Catching the Wave: Lessons from Ontario's Digital Manufacturing Early Adopters

Paul Boothe, Alister Smith, and David Zhang

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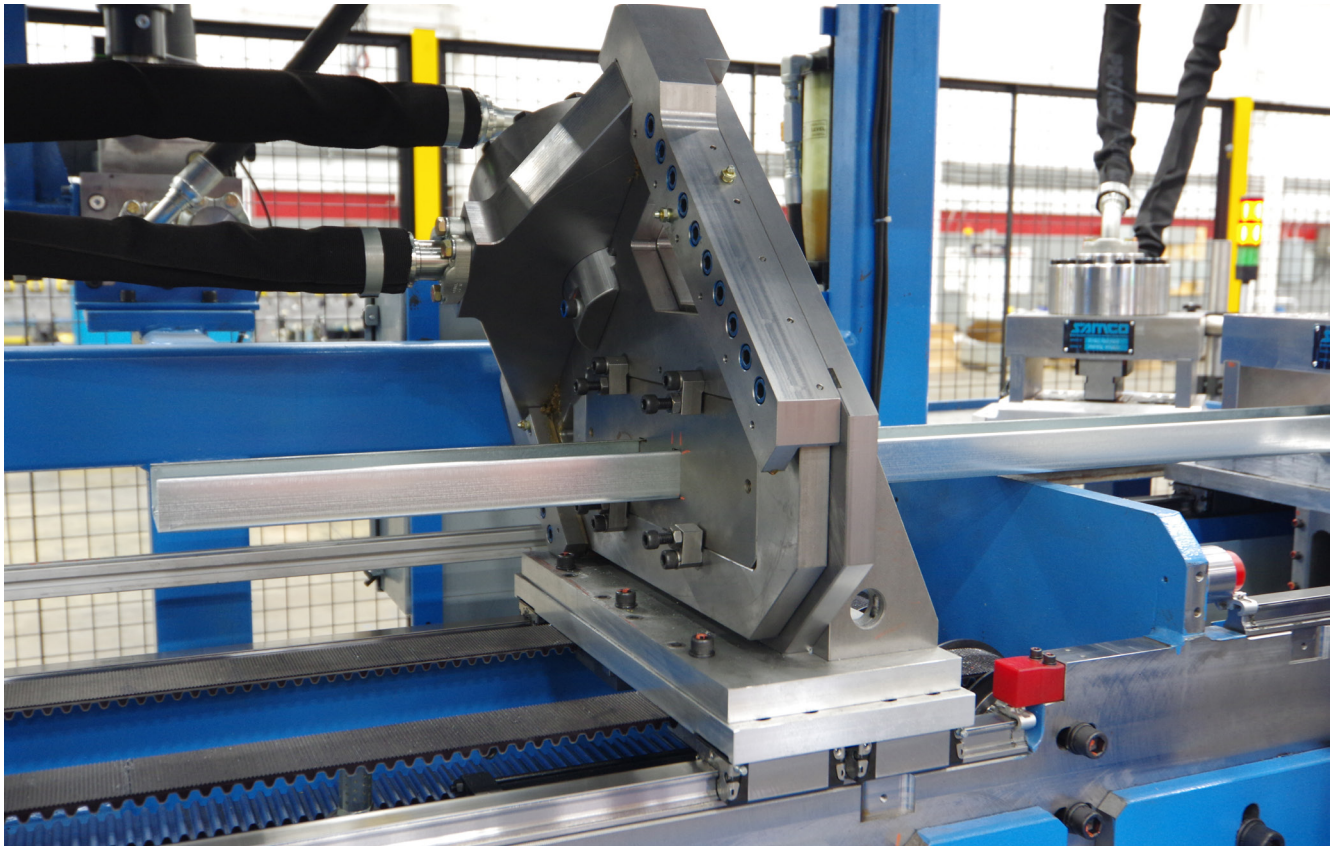
Table of Contents

Introduction

A wave of innovation is sweeping across manufacturing firms around the globe. Like the industrial revolutions driven by steam power, electricity, and computerized automation before it, this one has the potential to revolutionize every aspect of manufacturing, from design to production to distribution. Digital manufacturing is here and is leading to more efficient and economical manufacturing processes. Moreover, digital manufacturing improves product quality and better integrates product design with the production process. The machines and tools used in the digital manufacturing process require less unscheduled maintenance, have a smaller environmental footprint, and are better integrated with suppliers upstream and customers downstream.

