Digital Platforms Connecting the Workplace and Management

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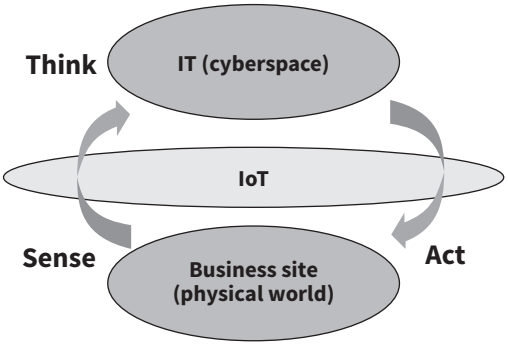
1. Introduction

Efforts to increase efficiency and to optimize business processes by utilizing digital technologies in manufacturing are taking place around the world, with examples such as Industrie 4.0 in Germany and the Industrial Internet Consortium in the USA[1]. Digital technology involves more than just converting analog systems to their digital equivalents. In the recent trend towards introducing the Internet of Things (IoT), digital technology often involves cyber-physical systems (CPS systems) that collect (sense) information from the real world and project it as data into cyberspace using the IoT, analyze the data in cyberspace (think), and feed the results back (using the IoT) to the real world (act) (see **Figure 1**). The process control systems of the 1970s can be considered the forerunners of CPS systems. However, today, the trend is towards utilizing the IoT to introduce CPS systems in various types of social infrastructure[2].

Figure 1 — Conceptual Diagram of CPS

Cyber-physical system (CPS) systems collect (sense) information from the real world and project it as data into cyberspace using the IoT, analyze the data in cyberspace (think), and feed the results back (using the IoT) to the real world (act).



IT: information technology IoT: Internet of Things

The manufacturing industry is looking at digital technology as a promising way, not only to drive business process efficiency gains and optimization, but also to create new value (such as mass customization) by connecting data throughout the value chain end-to-end. Hitachi, Ltd.'s core competencies span the areas of operational technology (OT), information technology (IT), production equipment and manufacturing sites. By drawing on its extensive portfolio of accumulated manufacturing knowledge, it aims to provide digital platforms that connect the value chain end-to-end.

This article presents some of the manufacturing solutions that Hitachi is working on to promote end-to-end value chain optimization and new value creation.

2. Changes in Manufacturing Using Digital Technology

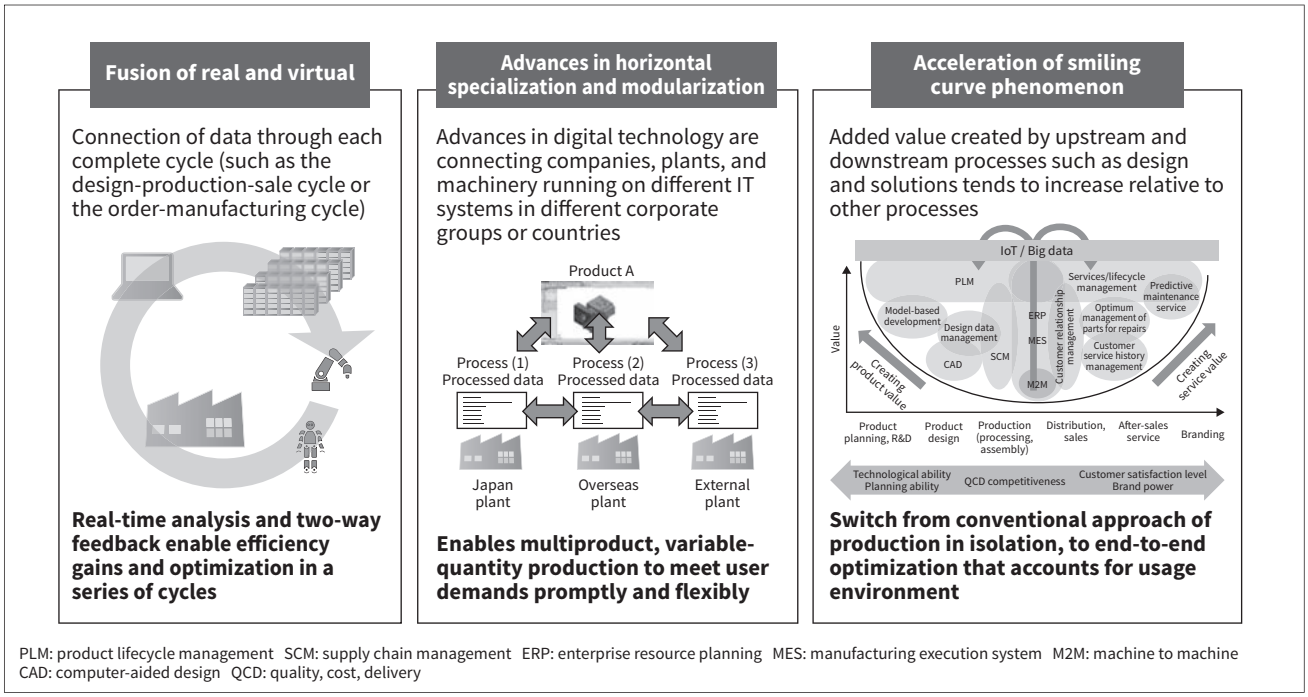
This section focuses on digital technology through examples of the IoT and digital engineering, and discusses the changes being brought about by digital technology in the manufacturing industry.

