# Technology Innovation:
## Industry

### 1 Development of Platform for Integrated Management of Value Chain for Regenerative Medicine Products

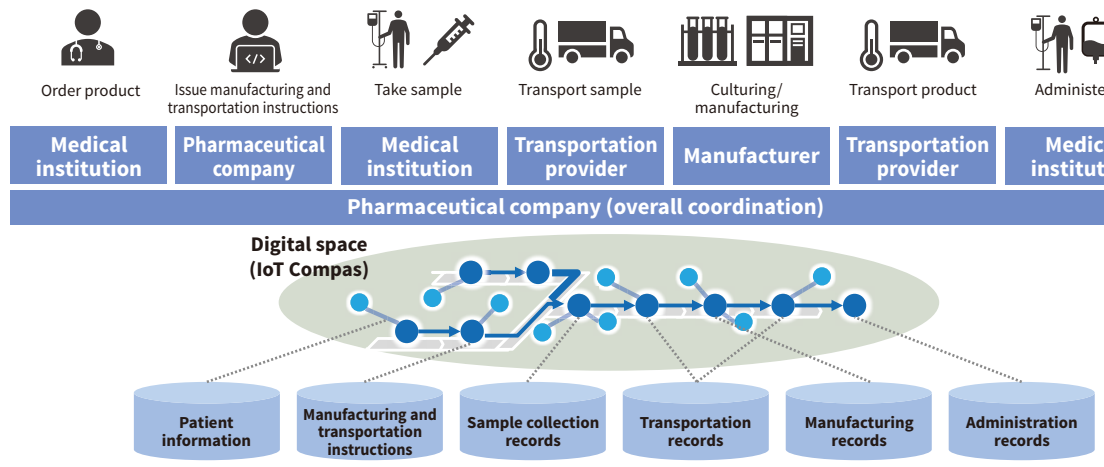
Because it involves multiple stakeholders along the series of steps from extracting a sample from the patient through to manufacturing, transportation, and administering the treatment back to the patient, regenerative medicine demands stringent quality control and information traceability. Accordingly, Hitachi has developed a workflow system that utilizes IoT Compas to record the progress of work as stakeholders hand on materials and information from one to the other.

As samples taken from the patient are managed across a number of branching processes, the resulting management of workflow information has a complex structure with multiple instances where steps branch or come back together again. Nevertheless, regenerative medicine information can be managed securely and with confidence by handling this data in IoT Compas with its ability to record data interrelationships, and by providing fine-grained control of access to the information. The system itself it is able to work with a variety of other systems by modifying the data model that defines the workflow. Hitachi plans to make it available to the pharmaceuticals industry as a data management system for regenerative medicine.

### 2 Virtualization of Robot System Integration Using Collaborative Simulator

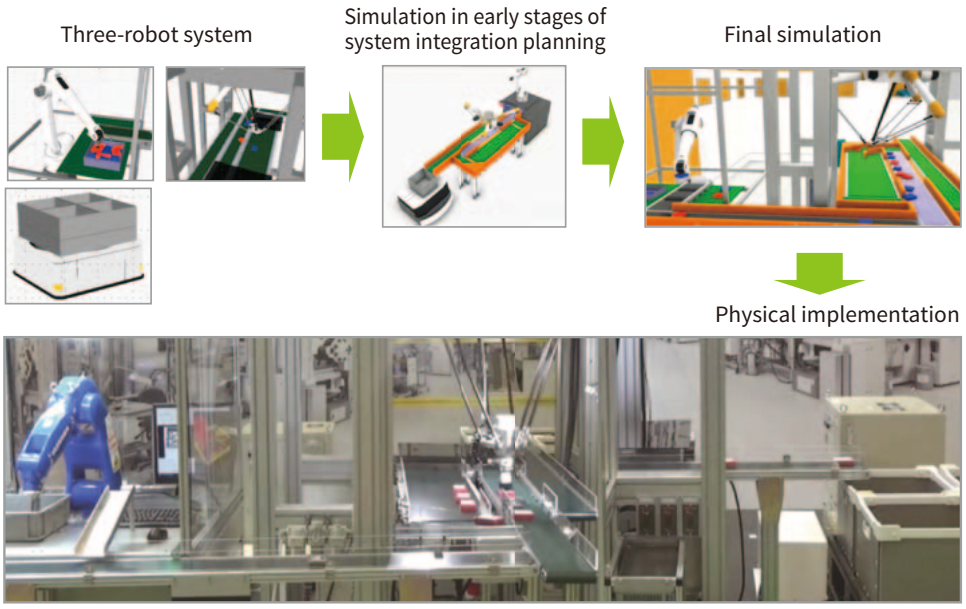
While there is rising demand for the automation of activities such as manufacturing and logistics, the diversity of the work makes it more important than ever that system integration (SI) coordinates and integrates the operation of a wide variety of robots and other machinery to take account of individual requirements. With this, there is also a need not only to maximize the value delivered, but also to make the design, approval, development, acceptance, and other steps faster, with allowance for people being spread across different remote locations without access to the actual hardware.