Yet introducing digital manufacturing is no easy task, especially for small and medium-sized enterprises (SMEs). Understanding what digital technologies and processes (DTPs) can do and where to start can be costly both in terms of resources and senior management time. Despite the fact that the potential rewards make business sense, the learning curve tends to be steep. Thus, many Ontario manufacturers are waiting to learn from the experiences of early adopters before implementing DTPs themselves. All the while, they risk losing ground to their early adopter competitors, leaving themselves vulnerable to disruption.

The aim of this paper is to help 'de-risk' the adoption of DTPs by Ontario manufacturing SMEs by providing access to knowledge gained by early adopters. Building on the knowledge gained by their peers, we hope to provide Ontario manufacturers with both the appetite for and the insight needed to implement digital manufacturing with the goal of growing sales and profitability.



What is Digital Manufacturing?

The concept of digital manufacturing, or 'Industry 4.0', originated in Germany nearly a decade ago. Industry 4.0 was conceived of as a strategic initiative to further integrate information and communication technologies into manufacturing processes[1]. The concept was characterized as the digitalization of manufacturing, or, the application of DTPs to (vertical) manufacturing value chains from product design to production to service and maintenance, as well as to (horizontal) supply chains and customers. Industry 4.0 was popularized as signalling the start of the fourth industrial revolution following those of 1) the mechanization of production through steam and water power, 2) the use of electric power to create mass production, and 3) the use of electronics and information technology to automate production[2]. In short, and while definitions vary, Industry 4.0 is generally thought of as the application of DTPs to manufacturing value chains.

1. Schuh, Gunter et al. (2017), "Industrie 4.0 Maturity Index. Managing the Digital Transformation of Companies," Acatech Study Series.
2. Schwab, Klaus (2016), "The Fourth Industrial Revolution: what it means, how to respond," World Economic Forum.

What are the Key Elements of Industry 4.0?

Digitalization is already occurring in manufacturing. Firms use information and communication technologies for myriad purposes. These include Enterprise and Resource Planning (ERP), Supply Chain Management (SCM), and increasingly, Manufacturing Execution Systems (MES). There is widespread use of embedded software and sensors in production machinery. Massive volumes of data are collected in modern factories, and sophisticated software packages on cloud computing platforms are used to analyze data to optimize production processes[3]. At the frontier, some firms use artificial intelligence (AI) to process data. Nonetheless, what is novel about Industry 4.0 is the potential for end-to-end integration of digital design, testing, production management, data analytics, and communication technologies in manufacturing.

Common Elements of Industry 4.0 Observed in Manufacturing Settings	
1	Integrated digital design and testing of new products and processes (including 'digital twins' of products and of production processes)
2	Advanced and 'smart' robotics
3	The Industrial Internet of Things (IIoT)
4	'Big Data' analytics

3. OECD (2017), The next production revolution: implications for government and business, (Paris: OECD Publications).

Why Adopt Industry 4.0/DTPs?

There are a number of reasons to adopt DTPs associated with Industry 4.0. An initial motivation in Germany and elsewhere in Europe was to improve competitiveness in manufacturing while maintaining high wages employment. The use of DTPs holds the promise of reducing production costs (including those related to unscheduled maintenance), accelerating innovation, improving product quality, and increasing employee engagement[4]. From a national or regional perspective, maintaining or improving international competitiveness remains a motivator behind the introduction of Industry 4.0. As leading manufacturers from Germany, the United States, and elsewhere adopt DTPs, their competitors must respond in order to keep pace.

The potential benefits of adopting DTPs are evident in firms that have made significant progress in this area. In addition to productivity, cost, and quality improvements, adopting DTPs permits greater control over production processes, greater agility in changes to products or processes, better coordination with suppliers, and greater responsiveness to customers. Indeed, DTPs are already improving manufacturing design and processes, enabling predictive maintenance of machinery and tooling, optimizing SCM, and accelerating the time to market of new products.

