Canada's Automation and Robotics Landscape

Background

Automation and Robotic technologies are some of the critical building blocks for advanced manufacturing. To better understand how NGen can work with its membership to improve adoption of these technologies in Canada a survey of 25 members was conducted. This was then followed by more in-depth one on one conversations to explore ideas for new initiatives and collaboration.

Figure 1 Example of Automation and Robotics: A modular high speed robotic case packaging system for packaging dozens of uniquely sized bags into uniquely sized cases for the consumer packaged goods industry with automatic tooling changeover to support lean manufacturing (Image courtesy of JMP Solutions)

Automation and Robotics – What are they, why are they important, and how does Canada rank?

Technically robotics is a subset of automation. We often associate (visualise) robots with automotive assembly lines, and indeed these lines feature both automation AND robotics. We tend to see the robots first and almost take for granted the automation that clamps the parts for robots to weld, and the moving line itself which is another form of automation.

Typically, automation performs a repetitive task. Whenever products are needed in high volumes then tasks can be automated. Automotive assembly and food/beverage lines are both examples of high volume, low mix products where automation is the rule. Some tasks simply cannot be performed at all without mechanical automation.

Robots have sometimes been characterised as good for "dull, dirty and dangerous" tasks, but (unfortunately) people are also often a cheaper way of doing these very tasks. What is simple for a human – picking and gripping a wide variety of objects, still presents a big challenge for most machines.

The annual turnover for global robotic installations in 2019 was $50B, including software and peripherals. A total of 373,000 robots were added in 2019 to bring the global operational stock of robots to 2.7m[1]. A third of these robots are used in automotive, as shown in Figure 2. The United States is now the third largest market for robot installations (after China and Japan) and is a major export market for many Canadian automation integrators (see Figure 3).

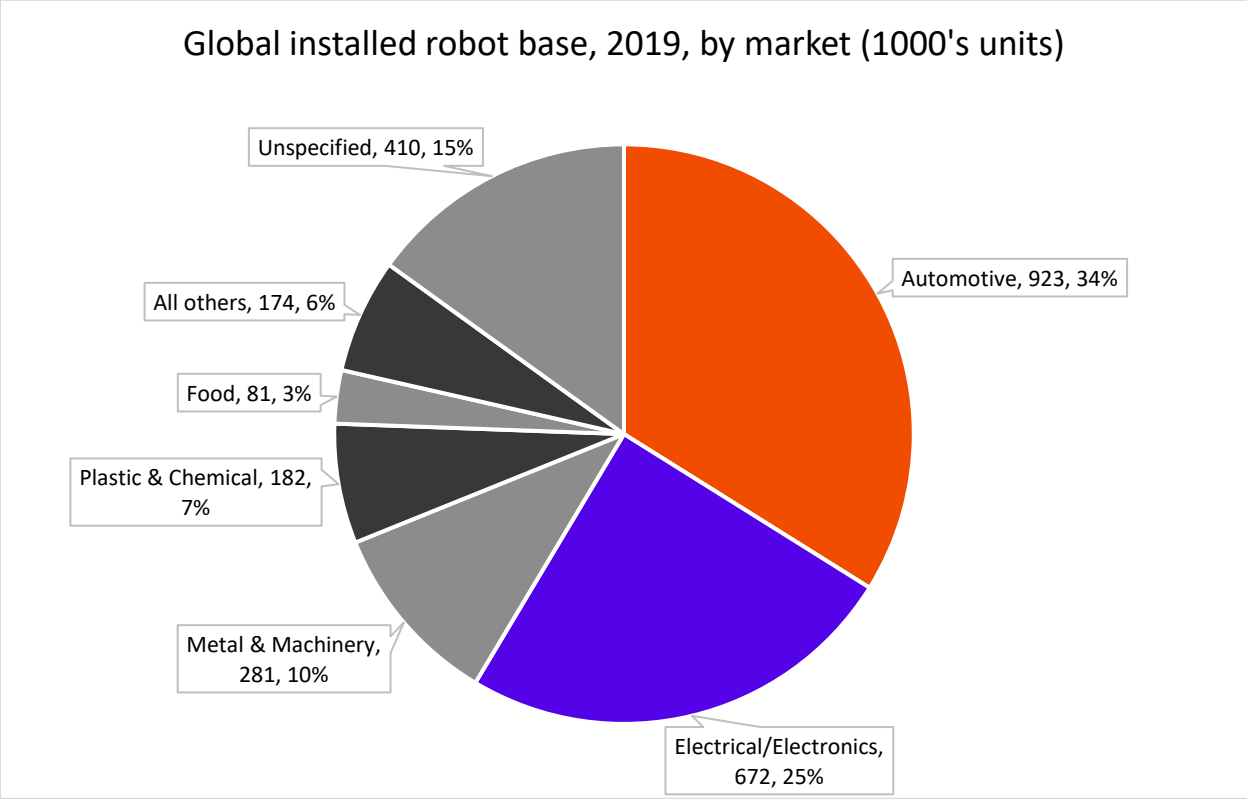

Figure 2 Global robot population, by market

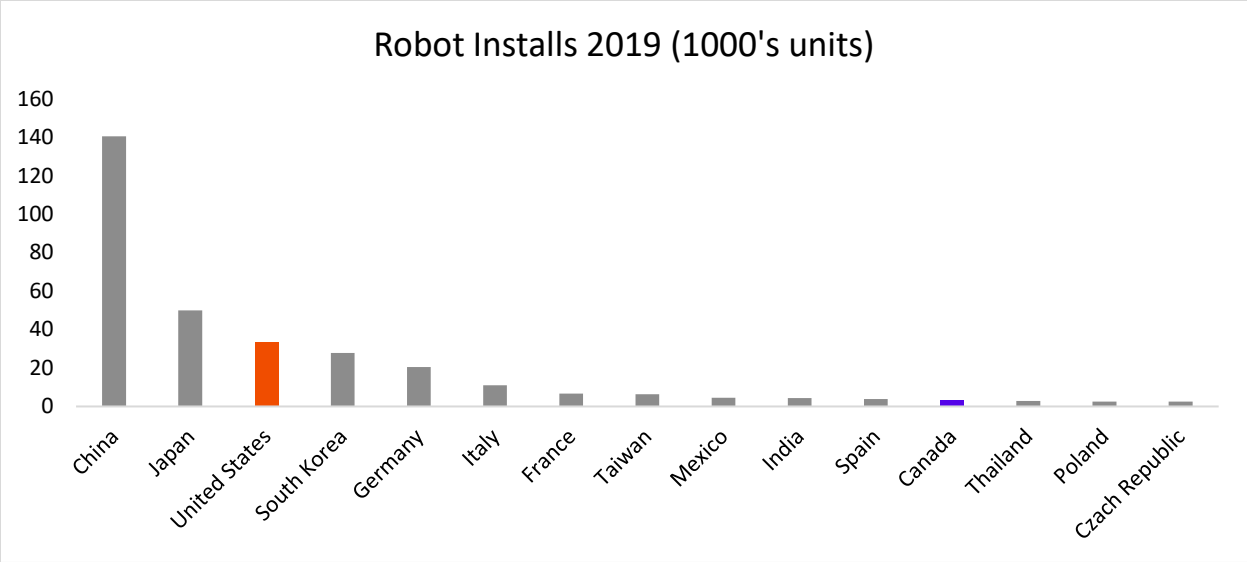

Figure 3 Number of robots installed in each country in 2019

The automotive market is a critical driver for robot adoption as new model releases always require an automated solution be planned several years ahead of the launch. Canada has a strong automotive manufacturing base and ranks above the global average of 113 for robot density at 165 (robots installed per 10,000 manufacturing jobs). Figure 4 shows the top 20 countries by robot density. The birthplace of Industry 4.0, Germany, has a robot density of 346, and the United States has 228 robots per 10,000 manufacturing jobs. Canada's apparent strength in robot adoption is distorted by its automotive sector, where the robot density is a staggering 1475, slightly higher than the US at 1311, as shown in Figure 5.

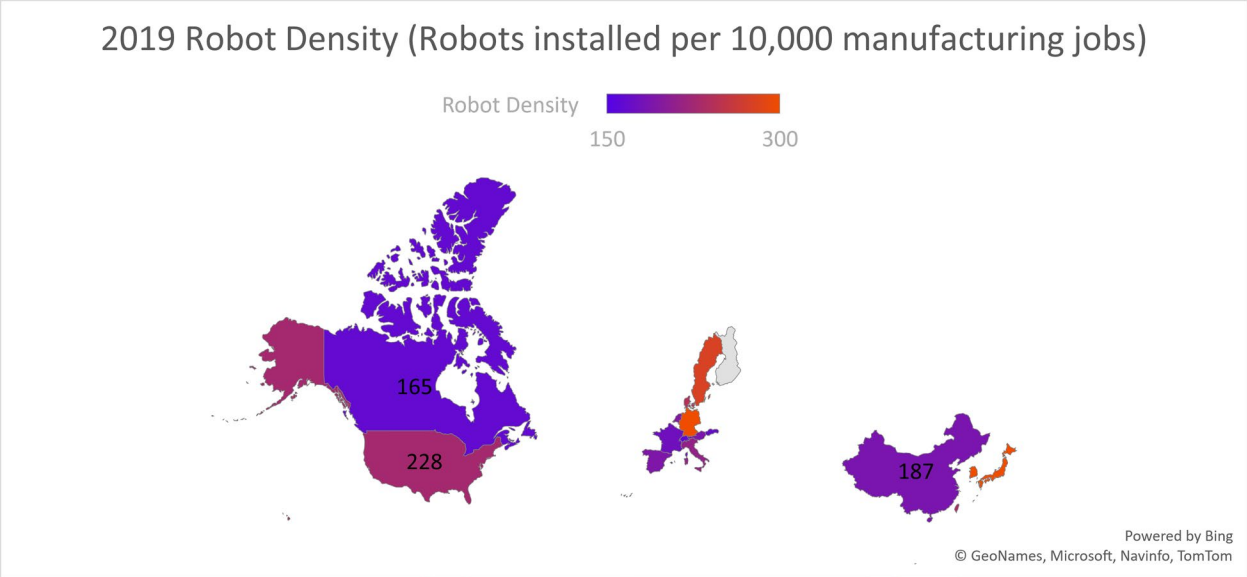

Figure 4 Top 20 countries by robot density

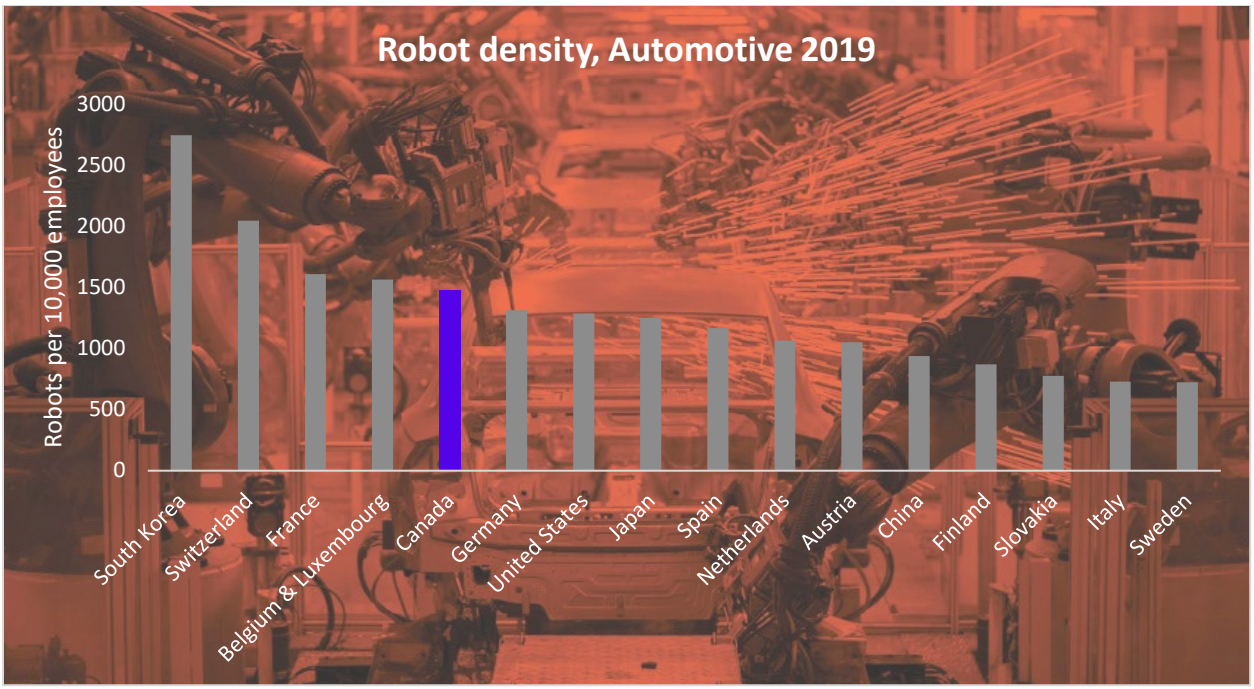

Figure 5 Robot density by country in automotive sectors

However, when the automotive sector is removed Canada appears to be lagging in terms of adoption compared to other countries, especially the United States, as shown in Figure 6. This shows Canada's adoption (installed base) is half of that in the US (normalised to manufacturing jobs). A robot density of 71 in Canada means on average you would only find a robot in companies employing more than 140 people in manufacturing.

