



Creating connected manufacturing operations in the Internet of Things

Software Innovations



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White Paper

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Overview

Henry Ford introduced the first assembly line on Dec. 1, 1913 and organizations have been looking for ways to improve their manufacturing processes ever since. Major breakthroughs came about in the 1970s with the adoption of Programmable Logic Controllers (PLCs). PLCs allowed organizations to connect to machines within their plants, extract data and use it to maximize system uptime. Shortly after, Electronic Data Interchange (EDI) technology was introduced, allowing manufacturers to share inventory data with vendors and suppliers in near real-time. This enabled manufacturers to integrate to the supply chain and further improve the efficiency and agility of their operation. These innovations were revolutionary in terms of improving business efficiency on the plant floor. However, in order to have maximum impact on the business, manufacturers must look beyond their own operations and consider how to leverage connectivity for their distributors and customers.

The Internet of Things enables the connectivity of stakeholders along the value chain

The next paradigm shift in manufacturing is towards connecting manufacturing operations across the value chain. To do so, organizations will not only need to connect their plant equipment and supply chain, but also their demand chain. This can be achieved by connecting the products they create using machine-to-machine (M2M) technology for the Internet of Things (IoT). If an enterprise is connecting the assets it creates, it can gain powerful insights into its customers, business processes, distributors, maintenance requirements, product warranties and much more.

Supply and demand integration increases the visibility into assets and products

This white paper will discuss how organizations can connect their operations by leveraging the Internet of Things. It will provide insights into the evolution of manufacturing technology, the benefits of being a connected manufacturer, key enabling technologies and review important use cases.



The IoT is the next generation of the internet. It is a global system of IP-connected computer networks, sensors, actuators, machines, and devices. Based on research by the analyst firm Machina Research, 14 billion IP-enabled devices will be connected by 2022 ([download infographic](#)).

Merging the physical world with the virtual world of the internet and software enables companies and consumers to create and enjoy new services that are founded on web-based business models. This will have a big impact on the way we do business.

Industry 4.0 – The Fourth Industrial Revolution

Manufacturing is revolutionizing

There have been four major industrial revolutions over the centuries that have changed the face of manufacturing. The first, Industry 1.0, was the introduction of the mechanical loom in 1784 which simplified the process of manufacturing textiles. The second, Industry 2.0, was the introduction of the assembly line in 1913 by Henry Ford allowing for mass production of the classic Model T. The third, Industry 3.0, was the introduction of the PLC in 1969 which added intelligence to plant equipment, allowing manufacturers to maximize system uptime. With recent advancements in M2M and communications technology, the world is just now beginning to experience the next major industrial revolution – Industry 4.0.