(1) Connecting business process data using the IoT

Efforts to introduce digital technology into manufacturing are on the rise in various places, mainly through efforts focused on the IoT. These efforts are designed to enable the connection of data among objects and business processes, enabling efficiency gains and optimization of processes and a series of cycles (see left panel of **Figure 2**). Examples include

Figure 2 — Changes in Manufacturing Using Digital Technology[6]

The diagrams below are visual representations of specific examples given in the Ministry of Economy, Trade and Industry's *Connected Industries* concept framework.



PLM: product lifecycle management SCM: supply chain management ERP: enterprise resource planning MES: manufacturing execution system M2M: machine to machine CAD: computer-aided design QCD: quality, cost, delivery

efforts to connect the workplace and management to increase production efficiency and to give management a clearer view of production statuses.

(2) Advances in digital engineering and modularization

Though currently not as high-profile as the IoT, computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE) are areas of digital engineering that are of great importance to manufacturing. Digital engineering has been in full-fledged use for design work since the 1990s, and improvements in computer processing power and human-machine system functions have made it an indispensable tool for design today.

Modularization, meanwhile, is a design/manufacturing method used to standardize the interfaces of core components and combining them to create finished products. While the field of consumer electronics, typified by PCs and the like, is well-known for the use of this method, the field of mobility products such as automobiles typically uses the integrated manufacturing method. This integrate manufacturing method is unable to produce finished products just by standardizing and combining component shapes and interfaces. It must also evaluate the dynamic characteristics and safety of the whole assembled product in various ways, which has made modularization extremely difficult for mobility products compared with consumer electronics[3].

But, thanks to advances in digital engineering, the various evaluations that were once difficult to perform, can now be performed precisely by using simulations, which have become useful for enabling modularization of even integrated products. Carmakers seeking to enable high-mix production by combining core modules began creating modularization strategies around 2010[4]. Modularization is also being used to standardize business processes as well as objects. One of the aims of Industrie 4.0 is to create international standards for business processes. Naturally, modularization is also accelerating the growth of industrial specialization and globalization (see center panel of **Figure 2**).

(3) Generating smiling curves and connecting value chains

As a result of the industrial specialization and global manufacturing that modularization has enabled in manufacturing, manufacturers in various manufacturing fields have been working to generate the same smiling curve-shaped value chains that the field of electronic devices has often enjoyed (see right panel

of **Figure 2**). The smiling curve is a graphical representation that shows how the added value created by upstream processes (such as product planning and design) and downstream processes (such as sales and after-sales service) tends to increase relative to other processes. The IoT has accelerated this tendency. For example, methods such as supply chain management (SCM) and product lifecycle management (PLM) can be used to closely connect data to improve the efficiency of each business process and optimize the chain end-to-end. In other words, digital technology can direct manufacturing toward systemwide optimization by connecting the value chain end-to-end, extending from the workplace to management, and from suppliers to users. Various benefits can be provided as a result. For example, customer needs and information learned from sales or after-sales service activities can be fed back to product planning and design processes more precisely and in a shorter period[5]. Mass customization is an extreme example of the potential benefits, and is thought to be feasible for various manufacturing fields.

