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Strategic Insights Report
May 2019

The Big Makeover:

How Digital Transformation is Changing the Face of Canadian Manufacturing

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Foreword

Most manufacturing executives understand that we are entering a period of industry disruption so sweeping that it has already earned the weighty title Fourth Industrial Revolution. The source of this disruption is a wide range of new and emerging digital technologies that have the ability to radically transform processes and even render them obsolete. As Canadian manufacturers contemplate the challenges facing their industry, they would do well to remember Mark Twain's quip: "Everybody talks about the weather but nobody does anything about it." If manufacturers are to count themselves among the survivors of the Fourth Industrial Revolution, it won't be enough for them merely to talk about it – they too must do something about it.

But where to begin? What exactly are these new technologies, and who is using them? When will they really start making a competitive difference? And what do they mean for the industry? The purpose of this report is to provide some of the answers to these questions.

The IT Media Group (ITMG) undertook this research project with sponsorship from Salesforce Canada. The initiative was led by Nasheen Liu, ITMG Managing Partner and SVP Program Strategy. Primary research, industry polling, executive interviews, and initial content was completed by Dr. Peter Carr of the University of Waterloo. Dave Carey, ITMG VP Content, was responsible for additional research, content creation, and report editing. Content review, final edits, and report production was completed by Jeff Ishii, ITMG Chief Technologist and VP Operations.

This report contributes to ITMG's mission of supporting and adding value to the executive community in Canada. It is our goal to provide a wide range of opportunities for direct engagement between IT vendors and industry executives, enabling them to share knowledge and opinions, provide thought leadership, build relationships, and engage in a dialogue of benefit to both parties.

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Executive Summary

The manufacturing world is putting on a new face, and the makeover it is receiving from powerful new technologies has the potential to help Canada reaffirm its position as one of the world's leading manufacturing nations and win back work that has migrated to low-cost countries. Canada is currently ranked as the world's tenth largest manufacturer, but maintaining or improving that position will largely depend on whether or not the industry seizes the opportunities provided by new technologies to transform processes, reduce costs, build better ecosystems, spur innovation, and attract highly skilled workers.

With these new technologies available to all, Canada cannot afford to be a laggard in their uptake. Globalization makes the world a far too competitive place for that. However, 55% of our manufacturers have not yet invested in advanced manufacturing technologies and one in five does not intend to do so in the next five years. And in spite of our reputation as a leader in artificial intelligence, Canada ranked last out of ten countries in its implementation, with only 31% of firms claiming successful AI deployment.

Simply put, that's not good enough. We must do better. The objective of this report is to provide information that will help with that challenge.

Methodology

The IT Media Group has utilized its extensive relationships with leaders in the Canadian manufacturing and IT community in the preparation of this document. Research included analysis of ITMG's content repository and review of more than 70 articles and reports on digital transformation. A survey of Canadian manufacturers was specifically undertaken as part of the research, and findings can be found throughout. As well, the report includes insights and comments from interviews with dozens of manufacturing executives from across Canada and in a wide range of industry segments.

Scope

This study provides insights applicable to a wide range of businesses throughout the manufacturing ecosystem. It is intended for Canadian manufacturing executives, including CEOs, CIOs, CxOs and LoB leaders. The information herein applies to the entire range of functions throughout the industry, including the supply chain, the factory floor, product development, and sales and marketing. It is intended to shed light on how new digital technologies are impacting these functions, what present and future benefits they may offer, and the challenges involved in digital transformation.

Selected key findings

The report makes the case for why manufacturing matters in a country typically regarded as having a resource-based economy. In fact, manufacturing accounts for two thirds of Canada's exports, employs 1.81 million people, generates 11% of GDP, and is the biggest business sector in Canada. Also discussed is the regional make-up of the sector, and

the relatively slow uptake of new technologies by Canadian manufacturers. A section entitled “Drivers for Change” explores the dynamics behind the need to embrace transformative technologies.

A discussion around key technologies begins with the supply chain, which is being strongly impacted by AI and predictive analytics. Canadian transportation manufacturer Linamar is cited as an example of a company reaping the rewards of these technologies. Ottawa supply chain provider Kinaxis demonstrates the power of digital twins, and Mercuria shows how blockchain can make a big impact on logistics.

On the factory floor, impressive strides are being made with technologies such as additive manufacturing, machine learning, predictive and prescriptive maintenance, and advanced robotics. Cases cited include the making of the world’s first fully 3D printed e-motorcycle, Pratt & Whitney’s use of predictive maintenance for engines powering Bombardier’s C Series aircraft, and a soft robotic gripper, taught in a virtual environment with the aid of a digital twin, that mimics the human hand.

As for workers themselves, the report looks at connected worker technology and how it is making employees on the factory floor and in the field smarter, faster, safer, and even happier. It explains how 3M is using the technology to streamline the laborious safety inspection process at one of its large manufacturing plants. And finally, a look is taken at wearable technologies and how they are changing the lives of employees in production and service roles. Wearables cited include smart glasses for serving up information on a head-up display, wrist watches that can give the worker access to actionable workflow data, and gloves that can track and trace inventory, locate parts and provide fine motion control.

Conclusions and recommendations

There is much work to be done. Canadian manufacturers are already in catch-up mode, and the competition is fierce. Asia, Europe, and the U.S. will aggressively surge forward with digital transformation. We must do the same.

To help ensure success, organizations need to prepare for a transformation of their business models. Leaders also need to focus on evolving the workforce to be more digital and to nurture a company culture that embraces change.

This is no small feat. To ease this burden, we have provided industry insights, use-cases, and advice from Canadian manufacturing executives that will help organizations to foster innovation, become more customer centric, improve collaboration, and effectively leverage the vendor community.

Companies will need all hands on deck in order to survive. The industry has spent a lot of time talking about the Fourth Industrial Revolution. The time to start doing something about it is now.

Introduction: The digital imperatives for manufacturing

Canadian manufacturing leaders of all stripes, from CEOs to LoB executives to CIOs, must prepare themselves and their businesses for the coming wave of transformative technologies. This report provides manufacturing executives with a wealth of insights on which new technologies will have the most impact, how companies are implementing and reaping benefits from them, what the future holds for these technologies, and the challenges associated with them. Key trends in Canadian manufacturing are also identified, along with factors that are driving companies to invest in new technologies.

