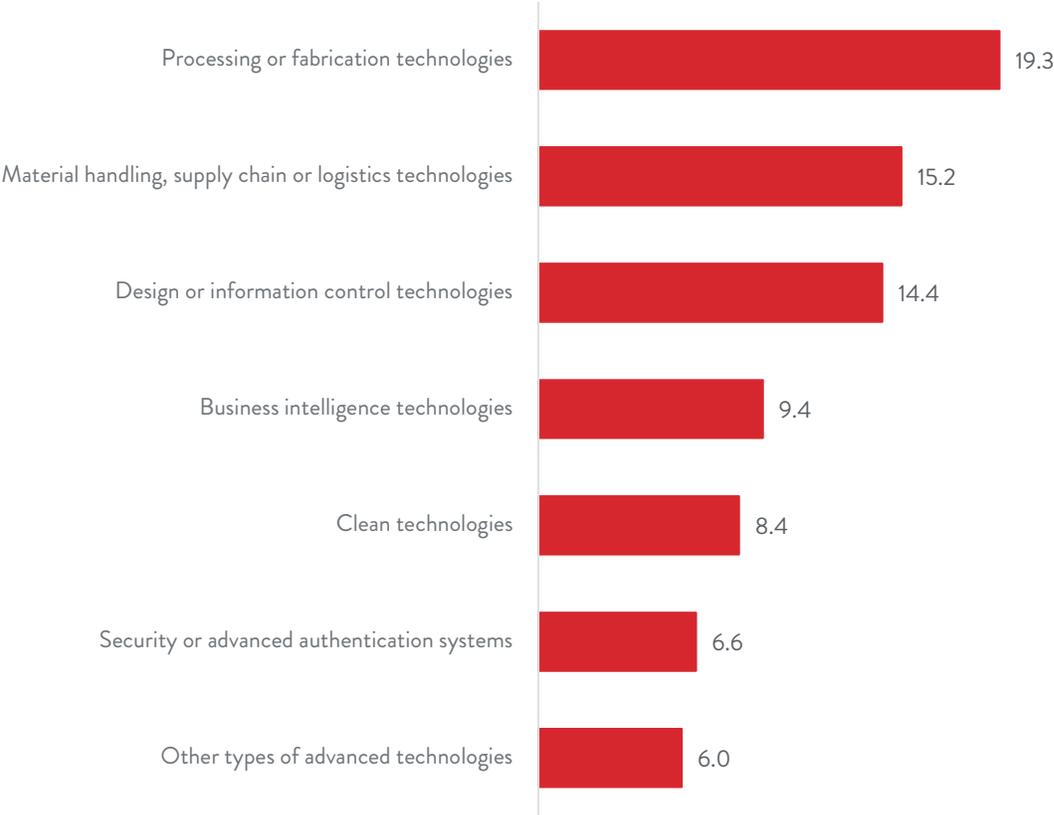


Source: Statistics Canada.

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The survey also asked participants whether they use specific types of advanced and emerging technologies. Among Atlantic Canadian manufacturers, processing or fabrication technologies was the most used advanced technology (19.3 per cent), followed by material handling, supply chain or logistics technologies (15.2 per cent), and design or information control technologies (14.4 per cent). (See Chart 3.) At the other end of the spectrum, security or advanced authentication systems were the least used (6.6 per cent).

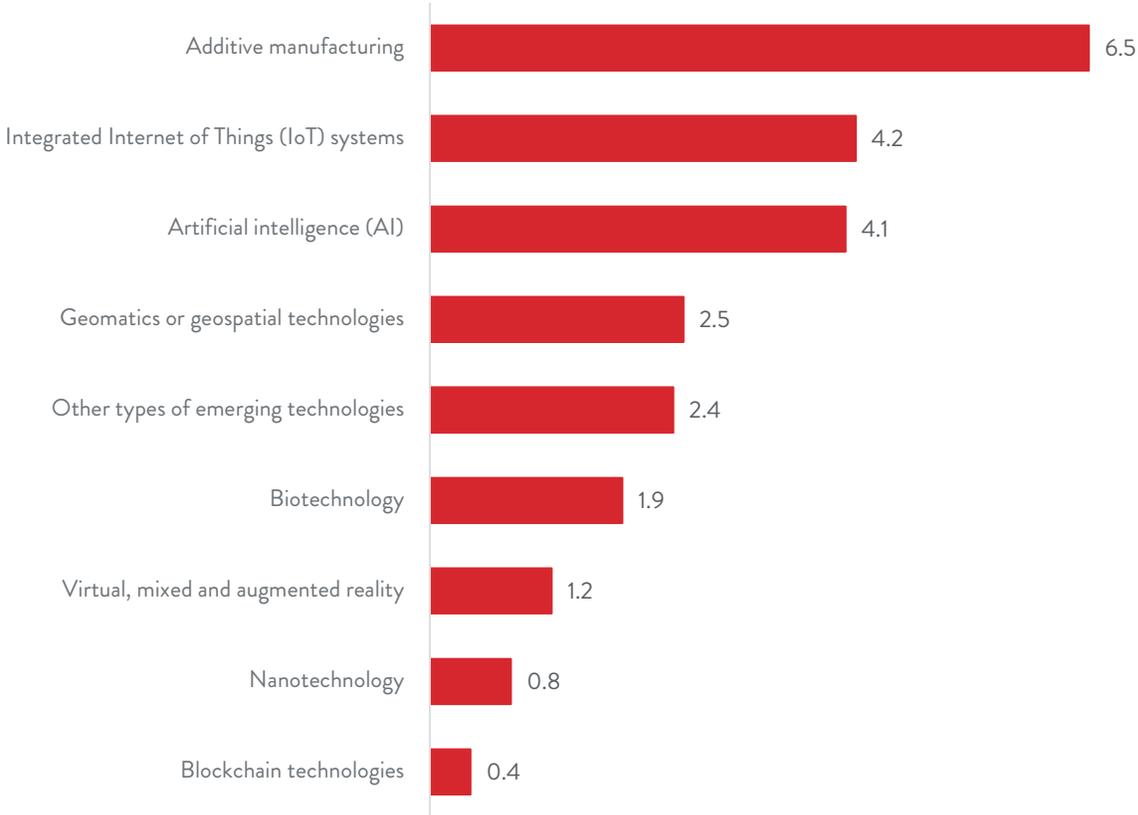
Chart 3
Use of Advanced Technologies in Manufacturing in Atlantic Canada
2019 (% of companies)



Source: Statistics Canada.