It was with this in mind that Hitachi developed its collaborative simulator, an integrated simulation environment. By providing a number of simulators intended for different purposes and applications, and by enabling tasks such as the sharing and presentation of data, parameters, and analysis results to be all tied together, analysis and design is able to proceed in a comprehensive manner that takes in various different layers, including physical phenomena, the individual and group operation of robots, and impacts on business. The simulator has also been equipped with the ability to incorporate artificial intelligence (AI) algorithms for things like the automatic




IoT: Internet of Things

1 Block diagram of workflow system using IoT Compas




The robot system at the center of the photograph was developed with support from a NEDO-funded project (Project for Innovative AI Chips and Next-Generation Computing Technology Development/Development of Innovative AI Edge Computing Technologies) (JPNP16007)
NEDO: New Energy and Industrial Technology Development Organization

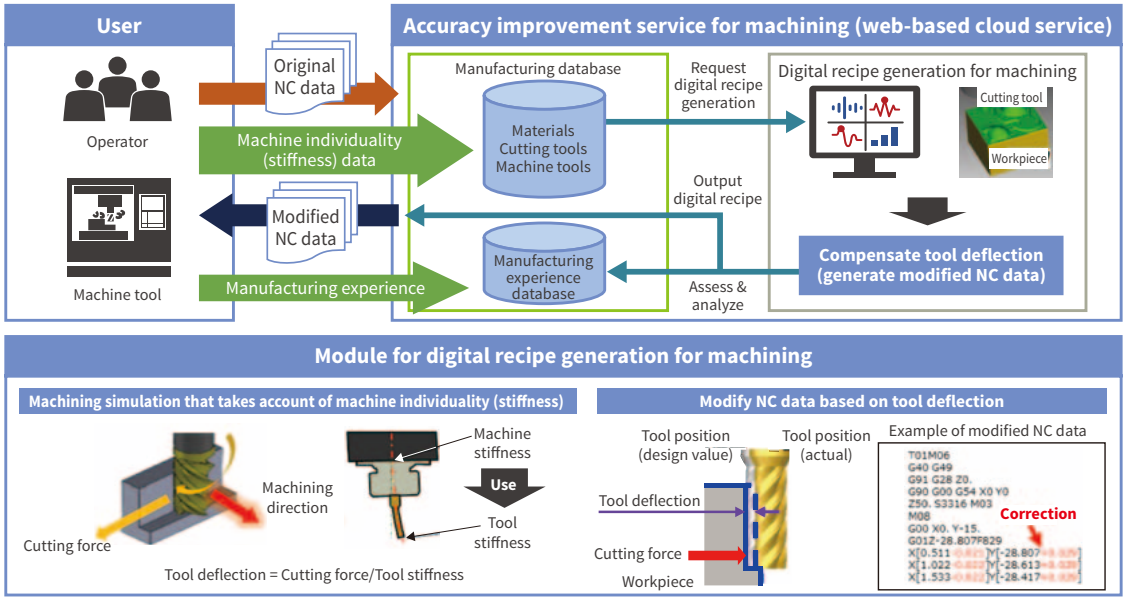
**2** Example of planning, design, and implementation using collaborative simulator

identification of bottlenecks or for optimization achieved through integration with IoT data.