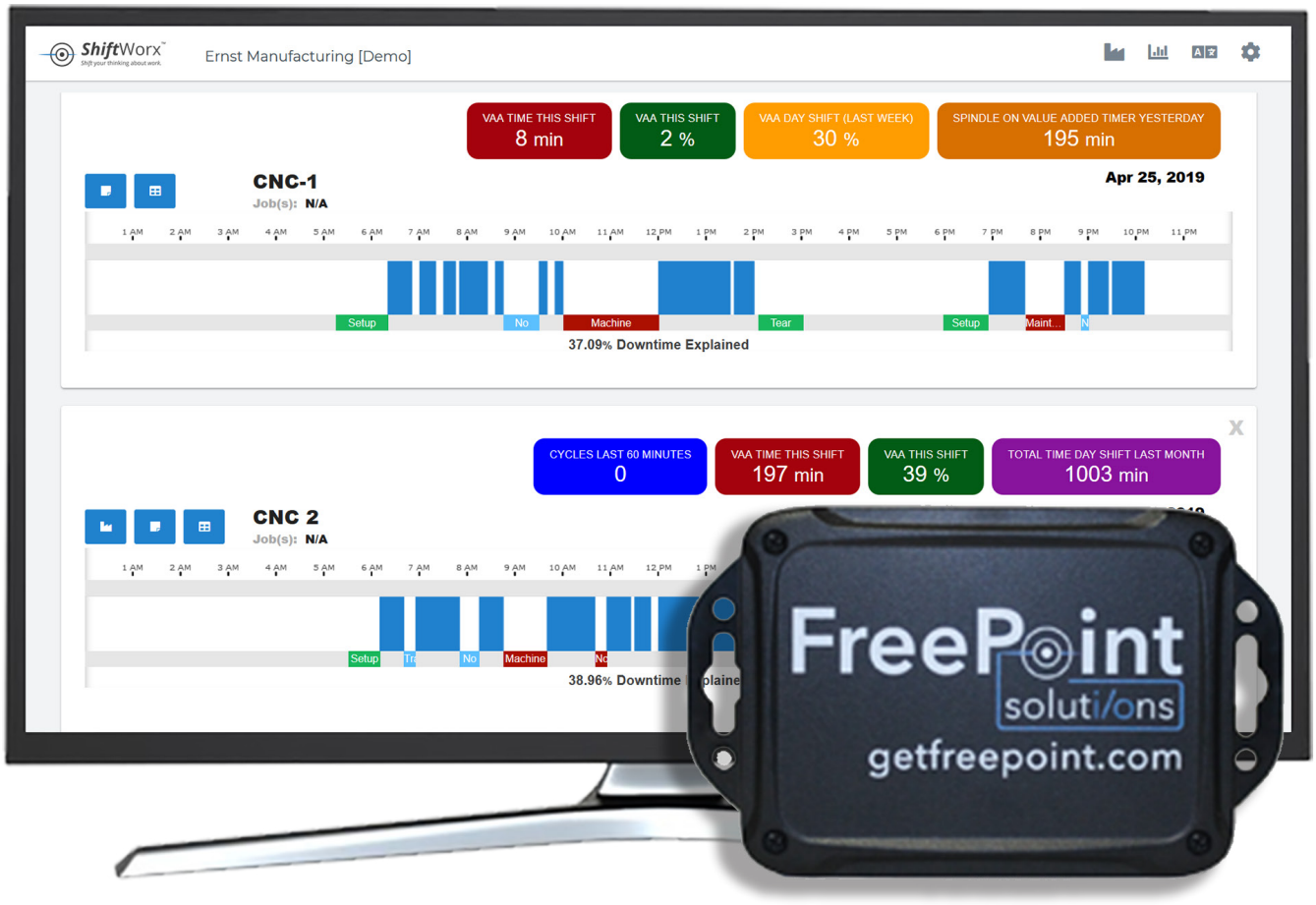
Although the necessary investments of time and capital may suggest that digitalization is not yet relevant to manufacturing SMEs, competitive realities suggest otherwise. The demands of larger customers that have implemented DTPs provide an incentive, if not a mandate, for SMEs to adopt similar or complementary technologies. For example, larger manufacturers often require downstream suppliers to track data on parts and components for the purposes of quality control and monitoring delivery status.

4. Aromaa, Susanna et al. (2018) "User Evaluation of Industry 4.0: Concepts for Worker Engagement." Human Systems Engineering and Design. Springer: Champaign.

This notwithstanding, manufacturing SMEs can face considerable challenges when implementing DTPs. Many must be convinced of the business case for making such a significant change. Practical examples from manufacturing SMEs who have successfully adopted DTPs therefore play an important role in convincing leaders to prioritize the adoption of DTPs themselves.

The costs of adopting DTPs are declining. However, they remain substantial, especially for manufacturing SMEs. Many SMEs may not have made initial investments in digital platforms and may need to improve their infrastructure before they can adopt DTPs. Even for firms that have invested in digital platforms, integrating new DTPs into those platforms can prove challenging. Furthermore, the skills and training requirements for employees can be an obstacle to adopting DTPs. For example, analyzing and using the data collected by DTPs to improve production processes may require hiring new employees with entirely different skill sets and investing in training for existing staff. Change management itself, while inevitable in the fast-moving world of manufacturing, presents its own complications.

