[i] World-leading Advanced Factory "Lighthouse"

Highly Efficient Production Solutions Linking Design and Operations for Manufacturing DX

Omika Works of Hitachi, Ltd. has used its "factory simulator" high-efficiency production solution to discover the needs of its assemble-to-order customers through collaborative creation while improving the features of solutions. At the same time, Omika Works has used its "assembly work navigation system" solution to create assembly work instructions for the mechanical ventilators necessary in the treatment of COVID-19 infection, and has provided them for free on the cloud. These solutions are based on the expertise Omika Works has accumulated while reforming production by utilizing IoT and have achieved a reduction in production lead times of 50% for its representative products[*1]. This article provides an outline focusing on these two efforts.

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1. Introduction

Hitachi, Ltd.'s Omika Works (city of Hitachi, Ibaraki prefecture) has been promoting digital transformation (DX) to achieve continuous on-site improvements and increases in productivity by utilizing Internet of Things (IoT) technology to connect design with the factory floor. Specifically, the factory constantly tracks the progress of each process utilizing approximately 80,000 radio frequency identification (RFID) tags, and formulates schedules with efficient allocations of personnel, parts, and other resources to improve productivity. The "factory simulator" is used for central control of these processes, resources, and deadlines, as well as to plan schedules. Omika Works also uses its "assembly work navigation system" to utilize three-dimensional computer-aided design (3D CAD) data created during the design process to automatically create 3D assembly work instructions for use on the manufacturing floor, which streamlines production preparation work. Rather than just using the factory simulator and assembly work navigation system internally, the factory is providing these technologies to customers as high-efficiency production solution products.

This article describes the factory simulator and assembly work navigation system that support the DX efforts of Omika Works, as well as the areas of improvement in functions that the factory has made while providing these technologies to customers and contributing to society. It also introduces the factory's implementation support services for these solutions along with efforts toward overall optimization, including global supply chains.

*1 Control devices for electric power as well as social and industrial process control, which make up approximately 20% of the products manufactured at Omika Works.

2. Function Improvements in the Factory Simulator Responding to Assemble-to-order Needs

Omika Works recently added functions to the factory simulator that can synchronize the scheduling of intermediate product manufacturing processes and final product assembly processes. This has made it possible to meet the needs of customers requesting assemble-to-order production. The "assemble-to-order" production mentioned here is a type of high-mix and low-quantity production that procures or manufactures parts and intermediate products necessary for the final product in advance, and then assembles them after an order is received. Until now, Omika Works has responded to a wide range of customer requests by designing and then manufacturing after receiving an order based on an order-design production method. For this reason, the factory simulator utilized inside the factory is a package specializing in the solution of problems in order-design production. This simulator was released as a Hitachi product that was adopted for use by multiple customers, including machine tool and plant equipment manufacturers. Since the number of customers mentioning a need for assemble-to-order production instead of order-design production has increased, Omika Works now supports assemble-to-order production.

