MESSAGE

A Factory of Total Integrated Systems with Domain Knowledge that Underpins Social Infrastructure

A Lighthouse Driving the Digital Transformation of Manufacturing

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The digital transformation of industrial production is getting underway in earnest in the manufacturing sector alongside rising expectations for reforming society by means of digital technology. The information and control systems that Hitachi has long provided for social infrastructure can be seen as among the earliest examples of digital transformation, being based on the cyber physical system concept of combining physical machinery with control logic in cyberspace to operate those machines in an optimal manner. Hitachi's Omika Works has been at the center of this work and has attracted attention for its production reforms, being recognized as a "Lighthouse" advanced factory by the World Economic Forum in January 2020. How is Hitachi utilizing information and control systems to contribute to the digital transformation of society and industry? Alongside in-house improvement, what is being done to advance digital transformation across the manufacturing industry as a whole? *Hitachi Review* put these questions to Hideki Hanami, the person in charge of overall operations at Omika Works.

Joined Hitachi, Ltd. in 1994. He was employed at Omika Works where he worked on the design of digital control systems, mainly for the central control rooms of Japanese nuclear power plants. His focus shifted to control security from around 2015 and he is currently engaged in consultation with other industries in his role as a member of Working Group 3 at the Study Group for Industrial Cybersecurity led by the Ministry of Economy, Trade and Industry. He took up his current appointment in April 2020. He is also a member of the World Economic Forum Global Lighthouse Network working on DX of manufacturing.

Ongoing Expansion of CPSs through Advances in Core Technologies

——There is rising interest in digital transformation (DX). The term "cyber physical system" (CPS) is also used in relation to the application of digital technology to innovation in industry and wider society. What is your own take on this trend toward digital reform?

Hanami: It goes without saying that the use of data is at the technological core of DX and CPSs, something that is underpinned by the ability to consolidate data. While the large IT companies in the USA collectively known as "big tech" are the recognized leaders in this sector, the operations of companies like these that are built around IT are mainly focused on using personal computers and various mobile devices to collect data on the behavior of people

that they then analyze to identify those people's interests and attributes, predict their needs, and so on.

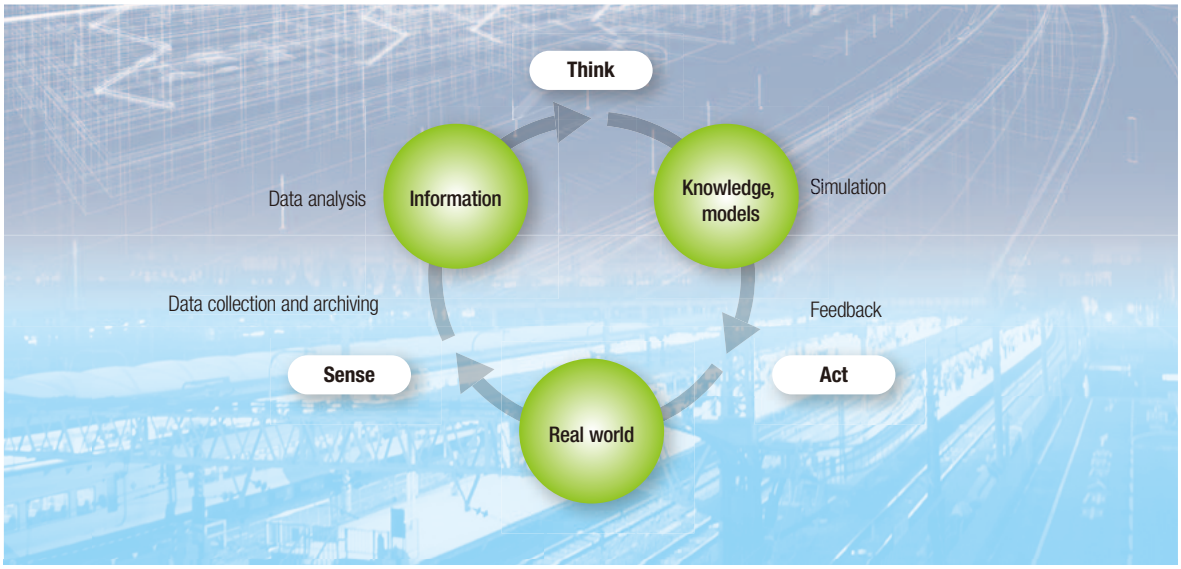
At Omika Works, in contrast, we deal with control equipment and systems, focusing on industries such as railways, electric power, water and sewage, and steel. Our work is based around machinery and other physical equipment used in industry, with a strategy of collecting and analyzing data from this equipment and using the results as feedback to optimize operation.