The simulator has also been used under entirely remote working conditions to design a system for demonstrations at trade shows that combines three different types of robot, including development of the associated coordination functions. The final hardware integration work conducted on-site was completed in a single day, with the combined system successfully operating in accordance with its design, without any need for rework. As a core technology for merging the cyber and physical spaces, the simulator will contribute to the deployment of advanced automation systems.

## 3 Accuracy Improvement Service for Machining through Digitized Expert Know-how

Manufacturing that is independent of areas and people is required in the trend of restructuring manufacturing




**3** Overview of accuracy improvement service for machining

bases accelerated by COVID-19 and international relations between major powers. To realize such a situation, product quality has to be stabilized regardless of the production equipment and skilled workers there. Therefore, Hitachi has developed a technique for digital recipe-generating technologies that digitize expert know-how and optimize process conditions input into production equipment. Hitachi provides an accuracy improvement service for machining, which is one of the major processing methods, as a web-based cloud service.

In this technology, cutting tool deflection is accurately calculated by machining simulation incorporating the individuality of each machine tool, and numerical control (NC) data is modified to compensate the calculated machining errors. By digitizing these machine individualities, which skilled workers hold as their own know-how, the service realizes accurate machining regardless of the machine tools and skilled workers. In the future, Hitachi plans to add services for digital recipe-generating technologies for other processes such as plastic forming and injection molding.

* This solution is supplied by Hitachi Solutions, Ltd.

## 4 New Oil-flooded Screw Air Compressors with Industry-leading Energy Efficiency


4 New oil-flooded screw air compressors (37 kW)

Hitachi has commenced mass-production of two new oil-flooded screw air compressors (22 and 37 kW) that adopt its proprietary impinging oil atomization mechanism. The new compressors are the first in the world* to feature this mechanism whereby impingements between lubricating oil causes it to atomize, thereby promoting cooling of the compressed air by the lubricant and reducing compression power. The result is world-leading energy efficiency [6.4 kW/($m^3$/min), an approximate 6% improvement on the previous model], that satisfies the GB1 class in China's energy efficiency regulations.

Along with an approximate 1.5-fold increase in rated operating speed, the compressor has also been downsized by about 10% by reducing the displacement and switching to a high-speed/low-torque motor. In addition to the product's energy efficiency, these measures also encourage optimal operation of the entire compressed air supply system by allowing compressors to be spread across the site, contributing to a reduction in plant carbon dioxide emissions.

Future plans include supplying the compressors to markets outside Japan, taking advantage of the standardization of core components with Sullair, LLC.
(Hitachi Industrial Equipment Systems Co., Ltd.)

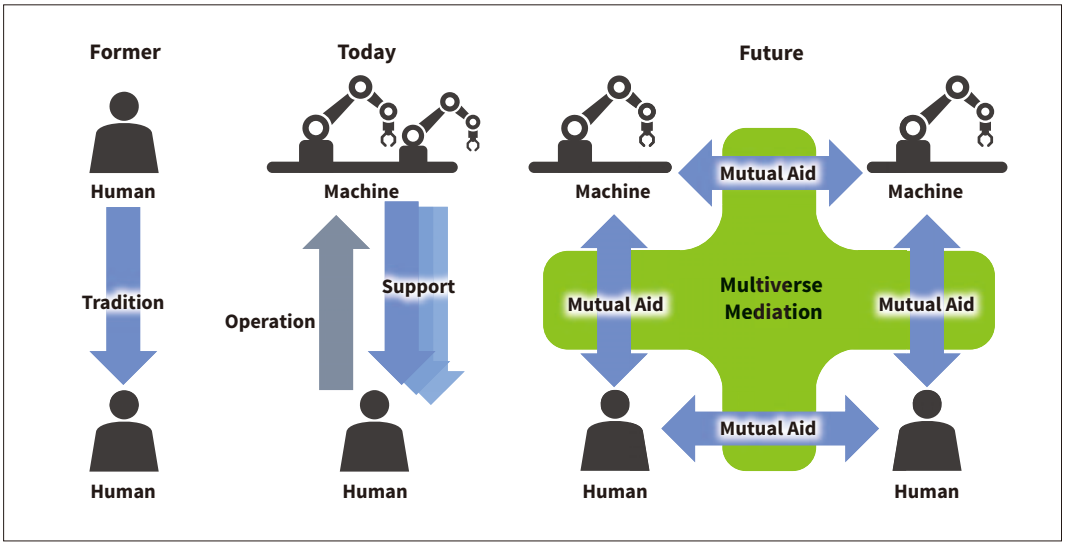
* As of October 2020, based on research by Hitachi Industrial Equipment Systems Co., Ltd.

