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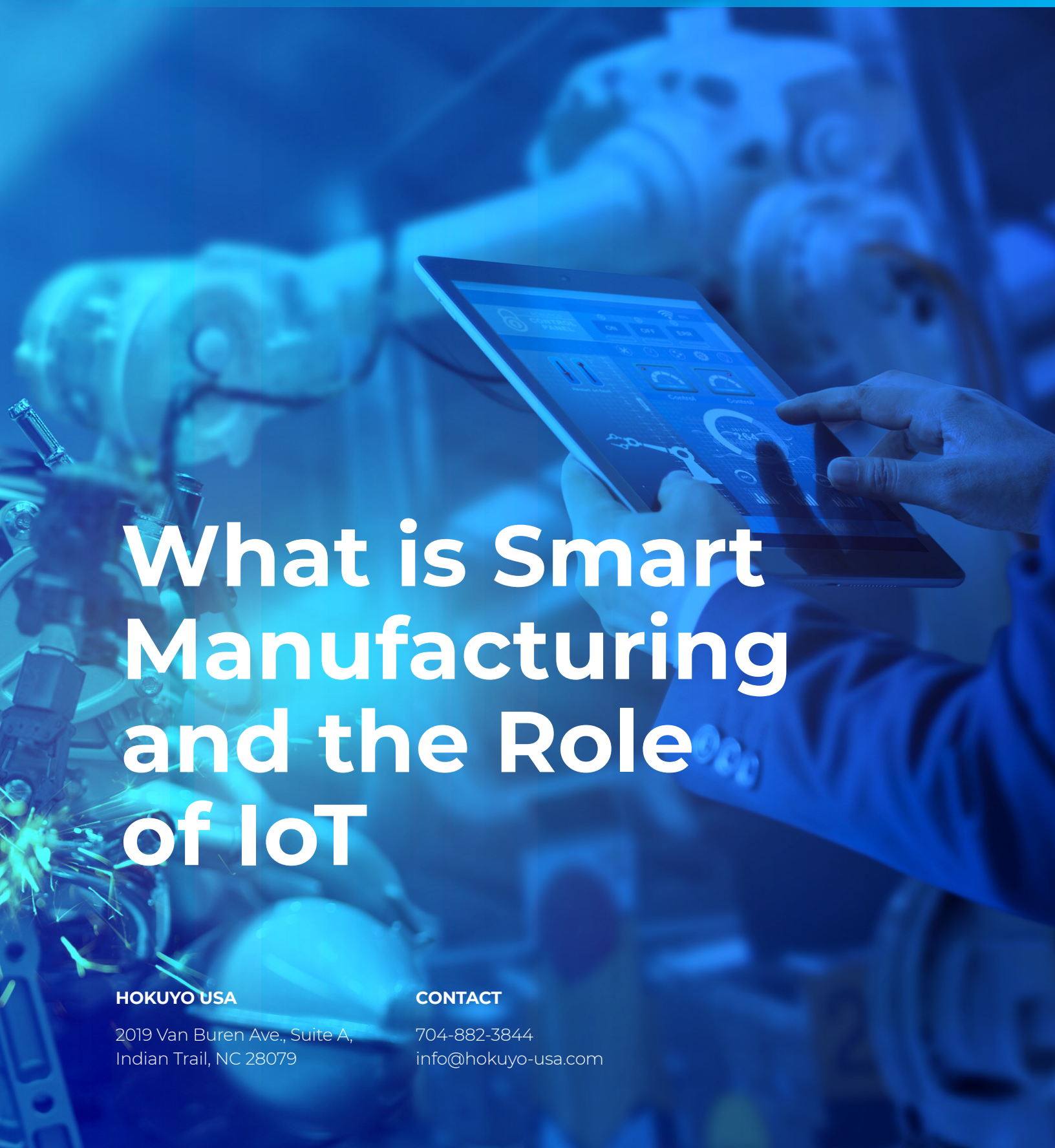