Uptake of emerging technologies was much lower, given that by their very nature such technology is more cutting edge. At 6.5 per cent, additive manufacturing was the most used emerging technology among manufacturers on the east coast. (See Chart 4.) This was followed by integrated Internet of Things (IoT) systems (4.2 per cent) and artificial intelligence (4.1 per cent). On the other hand, at 0.4 per cent, blockchain technologies was the least used emerging technology among Atlantic Canadian manufacturers.

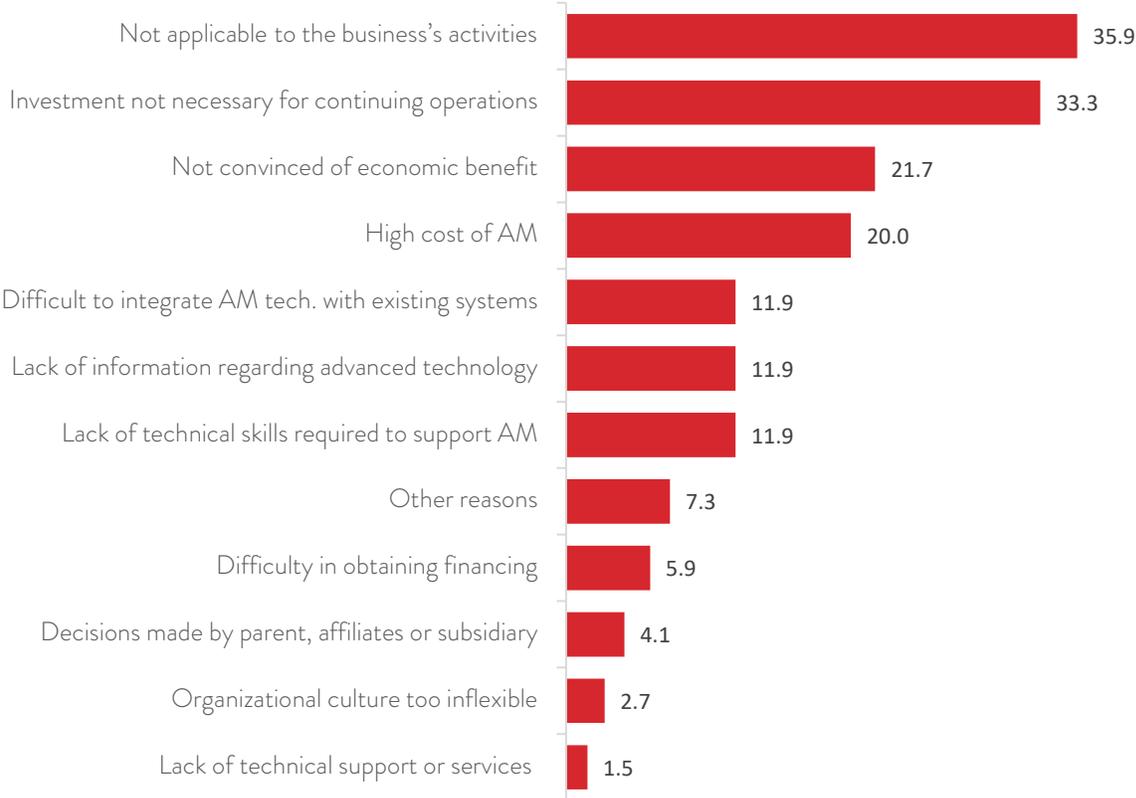
Chart 4
Use of Emerging Technologies in Manufacturing in Atlantic Canada
2019 (% of companies)



Source: Statistics Canada.

Finally, Statistics Canada’s survey asked respondents, including those in the Atlantic region, to list the reasons for not adopting or using advanced technologies. The number one reason, selected by 35.9 per cent of Atlantic Canadian manufacturers, was that using advanced technologies was not applicable to the business’s activities. (See Chart 5.) Other popular reasons included the fact that the investment was not necessary for continuing operations (33.3 per cent), that businesses were not convinced of the economic benefit (21.7 per cent), and that the cost was too high (20.0 per cent). As we shall see, the themes that emerge from our expert interviews line up well with the results of this survey question.

Chart 5
Reasons for Not Adopting or Using Advanced and Emerging Technologies in Manufacturing
2019 (Atlantic Canada, % of companies)



Source: Statistics Canada.

WHAT INTERVIEWEES SAID

The eight interrelated themes discussed below emerged from both direct and indirect questions about AM in NL. Respondents were asked directly to consider and discuss their AM experiences with emphasis on those factors that constrained or helped them. Generally, the factors reviewed and summarized by these eight themes are those that interviewees talked about the most. They are often those that many interviewees raised first, talked about the longest, talked about more than once in any given interview, and/or frequently described as having something important or critical to do with the adoption of AM technologies and processes in NL. Overall, many of the factors raised by interviewees regardless of theme were characterized as both helping factors (i.e., interviewees discussed that their presence helped or would normally help an AM adoption process), and hindering factors (i.e., interviewees discussed that their absence did or would likely hinder manufacturers with AM).

