



Digital Technology Adoption Roadmap

Accelerating Digital Transformation in Canada's Fabricated Metal Products Manufacturing Sector

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Roadmap produced by the Information and Communications Technology Council (ICTC)
in collaboration with Next Generation Manufacturing Canada (NGen)

Preface:

ICTC and NGen are proud to present this digital technology adoption roadmap covering the Canadian fabricated metal products manufacturing sector. The five-year roadmap details practical steps and considerations for Canadian machining and fabrication firms, particularly small- and medium-sized enterprises, interested in adopting advanced digital technologies, including artificial intelligence (AI), big data analytics, cloud computing, cybersecurity, digital twins, sensors and Internet of Things, and advanced robotics and industrial automation. The roadmap provides the fabricated metal products manufacturing sector with strategic-level guidance on digital technology adoption. The roadmaps have been developed in consultation with industry and include real-world examples and use cases on how digital technologies are being used on shop floors across Canada and integrated into production processes.

Other digital technology adoption roadmaps available for Canadian manufacturers in this series:



About ICTC:

The Information and Communications Technology Council (ICTC) is a neutral, not-for-profit national centre of expertise with the mission of strengthening Canada's digital advantage in the global economy. For over 30 years, ICTC has delivered forward-looking research, practical policy advice, and capacity-building solutions for individuals and businesses. The organization's goal is to ensure that technology is utilized to drive economic growth and innovation and that Canada's workforce remains competitive on a global scale.

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About NGen:

Next Generation Manufacturing Canada (NGen) is the industry-led, non-profit organization leading Canada's Global Innovation Cluster for Advanced Manufacturing. One of five national networks supported by Canada's ambitious Global Innovation Clusters Initiative. We are founded on the principle that digital transformation in advanced manufacturing will enrich the lives of Canadians, delivering better products and good jobs while generating the economic growth essential to a better future.

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Executive Summary

This five-year roadmap details practical steps and considerations for the Canadian fabricated metal products sector, particularly small- and medium-sized enterprises, interested in adopting advanced digital technologies and embarking on a digital transformation journey.

The roadmap provides a case study of real-world digital technology adoption in the Canadian fabricated metal products manufacturing sector—centered on Alberta-based Levy's Machine Works and Ontario-based Canada Tubeform—covering barriers, challenges, and solutions to digital transformation. It outlines how metals firms are adopting novel digital technologies, including artificial intelligence (AI), big data analytics, cloud computing, cybersecurity, digital twins, sensors and Internet of Things (IoT), and advanced robotics and industrial automation.

The roadmap also provides examples of practical planning tools to help Canadian metals manufacturers plan and execute their digital transformation journeys, including:

- 1. Digital technology use case matrix:** highlighting practical uses of the seven digital technologies in fabricated metal products manufacturing sector.
- 2. Return on investment (ROI) measurement framework:** outlining example metrics to assess ROI on digital technology adoption in categories including operational effectiveness, workforce productivity, capital productivity, market access, innovation, health and safety, and ESG measures, and align them with strategic firm objectives and investment inputs.
- 3. Change management checklist and digital transformation project phase gate framework:** providing a systematic, phased approach to

developing organizational change management strategies, and technology pilots to support digital transformation.

- 4. Risk management tools:** demonstrating contemporary risks manufacturing firms may face when undergoing digital transformation in today's market, as well as an example risk register and risk management trigger scenarios.
- 5. Talent and workforce training insights to support digital transformation:** overviewing baseline digital competencies for advanced manufacturing, workforce training and delivery models for manufacturers, and organizational strategies to foster digital competencies in the manufacturing workforce.
- 6. Advice for developing strategic partnerships to advance digital transformation:** discussing key partnership verticals and example partnership models, as well as key considerations for data-sharing when developing strategic partnerships.

By providing these real-world case studies, insights, and practical tools, this roadmap seeks to accelerate the adoption of key digital technologies in Canada's fabricated metal products manufacturing sector and support ongoing digital transformation efforts. Adopting novel digital technologies is critical for continued sectoral success, addressing long-term stagnation in productivity in Canadian manufacturing, and maintaining the sector's continued global competitiveness.



Table of Contents

Executive Summary	3
Acknowledgments.....	5
Why this Roadmap is Needed	6
Seven Key Digital Technologies for Metal Product Manufacturing	9
Digital Transformation and Digital Technology Adoption Time Horizons	11
Case Study: Digital Technology Adoption in Canada's Fabricated Metal Product Manufacturing Sector	12
Industry Overview and Context	12
Strategic Approaches to Digital Technology Adoption	13
Technology Applications in Practice	14
› Industrial Automation and Robotics	15
› Artificial Intelligence (AI)	16
› Digital Twins	16
› Cybersecurity.....	16
Understanding ROI and Measuring Digital Transformation Results.....	17
Barriers to Adoption	18
› Capital Costs and Financing Barriers	19
› Data, Systems Integration, and Cybersecurity Risk.....	19
› Sectoral Structural Constraints.....	19
Workforce and Skills Barriers.....	20
Considerations for Organizational Change Management	21
Digital Technology Adoption Horizon	22
Digital Technology in Metal Product Manufacturing Use Case Matrix.....	23
ROI Measurement Framework.....	26
Change Management Checklist	29
Digital Transformation Phase Gates	30
Managing Risk	31
Risk Management Trigger Scenarios.....	32
Talent, Workforce Development, and Training	33
Developing Strategic Partnerships	37
Information and Data-sharing for Fabricated Metal Product Manufacturing Strategic Partnerships	38
Digital Technology Adoption: A Call to Action	39
Action Steps	39
Research Methods	40

Acknowledgements

This roadmap was developed in consultation with digital transformation leaders from the Canadian metal products manufacturing sector, including five expert interviews and an industry roundtable. Representatives from machine shops and metal products manufacturers, digital technology vendors with expertise in the metals industry, consultants, and other experts all contributed insights towards this roadmap.

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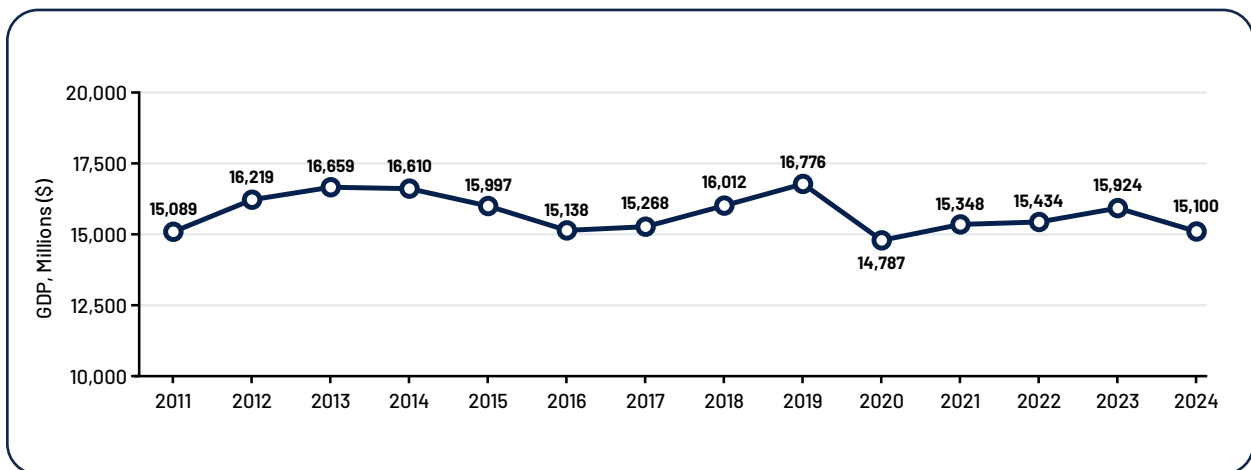
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- **Roger Campbell**, General Manager, Canada Tubeform Inc.
- **Ryder Britton**, Founder, Velocity Bolting
- **Yi Li**, Ph.D, Co-founder and EVP, Maple Advanced Robotics Inc.



Why this Roadmap is Needed

Canadian manufacturing is facing notable headwinds from declining productivity, underinvestment, and economic uncertainty stemming from international trade disputes. For the fabricated metal product manufacturing sector, including firms such as machine shops, fastener manufacturing, and structural fabricators, real GDP has faced cyclical rates of moderate growth and then contraction since 2011 (Figure 1).

Figure 1. Metal Product Manufacturing Sector GDP Value (2011-2024)



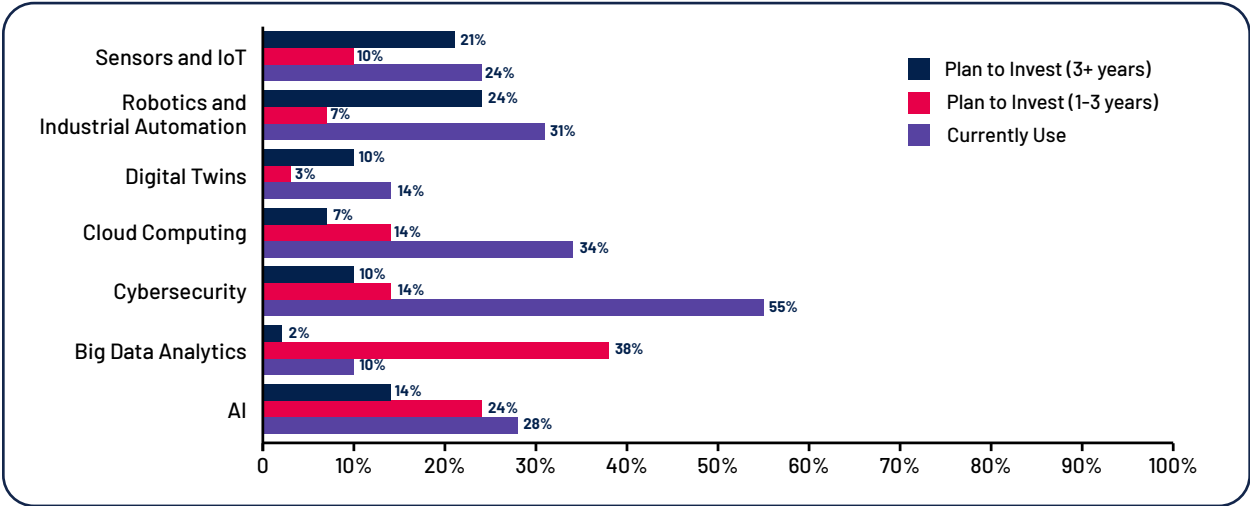
Source: Statistics Canada, Table: 36-10-0434-06 [NAICS 332].¹

Industry growth has come at a time of technological disruption, brought on by rapid advances in digital technology, most notably in artificial intelligence (AI), but also in adjacent technologies such as advanced robotics, sensors and Internet of Things (IoT), and digital twins, alongside basic digital infrastructure like cloud computing. Canadian metal products manufacturers can increase productivity

and accelerate growth by adopting more digital technologies across their manufacturing operations. An industry survey conducted by ICTC finds that while metal products manufacturers have widely adopted cloud computing and cybersecurity, other critical digital technologies such as artificial intelligence (AI), sensors and IoT technology, and big data analytics are much less common (Figure 2).

¹ Statistics Canada (Government of Canada), "Gross domestic product (GDP) at basic prices, by industry, annual average, industry detail (x 1,000,000)," Table: 36-10-0434-06, release date January 26, 2026, <https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3610043406>.