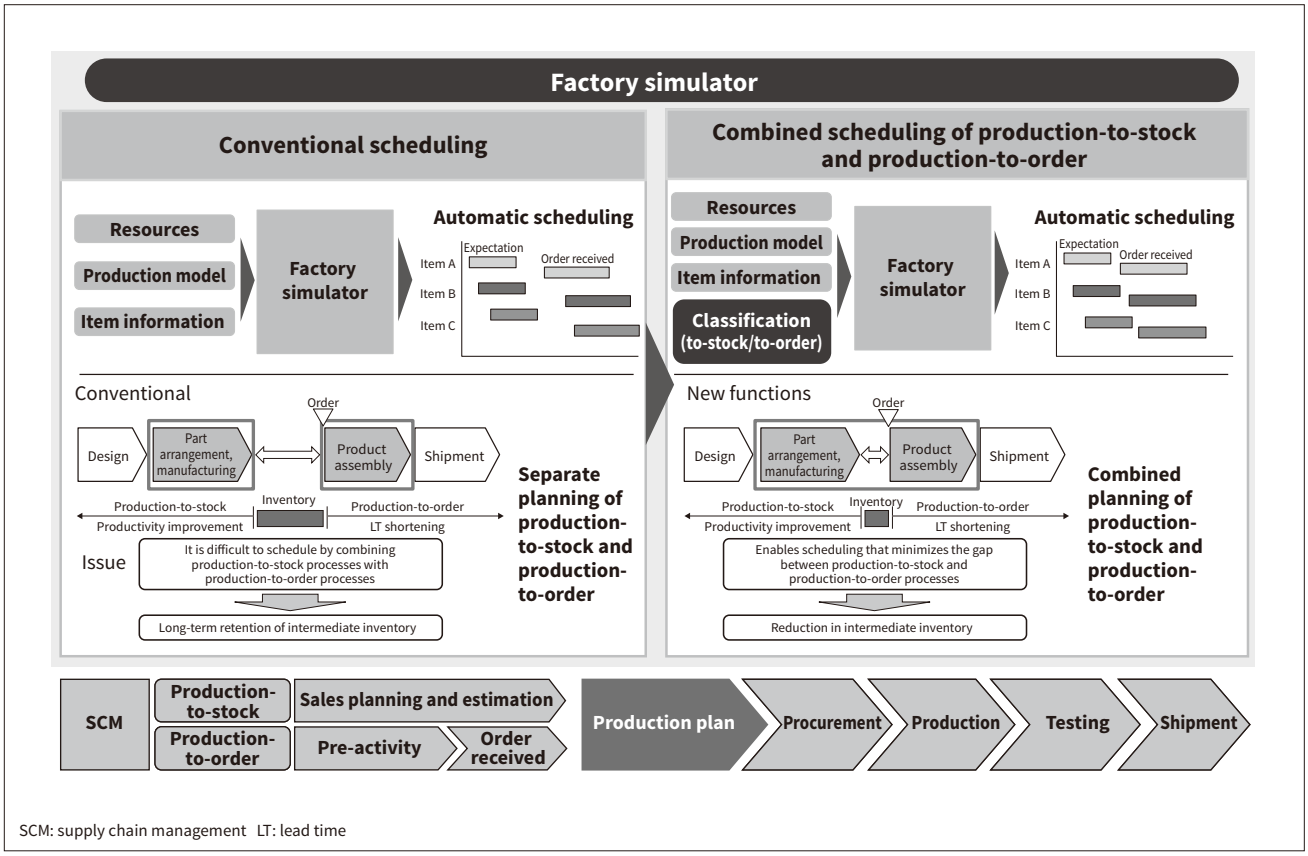
With assemble-to-order production, it is possible to quickly assemble final products for shipment once an order is received. On the other hand, in order to reduce the risk of holding intermediate inventory, it is necessary to coordinate the reservation schedules for intermediate and final products, and there is the risk of needing to maintain intermediate inventory over a long period of time. For this reason, one of the key goals of scheduling is to minimize as much as possible the period of time over which inventory must be held.

Due to these additional functions, not only is it possible to shorten the manufacturing lead time thanks to the advantages of assemble-to-order production, but scheduling can also reduce the risk of holding intermediate inventory (see **Figure 1**). Customers who have adopted the factory simulator can formulate schedules that conform to the actual conditions of the factory floor, while also reducing the need for schedule adjustment operations at the time of reservation.

Omika Works is also currently developing technology to enable scheduling optimization based on product demand, and is planning to provide this service as soon as possible.

