YOKOGAWA

Co-innovating tomorrow™

A Guide to Smart Manufacturing in the Process Industries

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A Guide to Smart Manufacturing in the Process Industries

Executive Summary

Process industry manufacturers are under constant pressure to enhance profitability, improve capital efficiency, and achieve sustainability in a business environment characterized by high volatility, uncertainty, complexity, and ambiguity.

As a continuous and sustainable path toward growth and improvement, enterprises, partnerships, and government agencies are leveraging the latest developments in digital technology, including new concepts such as smart manufacturing, Industry 4.0, and industrial internet of things (IIoT), in a process that requires collaboration among manufacturers, partners, and organizations.

Many advanced digital technologies such as artificial intelligence (AI), autonomous robots, cloud computing, intelligent sensor technology, and augmented reality (AR) have become practical in terms of cost and value. The question is how to best take advantage of these technologies in an era of rapid technological change and massive competition. The goals of adopting these new technologies include total optimization of efficiencies, flexibility and agility, safety, and other operational improvements.

Yokogawa, as a global provider of digital technology and solutions, has extensive experience in implementing digital transformation for process industry manufacturers. These implementations include the entire value chain optimization for supply chain, operations, maintenance, and production, with the ultimate objective being industrial autonomy.

This white paper explains how Yokogawa implements efficient and smart plant operations. We have a proven record of implementing solutions for process industry manufacturers to help them meet smart manufacturing goals, resulting in performance improvements and the creation of new business opportunities.

1. Background

The fast development and wide adoption of digital technologies are increasingly contributing to the efficiency and competitiveness of manufacturing industries. While digitalization is still relatively new for many manufacturers, it has become a strategic imperative that underpins the survival of many organizations. All businesses must embrace digitalization to be able to respond to rapidly changing market conditions and become part of a sustainable society.

For example, the camera film market has shrunk significantly since the introduction of digital cameras, thereby eliminating late adopters. Certain mainstream IT manufacturers have emerged as winners in the hypercompetitive world of PC manufacturing as a result of their supply chain reforms and implementation of one-to-one internet marketing. Thus, manufacturers must take note. The speed at which disruption is occurring means that manufacturers must continually transform their businesses and increase their competitiveness by applying digital technology and improving data utilization. Waiting to undertake this type of transformation is not wise.

Markets and industries must change the way they see themselves and operate (Figure 1). Maintaining the status quo is not an option. Survival in a continuously changing world requires the adoption of digitalization on a scale that enables enhanced flexibility and agility that transcend the levels possible with conventional organizational silos. Implementation of vertical and horizontal integration and other means of collaboration are important enablers of these efforts.