We use "sensing" to collect data, a process that in simple terms can be characterized as converting physical phenomena into electrical signals. Examples include the flow of water through a pipe, the level of fluid in a tank, or the speed of a turbine or motor. Measurements of these physical phenomena taking place in equipment are collected in the form of electrical signals. These signals are converted into information (distance, speed, pressure, and so on) and made available for use in control logic to calculate the optimal numeric parameters for equipment operation, which are then converted back to electrical signals and output to the plant as feedback. Information and control systems work by repeating this loop continuously. In this sense, they serve as examples of CPSs.

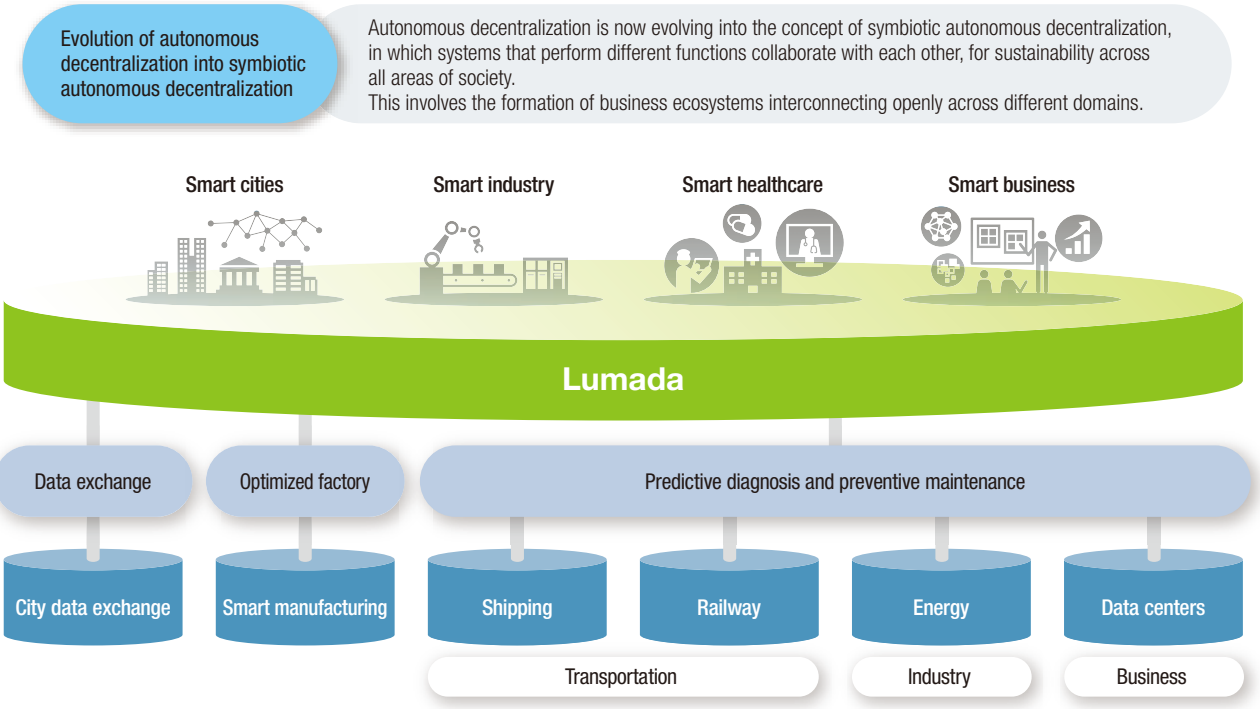
—But people have been working on this long before the term CPS was coined, correct?