Theme #1 – Identification of a clear need, purpose, or goal for the AM is essential

Many respondents stated directly and/or implied that the ability to successfully adopt AM has something important to do with company clearly identifying a need (purpose or goal) for the AM. Other terms used to denote this idea of ‘clear need’ include relevant need; clear idea; clear purpose; clear goal; clear sense of value; clearly envisioned or anticipated benefit or impact; clearly understood problem to be addressed. Respondents also noted that attempting to adopt AM without such ‘need clarity’ is likely a recipe for failure. More simply stated, to these respondents, the presence of a clear need was considered an essential helping factor while the absence of such a clear need was viewed as something that would very likely lead to failure and/or a new problem or challenge for the company (i.e., a hindering factor). Various people also noted that sometimes key people within a company may require help to see or understand the need or potential value of the advanced technology.

Theme #2 – Costs associated with AM, concerns about overall affordability, and anticipated difficulties regarding finding investors/borrowing money can dampen appetite for adopting AM

Emerging from many of the interviews is the notion that the perceived/likely and sometimes onerous costs associated with AM can dampen appetite for adopting it. Sometimes small entities simply do not have the resources - or cash-flow room - to pay for the desired advanced technology. They may also be concerned about the likely related costs that may come along with the advanced technology (e.g., the potential need to hire new staff to operate/manage new technology and who may demand higher than normal wages). Some other companies potentially interested in making an investment in AM may believe they will have trouble

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attracting the investors or borrowing the funds they need to do so. In some other instances, even companies who can afford to proceed with the adoption of AM may also shy away from it because the company simply has other competing priorities that may also require capital investments. They may also be unconvinced that the investment required makes sense from an overall corporate cost-benefit analysis perspective. Moreover, they may be worried about losses which can arise if the AM technology adopted does not perform as expected, or if costs associated with technical-service delays and lost productivity begin to add up. Furthermore, in the view of these interviewees, concerns over cost payback period and/or return on investment (ROI) can deter companies from investing in it (i.e., if markets are volatile or evolving or if the market share of competitors is growing, estimates of payback time could be significantly flawed).

Finally, some interviewees noted how with AM comes added pressure and work for senior company employees tasked with overall company operations and management. When advanced technology is incorporated into a company, there is a cascading effect in which other internal management processes are also often affected (i.e., roles may need to evolve; job descriptions may need to be rewritten; new hiring processes may be required; additional training will likely be needed; company protocols and procedures related to occupational health and safety may need to be recrafted; aspects of signed agreements with unions may need to be renegotiated; facilities may need to be renovated; systems may need to be upgraded). Such additional - and often unanticipated - 'adjacent costs' could cause general disruption for the company. They could overload key staff who may become unhappy (and who may have options in a tight labour market). All this could affect production, quality, and profitability.

Theme #3 – Knowledge and awareness of AM is considered a prerequisite for successful adoption

Many interviewees described adequate knowledge and awareness of (also exposure to) AM as a type of necessary precondition (helping factor) for the successful adoption of AM. Spending scarce resources and considerable amounts of time/effort on an AM change process without such knowledge/awareness was considered risky if not a poor business decision overall. Although many interviewees directly or indirectly noted knowledge and awareness as very important, none considered them sufficient for AM success. In their view, more than knowledge and awareness is required for success, but without them, mistakes could and likely would be made. Many also stressed that funding agency representatives, politicians and government decision-makers could also benefit from enhanced knowledge/awareness of AM as could company owners and operators new to the AM area.

Further to this, numerous respondents opined that a likely reason why at least some companies have not and do not adopt AM in NL, is because they simply do not know what is currently available, and potentially beneficial to their operation. As such, in the eyes of these respondents at least, if more companies are to be

incented or encouraged to adopt AM technologies and processes in NL, more must be done to educate their corporate decision-makers and in-house employees responsible for technology and operations. At a minimum these not-yet-aware decision-makers and employees - and potential funders - should be exposed to what is possible and is 'out there'. They should be informed as to what supports are currently available to help them navigate the varied AM possibilities in front of them. Ideally, they should be encouraged to begin a self-directed AM learning journey that many successful AM adopters have undertaken.

Moreover, numerous interviewees had specific ideas about how knowledge and awareness of AM developments, options, and possibilities could be strengthened in NL. Many mentioned the value associated with attending AM-focused trade fairs and conferences. Others described how visiting companies with highly advanced AM operations - presumably at locations/sites not usually found in NL - could help to expose employees to what is possible for their company. Still others described how networking between and among like-minded - and in some cases, very different - companies could also help in this regard (see Collaboration and Networking below). In their view, learning from firms that are different from you can sometimes be as valuable as learning from those that are like you. Some interviewees also went out of their way to thank CME-NL for its efforts to deepen knowledge and create awareness of AM within and across NL, while still others stressed that the provincial government in NL should/could play a bigger role in this area by supporting manufacturers to access the knowledge and awareness they need to seriously consider AM adoption (see Government below).

Finally, it's important to note that at least some respondents highlighted the fact that there is really nothing preventing companies from acquiring the AM knowledge and awareness they need to move forward should they be motivated to do so. They note that with modern communication technology and the seemingly endless amount of AM information available via the Internet, self-directed learning is possible and easy. Several also stressed the need to have the right type of employees involved with one's operations if AM is to be realized: those that were curious, inquisitive, open to new ideas and approaches, and not overly risk averse (see Owners/Employees below) were considered the 'right type'.