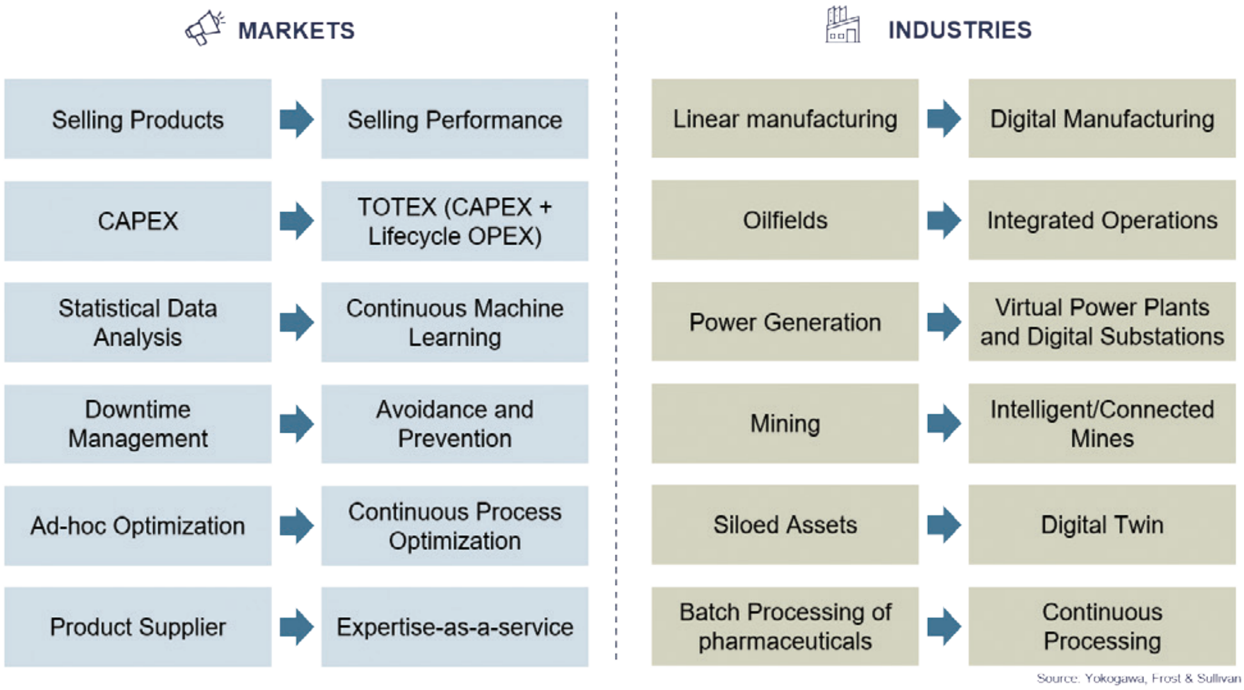

Figure 1:
Disruptive markets and industry changes

We define Digital Transformation (DX) as: the novel use of digital technology to accelerate a company's business strategy. It is about the application of digital technologies to empower people, optimize processes & automate systems of the organization to radically reorient its business performance. It is, however, important to consider issues such as leadership, new competences, and change management to ensure a successful DX journey.

The DX journey creates value by integrating data and business processes and by connecting workplace personnel and management (Figure 2).

PROCESS INDUSTRIES DX MATURITY MODEL

TARGETED OUTCOMES	RISK MINIMIZATION VULNERABLE	STABLE & REPEATABLE OPERATIONS OPERABLE	INDUSTRY LEADING EFFICIENCY OPTIMAL	SUSTAINABLE & AUTONOMOUS SUSTAINABLE
Business Strategy & Processes	**Ad-hoc or absent**	**Siloed initiatives and visions**	**Integrated common vision**	**Active ecosystem integration**
People & Culture	Disengaged and losing vital knowledge	Active knowledge transfer	Culture of learning & development	Leaders are digital innovators
IT / OT Collaboration	Siloed	Tolerant	Collaborating	Engaged & integrated
State of Data	Islands of information	Integrated plant data	Enterprise data lake	Value chain integration
State of Technology	Legacy	Current	Advanced	Innovative

Figure 2:
DX maturity model for process industries

2. Industrial Automation to Industrial Autonomy (IA2IA)

The process industries have benefited significantly from industrial automation. By leveraging its knowledge of process industries, Yokogawa has already helped to make many of these applications automated and unmanned. The process industries will advance further toward industrial autonomy by focusing on areas of innovation such as predictive maintenance, smart energy consumption, routing flexibility, remote monitoring and control, human-robot collaboration, digital performance management, real-time supply-chain optimization, advanced process control, digital quality management, and data-driven demand prediction. Yokogawa defines industrial autonomy as state in which plant assets and operations have learning and adaptive capabilities that enable responses with minimal human interaction, empowering operators to perform higher-level optimization tasks. Digital technologies sit at the core of realizing self-optimizing manufacturing processes and industrial autonomy.