Hanami: That's right. But what we now talk about with DX and CPSs are capabilities that are considerably higher thanks to advances in the core technology. The control systems that we worked with in the past were limited in terms of both the number of inputs and outputs and their processing capacity. The control loops, too, were by necessity small in scale. On the other hand, the fact that we faced so many constraints drove us to further hone the technology, putting ingenuity to work to deliver high-performance control. We worked closely with our customers to satisfy their particular goals and objectives, providing the best possible solutions, ranging from the development of special-purpose computers to the implementation, operation, and maintenance of entire systems.

CPSs: Using Data to Facilitate Control of Infrastructure



Evolution of Autonomous Decentralization



Now, central processing unit (CPU) processing power, memory capacity, and wireless communication speeds are all an order of magnitude greater. This has expanded the scope of control considerably, making it possible to implement systems that instantaneously collect large amounts of data, pass it to the cloud for analysis by artificial intelligence (AI), and send the results back to the field. While the core approach remains the same, involving a bringing together of the physical and cyber realms to establish a "Sense, Think, Act" loop, it is now possible to deliver optimal system-wide control by means of loops that span multiple sites rather than being limited to a single site as in the past.

Domain Knowledge and Autonomous Decentralized Systems Architecture Crucial to DX

——With this expansion in the scope of control, is there also a change in thinking about what form systems should take?

Hanami: While the basic architecture remains the same as in the past, the era of DX demands a broader perspective and a shift in thinking. The key to using digital technology for real-world innovation lies in our domain knowledge, namely our understanding and insight into the places and things where this technology is deployed, including physical phenomena and electrical properties.

In the case of predictive diagnostic and maintenance practices, for example, an understanding of physical phenomena is essential to determining the actual situation. While data analysis is needed to identify situations with the potential to become a fault, such as degraded materials or worn-out parts, such analyses deliver better results if informed by knowledge of materials or other physical phenomena. While there are no doubt some cases where analyzing data for correlations will deliver an answer by statistical means, the more that plant knowledge underpinned by many years of experience goes into such analyses, the greater value they deliver. By combining these capabilities with advanced technology, we deliver information and control systems that are fit for the DX era.

——The "autonomous decentralized systems" concept is one of the features of Hitachi's information and control systems. Although first developed in the

1970s and since incorporated into many different social infrastructure systems, the benefits of this approach are proving more useful than ever in this time of DX, aren't they?

Hanami: The benefits of the autonomous decentralized systems concept, and architecture, are widely recognized, being found in a wide range of applications beyond Hitachi systems. As I am sure you already know, autonomous decentralized systems, rather than working by means of centralized control, function as an effective whole through multiple subsystems operating in parallel. In this regard, they are analogous to systems found in nature. The autonomous decentralized systems concept allows for upgrades or other maintenance on individual subsystems to be completed without halting the whole system, and for this reason it is seen as ideal for social infrastructure systems where the requirement is to combine expandability with the continuity of safe and reliable operation.

It is also a concept that is needed in the era of DX, where value is generated by linking large numbers of disparate systems together. The terminology "symbiotic autonomous decentralization" has been adopted in recent times to refer to different products, sites, and industries interoperating with one another while still operating autonomously. By taking the lead in this environment where new value is created by linking things together, Hitachi aims to contribute to the enhancement of social infrastructure.

First Japanese Company to have Site Recognized as Lighthouse Advanced Factory

——The digitalization of industry appears to have come a long way over the decade or so since people first started using phrases such as the Fourth Industrial Revolution. What is your view of the current situation?