Why manufacturing matters

While much of the world thinks of Canada as a resource-based economy, the importance of the manufacturing sector cannot be overestimated. It is a vitally important element in the Canadian economy, providing tremendous export income and many high-quality, high-paying jobs.

The country's leading trade association in this sector, Canadian Manufacturers and Exporters (CME), notes that manufacturing:

- Accounts for two thirds of Canada's exports
- Employs 1.81 million people
- Generates 11% of Gross Domestic Product
- Is the biggest business sector in Canada

Manufacturing is an essential part of every province's economy, even that of tiny Prince Edward Island, whose manufacturers led the country in sales growth in 2016, and then increased that by another 8% in 2017, reaching almost $1.8 billion.

Not to be overlooked is manufacturing's importance as a driver of the knowledge economy, supporting the development and growth of Canada's tech sector in areas that will be valuable in international markets. Tech startups need customers. And manufacturers are big customers.

Regional tastes for technology

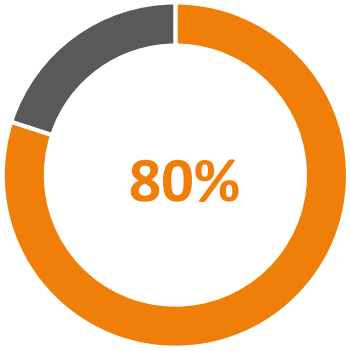
Regionally, there are clear differences in the appetite for new technologies, based on the types of manufacturing operations in those regions. Ontario's automotive sector, for example, relies on a mix of technologies such as AI and machine learning, along with emerging technologies such as wearable intelligent robots that assist humans in the manufacturing process. Forest products manufacturers in Quebec and B.C., already rich in data, are reaping benefits from AI and analytics that enable them to use that data to improve operations. In the Western provinces, where manufacturing is focused on sub-industries such as wood, food, petroleum, machinery and metal products, a host of opportunities is arising around things like mobile, the Internet of Things (IoT) and 3D printing, which will enable smaller manufacturers to transform operations. These advances also apply to the many smaller manufacturers in the

Atlantic Provinces; for example, intelligent packaging, which senses some properties of the food it encloses, may resonate in the fish processing industry.

"Canada's difficulty is in logistics. If we need multiple plants to work on producing a product, these plants need to be close together, but there are not a lot of close cities to allow that to happen. This means that the truck, rail, or flight requirements become a limiting factor for expediency and cost."
Global CTO, electronics manufacturer

Everybody's talking about it, but…

Canadian manufacturing executives might well be talking about how new technology is ushering in the Fourth Industrial Revolution, but as yet they aren't doing much about it. Most large manufacturers are considering its implications and have started to work with it, but overall, 55% of Canadian manufacturers have not yet invested in advanced technologies and one in five does not intend to do so in the next five years (CME). And in spite of Canada's reputation as a leader in artificial intelligence, the country ranked last out of ten, with only 31% claiming successful AI deployment, according to the Marketing Research and Intelligence Association.



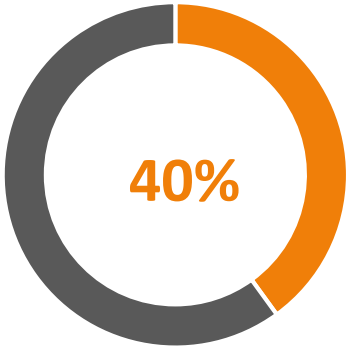
of respondents believe that digital transformation will significantly impact their company

Smaller companies have been slower to adopt new technologies, lacking the scale, resources and ability to invest. IDC reports that mid-sized organizations in Canada are lagging behind larger ones, with 54% of large manufacturers pursuing digital strategies and only 31 to 38% of mid-size companies doing so. This is confirmed by BDC (Business Development Bank of Canada), which found that 39% of Canadian small and mid-sized manufacturers have implemented Industry 4.0 projects, but most are in the early stages of adoption.

Provincially, Quebec is furthest ahead with 46% of small to medium-sized manufacturers having implemented digital technologies, followed by Manitoba and Saskatchewan at 44%, British Columbia and Ontario at 39%, Alberta at 36% and Atlantic Canada at 32%.

Drivers for change

So what is driving this need to embrace that endlessly buzzed about thing we call digital transformation? Well, that word *transformation* should be a big clue. Steam and water power didn't merely change the nature of industry in the nineteenth century; it kicked it in its sleepy backside and transformed it into a globe-spanning juggernaut. Those that succeeded in this First Industrial Revolution were the ones that were quick to figure out how to transform their businesses with the new capabilities at hand. Those that failed were the laggards and naysayers – and they were quick to disappear. History repeated itself in the Second and Third Industrial Revolutions, and the same will be true of the Fourth. Those savvy enough to understand the transformative wave about to hit their industry, and confident enough to do something about it, will succeed. Those who don't will likely find themselves on the lengthy casualty list associated with previous Industrial Revolutions.



of respondents said "changing international trading conditions" would influence their digital transformation decisions

A key driver for this new Revolution is globalization. No longer can manufacturers rely on domestic markets for their bread and butter. To be successful, they must tap global markets, even as those same markets bring stiff competition to Canadian firms on their home turf. And on the global stage, the prize does not go to the steady Eddies. It's those companies that can outcompete their competitors in such areas as price, quality, service and innovation that will win the day – all things that can be dramatically improved by new digital technologies.

"Manufacturing is on the decline in Canada, primarily due to globalization. Canada has higher costs than other locations. The critical mass required to leverage a broad base of manufacturing expertise is on the decline."
CIO, automotive manufacturer

Customer expectations are also driving the move to powerful new digital technologies. Business customers – especially those employing lean methodologies – expect higher levels of service and flexibility, and closer levels of collaboration with their suppliers. All of these are getting a big makeover with new technologies.

Consumers are experts at determining the best price and quality of the goods they are interested in, have more choice than ever before, and they want everything yesterday, making it incumbent on sellers to enhance their product offerings and provide high levels of customer service. This in turn puts pressure on manufacturers to excel at

all aspects of their business, from product development to the factory floor to the end-to-end supply chain. The cold dynamics of the situation are beyond argument: not taking advantage of the new technologies that are transforming these areas of the business will inevitably render many companies uncompetitive – a fact that manufacturing executives must carefully weigh when making investment decisions.