Theme #4 – The 'right type' of workers/employees are needed for successful AM adoption

Almost all interviewees noted that the successful adoption of AM had something to do with having the right type of workers or employees in place or available to the company in question. Most often the ideal type of worker/employee was considered one that was open to and interested in technology generally, as well as someone familiar with the specific AM technology being considered. Additional characteristics noted as being important were those that were interested in learning; curious; skilled; having a continuous learning mindset; not risk averse; analytical; and collaborative. Several respondents noted how these qualities are not often

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found in older workers, although some other respondents disputed this idea. Many interviewees also acknowledged that employees who only had general awareness of technology, but who were open to learning more, could be suitable for an AM change process. They could presumably get up to speed quickly and learn on-the-job about any specific AM technologies to be adopted.

A majority of interviewees also noted how finding the right workers/employees for opportunities in NL is or can be a key challenge for any company interested in adopting AM. They described how qualified employees often cannot be found in NL, and how candidates from other jurisdictions are often not interested in relocating here (Note: especially if the company is based in rural NL). According to some, even if candidates are open to relocation, their wage demands are often beyond the scope of small NL companies to meet. Furthermore, in the view of several respondents at least, employee/worker retention is or can also be a problem in NL. Those not from here who do accept positions can easily be lured away by other NL companies. Some may simply decide to relocate to other jurisdictions if better opportunities are presented to them.

Moreover, several respondents described how moving forward with an AM change process can sometimes cause problems with existing workers/employees - and in the case of unionized firms, their unions - especially if those workers/employees fear they will lose their jobs or will be demoted in favour of newer and more skilled people. That some workers may be concerned about having to take on onerous new tasks/roles that are beyond their current capabilities was another potential hindering factor raised by several respondents. Given such potential AM-related outcomes, many of the respondents commenting on this specific issue stressed the need to ensure all employees/workers at a company considering AM be kept well informed about proposed AM developments. According to them, if employee/worker resistance and even sabotage are to be avoided, they will need to be meaningfully engaged in the AM change process and in a timely manner (see Knowledge and Awareness above).

Finally, a number of these interviewees further noted how employee/worker engagement is ultimately the responsibility of company leaders. As such, owners, decision makers, and managers need to be sensitive to worker/employee needs and pre-emptively involve them about possible or likely AM developments. These leaders need to be forthcoming, motivating, supportive, and understanding of concerns that may be raised. Ideally, leaders will be company innovators and visionaries who communicate well with employees/workers such that they too quickly 'buy-in' to any/all new company directions.

Theme #5 – NL's geography/weather are important considerations for those interested in AM

All interviewees responded to questions and follow-up probes exploring potentially unique physical, social, cultural, or historical features of NL that could impact AM adoption. Almost all noted how NL's physical geography and weather can be a problem. The fact that Newfoundland is a rugged and mostly rural rocky

island in the North Atlantic, and Labrador is a vast, remote, and expensive to access wilderness area on the edge of North America, were regularly noted. Both notions were cited in the context of requiring companies to incur increased costs. These geographies ensure that it is more expensive to get raw materials needed for manufacturing here as compared to other places. It's also more expensive to ship things to market from here as compared to those areas closer to main transportation hubs. Weather delays were also regularly cited by respondents. Simply put, time is money and with constant delays due to weather events, companies can find themselves in very difficult situations.

According to those interviewed, servicing and maintenance of equipment is a core concern among those using or interested in using AM technologies. They fear that downtime due to weather and other delays (e.g., ferry disruptions to the island of Newfoundland are not always caused by weather) could cause production losses that irreparably harm their bottom lines. As companies wait for specialized technicians from other jurisdictions to arrive in NL, they could be in jeopardy of not fulfilling their market commitments and thus face potential contractual penalties. For all such reasons, NL companies can be hesitant to adopt expensive AM technologies and processes. General transportation costs here are already high and businesses know that other risks exist in terms of flight delays, road closures, and ferry cancellations.

Several respondents did point out that while these geography and weather concerns may be justified, advances in communications technology have made things less problematic at least in terms of servicing and maintenance of AM equipment. Thanks to video conferencing technology, it is not always necessary to get help for your technical or maintenance problem via a face-to-face visit from a specialist. Sometimes problems can be solved from a distance. Indeed, through Internet-based real-time data collection, some developers and providers now remotely monitor and finetune their technology from afar as part of their general maintenance and servicing agreements. Moreover, companies requiring staff to be orientated and trained in matters related to their AM investments can also sometimes receive such services via the internet (e.g., the use of QR codes on equipment that can take users to online orientation and training materials). Of course, for NL areas with internet bandwidth issues, these online service, maintenance (and orientation/training) possibilities may not be of much help.

Theme #6 – Certain cultural/social characteristics of the NL population may negatively and/or positively impact NL's adoption of AM

When respondents were asked to consider NL's uniqueness in the context of AM, some noted that certain cultural and social characteristics of the general NL population have constrained - and continue to do so - this province's adoption of AM technologies and processes. They noted how some NL people - including some workers/employees at manufacturing and processing facilities - are lacking in confidence and curiosity. They

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are not interested in or open to new ways of doing things. To these respondents, many people involved with manufacturing now in NL are not entrepreneurial, are resistant to change, and are risk averse.

On the other hand, some other respondents disputed this view and countered with the notion that the NL population in fact has positive traits that can and should be better harnessed to expedite the adoption of AM in this province. They characterized the perceived caution and hesitancy towards AM adoption in NL quite differently. Rather than fearing change, local people are simply conducting smart business cost-benefit and risk analyses. They are sage survivors who have and continue to make made intelligent and sensible decisions under difficult circumstances. They are also exceptionally familiar with the limits of living in and manufacturing and exporting from this comparably remote place. They do not allow themselves to be lured into the purchase of hypothetically valuable AM technologies because they know their markets well, and many of them believe they can get by without AM. They also know about the weather and its tendency to cause delays and increase costs here. Furthermore, they know how most of their non-NL competitors have an advantage over them and are cautious about overextending themselves.