What is Smart Manufacturing and the Role of IoT

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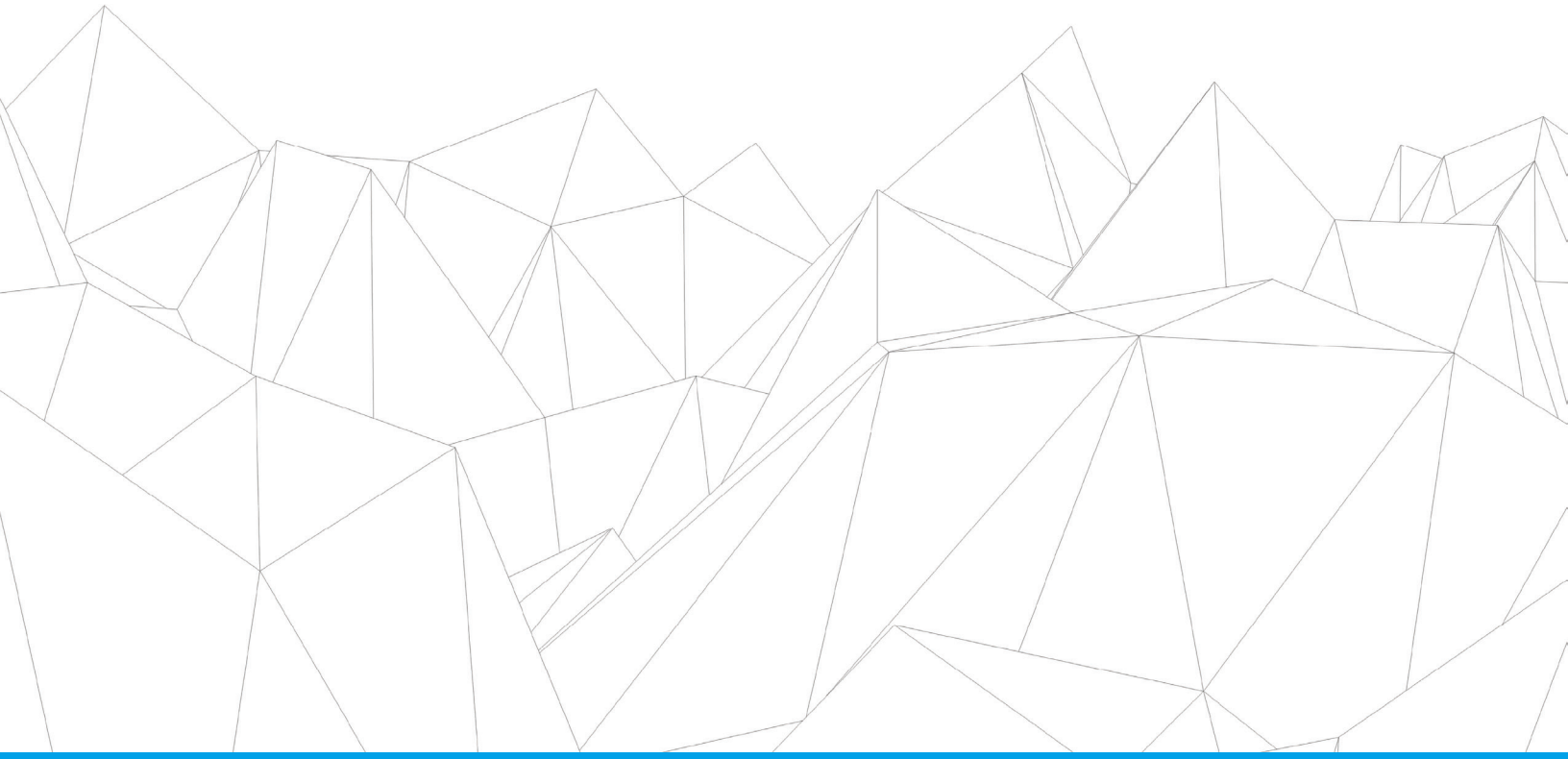

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Introduction

The Industrial Revolution brought significant changes in technology and the global economy. It was characterized by the development of new manufacturing techniques and equipment, the expansion of factories, and the emergence of new markets and transportation networks.

Our world has witnessed four industrial revolutions. The invention of steam power and mechanization triggered the first industrial revolution. Electrification brought the second, and digitalization led to the third.

The technology that creates a greater shift, like an industrial revolution, is called general purpose technology, or GPT. Steam power, electricity, and computerization are the three GPTs of the previous three industrial revolutions. The current industrial revolution—the fourth industrial revolution, or Industry 4.0 — is caused by combining all of the GPTs of the past three revolutions and a wide range of innovative technologies.

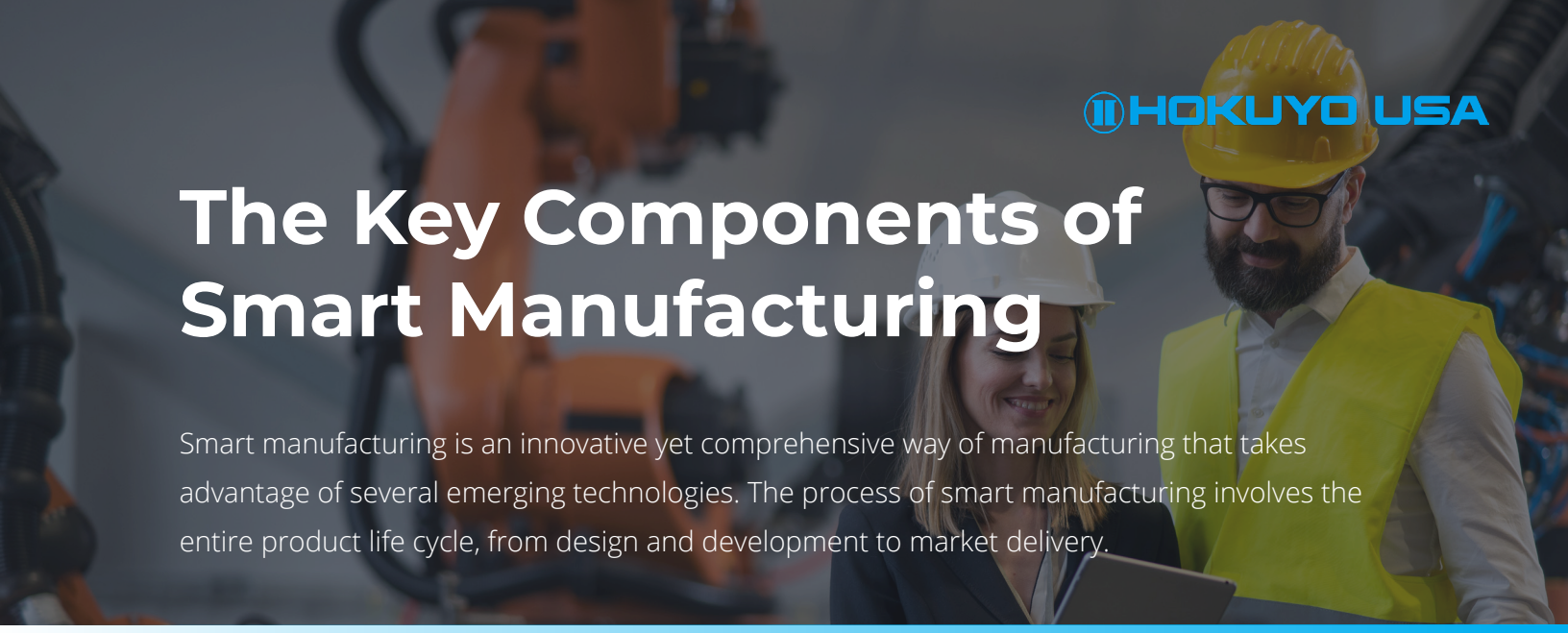
Data analytics, the Internet of Things (IoT), cloud computing, artificial intelligence (AI), machine learning (ML), and robotics are a few of these innovative technologies capable of automating and optimizing industrial production processes.