A guide to navigating the digital landscape

This study provides insights applicable to a wide range of businesses throughout the manufacturing ecosystem. It is intended for Canadian manufacturing executives, including CEOs, CIOs, CxOs and LoB leaders. The information herein applies to the entire range of functions throughout the industry, including the supply chain, the factory floor, product development, and sales and marketing. It is intended to shed light on how new digital technologies are impacting these functions, what present and future benefits they may offer, the challenges involved in digital transformation, and advice for successfully navigating the digital transformation journey.

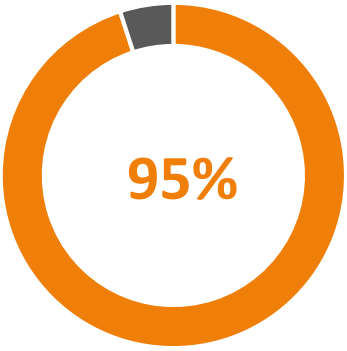
As a long-time content and event producer in the Canadian technology sector, The IT Media Group (ITMG) has captured countless insights on the impacts of digital transformation. This study taps into that storehouse of knowledge, gathered from eight years of hosting private roundtables with technology executives across Canada. In addition, we completed both global and Canada specific industry research and interviewed dozens of Canadian manufacturing leaders across 20 companies. Finally, in March 2019, we conducted a poll focusing on digital transformation on a cross-section of Canadian executives, whose organizations have manufacturing interests in all 10 provinces and all three territories.

The Big Makeover: Changing the face of manufacturers

While Canadian manufacturers cautiously dip their toes into the digital transformation waters, an extraordinary immersive experience awaits them when they finally take the plunge. Even at this formative stage of development, 60% of small to medium-size manufacturers adopting such technology said that it boosted productivity; 50% said it improved operating costs; 42% said it improved quality; and 13% said it gave them greater capacity to innovate, according to BDC. What's more, they predicted greater growth than their competitors because of it.

The very nature of manufacturing makes it ripe for digitization. A host of new and diverse technologies are entering the market that have the ability to turn the industry on its ear. Their impact will be felt in such areas as the supply chain, customer relationships, equipment maintenance, and factory floor operations. This section describes some of the possibilities that are available – and more are appearing every day.

Supply Chain 4.0: Creating the new customer experience



of respondents indicated that customer expectations would influence their decisions on digital transformation

Ultimately, the supply chain is about serving the end customer, and today's customers are a whole new breed compared to previous generations: they are awash in choices, they're rigorous comparative shoppers when it comes to price, quality and features, they expect great service, and they want near instant gratification. And if that isn't enough to give a manufacturing executive heartburn, they're also strongly influenced by social media and acutely sensitive to corporate security and ethics lapses – one false step and a customer can be lost for life.

"We did a series of engagements with supply chain and process improvement consultants. Every time we mapped out a process, we could launch a series of very effective lean projects that focused on corporate objectives, growth strategy, and industry trends."
Senior Vice President, commercial manufacturer

All of that can be translated into a critical business imperative: the supply chain must be seen as one of the corporate crown jewels, and every effort must be made to ensure that it equals or excels that of other global manufacturers, who are beating the bushes for new technologies that will allow them to steal market share from their competition. Canadian companies must find ways to exploit new technologies that impact the supply chain, or fall to the wayside.

> "Customer experience must be better or different. The goal is to give customers some form of customization quickly and easily."
> CTO, Industry & Enterprise Architecture, global manufacturer

Some of the powerful technologies that will reshape the supply chain are artificial intelligence (AI), predictive analytics, digital twins and blockchain.

AI and predictive analytics create competitive advantages

Nowhere is AI having a bigger impact than in the automotive industry, which has staked much of its future on autonomous vehicles. And how profound might the impact of this AI-enabled market segment be? Intel predicts it will be worth US$7 trillion dollars in the next three decades, and that self-driving vehicles could save almost 600,000 lives from 2035 to 2045. But automotive AI doesn't start and end with autonomous vehicles. AI-based predictive capabilities are helping manufacturers anticipate future market demand, enabling them to design and produce vehicles with much more sensitivity to customer desires. Transport and delivery can be taken to the next level of efficiency, eliminating costly logistics errors and miscalculations. And AI is already being used to analyze photos and detect damage to vehicles in transit. It is also being used in automotive and other types of manufacturing to create numerous opportunities to reduce costs, improve operations, and optimize pricing by predicting and matching demand and supply, notes McKinsey.

> "It comes down to having data at your fingertips. You can't manage what you can't measure. Data lets you do that. You have to agree that you are a data-driven company."
> Head of IT, smart cities provider

At Linamar, a Canadian manufacturer of transportation, infrastructure, and agricultural parts and equipment, AI means more market share. The company, which earned $6.5 billion in 2017, is applying AI-enabled machine learning to advanced robotics, equipment data analysis, prediction, vision systems, and 3D printing. The widespread use of AI has contributed to the company's double-digit revenue and profit growth, and has supported a trend toward a larger workforce with higher wages due to the company's increased competitiveness.

> "The connection between the stores and manufacturers regarding supply forecast and product replenishment can be greatly improved by automation. Tools such as AI, ML and big data analytics can play a big role in making the business more efficient and effective."
> Manger, Finance, retail and logistics distribution company

New technologies are emerging so quickly in the auto industry that OEMs are having a tough time keeping up. By the time they learn a new technology and how to implement it into their supply chain, the technology is already "old" by innovation standards, asserts media firm Supply Chain Dive.

Digital twins join the manufacturing family

As in the parenting world, the arrival of twins in the manufacturing world is turning out to be an important, if disruptive, event. The twins we are talking about here are the digital variety: simulated models of real objects that change as the corresponding real objects change, integrating input from things like AI, machine learning, and IoT. Digital twins continuously learn from a variety of sources including their own operating conditions, industry experts, and similar objects.

Manufacturing executives would do well to pay attention to this emerging technology, as it could have a profound impact on the industry. Deloitte notes that digital twins can provide a complete digital footprint of products from design and development through to the end of the life cycle, enabling companies to realize significant value in speed to market, improved operations, reduced defects, and the creation of new business models.

