Industrial Digital Solutions

1 Motor Current Predictive-diagnosis Solution for Stable Equipment Operation and Maintenance Costs Reduction

In recent years, Japan's workforce has been declining, and the digitalization and streamlining of tasks utilizing various sensors and the Internet of Things (IoT) is required in the manufacturing industry. In the facility maintenance field as well, labor-saving initiatives are being advanced through digital transformation (DX) for inspection work which was previously carried out by having a maintenance worker go around and check each piece of equipment.

Amidst these changes, Hitachi has developed a solution for diagnosing equipment anomalies that utilizes the current data of the motors used to drive equipment. This solution measures motor current and uses a proprietary Hitachi algorithm that utilizes artificial intelligence (AI) to diagnose anomalies in the motor itself and in the equipment driven by the motor. Moreover, the solution contributes to stable equipment operation and reduced maintenance costs with the following three features.

(1) Diagnosis based only on current sensor data

Since the only data required for diagnosis is the current data supplied to the motor, the system can be implemented comparatively easily.

(2) Able to diagnose motors with variable speed and load

Equipped with an algorithm that automatically extracts current data that is suitable for diagnosis, it enables diagnosis during normal operation even for motors with variable speed and load.
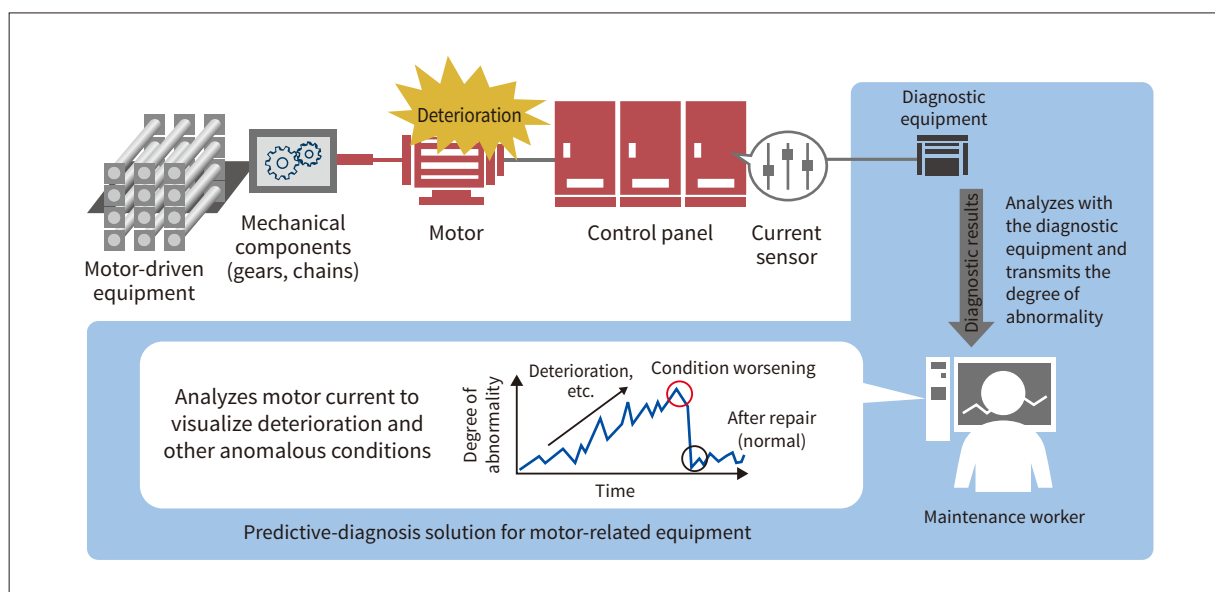
(3) Solves the issue of task individualization in equipment diagnosis

By quantifying the anomalous conditions of equipment (degree of abnormality), it can eliminate variations in human judgment, thereby resolving the problem of a lack of maintenance personnel with advanced skills.
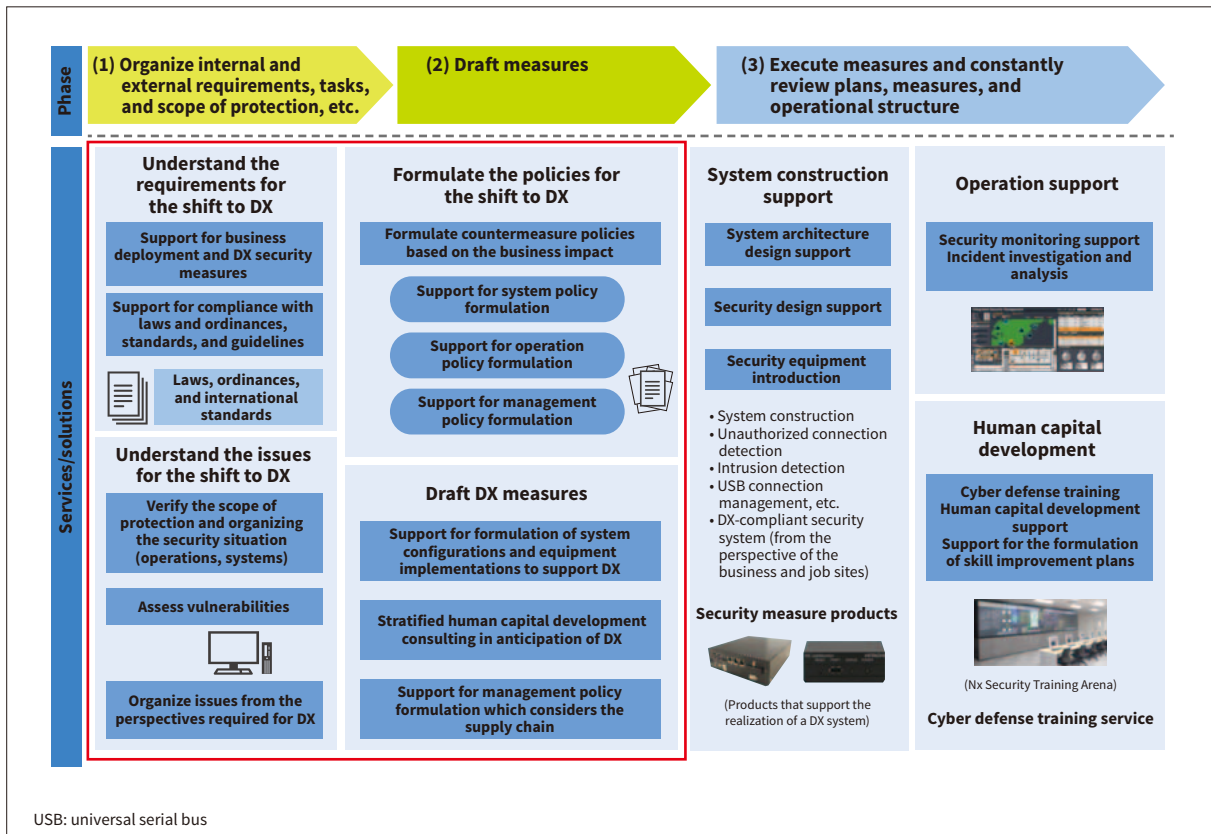
2 Advanced DX-compliant Security Services that Protect Control Systems from New Threats

When it comes to utilizing DX, it is essential to introduce equipment with standard interfaces and the capability of linking internal and external systems. However, the introduction of such equipment comes with security threats, which have a greater impact on business continuity, safety, quality, production planning, and costs than ever before.