Industry 4.0 connects the digital world, driven by information technology (IT), and the physical world, which is driven by operations technology (OT). This connection makes it easier to transform the supply chain from a linear, sequential chain to a digital supply network, a connected, open system for running the supply chain. Industry 4.0 is also setting the stage for how manufacturers will compete in the future.

In fact, with rising investments in additive manufacturing and digital technologies like AI, ML, Cloud, IoT, and 5G, the Industry 4.0 market is poised for substantial growth over the coming years. It is estimated that this market will reach **USD 165.5 billion by 2026**, growing at an impressive CAGR of 20.6%.

There are many terms used to address this shift, including **"Industry 4.0," "smart manufacturing," "the factory of the future," and "society 5.0"**. However, they all primarily refer to the integration of advanced technologies and automation into manufacturing processes to create more efficient, productive, and flexible systems.

This white paper describes the key components and benefits of smart manufacturing, along with the role of IoT in smart manufacturing. The paper also provides an overview of the technical, organizational, and cultural challenges and barriers to using IoT in smart manufacturing.



The Key Components of Smart Manufacturing

Smart manufacturing is an innovative yet comprehensive way of manufacturing that takes advantage of several emerging technologies. The process of smart manufacturing involves the entire product life cycle, from design and development to market delivery.

Smart manufacturing aims to make factories more flexible, efficient, and eco-friendly so they can respond quickly to ever-changing market trends. It can also help manufacturers develop new ideas to grow their businesses. To do this, smart manufacturing utilizes several components to get deeper insights into the manufacturing process and increase the efficacy of the operations.

These components include the following:

Sensor technology and automation systems

Advanced sensors enable data collection from different segments of the manufacturing process. Sensors are built into factory equipment and products. They are also deployed in the work environment to measure several metrics such as pressure, temperature, humidity, and motion in real time. All these sensors send the data to a central system, which analyzes patterns, trends, and anomalies.

Some of the essential automation systems in smart manufacturing are robotic arms, collaborative robots (cobots), automated guided vehicles (AGVs), autonomous mobile robots (AMRs), and automated storage and retrieval systems (AS/RS).

These automation systems make it possible to connect and coordinate different repetitive and mundane manufacturing tasks and can drastically reduce human intervention and errors. These systems further help in controlling and improving assembly lines, production lines, and quality control systems.

Combining automation and robotics technologies lead to intelligent manufacturing systems that can adapt to the production environment and market conditions, delivering optimized performance with minimal human supervision.

Cloud computing and data analytics

Cloud computing and data analytics make it possible to collect, analyze, and store large volumes of data collected by integrated devices like sensors in a smart manufacturing environment.

Cloud computing lets manufacturers store and process data on remote servers instead of on their own computers or servers. This makes it easier for manufacturers to expand their data storage and processing abilities as their needs change. The powerful processing capability of the cloud enables manufacturers to analyze large data sets without investing in expensive computing resources.

By leveraging data analytics, manufacturing businesses can identify patterns, trends, and insights to help them make better business decisions. In smart manufacturing, data analytics is used to analyze data from sources like sensors to optimize manufacturing processes, improve product quality, and cut costs.