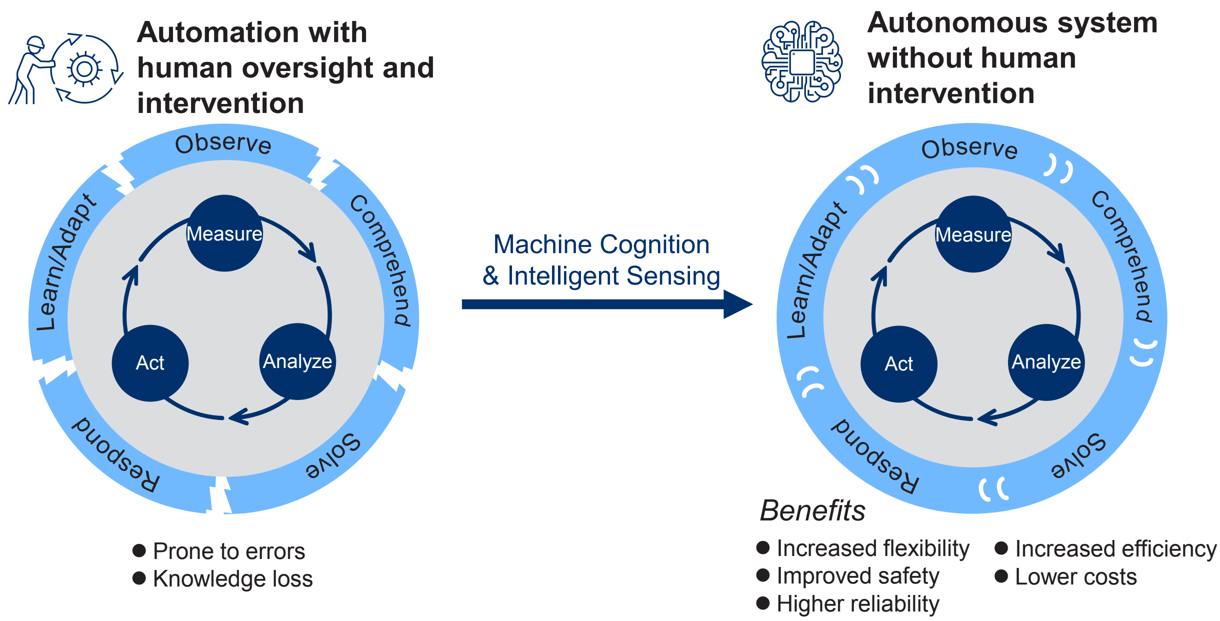

Figure 3:
Industrial autonomy enhances industrial automation

Industrial autonomy is different from industrial automation in many ways. Industrial automation involves performing a sequence of highly structured pre-programmed tasks, each of which require human oversight and intervention in case something goes wrong (Figure 3). In addition, between their pre-programmed tasks, humans must perform other ad hoc tasks and are ultimately responsible for the safe and profitable completion of entire procedures. Examples of procedures requiring significant human oversight and intervention include startups, shutdowns, grade changes, quality control adjustments, and managing of abnormal conditions.

Industrial autonomy transcends industrial automation by adding layers of intelligent sensing and artificial intelligence (AI) to anticipate and adapt to both known and unforeseen circumstances. This removes the need for constant human intervention. In a fully autonomous operation, the industrial autonomous system is responsible for all aspects of operation, from start up to shut down.

Within a plant, any process or operation can potentially be made autonomous. This includes manipulating and controlling the process, as well as performing other activities such as manufacturing operating procedures, planning and scheduling, supply chain activities, margin optimization, and compliance measures. It is also possible to make the operation of devices, equipment, units, and business systems—or ideally entire plants—autonomous, so each is self-aware and able to understand and adapt to the context in which it operates (Figure 4).

