An End-to-End Approach to Industry 4.0
Aligning Manufacturing with Business Priorities
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EXECUTIVE SUMMARY

Today we are in the midst of the Fourth Industrial Revolution, fundamentally different from the previous industrial revolutions of mechanism, mass production and computerization. It is characterized by a range of new technologies that are combining the physical and digital worlds.

A byproduct of the Fourth Industrial revolution is Industry 4.0, which focuses specifically on the future of factories moving from computerization and basic automations to the next generation by connecting core operations with the enterprise-level systems as well as key stakeholders. The technologies and digital processes create the cyber-physical foundation. However, there has not been widespread implementation due to various challenges ranging from investment costs to organizational resistance.

During the last decade, solutions have advanced or were specifically developed (at high cost) to bridge connectivity gaps between legacy and standalone systems to gain access to the data. While at the same time, companies saw how early adopters used Industry 4.0 as a foundation to become market leaders.

The benefits of aligning their manufacturing with goals and priorities became clear. Smart industry leaders see beyond the technology and understand how Industry 4.0 transforms more than operations. Intelligent enterprises seek to connect cloud and IoT technology that powers big data and industrial analytics in order to adapt their business to meet customer demands and remain competitive in the global market. They know changes caused by the next revolution are just over the horizon.
INTRODUCTION

Significant shifts in the manufacturing sector are often called industrial revolutions. The first or 1.0 was when society moved from the countryside to towns and cities to work in factories. From there, manufacturing progressed through increased levels of production efficiency to various levels of automation and computerization.

INDUSTRIAL REVOLUTION

1.0
Mechanization, steam power, weaving loom.

2.0
Mass production, assembly line, electrical energy.

3.0
Automation, computers and electronics.

4.0
Cyber Physical Systems, internet of things, network.

Encyclopedia Britannica notes¹ “Like the First Industrial Revolution's steam-powered factories, the Second Industrial Revolution’s application of science to mass production and manufacturing, and the Third Industrial Revolution’s start into digitization, the Fourth Industrial Revolution's technologies, such as artificial intelligence, genome editing, augmented reality, robotics, and 3-D printing, are rapidly changing the way humans create, exchange, and distribute value.”

Each industrial revolution impacts society in some way. The fourth revolution is already having a global impact beyond manufacturing. Through the synchronization of virtual and physical, companies streamline operations and create new business models to take advantage of market opportunities, such as mass personalization. However, not every company is ready for these changes because the path to digital maturity is fuzzy at times.

This paper will explore the benefits of Industry 4.0 and provide guidance on how to overcome some common challenges. It will also discuss the next evolution and some of its technologies. Armed with this knowledge, a strategy towards digital transformation should become clearer.

“Industry 4.0 is revolutionary because it enables organizations to capture data from the physical world, analyze it digitally and drive informed action back in the physical world.”

Deloitte: “The Fourth Industrial Revolution is here—are you ready?”, 2018²
THE DIGITAL FOUNDATION

Intelligent enterprises understand how the power of cyber and physical integration can transform their operations. They have already begun to implement technology to enable the collection and sharing of data in real-time. It is allowing them to make critical decisions that drive their operations forward with reduced risk and the ability to satisfy their global customer demands. An Automation Alley report expects Industry 4.0 implementations to generate almost $1 trillion in economic value by 2025. It is a sign that companies are embracing the idea and moving forward with it.

At the core of Industry 4.0 is a digital manufacturing initiative of connecting operational and informational processes and technologies, or sometimes known simply as connecting the shop floor to the top floor. These solutions and systems when integrated start the digital transformation. The shared data creates a foundation of standardized language, communication and knowledge. It becomes easily accessible anywhere at any time by anyone with the correct permissions. The real-time information is applied to both operations and enterprise planning.

Technology Behind the Transformation

A significant part of the transition to Industry 4.0 is the underlying technology that helps connect the workforce, resources, processes and machines. While many of these elements are already in place, the key point is to integrate them across the business vs. keeping them in their operational or enterprise silos.