Under such conditions, Hitachi considered the business continuity and safety, quality, delivery time, cost (SQDC)

Deterioration

Motor-driven equipment

Mechanical components (gears, chains)

Motor

Control panel

Current sensor

Diagnostic equipment

Analyzes with the diagnostic equipment and transmits the degree of abnormality

Analyzes motor current to visualize deterioration and other anomalous conditions

Degree of abnormality

Deterioration, etc.

Condition worsening

After repair (normal)

Time

Predictive-diagnosis solution for motor-related equipment

Maintenance worker

1 Overview of motor current predictive-diagnosis solution

Phase

(1) Organize internal and external requirements, tasks, and scope of protection, etc.　　**(2) Draft measures**　　**(3) Execute measures and constantly review plans, measures, and operational structure**

Services/solutions

Understand the requirements for the shift to DX

Support for business deployment and DX security measures

Support for compliance with laws and ordinances, standards, and guidelines

Laws, ordinances, and international standards

Understand the issues for the shift to DX

Verify the scope of protection and organizing the security situation (operations, systems)

Assess vulnerabilities

Organize issues from the perspectives required for DX

Formulate the policies for the shift to DX

Formulate countermeasure policies based on the business impact

Support for system policy formulation

Support for operation policy formulation

Support for management policy formulation

Draft DX measures

Support for formulation of system configurations and equipment implementations to support DX

Stratified human capital development consulting in anticipation of DX

Support for management policy formulation which considers the supply chain

System construction support

System architecture design support

Security design support

Security equipment introduction

- System construction
- Unauthorized connection detection
- Intrusion detection
- USB connection management, etc.
- DX-compliant security system (from the perspective of the business and job sites)

Security measure products

(Products that support the realization of a DX system)

Operation support

Security monitoring support
Incident investigation and analysis

Human capital development

Cyber defense training
Human capital development support
Support for the formulation of skill improvement plans

(Nx Security Training Arena)

Cyber defense training service

USB: universal serial bus

2 Providing advanced security services for DX upstream processes

which should be protected from new security threats and broadly provides everything from (1) organization of internal and external requirements, tasks, and scope of protection, to (2) drafting measures and (3) executing measures and constant reviewing of plans, measures, and operational structure as solutions to support DX based on the Cyber and Physical Security Guidelines for Factory Systems from the Ministry of Economy, Trade and Industry. In particular, Hitachi provides advanced security services which support the creation of new guidelines and the evaluation of vulnerabilities (penetration and fuzzing tests, etc.) for the DX planning phase and other upstream processes [Phases (1) and (2)]. Phases (1) and (2) each include the following features.
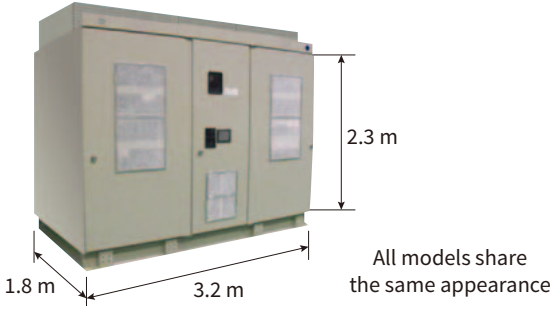
(1) Understanding the requirements for the shift to DX (linking security-related laws and ordinances, standards, guideline requirements to business planning and understanding the requirements) and understanding the issues in the shift to DX (objectively understanding the current system and operation while also organizing the issues in the shift to DX)

(2) Formulation of policies for the shift to DX (considering the business impact and supporting the formulation of security policies aimed at the shift to DX) and draft measures under DX (proposing measures from the perspective of systems, human capital, and management based on the security policies)

3 Universal Main Motor Drive System for Steel Plants

A quarter of a century has passed since the application of the cell concept* to motor drive systems for steel plants. During that time, through continuous technological advances, Hitachi has achieved high functionality, miniaturization, and retrofitting of motor drive systems, and has contributed to customers' facility management through the optimization of system installation and operation costs. The company recently universalized functional cells that enable the application of three types of insulated gate bipolar transistors (IGBTs) and commercialized its universal main motor drive system with a selection of three levels of alternating current (AC) output voltages, 2.25 kV, 3.31 kV, and 4.50 kV. The key features of this system are as follows.

(1) By adding the 3.31 kV AC output voltage to the lineup, Hitachi expanded the voltage range of main motors that can be driven, enhancing the system's ability to support customers' facility planning.

(2) Applies the global standard module types of 3.3 kV, 4.5 kV, and 6.5 kV IGBTs to achieve long-term stable supply for systems.

(3) The capacity for the same system was serialized through a combination of functional cells.

Model name	MH2A plus	H2LA plus	H2A plus
AC output voltage (kV)	2.25	3.31	4.5
Output capacity (MVA)	4.3–18.0	4.2–15.0	5.8–18.0
Main circuit system	Three levels		
Cooling system	Water-cooled		
Overload specifications	150% (for one minute)		
Conversion efficiency	98% or more (during rated output)		
System (converter + inverter)	2.3 m / 1.8 m / 3.2 m / All models share the same appearance		

3 Overview of universal main motor drive system for steel plants

Going forward, Hitachi plans to evolve this product into a motor drive system that can deeply contribute to customers' facility management.

* A design philosophy that achieves overall functionality through the selection and combination of cells by function.