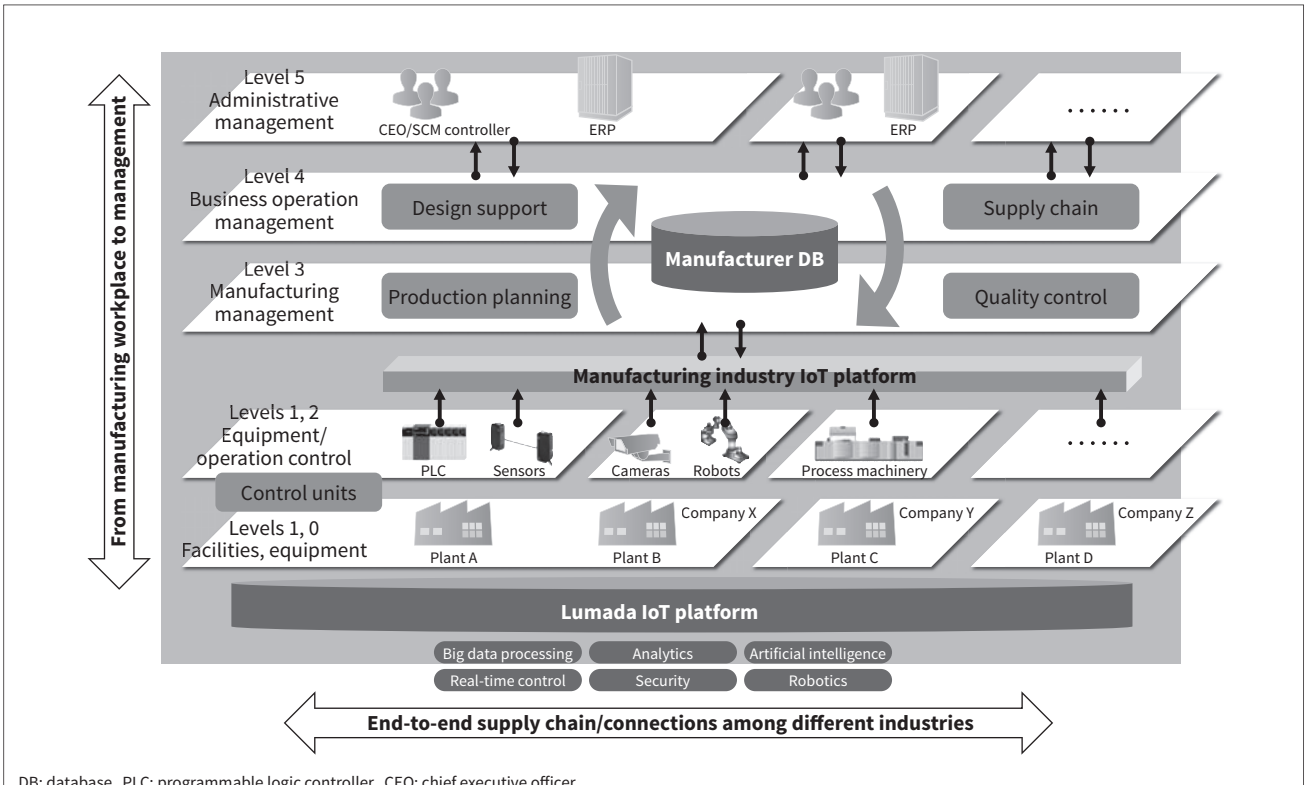
3. Hitachi's Efforts in the Manufacturing Fields

Hitachi aims to provide digital platforms that connect the value chain end-to-end, extending from the workplace to management, and from suppliers to users. This section focuses on the manufacturing solutions that form the core of these platforms by connecting the workplace and management (see **Figure 3**).