Hanami: For all the talk of the Fourth Industrial Revolution, the reality is that there are few places where it has really had an impact. Recognizing that most manufacturers are still groping around in the dark, having only adopted digital technology on a piecemeal basis, the World Economic Forum together with McKinsey & Company established a community of manufacturers called the Global Lighthouse Network in 2017. The network identifies leading manufacturing facilities around the world and designates them as "lighthouses," the aim being to underpin DX of the manufacturing industry as a whole by sending out information from these lighthouses. The lighthouse designation for Omika Works was granted in January 2020, the first for a Japanese manufacturer.

——So, is it fair to say that digitalization at Omika Works is well advanced compared to other Japanese manufacturers?

Hanami: While that is true in some respects, being recognized as a Lighthouse does not necessarily make us a model for all manufacturing industry. Including Omika Works, there are a total of 69 designated lighthouse advanced factories around the world and they are recognized as such because they go about digitalization according to their own particular circumstances, having their own products and industry sector. In our case, we operate the sort of processes required for the short-run production of a wide variety of hardware and software for infrastructure information and control systems and were selected on the basis of accomplishments such as our contribution to the reliable supply and operation of social infrastructure, which we achieve by optimizing all steps along the value chain from product design to delivery, operation, and maintenance and delivering a 50% reduction in lead times compared to how things were done before.

A feature of Omika Works is that we deal with all aspects of control equipment, from hardware to operating systems (OSs), middleware, and applications as we seek to take a "white box" approach to product optimization. This is something we have in common with many other lighthouses that have been recognized for end-to-end value chain optimization.

Taking a broad view, there is no doubt that Japanese manufacturing lags behind in digitalization. You can also interpret that as being the flip side of our high level of workplace skills. While factors like culture and employment practices play a part, I believe there is much to admire in our approach of acquiring skills through engagement in work, with fertile soil for the aggressive pursuit of improvement from the bottom up. On the other hand, our high level of workplace skill means we tend to believe that past practices are the right ones, and this in itself is an impediment to acknowledging the problem. In this regard, we find it difficult to make drastic improvements.

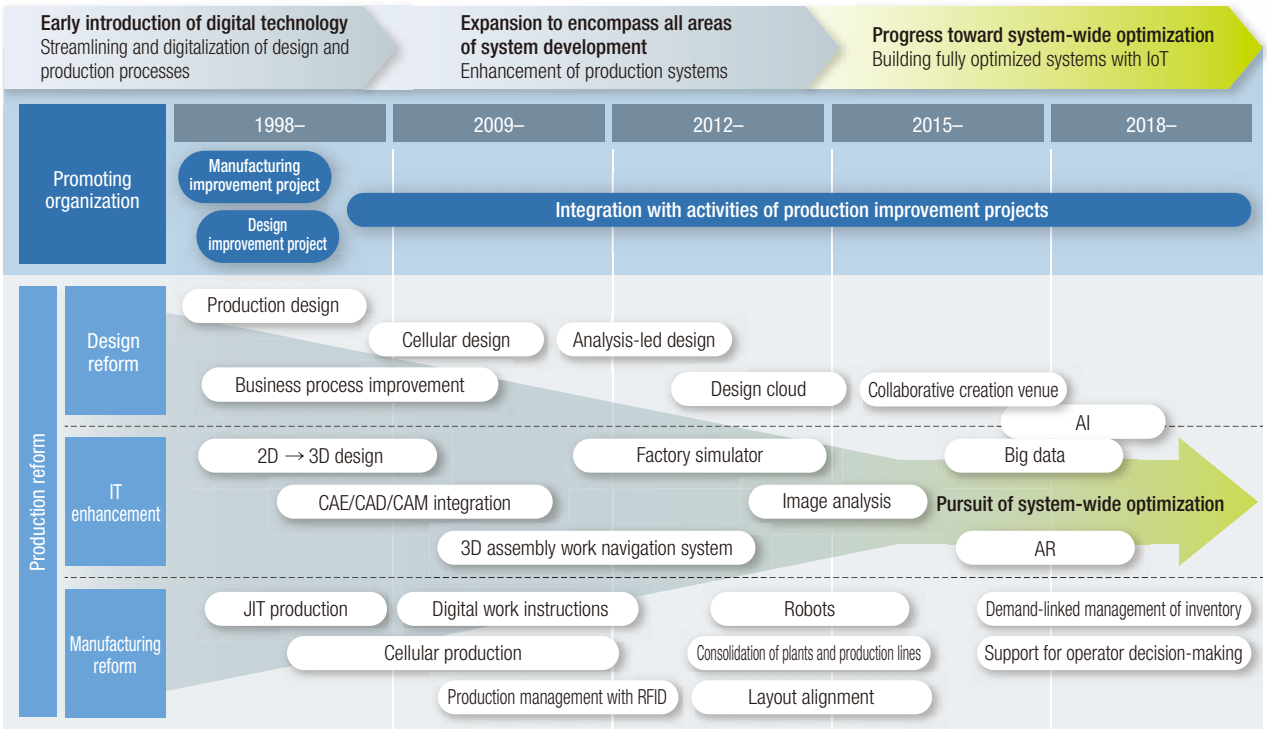
Pursuing Plant Digitalization in Response to Rising Workload