Moreover, according to this cluster of respondents, there are additional social and cultural characteristics that can be harnessed positively for manufacturing in NL, and which can support AM adoption. For instance, in the views of some, there is still a sense of community in most cities, towns, and rural outports across NL. People and companies including competitors are still willing to help one another out. This can be an advantage for new entrants to the manufacturing community. Such attributes help to explain how and why NL has done as well as it has with manufacturing and processing in this province. In sum, rather than viewing the manufacturing sector in NL as lagging, these interviewees see it as one that has excelled against tough odds. Rather than seeing NLers as disinterested in and/or afraid of AM, they see them as shrewd businesspeople who understand who they are and where they live. As such, decisions to not adopt AM here should not necessarily be linked to resistance, fear, disinterest or lethargy.

Theme #7 – Support and properly resourced support agencies are essential for the successful adoption of AM in NL

Many respondents noted that if AM adoption is to be successfully advanced in NL, additional and better, and in some cases different, supports are required especially when SMEs are involved. Numerous interviewees highlighted how there is an important role for governments when it comes to the provision of these supports. Some highlighted how their company's own successful efforts have been indirectly and directly supported by governments. Still others noted how governments could do more to support AM adoption in NL by making it easier to access funding that already exists. Still others noted how government could help the manufacturing sector including AM overall by reducing paperwork and 'red tape', and by developing clear regulations related to the sector. Several further noted that the Government of Newfoundland and Labrador (GNL) could

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change its procurement policies such that innovative companies wishing to move into AM could, to the degree possible, be assured that some of their AM products and services would be purchased by the government. Finally, several interviewees called upon the GNL to develop new and improve existing technology-related educational/training programs in NL because without them, we will never have the number of skilled workers needed to create and grow AM companies overall.

Governments were not the only entities cited as having an important support role to play when it comes to advancing the uptake of AM in NL. Others noted included consultants, technology vendors, and third-party partners. Two entities regularly cited in the interviews were CME-NL and the Genesis Center. According to numerous respondents, both have already played key roles in NL in terms of assisting companies to adopt AM. Not only have they helped to inform people and companies of the AM opportunities available, but they have also been a source of mentoring, advice, research, guidance, and encouragement. The CME-NL was lauded by some study participants for its impressive efforts to bring key actors together in learning and sharing collaboration and networking environments. The work of the Genesis Center and its flagship incubator program was also lauded for its past and current efforts to help start-ups to develop their ideas and to scale up new businesses, some of which became or were AM businesses. Finally, several respondents stressed how more could be done to support the recognition and celebration of successful applications of AM in this province, with the CME-NL - likely with some additional supports from governments - being noted as the agency most suited to do this.

Theme #8 – Collaboration/networking are essential for the successful adoption of AM in NL

One of the explicit aims of this research initiative was to lay the groundwork for the potential development of an Advanced Manufacturing Cluster in NL. As such, each interviewee was asked to share their views (e.g., ideas; insights; concerns about; value of; practical ideas for) collaboration and networking in terms of if/how they could be harnessed to stimulate and support AM in NL. Interviewees had a lot to say about this topic. Most interviewees agreed that networking and collaboration had important roles to play in terms of helping support and grow AM in NL. All interviewees said they would be open to participating in discussions about how best to create a collaborative structure or process (consortium, cluster, or other) that could see NL companies appropriately learning, sharing, and possibly acting together, although there were divergent views about how best to create/manage such a process/structure (e.g., formal versus informal structure; broad versus narrow membership; new versus building on an existing process).

Some noted that NL did not need another new entity or structure dedicated solely to AM, or if one was to be created, it needed to be nimble, informal and 'structure-lite'. For these respondents, concerns about the likely costs of participating in such a new structure/process (e.g., being required to dedicate scarce time to

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meetings), and some skepticism over what such a process/structure could practically accomplish, gave them pause. For these people, the level or degree of their involvement in any new process/structure will be based on the type and the participation demands associated with what is created. On the other hand, even these hesitant respondents were more than willing to, at a minimum, participate in discussions about how best to create the 'right' mechanism, with the 'right' people involved. Their view seemed to be that anything new needed to maximize the possible benefits of collaboration and networking, but also keep the costs of participation modest. Despite some doubts or questioning about form, structure, costs, and benefits, all these respondents clearly noted the value in sharing and learning together, at least to some appropriate degree.

Notwithstanding that some respondents expressed doubts about the need for a new AM process/structure for collaboration and networking purposes - they wondered whether an existing one could simply be harnessed, modified or expanded - most interviewees overall did not express such concerns/doubts. Even though they too were very busy individuals, they expressed interest and willingness to participate in any effort that would help to stimulate and advance AM in NL via a dedicated AM collaboration/networking mechanism.

When it came to specifics about how exactly to create such a mechanism however, or what specifically it could or should do, respondents were not so clear. Many generically cited how such a new structure/process could be used for information sharing and collaborative learning opportunities, but few had additional specifics to propose. Some however did broadly offer practical suggestions including: working together to change government policies related to procurement and tax breaks; collaborating to access funding which could help participants to visit leading AM jurisdictions; creating and finding support for mentoring activities whereby more experienced companies could guide those new to AM without having to incur all related costs (e.g., find resources that could help with the hiring of replacement workers when their mentors are off-site helping others); and AM-related research activities including the development of an inventory of NL manufacturers and processors interested in or active with AM.