The following subsections present the business operation management layer, the manufacturing management layer, and OT-related technology at production sites. The business operation management layer consists of design support services that underpin global manufacturing. The manufacturing management layer consists of production planning simulations used to support high-mix low-volume production, and expert skills quantification technology used to transfer skills and stabilize quality. OT-related technology at production sites includes IoT-compatible industrial controllers and IoT platform solutions connecting

Figure 3 — Manufacturing Solutions Supporting End-to-End Value Chain Optimization

Solutions for the business operation management layer, manufacturing management layer, and equipment/operation control layer are organically connected to support the value chain.



DB: database PLC: programmable logic controller CEO: chief executive officer

OT and IT. These solutions connect to Hitachi's Lumada IoT platform to help increase manufacturing efficiency and to promote end-to-end value chain optimization.

3. 1
Design Support Services that Underpin Global Manufacturing

The growth in worldwide industrial specialization made possible by advances in modularization is creating a greater need for multiple offices to collaborate on design work and share design data. Hitachi provides an environment that can connect business processes among multiple offices through cloud-based management of design data and the design environment. The benefit of the environment it provides lies in its ability to help increase design work efficiency and quality, while training young designers. The environment's functions include operation management that supports the standardization of design processes and design rules, design expertise management associated with design documents, and unified management of the design environment and design tools (see **Figure 4**).

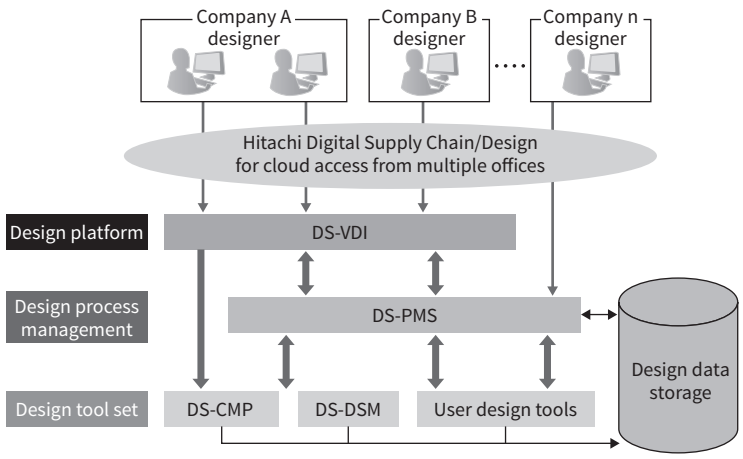
3. 2
Manufacturing Management Solutions

(1) Production planning simulations

Connecting the value chain increases the need for high-mix low-volume production to meet the demands of a wide range of users. High-mix low-volume production frequently entails a wide range of productivity-reducing factors such as demand fluctuations and repeated process changes. Therefore, it is important to be able to view 'man,' 'machine,' and 'material' (3M) information (relating to personnel, facilities, and resources, respectively) over the medium and long terms, and to quickly adapt production plans in response to any changes that may occur. To solve this challenge, Hitachi has developed a factory simulator that utilizes the IoT to connect 3M information and various other types of data visualizations at the production site, and automatically generates a production plan optimized for the entire site over the medium and long terms (see **Figure 5**).

(2) Digital encapsulation of manufacturing site expertise

As mentioned above, modularization is helping manufacturers generate smiling curve value chains. But, even now, some products still require expert skills to produce, making modularization difficult. These skills are like hidden technology assets, so protecting and transferring them is a crucial element of corporate strategy. To help manufacturers transfer expert skills and stabilize quality, Hitachi is using image analysis technology to develop tools for quantifying expert skills. Specifically, co-creation projects with customers have enabled Hitachi to create a tool for digitizing the brazing process used in manufacturing air conditioners, and a tool for digitizing chemical reaction process states in manufacturing processes for fluorine-based chemicals.