> "We created a digital twin of the factory floor. It identifies money-saving opportunities when designing overall process flows and allows virtual planning of the factory, reducing re-work costs during the build. It also provides us the ability to define what investments are required to build the factory."
> Head, technology manufacturer

Ottawa-based Kinaxis has become a world leader in supply chain management for manufacturers, based on its unique ability to create a digital twin of an entire end-to-end supply chain data set, often measured in billions of records, in a fraction of a second. Users can simulate any event, anytime, from anywhere; and by creating "what if" scenarios, they can fine-tune their supply chain strategy. Kinaxis' customers include the likes of Casio, Celestica, Ford, Nikon and Toyota.

Blockchain enters the supply chain

Manufacturing executives responsible for the supply chain face the daunting task of riding herd on innumerable entities, from suppliers, to sources of raw materials, to logistics operations, to regulations and certifications, to endless forms of paperwork and communications, and the list goes on. All of these things contribute to a mountain of data that can be mined for ways to improve the process – but how to do it efficiently and transparently? Enter blockchain, a powerful new technology with its sights set squarely on the manufacturing industry.

> "A future possibility for the use of blockchain technologies is for the creation of a service bureau to offload underlying services that can be shared amongst manufacturers."
> COO, commercial manufacturer and distributor

In essence, blockchain is a distributed ledger that records and compares encrypted transactions on many different machines, none of which holds all of the information. The data cannot be altered retroactively, making transactions

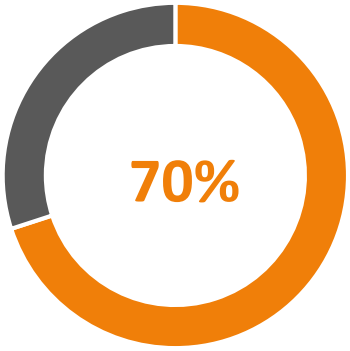
highly secure and verifiable, and particularly suited to the manufacturing industry's complex supply chains. In fact, Forbes asserts that blockchain will increase visibility across every area of manufacturing starting with suppliers, strategic sourcing, procurement, and supplier quality to shop floor operations, including machine-level monitoring and service, enabling entirely new manufacturing business models.

Still, blockchain is in its infancy, with only 3% of organizations implementing use cases on a large scale, according to Capgemini. And the manufacturing industry has yet to embrace it in any significant way. But we can turn to logistics to see what kind of an impact it can have in the real world. In 2017, Mercuria, one of the world's largest commodity traders, announced the first large oil trade based on blockchain. "Thanks to blockchain technology, we are able to bring more efficiency into a typical commodity chain," said the company's CEO, Marco Dunand. "If you take a crude oil cargo loading in West Africa and going to Asia, it typically takes about forty days for the documents – the bills of lading and so forth – to circulate before they come to the end user. We've run these tests on a parallel basis and we did it in seven days." Dunand said he could see blockchains reducing transactional costs in some markets by as much as 30 percent.

Cheaper, better, faster: How digital is disrupting the factory floor

Reduced costs, continuously improving processes, greater speed to market – these are the things all manufacturers strive for. And with the new digital technologies, they are becoming more achievable goals than ever before.

Some of the new technologies that can be brought to bear in the pursuit of cheaper, better, faster are 3D printing, machine learning, predictive and prescriptive maintenance, and advanced robotics.



of respondents said "a desire to create new products and/or services" would influence their digital transformation decisions

Doing it cheaper

When it comes to cheaper, manufacturers are gravitating towards the remarkable technology of 3D printing. Unlike traditional manufacturing methods, which are subtractive in nature, 3D printing is an additive process, building up objects layer by layer using a variety of materials such as thermoplastics, resins, powders, nylon and photopolymers. Hence the alternative name *additive manufacturing*, or AM.

The technology came to the public's attention in the early 2010s, when home 3D printers briefly held the spotlight, and imaginations started running wild over where the technology would go. Well, as far as the public was concerned, it didn't go far, and like many other overhyped products, it soon faded from the public consciousness.

But for manufacturers, the potential for 3D printing was tantalizing, and R&D continued apace to the point where the technology is now a thriving part of the industry with a projected CAGR of 22.3% over the next three years, and an expected market value of US$36 billion by 2021, according to Deloitte. 3D printers have graduated from turning out cheap plastic trinkets at home to producing complex hard-to-make parts for demanding industries such as aerospace and automotive.

> "Incremental adoption of AM can outperform complete workflow rework by ensuring the best process is chosen on its own merits, not due to its novelty or to its disruptive quality. Remember: The early bird gets the worm, but the second mouse gets the cheese."
> President, additive manufacturing firm

For manufacturing executives still uncertain about the capabilities and benefits of additive manufacturing within their own operations, consider the following:

- German design firm NOWlab has developed the world's first fully 3D printed and functional e-motorcycle, the NERA e-motorcycle. All bike parts, excluding electrical components, have been 3D printed, including tires, rims, frame, fork and seat.
- The U.S. Department of Energy's Manufacturing Demonstration Facility has a Big Area Additive Manufacturing (BAAM) machine that has 3D printed a car, a house and the hull of a submarine.
- Bell Helicopter, a frequent user of additive manufacturing for prototyping, has set its sights on employing additively manufactured components throughout the aircraft systems of their commercial helicopters.
- General Motors, long a user of 3D printing in Canada, is bolstering additive manufacturing throughout its operations.

Doing it better

In this age of fierce global competition, continuous quality improvement has become table stakes for manufacturers. Achieving it demands that the organization incorporate new technologies and rigorously seek to improve and fine tune processes.

> "If you have an organization where continuous improvement is part of the culture, it makes it much easier to change."
> President, package and printing firm

In the pursuit of better, two important technologies for manufacturers are machine learning and predictive and prescriptive maintenance.

Machine learning, a subset of AI, uses algorithms and statistical models to help make predictions or decisions. On the factory floor, it can be used to continuously monitor all of the manufacturer's equipment and detect problems that

could lead to malfunction or failure. It's also a great way to keep tabs on quality, predicting the quality of a product early in its development to within a millimeter. Produce first, check the quality later? That approach could soon be a thing of the past thanks to machine learning solutions, according to Hannover Messe. The company suggests conventional testing could be almost completely replaced in the future.