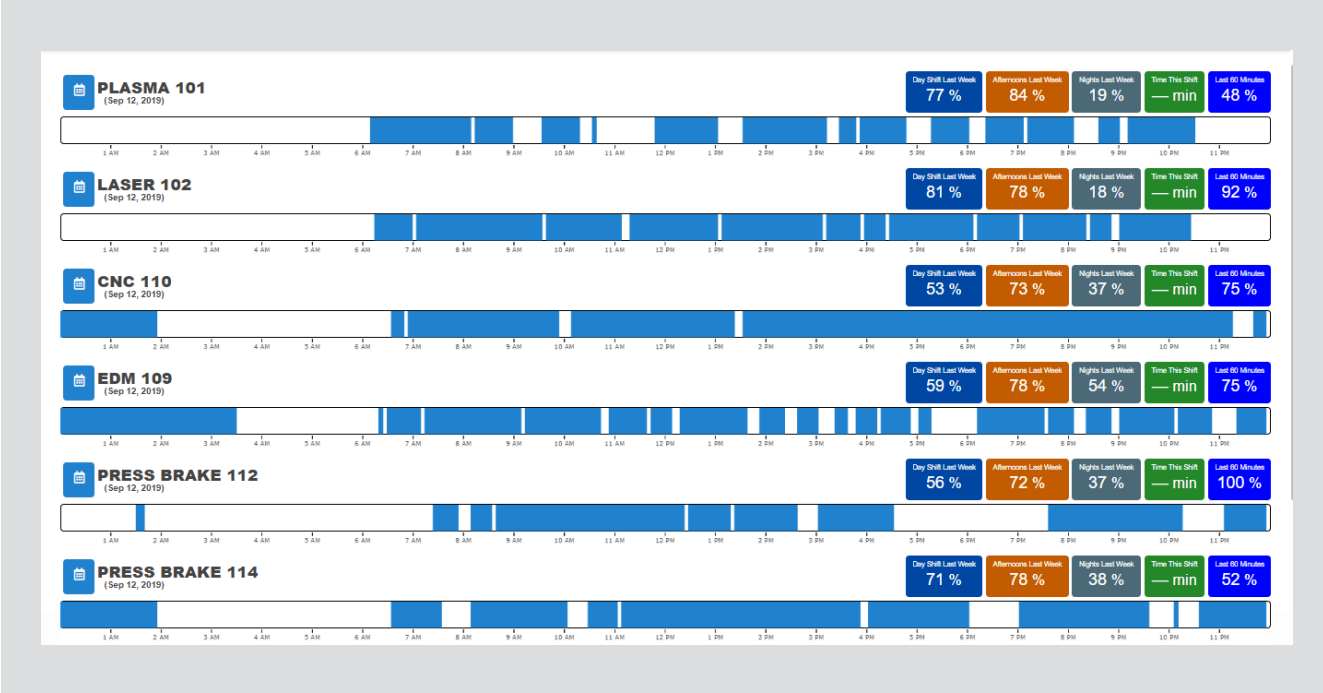
Adopting Industry 4.0: Lessons from Five Ontario Firms



To better understand the practical implications of adopting DTPs for Ontario manufacturing SMEs, we interviewed representatives of five early adopters: Freepoint Technologies, Hudson Boat Works, IMT Precision, Linear Transfer Automation (LTA), and Samco Machinery. These firms produce a range of products including software (Freepoint Technologies), Olympic-class rowing boats (Hudson Boat Works), rollforming machines (Samco Machinery), metal components for the transportation equipment and defence industries (IMT Precision), and industrial handling equipment (LTA).

These firms adopted DTPs for several reasons. Some did so to enhance their own production processes. Others did so to enhance the services they provided to customers. Some developed DTPs internally, while others did so in partnership with firms such as Freepoint Technologies, who provide software and hardware that enables the adoption of DTPs.

Interviewees were provided with four questions in advance to guide discussion. Interviews took place in person or over the telephone. Interviewees were subsequently asked to review interview notes for the purposes of clarification and to provide additional context. This section provides a summary of interviewees' responses to each question.



What digital technologies and processes (DTPs) are you currently using? Have they changed your operations as much as you expected or were there unexpected successes and failures?

The most common response was that DTPs were deployed to enable predictive maintenance. These DTPs included sensors that monitored machine performance and enabled comparisons with predicted values. Deviations from predicted values signal the need for preventative maintenance, potentially reducing downtime as a result of unscheduled production stoppages. This was especially helpful for firms that serviced customers remotely or in distant and hard-to-access locations.