Digital Manufacturing Foundation Components
Automation & IoT

The rapid adoption of automation continues to be driven by cheaper and more intelligent industrial machines and robots. Oxford Economics notes since 2010 the number of robots in manufacturing has doubled in use and comprise 86% of the operational industrial robot market at the end of 2016. This automation is now being deployed in other industries such as agriculture, construction and logistics which helps improve the supply and value chains. These resources produce terabytes of data which are then used for advanced analytics, AI, machine learning and other systems.

IoT advancements have benefited from increasing access to smart devices which have driven innovation in many industries. The reduction of cost and size of sensor technology provides easy access to help power automation and visibility. These sensors capture and transmit data at pre-programmed intervals to the cloud over Bluetooth, cellular or Wi-Fi connections that enable alerts, analysis and reporting.

The logistics industry has embraced this technology. Companies use smart sensors paired with telematics to offer greater visibility of shipments or packages during transit, in a warehouse or on the shop floor. It is not only location that is tracked but proximity and environmental conditions. Management by exception becomes the model because parameters can be set to trigger alerts when deviations occur, such as long dwell times or temperature fluctuations.

For manufacturing, there are multiple applications because the value comes from pushing intelligence into the devices. One example is equipment costing upwards of $3 million in the past. Today, the programmable logic controllers (PLCs) are around $1,000 each and communicate with a company’s ERP. Another is by extending their supply chain visibility, operations can better manage inventory of ingredients, materials and parts as well as the finished product for regulatory compliance and quality.

Cloud & System Integrations

Key components of Industry 4.0 are the software and physical systems which are integrated to achieve maximum cyber-physical value. Operational systems and technology translate recipes, specifications and other directives into machine language for production. Integrated systems enable companies to digitally take orders that transmit directly into the production equipment.
Cloud technology offers flexibility, interoperability, reliability, scalability and storage. It provides the foundation for the processing of advanced and predictive analytics as well as simulation capabilities. One example is digital twins which exist in a virtual environment where current and experimental conditions can be tested without risk. Preferred results can then be applied in the real world. The cloud and integrated solutions are accessible anywhere at any time assuming the right permissions are in place.

A 2017 Harvey Nash/KPMG survey found the top three reasons CIOs sought out cloud computing were to:

- Improve agility and responsiveness
- Accelerate product development and innovation
- Save money

**Common Types of Cloud Technology**

There are three common types of cloud technology in use.

- **IaaS**: Infrastructure-as-a-Service – Gartner defines IaaS as a standardized, highly automated offering in which computing resources owned by a service provider, complemented by storage and networking capabilities, are offered to customers on demand. Resources are scalable and elastic in near real time and metered by use. Self-service interfaces, including an API and a graphical user interface (GUI), are exposed directly to customers. Resources may be single-tenant or multitenant and are hosted by the service provider or on-premises in a customer’s data center.
- **PaaS**: Platform-as-a-Service – These solutions, per Infoworld, offer a platform to clients so they can develop, run and manage business applications without the need to build and maintain infrastructure, such as mainframes and servers. There are hybrid, private and public clouds.
- **SaaS**: Software-as-a-Service – This version is the most well-known and prevalent of the technologies with many office productivity tools such as spreadsheets in use.

**Data & Analytics**

Big data captured through the cyber and physical connectivity comes from multiple sources in different formats. On premise information is often supplemented from other sources including external stakeholders, such as suppliers or logistics companies. The resulting combination creates the foundation to analyze the exabytes of data points and allows manufacturers to take advantage of AI, machine learning and more for better maintenance, inventory management and production line configurations. The data-driven insights also create a 360° visibility of the business from the top down
that enables the agility to adapt to changing customer behavior, market demands and production conditions.

Data aligns company goals by providing a common platform. It results in a path to streamline operations, find new opportunities and update business models.