## 5 Discussion Paper on Revitalizing Human-machine Interaction in Digital Society Published in Collaboration with acatech

Given the greater workforce diversity that comes with a falling population and the greater diversity in machines due to technologies like the IoT and AI, industry too is seeing increasing variety in its humans and machines. For this to bring sustainable economic growth calls for a world where humans and machines can evolve in tandem.

acatech, the German Academy of Science and Engineering, has established a project that addresses this challenge and is led by Professor Henning Kagermann, one of the people behind Germany's Industrie 4.0 vision, with Yoichi Nonaka, a Senior Chief Researcher at Hitachi's Research & Development Group, as co-leader. The results of debate by experts from Japanese and German industry and academia were published in September 2019 in a discussion paper entitled, "Revitalizing Human-Machine Interaction for the Advancement of Society."

This paper described the need for a digital knowledge platform shared by humans and machines so as to provide ways in which they can uplift one another. Giving the name "Multiverse Mediation" to this platform, this paper also presented examples from Japan and Germany of flexible industrial systems that are able to achieve the best overall outcome by having a wide variety of humans



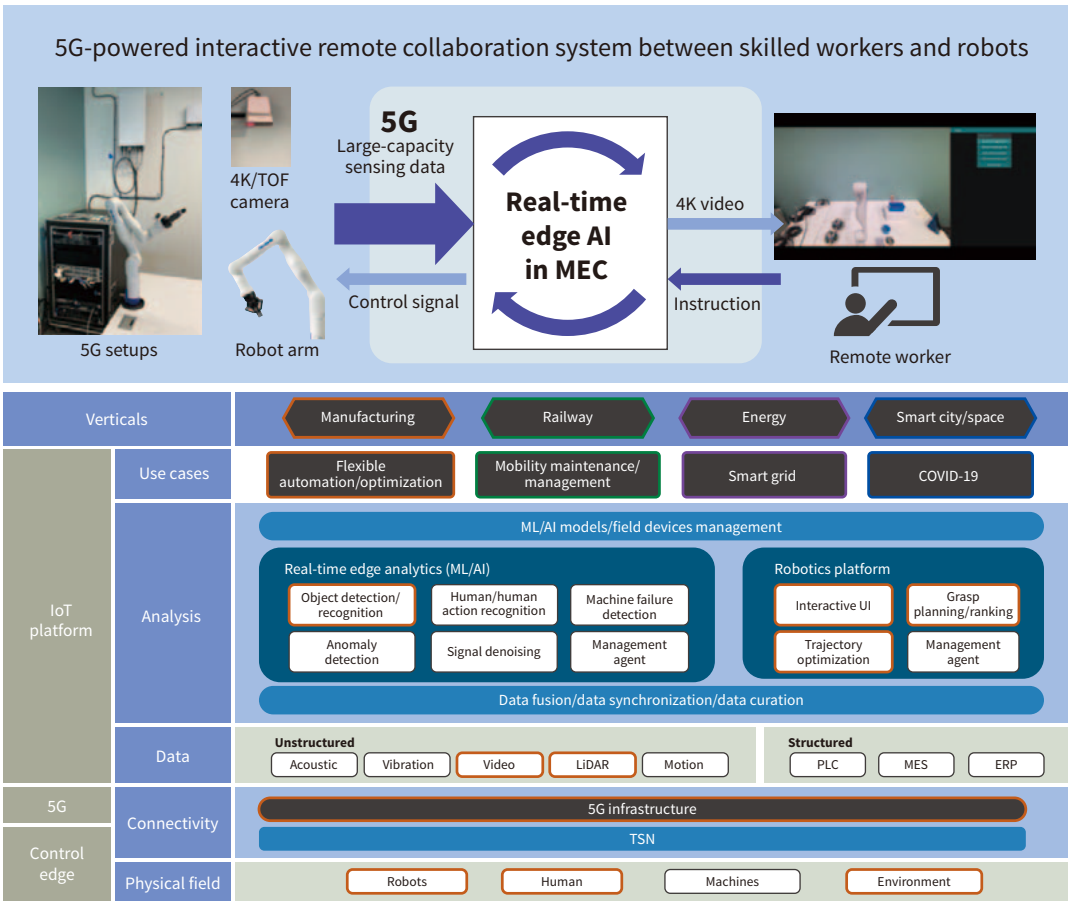

5 Evolution of human-machine interaction

and machines make up for each other's strengths and weaknesses.

The project is currently expanding the scope of debate and engaging in activities to help create a society in which humans and machines coexist.