Figure 2. Metal Product Manufacturing Digital Technology Adoption (2025)

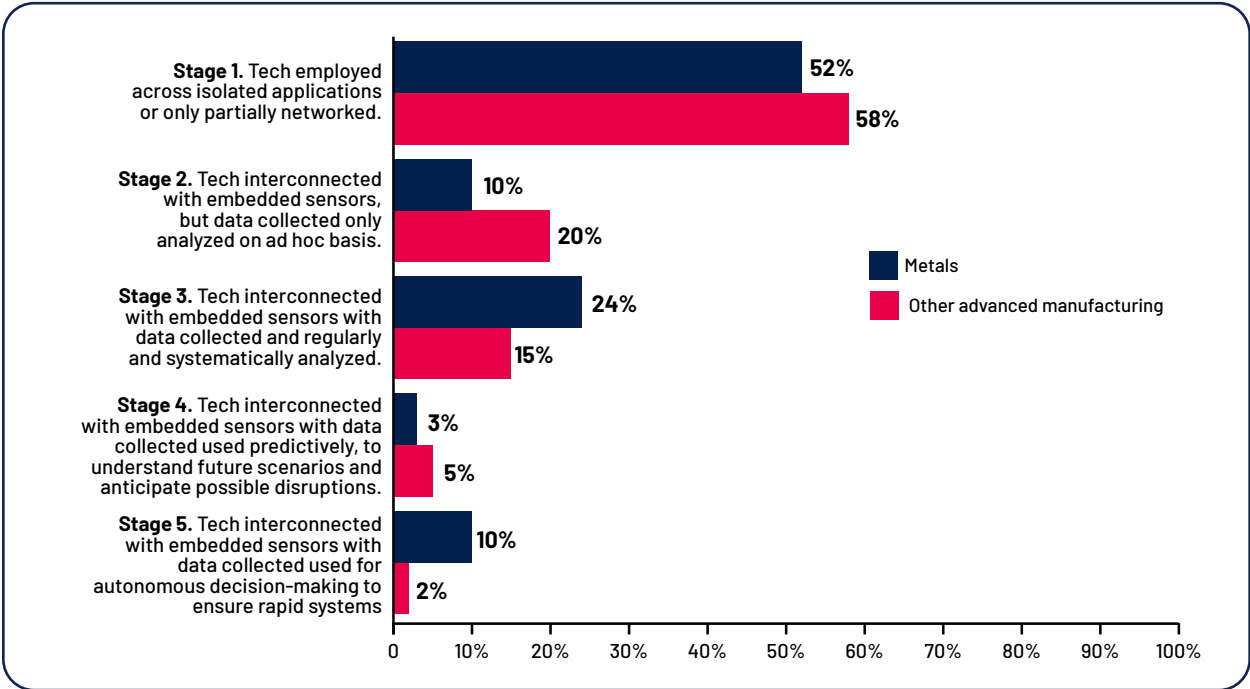


Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

Canadian manufacturing technology adoption shows mixed progress across industries. Within the Canadian metal products manufacturing sector, ICTC’s Canadian manufacturing digital technology adoption survey found that 52% of metal products manufacturers employed digital technology piecemeal, as isolated applications or only partially networked, 10% employed interconnected digital

technology but only analyzed collected data on an ad hoc basis, while 24% employed interconnected digital technology and analyzed collected data regularly and systematically. Furthermore, 3% used data collected from networked sensors for predictive analytics and 10% for supporting autonomous decision-making (Figure 3).

Figure 3. Canadian Metal Product Manufacturing Advanced Digital Technology Implementation Stage (2025)



Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

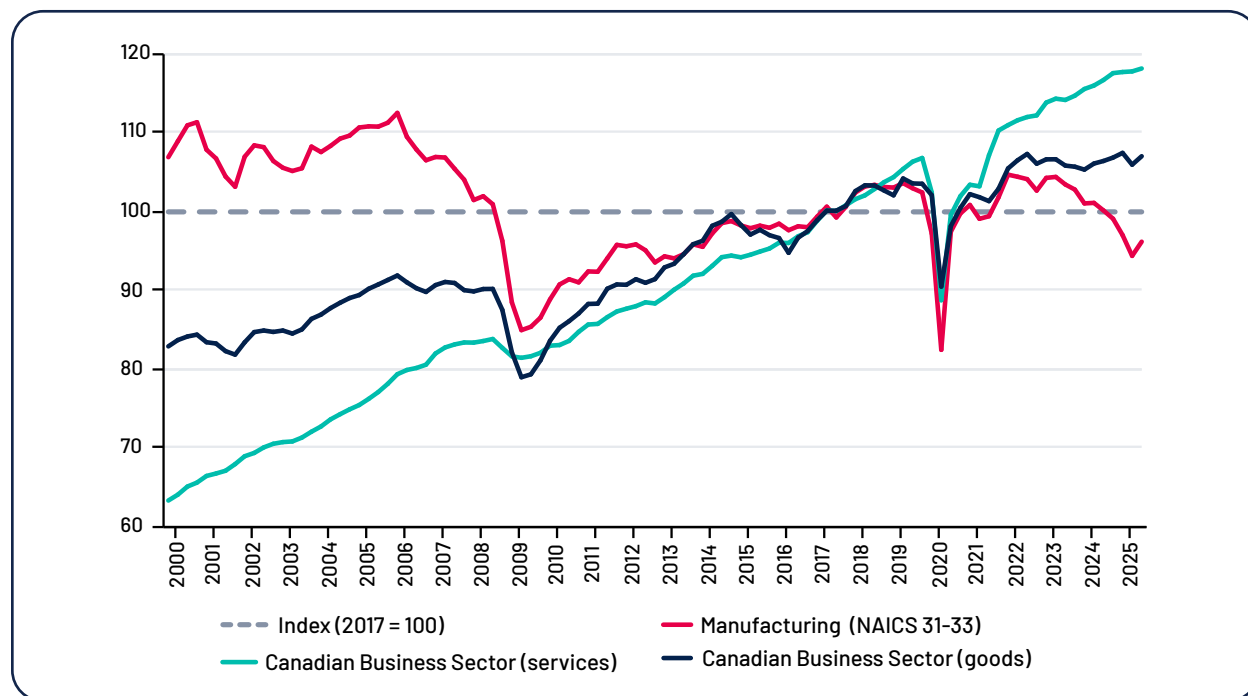
Further leveraging networked digital technologies towards integrated, autonomous operations across a manufacturing process, or even an entire manufacturing enterprise, could have a positive effect on labour productivity in Canada's manufacturing sector (Figure 4). This would be a welcome development, as lagging productivity amounts to a persistent drag on the Canadian economy.²

Productivity challenges are often discussed in national economic terms, but they have very real implications for individual businesses. Canadian manufacturers continue to lag behind peers such as the United States, which puts pressure on costs, pricing, and margins. For a typical metal fabrication SME with \$20 million in annual revenue and a 15%

EBITDA margin, even a modest 5–10% improvement in overall equipment effectiveness (OEE) can make a meaningful difference.

Improvements enabled by tools such as production monitoring, predictive maintenance, or better data use can increase throughput and reduce downtime without major new capital investment. For example, a 3% increase in output combined with small cost savings could translate into an additional \$300,000–\$600,000 in annual EBITDA—amounting to a 10–20% improvement in operating earnings. Seen this way, digital adoption is not just about upgrading technology; it is about strengthening profitability and long-term business value.

Figure 4. Index on Canadian Manufacturing Labour Productivity (2000 to Q3 2025)



Source: Statistics Canada, Table: 36-10-0207-01.³

² Tim Sargent, "Productivity Growth in Canada: What is Going on?," University of Calgary, School of Public Policy Briefing Paper, October 2024, <https://www.policyschool.ca/wp-content/uploads/2024/10/FP-9-ProductivityGrowth-Final.pdf>.

³ Statistics Canada (Government of Canada), "Indexes of labour productivity and related measures, by business sector industry, seasonally adjusted," Table: 36-10-0207-01, last update September 3, 2025, <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610020701>.

Seven Key Digital Technologies for Metal Product Manufacturing

With an industry-wide need to adopt advanced digital technologies across Canadian manufacturing, including further adoption within Canada's metal product manufacturing sector, ICTC and NGen evaluate the seven digital technologies (Figure 5) as being essential to the future of Canadian manufacturing.

Figure 5. Seven Key Digital Technologies Essential for Canadian Manufacturing

Artificial Intelligence (AI) and Machine Learning (ML)	AI-enabled systems can quickly parse large volumes of data, helping to optimize processes and predict outcomes, and automate decision-making tasks that would normally require human cognition. Machine learning models can ingest training data and learn to make predictions or correct decisions without explicit, hard-coded programming.
Big Data Analytics	Methods and tools used to collect and curate, process and integrate, and analyze extremely large volumes of data across a manufacturing operation to glean insights and improve decision-making.
Cloud Computing	On-demand, off-site computing services to access and store data, process information, and serve software applications via the internet. Cloud computing also allows manufacturers to dynamically scale their computing infrastructure as required.
Cybersecurity (IT and OT)	Protecting sensitive networks and data from threats. In a manufacturing environment, cybersecurity encompasses protecting both information technology (IT), such as networks and data, and operational technology (OT), such as machinery, control systems, and sensors.
Digital Twins	A virtual representation or model of a real-world asset, such as a piece of machinery, a production line, a manufactured product, or an entire manufacturing facility, continuously updated with new data, allowing the digital twin to mirror the status and condition of the real-world asset.
Sensors and Internet of Things (IoT)	Machinery, sensors, and other electronic devices can be interconnected to gather and share real-time data across a factory or supply chain, often referred to as the Internet of Things (IoT) or the Industrial Internet of Things (IIoT).
Robotics and Industrial Automation	Automation technologies have long been used in some metal product manufacturing applications, but advanced robotics, including cobots and humanoid robots, can be used in manufacturing across a variety of applications and integrated using technologies such as AI and IoT networks.

Figure 6. Digital Technology Maturity Tiers for Advanced Manufacturing

Digital Transformation Stage	Maturity Tiers	Key Digital Technology	Firm Digital Transformation Maturity Level
Basic	Foundational Technologies	› Cloud computing/ cloud ERP › Cybersecurity	Foundation: establish prerequisite digital infrastructure.
Intermediate	Operational Optimization Technologies	› Sensors and IoT › Big data analytics	Integrate and optimize: build data collection and analytical processes from foundational digital infrastructure. Provide data platform for transformational technologies.
Advanced	Advanced Transformation Technologies	› AI/ML › Robotics and industrial automation › Digital twins	Transformation: adopt advanced digital technologies to transform enterprise manufacturing operations.

Source: ICTC analysis, 2026.

No single digital technology delivers its full value in isolation—the true business value for all of these technologies is unlocked only when they are adopted in tech stacks. Fabricated metal products manufacturers can think of the seven key digital technologies as being in three maturity tiers (Figure 6):

1. foundational technologies (cloud computing/ cloud ERP, cybersecurity),
2. operational optimization technologies (sensors and IoT, big data analytics), and
3. advanced transformation technologies (AI/ML, robotics and industrial automation, and digital twins).

While any one of the seven digital technologies covered in this roadmap would, on its own, be consequential to advanced manufacturing in Canada, what makes these seven technologies truly impactful is how they interact with one another. These seven technologies can be digitally networked across a fabricated metal products manufacturing operation, or across an entire manufacturing supply chain, with significant gains in operational excellence, productivity, safety, product innovation, and market responsiveness.

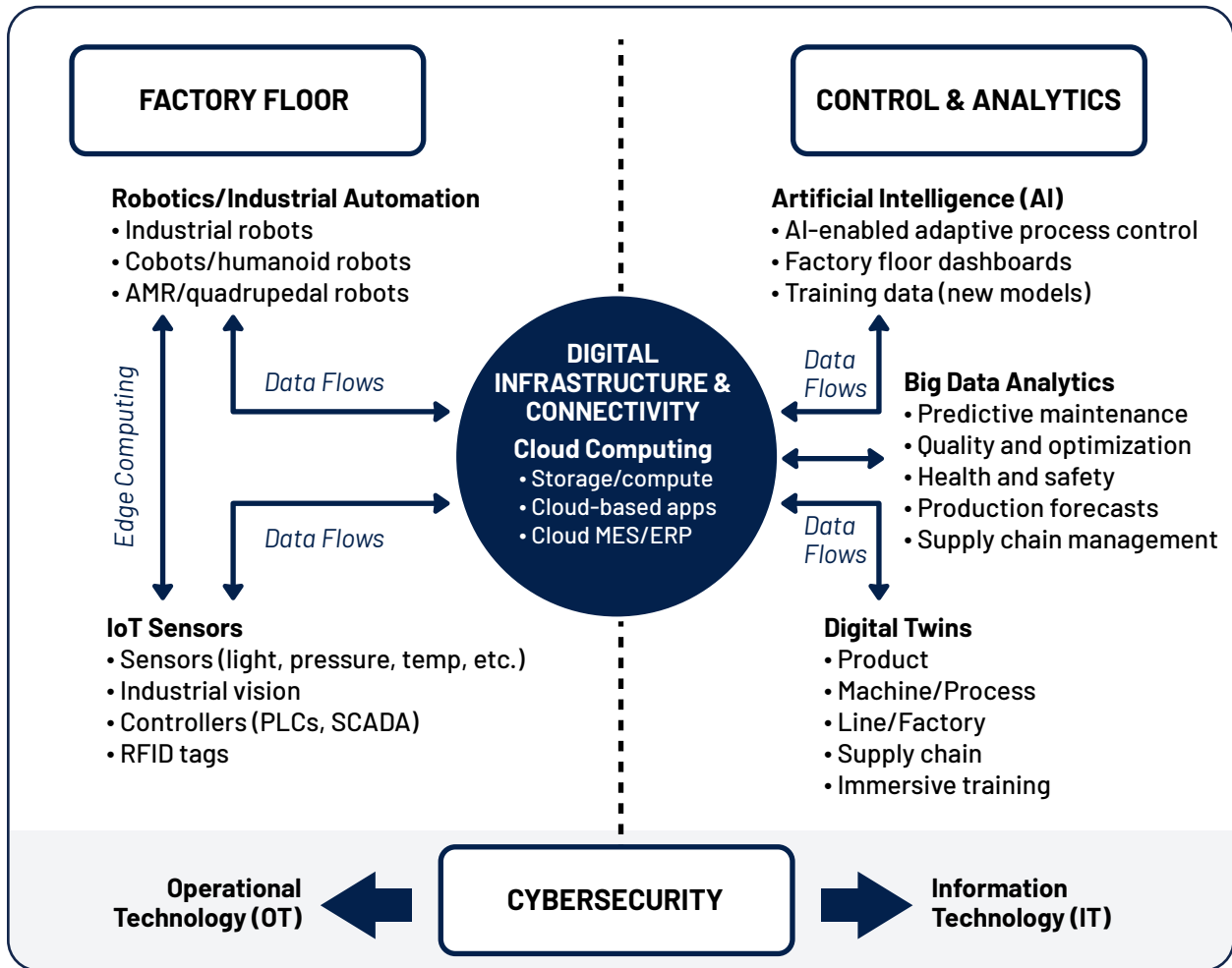
For example, sensors deployed across a manufacturing operation, on industrial robots and other production equipment, can collect significant

amounts of real-time data (i.e., big data) that can be stored and processed in a cloud environment. The data can be used to create digital twins of individual pieces of machinery and robots, manufacturing processes, products, and even the entire manufacturing enterprise.