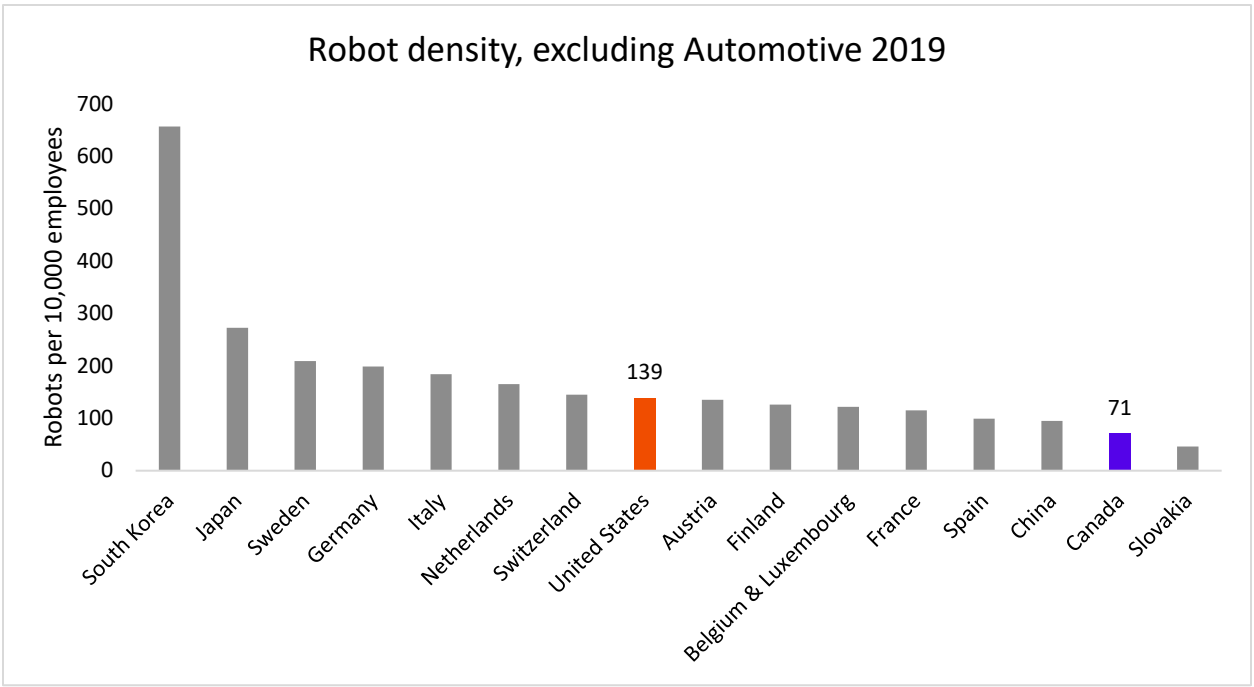

Figure 6 Robot density by country, excluding automotive

A further cause for concern could be the relatively slower ***rate*** of adoption in Canada compared to other countries, including the US, over the past 4 years, as shown in Figure 7. Average robot density increased by 39 in the US compared to only 20 for Canada. Another study[2] ranks Canada 14th globally, and as a laggard in terms of robot adoption - 44 percent below "expected" adoption rate - using payback relative to national wage levels as the expected driver for adoption.

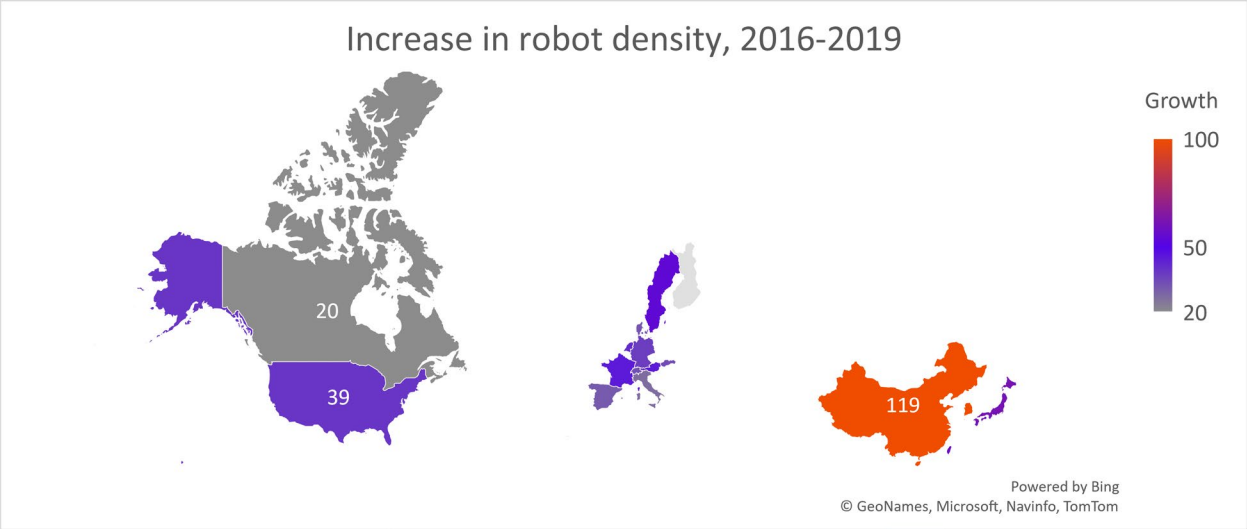

Figure 7 Growth in robot density from 2016 to 2019

Payback, ROI and the business case for automation is hard to generalise. For certain high-volume applications automation is essential - there is simply no other way to meet demand. However, the cost of integration, and relative lack of flexibility, remain significant barriers to adoption. Cheaper hardware, eg collaborative robots (cobots), may help, but they still only represent 5% of robots installed annually, and this sector is not growing rapidly (1% increase over the past 3 years[1]). Advances in machine vision, and machine learning, offer the potential for easier (lower cost) integration and increased system flexibility in the future.

Examples for manual material handling suggest autonomous mobile robots in a greenfield site can be just 10% the cost of using people, and half the cost of a fixed conveyor automation system. As organisations progress from islands of automation to digitised networks of automation, the bottom-line benefits are expected to compound. However, the price of entry remains relatively high, even for "low cost" robotic solutions, typically several years minimum wage salary.

In summary, there is a $50B global market in robotics, with automotive currently one of the most important sectors. Canada appears well positioned in terms of automotive adoption, and has a strong domestic supply chain of integrators, but is weaker outside of this sector. The automotive market itself is undergoing major changes with the advent of electric vehicles as well as light-weighting initiatives.

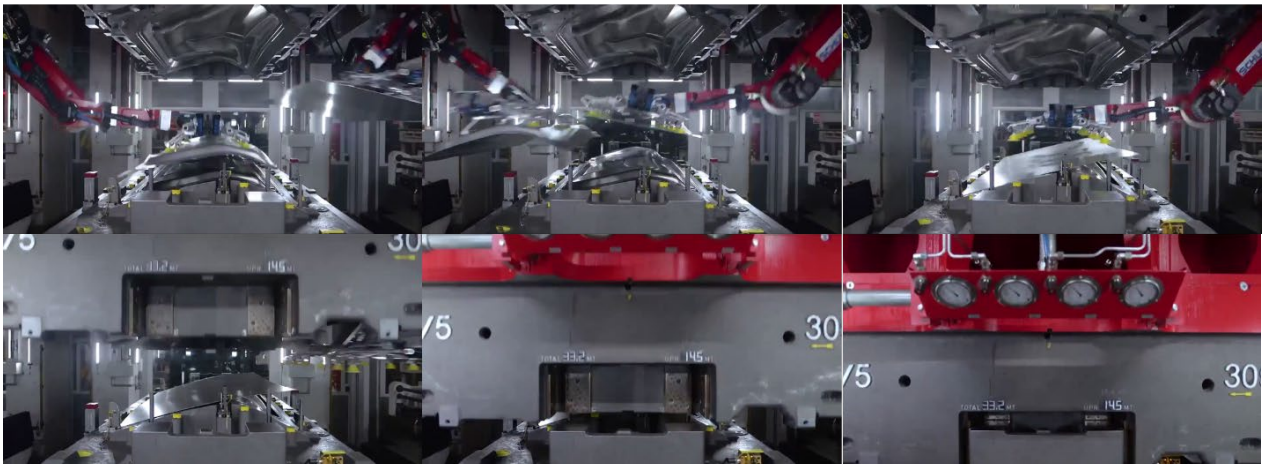

Figure 9 Robot loading and unloading of stamping press for automotive panels

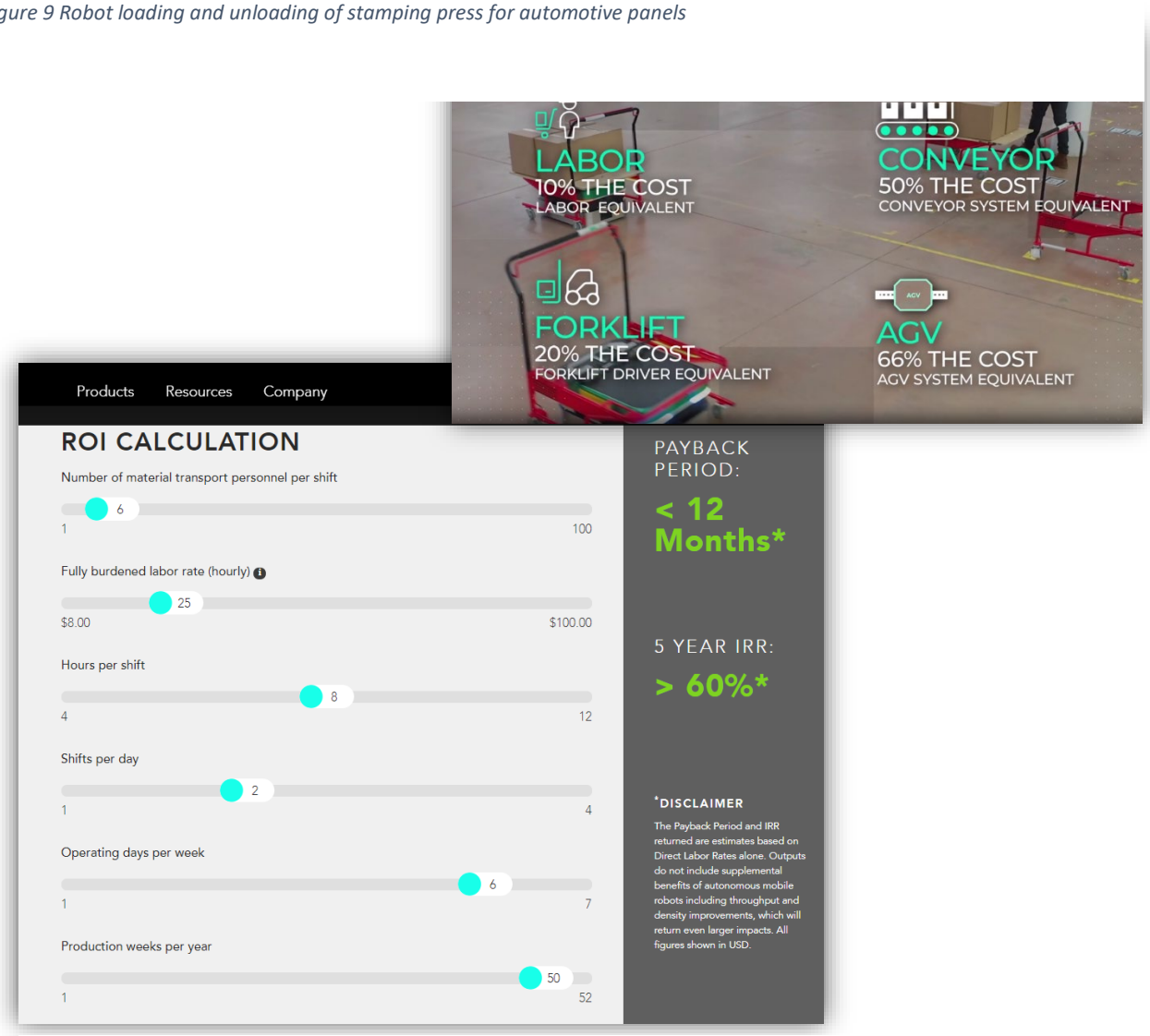

Figure 8 Payback examples and ROI calculators are often available from suppliers for real world applications (Otto Motors)

NGen Automation & Robotics Advisory Board

To better understand how NGen could help increase adoption of automation and robotics (A&R) across Canada, an advisory board was formed. The initial advisory group consisted of over 20 companies deeply involved in Canada's A&R ecosystem, see Table 1.

Advanced Intelligent Systems	ABB
AIS Technologies Group	ATS Robotics
ATSI Robotics	Attabotics Inc
Automate Canada	Automatix
Clearpath	CRIQ
Eclipse Automation	Festo
Hattin Foundation	Humber College
Integra-Co / Eficio	Kinova
NRC	Omni Robotics
REAI	Sensor Tech Canada
Siemens	Taiga Robotics
Whitfield Welding	

Table 1 Members of NGen A&R advisory board

An initial meeting was held in October 2020. The discussion was lively with many questions and comments. The group supported exploring how a technology portal hosted by NGen could help provide SME's with a path to adoption.