Interviewees also commented on other applications of DTPs, some of which were unanticipated. For some firms (e.g. Freepoint Technologies and IMT Precision), DTPs help optimize production processes. For others, such as Hudson Boat Works, software-based DTPs help link several aspects of their business, including sales, human resources, production, and after-sales service. Others still are experimenting with linking production data with parts and material ordering and control. Finally, Samco uses digital imaging and AI to deploy access and safety protocols within their plant.

What motivated your adoption of DTPs? What was your strategy when adopting them?

In many cases, adopting DTPs was motivated by customer demands - not for DTPs themselves, but for the enhanced services they enable. As early adopters, these firms were less likely to be motivated by a need to keep pace with competitors. Rather, they realized the potential for DTPs to improve their bottom line and sought to stay ahead of competitors.

While firm strategies differed, all used established project management competencies to adopt DTPs. Firms initiated projects based on customer demands or perceived contributions to improving production or business processes. None of the firms began with a vision of completely transforming to a digital enterprise. All began by integrating DTPs with existing processes, including adding sensors or software to existing equipment. The success of early DTP projects illustrates the benefits of adopting DTPs in other areas of the business and confidence in managing the risks inherent with additional projects.

What are the risks or challenges of adopting DTPs?

For some firms, the technical capabilities of facilities presented a risk. For example, manufacturing facilities owned by suppliers or customers without access to high-speed internet prevented the adoption of DTPs. For others, data security presented a risk. Some customers were unwilling to connect their network to the outside. Firms acknowledged that data security was a preoccupation in all applications that sought to take advantage of remote performance and problem diagnostics.

Finally, for software and hardware providers such as Freepoint Technologies, the risk averse nature of Canadian customers and unwillingness to increase capital expenditures despite a proven business case were identified as key risks.

How is your firms' use of DTPs likely to evolve in the future? Your customers? Your competitors?

All of the firms saw continued internal development of DTPs in their future. Freepoint Technologies expected to expand their services as they learned more about the needs and capabilities of their customers. Others, such as IMT Precision, expected to expand their use of DTPs to manage parts and material inventories.

LTA and Samco Machinery emphasized the role of DTP-based information in improved decision making, and anticipate that AI will help optimize production processes and improve safety. They also anticipate that encouraging customers to adopt DTPs will be a priority for them in the future.

Finally, Freepoint Technologies emphasized the importance of approaching DTPs as employee enablers. Rather than replacing employees, DTPs give them a new set of tools to minimize low-value, repetitive, or dangerous work while increasing their capabilities and productivity.

Adopting Industry 4.0: Lessons from Five Ontario Firms

A number of lessons that may be useful to SMEs interested in adopting DTPs can be distilled from the experiences of the five firms whose representatives we interviewed:

Common Elements of Industry 4.0 Observed in Manufacturing Settings	
1	Base the adoption of DTPs on practical requirements. The requirement to adopt DTPs may come internally (i.e. to improve production or business processes) or from customers. In that regard, interviewees emphasized the value of listening to customers and suppliers to determine their requirements without steering them to particular DTPs at the outset. DTPs may or may not be a solution to their problems. Adopting DTPs often starts with requirements for preventative maintenance. Interviewees emphasized the importance of focusing on the problem before determining if DTPs are the solution.
2	Incremental adoption is preferable. The adoption of DTPs should be incremental, and should integrate DTPs with existing production equipment and processes. As firms gain experience, the potential for DTPs to improve production and to integrate production and business processes will become apparent. Incremental adoption also allows firms to build expertise and support from their employees.
3	Use familiar processes to manage the adoption of DTPs. Successful early adopters integrate DTPs into existing processes. This was enabled by their familiarity with effective project management and continuous improvement practices. This reduced risk and shortened timelines. DTP adoption can be integrated into regular work schedules in a manner similar to other process improvements. However, doing so may require additional hiring (particularly of technical and professional occupations, such as engineers). Alternatively, firms may engage technology-based firms to provide the necessary expertise.
4	Use DTPs to enable rather than replace employees. Interviewees emphasized the value of combining the knowledge of experienced employees with the data generated by specific DTPs to enable improvements. While it may be necessary to hire new staff, training existing staff to take full advantage of DTPs is a key element of any adoption strategy.
5	Move ahead or get left behind. Waiting to see how competitors fare with DTPs is risky. Early adopters play a role in establishing both the direction and pace of technological change. A major disruption may be just around the corner for firms that wait too long.

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Connect.

Convene.

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Trillium Network for Advanced Manufacturing
Room 6306
Social Science Centre
Western University
London, Ontario, N6A 5C2
–
info@trilliummfg.ca
(519) 661-3351