4 Simulation-based Production Scheduling Optimization Solution for Flexible Production

In order to adapt to rapid changes in the business environment, including worldwide parts supply shortages, diversification of customer preferences, and support for environment, social, and governance (ESG), variable-mix, variable-volume production is required to produce and supply a diverse range of products in the quantities required, and in a timely manner. Therefore, flexible production is gathering attention as a new production method that can flexibly respond to demand fluctuations and production adjustments in the manufacturing industry. To achieve flexible production, it is necessary to ensure that it can support the complexity of production scheduling and the immediacy of demand fluctuations and equipment failures in terms of operations, and that the system can start small and scale up flexibly in accordance with production line expansion.
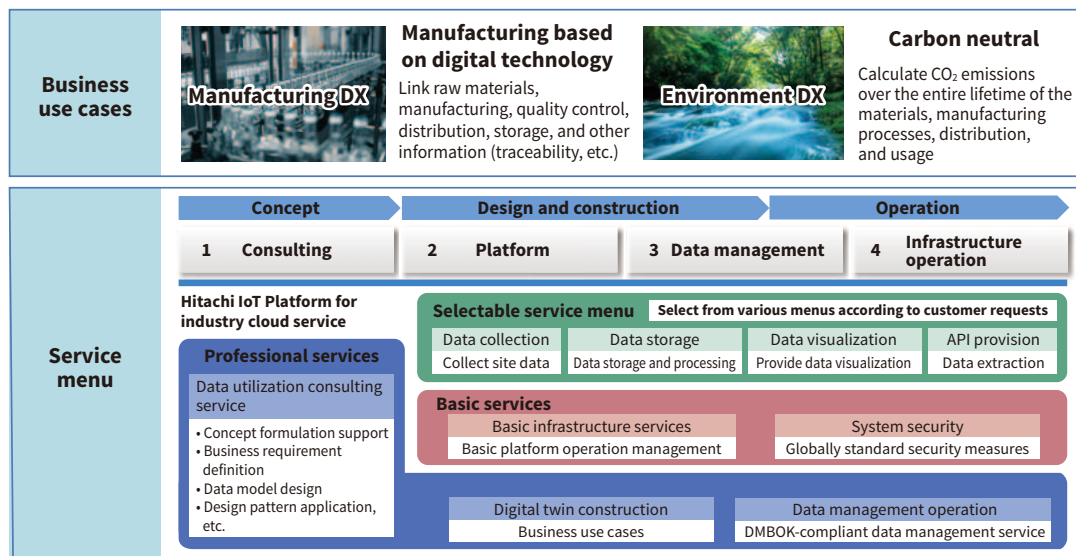
In response, Hitachi is developing a simulation-based production scheduling optimization solution that is useful for production scheduling in flexible production. This solution can provide fast and optimal production

Can be easily adapted to flexible production without changing the production scheduler

Customer — Flexible production line — Line scale expansion

Production scheduler

Data transfer / Scheduling instructions / Production schedule

Web API

Production scheduling optimization solution

Input DB — Product master, order, and other data

Computing environment

Simulation-based optimization engine — M1 M2 M3

Computing coverage expansion

Output DB — Production schedule

Feature (1) Ease of introduction
The complexity of flexible production is resolved by just selecting a template

Feature (2) Solution accuracy and high speed
High-speed optimization engine that can adapt to production adjustments every few hours and respond immediately to equipment failures

Feature (3) System construction and expandability
Supports small start and can be scaled up as needed

DB: database

4 Overview of production scheduling optimization solution

| Business use cases | **Manufacturing DX** Manufacturing based on digital technology | Link raw materials, manufacturing, quality control, distribution, storage, and other information (traceability, etc.) | **Environment DX** | Carbon neutral Calculate CO_2 emissions over the entire lifetime of the materials, manufacturing processes, distribution, and usage |

	Concept	**Design and construction**	**Operation**
	1 Consulting	2 Platform	3 Data management · 4 Infrastructure operation

Service menu

Hitachi IoT Platform for industry cloud service

Professional services

Data utilization consulting service

- Concept formulation support
- Business requirement definition
- Data model design
- Design pattern application, etc.

Selectable service menu — Select from various menus according to customer requests

Data collection	Data storage	Data visualization	API provision
Collect site data	Data storage and processing	Provide data visualization	Data extraction

Basic services

Basic infrastructure services	System security
Basic platform operation management	Globally standard security measures

Digital twin construction	Data management operation
Business use cases	DMBOK-compliant data management service

DMBOK: Data Management Body of Knowledge, a reference book published by DAMA International that is a non-profit organization made up of international data experts

5 Hitachi IoT Platform for industry cloud service business use case examples and service menu

scheduling even for such a complex production schedule as flexible production by combining the application of scheduling logic libraries and simulation-based search according to the features of the production line.

Moreover, this solution provides a Web application programming interface (API) as a microservice to easily link with existing production schedulers and achieves flexible scaling up according to production line expansion through container implementation for the simulation-based optimization engine.

5 Hitachi IoT Platform for industry Cloud Service

With the spread of COVID-19, the fragmentation of supply chains in the industrial world and other inter-operational and inter-business *kiwa* (gap) issues have become more apparent and a hindrance to integrated analysis and total optimum decision-making.

In response, Hitachi has developed the Hitachi IoT Platform for industry cloud service to understand the actual site conditions and use site data to model operations in cyberspace (data models) as well as to support system construction in cyberspace to realize a gapless system utilizing the model. In this service, DX professionals delve into the customer's management and operational issues and realize DX concepts with proven business use cases, such as production traceability and calculation of carbon dioxide (CO_2) emissions throughout the product lifecycle.

Moreover, they prepare a data utilization platform and data model that suit the customer's environment by putting together a menu of services prepared in advance, and provide this platform as a fully-managed service so that the customer can focus on business execution.

6 AI Solutions Increasingly Being Used in the Medical Field

In recent years, the development of AI solutions for the medical field has been advancing to support medical treatment and drug discovery research and development work at medical care, drug discovery, and other sites.

Hitachi's AI solution, Hitachi Digital Solution for Pharma/Biomarker Discovery Service, extracts important factors that characterize each disease, side effect, and various other symptoms and factors that are important for the prediction of treatment efficacy with evidence by using Hitachi's proprietary explainable AI (XAI) technology to analyze clinical research as well as electronic medical charts and other patient data. In addition, by combining the extracted factors with simple formulas, new indicators that can predict the therapeutic effect with high precision can be automatically generated in a short period of time. Compared to existing AI, the system has been praised for its superior interpretability of results, and it is being increasingly utilized in various areas of disease such as cancer, lifestyle diseases, other intractable diseases, and infectious diseases.
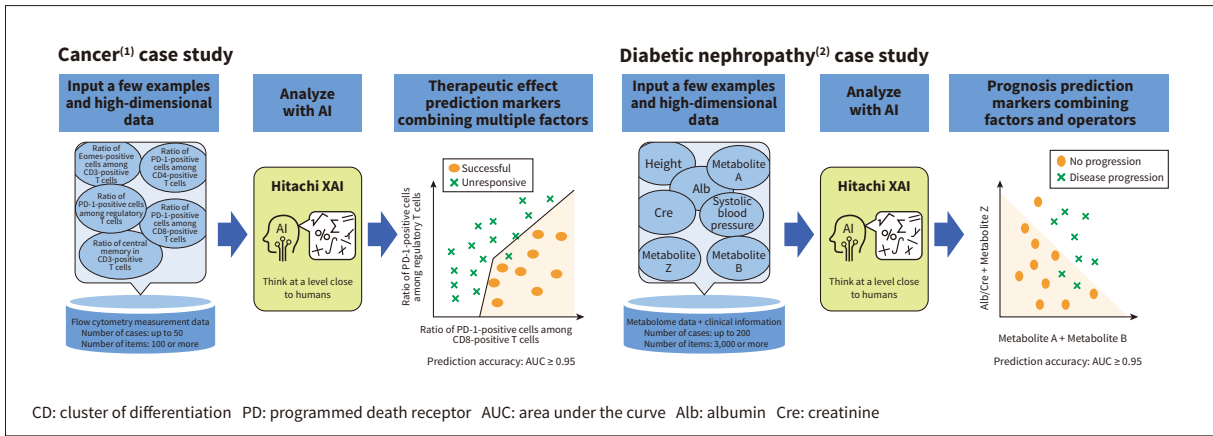
6 XAI solution case studies

Hitachi is planning to release an analysis service that will allow users to directly use this XAI analysis feature within 2023 to broadly contribute to the progress of the medical field.