An online survey of the group was conducted, to better understand the issues around A&R adoption in Canada, and strengths and weaknesses in the ecosystem. The survey was then followed by one-on-one interviews, typically lasting an hour, to explore individual experiences, opinions, and suggestions for action. The survey group is only a sample of Canada's significant A&R ecosystem, but common themes still frequently emerged. This report summarises the survey results and discusses the interview findings.

Survey Results

The initial survey questions were designed to give an overview of solutions offered by the respondents to different markets, and the specific application areas for Automation and Robotics.

Unsurprisingly the automotive sector was one of the largest cited, after "other sectors" where aquaculture, medical, mining, defense and lumber were mentioned.

The application areas were consistent with global use cases, with handling and assembly being dominant. Other use cases were vision guided quality control, teleoperation, and additive manufacturing.

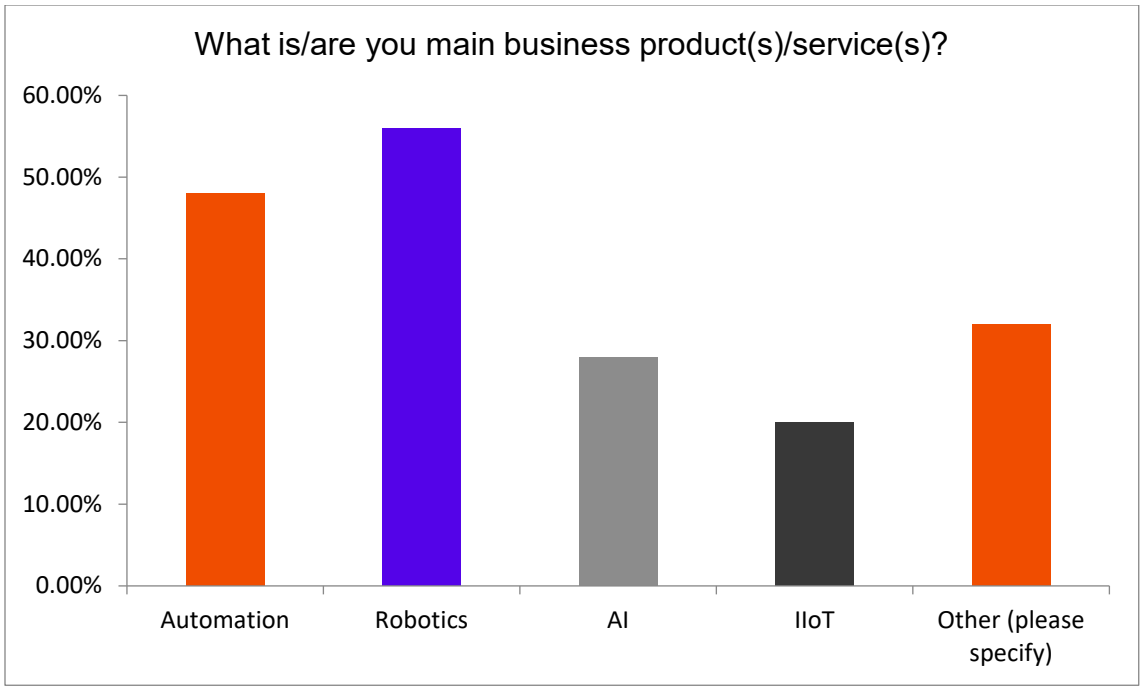

Figure 10

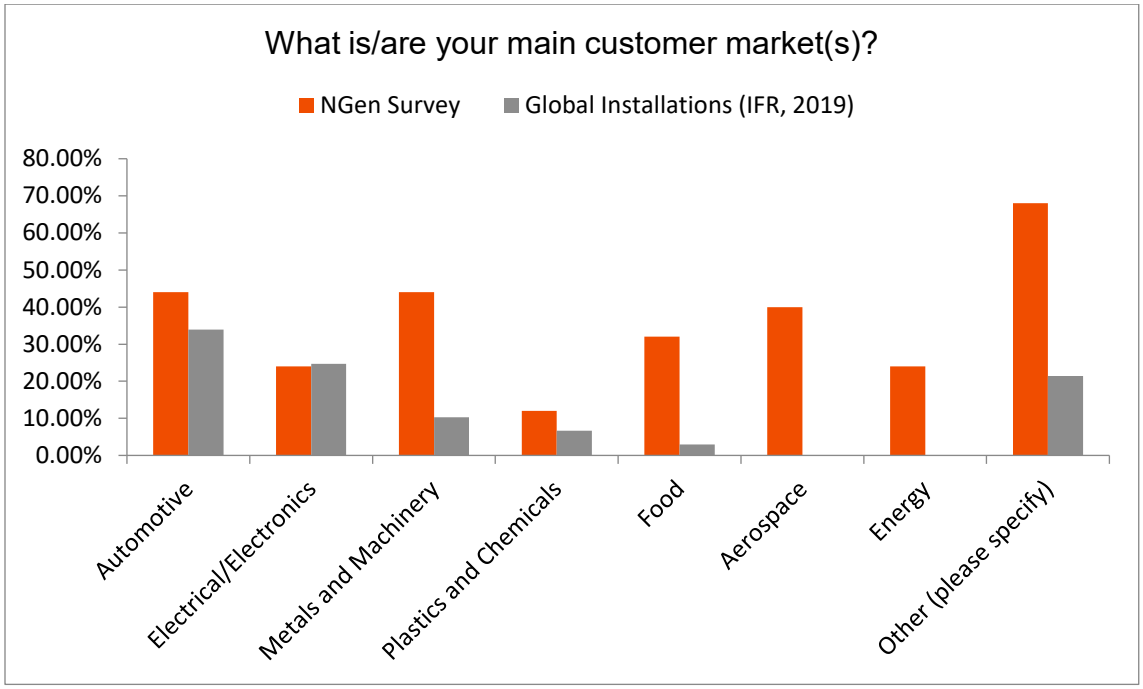

Figure 11

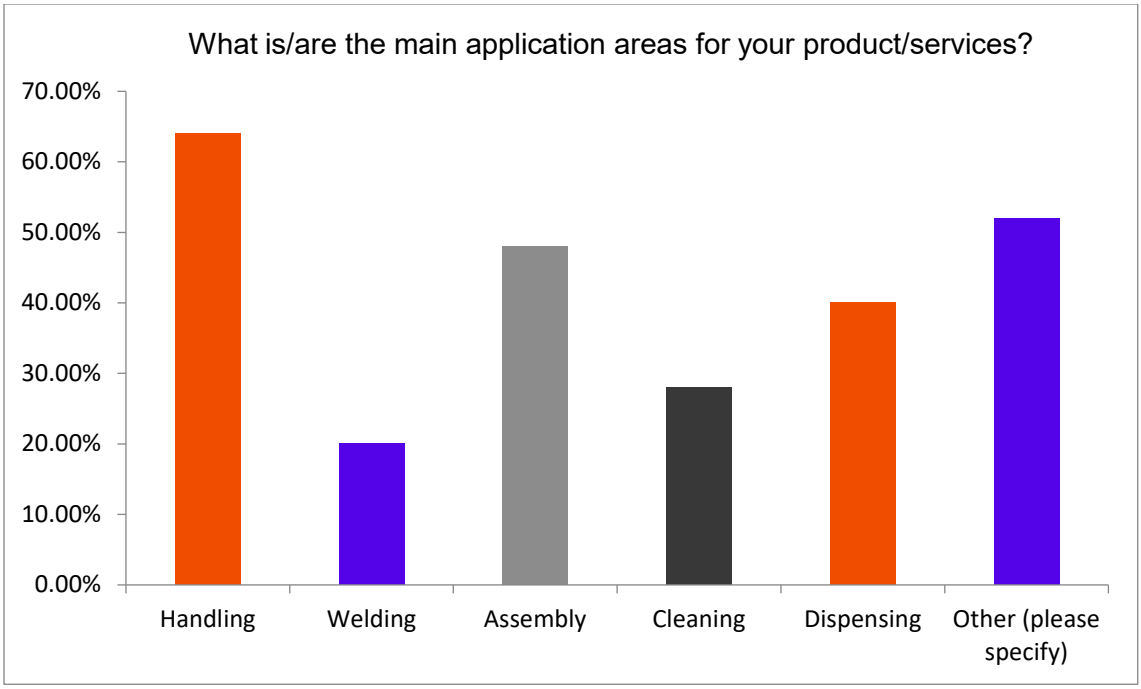

Figure 12

It was unsurprising that a large proportion of respondents had nearly all their sales to Canadian businesses (see Figure 13). What was unexpected was a significant proportion stated that all, or nearly all, of their business came from OUTSIDE Canada. The reasons for this were discussed during the one-on-one interviews.

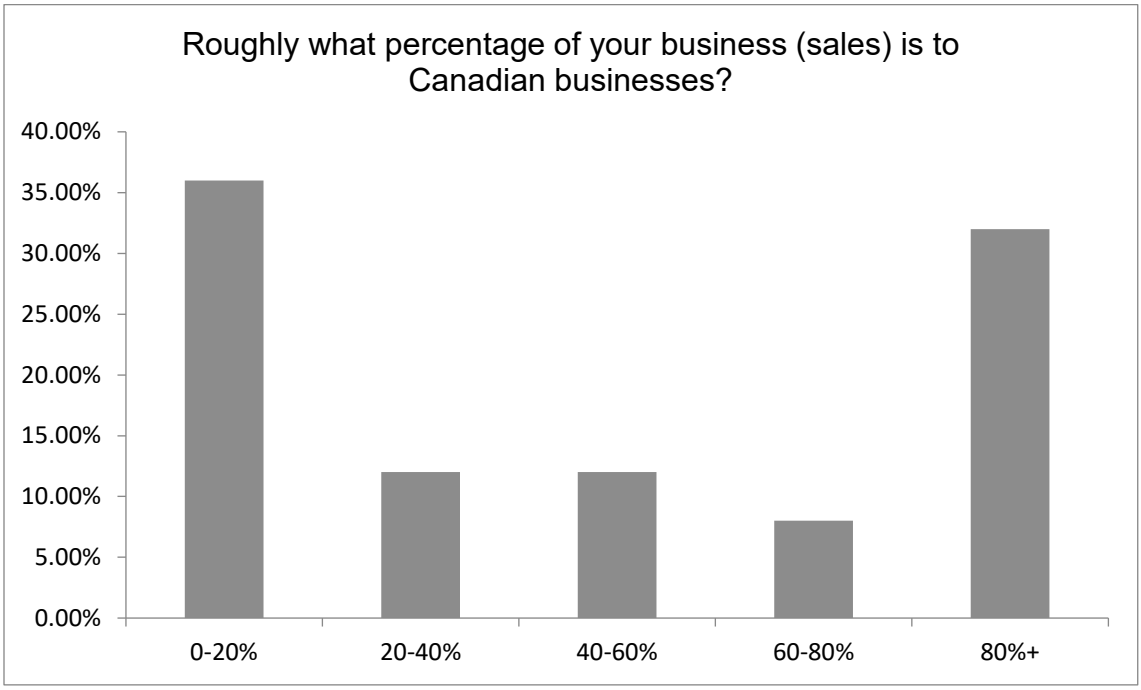

Figure 13

Opinion was largely neutral on whether Canadian companies had a good understanding of the business case for adoption (Figure 14), although this is somewhat contradicted by the significant proportion of time most respondents later said they had to spend helping educate their potential customers.

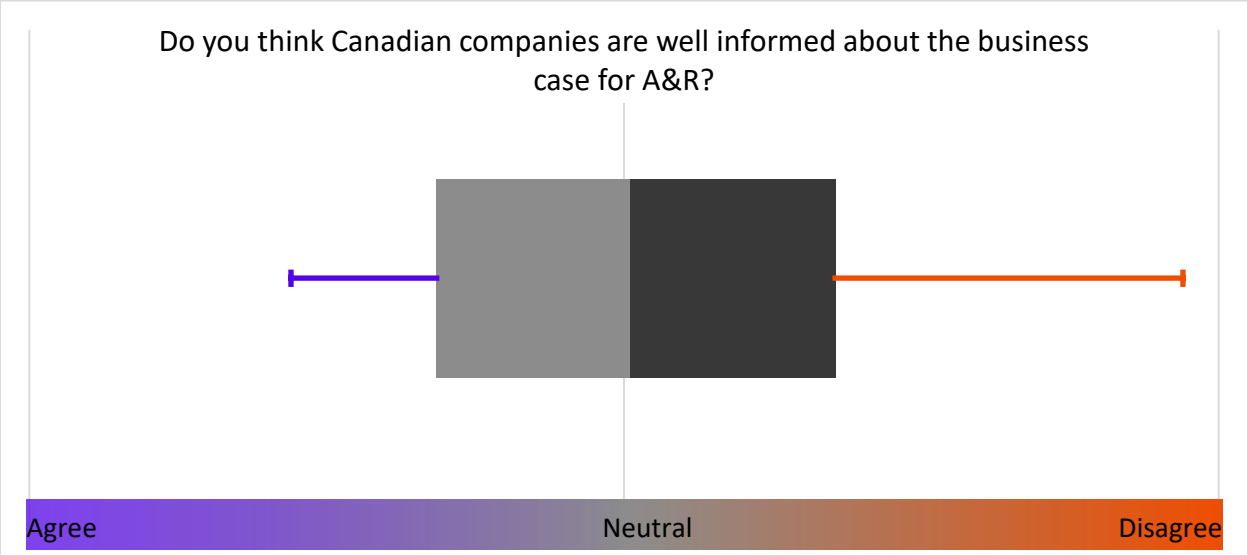

Figure 14

Opinion was more negative, and divided, over whether students and future workers were being adequately prepared to work with automation and robotics (Figure 15). Suggestions for underlying reasons for possible poor workforce readiness and ideas for to how to improve were discussed during the follow up interviews.