——What were seen as the problems to be addressed when Omika Works first started on production reforms, which I understand was back around 1998?

Hanami: It was. Back then, although we had taken on a large number of jobs and faced a significant increase in workload, our production practices were very dependent on skilled staff. One such problem was that knowledge of how best to go about the routing of electrical wiring, for example, which needs to take account of differences in voltage or the effect of noise, was concentrated in a small number of staff and dependent on their particular skills. This prevented us from rapidly ramping up production capacity. To overcome the problem, we developed a three-dimensional (3D) assembly work navigation system that presents work instructions in an easy-to-understand 3D form so that even workers with limited experience can do the work.

In response to another problem, a loss of efficiency caused by goods piling up in the plant due to rising workloads, we developed a factory simulator that provided an

Evolution of Production System at Omika Works



IoT: Internet of Things AI: artificial intelligence 2D: two-dimensional 3D: three-dimensional CAE: computer-aided engineering CAD: computer-aided design CAM: computer-aided manufacturing AR: augmented reality JIT: just in time RFID: radio-frequency identification

overview of what was going on and enabled us to take control of the situation. This significantly improved productivity by allowing us to respond effectively to sudden changes in product or delivery requirements.

While the digitalization of plants faces all sorts of resistance, it offers major advantages once it has been achieved, including by making it easier to implement improvements through the use of data. This experience of digitalization and DX also proved useful in our work supporting customer DX through information and control systems.

——While it was these production reform efforts that led to your Lighthouse designation, what are the strengths that set Omika Works apart from your competitors?

Hanami: As we talked about earlier, it may be that we do not have any directly comparable competitors in the sense of providing total support for social infrastructure that extends from the design and manufacture of hardware to system maintenance and operation. In this regard, I believe the source of our strength and what differentiates us from others is this approach of being an integrated system factory. I am proud of our speed of response and depth of analysis, both of which come from having a comprehensive involvement in all aspects of our business.

Our unique strength is that we deploy these capabilities across a wide range of social infrastructure, thereby building up a portfolio of core technologies as well as specific domain knowledge. These are capabilities that we can also put to use when linking systems together to solve problems and create value in the realm of DX and CPSs.

Working Practice Reforms for Decarbonization and the New Normal

——Hitachi was the first Japanese company to become a Principle Partner for the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26) to be held in the UK in November 2021. I expect that technologies that facilitate cross-sectorial collaboration will also prove to be a strength when it comes to helping overcome the major societal challenges posed by decarbonization.

Hanami: I believe so. Rather than companies or industries acting alone, synergies arise when all of society works together to address decarbonization collectively. Approaches that combine a variety of different elements will likely become more important than ever in the future, such as optimizing the operation of water or sewerage system pumps based on fluctuations in the supply and demand for electricity, or taking energy efficiency into account in railway operations, for example. I believe that situations such as ours where engineers from a variety of different fields are working in close proximity will be well placed to deliver such solutions.