Figure 1 — Scheduling to Reduce Intermediate Inventory Risk

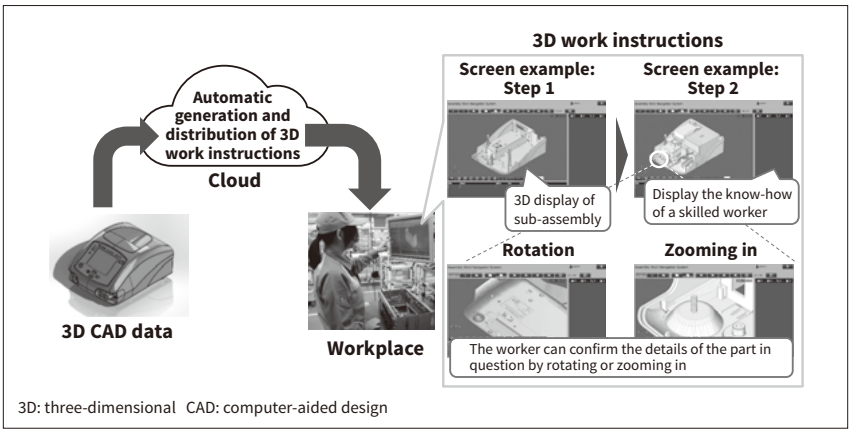
This solves the assemble-to-order production issue of reducing intermediate inventory while achieving a shortened manufacturing lead time.



SCM: supply chain management LT: lead time

Figure 2 — Mechanical Ventilator 3D Assembly Work Instructions Using Assembly Work Navigation System

By providing work instructions for assembling a mechanical ventilator that anyone could follow using a cloud service, Omika Works achieved manufacturing support for this urgently needed medical equipment.



3. Contributing to Society with the Assembly Work Navigation System and Migration to Cloud Service

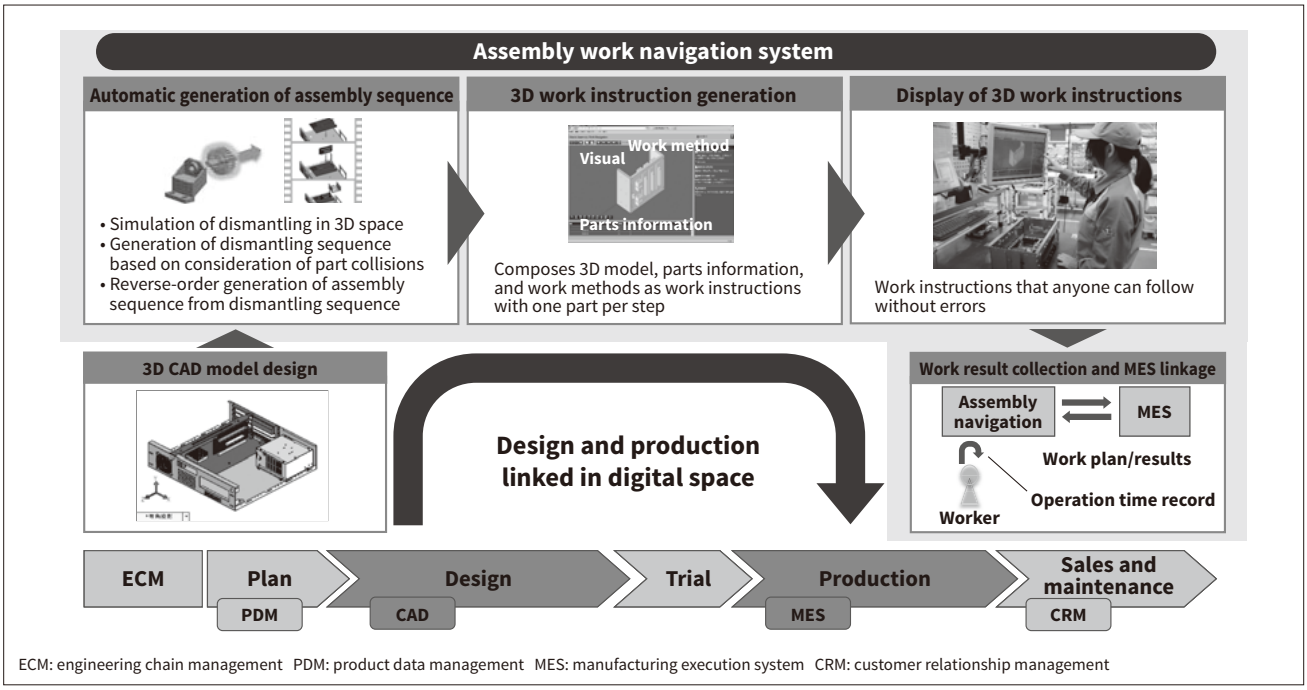
3. 1 Free Provision of Mechanical Ventilator 3D Assembly Work Instructions