## 6 5G-powered Real-time Edge AI Framework for Realizing Effective Remote Robot Control

Today's trend of multi-tiered systems requires IoT system to integrate with multiple technologies and co-exist with




MEC: multi-access edge computing ML: machine learning PLC: programmable logic controller TSN: time sensitive network MES: manufacturing execution system
ERP: enterprise resource planning TOF: time of fright UI: user interface LiDAR: light detection and ranging
* Function blocks surrounded by the red rectangles indicate utilized in the application.

6 Framework for 5G-powered real-time edge AI solutions, and its application to remote robot control

other solutions as well as partner/vendor ecosystem. To enable this scalable solution architecture for multiple verticals, Hitachi America, Ltd. has established a soft-coupling approach in the fifth-generation (5G)-powered framework for real-time edge AI and robotics.

In order to perform realistic validation of this framework, the company established a real-time and interactive remote collaboration system between skilled workers and robots in close collaboration with Georgia Institute of Technology. The core function of this system is real-time edge AI extracting insights not only from large-volume sensing data relayed over dedicated 5G network, but also human interaction data collected via intuitive human machine interface (HMI) which, with support of 5G's enhanced mobile broadband (eMBB) feature, drastically improves response time and usability for remote workers. This validates the capability of the framework to explore new age of flexible automation in manufacturing industry, as well as possibility of this framework to scale multiple verticals.

(Hitachi America, Ltd.)

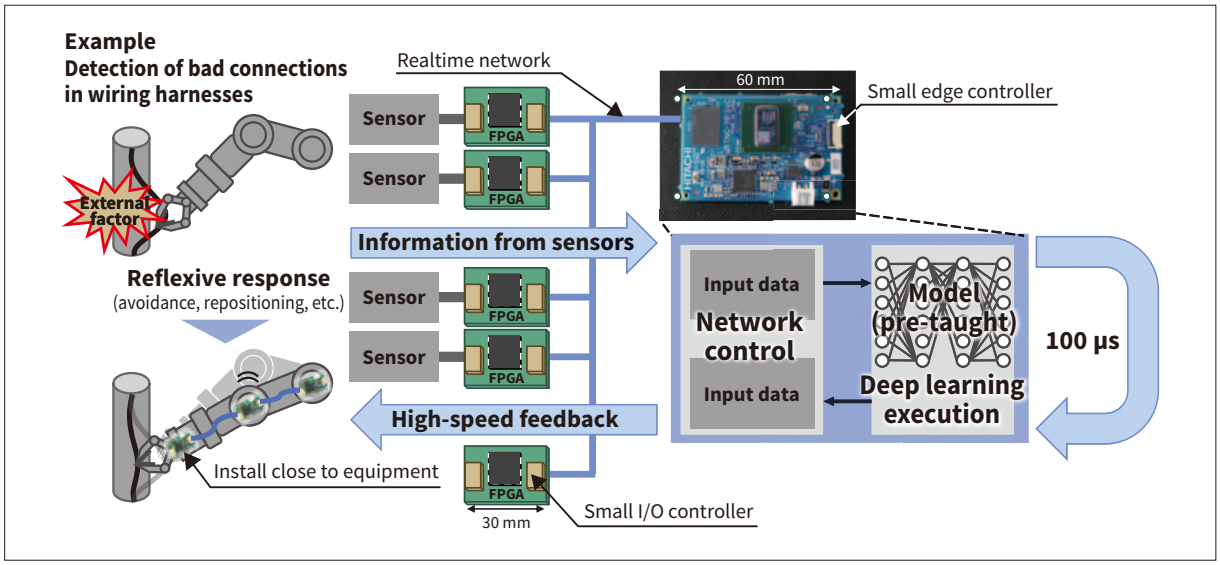
## 7 High-speed Controller System with Hardware-based Network Control and Deep Learning