The data can also be used to train AI models and run inference to help manage and optimize manufacturing operations. The digital infrastructure and valuable data, integrated across a manufacturing enterprise's information technology (IT) and operational technology (OT) assets, must be secured against cyber threats, such as data breaches and cyberattacks, through a robust cybersecurity program. Figure 7 outlines, at a high level, how the seven digital technologies covered in this roadmap can be integrated together on the lab or production floor and across an enterprise in the metal product manufacturing sector.

The model presented in Figure 7 is aspirational and intended to provide an overview of what is possible in the long term. Today, most Canadian metal product manufacturers have not achieved this level of total integration. Instead, Canadian metal product manufacturing interviewed for this roadmap tend to adopt stacks of digital technologies incrementally, through strategic investments, pilot projects, experimentation, and organizational learning.

Figure 7. Advanced Digital Technology in Manufacturing Integration Model



Source: ICTC analysis, 2026.

Digital Transformation and Digital Technology Adoption Time Horizons

When discussing digital transformation and technology adoption in Canadian manufacturing, it is critical to develop achievable, realistic timelines. The complexities of digital technology adoption, both technical and organizational, are significant. For metal product manufacturers adopting novel digital technologies, such as AI, digital twins, or advanced robotics, for the first time, it can take years to derive the full value from the investment and get the most out of the new technology.

A phased, five-year timeline provides metal product manufacturers, including those undergoing a digital transformation project for the first time, with a realistic timeline for effectively adopting digital technologies. Firms should expect to spend the first one to two years piloting new technologies,

gathering data, and developing a full business case, and then up to three years scaling successful pilots across their manufacturing operations and beginning digital integration with other manufacturing and enterprise systems.

Alongside piloting and adopting new digital technologies on the shop floor, metal product manufacturers must also train their workforce, align HR policies and recruitment strategies towards digital transformation efforts, and provide training to the existing workforce. Furthermore, not all digital technology adoption initiatives will yield results. Manufacturers must also effectively manage risk when adopting new digital technologies into their manufacturing operations.

Digital Technology Adoption in Canada's Fabricated Metal Product Manufacturing Sector

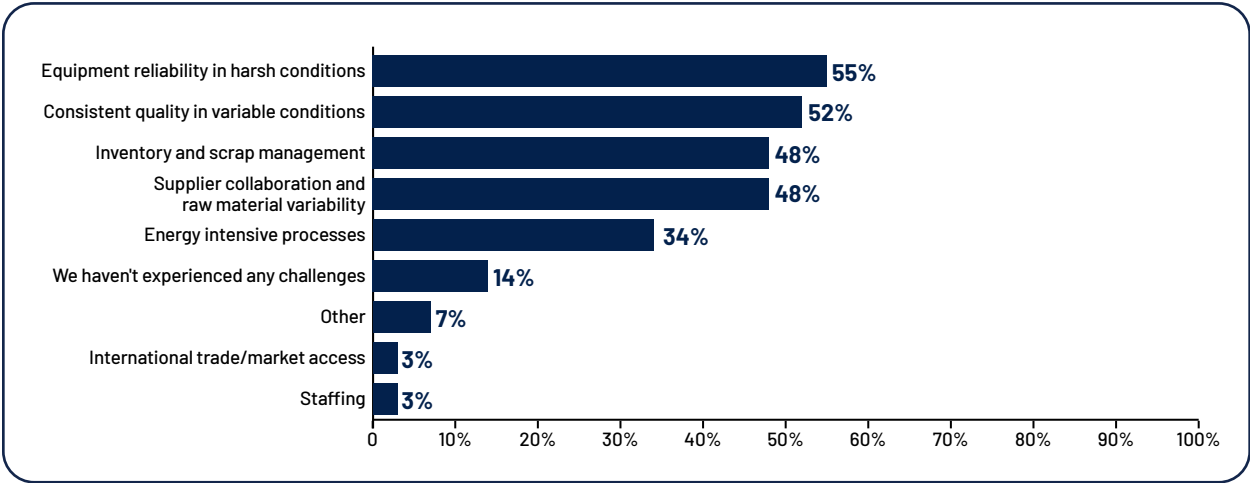
This case study synthesizes insights from companies operating at different points across Canada's metals fabrication ecosystem, ranging from precision component and forming operations to large-scale machining and production environments that support downstream manufacturing supply chains. Within this broader landscape, we highlight two standout examples, Canada Tubeform and Levy's Machine Works, which together illustrate how established Canadian manufacturers are responding to shifting customer requirements and competitiveness pressures through investments in equipment, shop-floor efficiency, and workforce development.

Canada Tubeform manufactures high-volume tubular steel and aluminum components and assemblies for the automotive industry, leveraging leading-edge tube-forming technologies and production methods to support consistent, high-throughput delivery. Levy's Machine Works specializes in precision machining, producing high-complexity, tight-tolerance parts (including work in exotic materials) through CNC turning and milling, prototyping, and complementary fabrication for customers across sectors such as oil and gas, scientific and medical equipment, and aerospace and defence. Their experiences provide a grounded view of how metals and fabrication employers think about productivity, talent pipelines, and practical adoption of new tools and processes.

Industry Overview and Context

The fabricated metal products sector is a foundational part of the global economy, supporting critical value chains in sectors that are as varied as construction, automotive, energy, aerospace, and consumer goods. Through processes such as milling, cutting, bending, welding, and assembling, firms in this sector transform raw metal inputs into the components and products that underpin modern manufacturing and infrastructure. Driving metal product manufacturers' digital transformation is a need to solve practical business problems, including maintaining equipment reliability in harsh conditions, maintaining quality in variable conditions, managing inventories and scrap, and collaborating with suppliers (Figure 8).

Figure 8. Most Pressing Business Challenges (Choose Top Three) – Metal Product Manufacturing (2025)



Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

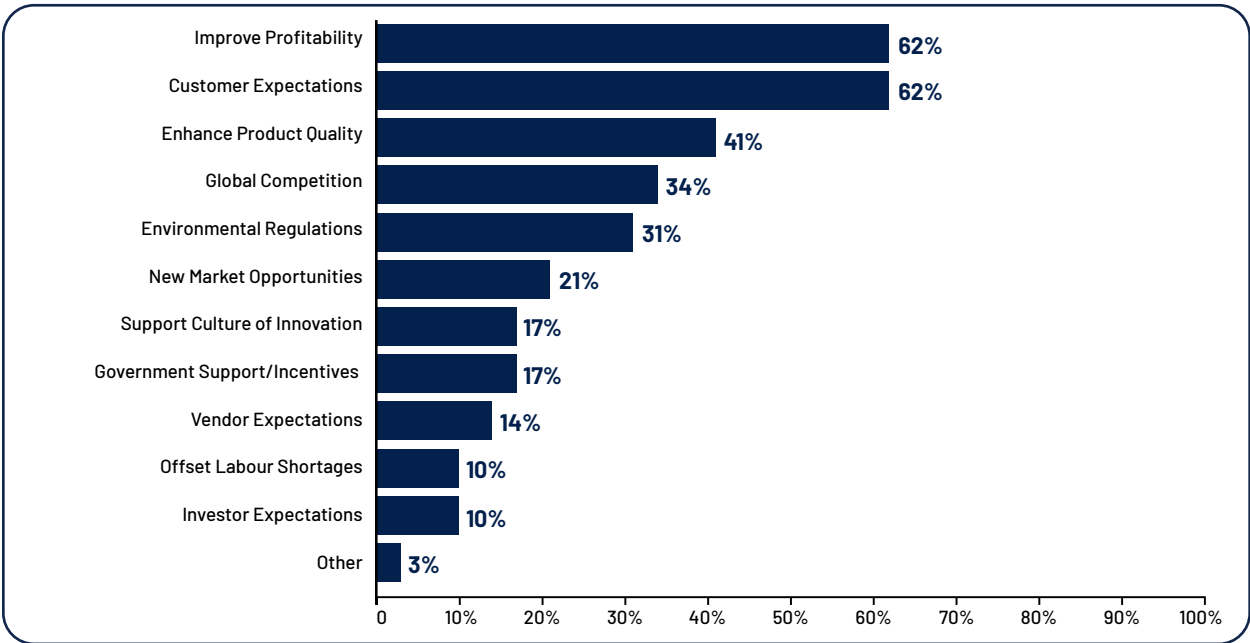
Strategic Approaches to Digital Technology Adoption

For Canada’s metal product manufacturers, digital adoption is widely seen as essential to remain competitive in an increasingly uncertain business environment. Metal products manufacturers face persistent skilled labour constraints, and increasing pressure to modernize processes, digitize workflows, and strengthen internal training pathways—particularly within small and mid-sized firms. When deployed strategically, digital technologies can shift

cost structures, streamline operations, and enable more automated, data-driven management.

What constitutes “strategic” adoption varies by context, but major strategic goals of digital technology adoption include improving profitability, meeting customer expectations, enhancing product quality, responding to global competition, adhering to environmental regulations, and developing new market opportunities (Figure 9).

Figure 9. Most Important Factors Driving Digital Technology Adoption – Metal Product Manufacturing (2025)



Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

Technology Applications in Practice

Across the metals and fabrication interviews and roundtable, firms described a clear shift toward connected, shop-floor digital systems that make production status, quality checks, and documentation visible in real time and traceable after the fact. Rather than relying on paper travellers and scattered spreadsheets, participants emphasized practical combinations of ERP, quality modules, machine connectivity, and cybersecurity practices that improve day-to-day execution and customer confidence.

A common baseline use case is replacing paper-based routing and manual status updates with an ERP backbone. One firm interviewed described taking over a legacy machine shop and positioning themselves as “a younger, tech-savvy, forward-looking player in the space.” They explained that, prior to their involvement, the business relied on older manual processes and had not yet adopted modern software or standardized procedures. According to this interviewee, prior to this shift to advanced technologies, “there were hundreds and if not thousands of pieces of paper floating around the manufacturing floor, some partially filled in and some not,” noting how tracking an order required “a physical walk around the shop trying to figure out where a job was.”

In contrast, their current model is structured around a machining-focused ERP, with a digital ERP system acting as a “cornerstone of the tech stack,” supported by point-of-use access across the shop floor as they “have got a computer at every single CNC machine.” According to the firm’s owner, full participation matters, noting that “there isn’t a single person in our business that doesn’t have access.” In practice, this means the ERP holds the designs, work orders, routing steps, and progress updates from machining through finishing, packaging, and shipping.

At Levy’s Machine Works, the transition to a paperless ERP was framed as a practical means to enhance traceability, consistency, and day-to-day execution. Under a fully digital workflow, serial numbers are assigned at the start of a job and tracked through every operation, with setup time, run time, and job notes recorded at each workstation, so operators aren’t hunting for “setup sheets, specifications, or drawings” in binders. As

a leader at Levy’s observed, the advantage isn’t just access to information, but accountability, arguing that “in a digital system, required steps must be completed before moving forward.”

Canada Tubeform described how its digital infrastructure, tied into its ERP and shop-floor controls, creates real-time dashboards for each production cell. These screens show who is running the cell, current output, downtime reasons, scrap counts, and whether cycle times are on target, so operators and supervisors can quickly see issues in real time and quickly intervene if needed.

Digitalization was also described as tightly linked to quality assurance and traceability, particularly for customers requiring auditable records. One interviewee emphasized that traceability becomes non-negotiable at scale—when you’re shipping 150 thousand to 200 thousand parts a year, you “can’t keep track of what happened to which part without a system in place.” With the right system, this interviewee explained, traceability can extend to the level of knowing “exactly who moved every single part through the system,” so that if an issue arises, they can “trace it back to the exact operation, and even the individual machinists who worked on it.”