References
1) S. Kumagai et al., "The PD-1 expression balance between effector and regulatory T cells predicts the clinical efficacy of PD-1 blockade therapies," Nature Immunology (2020).
2) Y. Hirakawa et al., "Potential progression biomarkers of diabetic kidney disease determined using comprehensive machine learning analysis of non-targeted metabolomics," Scientific Report (2022).
3) Y. Kanatani, Y. Sato, S. Nemoto, M. Ichikawa, & O. Onodera, "Improving the Accuracy of Diagnosis for Multiple-System Atrophy Using Deep Learning-based Method," Biology (2022).

7 Hitachi Application Template for Manufacturing Seamlessly Connects ECM and SCM

In the manufacturing industry, the desire to link engineering chain management (ECM) and supply chain
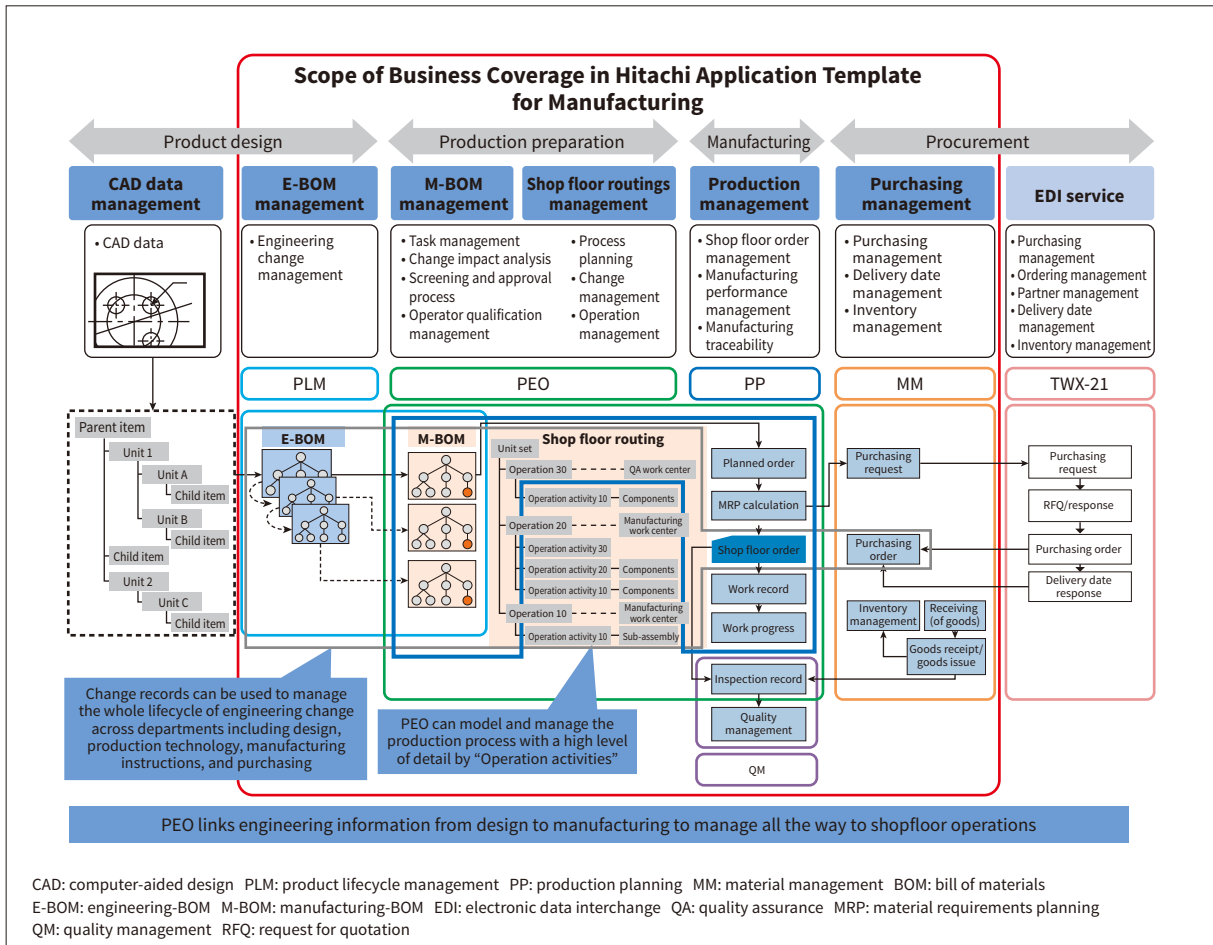
7 Scope of business coverage in Hitachi Application Template for Manufacturing

management (SCM) in a seamless and timely manner is a challenge, and initiatives to eliminate the gaps between tasks are continuing through the promotion of DX. In response, the Hitachi Group is using SAP S/4HANA* Manufacturing for production engineering and operations (PEO) to tie together the information from design to production preparation and manufacturing to build a seamlessly linked system.

Utilizing this experience, Hitachi completed development of its Hitachi Application Template for Manufacturing in September 2022 and started providing it as a service to customers in the manufacturing industry to support systematization studies and requirements definition.

Based on the fit to standard approach, this template provides a business process flow that reflects Hitachi's manufacturing know-how and an environment in which typical business processes can be verified. Using this template makes it possible to walk through customer requirements and issues while checking them in a more specific manner, and to efficiently examine business processes and systems across departments without omissions.

*See the list of "Trademarks."

8 Hitachi Digital Solution for Retail/Demand Forecasting Automated Ordering Service

The Hitachi Digital Solution for Retail/Demand Prediction Automatic Ordering Service predicts the amount of demand based on consumer needs, events, weather, and other causal factors and recommends order quantities by also taking inventory into consideration to achieve a transformation of shop and sales floor operations.

In a case study of wholesale company A, Hitachi introduced the Hitachi total logistics management system and the Hitachi Digital Solution for Retail/Demand Prediction Automated Ordering Service together to deal with social issues such as task individualization and food loss in ordering and inventory management operations to achieve automated ordering and inventory management centralization. By forecasting the amount of demand and the amount of arriving goods, they were able to reduce costs through improvements in truck loading efficiency and dispatching through the system, resource conservation, reduction of Scope 3 emissions through controlling exhaust gas, and reduction of food loss. In addition, this will also lead to Hitachi's goals of contributing to the environment and realizing a happy society.

