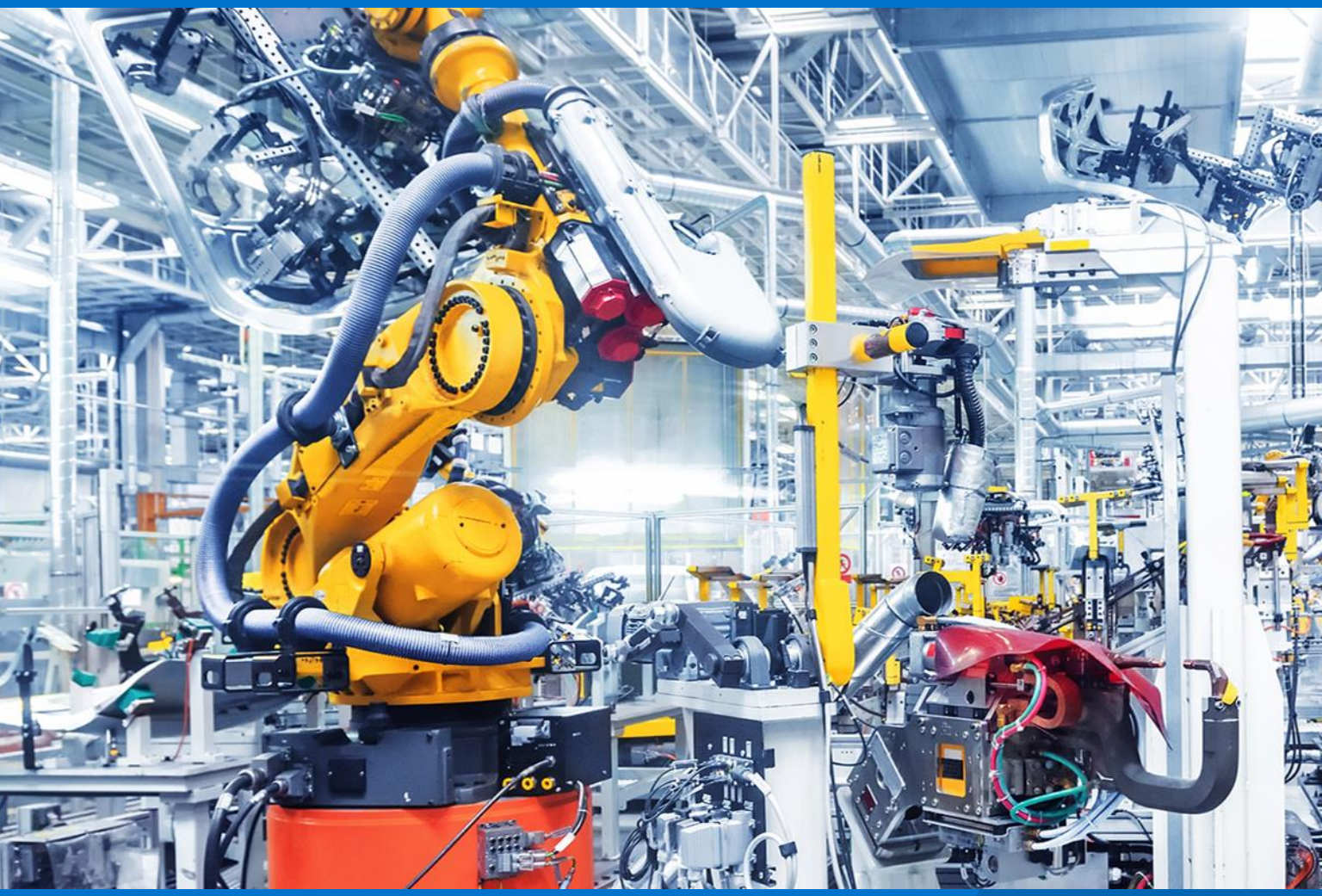
Industrials Insider

June 2021

IoT in Manufacturing



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Summary of the Insider

The manufacturing industry plays an essential role in the global economy. It generates 10% of the GDP in developed countries such as the USA and Germany and more than 20% of the GDP in countries like China and Japan, where large manufacturing bases support the manufacturing industry. Being such a large industry, it is one of the potential sectors where IoT transforms traditional manufacturing to cope with the industry 4.0 era.

Today manufacturers cannot rely on traditional manufacturing processes to produce high-quality physical products. Globally, the growing demand for low-cost products, a competitive environment, and dynamic customer demand for personalized products need advanced technologies and automation in the manufacturing process. Therefore, manufacturers are adopting IoT to improve manufacturing operations and differentiate their products and services to enhance the customer experience.

Over the past decade manufacturing industry experienced tremendous changes by shifting manual operations to the growing usage of automation in both discrete and processed manufacturing. The present pandemic situation forced manufacturers to rethink on IoT adoption to focus on more automation to utilize available resources

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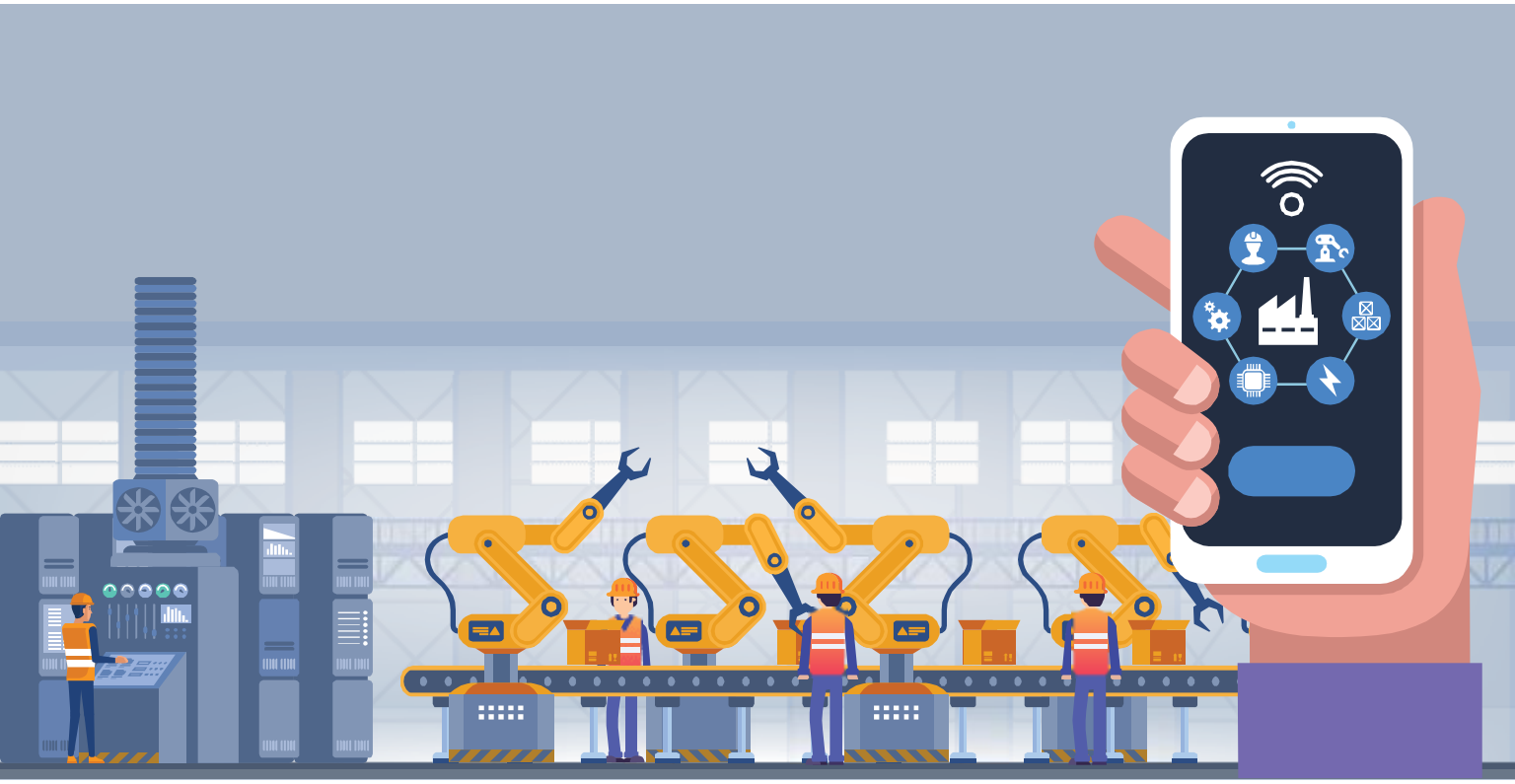
1 Introduction - IoT in Manufacturing

IoT in Manufacturing

IoT technology is beneficial in the field where faster product development and quality are essential factors to gain a higher Return on Investment. Manufacturing, one such industry which has timely proven for new age adoption and enhanced with technological evolution. IoT enabled manufacturing has transformed the manufacturing process with automation and streamlined connectivity among industrial equipment, systems, devices, and machinery to increase workplace safety, product quality and lessen manual operations dependency.



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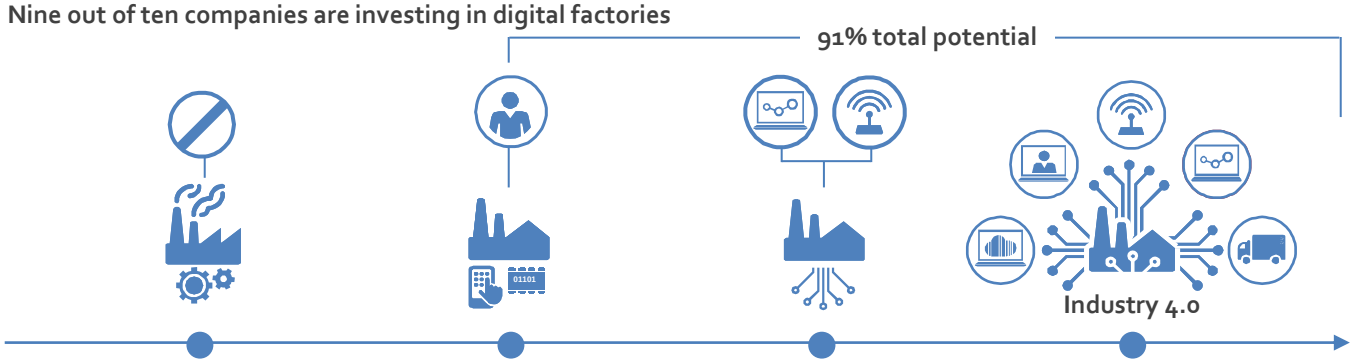
How IoT Transforms Manufacturing Industry?

IoT shaping the future of Manufacturing Industry

IoT has permeated in more than half of the industries across globe connecting physicals objects with the internet; thereby creating an interactive communication without human intervention. A survey (Global 95 discrete manufacturers 2018/19) from IDC reports nearly 55% of discrete manufacturers are researching, piloting, or in production with IoT initiatives in the manufacturing sector. Manufacturing is currently the fifth leading segment incorporating this technology. Factory premises, production of goods increasingly incorporating smart software, interconnected sensors, automation devices and wireless internet connectivity to create products; thus, providing a foundation for an Industrial Internet of Things (IIoT) /Industry 4.0.

Digitization of Manufacturing Operations: Considering Germany as the manufacturing sector hub, we have taken survey result of Digital Factory in Germany/Europe. The below figure depicts the strong commitments of the industrial companies in Germany/Europe to bring technological advances to their factories

Nine out of ten companies are investing in digital factories



Data Set: 200 Executives from industrial companies in Germany/Europe (PWC)

IoT has brought exceptional positive disruptions to the manufacturing processes, pushing automation into a new hi-tech future. Manufacturing industries are process driven and these manufacturing-specific IoT software connects IoT endpoints such as sensors, controllers to detect workflow inefficiencies.

Manufacturing industries are deploying IoT in three major areas—Product development, Traditional supply chain, and manufacturing processes.

13.8 billion **2025**

500% 2.4bn 2016

Industrial IoT Connections Globally in 2025

Source: GSMA

IoT in traditional product development help document actual product performance, creating early warning and detection signals to drive quality improvements in future products. At the same time, connected supply chain is more focused into adoption of mobile devices. It uses RFID and GPS technology to enable better tracking of inventory and assets.

Major Applications in IoT in Manufacturing

Applications

There are a broad range of applications of IoT in the manufacturing sector including logistics and warehousing, monitoring and maintenance, production IT, factory automation, process automation, and human-machine interfaces. These applications are key enabler to improve operational visibility, productivity, and efficiency of the manufacturing processes. Since, manufacturing sector involve a lot of resources, managing them efficiently is critical for production planning

Major Applications in IoT in Manufacturing

Logistics and warehousing

Managing the fleet real-time via IoT-driven devices that will help manufacturers to eliminate the risk concerning the cost related to vehicle breakdown

Monitoring and maintenance

IoT helps manufacturers to perform passive monitoring of specific processes/assets for predictive maintenance and overhauling.

Production IT

An automated IT system monitors the production lines in real-time starting from the refining process down to the packaging of final products. This provides scope to recommend adjustments in operations for better management of OPEX

Factory automation

IoT enabled machinery can transmit operational information to OEMs and field engineers which will enable operation managers and factory heads to remotely manage the factory units and achieve process automation and optimization

Human-machine interfaces

Human-machine interfaces (HMIs) are terminals that let a worker connect to industrial systems.

Source: SGA Analysis

Major Investment and Partnerships

Dec 2020: Hyundai purchased a controlling stake in Boston Dynamics in a $1.1b deal from Softbank in December 2020

Hyundai Motor Group took an 80% stake in the company, with SoftBank controlling the leftover 20%. With this acquisition, Hyundai aims to develop agile, mobile robots that have been successfully integrated into various business operations. It is focusing on developing ultimate mobility vehicles" (UMVs) which is said to be an all-terrain vehicle.

Nov 2020: Volkswagen Group raises investments in future technologies to EUR73b

The company is pressing ahead to transform into a digital mobility company. Investments in digitalization is expected to be doubled ~EUR27b which will majorly include electrification, hybrid powertrains and digital technology over the next five years. The company has strong focus on building up software capabilities for its 70 all-electric models by 2030. It aims to use as many as 70 separate sensors and controllers into a few devices in all of its cars

Nov 2020: Hitachi, Ltd . has developed an IoT platform using Microsoft Azure and Microsoft Dynamics 365 that brings high efficiency of building management and improved comfort for building users

The IoT platform in which Hitachi has invested into aims to help conglomerate standardize technologies and identify best practices that could be extended across its operations. The IoT platform for buildings will enables comprehensive remote monitoring and analysis of the operating status of building equipment, including elevators, escalators, and air-conditioning systems.