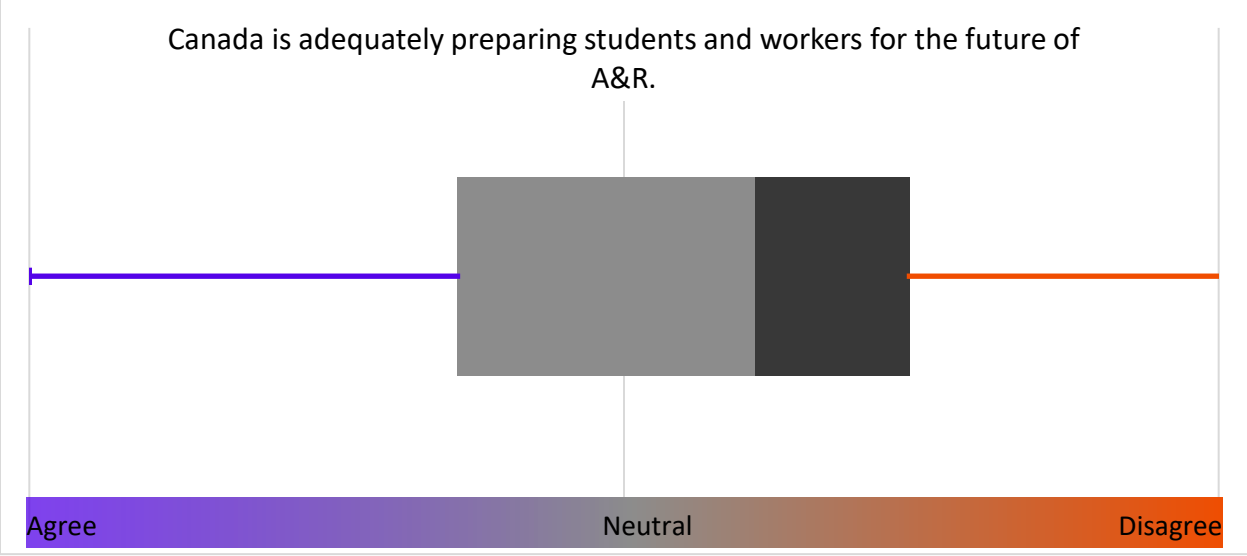

Figure 15

The more important skill sets missing (shown as colourful sections of Figure 16) appeared to be practical applications, either business case justification or programming and optimisation of automated operations. As one survey respondent noted, while the robot manufacturers are the driver, and the SME is the adopter there is still an application knowledge gap that cannot be filled with 3 days manufacturer training. True project-based learning at educational facilities with both the floor space and curriculum time can help fill this knowledge gap, and lead to job creation.

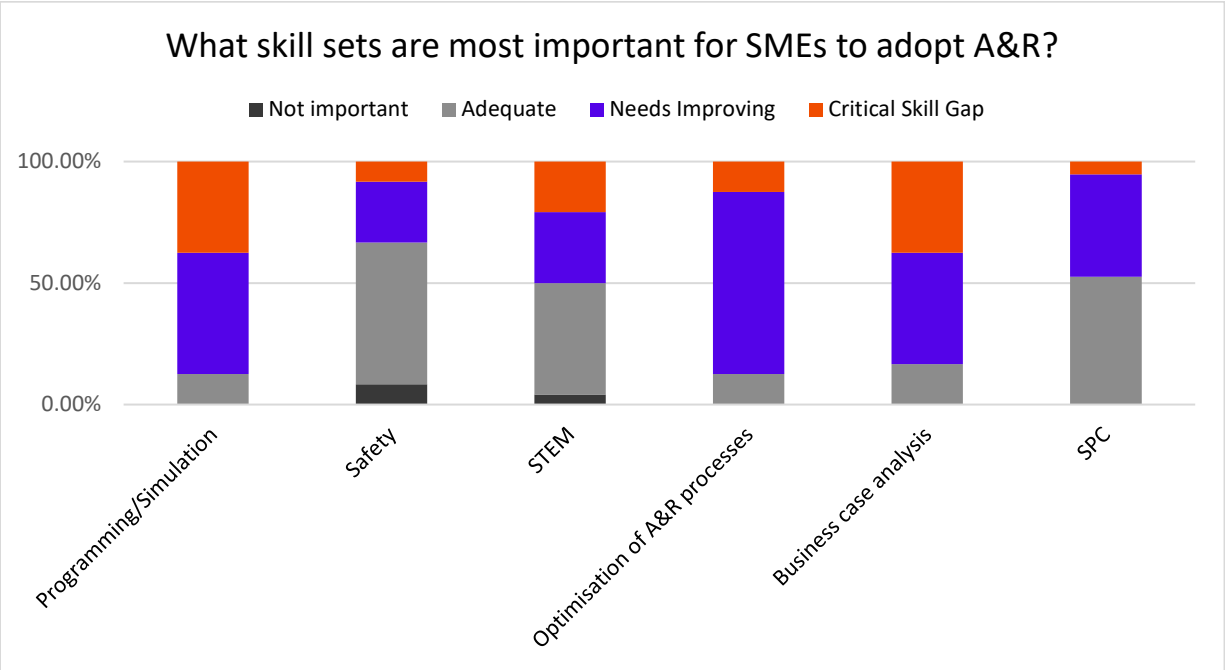

Figure 16

The strengths and weaknesses impacting adoption in Canada showed overall positive perception of technology and innovation in Canada, with a highly negative view of funding mechanisms (a barrier to adoption), as shown in Figure 17. It was interesting that Canadian competitors were viewed as a strength, more so than collaboration. The impact of Covid was evenly split as either an opportunity or a threat, as was surprisingly the opinion on people.

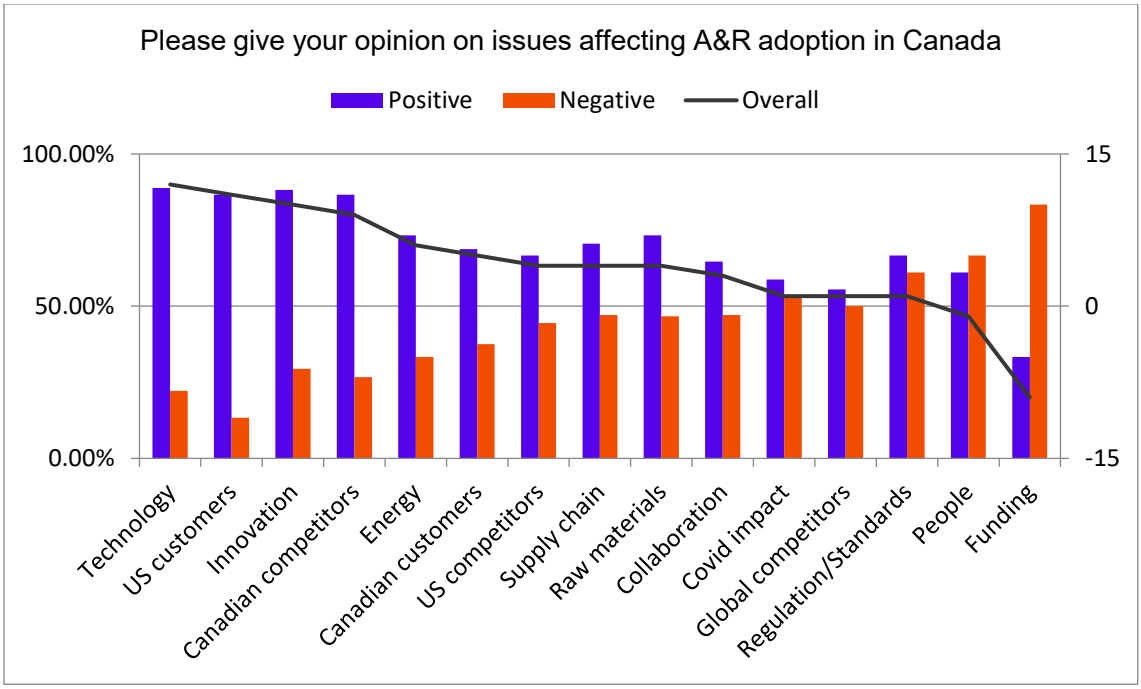

Figure 17

The survey respondents were generally neutral in their assessment of Canadian industry understanding of automation's capability and cost, with customers tending to underestimate the costs (Figure 18 and Figure 19). However, all the respondents spent a considerable amount of effort helping to educate customers, as shown in Figure 20.