While machine learning holds great promise for the factory floor, its benefits can be extended to other aspects of the manufacturer's business as well. Powered by machine learning, predictive analytics and natural language processing, Salesforce's Einstein gets smarter with every interaction and additional piece of data. Its intelligence can be embedded within the context of company's sales and marketing operations, automatically discovering relevant insights, predicting future behavior, proactively recommending best next actions and even automating tasks.

> "A number might be returned, predicting the likelihood of closing a deal… it would say what informed this prediction and the follow-up steps that would increase the probability of closing the deal."
> Director of Data Science, Salesforce Einstein

Most manufacturing executives will be familiar with predictive maintenance, Industry 4.0's leap forward from preventive maintenance, using real equipment conditions to determine maintenance, rather than merely machine-life statistics. By continuously monitoring the condition of the equipment, maintenance can be scheduled in the most cost-effective manner, and unplanned downtime can be reduced.

Prescriptive maintenance, the powerful follow-on to predictive maintenance, is already beginning to emerge as the logical next step in the evolution of equipment servicing. Also enabled by AI, prescriptive maintenance seeks to "explicitly diagnose root cause issues and then indicate precise and timely actions to change the outcome in a timely manner", according to Machine Learning and Deep Learning Engineer, Partha Deka, who describes the technology as a paradigm shift in capability.

> "Our traditional business was to wait for a customer call because a machine broke or knock on a customer's door to walk around and see what they need. We're moving to a model where the data and analytics tell us those things in advance."
> CIO, industrial equipment company

Just how powerful can predictive maintenance be? Aircraft engine manufacturer Pratt & Whitney provides a telling example. The company's eFAST data acquisition system has been in use on Pratt & Whitney engines powering Bombardier's C Series aircraft for two years now, providing a wealth of information that is being utilized for predictive maintenance. "Today, the data generated by one flight on our C Series platform is more than the data generated in flight from our entire existing fleet," said Pratt & Whitney's associate director, engine health monitoring, Karine Lavoie-Trembley in an interview with MRO-Network.com.

Ultimately, the impact of such advances in the airline industry will be huge, as with predictive – and ultimately prescriptive – maintenance, the airlines themselves will be much better able to manage and schedule their fleets, resulting in less downtime and huge savings.

Doing it faster

While early industrial robots were great at repetitive tasks, they were sorely lacking in the brains department. Today, they are relative geniuses, having more in common with C3PO and R2D2 than their ancestors from the 1960s and 70s. The industrial robots of today can leverage the cloud, AI, IoT, augmented reality and a host of other advanced technologies to perform complex tasks and learn on the job while speeding up factory floor operations.

Cloud robots facilitate the delegation of tasks to robots, effectively giving them a brain in the cloud. With the arrival of 5G wireless connectivity, cloud robots will be able to fully realize their potential in manufacturing environments. With near real-time communication with the cloud, and interconnectivity between each other, these robots will be able to take on many different types of tasks and facilitate better factory workflow.

Manufacturing executives concerned about the cost of such robotic devices can take heart from the rise of "Robot as a Service", or RaaS. This rental-type business model will allow manufacturers to make use of robots without incurring the prohibitive cost of purchasing them. Innova Research predicts that by 2020, 30% of robots will be sold globally on the RaaS business model.

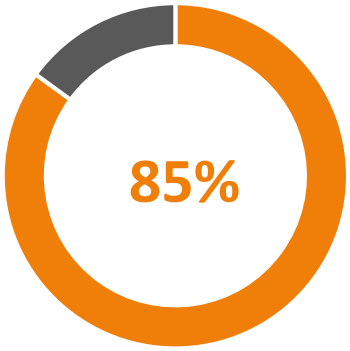
Not only are robots doing things faster these days, they're also doing them safer, with the introduction of 'soft robots' built of smart fabrics, pliable materials and inflatable bladders helping prevent injuries to humans on the factory floor. Festo Corp.'s BionicSoftHand, a pneumatic robotic gripper that mimics the human hand and interacts safely with people, is one such device. Its movement strategy is taught in a virtual environment with the aid of a digital twin, created with the help of data from a depth-sensing camera via computer vision and AI algorithms.

Man meets machine: Bringing digital up close and personal

Manufacturing's makeover by new digital technologies would not be complete without a makeover for employees themselves, and they are getting one with a spate of new technologies and capabilities that leverage such things as the cloud, IoT, augmented reality and 5G connectivity. All of these aids can be part of the toolbox for the connected worker.

> "IoT is the key for defining our path to business modernization. We're using sensors in the meeting rooms and plants and creating a smart environment for productivity gain. We're also using connected worker technology to optimize the process and workforce."
>
> Head of IT Operations, pharmaceutical manufacturer

If you are not sure if connected workers will have much of an impact on your company's future, you are in a distinct minority. In a survey of over 500 manufacturing executives in North America, Europe and Asia, Accenture found that 85% believe connected workers will be commonplace in their plants by 2020, and more than half expect large productivity improvements as a result.



of manufacturing executives believe that connected workers will be commonpace in their plants by 2020

Today's employees are inseparable from their smart devices. They want and expect to use them in their jobs, and connected worker technology allows them to do that. Such workers are able to access critical information in real time on the factory floor or in the field, enabling them to complete jobs faster, avoid accidents, instantly access manuals and operating procedures, receive on-site coaching, improve first-time fix rates, prevent catastrophic failures, and collaborate better with team members.

3M used connected worker technology to streamline the laborious safety inspection process at one of its large manufacturing plants, which involved thousands of monthly inspections that required printing, stapling and sorting paperwork, along with time-consuming administrative steps. The solution identifies each individual station and applies a number and RFID tag to it. Technicians receive a list of inspection locations and expectations on a hand-held device or smart phone, and with the RFID tagged equipment, they're able to perform tasks with greater accountability and verification. The system is programmed with questions specific to each safety check, and users can expand on inspection metrics by adding real-time photos and comments to document historical context for why a particular inspection passed or failed.