Firms described using sensors and IoT monitoring tools to “see” what’s happening in production and in the field, especially when issues are hard to catch by eye. For example, Canada Tubeform pointed to practical, lower-barrier sensing tools already in use, such as cameras that help teams review what was happening at the moment a defect occurred and machine-vision systems that inspect parts as they move through tube-forming processes.

Several metal products manufacturers interviewed described the importance of moving toward ever higher levels of automation and connectivity. One shop outlined plans to expand beyond an ERP backbone to advanced monitoring and automation as it moves toward lights-out machining capability. Common pitfalls reported by fabricated metal products manufacturers interviewed for this roadmap include underestimating the data cleaning burden when adopting digital technologies such as AI and digital twins, effectively training staff, and maintaining interoperability with legacy systems and processes.



Industrial Automation and Robotics

In another example, one Alberta-based shop with strong capabilities in additive manufacturing noted a promising next step in the firm's digital transformation journey is adding a robotic cell that can scan a 3D-printed metal part, compare it to the CAD design, and automatically remove the metal supports using different tools. They noted this kind of automation becomes much easier to justify and set up once they have more repeat and serial production work, and it could also improve workplace safety by reducing the amount of hands-on cutting, chiseling, and handling required during support removal.

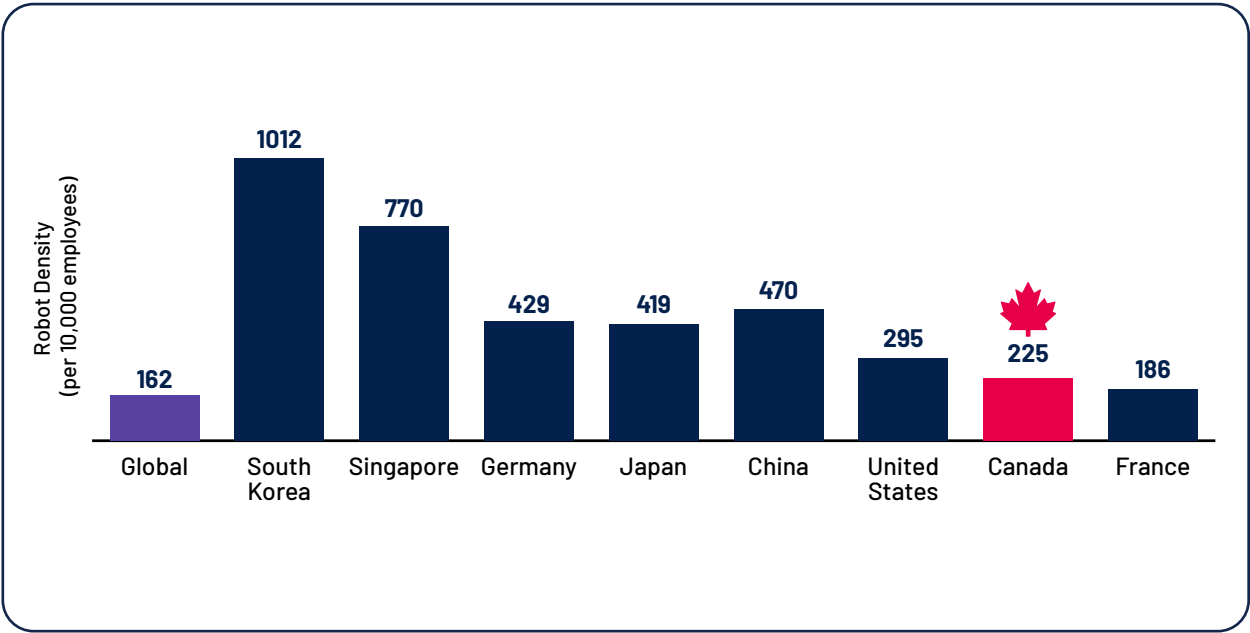
Similarly, at Canada Tubeform, digitization is integrated into day-to-day production and into how quality issues are identified and addressed. Instead of paper records that "go in a file and just sit there," non-conformance and stoppage events are captured digitally, making them easy to search, sort, and download for analysis. This has been especially important for defect containment. As a senior leader at Canada Tubeform put it, "in most cases, we were identifying problems and defective parts, but we're not containing them." To close that gap, the company introduced targeted monitoring tools, including a production camera that lets them review

what was happening in a production cell at the exact time a defect occurred. Canada Tubeform has also implemented machine-vision systems in some tube-forming processes, where cameras "learn to look for defects," enabling inspection of every part even as robotics reduces manual handling.

While robotics is not yet being widely used across the participating firms, Canada Tubeform stands out as an active adopter, using robots primarily for part handling to reduce manual handling and support day-to-day shop-floor efficiency. Canada Tubeform links this directly to workforce sustainability and notes that "as we've gotten more robotics, we've had people with less handling of parts," and "we're just not wearing them out because we're letting robots handle all the parts."

Importantly, robotics adoption is context-dependent rather than a signal of digital maturity, with firms making deliberate choices based on volume, variability, and economic fit rather than technological readiness alone. While Canada enjoys robot densities above the global average in its manufacturing sector, and compares well with peer economies such as France and the United States, it lags behind leaders such as South Korea and Singapore (Figure 10).

Figure 10. Robot Densities in Canada and Select Countries (2023)



Data source: International Federation of Robotics, 2024.⁴

⁴ See: International Federation of Robotics, "Global Robot Density in Factories Doubled in Seven Years (press release)," November 10, 2024, <https://ifr.org/ifr-press-releases/news/global-robot-density-in-factories-doubled-in-seven-years>.

Artificial Intelligence (AI)

Across participating firms, AI adoption is concentrated in office-side efficiency, quality assurance, and faster access to technical knowledge. AI is not yet commonly automating production decision-making within Canada's fabricated metal product manufacturing sector. While some companies found that AI was not yet effective enough to generate CNC programs or toolpaths or even estimate cycle times, describing it as "so far away from actually being effective," metal products manufacturing firms are using AI to reduce administrative burden in reporting, documentation, and compliance monitoring.

Adopting simple back office AI use cases before experimenting with deploying the technology to the production floor allowed fabricated metal products manufacturers runway to become comfortable with the technology through phased implementation.

Levy's Machine Works reported that it uses "AI for reporting and analytics," which saves significant time. They added that it helps them "track complex tariff changes and compliance requirements that would otherwise require extensive manual effort." Levy's also shared that "AI is helping with material test reports by quickly identifying country of origin, specifications, and compliance details," which frees the time of experienced staff to focus on higher-value work. This limited shop-floor adoption reflects practical concerns around reliability, liability, and risk, as errors in automated production decisions can carry significant cost and safety implications in high-precision manufacturing environments.

Another firm emphasized that LLMs are already embedded in everyday office workflows, noting that "most of our office staff use it on a daily basis," particularly for tasks such as producing marketing content, assisting with grant-writing and business development, generating job descriptions, and handling compliance documentation.

One interviewee described a highly practical AI use case on the shop floor. They turned their machine documentation into an AI-enabled "chatbot" so staff can troubleshoot issues faster. After uploading operating, maintenance, and programming manuals into an AI tool, they can simply ask questions like "error code 4344...what does that mean?" and get likely fixes pulled directly from the manuals creating a dynamic, interactive troubleshooting knowledge base instead of forcing technicians to flip through repair manuals and binders.

Digital Twins

Across firms, digital twins are increasingly viewed as a pragmatic, narrow-use capability rather than a fully deployed end-to-end system. Currently, the clearest use is planning shop floor or production cell layouts. Another common use case for digital twins is using them to check product fit and basic engineering details. For example, Levy's Machine Works's framed their current approach as a lightweight twin for layout decisions, noting "Our version of a digital twins is we do a 3D mapping of the shop floor." This is used to support a planned re-layout when "we're looking to pick everything up and move some of the machines around," and potentially organize equipment into more efficient cells. In practice, digital twins are most valuable where process stability exists, and less effective in high-mix, highly variable environments, which define many metal product fabrication operations such as machine shops. As digital twin technologies develop and mature, there may be increasing scope to adopt product digital twins in fabricated metal products manufacturing.

Cybersecurity

Across the participating firms, cybersecurity was framed as a practical "keep the business running" requirement, especially as operations become more digitally connected through cloud tools, shared data platforms, and tighter links between office systems (e.g., ERP) and shop-floor technologies. With worries over "production line shut down in a ransomware attacks" firms emphasized the need to control access to sensitive information, including proprietary production data and intellectual property, while also meeting customer and regulatory expectations.

Cybersecurity was also discussed as a supply-chain issue; even when firms are not heavily engaged in cross-border trade, digital supply chains and interprovincial supply chains increase exposure and make strong security practices a baseline expectation. Overall, the emphasis was on building security into systems from the start so that daily operations are protected from disruptions like ransomware, and contact/customer information is handled in a secure, consistent way across integrated IT/OT environments.

Understanding ROI and Measuring Digital Transformation Results

Across the fabricated metal products manufacturing firms engaged with for this roadmap, “success” in digital transformation is measured less by one headline metric and more by a cluster of operational signals including how reliably production runs, how quickly problems are caught and issues get resolved, how consistently work is performed across shifts, and how confidently firms can meet customer documentation and compliance requirements.

What stands out is that many of the most meaningful gains show up first as visibility and control, meaning better and quicker access to reliable information. Only after that foundation is in place do firms begin to see the downstream improvements in traditional productivity measures such as improved production throughput and efficiency, and scrap reduction and reduced rework.

At Canada Tubeform, the most immediate results are tied to real-time performance management. By linking shop-floor inputs and equipment data into dashboards, the company can see “how efficient we are running today, the reasons that we’ve had downtime,” whether finished goods are below target, and even whether a preventive maintenance task is coming due.

Instead of end-of-shift manual reporting, daily performance reporting is now generated automatically, with information on production, downtime, scrap, and maintenance notes pulled directly from the system and reported to managers, supervisors, and production team members. Canada Tubeform reports measurable operational gains, with one leader sharing that “since last summer, we’ve seen our efficiency grow by at least 10%,” and “our scrap levels have dropped more than 50%” in many cases, which are improvements attributed to earlier detection and faster error correction.

Levy’s Machine Works frames measurement even more explicitly around profitability, quoting accuracy, and compliance readiness, using data analytics to connect shop performance to business outcomes. Levy’s transformation started with reporting expectations, in that “we use a tool that allows us to export data from our ERP system into dashboards and visualizations that show real-time performance,” which required them to “put a lot of work into understanding and measuring everything we do.” Results are being tracked through estimate-to-actual time performance, utilization, and the ability to identify “where we are making money,

where we are not, and where issues exist”. As a representative from the firm explains, previously they “didn’t always know which jobs were profitable,” but now they can quote with more confidence because they’ve built accurate routings and time benchmarks, critical in an environment where “competition is tighter.”

For Levy’s, results are also measured through reduced non-conformance and stronger document control, particularly as they work toward aerospace and defence requirements. They see a measurable advantage in moving from paper travellers and binders, where people must hunt for drawings and setup sheets, to digital enforcement, where “required steps must be completed before moving forward.” In other words, part of the “return” is fewer missed steps, fewer information gaps, and fewer downstream quality escapes, all benefits that don’t always show up immediately as unit cost reductions but strongly affect audit readiness and customer confidence.

Unsurprisingly, Levy’s evaluates ROI across multiple dimensions, “efficiency gains, reduced non-conformance, compliance readiness, and access to new markets,” even while noting that the costs of ERP, such as hardware, software licenses, and cybersecurity are significant.

A third measure used across firms is the growing importance of digital traceability and documentation throughput as a performance outcome in its own right. One interviewee contrasted pen-and-paper inspection records, “a PDF with handwritten things about inspection reports,” with the advantages of working with partners whose systems are “living portaled so you can get it at any point.”

For fabricated metals products manufacturers serving customers with significant documentation requirements, the ability to quickly retrieve material test reports, inspection records, and process information quickly becomes a measurable operational capability that can reduce administrative burden, expedite approvals, and lower the risk of costly back-and-forth with customers. In fact, the administrative burden can become a decisive operational constraint, as one industry leader put it, certain customers require “ten times as much paperwork,” making a strong digital footprint a practical requirement for sustaining this type of work.



Finally, fabricated metals products manufacturers are also measuring transformation outcomes through workforce adoption and training lift, because digital systems only deliver value if people use them consistently at the workstation. Overall, results across these firms are not just faster machines, it's faster detection, tighter control, clearer accountability, and more informed decision making. Productivity gains, including efficiency, scrap reduction, and fewer quality issues are real

and are being enabled by upstream improvements in visibility, traceability, and disciplined execution, often measured in the everyday ability to know what's happening in real time, not retrospectively days or weeks later. These measurement practices reinforce a culture of continuous improvement, where real-time visibility enables faster learning, accountability, and incremental operational gains rather than one-time transformation efforts.