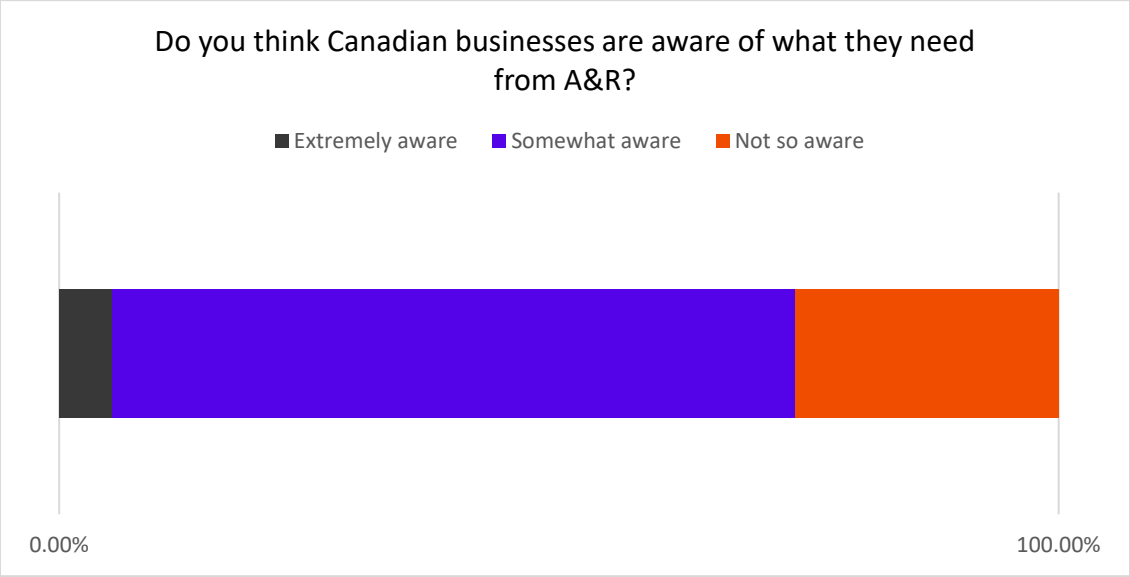

Figure 18

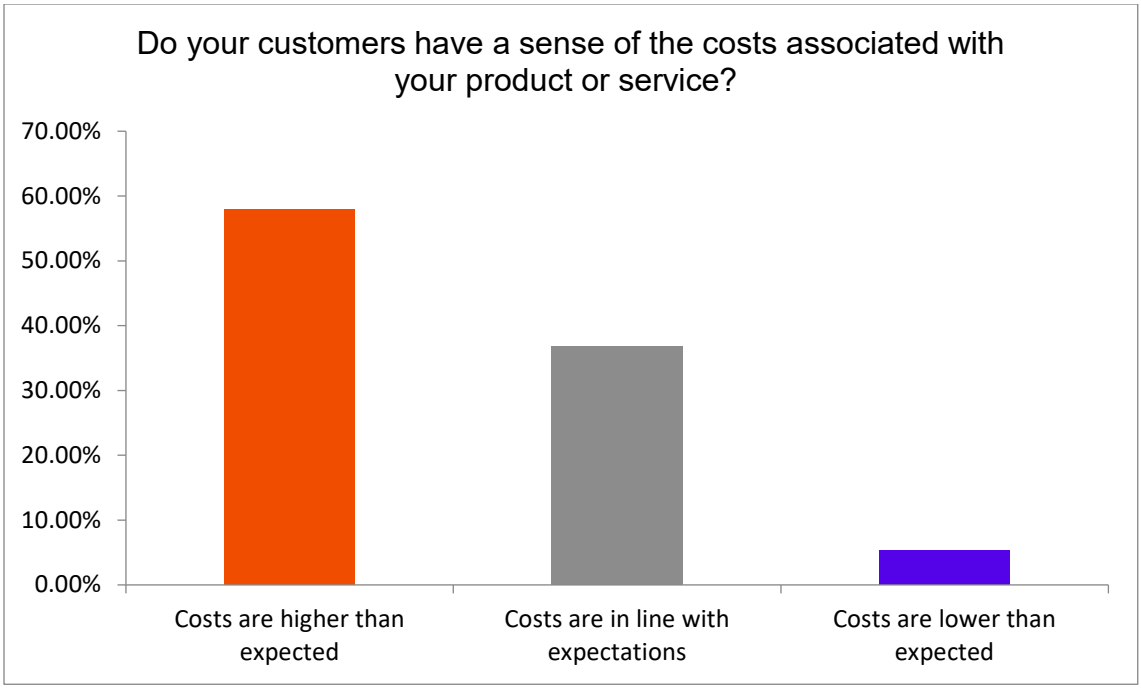

Figure 19

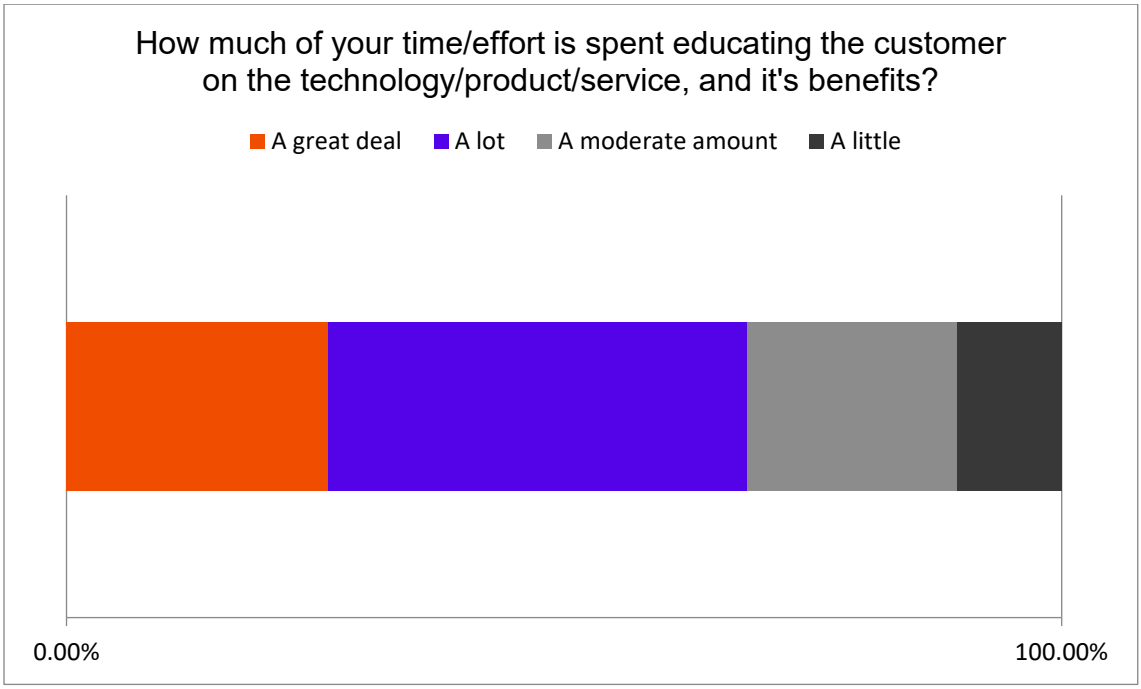

Figure 20

Opinion was polarised (and from the follow up discussions, passionate) on whether creating automation demonstration facilities would increase industry adoption, as shown in Figure 21. One argument against "artificial" demo facilities was that technology was rapidly evolving and was best showcased in the latest customer sites. Connecting potential customers with appropriate sites (by geography and technology application) could be of significant value for NGen's members.

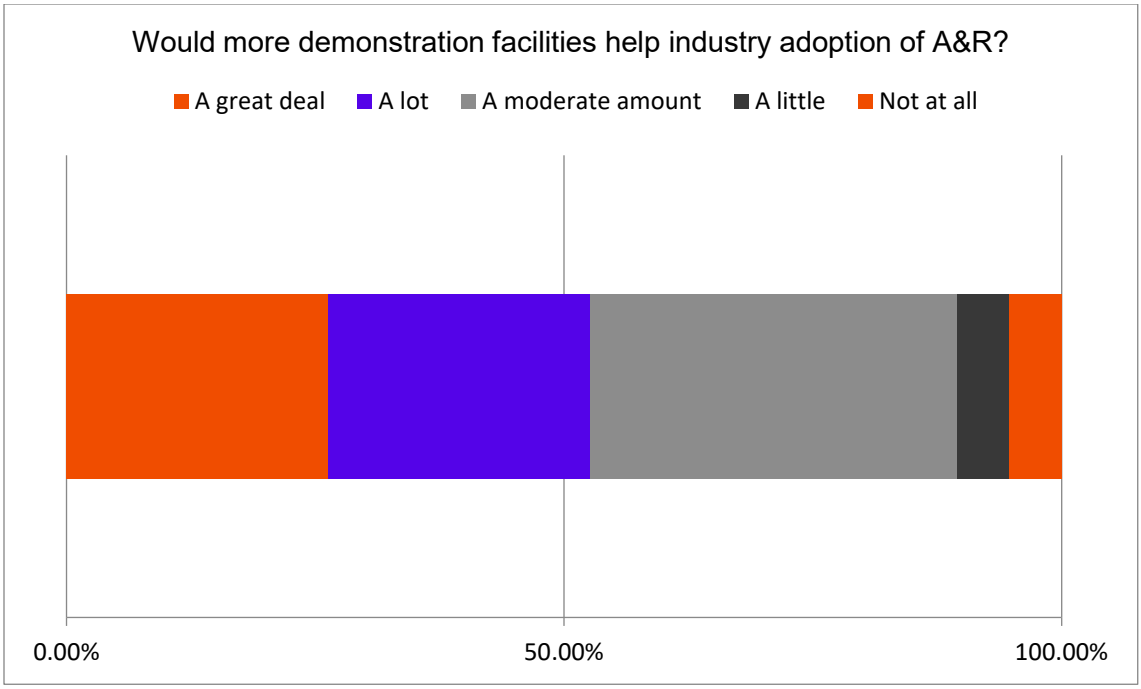

Figure 21

Survey Discussion and Follow Up Interviews

"Time, money and talent"

One of the survey questions was "What should NGen ask its members about Automation and Robotics?", to which one respondent suggested asking "What is the main reason why you are not implementing A&R?". During the one-on-one call that respondent was asked what they expected the reply would be. Without hesitation the answer came back: "Time, money and talent". The respondent went further and said that as far as (lack of) talent went, it really boiled down to an inability to recruit people to work in unexciting, poorly paid jobs. MIT's Work of the Future report[3] also noted that the dilemma of no workers to hire was simply "a dearth of people willing to work long shifts for close to minimum wage and no training."

Canada's manufacturing landscape consists of many smaller companies compared to the US where fewer, larger companies dominate the economy. One of the biggest barriers for smaller companies to adopt automation is the relatively high cost of an integrated solution (hardware and software/controls) that may not be (very) flexible and so does not fit well with the high mix, low volume environment typical of a small company. Small companies are often making products designed by larger companies. There is high variety and little security or visibility of what lies ahead for the smaller producer. People are incredibly adaptable, and the cost of an automated solution may be several years salary. The feeling is often that there is no need to act now, that "the business is not going to die today or tomorrow," and there is "always a bigger emergency to focus on."

A recent study by MIT also found very few robots in smaller companies across the USA. A policy suggestion was to link the award of defense contracts to new capital investment (in advanced manufacturing equipment) by the supply chain benefitting from the contract. Defense work offers longer term visibility of requirements and little chance the work will be offshored.

In complete contrast to the lack of urgency perceived by smaller businesses in Canada, the automotive sector must make investment decisions today to be ready for planned model launches in several years time. It is therefore both the pace and size of the automotive sector in Canada that is critical for the future. As one respondent noted, "Canada absolutely cannot afford to lose its automotive industry."

The automotive sector is also undergoing significant changes with the emergence of electric vehicles. Magna has commented about an explosion of complexity[4] as the industry transitions from 8-10 basic ICE powertrains to a huge variety of electric motor sizes, and new configurations for motor and battery placement in vehicles. It will be interesting to see if this increase in complexity drives innovation in automation and robotic solutions. It is hard to imagine that better solutions will not emerge for high(er) mix, low(er) volumes. What is unclear is how quickly these new solutions will diffuse outside this sector.

Tesla is consolidating many components into a very large structural die-casting and expects to eliminate hundreds of smaller robots that would have been required to join all the previously separate parts. So here the trend may be towards fewer, but larger, robots handling mega parts. Additive manufacturing, and other revisited conventional technologies,

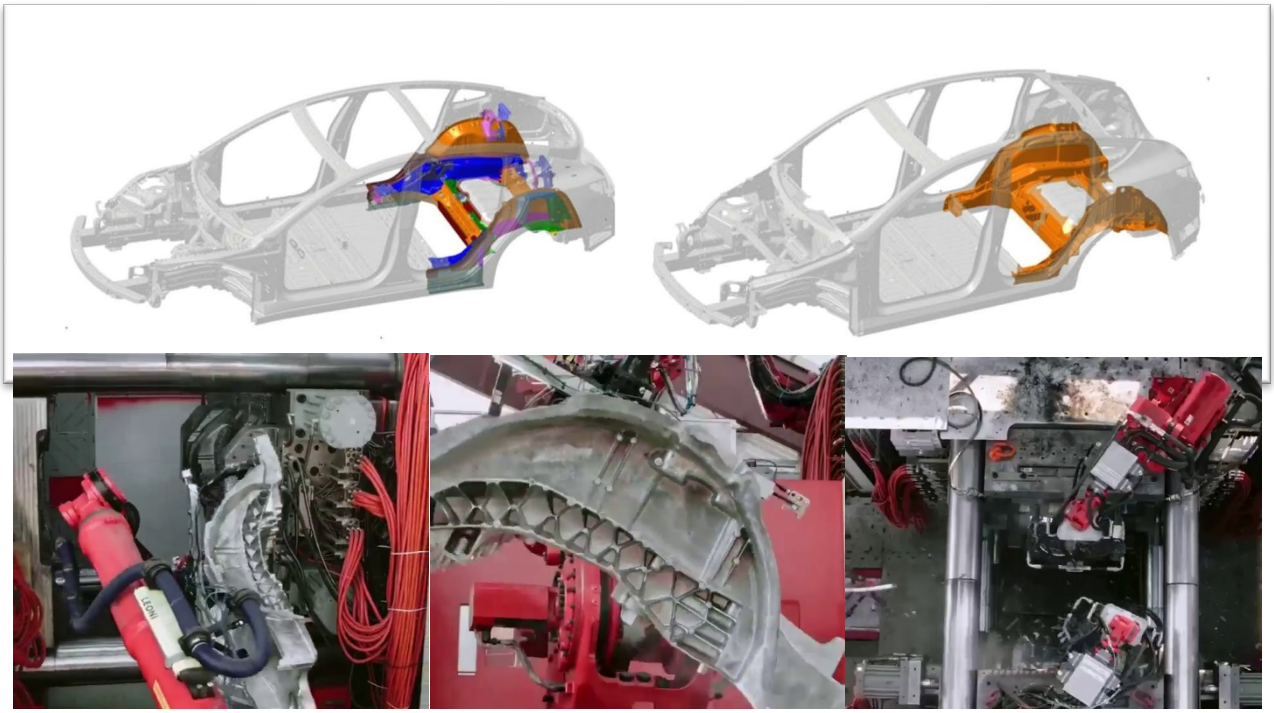

Figure 22 Example of automotive manufacturing reducing the number of robots required for assembly by consolidating multiple parts into a massive die-cast component (Tesla Model Y)

like Tesla's die-casting example, may enable part consolidation and so reduce automation complexity for electric vehicle production.

It was clear from the respondents interviewed that Canada has a rich automation and robotic ecosystem, despite nearly all industrial robots being imported into Canada as there is not a major domestic based producer. Canada offers world class solutions for existing (but evolving) sectors such as automotive, as well as rapidly emerging sectors such as logistics, and vertical farming. Nearly every business requires some form of "kit", and the picking and delivery of these kits to the point of use is an automation capability that is underexploited, particularly in manufacturing. However, some survey respondents felt that much larger global players like Amazon in logistics were already too far ahead of Canadian A&R suppliers trying to compete in the same space.

Most smaller companies in Canada have not fully automated their processes, certainly beyond "islands of automation" (eg material feeding a machine). Fully connected enterprises - using Industry 4.0 digital data and sensors (Internet of Things) internally and externally - often seems to be somewhere on the Gartner hype curve, with few Canadian exemplars.

Canada's A&R capability is still not well understood by many businesses. One respondent went so far as to suggest that domestic A&R companies were perceived as NOT being experts in the field by other Canadians. Automate Canada was founded noted one respondent precisely because "automation didn't have a lobbyist in Ottawa".

There was a robust discussion among the advisory board members as to whether (more) demo facilities, or even a mobile road show "battle bus" would help with adoption.

Only a few suppliers had solutions that were small enough to travel and could be programmed dynamically to demonstrate "live" to a customer. As noted earlier, one of the difficulties with most automation solutions is that the hardware and software is expensive to integrate for a specific application, and cannot simply perform tasks never seen before without eg tooling and programming.