GENERAL CONCLUSIONS

Several general conclusions can be tentatively drawn from the 28 interviews conducted as part of this qualitative research project. They are presented below and are organized into two groups: broad project conclusions about AM in NL; and specific project conclusions by theme. They are presented here as a hopefully helpful contribution to our general understanding about AM in NL with emphasis on possible barriers, constraints, and accelerants (helping and hindering factors). Clearly, given the limits of this modest study outlined earlier in this report, those interested in working to positively advance AM in NL or beyond should not consider any of these to be statements of fact. Rather they are encouraged to reflect upon them, and potentially use them as a jumping off point for their own future assessments of and investigations into this important topic.

General Project Conclusions Regarding AM in NL

AM barriers, constraints and accelerants exist in NL (ordinary and potentially unique)

There are indeed barriers and constraints to AM in NL; many appear to be similar to those cited in other reports on AM; however, there are also some that can significantly affect some companies here which appear unique or at least the degree to which they can impact businesses here (i.e., their intensity) may be unique (e.g., geography; weather; lack of skilled workers; sense of community/mutual support that can emerge in rural areas or on islands in the case of Newfoundland); to a degree barriers and constraints are experienced differently by rural versus urban based firms; to some extent, smaller firms also experience different barriers than larger ones.

Hindering factors can 'stack up' and result in a negative confluence of factors in NL

The interviews did not appear to reveal a single most important hindering factor; many interviewees describing their realities noted multiple factors at work; the combination of these factors may result in a type of super-barrier to AM adoption (e.g., it's not just distance-related additional shipping costs that impact a company's willingness to adopt AM in NL, but rather those costs combined with extra costs associated with: finding and retaining skilled workers; maintaining and servicing AM equipment; lost time due to weather disruptions; needing to constantly rehire and retrain workers if those previously hired are lured away by competitors due to a limited labour pool overall).

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There is no shortage of possible interventions that can be taken to try and stimulate or advance AM in NL, but commitment and resources are required

Interviewees had many ideas about how to positively simulate AM in NL; although often light on details there appear to be roles for governments, academic institutions, manufacturers, and support agencies; however, notwithstanding this, commitment and resources will be required for most activities.

There is a lot we do not know regarding why companies choose to adopt or not adopt AM and more investigation is required

Precise transferable findings regarding how and why diverse companies of varying types and sizes (situated in evolving business, economic, and technological environments) choose to adopt or not adopt AM, could not realistically have been identified by this limited snapshot-in-time research effort; indeed, this modest study raises many additional questions including:

1. Are some factors much more important than others?
2. Is the chemistry of helping and hindering factors affecting rural-based firms in NL truly different from the chemistry affecting urban-based firms and, if yes, how different?
3. How much does size of company matter?
4. What types of collaboration and networking are best for AM in NL?

Specific Project Conclusions by Theme Regarding AM in NL

Theme #1 - Need/Purpose/Goal

A precondition for the successful adoption of AM in NL or anywhere for that matter is that the company in question has clearly identified an important need for the AM (and/or the company goal the AM is intended to achieve); attempting to adopt AM without such 'need clarity' is likely a recipe for failure.

Theme #2 - Cost/Affordability/Investment

Sometimes onerous costs associated with AM - or concern about their likelihood - can dampen appetite for adopting it; small entities in NL often do not have the resources - or cash-flow room - to pay for desired new technologies; other costs often come along with AM such as the need to hire new staff, restructure operations, or renovate buildings; some companies also likely do not adopt AM because they cannot borrow the money or attract the investors they need; still others are worried about ROI.

Theme #3 - Knowledge/Awareness

There is clearly an awareness/knowledge/exposure problem here in NL and at various levels; much can/needs to be done at various scales; formal training courses, general awareness for the public, the media and

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politicians, early education with children, and knowledge and awareness opportunities for manufacturers and processors including direct exposure to companies experienced with AM are all needed.

Theme #4 - Workers/Employees

NL has a special skilled worker/employee challenge; it is often difficult to find the workers required for AM here; talent can be attracted and brought in from other jurisdictions, but this can place additional cost pressures on already fiscally challenged smaller companies; other jurisdictions that also face skilled worker/employee challenges may not experience them to the same degree as NL does given decades of outmigration have resulted in a depleted skilled labour pool overall.

Theme #5 - NL Geography/Weather

NL geography and weather can and do impact manufacturing here largely in relation to increased shipping costs (i.e., both raw materials and finished products); weather delays leading to downtime and potentially lost revenue are also not unusual; both can cause problems for AM companies when it comes to servicing and maintenance of equipment, and accessing in-person training resources, although the advent of remote maintenance and repair of industrial equipment and of remote training, thanks to advances in communication technology, could be lasting solutions to these particular problems.

Theme #6 - NL People and Attitudes

Some people involved with manufacturing in NL believe that certain cultural and social characteristics of the NL population have constrained NL's adoption of AM technologies and processes; on the other hand, others dispute this and believe the NL population exhibits positive traits that can and should be better harnessed to expedite the adoption of AM.

Theme #7 - Support/Support Agencies

If AM adoption is to be successfully advanced in NL, additional and better, and in some cases different, supports will be required especially when small manufacturers are involved; there is an important role for governments when it comes to the provision of these supports, although additional government support on its own would likely be insufficient for AM growth; consultants, technology vendors, third-party partners also have roles to play; of particular importance are support entities such as CME-NL, although to fully play the role that many believe they could and should play, related to collaboration, mentoring, knowledge- and awareness-building, more resources would likely be required.

Theme #8 – Collaboration and Networking

Collaboration and networking can help support the adoption of AM in NL; much can be done; considerable care must be taken when conceptualizing and designing any new collaboration and networking process/entity for AM in NL to avoid the creation of onerous participation costs for prospective members/participants.