Jul 2020: Terex deepens its partnership with telematics expert ORBCOMM

A manufacturer of lifting and material-handling plant for various industries has expanded its partnership with ORBCOMM for heavy equipment IoT device and cloud-based data reporting and analytics platform. ORBCOMM's dual-mode device provides seamless fallback to multi-band 3G and 2G networks if 4G is not available, and to satellite in absence of cellular network. The analytics platform helps to stay connected with equipment, manage logistics, access critical machine information and perform remote operations. Similar, partnership is also formed with ZTR Control Systems in Feb 2019.

Mar 2020: Celli Group has partnered with Microsoft and PTC to create IntelliDraught

It is a connected beverage distribution system that turns retrofittable and Celli Group equipment into smart devices which can unlock insights where beverages are dispensed. The solution improves quality, sales & service, and inventory management for customers. Celli has developed smart fountains, pumps, and taps for pouring beer and soft drinks, and has leased them to beverage companies. This helps them to collect data on the equipment and beverages at the PoS. It helps to optimize inventory management and improve quality control.

John Deere is embracing IoT technology holistically to meet customer needs

The company is working towards agile delivery process to bring software solutions to the market. It has developed self-propelled sprayer with over 400 sensors. Also, it paid over $300m to acquire Blue River Technology which majorly has expertise in machine learning-based technology called "See and Spray,

Major Investment and Partnerships

Hanergy Holding Group Ltd. partnered with CISCO to simplify its network operation

Hanergy is a clean energy provider company which faced a lot of challenge with architecture scalability, and collaboration strategy due to lack of IoT solution deployment. Moreover, conventional network architectures had slow response time, resulting in failure of rapid responses. Lately in 2019, company started investing in IoT solutions from CISCO which enabled them to rapidly expand its new campus, exponentially increase the number of employees, and make business available online without increasing the number of network administrators. It also helped to simplify network operations and maintenance, and prepare strategic opportunities for rapid development of the group's businesses.

BDR Thermea is implementing connected services in association with Microsoft Azure

In 2020, BDR Thermea, a global manufacturer and distributor of sustainable and smart climate invested into an IoT Connected Services platform to check the status of its connected devices. This enabled the company to not just be a manufacturer but establish itself as a service provider in the highly competitive market. The company experienced a 60% decrease in service calls with the pilot solution, and also expects to reduce service operational costs by 10%.

IoT in Manufacturing Use Cases

A **global tool manufacturing company** with multiple lines of business and more than 100 factories globally lacked visibility into production metrics including overall equipment effectiveness (OEE). In association with Cognizant they retrofitted equipment with wireless IoT sensors to enable monitoring efficiency as well as uptime, yield and productivity measures for workers, assets and entire facilities. Some highlights-

- Scaled up facilities to connect 1000+ machines and production lines
- Implemented IoT platform at four plants in less than 12 weeks
- Targeting $100mn+ in cost savings and profitability gains over a five-year period

American Instrumentation giant manufactures more than 100,000 state-of-the-art products. These products are majorly used to control & process temperature, pressure, humidity, force, strain, level, pH, flow, and conductivity. Recently the company has deployed Microsoft Azure-enabled IoT solutions to cope with challenges like bi-directional communication set-up, scalability & data storage in the existing platform.

- The IIoT platform enabled the client to connect over 100 enterprise gateways to the cloud
- These gateways can handle up to 30 end-points
- It also operates with a data collection frequency of 1 min to an hour and supports a robust data management system to store up to 150 GB of data per day
- It also provides real-time visibility of measurement & control data

A **leading manufacturer** of commercial trucks and buses improved fleet uptime, speed up repairs and enhance customer service by utilizing continuous data insights across the value chain from a data-driven IoT solution provided by Cognizant. The company implemented an easy-to-use portal monitors, triages and triggers events for every vehicle based on data provided by the telematics platform. At the same time remote diagnostics helped dealers plan vehicle repairs, while advanced filtering and sorting options allowed stakeholders to identify and locate vehicles and dealers. Some highlights-

- Reduced customer repair and maintenance costs by 30%
- Delivered 73% improvement in responsive 24-hour repair across the enterprise portfolio of vehicles

Improved safety and fuel efficiency by monitoring driver's behavior

Fresenius Kabi, a global healthcare company added IoT-based RFID tags to their portfolio of essential medications so that hospitals can immediately identify, locate, and manage their inventory. This replaces current manual method, which is time consuming and susceptible to errors. This RFID tag portfolio will automatically provide the National Drug Code, expiration date, lot number, and serial number (at the item level).

The company collaborated with IntelliGuard, a pharmacy automation vendor to set up these RFID-tagged medications.

INOVA Health System used IoT-based RFID technology from IntelliGuard to better manage kits, trays and crash carts. This helped them to improve patient safety by eliminating error-prone manual restocking while improving operational efficiency. Some highlights are as follows-

- 100% accuracy in tray replenishment and enhanced patient safety
- Nearly 8 weeks of productive staff time returned annually
- Item-level visibility leading to better inventory optimization

IoT in Manufacturing Use Cases

Shell is an international energy company engaged in exploration, production, refining and marketing of oil and natural gas across the world. Recently the company entered into an agreement with the IoT connectivity provider **Ingenu** and Koncar Inem a producer of industrial electronics and power electronics devices to enable digital oilfield capabilities across Shell Nigeria pipeline facility.

- The Digital Oilfield (DOF) solution offers pipeline surveillance and wellhead monitoring facilities to the remote infrastructure in the Niger Delta
- This integrated platform enables faster analysis and more efficient data management to offer insight into field processes
- It is a low-power, wide-area RPMA network solution needs minimal infrastructure that resulted the saving on overall project cost more than $1 million compared to other alternatives

A leading **U.S.-based heavy equipment manufacturer** was using telemetry data for more than 10 years to support its fleet and equipment management processes; however, its business units were working in isolation. Cognizant leveraged Microsoft Azure platform to build an enterprise-wide telemetry platform that stores, manages and analyses telemetry data from equipment and products. The solution also provided unified platform for data collection and enables easy exchange of information across applications. Some highlights-

- 2 million installed machines can be supported, up from the current 300,000
- 6,000 terabytes data collected in the field, up from 15 gigabytes per day
- Weeks to hours - increase in the accessibility of equipment and job data

A leading textile company has up to 2,000 textile carts in use. These carts are used to push materials or semi-finished products from one room to another room. The traditional product tracking method is complicated because each cart was previously attached with the description's handwritten paper. Therefore, the company associated with the intelligent solution provider **Advantech** to deploy a cart tracking system to attach RFID tags to each cart.

- It is a cost-efficient solution that integrates RFID technology to implement electronic management and real-time asset tracking

Chettinad Cement is a part of Chettinad Group, a major cement supplier in the southern part of India. The company was looking to invest in comprehensive operational and control technologies to manage and derive productivity and energy efficiency gains from the assets on Line 2, their second plant in India. Therefore, Chettinad Cement company associated with ABB to deploy ABB System 800xA, the human-machine interface, and ABB gas analyzer.

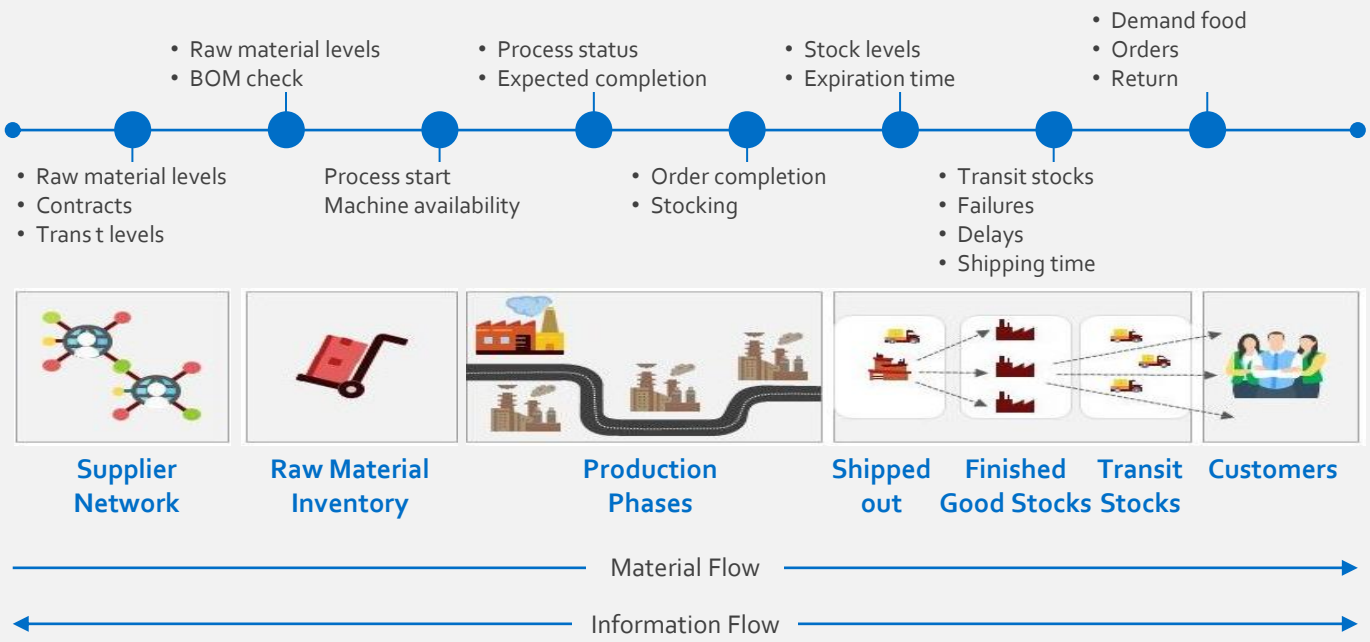
- The ABB solution helped to achieve energy efficiency to improve the production processes and reduce the production cost
- Technicians can query instruments remotely during commissioning to confirm device functionality.
- Real-time status reports enable maintenance personnel to diagnose the status of a device remotely.

3

IoT Manufacturing Supply Chain Analysis

In manufacturing sector IoT revolutionize the supply chain function with the both aspects such as operational efficiencies and revenue opportunities by bringing more transparency in the overall supply chain process. Today manufacturers are considering supply chain as a way to gain an advantage on competitors and build their own brand in the market. The below diagram shows how IoT brought the real-time visibility in supply chain process in manufacturing industry

IoT Manufacturing Supply Chain Flow



IoT impact on Global Manufacturing Supply Chain

Pervasive Visibility

End to end visibility of the shipment from manufacture point to point the delivery

Proactive replenishment

Optimization and automated ordering of inventory

Predictive maintenance

Self diagnostics identity failing components resulting in automated parts ordering

The below two areas highly impacted by IoT in manufacturing industry supply chain.

Operational Efficiency

In operational efficiency, the IoT has improved many areas

Asset Tracking:

- IoT has reduced spending on traditional asset tracking systems such as tracking numbers and barcode methods
- IoT's RFID and GPS sensors enabled manufacturers to track product from floor to store
- These sensors help to gain granular data product such as its storage time, transportation method, and shelf time
- These kinds of tracking system enabled manufacturer to gain a tighter grip on quality control, on-time product delivery, and inventory forecasting

Vendor Relations

- The data collected from the asset tracking system helps manufacturers to tweak the production based on vendor relationship
- According to IBM's Watson AI technology, 65% of the product price derived from its suppliers; therefore, a huge incentive needs to pay to the supplier, which requires closer attention from vendors while handling the supplies
- IoT technology-enabled manufacturers to monitor the real-time data of the suppliers and take the appropriate decisions to bring operational efficiency to the organization

Forecasting and Inventory management

- IoT can provide accurate information on the inventory to manage manufacturing operations
- The tracking system helps to manage inventory at present and future at one click
- The manufacturer does not miss the deadline and help them to make a manufacturing schedule for the future
- For instance, Amazon is using WiFi robots to scan the product code and track their inventory in warehouses

Connected Fleet

- IoT brings connectivity among all the carriers, be it shipping containers, delivery trucks, and vans
- Manufacturers use the data for the faster delivery of the product by maintaining the high quality of the product

Manage Maintenance Schedule

- The sensors deployed in manufacturing plants also helps to manage the planned and predictive maintenance operations
- These sensors prevent the down-time in the production process

Revenue Opportunity

- IoT technology brings more transparency to the supply chain process
- It helps to know more about the customer, their habits, and trends associated with them
- This approach allows them to connect with customers and market new products to them
- The IoT based supply chain brings creative ideas to connect the customers, which help manufacturers to bring new revenue opportunities

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4

Industry Trends & Growth Drivers

Major Trends in IoT in manufacturing industry

The IoT becomes an essential resource for factories to provide an information network to deliver automation, analytics, and real-time decision-making capabilities. Nearly one-third of production processes and equipment use IoT technology. As a result of this, the manufacturing system brings pervasive visibility across factory operations and streamline the manufacturing process.

Some of the Major Trends in IoT in manufacturing industry

Digital Twins

Digital representations of physical objects and systems are well-established ideas. When these ideas are integrated with analytics and real-time data, they can be powerful manufacturing operations tools. Manufacturers are focusing on the digital twin approach to identify the potential outcomes of maintenance. Globally, manufacturers are spending on billions of dollars on digital transformation. For instance, Volkswagen a leading automotive company planned to pour billion euros in digitization projects by 2023. In addition to this, manufacturer also said that the digitization brings more than 2,000 new job opportunities in digitization projects. The emergence of digital twin brought new revolution where IoT, digitization, AI, ML disrupt the automotive industry. It enables to use computer program to observe the physical objects in the real world and mimicking to monitor and predict the behavior of virtual platform in the automotive industry

Manufacturing companies Spent **$267** billion On Digitization in 2020

Source: Business Insider

Sensors

Today, manufacturers are utilizing sensors in everything from product tags to production equipment. They collect all types of data, sensors feed data into factories analytics systems, track everything from access logs. Therefore, globally increasing the demand for Radio Frequency Identification (RFID) tags which are majorly attached to the all the equipment in the manufacturing industry such as name tags, product containers, manufacturing equipment and other objects. These sensors help to keep a track of the employees and assets in the production operation. Globally, the industrial sensors market is driven by manufacturing industry due to growing demand for sensors in automotive, aerospace and heavy equipment manufacturing industries

Swarm Intelligence

Swarm intelligence is emerged as a new trend in manufacturing industry. It is a process collecting information from various sources and applying analytics tools to create actionable insights from connected devices. Globally, manufacturers are applying swarm intelligence in complex IoT systems to analyze and logically control the production operations. Swarm intelligence algorithms helps to resolve the complicated issues connected with IoT systems. The swarm intelligence helps to detect bottlenecks and optimize the manufacturing processes to streamline production flow.