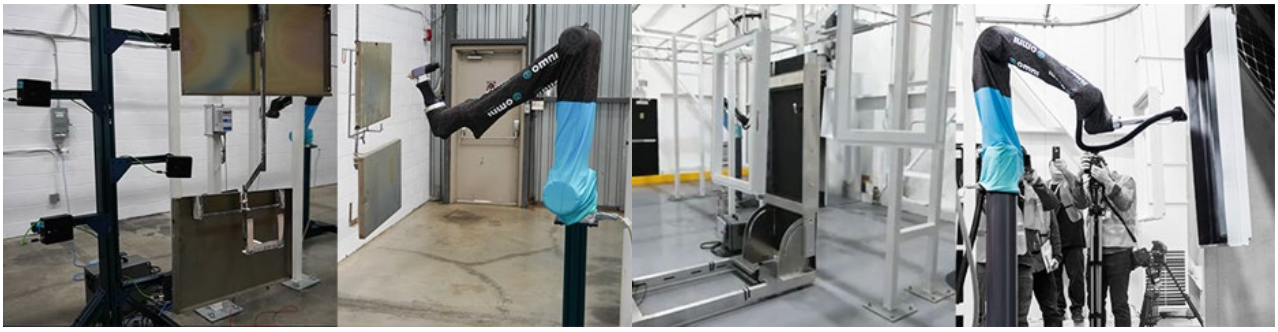

Figure 23 Omnirobotic's Shape-to-Motion™ Technology uses 3D scanning and reconstruction to autonomously generate a robot program in a simulation environment and subsequently drive existing industrial robots in the real world. This not only removes the extensive programming and jigging costs that come with traditional industrial robots, but allows these robots to adapt to any type of part, part order and position in real process time."

One idea suggested was for a programme like CanadaMakes in additive, to partially fund the cost of prototype tooling for a proof-of-concept demonstration to a customer, leveraging existing investment in flexible automation equipment at some suppliers.

Figure 24 Symphoni™ technology is an innovative, high-performance digital manufacturing system that is made up of standard modules. This "plug-and-play" approach is designed with versatility in mind to accommodate product mixes, varying processes, and part assembly. (Images courtesy of ATS Automation Tooling Ssystems Inc)

When asked if virtual environments and simulations would be effective selling tools, the response was decidedly mixed. One supplier uses plant simulation to successfully demonstrate the value of Industry 4.0 instrumentation. However, others talked of customer resistance to simulated results, and that there was "an innate curiosity and a visceral experience watching real robots in action."

"A visceral experience watching real robots in action"

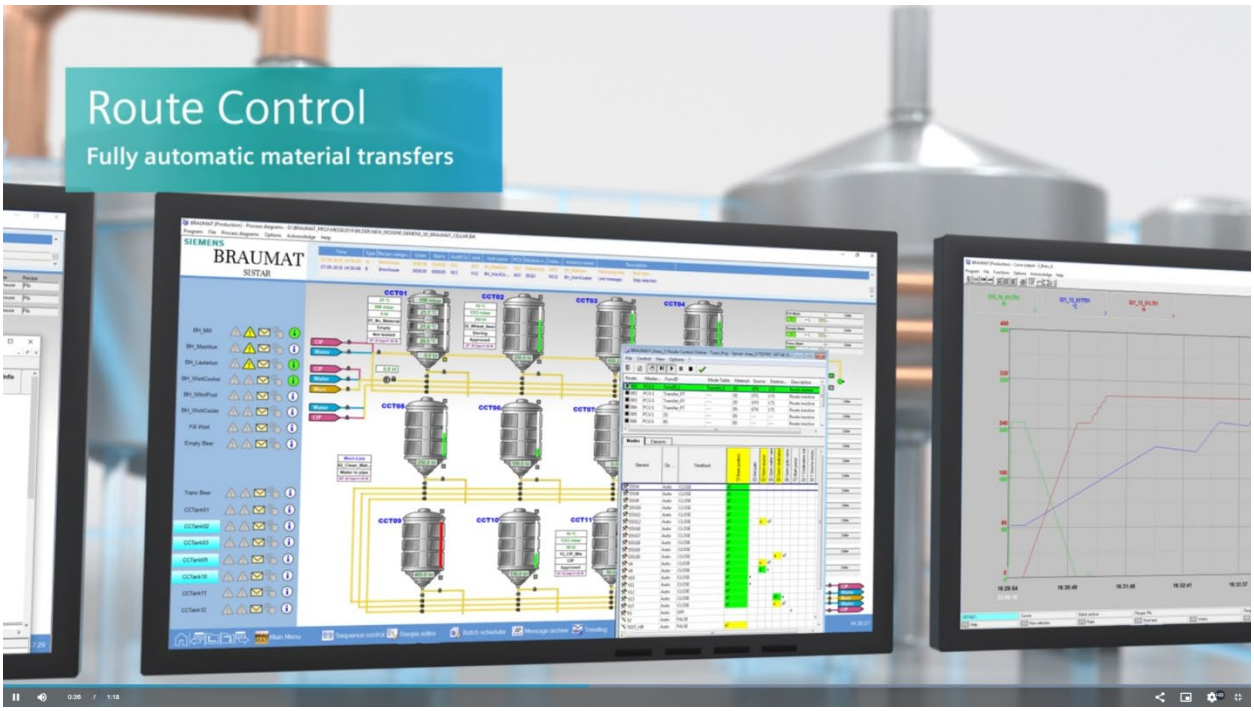

Figure 25 Digital brewery solution, BRAUMAT, by Siemens provides a compelling simulation experience

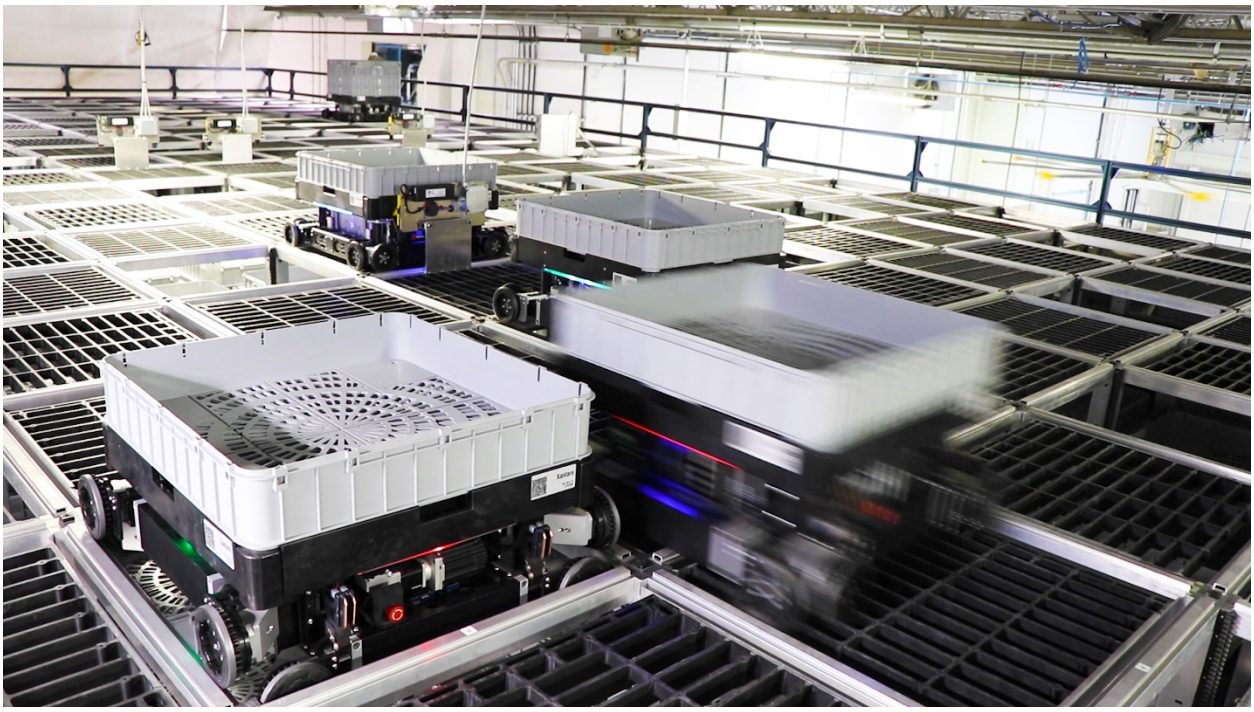

Figure 26 Watching robots in motion can create a powerful, positive impact on customers considering automation solutions (Image courtesy of Attabotics)

A popular view was that ideally there would always be a suitable industry site that a potential adopter could visit. This should ensure the latest solutions are seen in action with no additional investment required to create a demo facility. Providing NGen members with a

clear map and process to facilitate such visits would be a value-added service, as would promoting open access. NGen could provide a framework to navigate the practical difficulties allowing competitors to visit.

The value of global trade shows was highlighted. One respondent noted that Robert Irving, as head of Irving Tissue, thought it important enough to always attend all the major paper shows personally, continuously seeking better solutions. Another saw an Amazon tech lead at a trade show looking intently at robots sorting coloured pills. A year later Amazon Pharmacy was launched offering prescription delivery.

Wanting the best and wanting to grow were frequently cited by survey respondents as key differentiators of A&R adopters.

Collaboration via industry consortia was mentioned as an effective way to pool R&D dollars and make good use of existing infrastructure. Finding consensus among the partners was difficult, but critical for success. Companies might typically find 25 projects not important, 15 relevant and 10 critical to their business. Medium size businesses can probably benefit the most from this approach rather than being "home alone"[3] with just a drip feed of retained earnings to fund internal R&D. SME's will typically only be active in a couple of projects, but other technologies are now "on their radar."

Providing a Pathway for Adoption

A web portal could offer value to NGen's members in a variety of ways. Firstly, it could provide valuable self evaluation tools for a company considering whether automation is a viable solution to its problems. This would allow more efficient industry awareness, while simultaneously freeing up resource from the A&R supplier base, who spend much of their time "educating the customer on the technology/product/service, and it's benefits."

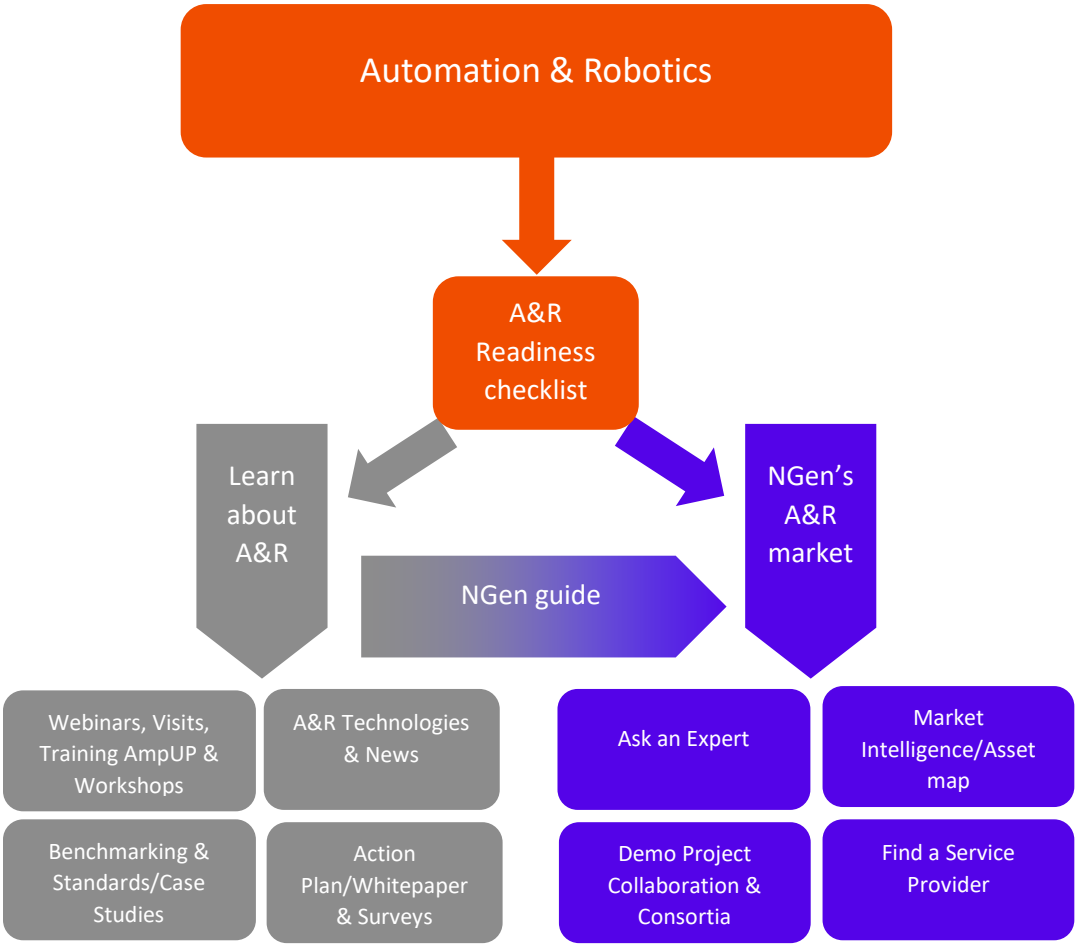

Figure 27 NGen A&R portal block diagram

A block diagram showing possible building blocks for a web portal are shown in Figure 27. The left-hand side contains education and awareness modules to help members learn, and the right-hand side are marketplace modules to stimulate adoption.