Artificial intelligence and machine learning

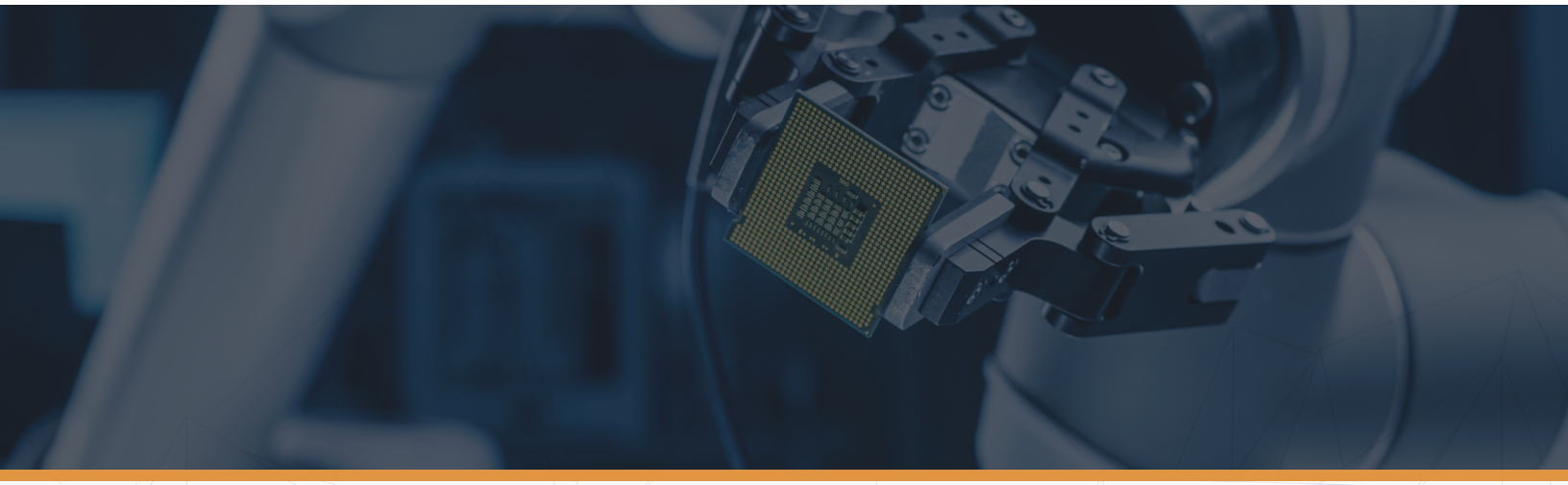
AI and ML allow businesses to automate complex tasks and analyze large data sets to derive insights and improve manufacturing processes. AI and ML are used in smart manufacturing for various purposes. Some of them include predictive maintenance, quality control, supply chain optimization, and predictive analytics.

Robotics and digital twins

Robotics and digital twins enable manufacturers to automate and optimize production through simulation and visualization.

Robotic systems, in particular, are deployed in a manufacturing environment to automate repetitive tasks. For instance, robots are efficient for tasks such as material handling, assembly, and packaging. They are also useful for the inspection of the manufacturing process and the quality control of products.

A digital twin is a virtual copy of a tangible product or process created with real time data from sensors and other sources. For instance, in smart manufacturing, digital twins are used for testing and improving the layout and configuration of production lines or to simulate how a product or process will work in different situations.



Benefits of Smart Manufacturing

Smart manufacturing is a flexible system that can improve performance across a broader network, adapt to new conditions, learn from them, and run the entire production process independently. This autonomous manufacturing system comes with several benefits.
Some of these include:

Enhanced efficiency and productivity

The key benefit of smart manufacturing is improved efficiency and productivity, which is possible through automation, predictive maintenance, real time monitoring, and predictive analytics.

While automation reduces the need for manual tasks and ensures the speedy and accurate execution of manufacturing processes, predictive maintenance prevents unforeseen downtime and sustains the efficient functioning of machines. Besides, with real time monitoring, manufacturers can closely watch their production processes and react quickly to changes.

In fact, a Deloitte survey shows that predictive maintenance can **increase productivity by 25%, reduce breakdowns by 70%, and lower the cost of maintenance by 25%.**

Enhanced supply chain management is another benefit of implementing smart manufacturing. Using simulation tools, manufacturers can simulate ideal production output versus warehouse throughput to determine the resources needed to boost warehouse efficiency and enable faster order fulfillment times.

In addition to faster shipments, data-driven smart manufacturing also allows manufacturers to test different warehouse scenarios and optimize their inventory according to demand fluctuations.

Improved quality and safety

Smart manufacturing improves both the product's quality and the workplace's safety.

Sensor technology and advanced analytical tools like machine learning algorithms, statistical process control (SPC), and data visualization tools allow businesses to monitor the production processes actively. These technologies help manufacturers identify issues with product quality and defects early on, so there will be fewer defects and reduced wastage.

By leveraging data analytics, manufacturers can further look at their production data and find trends and patterns to optimize their production methods and the quality of their products over time.

Another crucial advantage with smart manufacturing is predictive maintenance which helps in keeping operations safer in a production environment, limiting the chances of accidents or injuries caused by machinery failures.

According to the Bureau of Labor Statistics, 5,000 fatal and 2.8 million nonfatal workplace injuries occurred in 2019. However, research carried out using a sampling of 80,000 workers in "high-hazard" industries revealed that implementing 1.34 robots for every 1000 workers can reduce 12 fewer injuries.

Robotics can further help create a safer working environment by preventing humans from working in hazardous environments. Cobots are another category of robots that can do the heavy lifting for human workers and lower the risk of injuries.

Lower operation costs and waste

With smart manufacturing, manufacturing businesses can also lower their operating costs and minimize wastage. Using advanced sensor technology and analytics, manufacturers can perform real time monitoring and analysis of production processes. It enables them to identify inefficiencies and bottlenecks immediately, preventing expensive equipment repairs and breakdowns that could impact the production efficiency.

More agility and flexibility

Sensor technology implemented in a smart manufacturing unit offers a wealth of production data that manufacturers can leverage to check machine performance, identify errors, and avoid unforeseen disruptions. Since these insights allow effective optimization of production processes and efficient resource allocation, businesses can achieve greater agility.