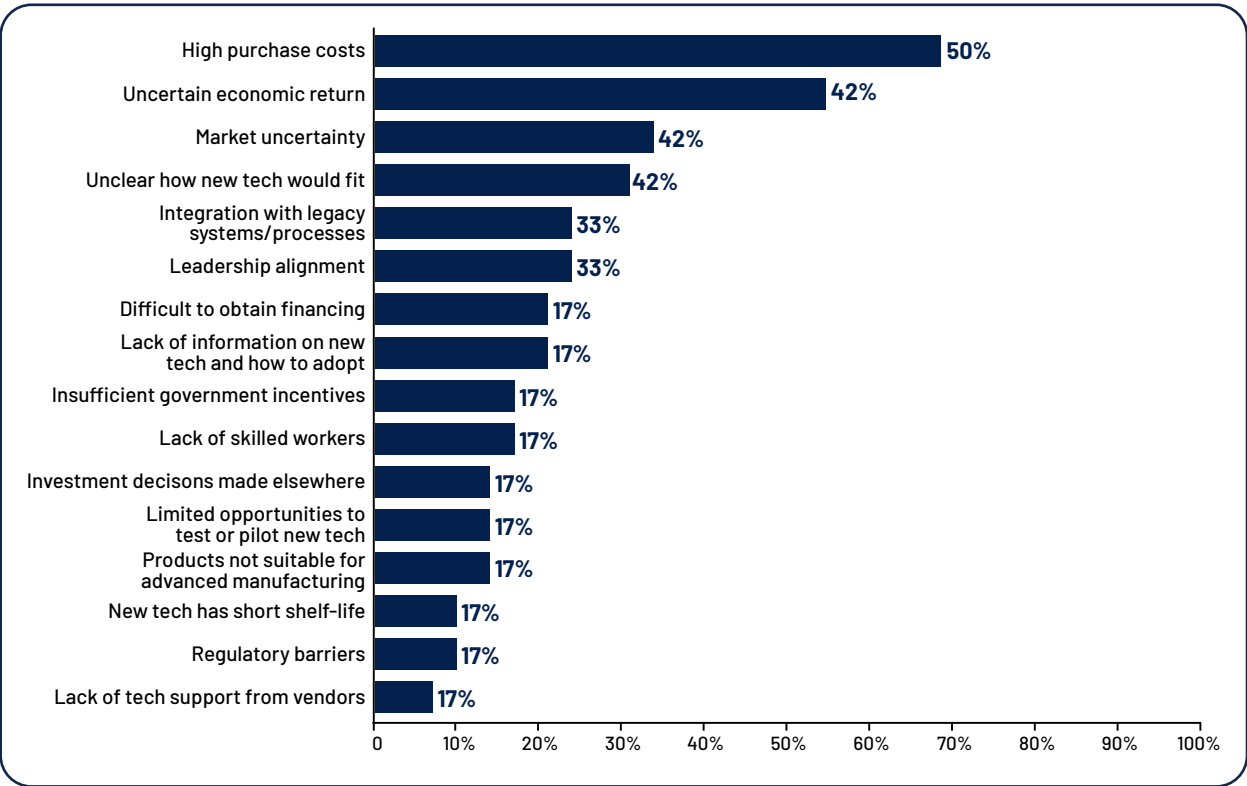
Barriers to Adoption

Even among fabricated metals manufacturers that are actively digitalizing their operations, industry leaders described recurring barriers that can slow, complicate, or narrow the scope of digital technology adoption. ICTC's Canadian Manufacturing Digital Technology Adoption Survey found that fabricated metals manufacturers reported high purchasing costs of acquiring new technologies and uncertain economic returns as major obstacles to digital technology adoption. Other important factors reported by fabricated metal products manufacturers included market uncertainty, difficulty integrating

new digital technologies into legacy systems and processes and being unclear how novel digital technologies fit into existing metals fabrication operations (Figure 11).

These barriers were not a reflection of a lack of interest in technology, rather, they reflected practical constraints tied to capital intensity, the realities of high-mix production, uneven digital maturity across the supply chain, and rising compliance expectations—particularly for firms pursuing aerospace, defence, and other high-assurance markets.

Figure 11. Main Obstacles to Adopting in Digital Technologies – Metal Product Manufacturing (2025)



Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

Capital Costs and Financing Barriers

A major barrier consistently emphasized by fabricated metal products firms was capital cost, particularly when companies move beyond “foundational” digitization such as ERP adoption and digitized quality records into automation and robotics. Canada Tubeform described the hurdle bluntly, “the big thing obviously is the expense, the expenditure,” noting that digitization required investments in “PCs, printers, the training,” plus an ERP-PLC interface and “a SCADA application, a \$20,000 piece of software, with \$3,000 in fees for annual maintenance and support.”

Several leaders interviewed for this roadmap stressed that many advanced digital tools are easiest to justify when production is high-volume and repeatable. In custom machining, the economics differ for digital technology adoption. For example, robotics utilization can often be the sticking point. One noted that in many shops, a robot becomes more of a visible showpiece than a consistently productive asset. According to this interviewee, “It’s a part of the tour... it’s cool to say you have one, but it’s always sitting there doing nothing.” In other words, the barrier isn’t simply access to robotics, it’s whether the shop has the steady volumes, repeatable cycles, and standardized setups needed to keep it running enough to justify the investment.

One industry expert interviewed for this roadmap mentioned financing strategies, such as technology leasing, phased capex programs, co-investment options with supply chain partners, and tax credits may help increase fabricated metal products manufacturers’ access to digital technologies.

Data, Systems Integration, and Cybersecurity Risk

Another barrier was data capture and integration. Even in firms that have “gone digital,” many systems still rely on humans to “manually punch in data,” meaning that people are still required to enter and validate data at the machine. In practice, that means the weakest link isn’t always the software itself, but the friction of getting clean, consistent data into it and moving it across systems. Several companies described environments where digitization has replaced paper and improved visibility, yet key information like job status, downtime reasons, quality checks, time tracking, still relies on operators logging inputs at the point

of work. The result is a hybrid reality that can bottleneck processes.

While digitization can improve traceability, the workload can shift onto operators and supervisors unless additional sensors, connectors, or monitoring tools are implemented. The “next tier” of Industry 4.0, machine metrics, automated data capture, real-time monitoring, often remains out of reach without further investment and integration work.

Companies also face cybersecurity and compliance burdens, especially for firms that want to sell into defence-related supply chains, where “good enough” IT security is no longer sufficient. Several participants described having baseline protections in place, like formal procedures, and outsourced managed IT, but emphasized that defence-oriented requirements raise the bar dramatically and are increasingly unavoidable. As one interviewee put it, “especially if you want to play in the defense market it’s just a matter of time,” pointing to expanding compliance regimes such as CMMC in the United States and CPCSC in Canada.

Sectoral Structural Constraints

Finally, participants pointed to structural constraints in the fabricated metal products manufacturing sector, especially fragmentation and uneven modernization, that shape what is feasible for digital adoption. One interviewee characterized the industry as “very fragmented,” dominated by small, owner-operated shops where succession planning is often weak. In that context, scale becomes a prerequisite for many digital investments. Firms that are not growing find it difficult to justify major systems and upgrades, which in turn widens the gap between digitally advanced leaders and the long tail of smaller laggards.

These pressures are compounded by cost-competitiveness dynamics. As one participant noted, offshore machining can sometimes undercut domestic production, “the added cost to get a machined part back into Canada is less than some of our costs in Canada,” creating a tougher investment case unless digitization can clearly move the needle on productivity, documentation efficiency, and the kinds of audit-ready capabilities that sustain customer confidence. A number of industry leaders ICTC engaged with for this roadmap shared how smaller fabricated metal products firms, such as independent machine shops, are currently being consolidated and recapitalized by investors, such as private equity firms.



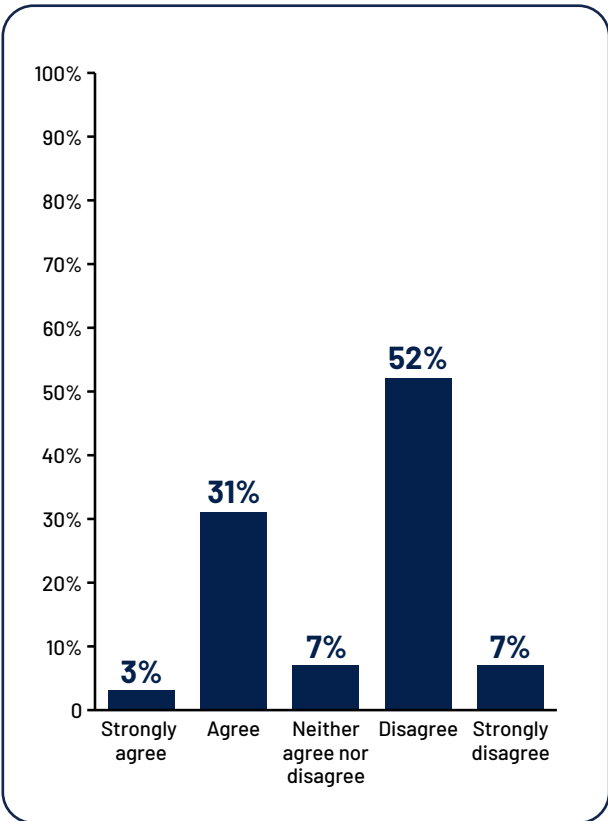
Workforce and Skills Barriers

Workforce capacity and specialized skills, especially for advanced automation and high-mix, high-precision work also emerged as a barrier. Even where core machining capability is strong, achieving significant automation, or even “lights-out” production, demands significant amounts of digital technology expertise. As one executive observed, digital manufacturing “it’s a very specific skillset, you’d be developing how to anticipate issues when you’re trying to run lights out.” This anticipatory, systems-oriented skillset, combining machining knowledge with process engineering, tooling

strategy, and data-driven troubleshooting, can be difficult to recruit and takes time to build internally.

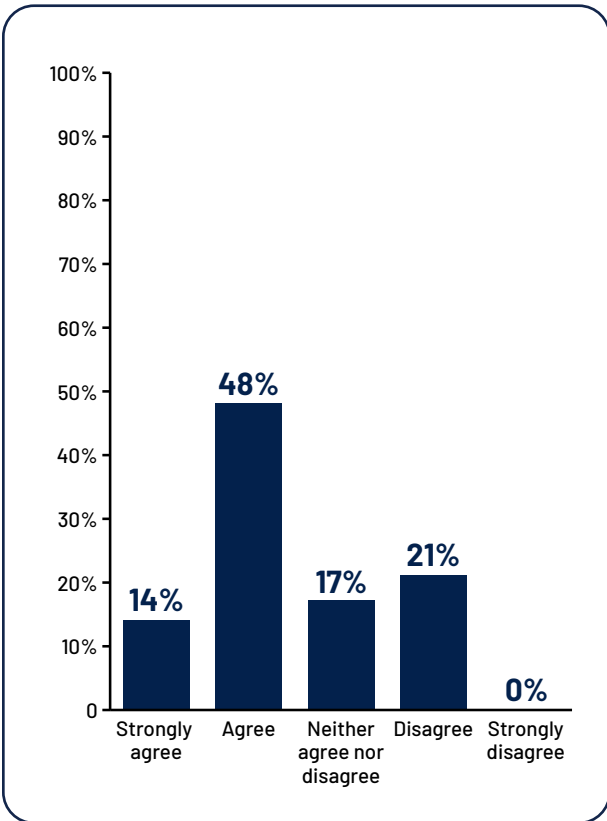
When it comes to staff training and workforce development to drive digital transformation, 62% of Canada’s fabricated metal products manufacturers reported having staff with the digital skills required to adopt new digital technologies. Only 34% of fabricated metal products manufacturers reported having formalized staff training plans for adopting and implementing new digital technologies (Figures 12 and 13).

Figure 12. Agree/Disagree: My organization has a staff training plan required to implement and adopt new digital technologies – Metal Products (2025)



Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

Figure 13. Agree/Disagree: My organization has staff with the digital technology skills required to implement and adopt new technologies – Metal Products (2025)



Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

Considerations for Organizational Change Management

Across Canada’s metals and fabrication industry, firms described their journey towards digital adoption as a sequenced, operational decision that often began with a single “backbone” system, that they only expand on once it is proven on the shop floor. Firms also highlighted governance and staged rollout as central to making adoption stick. Rather than trying to train everyone on everything at once, one company shared how it was deliberately rolling out digital technology implementation in manageable phases. For this firm it wasn’t “new software for the sake of it,” but as a long-term survival strategy as they indicated to staff “If you guys want to work here for the next 30 years, we need to be ahead of the curve, not behind it—otherwise we’ll just slowly deteriorate out of the market.”