In June 2020, with the goal of supporting the manufacture of mechanical ventilators indispensable for treating COVID-19 infection, Omika Works started providing 3D assembly work instructions created using its assembly work navigation system, free of charge, via a cloud service (see **Figure 2**). As COVID-19 infections expanded, the burden on the healthcare industry grew sharply along with the number of infected persons, and shortages in mechanical ventilators and other medical equipment also became urgent. By publishing these 3D assembly work instructions created with the system, Omika Works expected to be able to support corporations without experience in manufacturing mechanical ventilators.

Even when a worker without 3D CAD data-based experience uses the assembly work navigation system, they can still create 3D assembly work instructions that can be understood intuitively. In general, when a product is to be assembled, it is necessary to first consider assembly methods in advance in order to create assembly work instructions that the manufacturing workers can understand. Assembly methods can be considered by creating actual prototypes, or a specialist can use 3D CAD to consider implementable methods. Assembly work instructions use photographs taken of prototyping

Figure 3 — Assembly Work Navigation Automatically Generates Parts Assembly Sequences from 3D CAD

An automatic assembly sequence generation function reduces the workload required to create work instructions, and improves the efficiency and quality of work by displaying 3D work instructions that can be understood intuitively.



work from easy-to-view angles, add explanations of work methods, and summarize the flow of work in a booklet or other such document. The assembly work navigation system, on the other hand, automatically generates sequences for assembling executable parts from the 3D CAD data itself, producing assembly work instructions that display each part involved in the assembly work in 3D (see **Figure 3**).

3D assembly work instructions are provided via a cloud service in software as a service (SaaS) format so that they can be used independently of hardware, rather than in the previous on-premises format. This service can be used from any terminal that can view a Web browser. At Omika Works, the times when workers perform operations on the assembly work navigation system screen are recorded, and managers can analyze the recorded times and use this information to assist in improving operations on the factory floor. The factory also displays 3D assembly work instructions by part to stabilize manufacturing quality and prevent variations depending on the worker.

3. 2
Migration of Assembly Work Navigation System to Cloud Service

Migration to cloud services in a shorter period than ever before was mandatory due to the rapid spread of COVID-19. To this end, product specifications that were designed to be used on-premises had to be made compatible with system scaling that could support the security and increase in users inherent in publishing over the Internet, without necessitating any major changes. In order to achieve this, Omika Works designed a network configuration over a public cloud, and moved forward with the automation of environmental construction and deployment (see **Figure 4**).