These IT solutions, including the Demand Prediction Automated Ordering Service, will help solve onsite issues and reduce environmental load by realizing a cyber-physical system (CPS) for supply chains, logistics centers, and transportation and delivery operations.
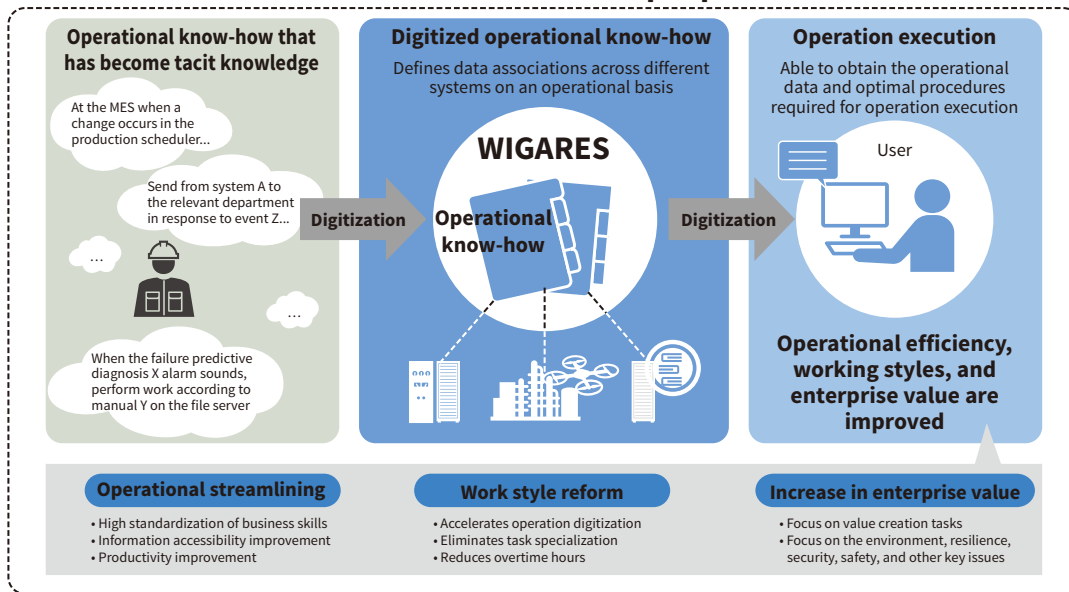
9 WIGARES Platform for Achieving Plant Operation Automation

Realizing plant operation automation requires coordination between systems as well as the digitization of the latent operational know-how in legacy systems and experienced workers to utilize them. This is thought to be one factor hindering the realization of plant operation automation.
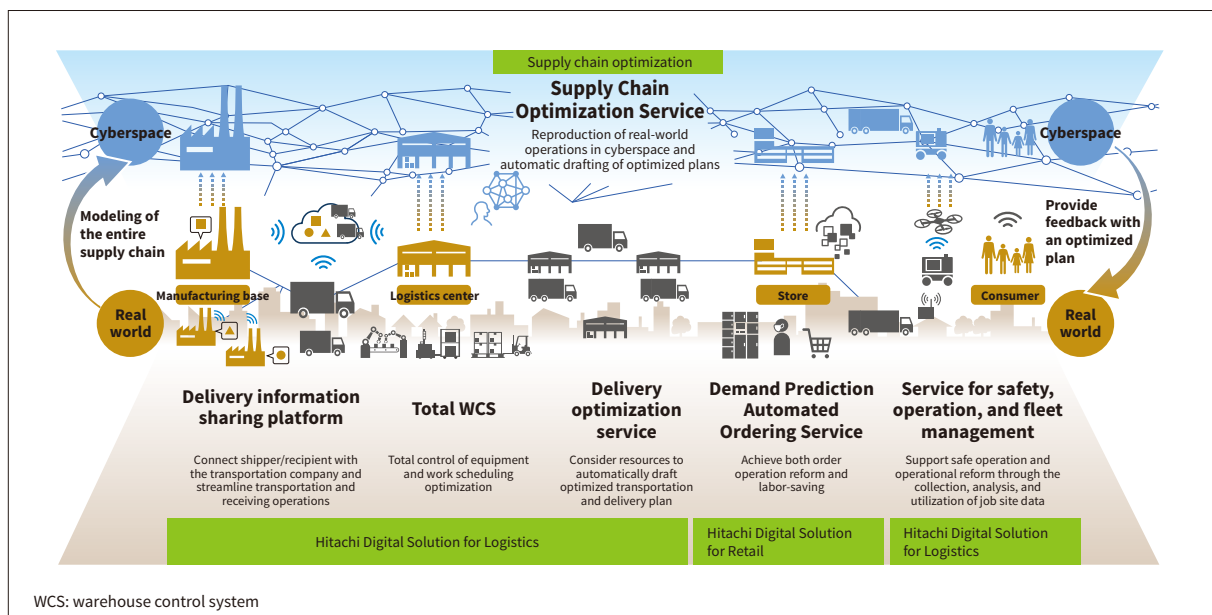
8 Logistics IT solution to support supply chains

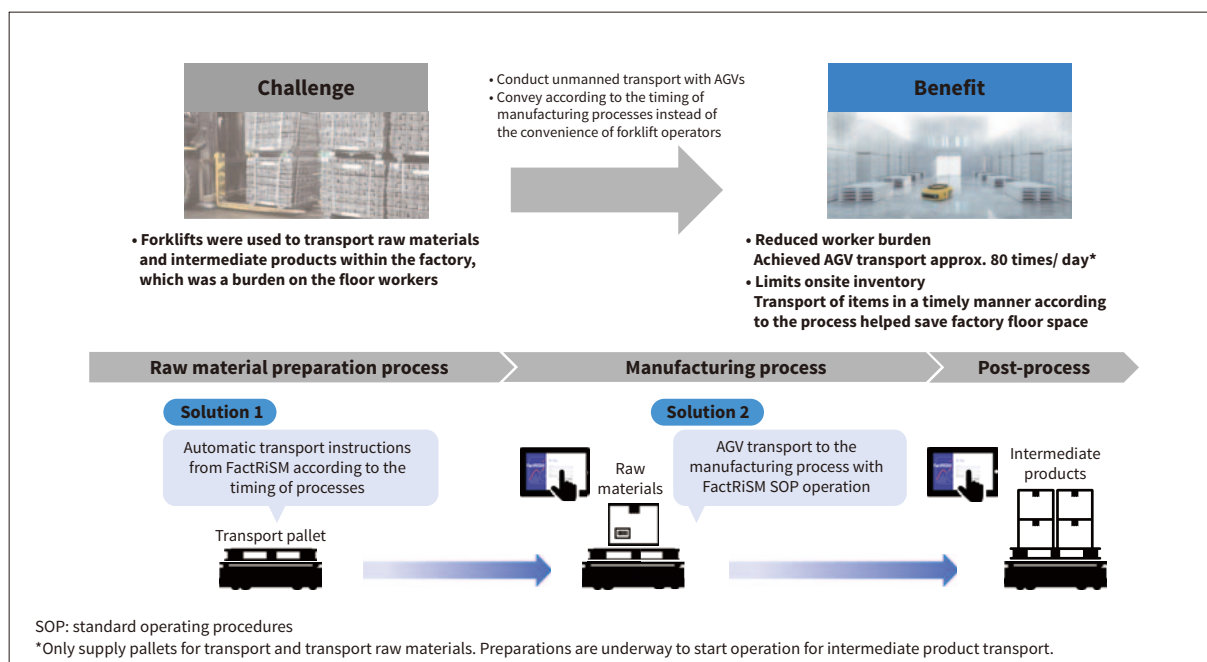## Digitizes data scattered across systems and latent operational know-how between people