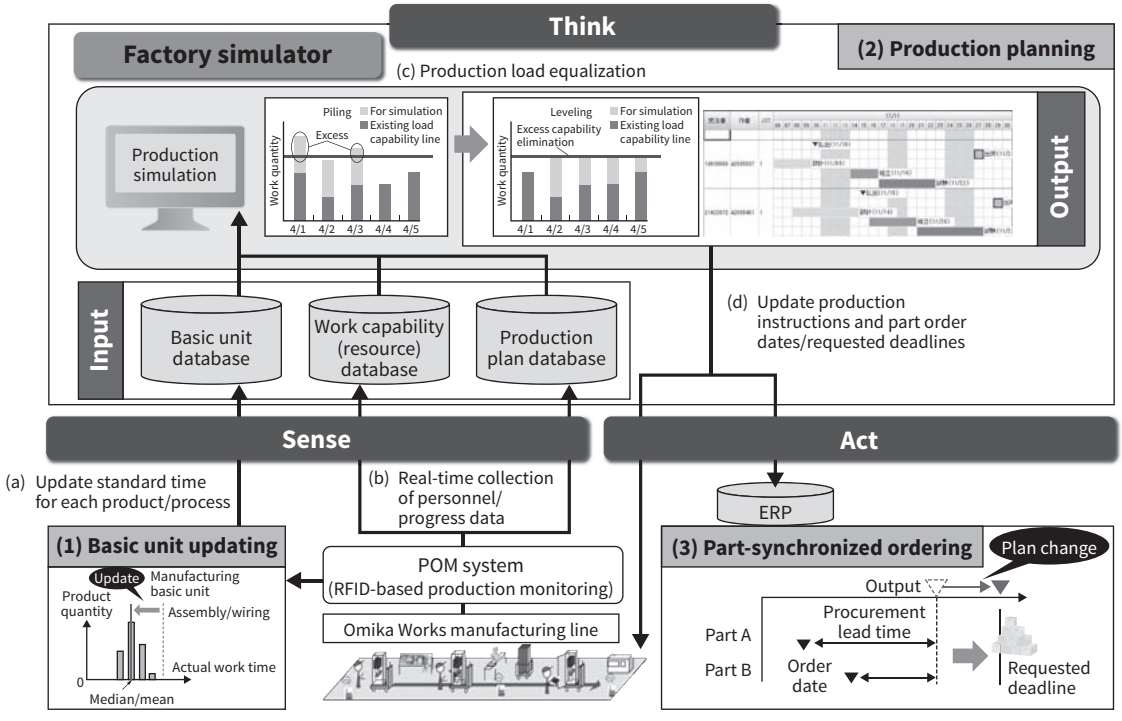
VDI: virtual desktop infrastructure PMS: process management system CMP: CAE modeling platform
DSM: design-development schedule management CAE: computer-aided engineering

Figure 4 — Design Support Services that Underpin Global Manufacturing

Services that provide cloud-based functions needed for design work spanning different companies or organizations consist of DS-VDI (the design platform), DS-PMS (used to manage design processes), and a design tool set.

Figure 5 — Factory Simulator Application Method

A circulation model of the sense (visualize data), think (analyze the data), and act (respond) cycles was created by connecting the factory simulator, POM system (RFID-based production monitoring), and the plant's ERP software. The model has helped optimize plantwide production planning and decrease inventories of resources such as parts.



POM: progress and operation monitoring RFID: radio frequency identification

3. 3
Solutions Connecting OT and IT

(1) IoT-compatible industrial controllers

Industrial controllers collect manufacturing site data and various other types of data needed to control equipment and machinery. While controllers have traditionally only been used for control applications, the rise of the IoT is creating expectations for other effective uses. IoT-compatible industrial controllers are controllers that can simultaneously perform control processes and data processes (collecting data and connecting it with higher-level IT systems). In addition to executing sequence control (control functions), these controllers can execute Internet protocol (IP) communication and data processes programmed in languages such as C or C+ without affecting the control operations (see **Figure 6**).