Artificial Intelligence

Today, AI adoption is growing rapidly across various industries and specifically manufacturing industry experienced tremendous change. The artificial intelligence is essential tool for predictive maintenance, vast amount of data interpretation, understand the patterns of data to take the insightful decisions. The artificial intelligence enables manufacturers to recommend predictive maintenance option before the machine or equipment fails. In the coming future AI will perform hazardous jobs in the production process to minimize the employee injuries and increase the efficiency.

The major issue in manufacturing industry employee retention, cost of production and high competition. However, the integration of AI and IoT will bring the better connectivity, reduce the dependency human resource, enable real-time tracking, and optimum utilization of available resources. Therefore, the AI and IoT bring the new revolution in the industry to achieve high production at low cost.

- The manufacturing sector accounted 25% of overall AI implementation across the world for maintaining machinery and production assets
- For instance, General Motors detected 72 instances of component failure across 7000 robots to identify issues the before it could result in unplanned outages

Augmented Reality

Today augmented reality is acquiring a new dimension with IoT to connect the digital world and utilize digital information from physical devices. Augmented reality is the enhanced version of the physical world, which can be achieved using digital visual elements and sounds. IoT works as a bridge between physical assets and digital infrastructure, while AR brings digital to life by interacting with physical infrastructure in real-time. AR uses specialized software and hardware to connect with the real world seamlessly. The manufacturing industry can be benefited from this technology by providing real-time information and instructions to the workers about equipment and machinery performance.

Globally, augmented and virtual reality technology spending reached at $10.5 billion in 2020, and the spending will grow at a CAGR of 70% from 2019 to 2023. In overall spending, the manufacturing industry accounted 19% of the overall spending.

Major Growth Drivers in IoT in manufacturing industry

Growing focus on centralized monitoring and predictive maintenance of assets

Predictive maintenance helps manufacturers know the condition of their equipment while it is in service and determines the optimal service interval, thus saving time and money by completing maintenance activity only when necessary. Predictive maintenance allows longer periods of operation between maintenance tasks, resulting in less downtime for essential machinery.

Smart sensing and automation environments setup in factories powered by IoT, can capture various data points which are analyzed using intelligent software solutions and further utilized for various purposes such as performance analysis or for setting up updates, warnings or alerts. Further, automated systems can be directed to order replacement parts and schedule the replacement or repair in such a way that minimizes unplanned production downtime..

Example

The Volvo group uses an IoT-based predictive maintenance solution which can predict damage to spindles, identify cracking and spalling of rotating equipment, gearing, and motor defects. The resulting improvements to OEE saw a 70% reduction in diagnostic time and a 25% reduction in repair times

Improving product quality

Manual inspection of products in order to meet quality controls can be costly and time-consuming. Furthermore, human error during the review process can lead to defective products reaching customers, which could affect the company's brand. The IoT sensors are used to collect data on product specifications and other parameters. With help of sensors manufacturer can determine product quality based on product conditions in manufacturing process. Therefore, globally manufactures are using IoT solutions to meet the product quality standards..

Example

Piramal Glass switched from a paper-based logbooks approach for capturing production data to using the Microsoft Azure IoT platform to get real-time visibility into its manufacturing operations and analyze defects at various stages.

The Azure IoT Hub helps to transfer data from equipment and high-speed production line sensors to the cloud for analysis and it has led to a 1% improvement in production efficiency and 5 % reduction in defects, which translates into better quality and enhanced predictability of delivery timelines for Piramal's customers.

Increase security and efficiency

Manual actions such as assembling parts and packing boxes, being performed in a factory, tend to have a negative impact on overall productivity and efficiency. The workers performing these actions cannot simultaneously work on other tasks which require human insight. In such situations, it makes sense for manufacturers to upgrade to a digitally enabled factory by revising their current processes.

Making use of IoT sensors for data collection and transmission can free up workers for other tasks which require human judgement and decision making. This enable factories to gain visibility over the production process and increase production efficiency. With the access to these large data sets, securing the information too presents a challenge. Having a good information security platform and infrastructure helps manufactures secure their critical data for both cloud and on-premise environments.

Example

Samudra LED has collaborated with Microsoft Azure to maintain the security of new data center. The data center is being used to deploy smart LEDs and process and analyze information about their working conditions

Better Inventory Management

With technologies like RFID and IoT connectivity, inventory management staff can leverage automated asset tracking and reporting through ERP to avoid the mistakes that come with working with older inventory tracking systems. This connectivity enable items to be tracked and the data recorded to the ERP system automatically.

These performance management capabilities made possible through IoT connectivity and ERP can help organizations reduce the number of working hours committed to inventory management and reduce the probability of human error. .

Production Visibility to Identify Bottlenecks And Improve Processes

Continuous monitoring of production processes through IoT connectivity will enable improvements to be made on a rolling basis. Clear visibility into manufacturing operations aids in tackling potential bottlenecks and helps realize better approaches to production management and the reduction of operational costs.

In addition to this, part waste is minimized alongside fewer resources tied up in inventory and better overall product delivery. In some organizations, IoT connectivity will lead to a 15% productivity increase in delivery and supply chain performance.

Improved revenue stability

Ensuring revenue stability during business cycles helps companies become more resilient during unexpected downturns. Dynamic pricing optimization can be achieved by using IoT-enabled pricing tools that can analyze data on supply and demand from connected assets, including information on stock levels, available capacity, production schedules, and anticipated delivery dates. The analysis enable tools to recommend the best price for a particular date, letting companies to make updates more frequently and enable them to simplify pricing frameworks for new products.

5

Key Reasons, Benefits, and Challenges to IoT Adoption

A few of the compelling reasons why manufacturing industry is implementing IoT are— reduce cost, revenue monetization, enhance safety and security, improve product quality, etc. Also, demanding customers are pressing manufacturers to shorten their business/production cycle to meet their requirements for personalized products and higher levels of service. Customer demands and continuous change in the emerging markets are reshaping supply chains and product strategies to support manufacturing processes in emerging economies, and local markets. Thus, manufacturers are participating and managing complex, overlapping value chains which has frequent changes.

Key reasons for IoT adoption in manufacturing

Manufacturers need visibility across discrete business processes to improve business maturity

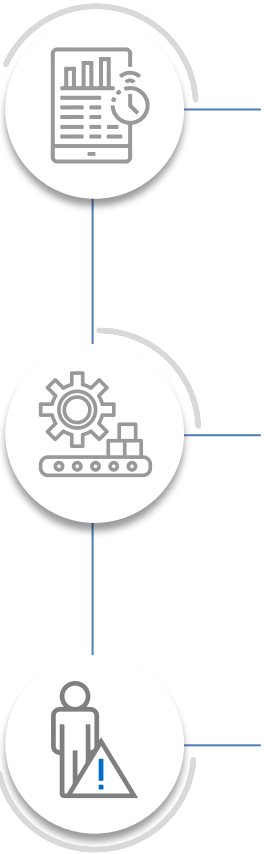
Lack of company-wide visibility is leading to ineffective communication between discrete business processes. Also, absence of system integration has resultant into connectivity issues within business functions leading to risk of errors and false output. Thus, it is imperative for manufacturers to derive business value and competitive differentiation with the help of predictive capabilities. Thus, IoT is the digital thread that is bringing these processes together.

Need to drive innovation with data analytics

Manufacturers are continuously facing challenges while interacting with their customers due to lack of insights, product information, ineffective sales and support in the advent of smart system. Thus, IoT can help bring down barrier between the customers and manufacturers with data derived from connected devices. It can help manufacturers to make intelligent decision which in turn will drive new innovations.

Need to improve efficiency with fleet monitoring

Manufacturers lack real-time insights into their fleet with their conventional fleet management systems. This leads to unassisted breakdown of vehicle on road, negative customer experience, delayed location and tracking, and losses due to wrong ETA forecast. IoT can deep dig into these logistics data and help in informed decision making with its real-time fleet monitoring and tracking solution..



Manufacturers lack real-time insights from their devices

Most of the time, in the process industry costly wastage due to spoilage happens as a result of inappropriate temperature, humidity, storage, and location. IoT in such scenarios can help sense the spoilage using sensors and predictive analysis. It can also retain food quality with real-time monitoring during transportation and storage.

Improvement in production with data analytics

Catastrophic failures of machine in the manufacturing industry can lead to heavy losses and reduced margins. Also, it can make the whole system become stand-still. However, with the integration of IoT, companies can stay competitive by reducing down-time and faster delivery.

Requirement to eliminate human errors and risk with automation

Stress, repetition of job, and fatigue can result into human errors at workplace. Also, human error is one of the most sought out reasons for security breach. IoT based wearable can help manufacturers to gain insight into their worksites and workers health. Also, automation in the system can help to mitigate possible human error and security breach at the workplace.

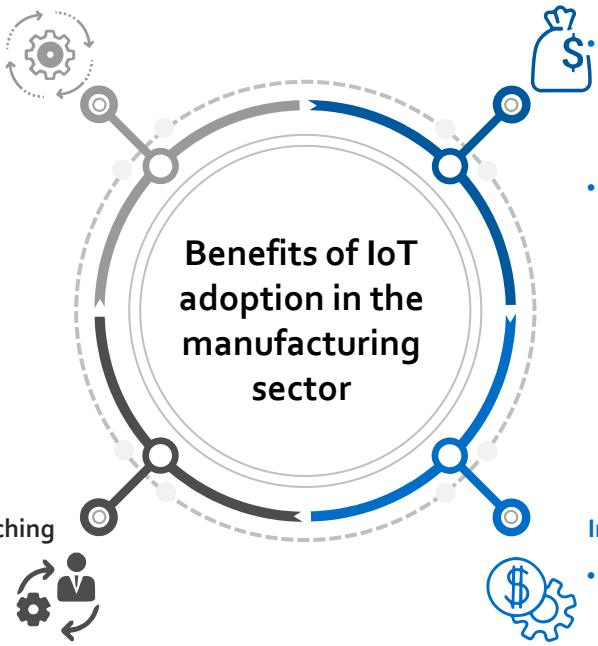
Key benefits for IoT adoption in manufacturing

Benefit of IoT adoption in the manufacturing industry is significant. Emerging industry 4.0 and its technologies can entirely transform the manufacturing value chain. From increased production efficiency to innovative product and service deployments are benefitting manufacturers in a larger way. Also, it has enhanced the interaction between customers and suppliers.

Benefits of IoT Adoption in the Manufacturing Sector

Machine downtime reductions

- Predictive maintenance can spot repetitive patterns that precede failures, notify teams and have them schedule an inspection.
- ML system which manufacturers are implementing can learn over time to spot even more granular changes and help continuously optimize production process.



Revenue gains

- Trailblazing companies have witnessed an above-average growth with digitized product portfolios in the past 3 years.
- Nearly, 50% of business with industry 4.0. projects underway are expected to see double-digit growth in the next 5 years.
- One in five businesses also expects a 20% sales rise.

Improved supply/demand matching

- Cloud-based inventory management has enabled better interaction with suppliers.
- Also, with the implementation of data analytics in the solution alongside inventory management demand forecast can be improved by at least 85%.
- Real-time supply chain optimization and can help gain better visibility on possible bottlenecks

Increased efficiency and productivity

- Switching to an automated system can boost productivity in technical professions by 45%-55%.
- New-gen robots and cobots can help manufacturers to automate low-value parts of the production processes and speed up time-to-market.
- Also, collaboration with robots can reduce workers' idle time by 85%.

Challenges of IoT adoption in manufacturing

IoT has penetrated into a variety of sectors including manufacturing. However, the adoption of it is very delicate and involves risk. CMOs, CEOs and other executives of enterprises are concerned about IoT technology.

A survey from The Telecommunications Industry Association (TIA) also confirms,:

> **Internet of Things solutions have reached critical mass, fast becoming a top concern for U.S. enterprise decision makers.**

As manufacturing companies are planning to implement IoT in a holistic way to drive innovation, they should also be aware of possible risks connected with it especially new and unused technology. In addition to the fact, introducing new technology can be costly, it can also lead to unpredictable consequences.

Below are some of the challenge's manufacturers can face while implementing IoT

1 Lack of ability to link all the data together and process it effectively

As a greater number of devices connect together, they generate a large amount of meta-data. Also, a number of AI and ML solutions need to be deployed to analyze true data..

2 Incompetence to establish same technology standards across connected devices

The whole IoT system work as one system. Thus, processing of all data collected from connected devices is not enough. Also, each connected device needs to collaborate and communicate effectively. Moreover, there is no universally accepted standards designed for IoT-enabled devices.

3 Security and data privacy threats

There is a legitimate concern regarding the security of IoT-enabled systems and devices. With all the interconnected data, even a small security hole can cause a potential threat to the entire business. Hackers can potentially harm the business with a little leakage of sensitive information..

4 Lack of right talent and skills to implement and maintain IoT ecosystem

Talent and training continue to be focus areas for leaders, and consistently rate as a top concern and challenge with respect to exploring digital transformation. Moreover, 'training and development of a workforce with the necessary skills to compete' is also a core investment area for manufacturers implementing IoT.

5 Technical challenges of connectivity, compatibility, and interoperability

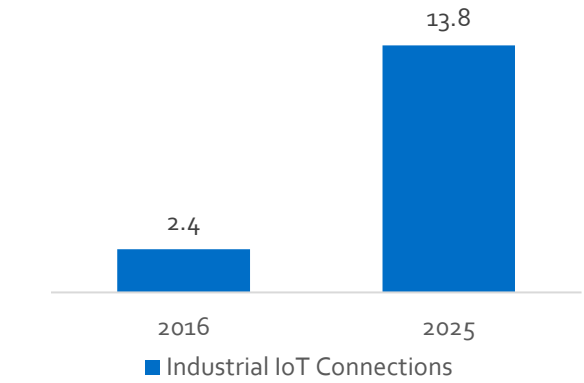
IoT technology requires a healthy ecosystem of OEMs, service providers, and enterprises. The ecosystem majorly depends on various devices and systems for managing business operations. However, the interoperability, connectivity, and compatibility issues between systems are a significant challenge that hinders IoT implementation in the manufacturing sector.

6

Business Opportunity & Forecast Value

IoT is creating business opportunities and disrupting the manufacturing industry positively. Globally, manufacturers are adopting the internet of things to create new business opportunities by understanding consumer needs from both aspects, such as inside the organization and the stakeholder's ecosystem. Industry leaders worldwide are initiating to grab IoT projects and using IoT devices and building smart connected platforms by using IoT technologies. Major manufacturers adopt IoT connections and devices to leverage advanced tools like predictive maintenance and data analytics to improve productivity and supply chain operations. Today, automation is changing the way things work, and a large number of manufacturing organizations are convinced that integrating IoT technologies with production operations is beneficial and minimize the risk of production failure.