Operational know-how that has become tacit knowledge

At the MES when a change occurs in the production scheduler…

Send from system A to the relevant department in response to event Z…

…

…

When the failure predictive diagnosis X alarm sounds, perform work according to manual Y on the file server

Digitization →

Digitized operational know-how
Defines data associations across different systems on an operational basis

WIGARES
Operational know-how

Digitization →

Operation execution
Able to obtain the operational data and optimal procedures required for operation execution

User

Operational efficiency, working styles, and enterprise value are improved

Operational streamlining
- High standardization of business skills
- Information accessibility improvement
- Productivity improvement

Work style reform
- Accelerates operation digitization
- Eliminates task specialization
- Reduces overtime hours

Increase in enterprise value
- Focus on value creation tasks
- Focus on the environment, resilience, security, safety, and other key issues

9 WIGARES centralized information management platform digitizes operational know-how of the manufacturing industry

To overcome this challenge, Hitachi started offering WIGARES, a centralized information management platform that automatically provides the necessary information from scattered systems and digitizes the specialized operational know-how of the manufacturing industry. This product is characterized by its ability to correlate data from different systems and to define it based on operations. The defined operational know-how can be presented to users from systems in an event-driven push notification. As a result, useful information based on expert experience can reach anyone, which can be expected to provide forms of value such as skills transmission and business efficiency.

Going forward, the company aims to provide WIGARES to a wide range of manufacturing companies in Japan while also realizing automation of plant operations through feature expansion.

Challenge

- Forklifts were used to transport raw materials and intermediate products within the factory, which was a burden on the floor workers

- Conduct unmanned transport with AGVs
- Convey according to the timing of manufacturing processes instead of the convenience of forklift operators

Benefit

- Reduced worker burden
  Achieved AGV transport approx. 80 times/ day*
- Limits onsite inventory
  Transport of items in a timely manner according to the process helped save factory floor space

Raw material preparation process > **Manufacturing process** > **Post-process**

Solution 1
Automatic transport instructions from FactRiSM according to the timing of processes

Transport pallet

Raw materials

Solution 2
AGV transport to the manufacturing process with FactRiSM SOP operation

Intermediate products

SOP: standard operating procedures
*Only supply pallets for transport and transport raw materials. Preparations are underway to start operation for intermediate product transport.

10 FactRiSM and AGV linkage

10 Case Study on Introduction of FactRiSM and AGV Linkage to Promote Automation

The promotion of automation is an inevitable trend in the manufacturing industry, and the movement toward linking manufacturing execution systems (MES) with the manufacturing equipment on the factory floor to collect results is gaining momentum.

Recently, Hitachi simultaneously introduced the Hitachi MES package, FactRiSM, and automatic guided vehicles (AGV)* to a customer aiming to implement a smart factory.

Before the introduction of this solution, forklifts were used to transport raw materials and intermediate products within the factory, which was a burden on the floor workers. However, that burden was reduced with unmanned transport by AGVs according to instructions from FactRiSM, which understands production plans, process progress, and transport constraints. In addition, automatic transport of items in a timely manner when they were needed on the factory floor helped to reduce onsite inventory and limit temporary storage space.

* The AGVs were delivered by Hitachi Industrial Equipment Systems Co., Ltd.

11 Construction of a Picking Robot System for Logistics Warehouses

As workloads increase in the logistics industry due to the increase in electronic commerce (EC) businesses and the support for high-mix low-volume shipments, the constant labor shortage is becoming an issue. In response to this issue, Hitachi is working on the utilization of logistics robots and the evolution of the operational control of the entire center as well as promoting automation and streamlining.

Hitachi recently focused on the picking work that has historically relied on manual labor and created a picking robot proof of concept (PoC) aimed at automating the work of feeding products into automatic sorting machines (sorters) and introduced the system to a logistics center in October 2022.

The features of this system are as follows.
(1) Application of high-resolution three-dimensional recognition vision systems

Recognizes the products in the bucket with high resolution and at high speed and can handle various types of packages in various positions.
(2) Automation of the entire picking process

Embeds not only picking, but also features that are required for pre- and post-processes (opening and closing bucket lids, product inversion, etc.) into the system to achieve full automation of a sequence of actions.

Going forward, the company will continue to advance automation technologies while also working on further innovations at logistics sites through the utilization of digital data.

Picking robot — Vision sensor — Product inversion device — Bucket lid opening/closing mechanism

11 Construction of a picking robot system for logistics warehouses

Storage shelf assembly

Traveling on the frame

Pallet shelves

Vertical conveyor

Picking station

Racrew

Safety fence

12 Image of the hierarchical solution

12 Racrew Hierarchical Solution

In recent years, many goods-to-person (GTP) picking systems based on AGV have been introduced as solutions to support the streamlining of tasks inside warehouses, but typical warehouses have high ceilings, and making effective use of the space above these systems has been an issue.

To resolve this issue, Hitachi developed the Racrew Hierarchical Solution which divides the picking system storage area of the Hitachi Racrew shelf transport robot into two tiers.

The adopted frame design features frame columns with low loss to minimize the impact on storage capacity. Moreover, consideration was also given so that the traveling surface of the frame would not be included in the floor area stipulated by the Building Standards Act. The storage area was not simply separated into two tiers, but was also designed with flexibility in terms of operation, such as separating the product categories and management systems managed on the second tier as well as making it possible to load conveyors and other equipment.

Going forward, the company will continue to develop and provide solutions to meet such customer needs.

13 EMilia—Integrated Management Service for Energy and Equipment

Achieving carbon neutrality requires four initiatives consisting of energy saving to reduce the amount of energy used, energy production to create and utilize our own carbon-free renewable energy sources, renewable energy source procurement to procure green energy, and offset for emitted carbon through the purchase of environmental certificates, etc.

The EMilia integrated management service for energy and equipment supports energy saving and energy production through demand forecasting using memory-based reasoning (MBR) and the drafting of optimal operation plans and equipment control which consider the operational restrictions and performance characteristics of equipment. Moreover, it also encourages renewable energy procurement by providing functions for the balancing market that assist in calculating the adjustment power that can be delivered and the correction of deviations from the target value. In addition, offset assistance by linking with external systems is also available.