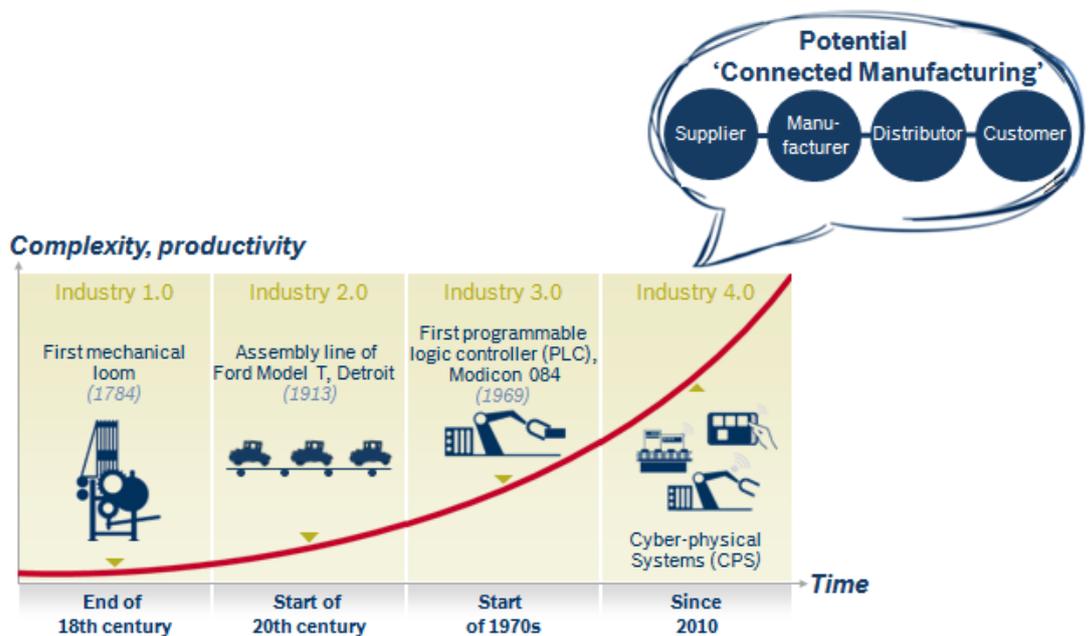


Figure 1: The Fourth Industrial Revolution

Source: Forschungsunion, acatech, Abschlussbericht Arbeitskreis Industrie 4.0

Industry 4.0 allows organizations to create connected manufacturing operations

Industry 4.0 will allow organizations to become connected manufacturers. From the supplier, to the plant, to the distributor, to the manufactured product itself, everything in and around the manufacturing operation will be connected enabling a true integration of business processes and technology. This allows organizations to

go deeper in the demand chain to not only monitor the plant, but also the asset created within the plant as it goes through the distributor/dealer network to the end customer. With this level of visibility into product data, manufacturers can glean valuable information around service delivery, how the equipment is being used and maintained, as well as other important data to improve the customer experience and boost revenue. For example, with a connected asset in the field, a customer service department could respond to auto-generated/auto-scheduled service tickets when one of its machines malfunctions (or is close to failure) rather than waiting for someone to recognize an issue and manually create an alert. This would allow an enterprise to improve on-time performance metrics and enhance customer service.

New relationships for a new value chain

Using IoT technology to integrate the demand and supply chains allows manufacturers to engage with end customers in a way that they never have before. By connecting the suppliers, equipment within the plant, the distributor/dealer network and end customers, organizations can pull data through the supply and demand chains, truly enabling a connected manufacturing operation.



Industry 4.0 is a term shaped by representatives of German industry leaders, researchers, industry associations and unions. It describes how Internet of Things-enabled systems will improve engineering, production and logistic processes by connecting machines, systems and stakeholders along the manufacturing value chain.

Business Opportunities

Integrating equipment and product data throughout the enterprise can impact the business in numerous ways. From improving operational efficiency to enhancing customer service, organizations are achieving tremendous return on investment (ROI) from their IoT technology deployments.

Efficient use of labor: The points where customers and companies come together change. Instead of 'meeting at the point of sales,' it becomes a continuous interaction as long as the customer uses a product or services. When a product becomes an agent interacting with humans and providing multiple services over a lifetime, it provides a new perspective on business.

Transparent processes can significantly reduce operating costs

Energy consumption: It is important for organizations to identify key stakeholders within the organization and have a clear understanding of what energy consumption data is needed to impact the business. At the macro level, a connected operation will result in less energy consumption because the organization is optimizing machine usage, labor, and product and service delivery. However, this is only a fraction of what an organization can achieve using energy consumption data. At the

micro level, organizations can monitor the energy consumption of its products in the field to improve customer service. For example, if a manufacturer detects that a motor on one of its products is consuming twice the power that it should, this may indicate that it is trending towards failure. It could then proactively address the issue with the customer before it becomes a problem. In addition to improving the customer experience, this could be a revenue-generating opportunity for service/parts for the manufacturer or dealer.

Supply chain: Organizations often struggle to manage inventory so that the appropriate amount of product or equipment part is available at the right time. For example, a technical support group must keep replacement parts on inventory to support equipment in order to be effective. However, maintaining this inventory depletes organizational capital. Additionally, carrying too much inventory can lead to lower turns, inefficiency, and additional (capital) storage and maintenance costs. On the contrary, not carrying enough inventory can lead to machine down time, frustrated customers and most importantly, lost revenue. Therefore, companies seek to maintain the optimal level of inventory. This can be achieved by creating a digital network of suppliers, factories, warehouses, distribution centers, retailers, and customers, real-time collecting and processing of data to close the gap between material objects and their representation in information systems.