Additive manufacturing and digital twins are two other smart manufacturing technologies that can help enhance flexibility through customization and personalization. Through these technologies, manufacturers can develop and test new product designs quickly and more efficiently. They can also expand their range of products and offer customization to fit the needs of an individual customer.

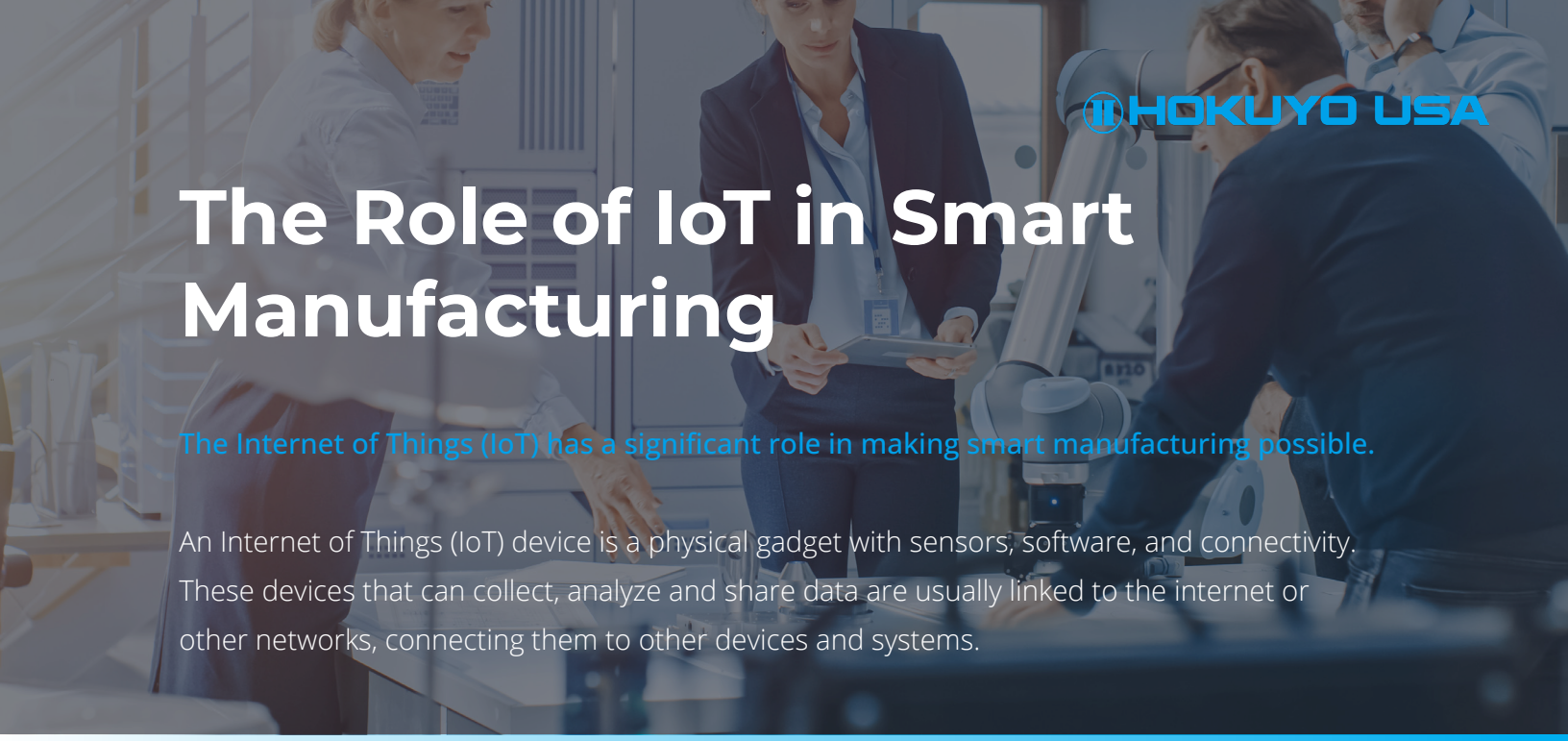
In addition to these digital technologies, IoT devices and cloud-based systems further enable remote monitoring and control. That means manufacturers can monitor and control their facilities, machines, and processes from anywhere in the world. This approach helps them respond quickly to changes in market demands or unexpected disruptions. It can also reduce the need for onsite staff.

Boosted customer satisfaction and loyalty

Smart manufacturing can boost customer satisfaction and loyalty in several ways. When a manufacturing facility is driven by real time data, it can quickly identify and fix product quality issues. Such an approach reduces the number of defective products and gives out products of high quality.

With optimized production processes and efficient supply chain management, businesses can also get their products to customers faster. In addition, transparency and traceability in the smart manufacturing and delivery process build customer trust and loyalty.

By leveraging digital technologies such as faster networks, advanced cloud platforms, and AI-powered chatbots, manufacturers can offer enhanced customer service in terms of efficient order handling or managing customer queries. This results in faster delivery of products and a quicker response to customer inquiries and the resolution of issues.



The Role of IoT in Smart Manufacturing

The Internet of Things (IoT) has a significant role in making smart manufacturing possible.