By providing the EMilia service, Hitachi will continue to support resilient businesses and sustainable growth while responding to the various challenges faced by customers due to changes in the business environment.
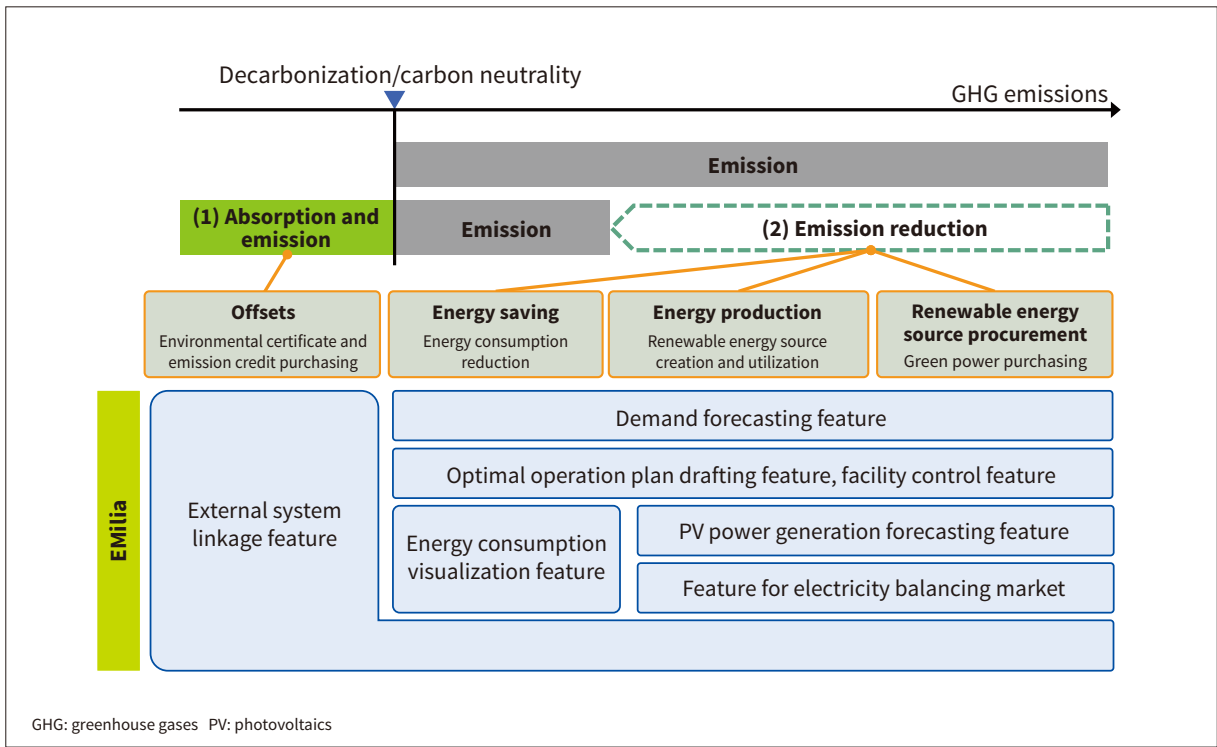
13 Carbon-neutral implementation methods and features provided by EMilia

GHG: greenhouse gases PV: photovoltaics

14 | Video Analytics Solution

Hitachi provides video analytics technologies as a way to convert various people, events, and products into digital data through video analytics to solve problems with the goal of achieving DX in the social infrastructure field.

Recently, the company has been working on developing security solutions utilizing its proven integrated physical security platform and video analytics technologies, and expanding into safety management solutions. For example, at a manufacturing site, the company developed an intruder detection solution that detects workers' unintentional intrusions into hazardous areas and a

IPU: image processing unit
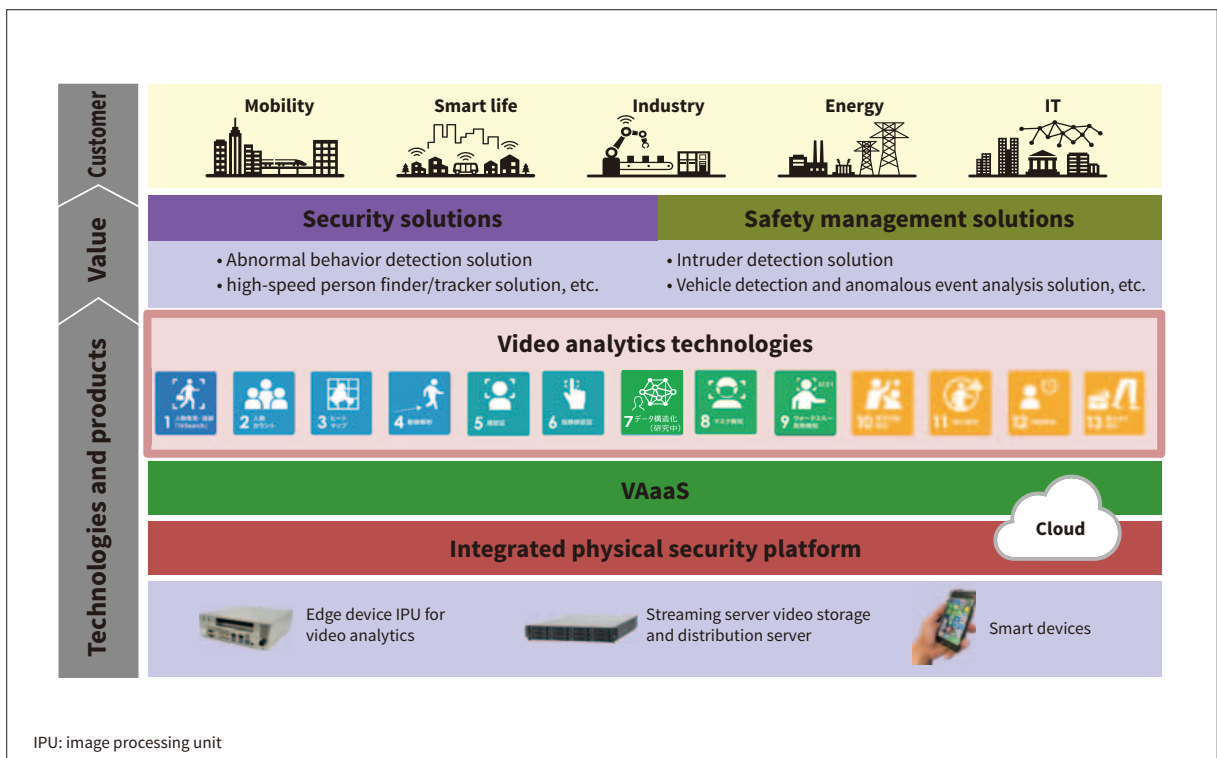
14 Solutions utilizing video analytics

vehicle detection and anomalous event analysis solution that detects falling objects on the road and the intrusion of two-wheeled vehicles and people onto highways.