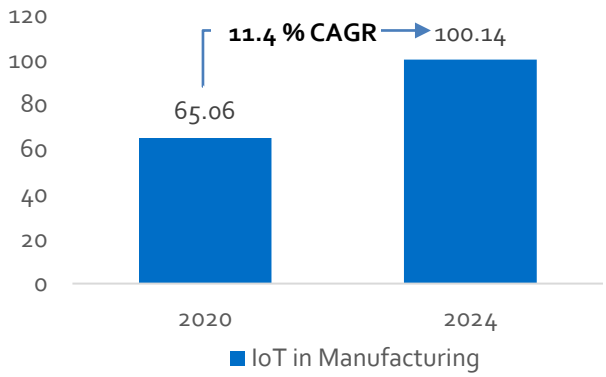
Industrial IoT Connection Globally (Units Billion) Billion)



The adjacent chart depicts that globally, in the coming future industrial IoT connections will grow rapidly. The Industrial IoT connections will overtake consumer IoT connections by 2023, and it will account for half of the global IoT connections by 2025. The major factors driving the industrial IoT are growing demand in the manufacturing and energy management sector.

Source: GSMA

IoT in Manufacturing Market Value $Billion

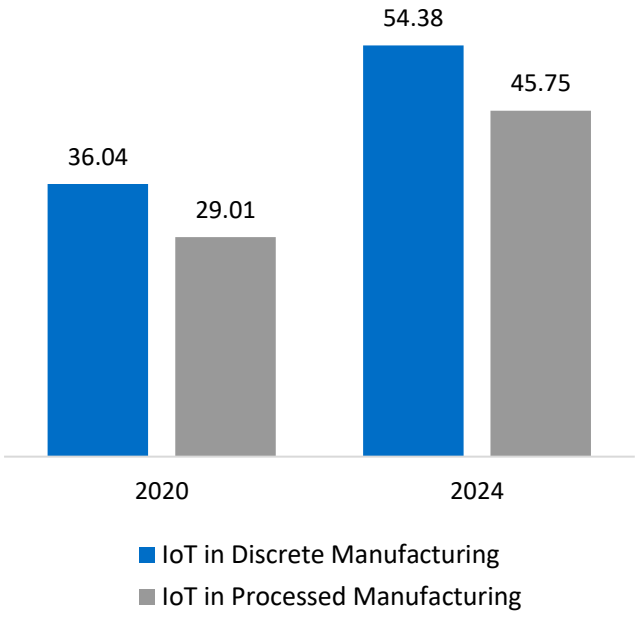


IoT in Manufacturing market value consists of the revenue generated by IoT solution, product, and service providers. Some of the major players are Cisco, IBM, Microsoft, SAP, Siemens, Huawei, HCL Technologies Limited, Intel, and Oracle.

Global IoT in manufacturing value is expected to grow from $65.06 billion in 2020 to $100.14 billion by 2024 growing at a CAGR of 11.4% from 2020-2024. IoT in the manufacturing market is majorly driven by various factors such as the growing popularity of intelligent technologies in the manufacturing sector, increasing investment digitization, and the emergence of advanced technologies such as AI, ML, and analytics to streamline the manufacturing processes.

Source: GlobalData

IoT in Manufacturing Market Value By Type $ Billion



Source: GlobalData

The above diagram shows the IoT in the manufacturing market share by type. IoT in the discrete manufacturing market accounted for 55.41% of the market share and 44.59% by IoT in processed manufacturing in the overall market in 2020.

The discrete manufacturing market is driven by growing demand for innovation in complex manufacturing operations, increasing spending on IoT solutions to gain competitive advantage, and enhancing its profitability.

The processed manufacturing market is estimated to reach $45.75 billion by 2024 due to the growing focus on customer satisfaction with new services, new opportunities for topline growth, and growing demand for safety and security.

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7

Discrete Manufacturing

In the present dynamic discrete market, manufacturers are aggressive in their growth strategies. They are focusing on reducing operational costs with industrial automation, production flow monitoring, planning and scheduling and achieve high-efficiency levels in production and supply chain with quality and compliance. Some of the discrete manufacturing sectors are analyzed below to understand the overall discrete manufacturing industry.

Automotive

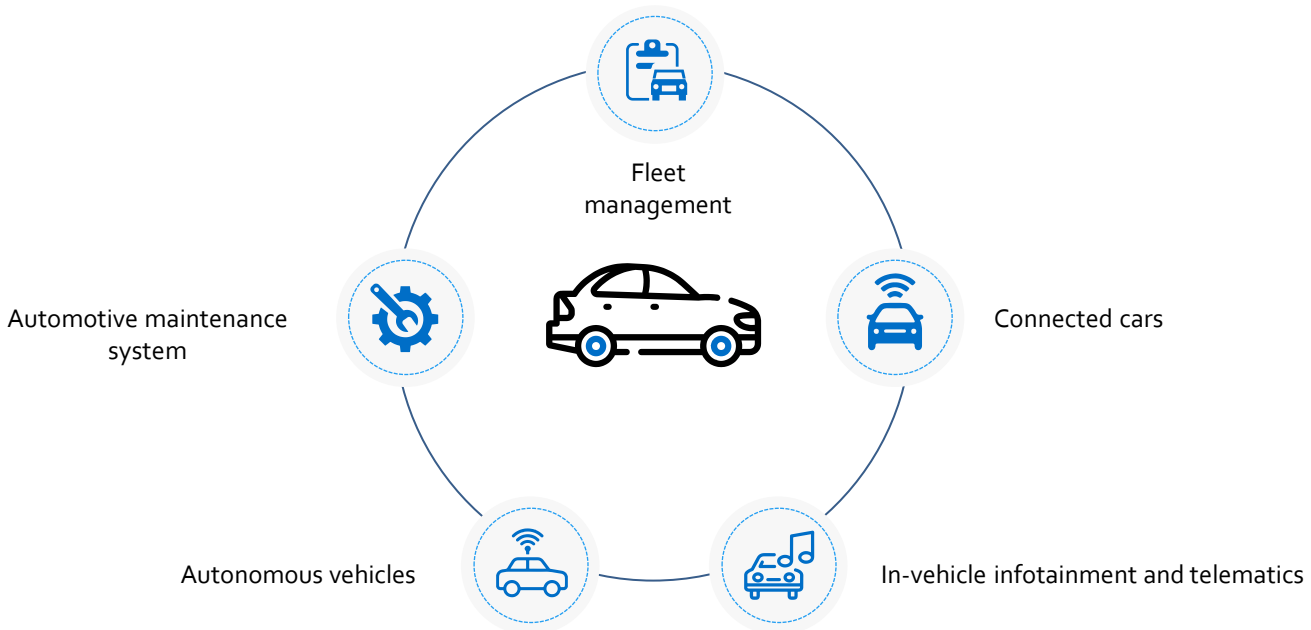
With over 92.8 million motor vehicles production globally in 2019, automotive is one of the biggest manufacturing industries in the world. It is expected to grow at a CAGR of 20.78% by 2028 and globally 73 million connected cars sold by 2023. The automotive industry currently contributing to ~4% to global GDP. In addition to this the more than $700 billion will be invested in automotive industry for IoT technology by 2025.

The advent of IoT in the automotive industry has opened new avenues for carmakers as well as buyers. As the usage is at both industrial and commercial level, IoT has multi-varied applications in this sector.

VOLVO TRUCKS

Volvo Trucks North America are getting smarter with AI and IoT connectivity. The company has fitted hundreds of IoT sensors in its truck to monitor conditions and send data for troubleshooting and analysis. It also has embedded telematics which are connected with back-end analytics platform enabling them to reduce diagnostic time by 70% and truck repair time by 25%. It has partnered with analytics vendor SAS to deploy a more advanced platform. The analytics system processes over 1.5 million fault alerts per day while engine runs around 4000 rules each day.

Some of the staggering use case in the automotive sector are



Machine Manufacturing

IoT in the machinery manufacturing segment is continuously gaining importance due to significant benefits and savings to machine owners. Automated and analytical applications based on machine data will reduce downtime, increase economies of scale, and improve product quality while saving amount spent on energy.

There are multiple value propositions of IoT in the machinery manufacturing sector :

Service and aftermarket programs: With IoT, machine manufacturers can provide enhanced services, security, and proactive parts delivery by implementing automated inventory management and predictive analytics. Also, in the event of servicing, a technician can make virtual visit to machine controls using secure connections and remote monitoring. .

Secure Remote Service + Advanced Data Analytics = Revenue Boost

Increased machine utilization: Machinery manufacturers often use Lean Six Sigma to collaborate and increase performance by systematically eliminating waste and downtime. Cloud services with OEE data, performance benchmarking is some of the application areas.

An increase in OEE of 10 to 15% can often be achieved in the first year; this can translate to a 50% increase in Return on Assets (ROA).

Cloud-based quality management: Machine manufacturers can focus on every elementary step of their process to reduce cost of quality with a cloud solution. By continuously measuring and testing quality of the products produced, they can provide its end-users with tools to improve output.

Digital quality management helps end users manage and ultimately reduce their cost of quality up to 20%

Savings on energy and resource: Sustainability is one of the important aspects in the machinery segment. Machine builders promoting sustainability gains sales advantage over its competitors. An IoT-enabled application embedded in the machine helps end-users to measure, analyze, and track energy usage. Also, combining the expertise of cloud-based advanced analytics, efficiency can be achieved to drive profitable sales.

Electrical and Electronics

Prominent implementation of IoT in electrical systems is comprehensive perception, reliable transmission, and intelligent processing. Some of the significant applications include- IoT SCADA, Smart metering, and Smart grid. IoT technology used in overhead transmission lines and grid systems not only carry out line state monitoring but also collects operating condition including meteorological conditions, ice cover, ground wire breeze vibration, conductor temperature.

In the semiconductor industry, new generation of edge artificial intelligence (AI) chips for smartphones is a revolution. As per a prediction from Deloitte , sales of edge AI chips is expected to exceed 1.5 billion which will represent annual unit sales growth of at least 20 percent. These chips will perform or catalyze machine learning tasks on-device, rather than at a remote location. This will also eliminate the concern of data breach among IoT users. Some of the other application areas are —tablets, wearables, and smart speakers. ARM, Qualcomm, MediaTek, Huawei, Apple, Samsung are some of the companies actively involved in this kind of manufacturing.

Others

Others sub-sector includes medical devices, aerospace and defense, modular construction, metal fabrication, kitchen ware, etc. IoT has rapid penetration in all facets of industries whether major or minor.

Medical device manufacturing

Medical device manufacturing is one such industry which is adopting IoT at a faster pace. Their IoT system includes edge devices (e.g., glucose monitors, ventilators, pacemakers), gateway devices (aggregate edge device data and transmit it to the cloud), and cloud-based systems (analyze device data to draw conclusions). IoMT (Internet of Medical Things) is proving of great usability and wide functionality. It can also be integrated with any platform and can help clinic to improve treatment, boost operational performance and ensure a patient's health and safety. Globally, billions of amounts spent on IoT solutions in healthcare sector.

Aerospace and defense sector

The aerospace and defense sector spent more than $90 billion in 2018 on IoT technologies and it is estimated that the spending will double in the next five years. The majority of spending is coming from North America region. As part of IoT technologies, sensors embedded in the flights improve the safety and security and also increase the operational efficiency. For instance, AI and IoT integrations help to provide the real time data from sensors and saves 10-15% fuel to reduce the carbon emission .

Discrete Manufacturing Mapping

Discrete Manufacturer	Industry	IoT Platform / Provider	Technology implementation	Comments
Thyssenkrupp Elevator	Manufacturing (Industrial engineering)	Microsoft Azure	Digital Twin	The company has formed a digitalized virtual model (Willow) of the physical building using Azure Digital Twins services
Legrand	Electrical and Building	Microsoft Azure	API and Device Management	Established 'Eliot' to provide product groups with a single interoperability standard for rapid delivery of innovative smart-home products.
ABB	Robotics, Heavy electrical equipment and automation	Microsoft Azure	Workforce management embedding with SaaS	Implemented Ellipse Workforce Management (WFM) to mobilize maintenance, inspection, and outage work, in order to deliver greater worker efficiency, vast scalability, continuous innovation, and lower costs.
Volvo Trucks	Transportation	SAS	Remote Diagnostics with advanced analytics platform	It is strengthening its portfolio of uptime-boosting services by implementing machine learning and artificial intelligence in monitoring and decision-making.
Fresenius Kabi	Healthcare	IntelliGuard	IoT-based RFID tags to their portfolio of essential medications	It will help to identify, locate, and manage their inventory of medicines for a smooth supply chain management.
Ralph Lauren Corporation	Fashion and lifestyle	EVRYTHNG	Digital product IDs on an agile platform	In partnership with Avery Dennison, the company has launched mass-scale product digitization to build a strong, and more personalized relationship with customers
Emerson	Energy (Oil and Gas)	CISCO	Industrial access points to securely connect people and things	Together they bought industrial access points and gateways to create a wireless mesh architecture to connect people and things.
I-D Foods Corporation	Food and beverages	SAP	Warehouse management and ERP	The company collaborated with SAP to streamline operations, optimize warehouse management, speed deliveries, and deepen customer insights
Kone	Manufacturing (Industrial engineering)	IBM Watson	Predictive maintenance	The company has implemented IoT platform to identify the issues and reserve the correct spare parts in advance before driving to the site
John Deere	Agriculture and equipment	AWS Lambda	Telematics, predictive analysis	Actively engaged into incorporating telematics to report, monitor, and control machine operations

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Processed Manufacturing

IoT in the process manufacturing are often implemented for quality and compliance, maximize production yield while reducing waste and monitor asset integrity to avoid critical and costly downtime. Implementation of IoT in the process industry is comparatively less complex as against discrete manufacturing. Moreover, it is also less susceptible to defects and experiences fewer interruptions with automation.

However, since process industry uses a formula or a continuous-flow technique the complexity of process industry in itself remains vital. Manufacturers often deploy ERP platform that have specific functions such as streamlining R&D flow, enforcing production quality, managing complex productions, and optimizing inventory. They also rely on tracing and scheduling tools and software to maintain peak operational efficiency.

Food and beverages

F&B is a highly dynamic and evolving industry, where IoT can create real value for business in production, packaging, distribution, and marketing. It is also helping companies to achieve high levels of food safety, improve traceability, cut down wastage, and reduce costs and risks across the different stages of food processing and packaging. Moreover, IoT also assist companies to gain greater visibility over their manufacturing, production, and transportation processes in order to provide higher quality products for end consumers while maintaining operational efficiency and remain compliant with government regulations. Also, many industrial reports mention that the expected IoT growth will reach a rate of nearly 10% in the next five years.

Value proposition of IoT in the Food and Beverage industry are-

Smart inventory: Majority of the F&B companies suffers issue of inventory control due to short shelf life and a large volume of products which need to be supplied just-in-time to markets. This requires real-time monitoring as well as warehouse optimization solutions. Pressure-sensitive sensors which are IoT-enabled thus provide accurate unit number associated with identified products. Furthermore, IoT can bring insight on data and evidence to predict consumer's purchase patterns or future purchase trends.