An Internet of Things (IoT) device is a physical gadget with sensors, software, and connectivity. These devices that can collect, analyze and share data are usually linked to the internet or other networks, connecting them to other devices and systems.

The data collected by IoT devices are used to learn about different processes and operations, primarily related to businesses and industrial units. This helps companies and people make better and more informed decisions. IoT devices range from simple devices like temperature sensors and smart switches to complicated machines like self-driving cars and factory equipment.

The Internet of Things has a massive and growing effect on production or manufacturing businesses. This technology is transforming business operations and is helping make smart factories. As a result, IoT plays an inevitable role in making Industry 4.0 work.

The rapid growth of the global IoT market also backs up this research. It is expected that the global IoT market will grow from $300.3 billion in 2021 to **$650.5 billion in 2026**, with a CAGR of 16.7%.

IoT solutions are at the heart of the digital transformation of almost every industry. All these led to the creation of a subset of IoT technology called the Industrial Internet of Things (IIoT).

The Industrial Internet of Things is an interconnected network of interconnected machines, tools, vehicles, warehouses, and stock. These interconnected industrial assets have built-in

software and sensors to collect and share data. As a result, manufacturers can use a single IoT platform to control and gain insights from these smart assets.

With the increasing availability of affordable processors and sensors capable of collecting real time data, the IIoT market is seeing a rapid growth in the past few years. Estimates suggest that this market which was valued at USD 321.81 billion in 2022 will continue to expand at a CAGR of 23.2% from 2023 to 2030.

Following are some of the ways IoT devices improve, optimize, and automate manufacturing units.

Real-time data collection and analysis

IoT devices that collect and analyze data in real time are a crucial component of smart manufacturing, as they help manufacturers monitor and control production processes efficiently.

These devices have sensors that can monitor various performance metrics such as temperature, pressure, motion, and the machine's condition. For example, if a sensor detects that a production parameter isn't being achieved, the system automatically adjusts the process to get it back on track.

Enhanced communication and interactive collaboration

One of the fundamental requisites of smart manufacturing is enhanced communication and interactive collaboration. The interconnection of IoT devices and systems creates a continuous flow of information throughout the manufacturing process, giving way to real time collaboration and efficient decision-making.

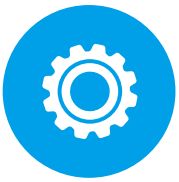
IoT devices also bring clarity to human-machine communication. Workers, for instance, can use mobile devices to monitor machines' conditions, control

operations, and get alerts when any trouble arises. This clear-cut human-machine communication boosts worker productivity and reduces the risk of errors or accidents.

Predictive maintenance and optimization

IoT devices embedded with sensors and advanced analytical tools make predictive maintenance and optimization in smart manufacturing possible. The real time data and alerts from IoT devices allow manufacturers to predict the likelihood of machine failures and take precautions to avert downtime and costly repairs.

It can also improve the equipment's performance, extend lifespan, and optimize production processes.