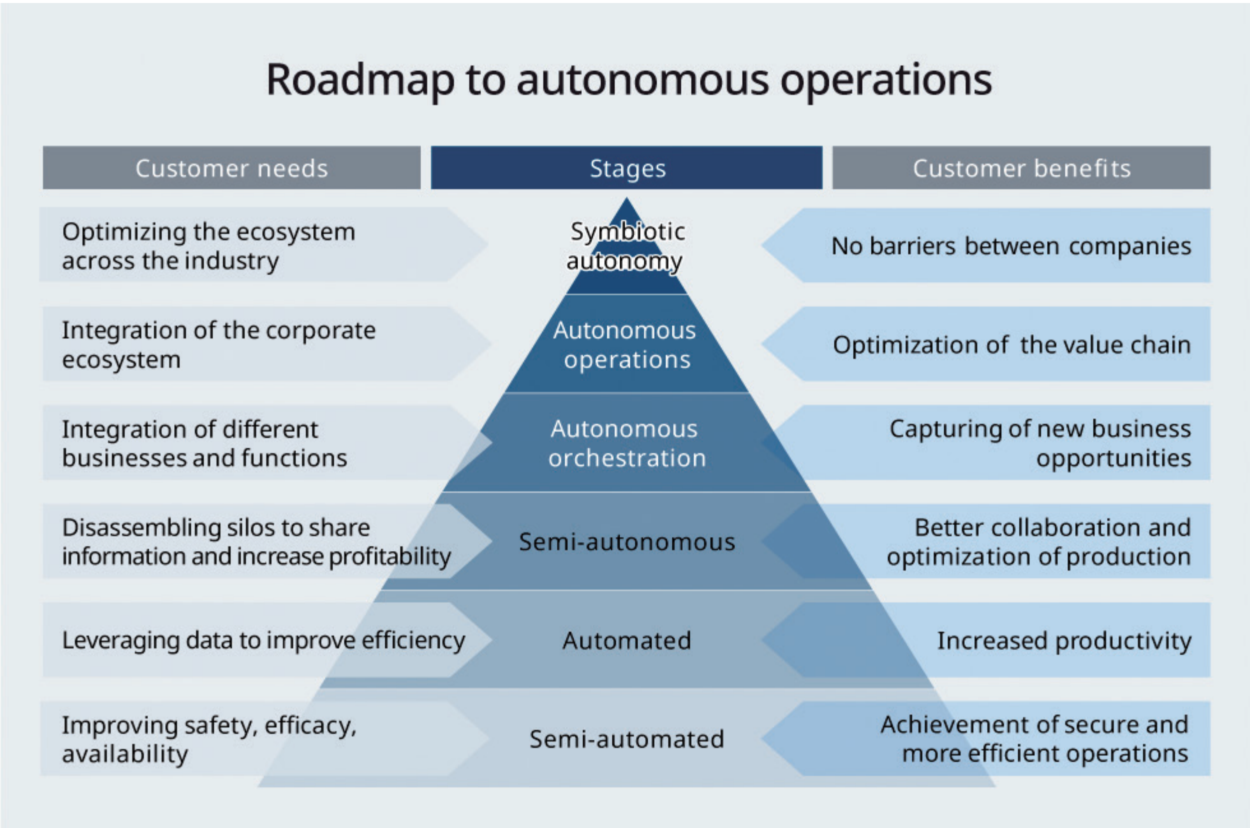

Figure 4:
Industrial autonomy maturity levels

The most forward-looking companies are beginning to think about autonomous operations, and some are achieving unattended remote operations. Many of the steps necessary to achieve remote operations are also needed to achieve autonomy.

For field operations, this means moving from an absence of autonomy, where all tasks are performed by humans, to mid-level autonomy, where the system identifies tasks and guides operators on what to do and provides instruction on how to accomplish each task. Further along the autonomy journey, manual tasks must be converted to fully automated tasks, with human action only required as an exception. Fully autonomous operations require no human interaction. At this level, robotics plays a key role by conducting routine operator rounds and collecting samples and by performing monitoring, inspection, and surveillance. Robots will thus perform all necessary field operations and maintenance tasks.

Process industry manufacturers will need to implement industrial autonomy sooner rather than later to improve productivity, flexibility, and profitability. Industrial autonomy will also reduce human errors, remove people from hazardous environments, and help compensate for the loss of experienced workers due to the “great crew change.”

In certain industries, completely autonomous plants are unlikely in the near future. However, it is reasonable to expect that certain functions will be autonomous based on the application, needs, and cost/benefit ratio. In these cases, human intervention and decision-making will continue to be important as plant personal learn to work alongside autonomous systems.

Yokogawa helps process industry manufacturers connect vital components of their value chains to achieve more efficient and smarter manufacturing in their journey toward industrial autonomy.

3. Smart Manufacturing for Process Industries

Smart Manufacturing is defined by ISO and IEC as follows:

*Manufacturing that improves its performance aspects(*1) with integrated and intelligent use of processes and resources in cyber, physical and human spheres to create and deliver products and services, which also collaborates with other domains(*2) within enterprises' value chains.*

(*1) *Note 1: Performance aspects include agility, efficiency, safety, security, sustainability, or any other performance indicator identified by the enterprise.*

(*2) *Note 2: In addition to manufacturing, other enterprise domains can include engineering, logistics, marketing, procurement, sales, or any other domain identified by the enterprise.*

Smart manufacturing involves the DX of manufacturing operations and is applicable to the process industry. Yokogawa provides end-to-end solutions covering the entire value chain of the supply chain from feedstock sourcing to product delivery, as well as the asset lifecycle of facilities and processes from planning, design, construction, commissioning, and startup to production/manufacturing and maintenance. By integrating best-in-class domain knowledge with more than 100 years of industry expertise and production automation solutions, Yokogawa has a proven track record of optimizing the asset lifecycle, production, and the complete supply chain (Figure 5).