Some of the inventory management ERP solutions that are integrated with IoT for inventory management in F&B are - Oracle NetSuite ERP, Zoho inventory, TallyPrime, Horizon ERP, QuickBooks, BatchMaster ERP

Efficient collaboration and automation: IoT is bringing producers, retailers, intermediaries, and logistics providers together by communication technologies. Thereby, increasing operational efficiency by enhancing automation and reducing manual tasks. Also, data gathering from IoT solutions lead to maintenance of consistency among partners which reduces operational losses.

Use Cases: Genpact helped The Kraft Heinz to transform their business processes from manual to automatic using the robotic process automation (RPA). It scaled to 13 processes using 70 RPA bots across 10 countries. RPA delivered a 25%–40 % reduction in cost per transaction. The response time for Help desk ticket also improved by 60%. In collections and cash application, 50% of the transactions are being processed by bots with 98% accuracy

IoT can bring down food wastage: IoT can help F&B companies in warehouse management by triggering expiry date detection to reduce the waste volume before spoilage. Each year, 1.6 billion tons of food worth about $1.2tn are lost or get waste. This accounts to over one-third of the global food produced. IoT can help to maintain ideal condition for product preservation. Moreover, with efficient supply-chain and logistics, IoT solution can help in predictive market demand. to predict consumer's purchase patterns or future purchase trends.

IoT solutions improve food quality standard: Food safety regulations are getting stringent due to increasing consumer health concerns. F&B companies can utilize IoT and big data to optimize food safety with following possibilities-

- **More visibility:** Big data can help companies to analyze, record failure points, and patterns in food safety issues, and predict food spoilage conditions, based on those patterns
- **Better compliance with global standards:** IoT can help food manufacturers to identify possible weak links in their supply chains and take corrective action in the form of product recall
- **Helping companies learn about problems:** Advance sensors along with complementing products based on IoT and big data innovations can address concerns of companies related to spoilage, wastage, contamination, etc.

Pharmaceutical

IoT can help pharmaceutical companies to achieve optimization and improve efficiency of their machines and processes. It facilitates standardization within a facility by connecting equipment, networks, and systems to share information across the plant floor. Pharma companies are also sourcing IoT-based MES (manufacturing execution systems) to manage activities such as production, quality, maintenance, and inventory. Although IoT finds opportunities across the value chain, R&D, clinical trials and development, supply chain and patient centricity are major investment areas to reap most benefits.

E.g. Johnson & Johnson adopted IoT technologies to get FDA approval for shifting Prezista, an HIV medication, from batch to continuous manufacturing. The sensor technology adopted by them eliminated the need for separate testing and sampling steps in the manufacturing process.

Implementation of IoT in the Pharmaceutical industry is not hassle-free. Moreover, since it's a highly regulated industry, the intervention of regulatory bodies and health agencies is imperative. Thus, development of IoT application in this industry must follow due-diligence to analyze the people, process and technology readiness for IoT.

Value derivation for Pharma companies through IoT

Cost savings

IoT applications in pharmaceutical sector includes Organ on a chip or chip in a pill will drastically improve the productivity through rapid trials running multi-stage diagnostics. It will bring down costs and resources associated with clinical trials. Advanced analytics tools will also be able to feed data directly to generate vital diagnostics and real-time reporting of patients.

Improved quality

Smart systems provides better control on precision and quality of drug produced. Also, it eliminates manual errors which may result to adverse impact on patient. Smart reporting and analytics can also help to improve drug quality in terms of safety and thereby improving quality of care

Better compliance

Central information system can fetch real-time data from smart devices such as chips on pill, or wearable which can be used to generate insightful reports for leadership teams to help in intelligent decision making. Also, predictive alerts can help to minimize adverse event reporting

Better planning and reduce TTM

Feedbacks and changes related to drug post clinical trials and leadership decisions can be easily percolated back to the systems with IoT-enabled systems. This will be particularly useful in drug launch, pricing, and marketing related strategy-making

Energy and Utilities

Energy and utilities happens to be the sector upon which a large number of businesses rely upon for their daily functioning. The demand for energy is ever increasing and shows no signs of stopping. According to the U.S. Energy Information Administration, the world's energy consumption will rise by a staggering 48% by 2040. Moreover, energy consumption is also projected to increase by 43% by the year 2022, in the United States alone.

With the increase of smart meters and cheap sensors, energy and utilities companies are looking to technology as a catalyst for business change. IoT is changing the way how energy and utility companies are functioning. By combining smart meters with sensors across infrastructure, cognitive computing, and analytics at the edge of networks, energy and utility companies can re-think traditional operating models.

Shell deployed IoT sensors in its oil fields in Nigeria to provide pipeline surveillance and wellhead monitoring capabilities to remote infrastructure. It combined IT automation and instrumentation technologies to provide a support platform for remote field data and optimize operations. Big data analytics was used to provide insight into field processes and it lead to safer and more efficient oilfield operations. Using Iot devices to monitor the oil fields instead of field workforce site visits has saved Shell over **$1 million.**

Others

Others include personal care and beauty products, offshore oil production, mining, waste management, paper and products, etc.

Offshore oil production

IoT implementation in the off-shore oil production is one of the key applications of IoT due to hazardous nature of the work. IoT-enabled solutions help oil companies to accurately get the details of machine failures and process variables that are off-specs. IoT provides next-gen connectivity for reliable and cost-effective off-shore monitoring. Satellite monitoring has proven to be the most beneficial IoT connectivity technology in the off-shore drilling. Also, Low Power WAN networks provides versatility in large, complex facilities..

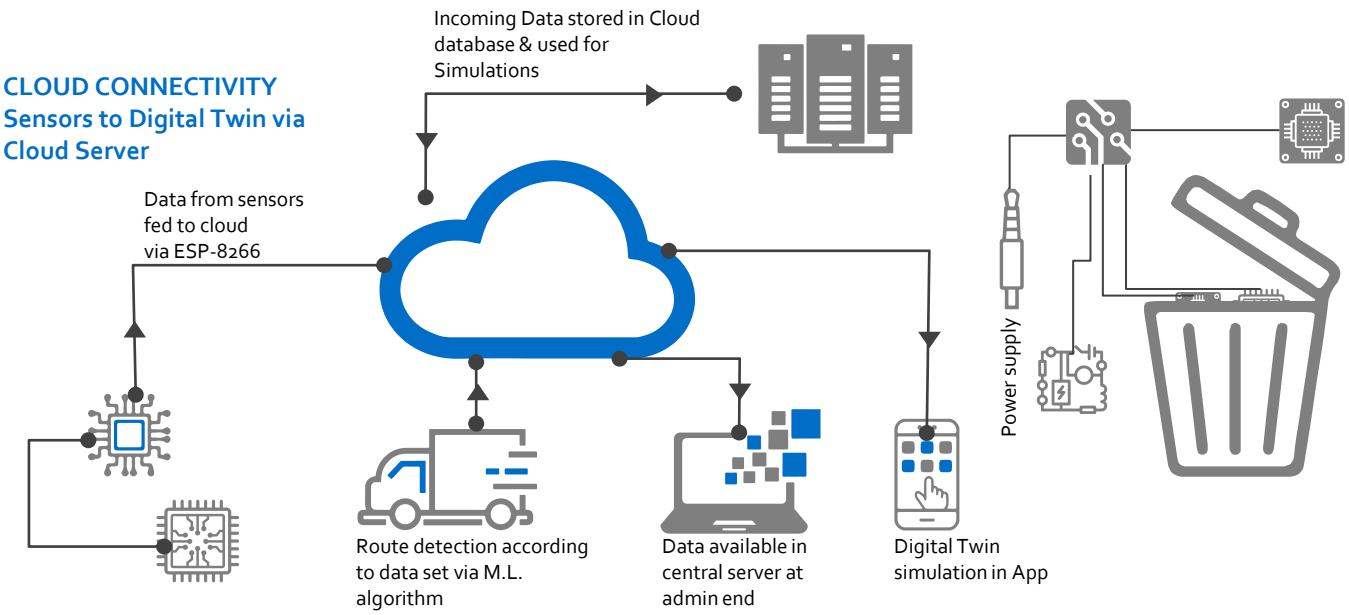
Waste management

Waste management is one of the most beneficial application area of IoT. As degree of urbanization across globe has increased by ~35% from 2009 to 2019, need for waste management has jumped. IoT presents a huge opportunity to reduce waste, lower the operating costs of waste management companies, and improve the quality of service to its residents.

IoT in the waste management can help where human struggles. With the introduction of 'digital bins' for waste material categorization, recycling and reuse will become easy.

For instance, a Polish company Bin-e has come up with "Smart Waste Bins" capable of identifying and sorting waste into up to four categories: glass, paper, plastic, and metal.

IoT can also help bring sustainability by integrating sensor data into software applications to better analyze waste patterns and optimize routes. Also, digital twin systems can open a new set of possibilities to recycle e-waste for precious and finite resources.



Processed Manufacturing Mapping

Process manufacturer	Industry	IoT Platform / Provider	Technology implementation	Comments
BUHLER	Processing foods and manufacturing advanced materials equipment	Microsoft Azure	Machine learning, AI, Image processing	Implementing IoT to reduce energy consumption and waste by thirty percent in their customers value chains
Syngenta	Provider of agrochemicals, seed protection and products	Microsoft Azure (OSIsoft)	Real-time data management, subscription-based software-as-a-service	Access and analyse plant data to quantify the operational benefits such as water and electricity
Tetra Pak	Packaging and processing company	Microsoft Azure	Predictive maintenance, Mixed-reality	Implements Azure cloud platform to collect operational data for informed maintenance and mixed reality to streamline diagnosis and quick repair
BASF	Chemicals and specialty materials	EcoStruxure™ (Schneider Electric India)	Predictive analysis	Digital dashboard to monitor critical-asset on continuous basis, optimize maintenance strategies
Total SE	Oil and gas	TrendMiner	Predictive performance	Improve OEE, Predictive performance based on history, Self-service analytics
GlaxoSmithKline	Pharmaceuticals	Cloudera	Data analytics	Accelerates development of new drugs, Reduces time for access to clinical trial data from months to minutes, decreases time and cost of participant selection for clinical trials
Pepsi Co	Food and beverages	SAS, Pep Worx	Machine learning, AI	Reduce downtime and streamline communication through remote monitoring
Asian Paints	Paints	SAP HANA, S/4	Data mining, predictive and prescriptive analytics	Insights into a wide variety of business problems in logistics, people analytics, and material sourcing
L'Oréal	Cosmetics and personal care	Perso	Augmented reality and AI	Patented motorized NFC-enabled cartridge system which provides personalized skincare formula through analysis, assessment, and custom formulation dispensing
Pfizer	Pharmaceuticals	Amazon Web Services (AWS IoT)	Deep learning, big data computing	Factory operations visibility & intelligence to improve efficiency, data management

9

Key Technologies Spotlight

Globally, manufacturing giants are integrating IoT with key technologies such as advanced robotics and automation, 3D printing, big data analytics, and 5G to transform manufacturing operations, cross-industry platforms, manufacturing integration (horizontal and vertical integrations), product quality, so on to achieve "*Zero Defect Manufacturing*"; therefore, these technologies play an essential role in IoT technology adoption

Advanced robotics and automation

Manufacturers are moving towards a future where humans and technology work hand in hand to develop an efficient, robust and safe production environment. Recognizing the potential of automation and robotics, there is a huge demand for robotic units with Q3 19 seeing orders of over $1.3 billion.

Collaborative robots (cobots) are experiencing rapid market growth in this sector of the robotics industry. The primary driving force behind this growth is a consistently decreasing price. Many collaborative robots are available for under $45K, making them a viable solution in a wide range of applications, inside and outside of the factory setting, for companies big and small.

Cobot applications

- Logistics
- Machine tending
- Pick and place
- Quality inspection
- Packaging
- Process automation
- Material handling
- Industrial cleaning

Cobots are easier to program, faster to deploy and generate returns quickly, all while providing manufacturers with safe, versatile, easy-to-use automation that supports human labor. They can be programmed to consistently perform non-value-added work, while people focus on skilled labor. Cobots are actually improving work conditions and empowering humans to have more fulfilling jobs in manufacturing industries.

There has been a noticeable uptick in the number of small and medium sized manufacturing companies embracing collaborative robots, primarily due to their moderate costs and ease of deployments and the fact that they can achieve significant cost savings by means of using robots.

3D Printing

The 3D printing or additive manufacturing technology is making a huge impact on industries such as aerospace, mining machinery, automobiles, firearms, and industrial equipment. The global 3D printing market is expected to reach $20 billion by 2025. Using computer-aided-design (CAD) software, manufacturers can now custom build parts and products one layer at a time for their customers. 3D printing is ideal for creating models, prototypes, molds, lost-wax castings, or components of final, finished products.

3D printing applications:

- Rapid prototyping
- Production parts
- Manufacturing tooling

Additive manufacturing is a significant time and cost-saving tool and will work towards making manufacturing more agile. By allowing consumers to dictate demand, 3D printing lends itself to increased supply chain mobility, adaptability and flexibility, therefore reducing costs and waste.

As it stands, the potential of the technology is really only starting to be fully unlocked and as companies across industries move ever-more towards smarter, digital manufacturing, the relevance of industrial 3D printing will only continue to increase.

Big Data analytics

The Manufacturing processes generate a lot of data, which without any analysis isn't of much use. In order to benefit from the data collected, it needs to be analyzed and insights need to be gained. The process of analyzing information is valuable, not only for decision making but for the company's bottom line. Manufacturers can significantly increase their efficiency and productivity with the technologies that allow them to collect, process and measure big data in real time.