SUMMARY AND NEXT STEPS

This research initiative had four aims or objectives. First, it sought to improve understanding of the barriers and constraints - and potential accelerants - facing or available to NL manufacturers when it comes to the successful adoption of AM. Second, it sought to illuminate new and different ways in which NL manufacturers could be supported to increase the adoption of AM. Third, the effort aimed to lay the groundwork for the development of an NL-based AM-related collaboration or networking process (e.g., cluster, consortium, special interest group, network or other collaborative arrangement) that could support the adoption of AM within and across NL. Finally, to the degree possible, it sought to educate and inform decisionmakers, policymakers, the media, and the general public as to the overall importance of advanced manufacturing to the future success of NL's manufacturing sector and overall economy.

In the view of the Project Team guiding this project, the objectives noted above have been met through this effort. Project interviewees revealed many barriers, constraints and accelerants related to the adoption of AM in NL. They also illuminated many possible new and different ways in which NL manufacturers could be supported with their AM pursuits. Regarding the possible creation of a collaborative process or structure that could further support those interested in AM within NL, the groundwork for next steps have clearly been laid. All interviewees were asked to comment on the merits of such a follow-up collaboration or networking initiative, and all agreed to become involved should one emerge or at a minimum, to participate in its creation. Finally, education and information sharing related to this project has begun with the sharing of this report and related follow-up presentations to key audiences. Additional education and awareness activities will be undertaken over the ensuing months as well.

Based upon the findings emerging from this study, as well as on information available via other similar or adjacent Canadian studies exploring factors that may help or hinder manufacturers to adopt AM, CME-NL has concluded that:

- AM can certainly be better and more proactively supported within and across NL
- There are support roles for multiple stakeholders working within the manufacturing 'space' including CME-NL, governments, academic institutions, industry associations, and individual manufacturers

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- Some new activities are required, and some pre-existing activities could be strengthened and expanded
- Some new funding will be needed for certain proposed activities
- Better communication, cooperation and collaboration between key sector actors is possible and required

Recommendations and Next Steps

Improving NL's AM adoption rate starts with manufacturers. The ultimate responsibility for keeping pace with technology and forging a path to success lies with them. But as many of the interviewees noted, manufacturers face numerous challenges when it comes to the adoption of AM technology. This is especially true for small and medium-sized enterprises that make up the bulk of NL's manufacturing sector, as they typically do not have the time or resources to fully explore the advanced technology options available to them.

Given these challenges, CME-NL is there to lead and partner with the province's manufacturers to enhance their competitiveness by building their knowledge and helping them work on their business, including by helping them identify and deploy ideal technology solutions. At the same time, governments and policymakers also have an important role to play to encourage faster AM technology adoption. It is especially incumbent on them to implement effective policies that create a supportive investment environment and allow manufacturers to grow and achieve scale.

Against this backdrop, CME-NL proposes the following recommendations and next steps to further increase understanding of AM in NL and to help manufacturers overcome the common barriers of advanced technology adoption:

1. Develop AM education and awareness programs and technology testing opportunities

This project revealed that education about and awareness-building related to AM and its potential for NL is sorely needed. Much can be done to educate and inform existing manufacturers, industry associations, government officials, funders, the media, and new entrepreneurs about the nature of AM and its potential. Awareness about AM could be raised through technology demonstration tours and site visits that showcase cutting-edge technology to NL manufacturers. Similarly, the creation of testing hubs, placed at strategic locations across the province, could be another way to raise awareness about AM. Both the demonstration tours and testing hubs could be supported by government funding.

2. Develop an online technology adoption roadmap

There are other ways in which governments could work with industry partners to help manufacturers accelerate the adoption of AM technologies. One effective strategy would involve the development of an online technology adoption roadmap. Available to all manufacturers in the province, the roadmap would allow businesses to learn about the various stages of technology adoption, assess their own progress in moving towards Industry 4.0, and get information on the steps needed to advance to the next level.

As noted by some interviewees, small and medium-sized enterprises (SMEs), which make up the bulk of NL's manufacturing sector, face unique challenges when it comes to the adoption of AM technologies. As such, governments should pay special attention to SMEs when developing their AM adoption policies. Based on successfully run programs in other provinces, a program specifically targeted at SMEs should include the following two elements: financial support to offset the costs of technology assessments by qualified professionals, and financial support to offset the costs of advanced technology adaptation and adoption. Technology assessment programs are especially valuable to small businesses that typically do not have the time or resources to fully explore the investment options available to them.

3. Promote networking and collaboration across the sector

All those interviewed as part of this project noted that better communication, cooperation and collaboration could help to support the adoption of AM within NL. While there were differences of opinion regarding how best to establish effective and efficient networking and collaboration processes, the general idea emerging was that those currently active with AM could do more to support those not yet ready to adopt. Enhanced communication between and collaboration across multiple industry associations (and/or other intermediary organizations that seek to support manufacturing) was also raised as a need.

4. Provide mentoring and direct support for adopters

The need for trained and experienced people who can guide, coach and/or mentor potential new AM adopters as they begin their respective AM journeys was regularly raised within and across the interviews. Such people need to be dedicated to this mentoring task – in other words, this role was not viewed as something that could be undertaken from the 'corner of one's desk.' While some organizations currently undertake such work, more could and should be done to support mentoring activities although new resources will be required.