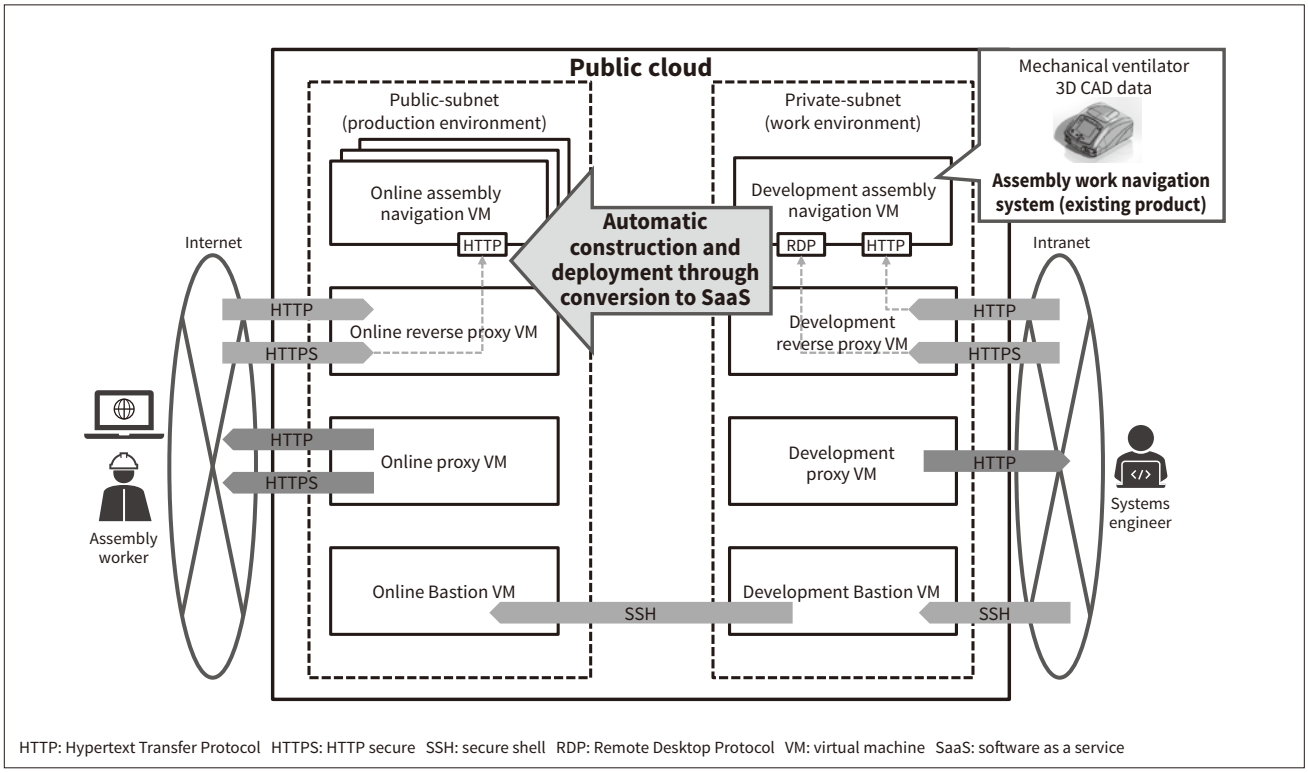
The factory split the network configurations in the public cloud into a network (work environment) for system engineers to work under and a network for users (production environment) to access over the Internet. It also set up a gateway for centralized control of external access to ensure security, and implemented features such as load sharing. Furthermore, the factory automated deployment from the work environment to the production environment by combining the open-source software (OSS) provisioning tool Ansible[*2] with Terraform and other tools. This simplifies scaling of the system when the number of users increases.

As a result of these efforts, Omika Works was able to migrate to a cloud service within a short timeframe of approximately six weeks from project launch to completion, without changing the server configuration or operations as currently configured. The factory will apply this network configuration philosophy, automatic construction, and automatic deployment mechanisms to other projects in addition to the mechanical ventilator project.

*2 Ansible is a registered trademark or trademark of Red Hat, Inc. in the United States and other countries.

Figure 4 — Network Configuration of Assembly Work Navigation on Public Cloud

Omika Works prepared an environment in advance that enabled automatic deployment from an on-premises system configuration to a cloud production environment, thereby achieving migration to cloud services in a short period of time.



HTTP: Hypertext Transfer Protocol HTTPS: HTTP secure SSH: secure shell RDP: Remote Desktop Protocol VM: virtual machine SaaS: software as a service

4. Providing Support Services for Solution Adoption

The effectiveness of adopting the two production innovation solutions described above can be improved by establishing concrete adoption goals and usage scenarios in advance.