(2) IoT platform solutions for manufacturing industry

Implementing IoT applications on a large scale from the outset requires overcoming several hurdles such as cost-benefit challenges, etc. This solution is an on-premises type that uses the IoT to compile data from devices and systems at the manufacturing site. The compiled data is analyzed and represented visually. Open-source software (OSS) is used to connect data with higher-level IT systems, enabling the creation of a solution quickly and easily, and starting at a small scale. The solution also plays a role as a gateway function that connects the manufacturing site to Lumada.

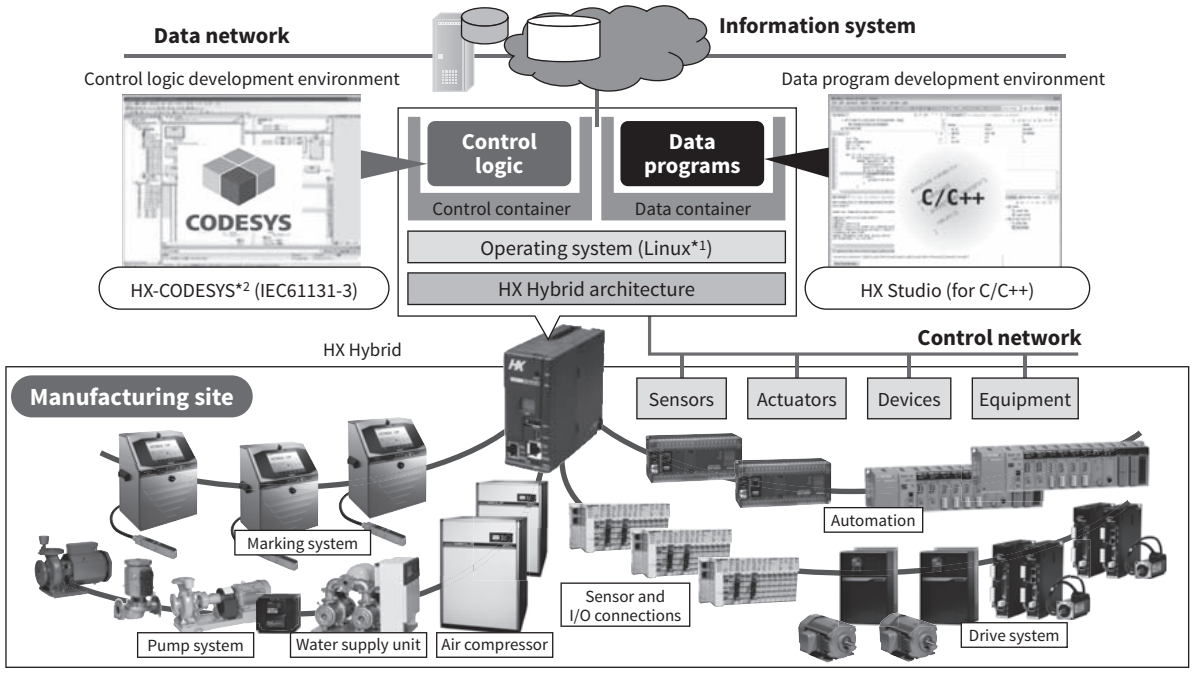
4. Conclusions

This article has looked at Hitachi's manufacturing solutions that connect the workplace and management.

These solutions also connect with Hitachi's Lumada IoT platform, helping to increase manufacturing efficiency and promote end-to-end value chain optimization. While Hitachi has an extensive track record in digital engineering for the manufacturing industry overall, its work with the IoT and artificial intelligence (AI) has yet to get fully underway. It is creating

Figure 6 — IoT-compatible Industrial Controller

The architecture of an IoT-compatible industrial controller is shown below. The controller is equipped with containers that enable independent execution of control operations and data processes.



I/O: input/output

*1 Linux® is the registered trademark of Linus Torvalds in the U.S. and other countries.

*2 CODESYS® is a registered trademark of 3S-Smart Software Solutions GmbH.

environments that enable the use of deep learning and various other types of AI as tools, but still needs to overcome several challenges such as gaining expertise in the acquisition and use of suitable learning data. Work on using image analysis technology to protect and pass on the skills of experts in the form of 'digitalized tacit knowledge' will be another key area.

Hitachi will continue to work toward advanced utilization of digital technology.

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