Connected workers now have access to a remarkable array of wearable technologies, including such devices as smart glasses and goggles, which can serve up information on a simple head-up display, wrist watches that can give workers access to actionable workflow data and provide real-time feedback about product defects or process deviations, and gloves and cuffs that can track and trace inventory, locate parts and provide fine motion control. With safety an important priority, workers can don footwear that determines if they are lifting loads above the recommended weight; they can be outfitted with innumerable sensors that monitor information such as toxic gas exposure, breathing, heart rate, posture and motion; and they can wear hard hats and caps with embedded biometric readers that can monitor such things as stress and fatigue.

"We're looking at using augmented reality, using a headset paired with a handheld device, to direct the picker to the right part and verify it's the right one. That will reduce human error and improve profit."
CIO, consumer goods manufacturer

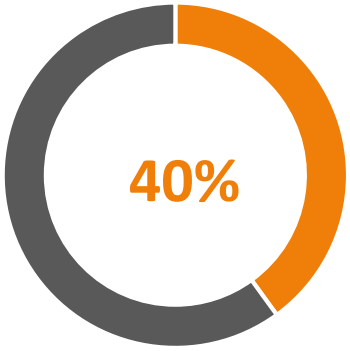
In addition to wearables, connected workers will also eventually be able to make use of Virtual Employee Assistants (VEAs), which will equip them with voice interface chatbots along the lines of Siri, Google and Alexa. VEAs are likely to find their way into manufacturing applications over the next few years, as they are already ramping up their presence in the enterprise, with Gartner predicting their use by 25% of digital workers by 2021.

Preparing for the makeover

The myriad of digital solutions becoming available for Canadian manufacturers presents extraordinary opportunities to improve both the top and bottom lines of the business; however, these opportunities come at no small expense. To truly embrace digital transformation, organizations must be prepared for a radical new look to their business models, their workforce, and their leadership.

A new look for manufacturers

There's no doubt that new and emerging technologies will fundamentally change the manufacturing industry. Many of today's companies will look very different in the future. New partnerships will form and better supply chain collaboration will allow them to work together in a highly effective manner, spurring new products, services and businesses. In fact, IDC reports that 63% of Canadian manufacturing companies are developing new business models through creating digital channels and business platforms, and 47% are expanding to new industries.



of respondents said that "a desire to create a new business model" would influence their decisions on digital transformation

Car manufacturers, for example, are investing in their own car share companies, exploiting technologies that enable sharing and anticipate changes in customer demand.

As businesses transform, they will create new relationships with organizations that provide products and services. As new business ecosystems form, the supply chain will become a critical competitive factor. Cloud services will play a key role in information sharing, and collaboration tools will enable members of the ecosystem to work better together, improve processes and respond more quickly to dynamic markets. IoT will become more and more relied upon to track activity, and AI will process big data from the entire supply chain to provide actionable insights.

A new look for the workforce

New business processes, models and ecosystems are putting manufacturing workers in the cross-hairs of change: changing roles, changing methods, changing work groups, changing management approaches – and perhaps most

important of all, changing skill sets. Not surprisingly, technology skills are a hot commodity as companies embark on digital transformation.

"As we introduce machines that do things differently (better, faster, customizable, digital), it requires new skills. Now we need IT skills that also have an operational technology understanding. We need data scientists, data analysts, BI specialists, and human/computer/machine interface experts. And these people are expensive."
CTO, Industry & Enterprise Architecture, global manufacturer

The Canadian Manufacturers and Exporters report that 35% of Canadian manufacturers see attracting or retaining skilled labour as a challenge. Our research indicates that, in a majority of cases, alignment of existing organizational skills with those that are required by the new technologies is weak. The new skills required are often technical but will also include communications, team work and continuous improvement.

of respondents said that "skills and knowledge of their existing employees" was a limiting factor in digital transformation

The good news for the industry is that digital transformation is making manufacturing environments more attractive. Many companies have already moved beyond dirty, repetitive, dangerous jobs and are now becoming fast-moving, technically advanced places to work. That makes them more attractive to millennials and young graduates who want jobs that will enable them to apply their high skill levels to interesting projects.

"We have people in enterprise environments that live and breathe data – many others don't and that is a challenge for them. They don't know why they would use technology and they don't understand the benefits that they will get. You need to staff with people who know technology and can help to apply and use it."
Head of IT, smart cities provider

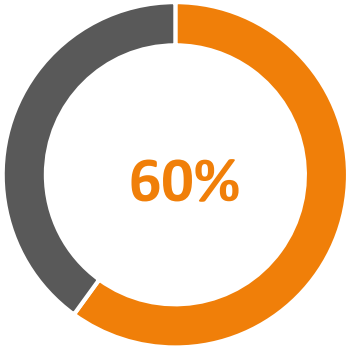
Employees need to be more learning-oriented than ever before, with skills and knowledge becoming a moving target as technology advances. Companies need to adopt programs that are designed to encourage employee education beyond the workplace, to stimulate creativity, and develop a thirst for lifelong learning.

> "Our CEO says this is a journey we must embark on, and it will be the survival of the fittest. Many people aren't prepared and fear they may not be competent enough to learn new skills. It's a journey of feeling uncomfortable until you get there, so it's turbulence for the next few years."
> CMO, oil and gas company

A remaining challenge is to capture the knowledge of boomers before they leave the organization. Connected worker technology is helping in this regard, making the knowledge of older workers no longer able or willing to work in difficult field conditions instantly available to their younger replacements.

A new look for leadership

Executives take note: our research clearly indicates that digital transformation in manufacturing will fail if there is not strong leadership in support of it – leadership from the top and throughout the managerial ranks. So far there is not much evidence of that happening. IDG reports that only 18% of organizations have thus far considered the change management that digital transformation will require.

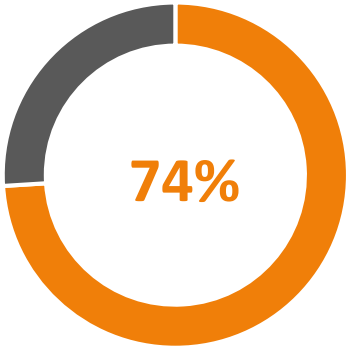


of respondents said that "lack of commitment from their senior management team" was a barrier to digital transformation

Transformational change requires the involvement of the entire senior leadership team, including the CEO. Each leader must ensure the participation of their people and model the behaviors that are needed in the innovation culture. Change, of course, is a source of fear for employees, and only those at the top can dispel it. The senior management team needs to reflect the behaviors that it expects in the rest of the organization, and managers throughout the organization must be able to motivate and lead employees throughout the challenging times ahead.