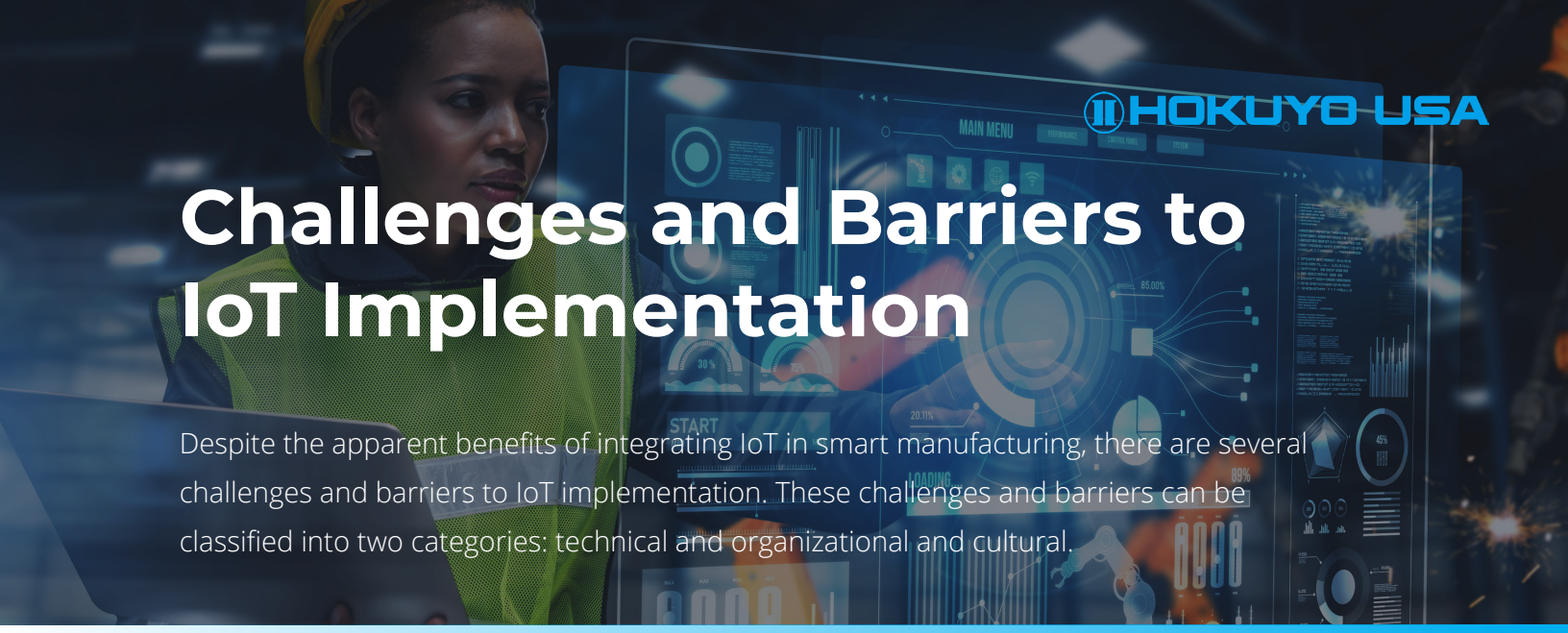


Seamless integration and interoperability

For a flexible and agile production environment, businesses must ensure easy communication and data exchange among IoT devices and systems. They must also ensure that all devices and systems adhere to the common standards and protocols to achieve seamless integration and interoperability.

These standards and protocols are associated with data exchange, communication, and security. Adoption of these standards and protocols lets IoT devices and systems communicate with one another regardless of their source or location.

Seamless integration and interoperability of IoT devices help companies capitalize on new technologies and innovations quickly. For instance, businesses can improve the accuracy and clarity of their data by integrating new sensors or devices into their existing systems and empowering themselves to make better, informed decisions.



Challenges and Barriers to IoT Implementation

Despite the apparent benefits of integrating IoT in smart manufacturing, there are several challenges and barriers to IoT implementation. These challenges and barriers can be classified into two categories: technical and organizational and cultural.

Technical challenges

Technical challenges are the issues or difficulties that arise during the design, development, testing, or operation of a technical system, product, or service. These challenges involve hardware or software components, system integration, data management, or user interface (UI) design issues.

In smart manufacturing, these challenges include data security and privacy, interoperability and standardization, scalability and complexity, legacy systems, and infrastructure.

Data security and privacy

There would be a greater number of connected devices in a smart manufacturing unit, making it difficult to secure the network and devices from unauthorized access and cyber threats. These cyber threats include malware, phishing attacks, ransomware, and others. As a result, data security and privacy have become one of the most critical technical challenges to implementing IoT in smart manufacturing.

A 2022 research revealed that with the rise in IoT connectivity in manufacturing environments, cyberattacks on IP-rich data available in the

cloud and edge servers will double by 2026.
In addition to cyber risks, manufacturers must also protect the sensitive data generated by these IoT devices. At the same time, they should abide by data privacy regulations such as the General Data Protection Regulation (GDPR).

Businesses can overcome these challenges by implementing robust security measures to protect their IoT devices, networks, and sensitive data. These preventive measures include encryption, multi-factor authentication, and intrusion detection systems.

Moreover, developing and implementing policies and procedures for data handling and storage would also help.

Interoperability and standardization

If multiple IoT devices and platforms lack standardization, integrating and managing these devices in the smart manufacturing environment turns into a challenging task. Greater complexity, higher costs, and poor efficiency follow suit.

Manufacturers must ensure interoperability and seamless communication among IoT devices and platforms. Adopting common standards and protocols, such as MQ Telemetry Transport (MQTT), OPC Unified Architecture (OPC UA), and others, help effective data exchange and communication among these devices.

Businesses must also work closely with IoT vendors to ensure their IoT devices and platforms are compatible with existing systems and infrastructure.

Scalability and complexity

Manufacturing is a highly dynamic industry, as most factories have a large number of machines and IoT devices that generate massive amounts of data. As a result, scaling IoT systems to handle large volumes of data while retaining their reliability and performance is a challenging task.

IoT devices and other machines in the manufacturing industry come in different shapes and sizes. Their capabilities and levels of connectivity also differ. So, it is a great challenge to manage a large number of heterogeneous devices and incorporate them into an integrated industrial ecosystem.

Smart manufacturing involves a complex layer of cutting-edge technologies, IT systems, and infrastructure. Sensors, cloud platforms, data storage, and analytics are only a few of them. Managing these technologies while ensuring their seamless interoperability is a challenging task.

Companies can overcome these challenges through meticulous planning, design, and implementation of IoT devices and systems that can handle large volumes of data and manage the complexity of the manufacturing environment.

Legacy systems and infrastructure

Many factories and manufacturing units still use outdated equipment and infrastructure, also called legacy equipment and infrastructure. These legacy systems may not be compatible with modern IoT technologies, and integrating them would be a challenging job.

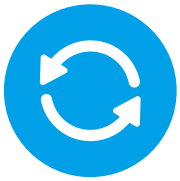
Upgrading legacy systems is expensive and time-consuming. Moreover, legacy systems lack the necessary security features to protect against cyber threats, and upgrading their security can be a crucial challenge. One of the ways manufacturers can tackle this problem is through smart

sensors and video cameras that can readily integrate with legacy systems and can offer communication through legacy protocols.

In addition to these devices, edge gateways can act as a central hub where analog data can be converted into digital. A cloud service connecting these gateways will enable manufacturers to utilize data for reporting and analysis.

Organizational and cultural challenges

Implementing IoT solutions in a smart manufacturing environment also comes with several organizational and cultural challenges. These typically include resistance to change, a talent-skills gap, a lack of leadership and vision, and regulatory and legal constraints.