Amid growing demand for robots as a solution to labor shortages, progress is being made on ways of controlling them without the need for programming by using deep learning to provide robot operation control. The problem with simply combining deep learning control with existing controllers, however, is that this is only realistic with control cycle times in the order of hundreds of milliseconds. This makes it impractical for use with control cycles of just a few milliseconds, which is what is needed to operate robots safely given the external factors found in the real world, such as floor vibration or arm collisions.

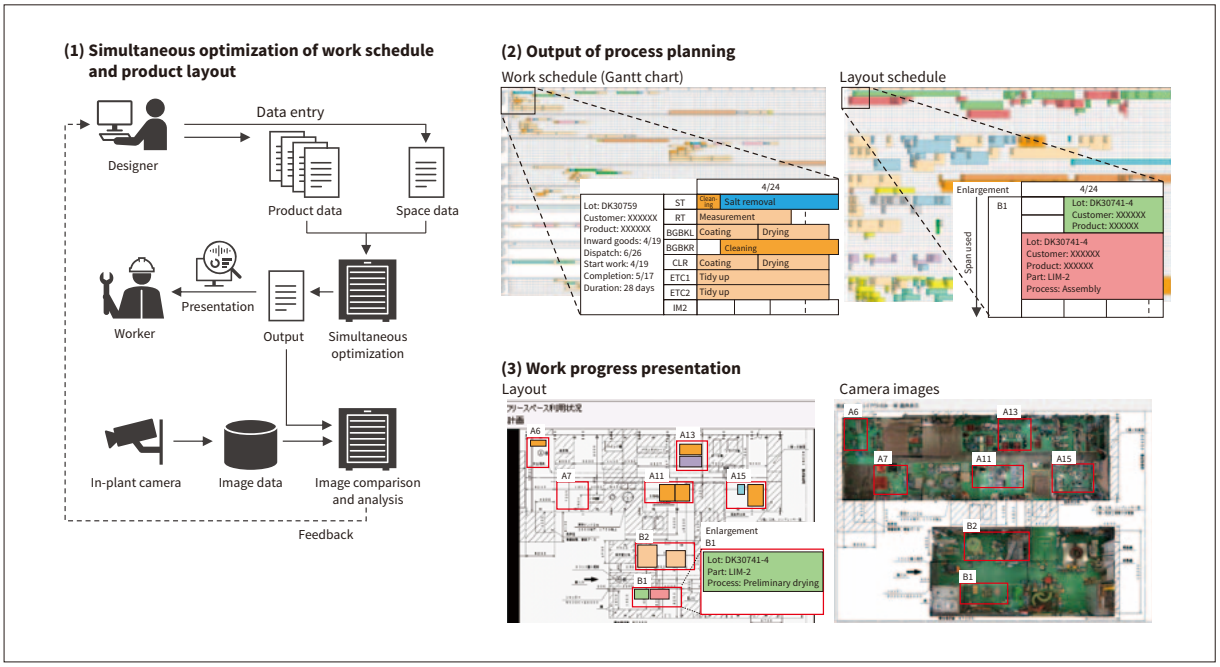
In response, Hitachi has developed a high-speed controller system made up of a small edge controller for executing control acquired from deep learning; a small input/output (I/O) controller to handle sensor, motor, and other I/O; and a real-time network linking these together. High-speed processing is achieved by implementing it in hardware circuits on field-programmable gate arrays (FPGAs) in the controllers. Testing has demonstrated that this can achieve a 5-ms response time for reacting to external events. The intention is to utilize the system in actual applications equipped with these controllers.