"Transformational changes can only happen when leadership have the ability to lead the change. It's extremely important that leaders don't say one thing and do another. They have to be one hundred percent behind the change; otherwise it's not going to happen."
VP, HR, manufacturing distribution company

Jabil reports that 74% of organizations believe that cultural changes are more challenging than technology changes in digital transformation. Success requires a clear strategy to support the implementation, thorough planning, good governance, excellent communications, adequate time, and strong employee engagement that includes the appropriate resources and training.



of organizations believe that cultural change is more challenging than technology change

Success also requires that the information technology function works closely with the operational elements of the organization. IT needs to better understand the requirements of operations than it often does today and the operations function needs to better understand the possibilities that exist from technology. The two functions need to collaborate.

"People want to be coached; they want to be motivated. If you're really out there for them – trying to understand what their motivation is and where their talents are, giving them feedback and helping them correct – then you will have somebody loyal for life."
Global CIO, aerospace manufacturer

Pulling it all together

Canadian manufacturers who have prepared themselves for the changes that digital transformation offers, still require advice on how to complete, or even begin their journeys. Our research has revealed a number of best practices that can be used by manufacturing executives to develop and execute the strategies necessary for successful digital transformation.

This section provides guidance for leaders on the effective use of technology to create sustainable change. We have paired that advice with words of wisdom from a cross section of Canadian manufacturing executives.

Moving the needle on innovation

Most manufacturers are very good at doing what they do today, however they are less good at inspiring innovative change. Companies need to welcome ideas and find better ways to generate them. They need to make resources available for innovation, and create processes that can take ideas and make them happen.

> "We recently had a hack-a-thon and all the different lines of business came together to solve one problem. All sorts of new ideas popped up and then they were judged in a Shark Tank type of format."
> CIO, automotive supplier

Pilots are a popular way to get innovative ideas off the ground. CDW estimates that 86% of organizations have initiated or piloted technology changes to support digital transformation. For many firms, however, there is little or no progress after the pilot stage because of the scale of investment and organizational change that are required to move forward. It's simply a high degree of risk that many are not prepared to take. A carefully staged strategy, rigorous vetting of projects, and earmarked pool of dollars designated for innovation are ways of overcoming this.

But pilots are only part of the picture. Successful innovation requires a culture, processes and practices that enable innovation to happen. This is especially important in digital transformation because the sweeping change it engenders requires the ability to rapidly respond to problems and opportunities.

> "We put an innovation council in place, chaired by the COO. We gathered agenda items and then brought the business leaders together to prioritize decisions. We looked at twenty things we could do, but drew the line at six or eight that we baked right into the planning process."
> Senior Business Partner, manufacturing logistics company

In organizations that are not good innovators, transformative initiatives are more likely to fail because of the inability to respond when challenges are encountered. And that could be the death knell of the business. In today's world, if you fail to seize emerging opportunities as they arise, you will be overtaken by those that can.

> "My groups have to have their own vision – they've envisioned where they're going to be five years down the road and they present that roadmap and vision to the entire organization."
> CEO, chemical producer

Putting the customer in the driver's seat

As manufacturers change products, processes and business models, it is critically important that they are sensitive to the impact that such transformation is having on the customer. The needs and expectations of customers should drive these investments and should be the focus of efforts to improve and fine tune them.

Customer relationship management (CRM) tools are an important pathway to more effective engagement. CRM can be enhanced with technologies such as IoT, which enables much more data to be gathered, and AI, which helps make sense of the data and provides a better understanding of customer motivators and behavior. As well, social media provides powerful tools for engagement and insight into customer behavior.

> "Once the manufacturing processes were made efficient, we needed to have sales processes modernized as well. We brought in a CRM system and started small, then integrated it with our ERP system to automatically import sales data. We also automated our manual customer budgeting processes to provide better visibility than what was available in the ERP."
> President, packaging and printing company

Canadian Tire's 'Tested for Life in Canada' program involves customers in its marketing and product development process. From 75,000 applicants willing to test products at home and share their experiences with other testers and customers online, the company whittled its test group to 15,000, reflecting a cross section of typical Canadian customers. These testers provide more in-depth product analysis than is typically found in customer reviews, and the information can be directly fed back to suppliers so that they can tweak their products and make them more desirable to the retailer's customer base. Launched in 2015, 'Tested for Life in Canada' is now a branded part of Canadian Tire's marketing strategy.

Crowdsourcing is also an effective means of gleaning customer insights. For example, LEGO has a highly visual and engaging 'Ideas' portal that taps fans for ideas for new toy sets. Not only are portal visitors given the opportunity to submit their ideas, they are enticed – with prizes such as shopping sprees, signed Lego sets, and even trips – to enter contests aimed at generating new product ideas. For example, Star Wars kits are a Lego mainstay, and customers are challenged to build their version of one of their favorite Star Wars battles, adding their own alternative twists to the scene. What better way to come up with a new kit idea than from customers themselves?

Yes, the old adage that 'the customer is king' still holds true in the era of the Fourth Industrial Revolution. And manufacturers would do well to make it a guiding principle.

Collaborating inside and out

The benefits of digital transformation can only be fully achieved with an integrated, organization-wide approach. These benefits will be even greater if that collaboration extends to the supply network and involves the partners in its new ecosystem.

> "We formalized our digital transformation program by branding all digital initiatives under the same banner. We look at processes and systems from a total corporate view; from order/sale through to manufacture, delivery and customer-support processes. Then we layer corporate objectives on top with a focus on global expansion, increased revenue, and reduced complexity."
>
> Senior Vice President, commercial manufacturer

Digital collaboration tools have been steadily improving for years but organizations have been slow to exploit them – not because of difficulties with the technology but because of a lack of enthusiasm and trust. Organizational silos often have antagonistic relationships and compete for power and resources. In supply networks, sharing of information can lead to pressure on prices and revenues. It is not surprising that collaboration has been slow. Trust is hard to create and easy to break.

Jabil research notes that 63% of manufacturers expect that partners will deliver capabilities that will help them transform. But making collaboration work effectively between everyone in the new ecosystem will be a tough nut to crack. Manufacturing executives must provide strong leadership to make it happen, and they must make sure that the time, resources, manpower and the right digital tools are in place to ensure success.