5. Encourage AM adoption by matching the Atlantic Investment Tax Credit

The high cost associated with advanced technology was also identified as a key barrier to its adoption, particularly for small businesses that are often cash flow constrained. The simplest way for governments to stimulate business investment in new technologies is through the tax system. One common approach involves

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providing businesses with a tax credit on the purchase of new machinery, equipment and technologies. This is the principle behind the federal government's Atlantic Investment Tax Credit (AITC), which allows Atlantic Canadian businesses to claim a tax credit of 10 per cent on the purchase of new buildings and machinery and equipment that will be used in farming, fishing, logging, manufacturing and processing. To increase the impact of the AITC and to encourage more capital investment, the NL government should consider providing a matching 10 per cent credit on the same base as the federal program, thus creating a shared 20 per cent tax credit.

6. Ensure education and training programs are a good match for the skills that manufacturers need and will need in the future

Interviewees made it clear that NL's acute labour and skilled worker shortage is a major barrier to technology adoption in the manufacturing sector. Without access to a skilled, innovative workforce, the economic case for investing in technology adoption evaporates. Skills shortages impact every step of the process of technology investment from selecting the right technology to integration, customization, operation, troubleshooting, and maintenance and repair. Each of these steps require workers with specialized and specific skills. Moreover, leveraging the opportunities of advanced and emerging technologies requires a completely different skillset to what students have been traditionally taught. Therefore, governments should work with industry and post-secondary institutions to ensure that education and training programs are a good match for the skills that manufacturers currently need and will need in the future.

7. Increase investments in trade-related infrastructure

Most interviewees also cited NL's unique geography and its effect of increasing shipping costs as another key barrier to advanced technology adoption. This indicates that governments should invest more in infrastructure that facilitates trade. This would not only lower shipping costs, but it would also increase access to key markets and make NL's economy more competitive.

8. Support additional research related to AM in NL

Finally, the need for additional research related to AM in NL has been illuminated by this effort. This project itself was limited in scope and scale – as such more needs to be known about why some manufacturers opt to move forward with AM while others do not, how urban and rural contexts affect the adoption of AM, and which types of companies are in most need of mentoring and support. Moreover, given this current project can be viewed as a 'snapshot-in-time', additional research conducted over time which could map the evolution of AM within NL is also thought important.

APPENDIX A—BIBLIOGRAPHY

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APPENDIX B—INTERVIEW GUIDE QUESTIONS

1. What is your name?
2. What is the name of the company/organization you are representing here today?
3. How long have you worked with your current company/organization?
4. How many years have you worked in the manufacturing sector?
5. How would you describe your overall degree of familiarity with/knowledge of the concepts of AM?
6. What role have you played in your company/organization regarding helping to introduce, use, or expand AM (successful or not)?
7. Can you give me a specific/concrete example of an AM experience/intervention from your current company/organization (or previous company/organization if no current example)?
8. If answering yes:
 - a. What were the main motivations to adopt AM?
 - b. What kind of impact did the adoption of AM technology have on the company’s key performance indicators (sales, revenues, expenditures, and profits)?
 - c. Did the adoption of AM techniques impact the number of workers they had on payroll (did the number of employees increase, decrease, or stay the same)?
 - d. Did the adoption of AM result in a shift of recruitment strategies (increased frequency of worker training, recruiting workers with more advanced skills and knowledge of STEM, requiring workers have/obtain new certifications)?
 - e. Did the AM technologies meet your expectations?
9. Based upon this experience(s) and your general awareness of AM, what insights can you share regarding what helps companies succeed with their AM efforts (or hinders/prevents them from succeeding)?
10. Based upon your experience(s), what Helping Factors do you believe need to be in place for successful AM adoption and is there a most important Helping Factor?
11. What Hindering Factors should those interested in advancing AM pay careful attention to? Is there a Hindering Factor that you believe is particularly problematic for AM?
12. To what degree are each of the following barriers/constraints (reasons for not investing in AM) relevant for the NL context/reality:
 - Lack of sufficient financial and/or tax incentives

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- Lack of skilled workers needed to make the most of these technologies
 - Can't get the financing
 - Lack of info about the new technologies available and how to integrate them into operations
 - Limited opportunities to test new technologies
 - Unclear how new technologies would fit into existing operations
 - Risk associated with investing in a product with uncertain application/return
 - Incorporating new technologies takes up too much time/is disruptive to ongoing operations
 - Cost of purchasing equipment is too high
 - Uncertainty about the economic return on investments
 - Learning about the technology and training employees is too expensive
 - Installation costs are prohibitive
 - Our products do not lend themselves to AM technologies
 - Satisfied with current production technology(s)
 - Not convinced of the economic benefits associated with AM
13. Has your company ever applied for and/or received funding/financing/other types of support from a government program/tax credit scheme, or a crown corporation (like BDC) to support the adoption of AM technologies?
14. If answering no, could you tell us why you haven't applied for such funding?
15. If answering yes:
- a. Could you tell us about your experience?
 - b. Was information about the program clear and easy to find?
 - c. How would you rate the application process? Did you find it simple or overly complicated?
 - d. Did you speak to government contacts about these programs? If yes, how helpful were they?
 - e. At the outset of the process, how confident were you that you were going to win funding?
 - f. How long did it take to receive funding?
 - g. If you had a poor experience, what advice would you give to government(s) to improve their programs/schemes?
16. Does your company have plans to invest AM technologies within the next 3-5 years?
17. Is there anything unique about the NL reality/context that can explain this province's current (relatively slow) AM adoption status?
18. For companies/organizations to become more serious about/committed to AM adoption, what conditions would need to be place (i.e., What would you/they need)?
19. Who could/should do what to help to improve the rate of AM adoption in this province (and what exactly could they do)?
20. In your view, what government measure(s) would be most effective in helping NL manufacturers adopt AM technologies?
21. Do you have any closing words of advice for those attempting to incent the use of AM across NL?

CM
& E