THREE ROADBLOCKS TO IMPLEMENTATION

There are three common organizational roadblocks that can keep companies from fully implementing Industry 4.0 and achieving its benefits.

Lack of Strategy

Companies focusing only on the technologies behind Industry 4.0 create a stumbling block towards transformation. There is a lack of understanding about how each component, when combined, will offer a greater change in their business. The emphasis should look beyond only improving operations and production. Another planning roadblock can happen even if the technologies’ benefits are understood. It appears when there is no strategy for applying the data and analytics which hinders decision making.

Bpifrance Le Lab surveyed over 1,800 French SMB and midcap executives in 2017 and found:

- 45% of CEOs have no clear vision of their company’s digital transformation
- 63% do not have a defined roadmap for their vision
- 73% have made very little progress

The study sampled across multiple industries, such as commerce, industry and transport. The results show despite great inroads, the next generation of digital connectivity has yet to be widely adopted. These businesses are still thinking in terms of product when value is the solution. For example, life sciences are not selling medication, but instead are offering improved health.

When these situations arise, project stakeholders should facilitate brainstorming workshops, training and example successful case studies. The emphasis needs to be on showing how the implementation is an ongoing process with various stages that must be taken in order to bring Industry 4.0 to fruition. An Automation Alley report says companies must approach
implementing Industry 4.0 innovations holistically rather than product by product or department by department. It will help reduce the perceived risks while providing more time to continue to build out the strategy and how to take advantage of the resulting benefits.

**Legacy Systems and Implementation Costs**

Another hurdle can be the company's legacy equipment and systems. The two options are to upgrade or replace in order to take advantage of advanced analytics, communications and data capture. Both choices can be difficult and expensive in way of resources and time to complete. Having an approved strategy in place helps companies determine when it is prudent to upgrade as well as how to plan for capital expenditures when replacements need to be made.

One frequent method to employ is bringing in a consultant or consulting group. They can provide an outside and objective perspective on the business. The scope of the project typically includes determining the current status; diagnosing issues and opportunities; and make recommendations based on the analysis. Often, the consulting team assists with the implementation as well as evaluating the results.

**The Fear of Change**

There is concern about the difficulty of learning new ways especially as the divide between information and operational technology groups disappears. Traditionally, companies have different teams (factory, IT) manage their own technologies which strive for different goals. Additionally, employees may be fearful about losing their jobs due to Industry 4.0 automation and digitalization.

A sound strategy combined with good change management will help guide company efforts and allay any uncertainties. The roadmap outlines what the new responsibilities will be and what necessary training is needed as part of the transition. Allowing for the appropriate amount of time to become comfortable with the changes is also advisable. For example, the operators at an industrial products plant were initially somewhat resistant to the intelligent manufacturing solution interfaces and processes. However, over time, they soon embraced the new way of working, which increased their productivity.
BENEFITS OF ALIGNING PRODUCTION WITH BUSINESS

Industry 4.0 is about making the right integrations to transform an Industry 3.0 factory into a smart one. As discussed earlier, the benefits are two-fold. The first part are improvements to operations while the second part arises from the opportunities created by the cyber realm that reduces risk and uncovers new ways to conduct business. It's more of an evolution than revolution as companies implement and integrate each stage of the process.\textsuperscript{10}

Smart Operations

Digital manufacturing makes the right connections for smart factories by reducing manual and paper processes. It also frees staff from mundane tasks to work on more advanced projects. Below are some of direct benefits:

- Grow productivity through better monitoring, controlling and production processes for greater overall equipment effectiveness (OEE) when the shop floor is connected to the top floor
- Reduce operational costs by using the sensor and other data to power real-time analytics for the identification of issues and
opportunities as well as provide corrective measures
• Standardize quality execution from leveraging ERP data to support consistency in process and measurement to deliver quality product in one plant or across multiple locations
• Improve design and production through the tracking of expected vs. actual results using consolidated data accessible within an ERP
• Increase manufacturing and product lifecycle traceability by linking product composition or design to orders to production; all required ingredients, parts and specifications are identified, and the process is monitored from request through delivery

The Intelligent Frontier

As-A-Service and New Models

Advances in cloud technology change the way companies think of software. While installed solutions are important in certain situations, virtual resources provide flexible access to computing resources and files that are on-demand and require very little IT management. The services can be priced by usage, storage or processing capacity as well as in combination depending on the provider and need.