Obviously, consideration of physical phenomena to make fundamental and direct improvements in energy efficiency will remain an essential approach. Reforming working practices to improve efficiency can also contribute indirectly to decarbonization and, considering the environment as a whole, plant-level actions are also important. Examples include reducing waste as well as making good use of water and helping to improve water quality. I believe there is a lot we can do in the area of decarbonization and the environment, small-scale actions included.

——Working practice reform will also be a requirement of the new normal.

Hanami: Whereas the workplace reforms we have made to date have been in the nature of production reforms, what will matter from now on will be reforms to working practices, including those of engineers. We are engaging in a variety of activities needed to advance to the next step in manufacturing.

Starting with initiatives such as systems for generating test certificates that work by automatically collecting test data in databases, our ultimate goal is to put practices in place that will allow everything from design to testing and on-site maintenance to be undertaken remotely. While customer buy-in and security assurance are clearly essential prerequisites, I believe that establishing the infrastructure needed to achieve this represents an investment in the future.

One thing that the members of the Global Lighthouse Network have in common is a firm belief that investment in digital manufacturing will continue. The purpose of this digital investment is not simply to adopt digital technology in place of existing practices, but rather to fundamentally transform how manufacturing is done. To be successful, this will require strong commitment and direction from leaders as well as bottom-up initiatives. I also believe it is vital that we approach these challenges in a flexible manner, learning from the mistakes that we make.

Contributing to DX in Industry from Global Perspective

——Your future-focused initiatives also include what you are doing as part of the Global Lighthouse Network.

Hanami: Rather than using our Lighthouse advanced factory designation as a means of promoting the cause within Hitachi, we are accepting offers to give presentations and the like in accordance with the network's purpose of helping to raise the bar for manufacturing as a whole. We were already giving factory tours to more than 300 companies annually before we became a Lighthouse advanced factory, and with the ongoing pandemic we have augmented this with virtual factory tours so that people can visit remotely.

The community of companies that make up the Global Lighthouse Network are actively debating what form manufacturing should take in the post-coronavirus world. I hope that the manufacturing industry in Japan will also be able to contribute to the debate with regard to this future direction, and so on. In practice, many of the issues under discussion relate to supply chain. The advance of globalization means that all manufacturers share a common challenge of how to maintain supply chains when distribution networks are disrupted, whether through a pandemic like we have now or due to other natural disasters.

We have been conscious of problems with the supply chain for some time and, for products that underpin

Virtual Factory Tour

important social infrastructure, recognize the need to maintain trust as well as ensuring their distribution networks and quality. As distribution networks expand globally, we are seeking to build trust chains that provide transparency, showing that our systems are manufactured on the basis of reliable quality assurance that extends to even the smallest parts. As this is clearly not something that can be accomplished by Hitachi on its own, we intend to raise and address this challenge as an issue for the manufacturing industry as a whole.

——Alongside the ongoing globalization of Hitachi's business, what is your thinking with regard to globalizing the knowledge and skills of Omika Works?

Hanami: The rise in the number of partners with a major global presence that Hitachi has brought in over the past decade or so is quite astonishing, including companies such as Ansaldo STS, JR Automation, and ABB. What is important is that we exploit synergies, combining our respective strengths, whether it be in products or in production technology. With the expansion of our customer base has come rising expectations for pursuing in-depth collaborative creation with other organizations in even larger numbers than before. In doing so, I hope that we can further hone our strengths in operational technology (OT) and take up the challenge of technological innovation.

By incorporating the technologies we have to offer, we intend to increase the value and competitiveness of group company products so that they can be put to use around the world. This is a process that should also be able to work in reverse. Progress is also being made on specific collaborations, something else we have just recently started. To expand these activities and contribute to DX across all areas of society while also boosting the global competitiveness of Japanese industry, we intend to continue taking up the challenges of production reform and technological innovation.