At present, Omika Works is providing a "high-efficiency production model planning service" aimed at the production sites of customers based on 20 years of innovation efforts and expertise. This service starts with field validation of the customer's production sites, hearings of known issues and surveys of potential issues, and a comprehensive consideration of factors such as the customer's key performance indicators (KPIs), followed by support for the establishment of goals for improvement efforts, the formulation of concrete utilization scenarios after system adoption, and the formulation of medium and long-term innovation efforts and roadmaps for systemization.

Also, for customers who want to streamline production but do not create assembly work instructions very often, and are not motivated to adopt the system, Omika Works offers operational services that utilize the solution as well. One of these solutions is the "assembly procedure manual creation agency service" that utilizes assembly work navigation. With this solution, Omika Works receives the customer's 3D CAD data and uses this to provide assembly work instructions generated using the assembly work navigation system, which can then be utilized for purposes such as prior validation of the effects of adopting the 3D assembly work instructions at the production site.

In this way, in addition to providing the same tangible system products as before, Omika Works can also provide intangible services in an integrated fashion, and is working to build an environment that can provide the customer with the maximum effectiveness in solution implementation.

5. Efforts toward Total Optimization including Global Supply Chains

Although these production innovation solutions have been aimed at the domestic manufacturing industry, demand is rising for the total optimization of global supply chains. To respond to this demand, Omika Works is accelerating its deployment of solutions to the Chinese and Southeast Asian markets while utilizing the space to deepen collaborative creation with customers.

Lumada Center Southeast Asia, which is located in Chonburi province in the Kingdom of Thailand (referred to as "Lumada Center" hereinafter), applies and exhibits production innovation solutions in a demo manufacturing line to introduce solutions to customers in a visual and easy-to-understand manner. By demonstrating the "operational technology (OT), IT, and products" as a solution adopted at the Lumada Center, Hitachi supports the realization of the DX concept while introducing its technology and solutions. Furthermore, Hitachi uses a discussion space in Lumada Center called a collaborative creation room to introduce total optimization solutions based on OT, IT, and products, while collaboratively creating new production innovation solutions that can discover, analyze, and respond to the challenges faced by customers.

6. Conclusions

This article introduced high-efficiency production solutions utilizing the IoT technology of Omika Works. The factory will continue contributing to DX by providing the solutions introduced here, starting with improvements to customer productivity and quality.

Acknowledgement

The rapid spread of COVID-19 infections made it necessary to publish the mechanical ventilator 3D assembly work instructions free-of-charge within a short period of time. Omika Works would like to express its deep appreciation to Medtronic PLC and the other concerned parties whose cooperation made it possible to achieve this goal in six weeks.

References

1) Hitachi News Release, "Hitachi Establishes High-Efficiency Production Model Using IoT at Omika Works" (Oct. 2016), https://www.hitachi.com/New/cnews/month/2016/10/161025.html
2) Hitachi News Release, "Hitachi Launches the Systems to Automatically Generate Optimized Production Schedules and 3D Work Instructions as a Solution Core for the IoT Platform 'Lumada'" (Oct. 2017), https://www.hitachi.com/New/cnews/month/2017/10/171017.html
3) Hitachi News Release, "Hitachi Provides a Free Cloud Service for 3D Procedure Manuals Using Hitachi's Assembly Navigation System to Support the Manufacturing of Ventilators, which Are Essential in Response to the COVID-19 Pandemic" (Jun. 2017), https://www.hitachi.com/New/cnews/month/2020/06/200605a.html
4) Hitachi News Release, "Hitachi's Omika Works Recognized as an 'Advanced 4th Industrial Revolution Lighthouse' by the World Economic Forum" (Jan. 2020), https://www.hitachi.com/New/cnews/month/2020/01/200110.html

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