Embracing the “as-a-service” concept, operations can consider buying machine time from a vendor for production or rent their equipment in the same fashion. It offers a new way of conducting business. For example, on a small scale, a company could combine 3D printing with AI which would allow a customer to upload their specifications to the system for production.

Enterprise Asset Management

To achieve operational excellence, companies need situational awareness of how their resources are functioning. Intelligent enterprise asset management powered by the enhanced data and analytical insights enable a way to manage the entire lifecycle of physical assets.

Companies are often organized by functionality, e.g. engineering and IT, or by division, e.g. Europe and Asia. These structures can create unintended barriers when it comes to communication or resource management. Another challenge is exchanging information with suppliers and partners. Different groups have their own language, systems and processes. The flow of data is slowed or impeded, which impacts decision making and execution.
Enterprise asset management addresses these issues through the creation of a shared data core and taxonomy which delivers a new, simplified technical object structure. This construction allows greater flexibility and better modeling of both simple and complex assets. The comprehensive and in-depth view of resources provides the ability to make predictive decisions on execution, maintenance and strategy. For example, a company’s plant maintenance department could eventually predict when a part will fail based on the conditions and hours of use. A technician is scheduled to replace the part which is in stock because it is automatically ordered when inventory falls below a certain threshold.

Digital Twins

The concept of digital twins has been around since the early 2000’s. Companies could program replicas on their computers and input the data to update the design or environment specifications, which was rarely received in real-time. This methodology was a very clunky and slow way to render these virtual duplicates.

With the advent of IoT technology, such as the cloud and smart sensors, digital twins became easier and cheaper to create, maintain and use. It is enabled through intelligent enterprise asset management’s influx of connected information that creates these exact virtual replications. In this sandbox environment, there can be greater experimentation and simulations.

Digital twins fed by zettabytes of real-time data that can be analyzed quickly becomes dynamic. Machine learning and AI are activated by the volume of information. SAP notes12 “The visualization allows companies to test for potential machine failures, optimize processes, plan for future capacity and more.” Positive results can then be communicated to the physical twin(s) for implementation.
Sandbox Environments

A sandbox creates an operational environment in which the execution, operation and processes of software testing is not affected by other running programs. (Techopedia)

Industry 4.0 Examples

Each company’s goals are different when implementing Industry 4.0; however, the core focus is about managing the product lifecycle from design through manufacturing to delivery. Here are couple of brief examples.

Driving Consistent Quality

A leading brand of golf clubs uses their established single set of standards to measure and build. It helps them produce consumer-focused standard and custom product consistently of the same quality from all their manufacturing plants.

Prior to Industry 4.0 implementation, the company relied on a locally developed system within one manufacturing plant. It was siloed and completely disconnected from all their SAP ERP instances and all other manufacturing plants. Any updates made would be difficult to transfer to their other locations.
The company decided to implement SAP Manufacturing Integration and Intelligence (MII). They wanted a common tool for leveraging enterprise data to support their global standards of consistency in process and measurement. The result is a tight integration between machines and test equipment as well as a connection from SAP ERP to machines.

The traceability application is the link between all make to stock and custom orders. Within their SAP MII app, they have the single set of standards to measure and cut consistently. It incorporates data from AI and machine learning to identify all parts and specifications used to make each club. The system interfaces to various pieces of manufacturing and test equipment to set the right specifications and check to make sure the final club meets them. It ties shop floor manufacturing and quality to the enterprise order and materials system.

Additionally, engineering and quality now have all the data to analyze and track the expected and actual results because the information is consolidated and available in their SAP ERP system.