Going forward, the company will provide video analytics as a service (VAaaS) to enable the utilization of video analytics as a cloud service to solve various customer issues, and will strive to develop and provide solutions that support the streamlining and improvement of operations at multiple sites across a wide area.
(Hitachi Industry & Control Solutions, Ltd.)

15 Service for Enhancing AI Value Promoting DX in Manufacturing and Logistics Peripheral Operations

In some cases, medium-sized manufacturing and logistics companies depend on manpower for coordination between systems and operations, and face a challenge in seamlessly linking information. To address this challenge, Hitachi is promoting a comprehensive proposal approach in which engineers who possess a variety of expertise work together with customers on digitization covering everything from organizing objects on the factory floor and operational flows to formulating a feasible improvement plan according to actual circumstances and constructing a system that is consistent across operations.

Hitachi's DX service, service for enhancing AI value, provides added value by utilizing AI technology to

address the issues raised in these efforts. For example, by applying this service to planning operations that must consider experienced workers' knowhow and various constraints, it is possible to automatically draft an optimal plan that takes the constraints into account while eliminating task individualization, which leads to stability and efficiency in planning quality.

Going forward, the company will expand the scope of automation by adding a service for enhancing AI value to digitization and promote initiatives aimed at realizing customers' visions for the future.

16 MBSE Utilization Solution to Support Design and Development in a Connected Era

In recent years, connected systems including mobility have been developed to connect with various external services and stakeholders. In an attempt to achieve precise control and automation that takes people and the environment into account, the requirements become more diverse, larger-scale, and more complex. In the design of connected systems, it is difficult to reconcile conflicts between requirements with conventional document-based design methods, and design rework is likely to occur.

Applying model-based systems engineering (MBSE), substantiating the relationships among multifaceted requirements in the form of a design information database, and visualizing the structure of complex requirements are
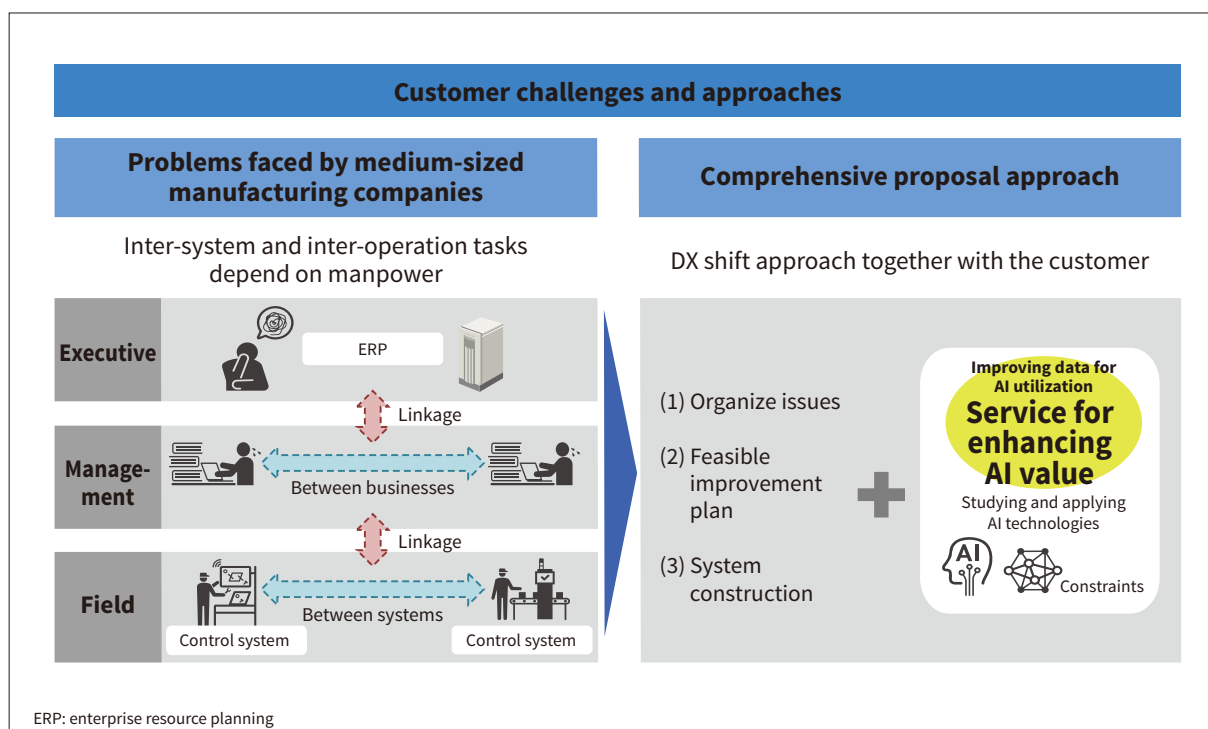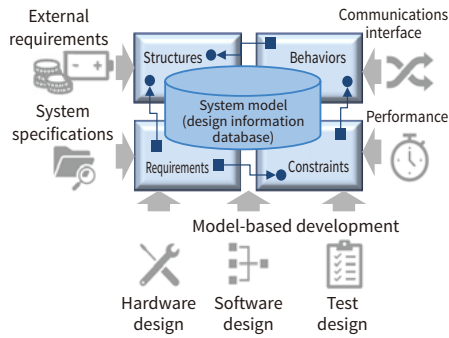

15 Customer challenges and approaches

16 MBSE utilization solution to support design and development in a connected era
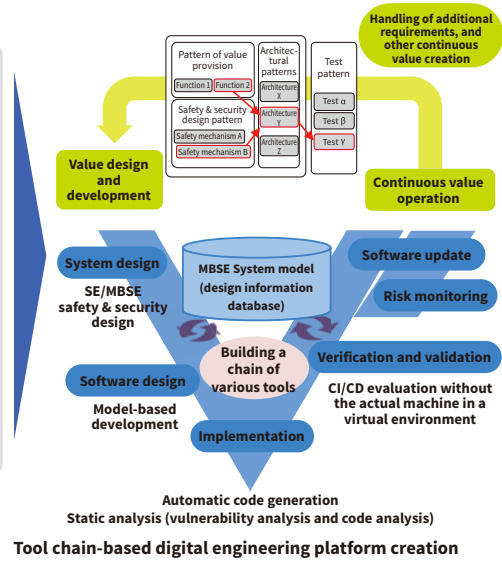
effective for resolving such issues. The MBSE utilization solution provides a digital engineering solution that integrates (1) a modeling methodology that utilizes tools, (2) an approach to systems engineering that complies with international standards (ISO/IEC/IEEE 15288), and (3) holistic view thinking that focuses on the system objectives and values (logical thinking and system thinking). As a result, it is possible to efficiently extract the scope of impact and conflicts between features associated with feature modifications, which enables rational iterative design. In addition, it enables the realization of a digital engineering platform that provides continuous value, such as early handling of additional requirements, by constructing a tool chain that seamlessly achieves design, implementation, and evaluation.