Leveraging vendor partnerships

Maximizing the benefits of new technologies requires an effective combination of skills, knowledge, resources, execution abilities and vision. Many of these will already exist within the business and some may be developed internally or recruited. Others will require the establishment of relationships with organizations that can provide them.

Vendors have invested huge amounts in research and development of their products and have extensive experience in their use. Their work with companies like yours can help you vastly improve the value of your investment.

> "Vendors have invested R&D dollars into our business collaboratively. It's a way to secure dollars that weren't there before. People really have to look at the partnership model and learn to have a conversation with a vendor. It's not just about buying stuff from them."
>
> CIO, consumer product manufacturer

Good vendors understand that they have a vested interest in your success – it contributes to their knowledge bank and reputation. When you select a mission-critical vendor, look for one that's a good fit with your culture, that has the depth of knowledge and appropriate resources to be a good strategic partner, that has a well-planned and executable roadmap, and that you believe will be highly committed to your success.

"We use our vendor community as our own CRM. They keep us informed about what's happening in the business, because sometimes we get bypassed. But when you have a good vendor at the table, usually they will try to bring you into the loop and almost act as your advocate."

VP, IT & Operations, consumer products manufacturer

Other partners will be needed to complete your ecosystem of collaborators. Education providers, consultants, recruiters and more will help you execute and reap maximum value from your transformation initiatives. With the proper mix, you will be on the right path to a successful technology makeover – and you too will be a survivor of the Fourth Industrial Revolution.

"We do workshops at organizations to help them with innovation. In one of them we bring people from all parts of the organization together to share ideas on how to solve problems, focused around the customer. And what is always eye opening to the executives is that the people that were never at the table – people that the executives never thought had the ideas – are the ones that come up with the answer."

Head, Solution Engineering, Salesforce

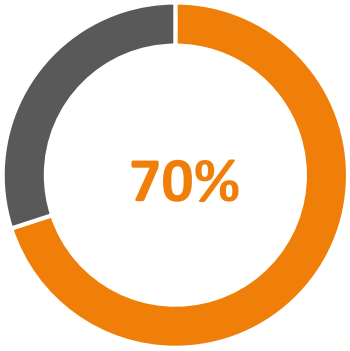
Manufacturing survey: What the numbers say

To help us determine the interest in and level of commitment to some of the key transformational technologies that will impact manufacturing over the next few years, we asked a number of Canadian executives from the sector to weigh in on various questions related to these technologies. The companies represented in this poll generally reflect the make-up of the industry as a whole and have manufacturing interests in all 10 provinces and all three territories.

The results of our survey have been presented throughout this report. Additional insights of interest to the manufacturing community are provided below.

Do companies with new technology-based business models in your sector make it hard for you to compete?

The response to our question around manufacturing competitiveness could not make the need to adopt transformational technologies more clear. Fully 70% of respondents agreed that they will struggle to compete against firms that have adopted new technology-based business models. Only 15% somewhat disagreed and none strongly disagreed.



of respondents feel that new technology-based business models models will make it hard to compete

To what extent are the following factors limiting your organization's ability to digitally transform?

What factor was cited most often by our respondents as a large barrier to digital transformation? Surprisingly, it wasn't funding, nor the commitment of senior management, nor the skills and knowledge of managers or the workforce. The culprit was "Employee reluctance to change", identified as a large barrier by 65% of respondents, nosing out "Our existing technology structure", which was cited by 60%. Obviously, much work is needed on both of these fronts.

To what extent are these factors influencing your digital transformation technologies investment today?

Of those factors most often cited as strongly influencing digital transformation investment, the clear favorite was "Desire to improve performance" at 63%, followed by "Customer expectations" at 53% and "Desire to create new

products and services" at 42%. Many would argue that all of these factors should be strong influencers of such investment decisions. Which begs the question, do we have our priorities straight?

Which of the following digital transformation technologies has your organization decided to invest in to date?

Cloud topped the list of technologies already invested in, at 70%, followed by big data and IoT, at 65% each, and mobile and social media, at 60% each. Still in the starting gate are digital twins, at 10%, and blockchain, at 5%. These latter technologies still have a ways to go before they enter the mainstream, but our next question shows that they have their legs well under them.

70%

have adopted cloud technologies

65%

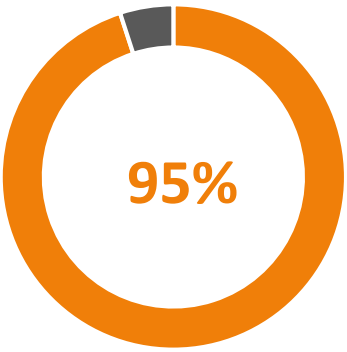
invested in big data and IoT

60%

using mobile and social media

Which of the following digital transformation technologies do you believe that your organization should be investing in within the next 3 years?

The industry has made up its mind: AI and machine learning are on pretty much everybody's dance card. They convincingly topped the list of 'must have technologies' in the next three years, with a whopping 95% of respondents putting them on their list. IoT, at 75%, and cloud and robotics/automation, at 70% each, showed that they're very much on respondents' wish lists as well. And those two emerging technologies with little present uptake, digital twins and blockchain, look like they're coming on strong, if executives are able to find the investment dollars needed to implement them. Digital twins move from today's 10% to tomorrow's 25%, and blockchain surges from today's 5% to tomorrow's 15% – clear evidence that these new digital technologies are getting the profile they deserve.



of respondents plan to invest in AI and machine learning over the next 3 yrs

Conclusion

This report is intended for the use of Canadian manufacturing executives across all functions in their organizations. It covers many of the critical areas important for manufacturers to survive and thrive in the coming years of disruption engendered by new digital technologies.

There is much work to be done. Canadian manufacturers are already in catch-up mode, and the competition is fierce. Asia, Europe, and the U.S. will aggressively surge forward with digital transformation. We must do the same.

The technologies outlined here are but a small part of the digital tsunami that is about to hit the manufacturing world. Companies will need all hands on deck in order to survive. The industry has spent a lot of time talking about the Fourth Industrial Revolution. The time start doing something about it is now.

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