## 8 System for Formulating and Managing Optimal Product Space Allocations and Process Plans in Factories with Wide Product Range

Because short-run manufacturing requires that the same equipment be used for different products, with those products having different sizes and taking up differing amounts of space in the production process, there is a need to formulate process plans that allow for efficient space allocation and equipment use sequencing. Unfortunately, the complexity and myriad permutations of space and equipment use has in the past meant that coming up with these plans has required a lot of work by expert staff.




7 Block diagram of new control system




8 Overview of system for formulation and management of process plans

In response, Hitachi has devised an algorithm that eliminates delays due to lack of space by planning where to put products while also taking account of the schedule of equipment use. A scheduling technique that automatically generates optimal process plans has also been developed. It can be used to investigate ways of keeping plans on track, being able to show the progress of work in the factory by cross-checking image data from cameras installed in the plant against the plan.

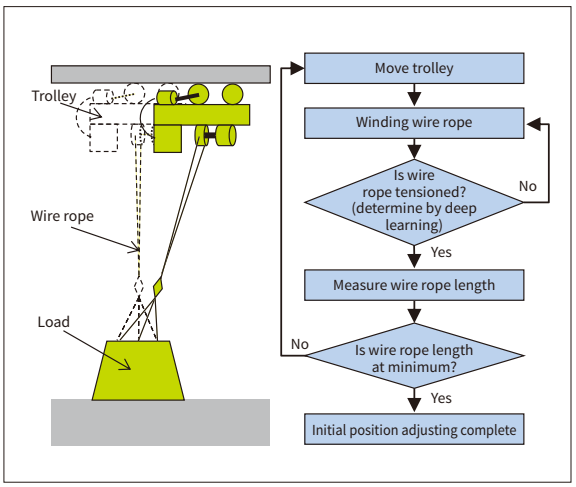
An evaluation of the new system made using historic operational data from a short-run manufacturing plant indicated that it could reduce work time by 20%.

## 9 Control Technology for Adjusting Initial Position of Hoist Crane

The labor shortage caused by the aging of skilled workers and rising demand for cranes is increasing the number of unskilled workers. Because such workers are unfamiliar with how to prevent load sway, this brings a heightened risk of collision, catch, and other such accidents, and causes an increase in work time. Accordingly, with the aim of improving safety and shortening work times, Hitachi has developed a control technology for adjusting the initial position of the hoist cranes that suppresses the load sway that occurs when a suspended load is lifted off the ground.

This problem of load sway at liftoff occurs if there is any horizontal misalignment between the top of the suspended load and the trolley used to transport it. The new control technology takes advantage of the fact that the wire rope length is at its shortest when there is no such misalignment. It works by winding the wire rope before lifting and measuring its length at the point where all of the slack is taken in and the wire rope becomes tensioned, moving the trolley to reduce the misalignment. To detect when the wire rope becomes tensioned, Hitachi also developed a load estimation method using deep learning to estimate the weight of the suspended load on the trolley. This is able to estimate the weight to within 50 kg and enables tensioning of the wire rope to be detected with high accuracy. By using these technologies, load sway at liftoff that would have been around 200 mm with manual operation was reduced to less than 100 mm.

In the future, Hitachi intends to further improve safety by developing even more precise control technology.




9 Control technology for adjusting initial position of hoist crane