With data analytics manufacturers can:

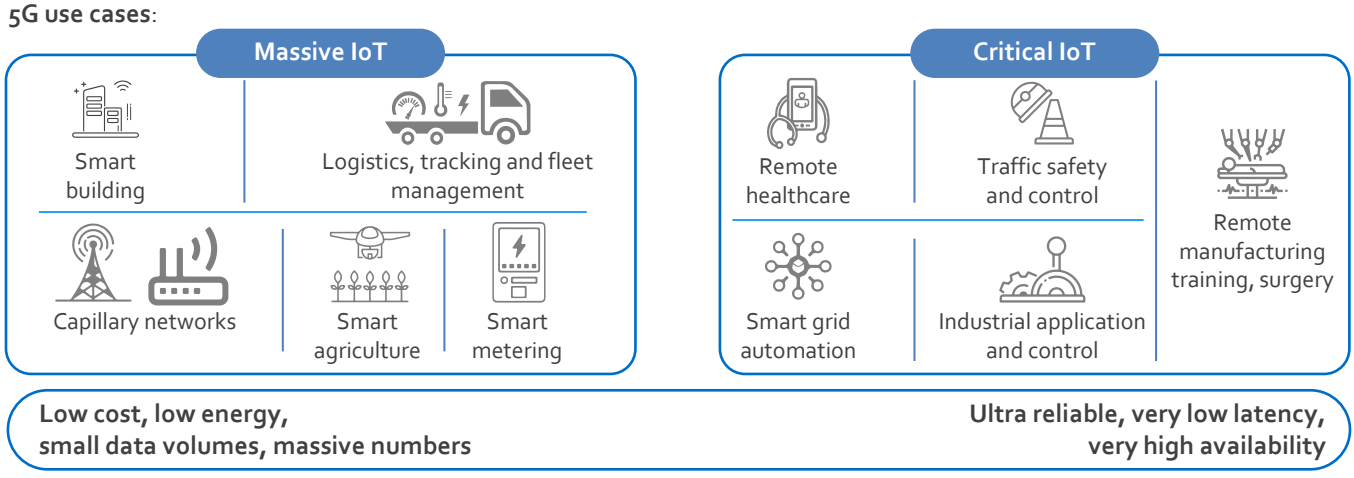
- Improve manufacturing
- Predictive maintenance
- Anomaly detection
- Ensure better quality assurance
- Manage the supply chain
- Production forecasting
- Customize product design
- Evaluate for any potential risk

Large number of manufacturers around the world have already invested or planning to invest in big data analytics. These manufacturers would be able to make informed decisions using productivity and waste performance data provided by big data analytics, lowering operating costs and increasing the overall yield.

5G

As the number of technologies impacting todays production environment increases at a fast pace, including the expansion of the IIoT and the number of connected devices, the bandwidth demands are ever increasing. 5G networks offer manufacturers and telecom operators the chance to build smart factories and take advantage of technologies such as automation, artificial intelligence, augmented reality for troubleshooting, and the Internet of Things (IoT).

5G use cases:



Manufacturers traditionally relied on fixed line networks for low latency and high reliability networks needed for supporting critical applications. 5G satisfies the need for high speed, reliable and secure connectivity that supports a new highly mobile reality. The mobile 5G technology will allow for higher flexibility, lower cost, and shorter lead times for factory floor production reconfiguration, layout changes, and alterations. 5G IoT will support the use cases that will drive the development of Industry 4.0.

GLOBAL M&A PARTNERS

10

Potential Early Adopters

Apr 2017: **Tetra Pak** placed sensors on carton-filling equipment across some of its factories and integrated this sensor data to the Azure cloud. The data collected helped predict future breakdowns, prompted **preventive maintenance** and **saved** their customers more than **$30,000.**

May 2018: **ABB** partnered with Microsoft to develop its workforce management app, ABB Ability Ellipse Workforce Management. Customers using this new cloud based app have **increased field productivity by 15-25%,** decreased their drive time between sites by 10%, and **improved customer satisfaction by 20%**.

Jul 2018: **Red Bull racing** partnered with Siemens to develop flexible and streamlined workflows in their design process using products from Siemens Digital Industries portfolio. As a result, Redbull were able to **cut build time by 30%** for some parts, **reduce material waste,** and minimize use of patches that added weight.

Nov 2016: **Shell** installed optical fiber cables with sensors within some of its oil wells in west Africa to collect data about the usage and performance of a variety of its assets and monitor sites remotely. This led to **lesser site visits** and **reduction in production downtime,** and the company saw a **return of over $1 million** on an initial investment of $87,000

Apr 2017: **Rolls Royce** used IoT sensing technology to work on fuel use efficiency, flight path optimization, and maintenance, using an integrated array of sensors in its aircraft engines. Attaining a 1% reduction in fuel usage translated to a **cost savings of $250,000 per plane**, per year.

2016: **Harley Davidson** moved one of its production plants to a fully IoT enabled factory fitted with sensing technology and automation solutions. The plant was able to **reduce its 21-day production schedule for new orders to 6 hours** and **cut operating costs by $200 million**, while improving production efficiency, and reducing downtime

Feb 2017: **Hershey's** fitted several of its massive chocolate vats with connected sensors to assess temperature, and other data along its production line. Using this data Hershey's improved production efficiency and adjusted the size of its products, to achieve **$500,000 in savings per 14,000-gallon batch.**

May 2018: **Schneider Electric** in its le Vaudreuil factory in France implemented the latest digital tools which used technologies such as remote sensing, automation and AR, which enables operators to speed up operation and maintenance. The deployment resulted **in 2-7% gain in productivity and 30% energy savings over the years**

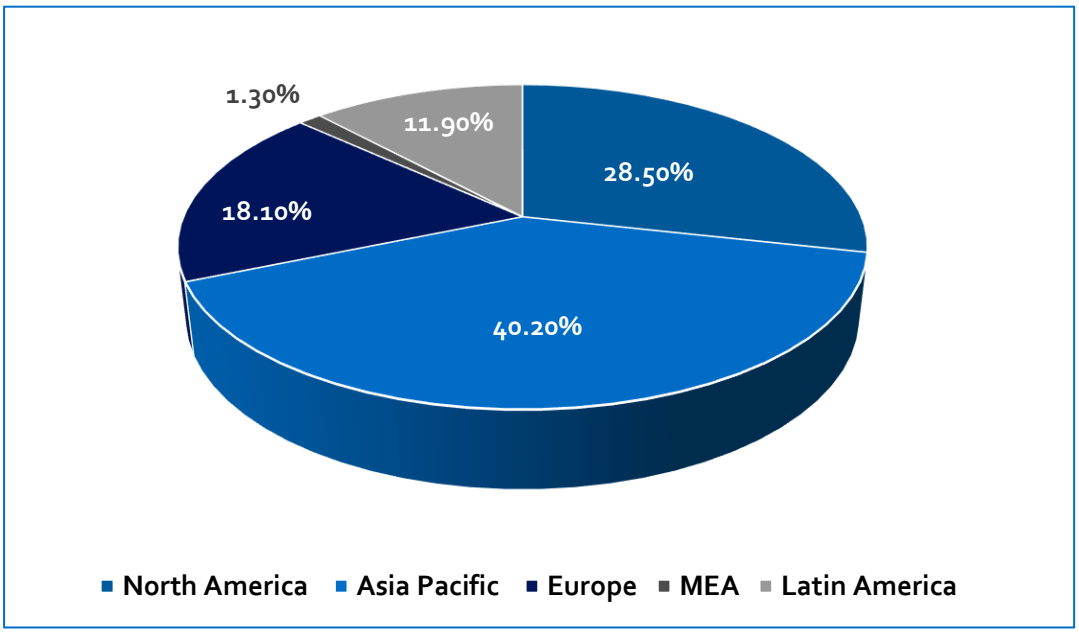
Mar 2017: **BMW** in its Regensburg plant in Germany made use of technologies ranging from robotics to 3D printing to smart data analytics , and were able to **reduce application deployment time by 80% and reduce quality issues by 5%**

11 Regional Outlook

Regional Analysis

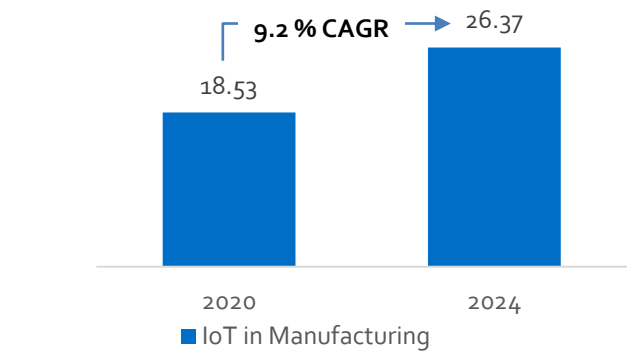
The below pie chart depicts the regional analysis of IoT in the manufacturing market. Globally, Asia Pacific has emerged as the leader in the IoT enabled manufacturing market due to considerable supports and mandates from the government. Major countries such as China, South Korea, Hong Kong, Taiwan, and Singapore have promoted & deployed IoT technologies to revolutionize manufacturing industry .

IoT in Manufacturing Market Share By Region 2020



Source: GlobalData

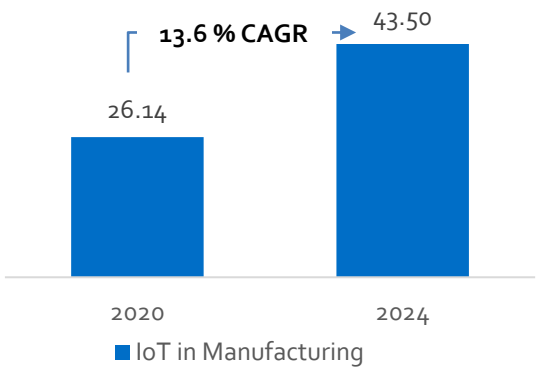
North America IoT in Manufacturing Market Value $ Billion



Source: GlobalData

The IoT in manufacturing market size for North America is expected to grow from $18.53 billion in 2020 to $26.37 billion by 2024, at a CAGR of 9.2% during the forecast period. US manufacturers have been one of the most ardent adopters of Industry 4.0. Due to the early adoption of trending technologies, such as IoT, big data, DevOps and Mobility, manufacturers in North America are keen to integrate IoT technologies in their processes. Growing number of SMEs and increasing digitization in manufacturing by large organizations, such as IBM and General Electric, have also aided the growth of the North American IoT in manufacturing market..

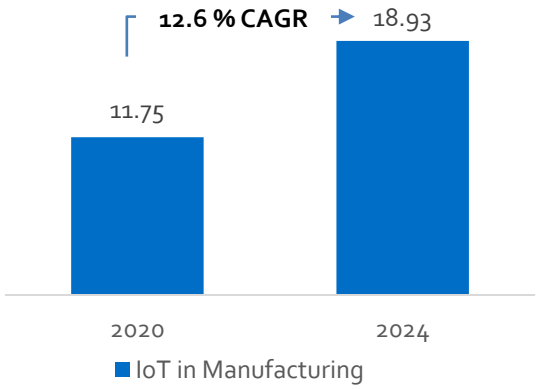
Asia Pacific IoT in Manufacturing Market Value $ Billion



Source: GlobalData

Asia Pacific (APAC) represents the single largest market for IoT in manufacturing and is expected to grow at a CAGR of 13.6% to reach $43.50 billion in 2024. The region is home to many organizations active in IoT, from the Shenzhen manufacturing base, to consumer electronics companies like Samsung and heavy industrial organizations, like Hitachi Construction Machinery. No other region has a similarly wide and diverse set of organizations involved in IoT. Out of all the Asia-Pacific countries, China is expected to spearhead industrial IoT spending and account for 49% of spending by 2020, Japan, South Korea, and India are expected quickly adopt IoT in manufacturing solutions over time. Majority of manufacturers in Asia Pacific have not only implemented but also planning to expand the use of IoT in their operations to stay competitive..

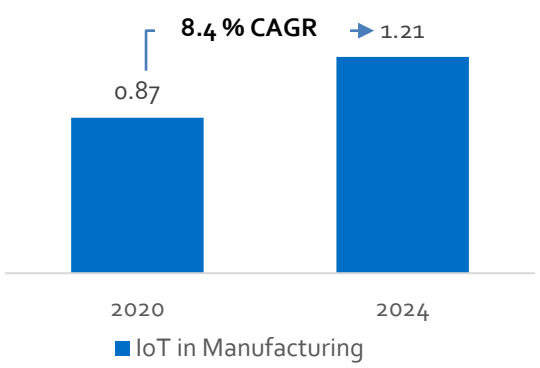
Europe IoT in Manufacturing Market Value $ Billion



Source: GlobalData

The European IoT in manufacturing market is expected to grow from $11.75 billion in 2020 to $18.93 billion by 2024, at a CAGR of 12.6% during the forecast period. Germany, the United Kingdom, France, Italy, Spain and the Netherlands are leading adopters of IoT in manufacturing, with Eastern European countries and the Nordics following closely. EU policy makers and regulatory bodies such as BEREC have looked into IoT and recognized the tremendous opportunities that IoT represents, and have thus embraced open policies to promote IoT across various sectors including manufacturing. Major brands like Nestle, Volkswagen, Daimler, Siemens, and BMW have implemented IoT in their manufacturing processes and are reaping its benefits

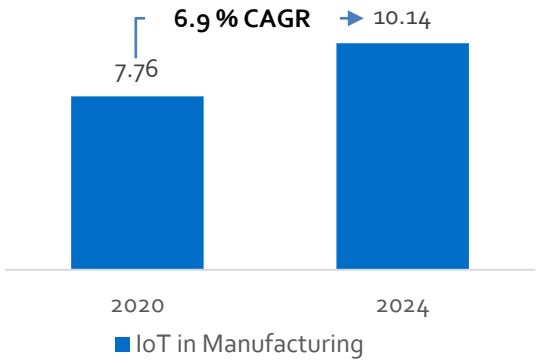
MEA IoT in Manufacturing Market Value $ Billion



Source: GlobalData

IoT in manufacturing is still at a nascent stage in MEA and is expected to reach $1.21 billion by 2024. The IoT market is mainly driven by the involvement of a number of Gulf countries' governments in smart city plans, including Saudi Arabia, Qatar and the UAE. Countries in the region are trying to move away from an oil driven economy and create alternate sources of income for which manufacturing is a focus area. Manufacturing sub-sectors such as rubber, plastics, processed foods and drinks, base metals, printing and publishing, chemicals, and electrical equipment and machinery are being given an impetus and IoT solutions are being implemented by manufacturers to streamline their processes and improve overall efficiency.

LATAM IoT in Manufacturing Market Value $ Billion



Source: GlobalData

The IoT in manufacturing market in LATAM is expected to grow from $7.76 billion in 2020 to $10.14 billion by 2024, at a CAGR of 6.9% during the forecast period. The automotive sector will be the major growth driver, with applications such as vehicle tracking, fleet management as well as Original Equipment Manufacturer (OEM) embedded solutions continuing to increase in deployment terms. From connected vehicles to fully automated manufacturing to real-time monitoring, IoT can accelerate innovation and increase productivity of manufacturers across the region.

GLOBAL M&A PARTNERS

12

Post Covid-19 Era

IoT in Manufacturing

1 Effects of COVID-19 on Manufacturing

The effects of the COVID-19 outbreak can be seen throughout almost every industry none more than manufacturing. The major impact areas seen across manufacturing include supply chain disruptions, issues with shipping and distribution, and staffing challenges.

In light of current events, the focus of manufacturers has shifted from streamlining and driving supply chain efficiencies to driving integration between IT and OT systems to maintaining basic levels of operations. Intelligence and foresight to help anticipate and tackle future challenges is essential, and to achieve this, manufacturers are turning to technology and smart devices.