Real-time visibility into assets and products is key for improving operational performance

Quality: Connected manufacturers not only monitor the quality of their products throughout the manufacturing process, but also once their assets have been deployed by customers in the field. Therefore, as quality issues arise, manufacturers have access to that data in near real-time. This information can be used by manufacturers in the research and development processes to enhance the quality of their products and minimize unplanned downtime.

Warranties: Warranty costs for organizations can be very high. However, a company traditionally provides a warranty without much visibility into how its customers are using its products. By monitoring products in the field, organizations can determine if the product was being used in the way it was intended. If so, the warranty claim can be honored. If not, it becomes a potential revenue opportunity for service and support. It also allows the organization to validate if the issue is with the equipment or due to user error, allowing the company to reduce warranty costs.



When transitioning to becoming a connected manufacturer, it is critical to determine all internal and external stakeholder needs and define the data needed from both the plant and the equipment in the field to meet each stakeholder's objectives. In doing so, organizations will maximize the ROI of their technology investment and impact the business in a meaningful way.

Technology Enablers

The technology exists now to become a connected manufacturer. Sensor, gateway, battery, platform and cellular network technology are enabling the transition to the fourth industrial revolution – and all have developed dramatically in recent years.

10 years ago, sensors were the size of a hockey puck and cost as much as \$300. Sensors were also connected via landline, if at all, and had limited battery life. Today, sensors have scaled from the size of a hockey puck to the size of a nickel and utilize wireless technology. They also cost a tenth of their previous price. Today's gateways are also much more efficient because they transmit data only when necessary – not continuously. Similarly, batteries now last longer in challenging environmental conditions such as colder, warmer and moisture-rich environments while also being much smaller.

Cellular technology is also faster and cheaper. Because organizations are sending data only when necessary, the cost for the implementation of IoT projects is decreasing. This allows companies to connect equipment that was previously uneconomical to instrument.

Finally, technology platforms have enabled greater adoption of IoT solutions. These platforms will enable organizations to optimize their portfolio of assets for improvements in the areas of predictive maintenance, production monitoring, asset tracking, asset management, supply chain management, cost management and more. In order to maximize the value of becoming a connected manufacturer, organizations need a robust platform that can handle data from multiple systems and devices, apply rules and business logic, and integrate it effectively. In order to obtain maximum value from machine data, the information must be integrated into the business process. The Bosch Software Innovations Suite is mainly comprised of three key components to help organizations do so.

IoT platforms connect the real and virtual worlds to enable communication between objects

Machine-to-Machine for Device Management (M2M): The M2M component provides the connection to the asset. This component connects devices with central backend systems, allowing customers to monitor and control remote assets.

Incoming data masses can be filtered, evaluated, and translated into meaningful information

Business Rules Management (BRM): Bosch's BRM tool applies business logic to the machine data. The component helps manufacturers collect, transfer, store and analyze raw machine data to drive intelligent actions. For example, it would detect if a power meter in a product deployed by a customer is measuring out of bounds, thereby violating the customer's warranty contract.

Business Process Management (BPM): The BPM component integrates data into backend systems. After the data has been collected and applied against business rules, BPM integrates the data into business systems like Oracle, SAP or other CRM or MRP systems where it can be analyzed and used by business leaders.

Case Studies

Bosch Software Innovations is working with various customers on the implementation of projects to enhance the performance of operations inside and outside of their manufacturing plants. As an active member of the Industry 4.0 working group, founded by Germany's Industry-Science Research Alliance, the Bosch Group contributes with its mechanical engineering and production know-how along with the software and systems expertise of Bosch Software Innovations to develop strategies for advanced manufacturing in the Internet of Things.