Results:
- Replace custom and non-supported local application with enterprise solution for increased business continuity and disaster recovery
- Formalize integration methods between SAP and shop floor equipment
- Access to always available current product specifications which is tracked everywhere
- Standardize equipment communication protocols for global deployment of like systems
- Allow for the capture and storage of club manufacturing data
- Provide for MES functionality foundation to be utilized on later manufacturing initiatives

**Joris Ide Group**

The Joris Ide Group is an international group in business for three decades and one of the leading European manufacturers of cladding products for the construction industry. A key company value is innovation. To fulfill this goal, they invested in Industry 4.0 through the implementation of digital manufacturing. It created a smart factory.
The company wanted to increase shop floor efficiency and visibility. It would enable them to improve production as well as better reporting to all staff from production operators to top management. This digital transformation would also allow Joris Ide to move from their current backflush accounting method to actual steel consumption measurements.

SAP Manufacturing Integration and Intelligence (MII) was implemented to integrate operations with their SAP ERP application. After a proof of concept, Joris Ide brought the system online across 52 of their manufacturing lines as well as installed SAP BusinessObjects™ solutions to improve reporting.

Results:
- 15% faster production lead times from efficient order preparation and machine data entry
- 50% fewer stock corrections due to automated updates
- 3% decrease in scrap due to greater visibility and tracking of handling units in real-time

CONCLUSION

With Industry 4.0 adoption now happening at an increasing pace, market leaders look to the future for maintaining their competitive edge to stay on top. The next generation solutions may come from those already in the marketplace which are becoming widespread, such as 3D printing and virtual reality. Innovation will also spring from outside forces such as governmental regulations or non-manufacturing industries. Consumer behavior may drive the current revolution further towards mass customization and enterprises will need to adapt to stay competitive by meeting that demand.

“There’s no such thing as “done”, you design something then you learn about more about it, hence you iterate. This process is then repeated continuously as technology evolve[s] and user habits change.”

-Jeremiah Lam, Trends to keep an eye on in 2020, November 2019
The below list contains some interesting areas to watch:

- **Augmented Reality (AR):** In 2020, Gartner expects 25% of companies to deploy AR in production. It pairs well with factory employees that must access information while on the production line. AR technology reduces the need for them to look away from their task. It displays the request, such as diagrams, digitally in front of them which can improve accuracy, productivity and safety.

- **Manufacturing-as-a-Service and Mass Customization (MaaS/ MC):** There are use cases in place of companies manufacturing on demand for customized requests from low volume parts to golf clubs. The idea is to have the request submitted directly to the production facility whether it be rendered on a 3D printer or produced on a full manufacturing line. There are still challenges of maintaining quality and scalability. However, it is a promising concept to customize on a mass scale. Aberdeen notes\(^\text{15}\) “companies who have currently implemented some form of customization see a 62% savings reduction relating to the cut in production downtime.”

- **Voice Search:** This concept has taken hold in the consumer and even within the ERP world. People ask questions to their smart devices from phones to digital assistants to their vehicles. It could provide the same benefit in the smart factory, where employees can request the information they need without disrupting their workflow. And, paired with AR, it could be displayed before them.

Regardless of the methodology or technology, the Fourth Industrial Revolution is well underway. Companies would be wise to start or continue moving further towards implementing Industry 4.0 because it is more of an evolution than a revolution. By overcoming the challenges and with a strategy in place, the introduced intelligent innovation will keep them competitive.

To discover how you can implement emerging technologies in your operations to drive Industry 4.0-based improvements and innovations, reach out to the Movilitas team at movilitas.com/contact
Footnotes in Chicago style generally include the author name, the publication title, publication date, publisher information with the very first citation, and a page number.

2 Deloitte, “The Fourth Industrial Revolution is here—are you ready?” https://www2.deloitte.com/content/dam/insights/us/articles/4364_Industry4-0_Are-you-ready/4364_Industry4-0_Are-you-ready_Report.pdf
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