Resistance to change

Employees may hesitate to adopt new technologies and processes if they have been working with legacy equipment and systems for years. Resistance to change brings delays in IoT implementation, lower employee morale, and poor productivity.

Talent-skills gap

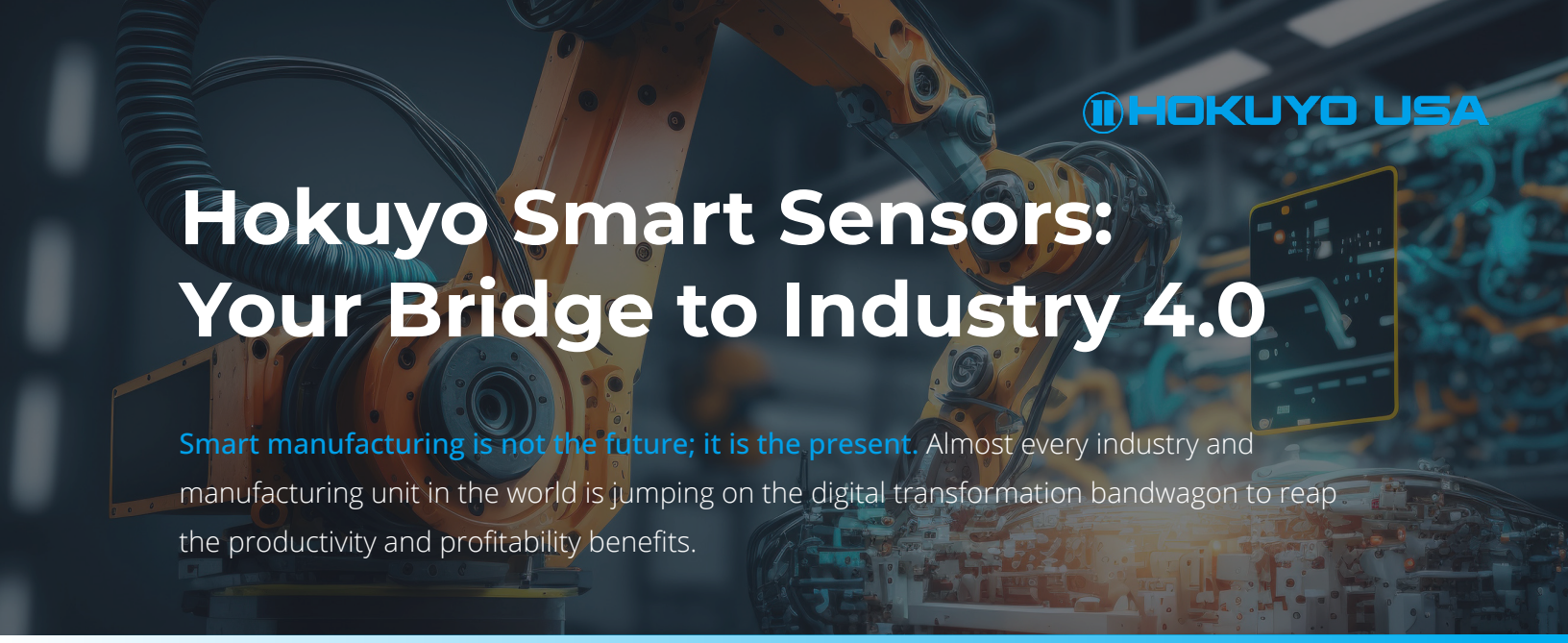
IoT implementation requires knowledge and skills in areas like data analytics, cybersecurity, and software development. Many businesses lack the necessary skills and talent sets to implement IoT solutions effectively. This situation can lead to a talent-skills gap, extra costs, and delays.

Lack of leadership and vision

Without solid leadership and vision, it is challenging to develop an IoT strategy that fits the organization's goals and objectives. The result would be the implementation of inefficient IoT systems.

Regulatory and legal constraints

Many countries have different data privacy, cybersecurity, and intellectual property regulations. This worldwide difference in laws and regulations creates legal barriers to implementing IoT solutions. On top of that, failure to comply with these regulations can result in legal complications and damage your reputation.



Hokuyo Smart Sensors: Your Bridge to Industry 4.0

Smart manufacturing is not the future; it is the present. Almost every industry and manufacturing unit in the world is jumping on the digital transformation bandwagon to reap the productivity and profitability benefits.

If your business stands still without making good decisions and taking appropriate actions, it will miss out on the opportunities offered by Industry 4.0. While the challenges and barriers are around the corner when embracing Industry 4.0, installing cutting-edge sensor technology can make a significant difference in industrial automation.

Hokuyo offers a wide range of industrial sensor products. Whether you are looking for factory automation, logistics automation, or process automation, Hokuyo has solutions at hand. We support original equipment manufacturers (OEMs), end-users, integrators, research and development (R&D) organizations, and resellers in manufacturing, autonomous robotics, and the metals industry, to name a few.

Our products include collision-avoidance sensors, laser rangefinders (LIDAR), safety lasers, and obstacle detection scanners. We also offer optical data transmission devices suitable for a range of industrial applications.

At Hokuyo, we combine reliable technology, extensive product distribution, and unbeatable service and support to meet the needs of our customers across different industry verticals.

Get in touch with us to learn more about how we can help you achieve smart manufacturing goals through our range of sensor products.

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