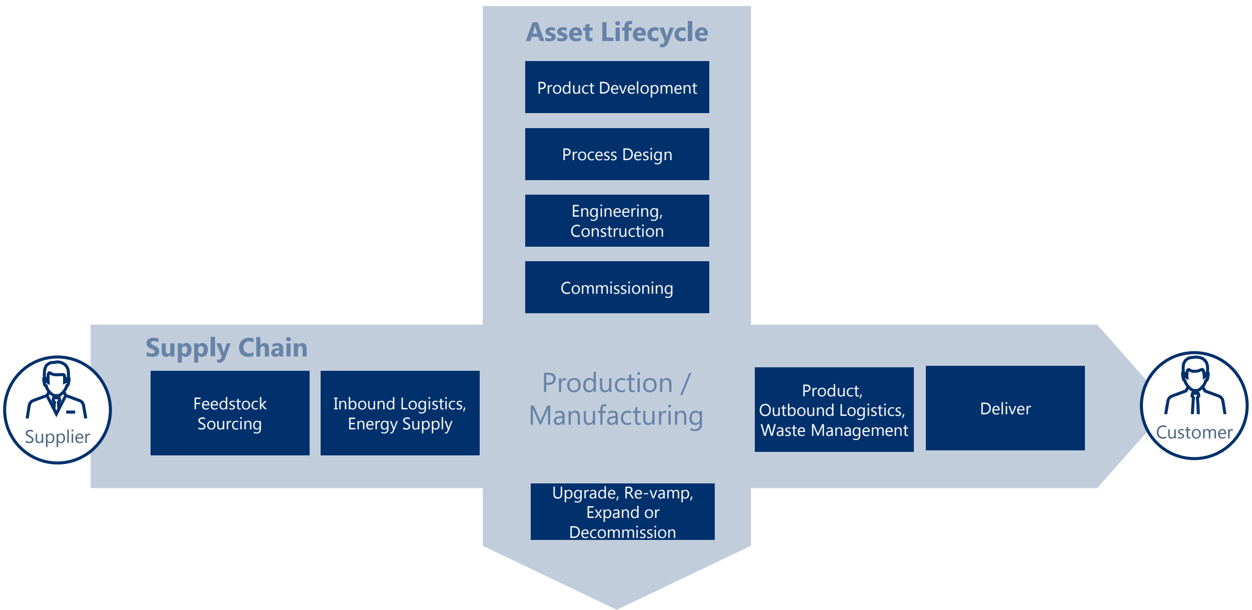

Figure 5:
Yokogawa provides end-to-end solutions covering the entire value chain

The scope of smart manufacturing is broad and involves a journey. Connectivity beyond plants and enterprises at the IIoT and cloud levels provides seamless integration of data, including supply chain information, leading to smart manufacturing (Figure 6).