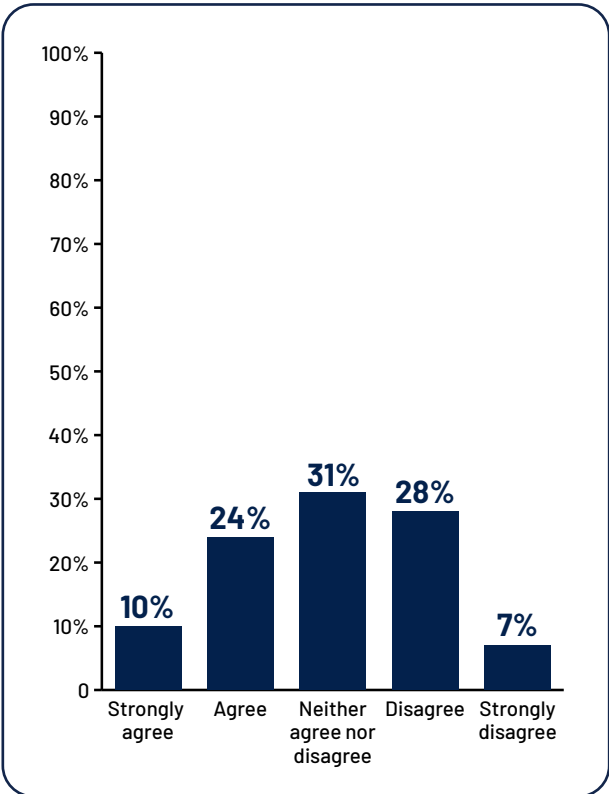
In a competitive environment, digital transformation promised exciting new opportunities for Canadian fabricated metal

products manufacturers, but the need to successfully manage organizational changes brought on by new digital technologies was a matter of continued competitiveness, relevance to customers, and ultimately firm survival.

Fabricated metals products manufacturers participating in ICTC’s digital transformation survey of Canadian manufacturers reported to be still developing digital transformation change capacity sector-wide.

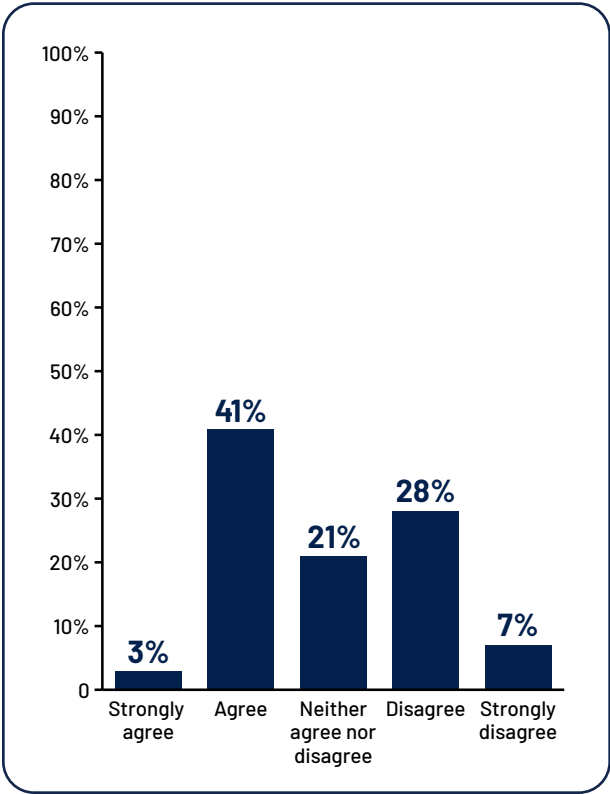
When it came to developing comprehensive digital technology adoption strategies and supporting a strong culture of change when supporting digital transformation, 34% of manufacturers reported having a comprehensive digital technology adoption strategy and 44% enjoyed a culture of change aligned to digital transformation (Figures 14 and 15).

Figure 14. Agree/Disagree: My organization has a comprehensive strategy for digital technology adoption – Metal Products (2025)



Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

Figure 15. Agree/Disagree: There is a strong culture of change aligning digital strategy, actions, and structure across the organization – Metal Products (2025)



Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

Digital Technology Adoption Horizon

As outlined in this case study, the technical and organizational complexities involved in adopting digital technologies and implementing digital transformation are immense yet not overwhelming. Fabricated metal products manufacturers should plan digital technology adoption over a five-year horizon. Figure 16 outlines the time horizons for digital technology adoption in the fabricated metal products manufacturing sector.

Figure 16. Digital Technology Adoption Horizon

Adoption Phase	Time Horizon	Illustrative Examples
I. Pilots	Years 1-2	Initial production automation experimentation, adopt AI production scheduling tools, cloud-based dashboards, and predictive maintenance pilots.
II. Scaling	Years 3-5	Expand successful pilots across production lines/plants, broaden workforce training programs, increased use of IoT sensors for real-time monitoring.
III. Integration	Years 5+	Integrate digital ecosystems (e.g., AI, IoT, cloud, digital twins) fully, implement enterprise-wide data platforms, and share data across the supply chain.

Note: This timeline reflects how firms in the case study see their own readiness and adoption pace. Actual timelines will vary by company size, resources, and market conditions.

Digital Technology in Metal Product Manufacturing Use Case Matrix

Use cases specify how different digital technologies can be adopted into a metal products manufacturing operation. Figure 17 provides a matrix outlining five example use cases for each of the seven digital technologies covered in this roadmap, alongside the benefits that can be derived for each use case. As there are likely dozens of use cases for each of these advanced digital technologies, with specific use cases relevant to different types of metal product manufacturing operations, the use cases presented are intended to be illustrative rather than exhaustive.

Figure 17. Digital Technology Use Case Matrix – Fabricated Metal Products Manufacturing

Technology	Example Use Case	Benefit
AI/ML	Predictive maintenance	Decrease the risk of unscheduled downtime and reduce incidents of equipment catastrophic failure.
	Maintenance/ troubleshooting chat bot	Reduce production equipment downtime by making maintenance and troubleshooting quicker.
	Compliance and technical documentation automation	Automate production of finished product documentation, such as material test reports
	AI-enabled production floor dashboard	Add predictive capabilities to data dashboards, automate routine decision-making.
	AI-enabled adaptive process control	Improve quality, increase throughput, reduce downtime, increase energy efficiency, and enhance production flexibility.

Technology	Example Use Case	Benefit
Big Data Analytics	Process optimization/root cause analysis	Increase throughput, identify root causes of variance, improve quality, and reduce materials wastage.
	Demand forecasting and inventory optimization	Increase market responsiveness, reduce scrap, and optimize production scheduling.
	Supplier performance dashboards/monitoring	Real-time monitoring of supplier performance, predicting supplier performance variance, and predicting supplier shortages.
	AI/ML training data collection for future AI model building	Collect large volumes of real-world data from production operations to train ML models for future AI implementation.
	Shop/job profitability tracking and analysis	Track job cycle times and inputs, understand shop profitability by job.
Cloud Computing	Product traceability and lifecycle management	Digital records to support product traceability and lifecycle management
	Centralized data sharing across facilities/ production sites	Seamless data-sharing across facilities and production sites, more efficient information flow.
	Scalable cloud-based MES/ERP systems	Increase MES/ERP flexibility, reduce risk of digital infrastructure/IT resource bottlenecks, and achieve cost savings.
	Digital twins hosting and scalable iteration	Host digital twins of the product, equipment, production line, or facility in a cloud environment.
	Individualized production worker data dashboards	Host data dashboards individualized for each production team members with critical information like production, safety incidents, unscheduled downtime, and special announcements.
Cybersecurity (IT/OT)	Intrusion Detection and Security Information and Event Management (SIEM)	Real-time detection, analysis, and response to incidents across networks and applications.
	Pen-testing and red team exercises	Stress-test critical IT/OT networks, identify vulnerabilities in networks and business processes.
	Cybersecurity standards and best practices (e.g., ISO 27001)	Enhance cybersecurity governance and compliance, reduce cyber risk, and adhere to insurance requirements.
	Digital forensics	Collect OT/IT network data for forensic analysis following an incident and support law enforcement.
	Secure backups and disaster recovery testing	Reduce the risk of catastrophic data loss and enhance business continuity.

Technology	Example Use Case	Benefit
Digital Twins	Production tooling digital twins	Predict machine tool wear based on historical usage and production schedule.
	Virtual (VR/XR) equipment operator training	Shortened training time for new hires, reduced time required to train workers on real equipment.
	Production line/facilities layout design/optimization	Shortened retooling time, lower hours needed by technicians to relocate equipment.
	Design-for-Manufacturing digital twin	Optimize product production steps, rapid product iteration and experimentation.
	Product design and collaboration	Enable product design and collaboration across design/production teams, facilities, supply chains.
Robotics & Industrial Automation	Robotic welding cells	Reduce worker exposure to welding fumes, reduce sparks, more uniform welds, faster welding speeds.
	Metal 3D printing support removal cells	Increased 3D printing support removal accuracy, enhanced worker safety.
	Robotic deburring/finishing cells	Reduce worker exposure to dust, debris, vibrations; improve deburring/finishing quality, increase output.
	Industrial robots/cobots enabled with machine vision for parts/materials handling	Increase pick accuracy, reduce worker fatigue, increase parts feed rate.
	Autonomous mobile robots (AMRs) for facility intralogistics	Reduced need for human material handling, real-time monitoring of material flows, agile material flows.
Sensors & IoT	Acoustic, temperature, vibration sensors on lathes, CNC machinery, 3D printers, etc.	Monitor variance in production equipment parameters for predictive maintenance.
	Automate data collection for production/ shop operations data dashboards	Automate data collection of productions and operations data for shop data dashboards.
	RFID tags for supply chain and inventory tracking	Track products, materials, and assets within the production environment to reduce the risk of asset or inventory loss.
	Automated energy and resource usage monitoring and management	Sensors automatically monitor resource usage (e.g., electricity, compressed air, coolants, water, etc.); detect resource usage variances.
	IoT sensors and worker wearables for real-time hazard monitoring and detection	Increase worker safety, reduce safety incidents, and shorten hazard resolution time.



ROI Measurement Framework

Like other business decisions, investing in digital transformation and the adoption of novel digital technologies should be assessed from a financial lens and should be aligned with strategic objectives, such as cost reduction, revenue growth, risk management, and alignment with high-level corporate strategy (Figure 18).

Figure 18. Digital Transformation Strategic Objectives

I. Reduce Costs	Leveraging advanced digital technologies and undergoing digital transformation to reduce costs, both from an operational perspective, by increasing output efficiencies, and an enterprise perspective, by reducing overheads and inputs.
II. Grow Revenue	Leveraging advanced digital technologies and undergoing digital transformation to support revenue growth, by expanding market access, increasing process and product innovation, and improving output capacity per unit.
III. Manage Risk	Leveraging advanced digital technologies and undergoing digital transformation to better manage operational, enterprise, and market risk, including reducing errors and improving quality, retaining customers, and improving workplace safety.
IV. Strategic Alignment	Leveraging advanced digital technologies and undergoing digital transformation in pursuit of long-term corporate vision and enterprise strategic planning, particularly regarding factors such as market access, innovation, workforce development, human resources, and profitability.

Figure 19. Digital Transformation Investment Inputs

Category	Investments/Spend	Illustrative Examples
Digital Technology & Equipment	Robotics(cobots and industrial robots)	ABB CRB15000 GoFa, BotX Cobot Welding System
	IoT/sensors	Sensors, controllers, RFID tags, machine vision cameras
Digital Infrastructure	Networking and connectivity	Industrial ethernet, 4G/5G, ISED NCLL spectrum ⁵
	Cybersecurity program (IT/OT)	Firewall, SIEM, endpoint protection, pen-testing
	Cloud services subscriptions	AWS, Microsoft Azure, Google Cloud
Software Licensing	IoT/IIoT plaforms	Siemens MindSphere, GE Predix, PTC ThingWorx
	Big data/AI platforms	Seebo, IBM Watson, Dassault Systèmes DELMIA Apriso
	Cybersecurity platforms (IT/OT)	Microsoft Defender, Palo Alto Networks IoT/OT security
	Cloud/hybrid ERP	JobBOSS, Epicor Kinetic, Oracle NetSuite
	Tariff/controlled goods platforms	Enterprise NEO, SAP Global Trade Services, F12.net,
Human Resources & Workforce Development	Workforce training/development	Employee training, tech. mentorship/coaching
	Digital talent recruitment	Campus recruiting, apprenticeships, co-op participation
	Change management	Internal communications, consultants
	HR management	Union negotiations, job description changes

Note: The software applications and hardware platforms mentioned in this table are intended to be illustrative examples and should not be construed as endorsements nor as procurement recommendations.

Required investments will include hard costs, such as new technology and equipment, underlying digital infrastructure, and software licensing, as well as soft costs, such as training and workforce development, change management, and HR issues (Figure 19).

Figure 20 outlines an ROI framework for adopting digital technologies for a manufacturing enterprise. This ROI framework is categorized into classes of benefits, including operational efficiencies, workforce and capital productivity, market access, innovation, health and safety, and ESG

(environmental, social, and governance), and is cross-referenced with the digital transformation strategic objectives discussed above.