The tool could triage and guide with a series of expert derived, but automated, questions. This would ensure that members are adequately prepared with the necessary business and process information before connecting via the "Ask an Expert" service. One supplier noted wildly different levels of preparation from potential customers, from 100-page very detailed

RFQ's, to multipage boiler plate legal contracts with only one page on the project description, down to some that were just a single sentence project description.

The reason for investigating automation might be growth eg with a new product line, or the need for quality improvement by reducing human variability, or cost reduction, to name a few (and of course it may be all of these). By providing members with an interactive asset map of A&R solutions across Canada, searchable by market and technologies, as well as the business drivers/benefits behind each asset, the portal would ensure Canadian businesses could easily see what others are already doing.

Eventually it might be possible to use machine learning to match the members supplied information to a prescriptive course of engagement. Machine learning is already being used to diagnose and respond to office process automation, with evaluation on ease of implementation and potential for automation.

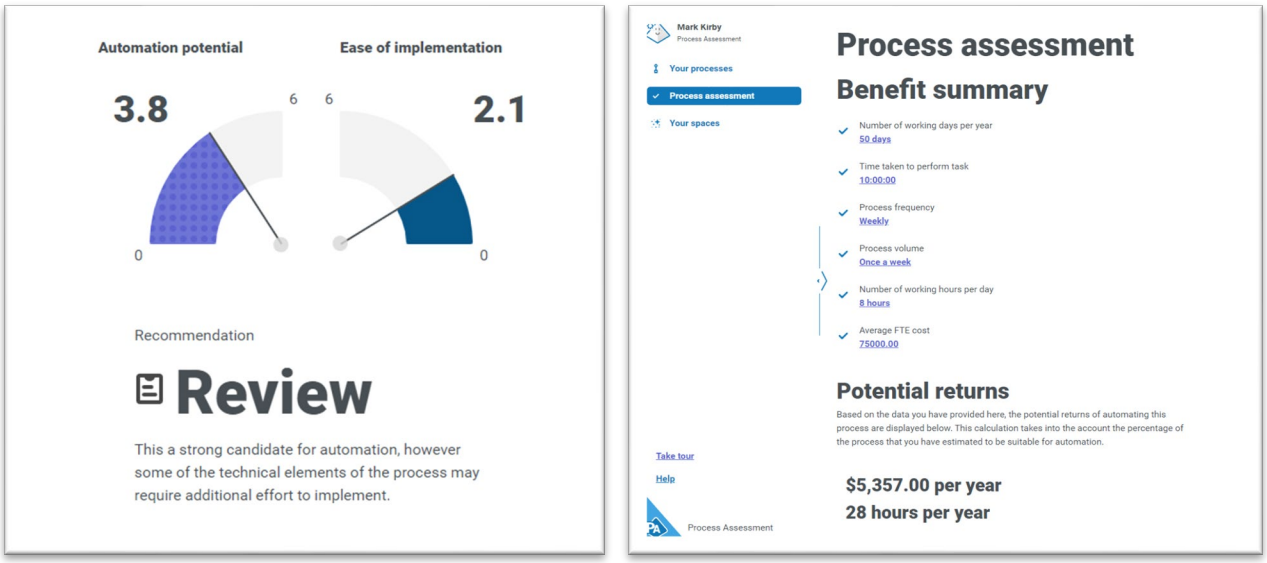

Figure 28 Machine learning example for process assessment (Blue Prism)

Key questions on a readiness checklist can help members navigate to the correct portal resources and suppliers. The portal should provide a high level, agnostic framework that sits above more application specific payback and evaluation tools provided by some A&R suppliers (for examples see Figure 29 and Figure 30). The checklist could evaluate what response mode a member is in: growth, trouble, even keel or overconfident. Case studies can be presented that resonate with the member. An example was mentioned in the survey where the lumber industry in Quebec successfully responded to an external crisis by employing big data and AI automation techniques.

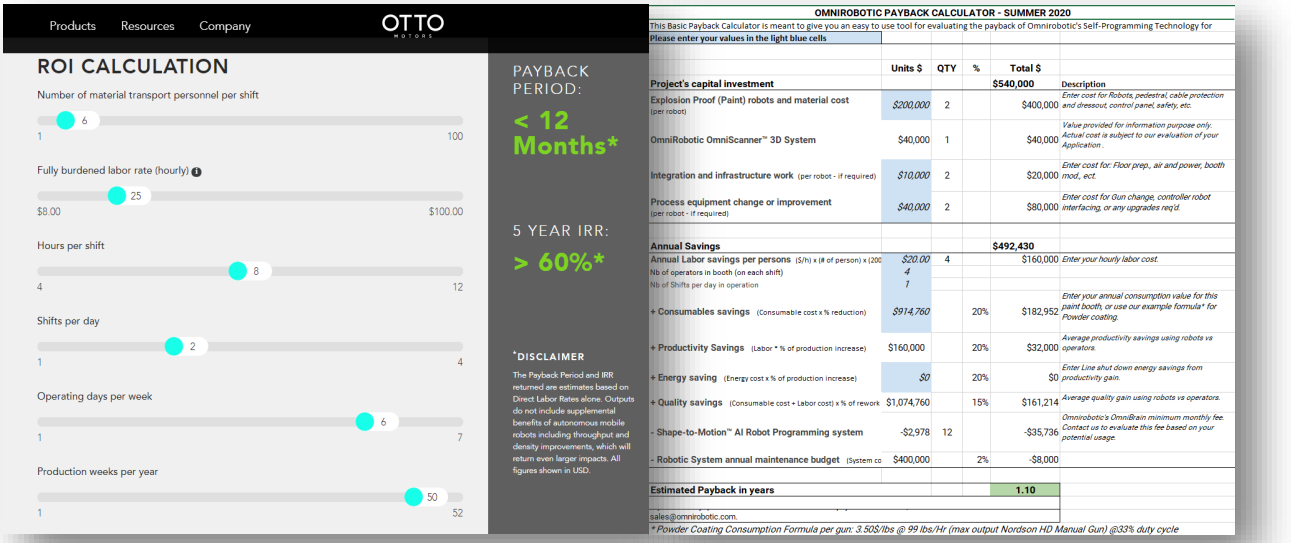

Figure 29 Payback calculators for specific applications (Otto Motors and OmniRobotics)

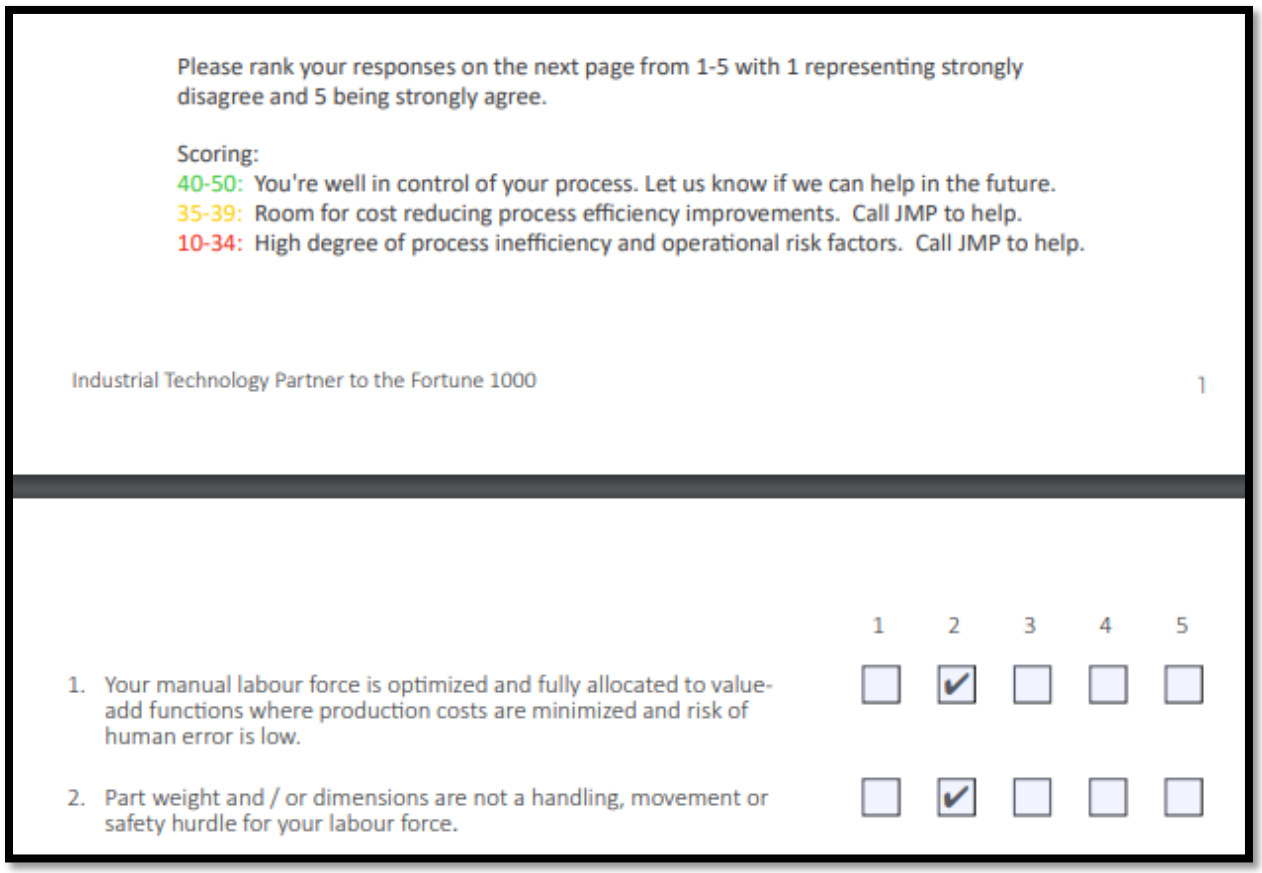

Figure 30 Self assessment worksheet, partial example (JMP Solutions)

Payback calculators can best help when the application is well defined. It may still be possible to provide useful value via the portal by giving members examples of different budget brackets and what can be accomplished for each cost increment, since the first question is often "How much will it cost?"

As an example, if a 3d vision system may be required as part of a solution, even though this sounds simple (get a point cloud for the shape) an expert would always ask more questions: "What resolution is needed, how big is the object to be imaged, how close is it, is it moving, what is the timescale, is it in a hostile environment?"

Even without answers to these questions, different solutions and capabilities could be presented to the user, with links to suppliers, in each budget bracket to encourage exploration as well as to better structure expectations, (see Table 2 as an example). The portal could provide a virtual solution shopping basket for members and a virtual storefront for A&R suppliers. Another example would be helping members understand cobots (see sidebar), and how these can provide a different cost/capability in the workplace.

Vision System Solutions	Consumer Grade Technology	Industrial Grade Entry level	Industrial Grade High Accuracy
Price bracket	***$200-$2000***	***$10k-$50k***	***$50k+***
Example	iPad Pro+apps	Laser scanner, structured light	High quality optics, robotic structured light

Table 2 Ngen portal can provide preliminary answers to capability/cost tradeoffs

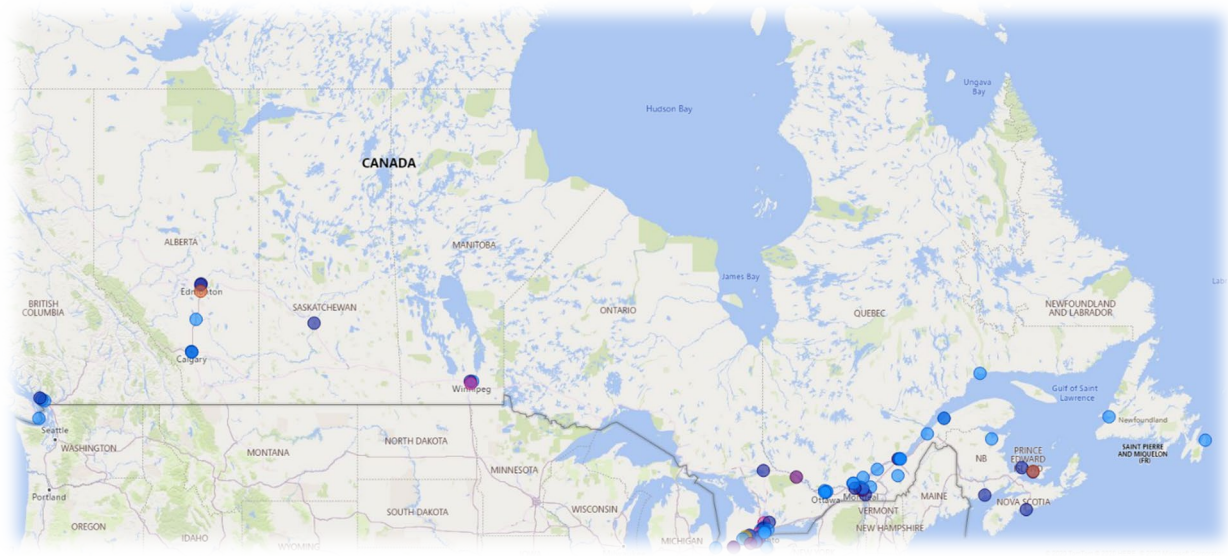

Figure 31 NGen portal could show members A&R suppliers, as well as industry installations by market/application, on asset maps

The NGen A&R advisory group could (and ideally should) provide much of the expert input needed to both guide members entering the portal and help shape the portal development