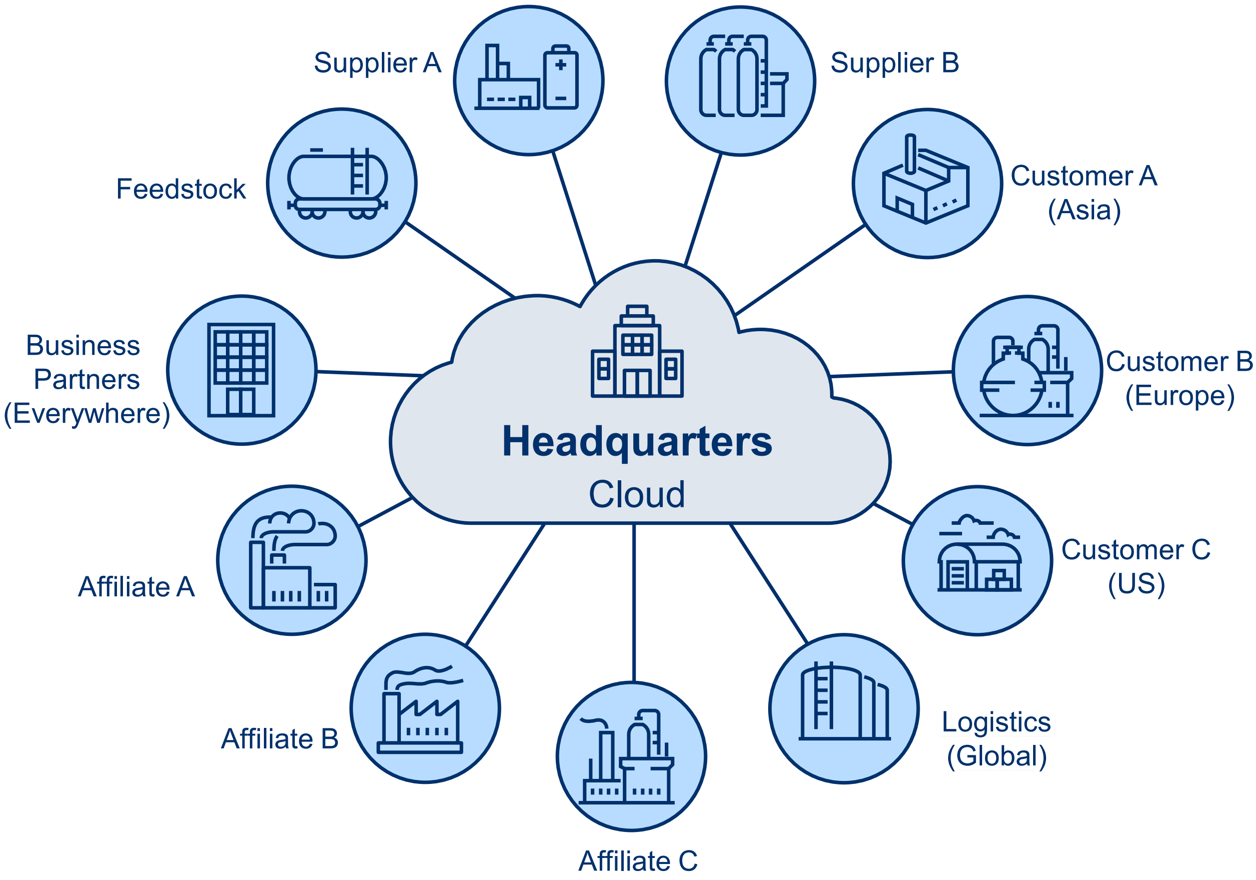

Figure 6:
Connectivity beyond plants and enterprises at the cloud and IIoT levels

To implement smart manufacturing, it is necessary to not only introduce new technologies as they become available but also prioritize the adoption of each solution based on a coherent vision of the future, along with analyses of the status quo and problems and their expected outcomes. Yokogawa works with process industry manufacturers using various methodologies to implement smart manufacturing initiatives according to the individual business environment of each process industry manufacturer.

Yokogawa believes that for many end users, autonomous operations is the destination to achieve their smart manufacturing goals.

4. Information Integration of the Entire Supply Chain and Plant Asset Lifecycle

4.1 Problems and Solutions for Information Integration to Implement Smart Manufacturing

Many diverse problems hinder the realization of smart manufacturing. For example, there may be difficulties with integration among systems because of cyber security requirements, organizational issues related to empowering employees, and inconsistencies in information, demand prediction accuracy, and other issues. From a broader perspective, there are many other issues that cannot be managed internally, such as drastic changes in economies and markets.

While there are many existing technologies for smart manufacturing implementations, no simple and general methodology has been established to dictate which technologies should be selected to enable smart manufacturing. Yokogawa supports process industry manufacturers on this journey by linking processes, technologies, and people to realize smart manufacturing.

Yokogawa believes that by integrating systems and data, predictive and quick actions along with adoption of the latest technologies such as digital twins will lead to smart manufacturing (Figure 7).

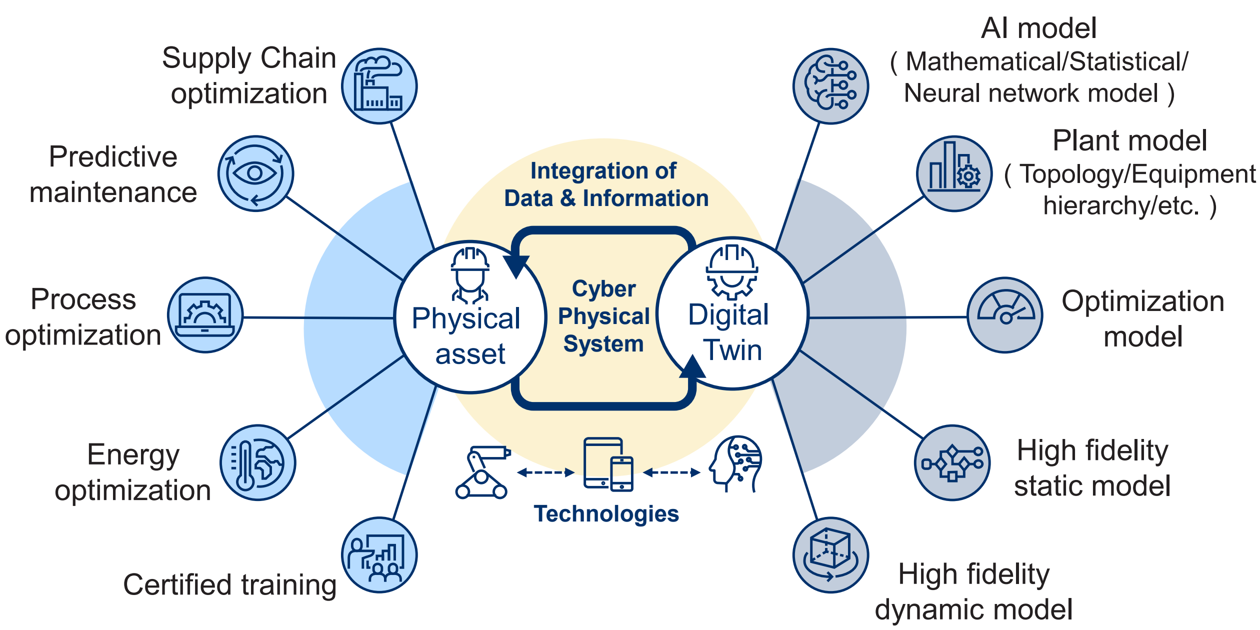

Figure 7:
Key Elements for Smart Manufacturing; Information Integration and Digital Twins allow organizations to benefit from the latest technologies