2 Manufacturing moving towards becoming "Smarter"

Manufacturing has seen a noticeable acceleration of technology adoption in response to the current situation surrounding COVID-19. With a new focus on efficient use of resources, manufacturers are expected to increasingly utilize remote technology, including autonomous equipment and sensors. These devices enabled with wireless connectivity, provide valuable data insights which would result in better decision-making and productivity for organizations that leverage the technology.

IoT technology such as location-based services and critical asset monitoring can provide manufacturers with increased visibility into their supply chain with actionable data for preventative maintenance and proactive risk mitigation. The newest IoT solutions for asset management include real-time alerts, allowing manufacturers to take action to minimize loss associated with delayed, damaged, or lost goods in transport. IoT has helped organizations to shift to an automated model of work, ensuring employee safety, continuity, and flexibility.

3 The future looks promising

While the pandemic proved to be challenging times for manufacturing, organizations that adopt technology and connectivity solutions will be better suited to face future crises situations and would be more adaptable. COVID-19 has made everyone rethink their business strategies and demonstrated the potential of the digital, connected world to run businesses smoothly. Creative problem solving using new and advanced technologies will not only accelerate the adoption of industrial IoT solutions but also help manufacturers ensure productivity and profitability through the next crisis and beyond.

13

Trading & Transactions

Company	Country	Market Cap (USD mn)	Enterprise Value (USD mn)	Revenue (USD mn)		EV/Revenue		EV/EBITDA		EV/EBIT		P/E	
				2020A	2021E	2020A	2021E	2020A	2021E	2020A	2021E	2020A	2021E
Diversified IoT/Industrial Technology													
Danaher	US	172,621	190,825	22,284	27,834	8.6x	6.9x	28.3x	20.6x	40.6x	26.2x	61.8x	27.2x
SAP	Germany	164,424	172,358	33,441	33,441	5.2x	5.2x	17.7x	15.3x	22.0x	17.6x	37.3x	21.8x
Honeywell	US	160,262	170,029	32,637	34,791	5.2x	4.9x	21.3x	19.5x	25.3x	23.3x	44.7x	28.9x
Siemens	Germany	133,112	162,163	70,379	74,862	2.3x	2.2x	18.0x	14.1x	29.9x	23.7x	33.9x	18.5x
Roper	US	47,280	56,023	5,527	6,391	10.1x	8.8x	27.7x	24.6x	39.2x	33.3x	62.8x	30.0x
Capgemini	France	31,098	38,698	19,386	20,951	2.0x	1.9x	13.8x	11.6x	19.3x	15.2x	27.4x	18.9x
AMETEK	US	31,375	32,775	4,540	5,331	7.2x	6.2x	24.2x	21.3x	31.2x	26.4x	51.0x	29.8x
Fortive	US	24,861	26,334	6,480	5,203	4.1x	5.1x	17.8x	21.0x	30.3x	31.1x	24.7x	28.3x
Teradyne	US	21,783	20,784	3,121	3,582	6.7x	5.8x	19.5x	16.7x	23.0x	18.6x	43.7x	24.5x
IDEX	US	16,964	17,159	2,352	2,665	7.3x	6.4x	26.3x	23.0x	31.9x	26.2x	54.7x	36.0x
PTC	US	15,280	16,669	1,531	1,759	10.9x	9.5x	42.6x	29.4x	56.6x	30.8x	112.1x	39.8x
AVEVA	UK	14,915	15,593	1,089	1,444	13.8x	10.8x	57.5x	28.8x	94.5x	37.4x	93.6x	40.2x
DXC Technology	US	10,131	14,466	18,159	16,845	0.8x	0.9x	4.5x	5.5x	18.8x	10.6x	30.0x	12.2x
Atos	France	7,176	9,393	13,677	13,878	0.7x	0.7x	4.8x	4.8x	10.0x	7.3x	13.0x	7.6x
Alten	France	4,281	4,249	2,853	3,178	1.5x	1.3x	17.1x	13.1x	25.6x	17.9x	35.7x	25.4x
ESCO Technologies	US	2,401	2,426	724	761	3.4x	3.2x	17.2x	15.5x	25.5x	20.5x	41.8x	28.8x
Average						**5.6x**	**5.0x**	**22.4x**	**17.8x**	**32.7x**	**22.9x**	**48.0x**	**26.1x**
Median						**5.2x**	**5.1x**	**18.7x**	**18.1x**	**27.8x**	**23.5x**	**42.7x**	**27.7x**
Large IoT companies													
Honeywell	US	160,262	170,029	32,637	34,791	5.2x	4.9x	21.3x	19.5x	25.3x	23.3x	44.7x	28.9x
Siemens	Germany	133,112	162,163	70,379	74,862	2.3x	2.2x	18.0x	14.1x	29.9x	23.7x	33.9x	18.5x
Schneider Electric	France	89,036	98,472	30,776	34,119	3.2x	2.9x	17.4x	15.3x	21.7x	18.1x	35.5x	23.8x
ABB	Switzerland	70,531	73,650	26,134	28,714	2.9x	2.6x	24.3x	16.1x	41.2x	21.0x	78.3x	28.1x
Emerson Electric	US	58,459	63,985	16,795	18,285	3.8x	3.5x	16.2x	15.4x	21.7x	20.0x	35.1x	24.4x
Fanuc	Japan	45,490	40,229	4,816	6,311	8.9x	6.4x	30.4x	22.5x	46.6x	23.7x	82.4x	33.1x
Rockwell Automation	US	31,552	33,594	6,211	7,219	5.4x	4.7x	25.1x	22.7x	31.9x	25.6x	52.3x	29.7x
Yokogawa Electric	Japan	4,259	3,878	3,651	3,487	1.1x	1.1x	8.1x	8.7x	13.0x	14.0x	24.5x	29.0x
KUKA	Germany	2,633	3,065	3,148	3,349	1.0x	0.9x	NM	20.7x	NM	NM	NM	NM
Automation Tooling Systems	Canada	2,294	2,573	1,097	1,510	2.2x	1.7x	18.2x	11.8x	28.2x	15.5x	56.4x	21.0x
Average						**3.6x**	**3.1x**	**19.9x**	**16.7x**	**28.8x**	**20.5x**	**49.2x**	**26.3x**
Median						**3.0x**	**2.7x**	**18.2x**	**15.8x**	**28.2x**	**21.0x**	**44.7x**	**28.1x**

Source: CapitalIQ as of 02-Jun-2021
Note: Financials calendarised to December

Company	Country	Market Cap (USD mn)	Enterprise Value (USD mn)	Revenue (USD mn)		EV/Revenue		EV/EBITDA		EV/EBIT		P/E	
				2020A	2021E	2020A	2021E	2020A	2021E	2020A	2021E	2020A	2021E
Industrial IoT													
Hexagon	Sweden	37,293	39,880	4,605	5,090	8.7x	7.8x	26.7x	21.3x	32.5x	28.7x	51.6x	33.6x
Xilinx	US	31,748	30,213	3,053	3,497	9.9x	8.6x	31.1x	28.4x	39.6x	33.8x	68.0x	37.7x
Trimble	US	19,683	20,910	3,148	3,483	6.6x	6.0x	27.6x	24.7x	41.2x	26.7x	73.6x	32.1x
Altair Engineering	US	5,031	5,015	470	509	10.7x	9.8x	NM	NM	NM	NM	NM	NM
CalAmp	US	488	602	339	331	1.8x	1.8x	48.8x	16.0x	NM	28.9x	NM	30.7x
Digi International	US	645	585	290	312	2.0x	1.9x	14.5x	12.4x	38.6x	40.1x	80.3x	18.4x
Sierra Wireless	Canada	590	492	449	484	1.0x	1.0x	NM	NM	NM	NM	NM	NM
MiX Telematics	US	329	288	129	136	2.1x	2.1x	7.2x	8.1x	15.6x	19.9x	30.9x	25.2x
Average						**5.4x**	**4.9x**	**26.0x**	**18.5x**	**33.5x**	**29.7x**	**60.9x**	**29.6x**
Median						**4.4x**	**4.1x**	**27.1x**	**18.6x**	**38.6x**	**28.8x**	**68.0x**	**31.4x**
Electronics & Connectivity													
TE Connectivity	Switzerland	44,934	47,873	12,526	14,822	3.8x	3.2x	18.6x	14.4x	25.9x	18.6x	40.4x	22.0x
Amphenol	US	40,494	42,831	8,599	10,016	5.0x	4.3x	20.9x	18.3x	26.1x	21.5x	43.8x	29.8x
Legrand	France	27,985	30,927	7,461	8,096	4.2x	3.8x	18.5x	16.1x	23.8x	19.0x	38.6x	25.3x
Hubbell	US	10,342	11,811	4,186	4,590	2.8x	2.6x	16.1x	15.5x	21.5x	19.3x	35.3x	22.4x
Acuity Brands	US	6,502	6,571	3,284	3,346	2.0x	2.0x	13.3x	12.4x	17.9x	14.2x	33.0x	19.9x
Synaptics	US	4,549	4,725	1,292	1,367	3.7x	3.5x	22.5x	12.0x	47.1x	11.8x	91.8x	15.3x
Belden	US	2,308	3,515	1,863	2,162	1.9x	1.6x	13.6x	11.2x	25.6x	13.1x	47.4x	14.1x
TT Electronics	UK	629	751	590	658	1.2x	1.1x	23.0x	10.2x	75.7x	15.1x	235.6x	17.7x
Average						**3.1x**	**2.8x**	**18.3x**	**13.8x**	**32.9x**	**16.6x**	**70.7x**	**20.8x**
Median						**3.2x**	**2.9x**	**18.6x**	**13.4x**	**25.8x**	**16.9x**	**42.1x**	**21.0x**
Sensors & Instruments													
Keyence	Japan	118,817	110,333	5,004	5,736	23.4x	19.2x	44.3x	36.6x	45.8x	36.1x	78.8x	53.3x
Cognizant Technology	US	37,599	37,156	16,652	17,993	2.2x	2.1x	11.5x	11.2x	15.6x	13.4x	26.1x	17.9x
Keysight Technologies	US	26,516	26,555	4,306	4,917	6.2x	5.4x	21.9x	18.4x	32.7x	20.0x	58.9x	24.3x
Cognex	US	13,948	13,587	811	1,013	16.8x	13.4x	58.4x	38.5x	65.9x	40.9x	77.1x	49.7x
Sensata	US	9,502	11,607	3,046	3,780	3.8x	3.1x	17.7x	12.8x	29.8x	14.8x	66.7x	17.6x
Spectris plc	UK	5,309	5,216	1,824	1,864	2.8x	2.8x	52.1x	14.2x	NM	18.1x	NM	23.4x
FARO Technologies	US	1,367	1,224	304	345	4.0x	3.6x	NM	41.8x	NM	63.6x	NM	74.7x
Average						**8.4x**	**7.1x**	**34.3x**	**24.8x**	**38.0x**	**29.5x**	**61.5x**	**37.3x**
Median						**4.0x**	**3.6x**	**33.1x**	**18.4x**	**32.7x**	**20.0x**	**66.7x**	**24.3x**
Discrete Technologies													
Nidec	Japan	68,139	71,052	15,117	16,046	5.0x	4.4x	36.1x	27.3x	58.7x	41.1x	96.0x	47.4x
Parker-Hannifin	US	40,068	46,312	13,505	15,149	3.4x	3.1x	17.1x	14.4x	21.8x	16.5x	34.9x	19.0x
Delta Electronics	Taiwan	28,043	28,419	10,060	11,681	2.8x	2.4x	16.6x	14.1x	25.0x	19.8x	38.7x	23.5x
WEG	Brazil	27,634	27,371	3,364	4,006	8.0x	6.8x	42.8x	36.8x	49.4x	42.9x	84.5x	50.0x
SKF	Sweden	12,455	13,146	9,114	9,786	1.5x	1.3x	10.9x	7.8x	16.0x	9.9x	28.3x	14.2x
YASKAWA Electric	Japan	12,663	12,909	3,652	4,008	3.7x	3.2x	31.6x	23.9x	52.0x	34.5x	85.2x	47.9x
The Timken Company	US	6,710	8,182	3,513	4,140	2.3x	2.0x	11.8x	10.3x	16.7x	13.2x	26.2x	16.4x
Rexnord	US	6,027	6,928	1,911	2,169	3.5x	3.2x	19.8x	14.2x	26.4x	17.8x	46.9x	25.4x
Regal Beloit	US	5,764	6,328	2,907	3,206	2.2x	2.0x	12.8x	11.2x	18.9x	14.4x	32.4x	18.2x
Altra Industrial Motion Corp.	US	4,265	5,459	1,726	1,855	3.2x	2.9x	14.6x	14.2x	23.5x	16.7x	42.8x	20.3x
Average						**3.5x**	**3.1x**	**21.4x**	**17.4x**	**30.8x**	**22.7x**	**51.6x**	**28.2x**
Median						**3.3x**	**3.0x**	**16.9x**	**14.2x**	**24.2x**	**17.3x**	**40.8x**	**21.9x**