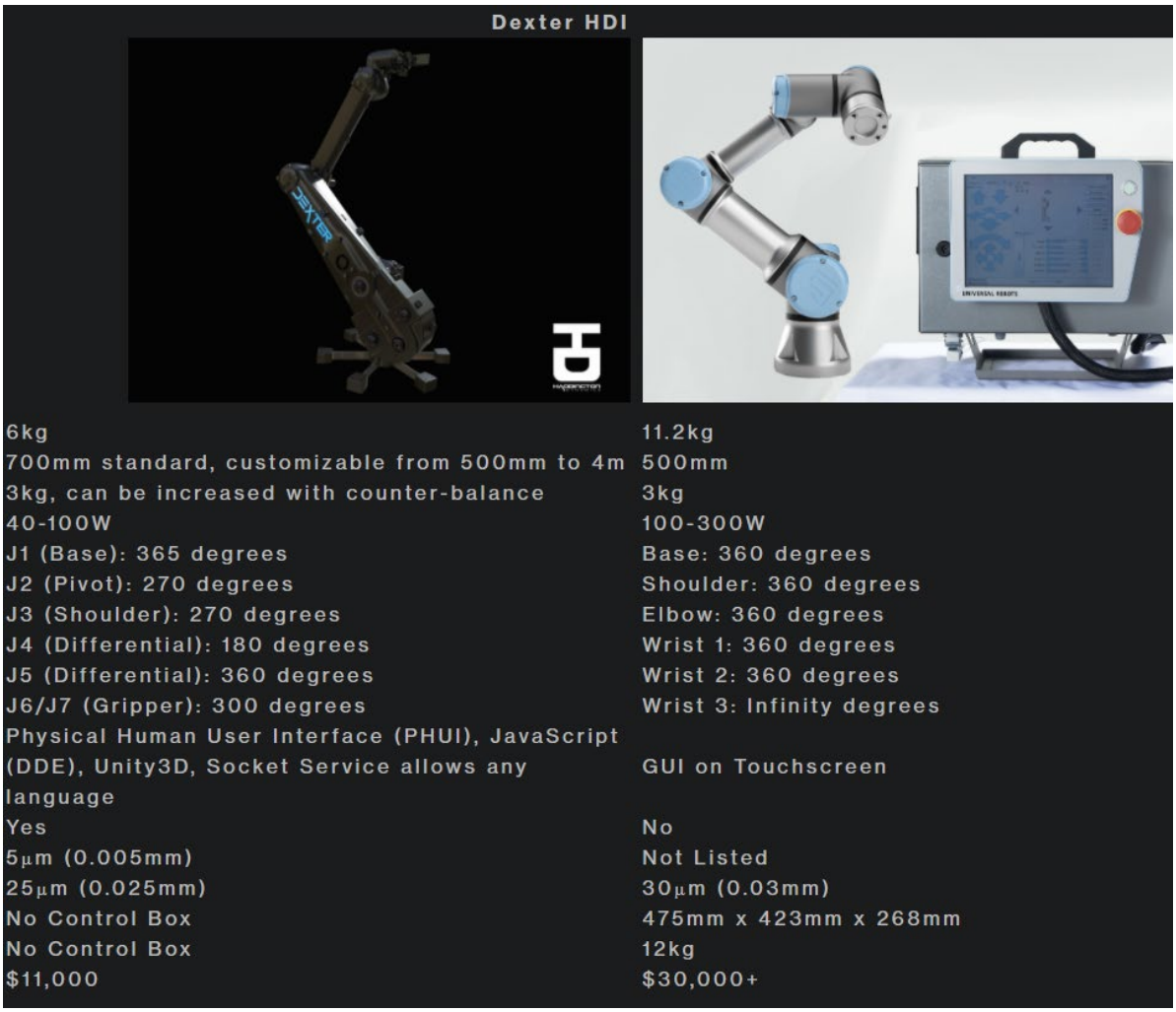

Figure 32 The portal can provide members with market intelligence on new technology developments such as very low cost robots like Dexter from Haddington Dynamics

Understanding Cobots

The affordability and reduced safety (not eliminated) requirements of the collaborative robot platforms allow us to think differently about the use and incorporation of automation. We are not constrained by the need to keep workers away from the robots and to keep the robots moving at maximum speeds without interruption. The collaborative systems can do many of the same things as industrial robots with the exception of payload, reach and speed, but were not an option to choose from in the past. In addition, we often can think of the collaborative systems as a tool for the skilled operator. The robot doing the 80% of the task that we often call the "acreage" or less complex/less skill required portions that are often tedious and repetitive, but necessary. The skilled operator continues to perform the portions of the task that are more complex and use their skills and cognitive capabilities – things that would require much more time and effort to configure and teach the robot to do. The operator can concentrate on tasks that use judgment and decision making and deploy the robot to tasks that benefit from the robot's consistency and durability. This reduces process inconsistencies and inefficiencies due to human fatigue, boredom and work stoppages, as well as the risk of repetitive motion injuries.

Text and image courtesy of Kane Robotics

Flexibility over Productivity?

Even if the process is well defined for a team of people, it may require rethinking completely for automation. As an example, domestic roofing contractors will often operate with one person on the ridge of the roof, feeding stockpiled asphalt shingles to several workers lower down on multiple sides.

However, it would not make sense to develop a robot to perform the identical task as the person on the roof ridge. Instead, a solution could be a robot arm with a shingle feeding mechanism that could manoeuvre and fix anywhere within its operating envelope, thus combining multiple tasks. The construction and fabrication industry has according to one respondent seen little automation adoption yet is a trillion-dollar market in North America. There is a worsening housing shortage, coupled with an aging and shrinking skilled trade force. However, according to the respondent while "current automation solutions for traditional manufacturing can help the construction industry, (they) don't solve the core issue of flexibility over productivity."

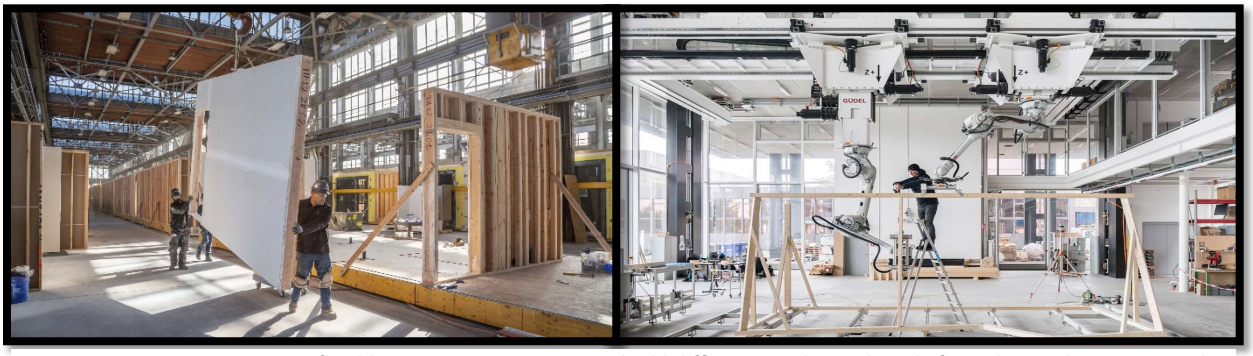

Figure 33Construction requires flexible automation systems to build different products, directly from design data. CAD2Path™ translates designs to data to dynamically direct, automate and monitor multi-function machines. The result: highly precise, highly flexible automated assembly and fabrication solutions for construction. (Excerpt from Construction PreFab, Courtesy of Brave Control Solutions)

3D Printed Robots and Microfactories

Current robots are precise because the parts that make up the robot are precisely machined. This requires high volume, expensive manufacturing processes, which are capital intensive. Deploying revolutionary robot technology licensed from Haddington Dynamics, Archytas Automation is planning to change the manufacturing paradigm.

Karen Caswelch, Co-Founder, explains more. "Our Microfactory concept to build this low-cost, highly precise robot can deliver economic opportunity to previously underdeveloped areas. All the robot's structural parts are 3D printed from Onyx (micro carbon fiber filled nylon) and PETG while the other hardware parts are mostly commodities. The Microfactories can build up to 40 robots a month with 8-10 employees, and each factory is supported through a 'factory in a box' concept, with consistent quality systems, build processes and supply chain management."

The low capital manufacturing approach – linked with the low cost, highly precise robot – is a key enabler to the future of automation, according to Caswelch.

Figure 34 Microfactory and 3d printing (Images courtesy of Archytas Automation)

"Canada cannot afford to lose its automotive industry."

Final Reflections, Closing Comments

Canada's history of automotive assembly and the resulting investment in automation and robotics has resulted in a strong A&R supply base that supports this sector domestically and exports to the US. A map of robot installations across the US (**Figure 35**) shows just how strategic the Windsor area is to the US epicentre of robots[5].

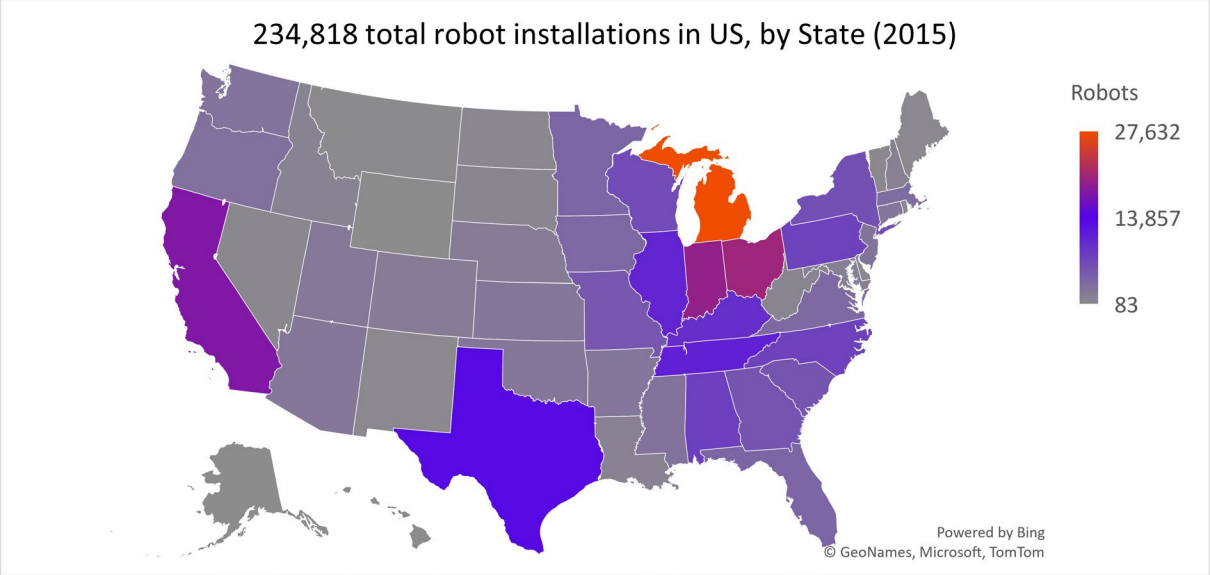

Figure 35 US Robot installations showing concentration along the Canadian border in Windsor area

While automation and robotics are also essential for other high volume manufacturing markets such as electronics, and food & beverage, Canada's A&R landscape has been, and continues to be, dominated by its automotive sector. With the emergence of electric vehicles there has been an increase in platform configuration complexity, as well as entirely new manufacturing challenges to mass produce high energy batteries for example. This increase in complexity might lead to a corresponding increase in A&R solutions. However, Tesla's recent move to consolidate parts suggests a different path with fewer (but larger) robots required for assembly. The only certainty is that if Canada can maintain its vehicle assembly market then new A&R investment and innovation will follow. Canada cannot afford to lose its automotive industry.

One of the key questions to ask (the company CEO) is - "What did you do in the past to change?"

For many Canadian companies A&R remains unappealing because of the relatively high cost and lack of flexibility, making it unattractive in a low volume, high mix, high uncertainty environment. The companies always "have a bigger emergency, and are not going to die today, or tomorrow." Even with new lower cost hardware such as cobots these companies may still not choose to invest. Some advisory board members felt that small companies often simply lacked a culture of innovation and an overwhelming desire to grow.

Canada has world class capability not only for automotive solutions but also for flexible assembly, autonomous mobile robots and kitting to name only a few important application areas. There is however strong global competition, and the Canadian market is often smaller and perhaps more risk averse than others. But for those Canadian companies that do want the best, and do want to scale, then the future looks exciting. Whether it is innovation driven by the auto sector, networks instead of islands of automation, or even distributed manufacturing enabled by additive manufacturing – future Canadian growth will literally be powered by the automation and robotics sector.

NGen can help all Canadian businesses by providing a web-based portal as the first stop and first step in their exploration of Automation and Robotics.

Endnotes

[1] https://ifr.org/downloads/press2018/Presentation_WR_2020.pdf
[2] https://itif.org/publications/2019/10/15/robotics-and-future-production-and-work
[3] https://workofthefuture.mit.edu/wp-content/uploads/2020/11/2020-Research-Brief-Berger.pdf
[4] https://www.sae.org/news/2021/01/magna-execs-warn-of-impending-ev-complexities
[5] https://www.brookings.edu/blog/the-avenue/2017/08/14/where-the-robots-are/

"Focus on those companies that want to grow"