To transform data into information, organizations need to acquire accurate and reliable data and utilize it more quickly by turning it into usable and valuable information. This goal has been difficult to achieve with hierarchical systems, communications, and organizations. By establishing vertical and horizontal integration and analyzing information, the ability of process industry manufacturers to achieve these goals will be greatly increased.

4.2 Smart Manufacturing Requires the Safe and Seamless Integration of Systems through a Digital Transformation Platform

To realize smart manufacturing, Yokogawa provides solutions to measure and transform plant data into valuable information and intelligence, regardless of whether an organization stores their data on premises or in the cloud. To effectively use these solutions and applications, the seamless integration of systems is important. Connectivity beyond plants and enterprises at the IIoT and cloud levels enables the seamless integration of business, production, and supply chain data.

Traditionally, process manufacturing operations are built and engineered to include a wide variety of mission-critical equipment, control systems, and human machine interfaces. Most of these items incorporate software, and all require some form of system integration. Common items include distributed control systems, safety instrumented systems, tank gauging systems, programmable logic controllers, and other automation components. These components receive inputs from instruments, analyzers, and other fields devices. Software logic is applied to these inputs to drive outputs to valves, motors, and other equipment.

For capital projects, most design efforts are completed up front on a one-time basis, with little or no formal plan for changes over the entire process plant operation lifecycle.

To support long-term flexibility and continuous asset and technology updates, OT architectures are moving toward open, modular, and interoperable frameworks with strong cyber security—such as the Open Process Automation Forum (OPAF) framework.

One outcome of this will be the decoupling of the hardware used for control from the software performing the control functions. This will enable radically different automation system architectures to be created using a small number of commercial off-the-shelf IT hardware in addition to software building blocks, creating a new generation of state-of-the-art automation software.

This new approach will create a high degree of interoperability at the plant floor level, which will also be needed across a company's broader IT systems. Therefore, a comprehensive view of software architecture must be considered holistically across the enterprise.

A new hybrid architecture is needed to integrate OT with IT systems and develop future applications. Yokogawa refers to this architecture as a DX platform, which can also be used to connect with IIoT devices and cloud-based systems (Figure 8).

The Edge Systems in Figure 8 are considered to be an important starting point for the convergence between OT and IT. An ideal digital solution is realized by combining edge and cloud data hosted by an on-premise or cloud-based engineering and solutions applications.