Detailed ROI calculations will be unique to individual manufacturers, including specific mixes of digital technologies and their associated use cases, and the presented ROI framework is intended to help manufacturers navigate ROI assessments and business case development. Like the use case matrix, the ROI framework is intended to be illustrative rather than exhaustive.

⁵ Innovation, Science and Economic Development Canada (Government of Canada), "Non-competitive local licensing (NCLL)," last update February 19, 2026, <https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/licences-and-certificates/non-competitive-local-licensing-ncll>.

Figure 20. Advanced Manufacturing Digital Technology Adoption ROI Framework

Benefits		ROI Metrics	Objective Alignment			
Benefit Types	Potential Benefits	Example Metrics	Reduce Costs	Grow Revenue	Manage Risk	Strategic Alignment
Operational Efficiencies	Increased production	% increase in finished products/hour		X		X
	Scheduling adherence	% decreased in scheduling variance	X		X	
	Reduced materials wastage	% reduction in materials waste	X			
	Reduced error	% reduction in error rate	X		X	
Workforce Productivity	Task automation	# labour hours saved	X			
	Workforce redeployment	% role revised for higher value tasks	X	X		X
	Enhance employee engagement	% increase in employee engagement	X		X	
	Reduce absenteeism	% decrease in absentee hours	X		X	
Capital Productivity	Equipment utilization	% increase in equipment utilization	X			
	Production line/cell flexibility	% reduction in line/cell retool time	X			X
	Reduced equipment downtime	% reduction in equipment downtime	X			
	Efficiency of capital investment	% increase in EBITDA per dollar PP&E	X			X
Market Access	New clients/customers	# new contacts		X		X
	Efficient business development	% bid-to-win rate for new contacts	X	X		
	Client/customer retention	% of existing customers retained	X	X	X	X
	Digital capability tie-ins	% of RFPs requiring digital capabilities		X		X
Innovation	Reduced product iteration time	% reduction in time to iterate designs	X	X		X
	Digital pilot projects launched	# of new digital tech adoption pilots			X	X
	Product development time	% reduction in product dev. time	X			X
	Reduce time-to-market	# week reduction time-to-market	X	X		
Health & Safety	Reduced lost-time incidents	% reduction in lost time incidents	X		X	
	Reduced repetitive strain injuries	% reduction in repetitive strain injuries	X		X	
	Reduced near-miss frequency	% reduction in near-miss incidents	X		X	
	Reduced WCB premiums	% reduction in WCB premiums	X		X	
ESG Measures	Reduced carbon footprint	% reduction in carbon footprint	X		X	X
	Increased energy efficiency	% reduction in facility electricity use	X		X	X
	Reduced material inputs	% reduction in material input per unit	X		X	X
	Reduced water use	% reduction in facility water use	X		X	X

Change Management Checklist

Adopting digital technologies into existing manufacturing operations necessitates careful change management planning. Investing time and resources in a change management strategy to support digital transformation can increase the likelihood that a project will meet its objectives by a factor of seven, while producing a three-to-one to seven-to-one ROI, according to a 2025 whitepaper by Culture Partners.⁶ Likewise, early engagement in change management can increase project ROI by 40-60%.⁷

Change management plans supporting digital technology adoption initiatives should include a project sponsor, a clear delineation of roles and responsibilities, identification of a champion to lead the change, and internal and external communication planning, as well as a staff training plan. Plans should also include pre-designed feedback loops, such as feedback portals, surveys, and staff town halls.

Lastly, they should include measurable goals and timelines to monitor progress, provisions to celebrate success when achieved, and options to scale successful pilots into larger digital transformation projects. Figure 21 below outlines a change management checklist for use in digital technology adoption initiatives.

Figure 21. Digital Technology Adoption Change Management Checklist

I. Pre-Implementation Phase:

- › Secure executive leadership commitment and clear digital transformation vision.
- › Conduct comprehensive skills assessment and identify training needs.
- › Establish dedicated project team with representatives from all affected departments.
- › Create communication plan addressing concerns and benefits for all stakeholders.
- › Define success metrics and establish baseline measurements for ROI tracking.

II. Implementation Phase:

- › Pilot technology with small, manageable scope before full deployment.
- › Provide hands-on training for all users, with special attention to production workers.
- › Establish feedback mechanisms and regular check-ins with implementation team.
- › Address resistance proactively through transparent communication and involvement.
- › Document lessons learned and adjust approach based on pilot results.

III. Post-Implementation Phase:

- › Measure outcomes against established success metrics and ROI framework.
- › Celebrate early wins and recognize team contributions to build momentum.
- › Establish continuous improvement processes for ongoing optimization.
- › Plan for scaling successful implementations across additional facilities or processes.
- › Update training programs based on real-world experience and user feedback.

⁶ Culture Partners, "Change Management ROI: Measuring Financial Returns and Business Impact," June 10, 2025, <https://culturepartners.com/insights/change-management-roi-measuring-financial-returns-and-business-impact/>.

⁷ Ibid.



Digital Transformation Phase Gates

When undertaking a digital transformation in manufacturing enterprises, a change management plan can be supported by structuring change through phase gates aligned with the digital transformation timeline outlined earlier in this document.

For example, if a fabricated metals product manufacturer, such as a machine shop, were interested in adopting a suite of IoT sensors for its production equipment such as lathes, CNC cutters, and vertical mills, Gate 1 could verify that the equipment is compatible with the new sensors and that the area the production cell is placed in has required connectivity for the sensors to transmit data to a cloud-based database.

Gate 2 is to validate whether the new IoT sensors reliably capture data over time and whether the

data provides management with useful insights into the state of the production process. After Gate 2 is cleared, manufacturers should financially validate the pilot to measure ROI and adherence to strategic objectives (i.e., cost reduction, revenue growth, risk management, and long-term strategic alignment). Intermediate financial validation helps firms reduce the chance of falling for sunk costs.

Gate 3 would include staff training for all production workers and machinists, while Phase 4 would expand the technology adoption initiative and add IoT sensors to other areas of the shop floor. Figure 22 outlines such a phased gate approach to digital transformation in manufacturing, including illustrative examples for each of the seven digital technologies covered in this roadmap.

Figure 22. Digital Transformation Phase Gates

Digital Technology	Gate 1: Tech Readiness Check	Gate 2: Pilot Validated	Intermediate Financial Validation Step	Gate 3: Workforce Trained	Gate 4: Integration Approved
AI/ML	Identify use case (e.g., predictive maintenance)	Pilot AI model on one machining cell	Predefined ROI metrics mapped to strategic objectives.	Train maintenance technicians to interpret outputs	Deploy across facilities
Big Data Analytics	Ensure data capture infrastructure is in place on production process.	Pilot dashboards for root cause analysis	Predefined ROI metrics mapped to strategic objectives.	Train data analysts, production team members	Scale to enterprise-level decision-making
Cloud Computing	Assess cloud vendor solutions/options	Pilot cloud-based MES on a trial basis	Predefined ROI metrics mapped to strategic objectives.	Train IT and shop managers on the new system	Fully migrate workflows to cloud ERP/MES
Cybersecurity (IT/OT)	Baseline security assessment	Pilot intrusion detection system	Predefined ROI metrics mapped to strategic objectives.	Train production staff on cyber protocols	Certify enterprise-wide compliance
Digital Twins	Develop a digital twin for one piece of machining equipment	Validate the twin against real performance	Predefined ROI metrics mapped to strategic objectives.	Train machinists and equipment operators with simulations	Expand to line or facility-wide twins
Sensors / IoT	Install sensors on one machine cell	Validate output improvement/downtime savings	Predefined ROI metrics mapped to strategic objectives.	Train machinists to use new technology	Expand across the machine shop
Robotics	Assess cobot's/robot's readiness for a machine shop task	Pilot cobot on metal part deburring and finishing	Predefined ROI metrics mapped to strategic objectives.	Train production team members on safety and cobot training and co-working	Integrate robotics into multiple machining cells

Managing Risk

As with any new initiative, risk and uncertainty are inherent to change and should be accounted for in project plans. Figure 23 below provides an example risk register. Such tools can be used to document and specify risks associated with technology adoption and digital transformation.

Figure 23. Canadian Metal Product Manufacturing Example Digital Transformation Risk Register

Risk Category	Specific Risk	Impact	Probability	Possible Mitigation Strategies
Technical	Integration failures	High	Medium	Pilots/testing, vendor partnerships
	Cybersecurity vulnerabilities	High	Medium	Security framework, audits, response
	Legacy compatibility	Medium	High	Assessment, middleware, migration
Financial	Cost overruns	High	Medium	Phased implementation, ROI metrics
	Negative ROI	Medium	Medium	Track ROI metrics
Human Resources	Digital skills gaps	High	High	Training, recruit for digital skills
	Workforce resistance	Medium	Medium	Employee ownership
Operational	Production disruptions	High	Medium	Parallel ops, scheduled downtime
	Supply chain disruptions	High	High	Multi-region sourcing, stockpiling
Vendor Risk	Tech vendor reliability issues	Medium	Medium	Multi-vendor, SLAs, backup plans
	Vendor lock-in	High	Medium	Open standards, portability, and exit strategy
Market/ External	Regulatory/policy changes	Medium	Medium	Monitoring, flexible compliance
	Competitive pressure	High	Medium	Market monitoring, agile strategy

Risk Management Trigger Scenarios

In addition to establishing a risk roster to support enterprise digital transformation, trigger scenarios can be adopted as a risk management tool. Trigger scenarios are indications that a risk is either occurring or is at a heightened probability to occur

in the future. Figure 24 below provides illustrative trigger scenarios with early warning indicators and suggested actions, showing metal products manufacturers how to spot when a risk is rising and take timely steps to mitigate it.

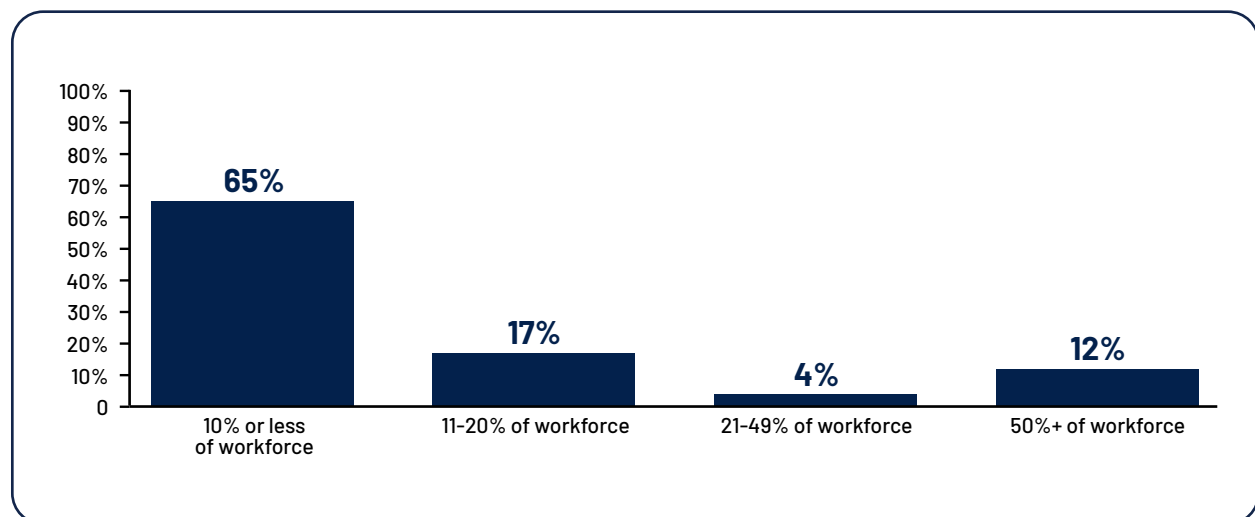
Figure 24. Example Fabricated Metal Products Manufacturing Trigger Scenarios

Trigger Scenario	Early Warning Indicator	Potential Action
I. Trade dispute leads to tariff and country-of-origin restrictions in key export market	Regulatory bodies issue call for comment on new regulations under consideration. Overseas customers signal potential changes in tariff regimes in key markets.	Use ERP to track HS codes for all material inputs and finished pieces destined for export; use enterprise data to quantify tariff export exposure on ongoing basis.
II. Key supplier shows signs of financial distress	Late deliveries, quality slippage, credit rating downgrades.	Identify alternate suppliers; build buffer stock; engage in contingency planning.
III. Workforce turnover spikes in production and skilled trades workforce	Increase in overtime reliance, exit interviews citing job dissatisfaction.	Launch retention measures; accelerate cross-training; adjust hiring plans.
IV. Equipment reliability declines	Rising unplanned downtime or repeated maintenance calls.	Initiate predictive maintenance pilot; carry out root-cause analysis of downtime; prioritize Capex replacement schedule.
V. Customer demand shifts suddenly	Drop in firm orders or requests for new product configurations.	Reassess production plan; explore using product digital twins; increase use of flexible automation.