Use Case 1: Connected Operations

A leading developer of equipment used in automotive, aircraft and train operations is transitioning to becoming a connected manufacturer. To help with this transition, they turned to Bosch Software Innovations to help them connect their advanced handheld tools, including tightening tools, screw drivers, grinders, glue guns and burnishing machines. Many of these network-connected tools feature onboard computers and wireless connectivity that allow the tool to control, for example, the work process efficiently and provide quality feedback to back-end systems. Bosch has built track and trace functionality leveraging indoor localization around the tools. For the networked tools, the equipment manufacturer can not only identify the location of the tools within its plant at any time, but also map the proximity of the tools to the workstations. This allows the company to determine which tool should be used on which product or part, and quickly direct employees to the tool's location to improve manufacturing efficiency. The tools also provide additional information such as tool calibration and battery status, which helps the company control the maintenance process and improve quality control.

Use Case 2: Predictive Maintenance

An \$8 billion dollar manufacturer of driving control technologies used in large machines for printing, mining, wind energy and other industries needed a way to allow its customers to monitor the health of their equipment in the field. It therefore selected Bosch Software Innovations' software to provide its customers access to a portal that offers near real-time machine component health data. The solution allows end customers to detect potential malfunctions before they occur. For example, it could conduct a liquid analysis to discover if any components are likely to breakdown to solve this problem immediately. A service technician can react to the issue before the machine goes down and plan maintenance routes that reduce repair costs, optimize maintenance efforts and reduce energy consumption. Ultimately, the solution allows the end customer to limit machine downtime and maximize the value of their equipment.

Use Case 3: Connected Asset

A manufacturer of dirt moving equipment was collecting data in and around the plant, but not from the equipment itself once it left its property. Bosch helped the company connect its equipment in the field, allowing it to collect and share critical equipment data with its dealer network. For example, if the manufacturer is gathering information about hydraulic fluid and it determines there is a particulate in the fluid on one of its customers' machines, it can proactively notify the dealer to address the issue. And because the manufacturer can gather information about its machines in the field, it can also see how changes in its manufacturing process or supply chain are impacting its customers. The Bosch solution enables the manufacturer to modify and improve its products based on real customer data and enhanced service delivery.



Learn more about Bosch ConnectedManufacturing

- ▶ *Connected World Blog:*
<http://blog.bosch-si.com/categories/manufacturing/>
- ▶ *Industry 4.0:*
<http://www.bosch-si.com/lp/connected-manufacturing.html>
- ▶ *ConnectedManufacturing podcasts:*
<http://www.ciotalkradio.com/connectedmanufacturing>

Bosch Software Innovations GmbH, the Bosch Group's software and systems house, designs, develops, and operates innovative software and system solutions that help our customers around the world both in the Internet of Things and in the traditional enterprise environment. We place particular focus on the topics of mobility, energy, industry, banking and insurance. Our software suite is the perfect foundation not only for projects relating to the Internet of Things but also for projects in the fields of Device Management (M2M), Business Process Management (BPM) and Business Rules Management (BRM).

With some 600 associates worldwide, Bosch Software Innovations has locations in Germany (Berlin, Immenstaad, and Stuttgart), Singapore, China (Shanghai), Australia (Melbourne), and the United States (Chicago and Palo Alto).

More information can be found at www.bosch-si.com.

The Bosch Group is a leading global supplier of technology and services. According to preliminary figures, its roughly 281,000 associates generated sales of 46.4 billion euros in 2013 (Note: due to a change in the legal rules governing consolidation, the 2013 figures can only be compared to a limited extent with the 2012 figures). Its operations are divided into four business sectors: Automotive Technology, Industrial Technology, Consumer Goods, and Energy and Building Technology. The Bosch Group comprises Robert Bosch GmbH and its more than 360 subsidiaries and regional companies in some 50 countries. If its sales and service partners are included, then Bosch is represented in roughly 150 countries. This worldwide development, manufacturing, and sales network is the foundation for further growth. In 2013, Bosch applied for some 5,000 patents worldwide. The Bosch Group's products and services are designed to fascinate, and to improve the quality of life by providing solutions which are both innovative and beneficial. In this way, the company offers technology worldwide that is "Invented for life."

Additional information is available online at www.bosch.com, and www.bosch-press.com, <http://twitter.com/BoschPresse>.

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