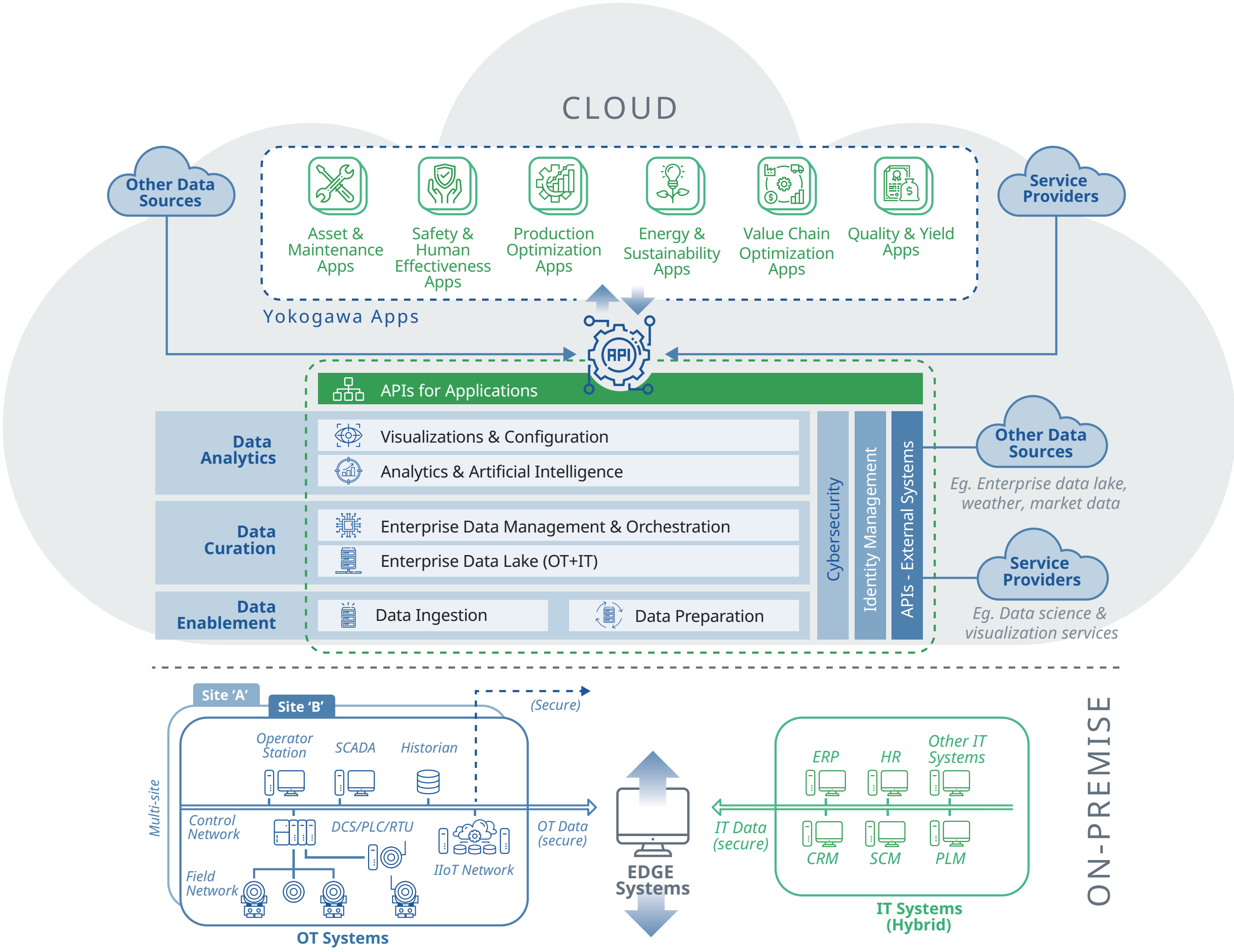

Figure 8:
DX platforms connect IIoT devices and cloud-based systems

This DX platform is used to create new opportunities, such as the following:

- Flexible and scalable connectivity. The traditional connectivity achieved through wiring and lots of software configuration make data availability expensive. DX requires data. DX is characterized as flexible, scalable, and affordable.
- Accessibility. The central deployment of data, information, and applications makes it easy for the user for gain secure access to the DX to obtain relevant information.
- Availability and sustainability. DX solutions have been proven to be reliable, and in conjunction with critical information that is still kept on premises, the solutions become sustainable.

DX enhances traditional manufacturing processes with new digital technologies to drive manufacturing forward and address inefficiencies. Yokogawa improves performance for process industry manufacturers by developing an architecture and applications to make full use of digital technologies such as AI, IIoT, and cloud-based applications. In addition, Yokogawa helps process industry manufacturers transform their performance through the process of DX, thereby leading to new opportunities for growth.

4.3 Future Direction of the Integration and Management of Plant Asset Information and Automation of Engineering

Project services provided by Yokogawa handle information from the equipment to the plant level. Plant asset designs can change daily based on feasibility studies of front-end engineering design, detailed design, operation, and decommissioning. In many cases, plant data are designed separately for each purpose, but these data should be maintained consistently throughout the asset lifecycle. Solutions for the mutual use of these data are progressing gradually, and these improvements should be accelerated.

Yokogawa expands the automation of engineering and the automatic diagnosis of assets. We integrate and manage disparate plant data and transform the data into information, knowledge, and intelligence for multipurpose use throughout the asset lifecycle. This is done by leveraging digital data, modeling technology, knowledge management, digital twins, and information integration.

5. Conclusion

Smart manufacturing requires organically linking process, equipment, technologies, and people to achieve stable, sustainable, and profitable operations, utilizing the latest technologies, integrated information systems, and applications such as digital twins as key elements. To realize this, it is necessary to create a future vision and understand the reality of plant floor operations.

Yokogawa co-innovates with process industry manufacturers to enable agile and adaptive management by bringing together an organization’s people, systems, data, services, assets, and supply chains—thereby completely optimizing operations and enabling the sustained creation of value. Our solutions, applications, and continuous innovation enable a more efficient and smarter plant operation, leading your business to sustained top-quartile performance. Come partner with us to realize the benefits of smart manufacturing.

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