Talent, Workforce Development, and Training

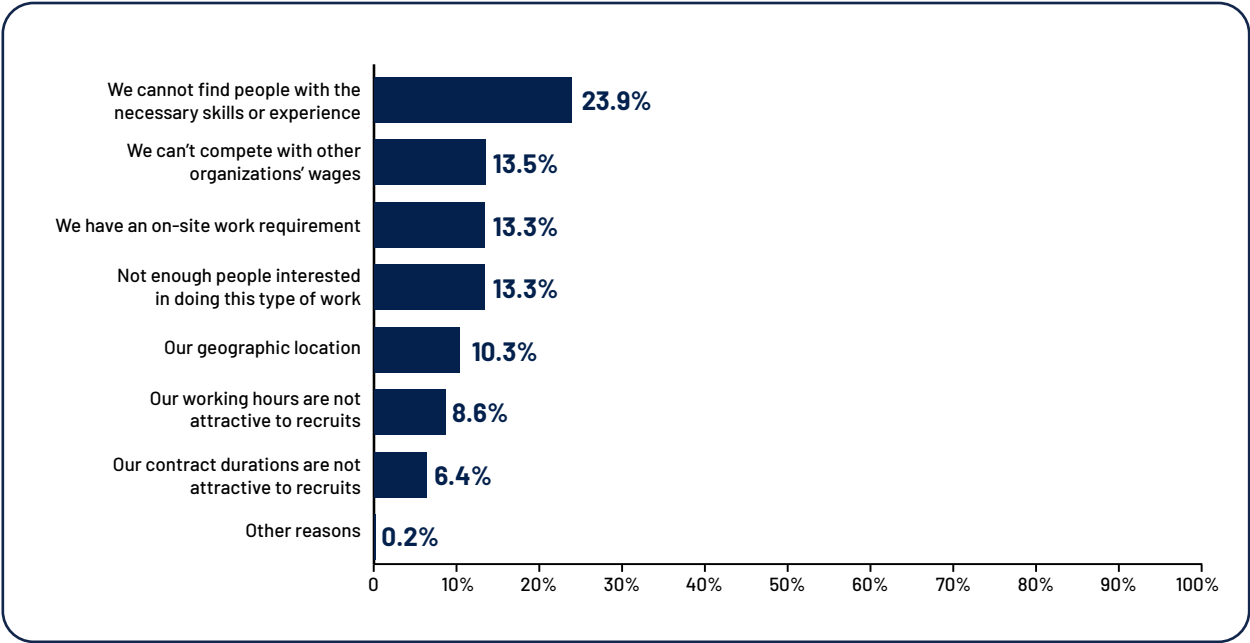
Developing a digitally skilled manufacturing workforce is essential to realize the full potential of digital transformation in Canada's fabricated metal products manufacturing sector. The need to accelerate the proportion of the workforce driving digital transformation in metal products manufacturing is important to sustain continued growth. ICTC's 2025 survey on digital technology adoption in Canadian manufacturing found that 65% of metal products manufacturers surveyed devote 10% or less of their workforce to digital transformation efforts (Figure 25).

Figure 25. Workforce Dedicated to Digital Transformation at Canadian Metal Product Manufacturers (2025)



Source: ICTC Canadian Manufacturing Digital Technology Adoption Survey, 2025.

Figure 26. Canadian Employers’ Challenges in Recruiting Technology Employees in Past 12 Months



Source: ICTC's 2024 Digital Economy Employer Survey.

Competition for digital talent in adjacent sectors to manufacturing—such as infrastructure, energy and natural resources, and technology—are immense. Indeed, recruiting technology workers with the needed mix of skills and experience was the top recruiting challenge faced by employers across Canada, according to ICTC's 2024 digital economy employer survey (Figure 26).⁸

On top of recruiting and retaining skilled digital talent to drive digital adoption in Canada's fabricated metal

product manufacturing sector, there are significant opportunities to invest in upskilling and retraining programs for the existing workforce.

Manufacturers adopting digital technologies into their operations as they undergo digital transformation need to establish baseline, essential digital competencies across their workforces. This includes the following essential advanced manufacturing digital competencies outlined in Figure 27.

⁸ Maryna Ivis, Todd Legere, Christopher Lindstrom, Sheldon Lopez, and Faun Rice, "Digital Economy Pulse: Productivity and Employment Trends in Canada," Information and Communications Technology Council (ICTC), 2025, <https://ictc-ctic.ca/reports/digital-economy-pulse-productivity-and-employment-trends-canada-august-2025>, 22, Figure 9.

Figure 27. Baseline Digital Competencies for Advanced Manufacturing

Advanced Robotics Interaction	Safely and productivity interacting with advanced robotics in machine shop or manufacturing environments, including interactions with cobots.
AI and ML Basics	Understanding capabilities and limitations of AI/ML systems and how autonomous systems are being adopted into metal product manufacturing applications.
Cloud Computing Applications	Working with cloud-based manufacturing and enterprise systems such as MES and ERP applications.
Cybersecurity Fundamentals	Basic IT/OT security awareness for machine shop or manufacturing environments.
Digital Twin Operation	Managing and interpreting virtual representations of physical systems.
Data Analytics and Interpretation	Understanding how to collect, curate, analyze, and act on large volumes of operational data

Most critically, metal product manufacturers engaging in digital transformation need to create a culture of continuous learning amongst their workforces through deliberate organizational strategies and embracing innovative training models to foster digital talent.⁹

Learning should be structured in a practical manner that conveys hands-on knowledge and digital skill development. Figures 28 and 29 outline organizational strategies and training delivery models for fostering digital talent in fabricated metal products manufacturing.

⁹ The Conference Board of Canada, "Building a Digitally Skilled Workforce: Insights from Canadian Employers and Skills Leaders," The Conference Board of Canada and Future Skills Centre, March 2022, <https://fsc-ccf.ca/research/building-a-digitally-skilled-workforce/>.

Figure 28. Organizational Strategies for Fostering Digital Competencies in Advanced Manufacturing

Integrate Digital Skills into Existing Roles	Integration of digital competencies into existing job roles rather than creating separate digital positions.
Provide Recognition and Incentives	Recognition and incentive systems that reward digital skill development and knowledge sharing.
Develop Internal Digital Skills Training Capabilities	Invest in internal training capabilities to reduce dependence on external providers.
Include Workforce in Pilot Projects	Create cross-functional teams made up of employees throughout manufacturing enterprise to launch technology adoption pilots, document learnings.
Pursue Digital Talent Development Partnerships	Partnerships with post-secondary institutions, technology vendors, and other ecosystem actors for ongoing skills development.

Figure 29. Training Delivery Models for Fostering Digital Competencies in Advanced Manufacturing

Cross-generational Mentoring	Pairing digitally skilled employees with experienced machinists, welders, and other production staff.
Simulation-Based Learning	Using digital twin environments, coupled with VR/XR for safe, realistic training experiences.
Micro-Learning Modules	Short, focused training sessions that accommodate shifts and production schedules.
Vendor-Supported Training	Leveraging technology supplier expertise for specific system training.
Micro-credentials	Short, skill-focused, and flexible educational programs, often delivered online.

Developing Strategic Partnerships

Canadian metal product manufacturers do not need to undertake their digital transformation journeys alone. Indeed, there are plenty of outside organizations within the manufacturing industry and the public sector that metal products manufacturers can develop strategic partnerships with. These include industry associations, as well as other ecosystem actors, such as industry working groups, industry-led training initiatives, and tech incubators. Post-secondary institutions can also be leveraged to provide workforce training, a pipeline of new talent, through work-integrated learning (WIL) initiatives, such as apprenticeships and co-op programs, campus recruiting, and joint applied research activities.

Likewise, relationships with stakeholders such as customers, suppliers, and technology vendors should be taken into account when undergoing digital transformation. Figure 30 below outlines key

strategic partnership and stakeholder management verticals, which should be accounted for when undergoing digital transformation.

Figure 30. Strategic Partnership Verticals

Customers	Vendors and Suppliers	Industry Associations and Ecosystem Groups	Post-Secondary Institutions
› Digital transformation co-investment and cost-sharing programs › Open digital platforms and interoperable data standards › Joint cyber/information security protocols › Joint digital transformation pilot programs	› Digital transformation co-investment and cost-sharing programs › Open digital platforms and interoperable data standards › Vendor training and technical mentorship/coaching programs › Joint cyber/information security protocols	› Industry working groups (e.g., joint digital transformation working group) › Technology/start-up incubator programs › Industry-led training and workforce development initiatives › Sectoral public affairs and governmental relations initiatives	› Workforce training and talent development › WIL programs (e.g., apprenticeships, co-ops practicums) › Campus recruiting (e.g., job fairs, industry nights) › Joint industry-academic research › Industry curriculum advisory councils

Information and Data-sharing for Fabricated Metal Product Manufacturing Strategic Partnerships

In addition to the key partnership verticals listed above, metal products manufacturers should be ready to jointly develop predefined partnership frameworks and agreements upfront between new partners. Co-developing a common understanding of partnership objectives, scope, and timelines is

critical to foster successful partnerships. Metal products manufacturers should also understand the types of potentially sensitive non-personal data, such as production and process, financial, supply chain data, that may be needed to share with partners (Figure 31).

Figure 31. Strategic Partnership Information and Data-sharing Considerations

Strategic Alignment

- › Objectives, scope, and partnership timeline
- › Business case and ROI expectations (e.g., financial/performance metrics)
- › Governance model and decision-making processes (e.g. IP ownership, dispute resolution)
- › Knowledge sharing frameworks (e.g., publication agreements, joint workshops, user groups, technology demonstrators, pilots)

Technical Data Requirements

- › Manufacturing systems and processes (e.g., enterprise systems and control systems (MES/ERP), machinery/ equipment inventory)
- › Facilities connectivity (e.g., 5G, ethernet)
- › Non-personal data sharing (e.g., production and process, IP/trade secrets, quality, financial, safety/incident, supply chain)
- › Interoperability standards and data formats
- › Cybersecurity standards/data protection

Safety, Regulation, and Compliance Requirements

- › Quality standards
- › Health and Safety standards
- › Environmental/ESG standards
- › IP and confidentiality agreements

Digital Technology Adoption: A Call to Action

Canada’s fabricated metals product sector stands to benefit from increasing digital technology adoption throughout its production enterprise. The sector is playing an important role in Canada’s economy, as a significant locus of production of key fabricated metal products essential to critical supply chains, such as aerospace and defence, automotive, and energy.

Over the next five to ten years, there are significant opportunities in emerging digital technologies such as advanced robotics, AI, IoT, and digital twins, but digital infrastructure must be continuously upgraded, while the fabricated metals product workforce needs to be continuously trained and upskilled to get the most out of novel digital technologies on the factory and shop floors. Canadian fabricated metal products manufacturing SMEs should strive to implement foundational digital infrastructure stacks, which include

technologies such as a cloud ERP backbone and a baseline IT and OT cybersecurity program.

Likewise, to get the most out of digital transformation, fabricated metals products need to understand and rigorously assess opportunities brought about by novel digital technologies and incorporating them into their business plans and long-term corporate strategies, developing business cases, measuring ROI, evaluating risk, managing organizational change, and mapping stakeholders and strategic partners.

Action Steps

Assess	Map your current processes and technological capabilities and identify digital gaps.
Pilot	Start with a small project (e.g., a lab automation, predictive maintenance, or AI production scheduling tool).
Train	Involve staff early, build digital change champions on the lab floor, recruit digital technology talent.
Partner	Engage with vendors and suppliers, post-secondaries, industry associations and ecosystem groups, and customers for expertise and shared resources.
Scale	Expand proven pilots across lines, labs, or product families.
Integrate	Network successfully scaled technology adoption initiatives into a cohesive technology stack to drive profitability, cost savings, and productivity.
Iterate	Repeat technology adoption cycle as new technologies emerge and markets evolve.

Research Methods

This roadmap for the Canadian fabricated metal products sector is informed by mixed methods research, including an industry survey of Canadian advanced manufacturers, a series of key informant interviews, an industry roundtable, and a comprehensive literature review.

ICTC carried out an industry survey of Canadian manufacturers (n = 133) from June and July 2025, which included responses from 29 firms from Canada's fabricated metal products manufacturing sector. Due to the wide variety of firm types involved in fabricated metal products manufacturing and a relatively small sample size, survey data may not fully reflect the state of all Canadian metals manufacturers. ICTC also carried out five semi-structured key informant interviews with senior executives, technical leaders, and other experts from the Canadian fabricated metal

products manufacturing sector. ICTC also hosted a fabricated metal products manufacturing sectoral roundtable with industry leaders in January 2026.

Prior to carrying out primary data collection, ICTC conducted a comprehensive literature review on digital transformation, digital technology use cases in manufacturing, and the current state of advanced manufacturing in Canada. Insights collected during the literature review helped to inform questions asked to research participants during the industry survey, key informant interviews, and focus groups, as well as design the final roadmap document.