Source: CapitalIQ as of 02-Jun-2021
Note: Financials calendarised to December

Company	Country	Market Cap (USD mn)	Enterprise Value (USD mn)	Revenue (USD mn)		EV/Revenue		EV/EBITDA		EV/EBIT		P/E	
				2020A	2021E	2020A	2021E	2020A	2021E	2020A	2021E	2020A	2021E
Process Technologies													
Xylem	US	21,384	22,829	4,876	5,334	4.7x	4.3x	27.0x	24.4x	46.3x	33.4x	81.2x	43.6x
Pentair	UK	11,747	12,668	3,018	3,343	4.2x	3.8x	21.8x	19.3x	26.7x	21.0x	41.6x	23.6x
Graco	US	12,716	12,477	1,650	1,897	7.6x	6.6x	25.6x	21.0x	29.6x	23.4x	50.4x	30.6x
A. O. Smith	US	11,433	10,922	2,895	3,323	3.8x	3.3x	20.2x	16.9x	24.7x	19.4x	41.1x	26.5x
ITT	US	8,104	7,487	2,478	2,728	3.0x	2.7x	21.8x	13.6x	36.4x	17.1x	63.7x	23.8x
Rexnord	US	6,027	6,928	1,911	2,169	3.5x	3.2x	19.8x	14.2x	26.4x	17.8x	46.9x	25.4x
Flowserve	US	5,533	6,424	3,728	3,629	1.7x	1.8x	11.8x	14.3x	16.8x	18.4x	29.2x	26.4x
Sulzer	Switzerland	4,392	4,887	3,751	3,879	1.3x	1.3x	11.8x	9.6x	21.0x	15.9x	35.6x	19.9x
Watts Water Technologies	US	4,704	4,677	1,509	1,629	3.1x	2.9x	18.3x	17.1x	24.1x	20.6x	42.2x	31.4x
Evoqua Water Technologies	US	3,796	4,515	1,406	1,470	3.2x	3.1x	17.4x	17.6x	34.9x	31.0x	70.6x	41.2x
Rotork plc	UK	4,297	4,044	825	864	4.7x	4.7x	18.0x	17.4x	22.2x	19.6x	37.7x	27.6x
Franklin Electric	US	3,908	3,919	1,247	1,514	3.1x	2.6x	22.0x	17.8x	30.2x	21.5x	50.2x	27.8x
SPX FLOW	US	2,882	2,910	1,351	1,521	2.2x	1.9x	18.1x	13.8x	29.8x	17.0x	68.8x	27.4x
Badger Meter	US	2,783	2,740	426	480	6.4x	5.7x	29.4x	27.0x	42.2x	37.1x	68.7x	50.0x
Average						**3.8x**	**3.4x**	**20.2x**	**17.4x**	**29.4x**	**22.4x**	**52.0x**	**30.4x**
Median						**3.4x**	**3.1x**	**20.0x**	**17.3x**	**28.1x**	**20.1x**	**48.5x**	**27.5x**
Engineered Machinery													
Illinois Tool Works	US	73,815	79,282	12,574	14,338	6.3x	5.5x	23.5x	19.3x	27.4x	21.7x	44.1x	27.5x
Sandvik	Sweden	34,051	34,008	10,521	11,420	3.3x	3.0x	16.1x	11.7x	22.0x	15.2x	38.2x	20.3x
Dover	US	21,768	24,294	6,684	7,519	3.6x	3.2x	18.1x	15.8x	24.7x	19.5x	39.9x	21.7x
Doosan	South Korea	1,444	14,562	15,593	15,264	1.0x	1.0x	21.1x	10.4x	NM	14.6x	NM	7.7x
Andritz	Austria	5,764	5,692	8,200	7,994	0.7x	0.7x	9.5x	7.1x	17.8x	11.3x	25.5x	16.1x
Marel	Iceland	5,379	5,623	1,514	1,706	3.5x	3.3x	20.5x	18.4x	28.6x	23.4x	50.3x	33.4x
John Bean Technologies	US	4,630	5,043	1,728	1,877	2.9x	2.7x	18.8x	17.8x	27.4x	24.4x	44.0x	31.8x
DMG MORI	Germany	3,957	3,885	2,257	NA	1.7x	NA	23.5x	NA	45.3x	NA	69.3x	NA
Dürr	Germany	2,876	2,886	4,067	4,427	0.7x	0.7x	20.3x	8.8x	NM	14.0x	NM	22.2x
Okuma	Japan	1,622	1,209	1,239	1,419	1.0x	0.9x	12.2x	7.0x	28.7x	11.3x	60.8x	21.4x
Bobst Group	Switzerland	1,179	1,181	1,551	1,600	0.8x	0.7x	18.6x	10.8x	64.3x	19.3x	48.4x	27.7x
Average						**2.3x**	**2.2x**	**18.4x**	**12.7x**	**31.8x**	**17.5x**	**46.7x**	**23.0x**
Median						**1.7x**	**1.8x**	**18.8x**	**11.3x**	**27.4x**	**17.3x**	**44.1x**	**21.9x**
Overall Avergae						**4.4x**	**3.9x**	**21.8x**	**17.2x**	**31.7x**	**22.3x**	**53.3x**	**27.5x**
Overall Median						**3.4x**	**3.1x**	**19.1x**	**15.5x**	**27.4x**	**19.8x**	**44.7x**	**25.4x**

Source: CapitalIQ as of 02-Jun-2021
Note: Financials calendarised to December

Indian IoT Companies

Company	Country	Market Cap (USD mn)	Enterprise Value (USD mn)	Revenue (USD mn)		EV/Revenue		EV/EBITDA		EV/EBIT		P/E	
				2020A	2021E	2020A	2021E	2020A	2021E	2020A	2021E	2020A	2021E
Indian IoT Companies													
Infosys	India	80,261	77,293	13,145	15,437	5.9x	5.0x	21.8x	18.6x	24.8x	21.2x	38.3x	27.1x
Wipro	India	40,648	37,364	8,409	9,640	4.4x	3.9x	20.0x	16.1x	24.3x	21.2x	39.5x	25.9x
HCL Technologies	India	35,117	33,942	10,022	11,417	3.4x	3.0x	12.2x	11.9x	15.7x	14.8x	25.8x	19.5x
Tech Mahindra	India	12,192	10,468	5,151	5,582	2.0x	1.9x	13.1x	9.8x	16.0x	12.3x	26.5x	18.2x
Mindtree	India	5,392	5,057	1,083	1,214	4.7x	4.2x	24.1x	20.2x	28.6x	23.9x	49.0x	31.0x
Mphasis	India	4,896	4,684	1,307	1,447	3.6x	3.2x	19.5x	16.9x	22.2x	19.7x	37.7x	26.2x
Bharat Electronics	India	5,023	3,814	1,781	2,100	2.1x	1.9x	10.1x	9.6x	11.7x	11.0x	23.9x	18.5x
Tata Elxsi	India	3,065	2,947	239	286	12.3x	10.3x	44.8x	36.9x	48.8x	40.1x	74.3x	49.5x
Sonata Software	India	964	879	559	665	1.6x	1.3x	16.7x	14.2x	18.7x	15.5x	32.8x	22.2x
Kellton Tech Solutions	India	95	94	106	NA	0.9x	NA	6.6x	NA	7.6x	NA	14.3x	NA
Datamatics Global Services	India	113	58	161	NA	0.4x	NA	3.6x	NA	4.6x	NA	12.5x	NA
Average						**3.7x**	**3.9x**	**17.5x**	**17.1x**	**20.3x**	**20.0x**	**34.0x**	**26.5x**
Median						**3.4x**	**3.2x**	**16.7x**	**16.1x**	**18.7x**	**19.7x**	**32.8x**	**25.9x**

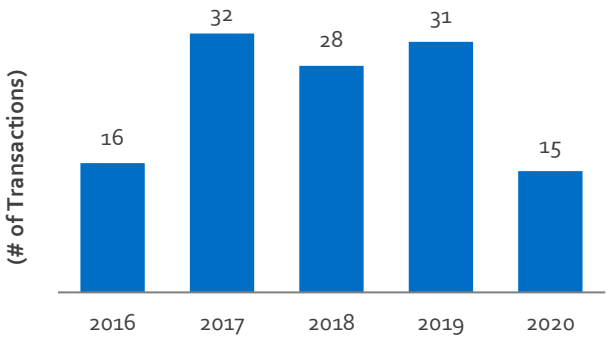
Source: CapitalIQ as of 02-Jun-2021
Note: Financials calendarised to December

Merger and Acquisitions

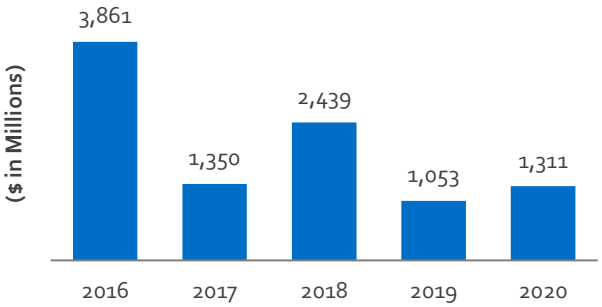
Date	Manufacturing Company	IoT/Technology Company	Deal Size	Impact analysis
December 2020	TVS Motors	Intellicar Telematics	INR150 Mn	The acquisition will enable TVS Motors to accelerate digital initiatives to enhance the customer experience.
June, 2020	Caterpillar	Marble Robot, Inc.	Undisclosed	Caterpillar will be able to leverage Marble Robot's fully integrated on-board autonomy technology including perception, localization and planning. This will help them to continue delivering smart, safe, more productive and cost-effective solutions to customers
October, 2019	Siemens	Pixeom	Undisclosed	Siemen acquired Container-Based Edge Platform From Pixeom in a bid to run applications at the edge in its factories. This helped Siemens in factory automation which will also drive its Digital Industries division. It also owns MindSphere IoT platform
April, 2019	Bridgestone	TomTom Telematics (now Webfleet Solutions)	EUR910 Mn	The acquisition will accelerate Bridgestone's digital transformation and status as preferred partner in mobility solutions to make fleet operations more effective and efficient
October, 2018	Siemens	Mendix	$730 Mn in cash	This acquisition eased the application development for Industrial IoT with the help of low-code and cloud-based application development software
September, 2018	ABB	Intrion	Undisclosed	The acquisition will advance ABB's logistics robotics offering and ensure that the customers and system partners are well equipped for the growth of e-commerce and shift to mass customization
July 2018	ENGIE	Flashnet	Undisclosed	ENGIE is multinational electric utility company acquired Flashnet an IoT company. The acquisition enables ENGIE to develop smart lighting products and intelligent energy management systems to fulfill the growing demand from smart cities.

IoT in Manufacturing

Number of Transactions



Disclosed Deal Value of Transactions



Select Precedent Transactions

Date	Target	Buyers	Deal Value (USD mn)	Implied EV (USD mn)	EV/Revenue (x)	EV/EBITDA (x)
22-Dec-20	Sparta Systems, Inc.	Honeywell International Inc.	1,300	1,300	-	-
16-Dec-20	Applied Vision Corporation	Antares Vision SpA	45	45	1.6x	11.0x
2-Dec-20	AIS Cayman Technology Co., Ltd. (37.64% Stake)	Ennoconn Corporation	29	-	-	-
30-Nov-20	IVISYS AB (60.7% Stake)	Athanase Industrial Partners II AB	5	8	7.8x	-
20-Aug-20	Soft Motions & Robotics	Crescendo Equity Partners Limited	42	-	-	-
28-Jul-20	Cogent Industrial Technologies Limited	Kadant Inc.	7	7	-	-
30-Jun-20	Convel Srl	Antares Vision SpA	14	14	3.0x	7.8x
10-Feb-20	ISRA Vision Systems AG	Atlas Copco AB	1,198	1,198	7.1x	21.4x
5-Feb-20	Cepton Technologies, Inc.	Koito Manufacturing Co. Ltd	50	-	-	-
8-Nov-19	KTICC Co., Ltd. (80% Stake)	Trescal SAS	10	-	-	-
19-Sep-19	BTG Group Limited	Voith GmbH & Co. KGaA	352	352	-	11.5x
26-Jul-19	PCTEST Engineering Laboratory	Element Materials Technology Holding USA Inc.	205	-	-	-
23-May-19	Alibaba Health Information Technology Ltd. (2.02% Stake)	Alibaba Group Holding Co., Ltd.	232	11,686	15.9x	1138.1x
7-May-19	XAVIS Co., Ltd.	XAVIS Co., Ltd.	37	37	3.2x	243.9x
3-May-19	Sensys Networks, Inc.	TagMaster AB	16	16	1.1x	9.4x
22-Apr-19	Elenium Automation Pty Ltd	Acorn Capital Limited	11	-	-	-
3-Apr-19	Rave LLC	Bruker Corporation	57	57	2.3x	-
28-Mar-19	Buoy Labs	Resideo Technologies, Inc.	6	6	-	-
26-Feb-19	Coastal Flow Measurement, Inc.	Quorum Business Solutions, Inc.	100	100	-	-
7-Jan-19	Humatics Corporation	Fontinalis Partners, LLC; Presidio Ventures, Inc.; Tenfore Holdings Capital Management LLC; JCI Ventures; Airbus Ventures; Lockheed Martin Ventures; Blackhorn Ventures	28	-	-	-
5-Dec-18	NIL Technology ApS	NGP Capital; Jolt Capital SAS	7	-	-	-
14-Nov-18	Alicona Imaging GmbH	Bruker Corporation	55	55	-	-
16-Oct-18	JSC VIST Group	ZYFRA Oy	30	-	-	-
16-Oct-18	Lakesight Technologies Holding	TKH Group NV	162	162	3.1x	-
10-Jul-18	Prodomax Automation Ltd.	Jenoptik AG	106	106	2.1x	-
11-Jun-18	PTC, Inc. (8.38% Stake)	Rockwell Automation, Inc.	1,000	12,275	10.5x	96.2x

Sources: Capital IQ and Factset

GLOBAL M&A PARTNERS

Transaction Comparables

Date	Target	Buyers	Deal Value (USD mn)	Implied EV (USD mn)	EV/Revenue (x)	EV/EBITDA (x)
11-Jun-18	AIM Systems, Inc.	Ace Equity Partners LLC	101	101	2.7x	12.9x
10-Apr-18	Analogic Corporation	Altaris Capital Partners, LLC	948	948	1.9x	-
29-Mar-18	Fast Corporation	Tokyo Electron Device Limited	19	-	-	-
21-Feb-18	MotionDSP, Inc.	Cubic Corporation	10	10	-	-
20-Dec-17	GroundProbe Pty Ltd	Orica Limited	157	157	-	-
1-Nov-17	Mini-Cam Enterprises Limited	Halma Plc	118	118	8.0x	17.0x
27-Oct-17	VIT SAS	Mycronic AB	9	9	-	-
20-Oct-17	AgEagle Aerial Systems, Inc.	EnerJex Resources, Inc.	20	20	53.6x	-
30-Aug-17	Microscan Systems, Inc.	Omron Corporation	157	157	-	-
9-Aug-17	Optofidelity Oy	Changyuan Group Ltd.	41	-	-	-
1-Aug-17	AvenAo Industrie	Prodways Group	14	14	1.2x	
11-Jul-17	Keytroller, LLC	ID Systems Inc	12	12	1.8x	10.0x
3-Jul-17	Cepton Technologies, Inc.	Undisclosed bidder	8	-	-	-
26-Jun-17	Naver Labs Europe	NAVER Corporation	23	23	-	-
19-Jun-17	PEGRight Inc	ProofID Limited	5	5	-	-
9-Jun-17	AIM Systems, Inc. (78% Stake)	Kamur Partners Private Equity	52	68	2.5x	11.9x
25-May-17	ABAX AS	Investcorp	213	213	3.6x	25.2x
17-Apr-17	MOCON, Inc.	AMETEK, Inc.	168	168	2.7x	19.0x
5-Apr-17	ViDi Systems S.A.	Cognex Corporation	23	23	-	-
6-Mar-17	Advanced Vision Technology	Danaher Corporation	103	102	1.8x	17.4x
3-Oct-16	findbox GmbH (94.62% Stake)	SES-imagotag	12	-	-	-
18-Jul-16	Medtech Societe Anonyme	Zimmer Biomet Holdings, Inc.	121	121	-	-
21-Jun-16	Dematic Group	KION Group AG	3,250	3,250	1.8x	-
15-Apr-16	Parkeon S.A.S. (90% Stake)	Astorg Partners	468	-	-	-
14-Jan-16	Mikrotron GmbH	Ambienta Sgr SpA	10	10	1.0x	5.0x
Average					**8.5x**	**34.6x**
Median					**2.7x**	**12.9x**

Sources: Capital IQ and Factset

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