

Services & Platforms

Technologies and Services for Creating Value through the Generation, Storage, and Use of Data

[Services that Create Innovative Value through Collaborative Creation]

1 Lumada Innovation Hub Tokyo: Responding to Rapid Changes in the World

Society is changing rapidly, driven by factors such as pandemics, natural disasters, and advances in digital technology. In the midst of all these changes, Hitachi has redefined the creation of innovation as “connecting knowledge and ideas that transcend industries, space, and time,” systemizing this in a space for services and collaborative creation. As its flagship hub for this work, Lumada Innovation Hub Tokyo was opened in April 2021 at a site attached to the Tokyo railway station complex.

Utilizing Lumada’s NEXPERIENCE collaborative creation methodology, services, and solutions, Hitachi is pursuing the digital transformation (DX) of society and its customers by using both virtual and real-world forums to bring customers and other partners together with its collaborative creation facilities and a diverse range of talented people. In its first six months of operation, the innovation hub provided services to around 2,600 people despite physical movements still being restricted by the state of emergency in force in Japan at the time. The site also won the

34th Nikkei New Office Award (New Office Promotion Award) as a leading facility for collaborative creation.

The Lumada Innovation Hub Tokyo has also joined with the worldwide offices of GlobalLogic Inc. to combine capabilities in areas like design thinking and software engineering. Plans include support for customer DX through services scheduled for launch in Japan during FY2022.

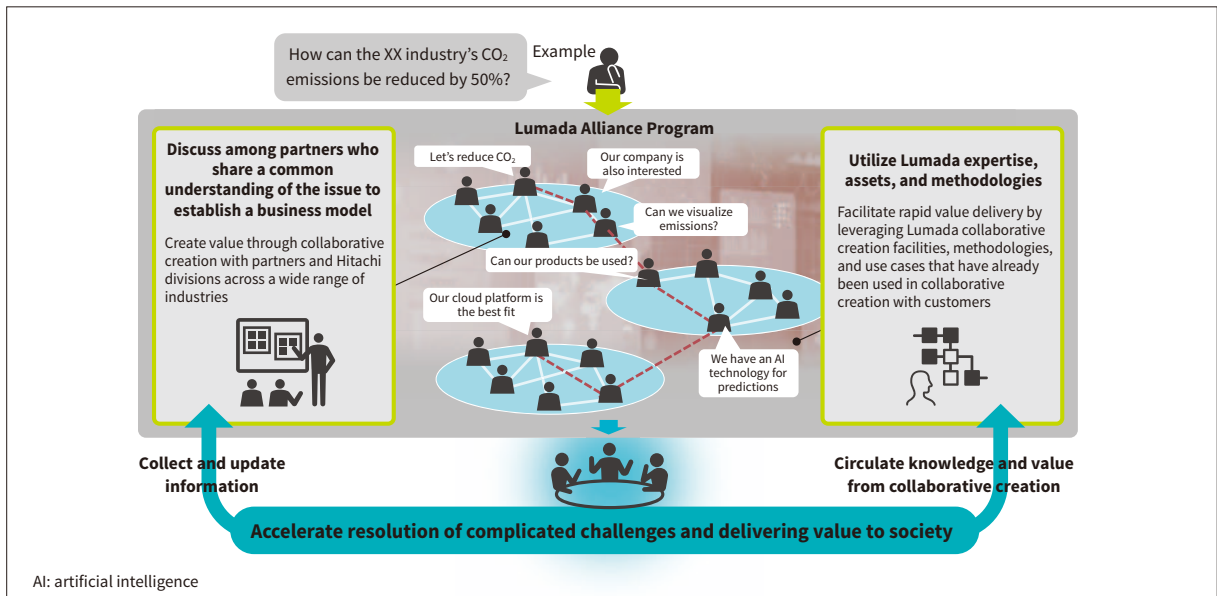
2 Lumada Alliance Program for Creating New Value out of Open Innovation that Addresses Societal Challenges

Major changes are happening in companies as their role shifts from the pursuit of short-term gain to one of delivering benefits to society as a whole and helping to create a sustainable society. It is against this background that Hitachi established the Lumada Alliance Program in 2020.

Since 2016, Hitachi has been accumulating the expertise, use cases, and methodologies it has built up through its support for customer DX as Lumada. From now on, these resources are being served as a platform for the creation of new value out of societal challenges and be made available to customers and other like-minded companies with outstanding technologies and expertise.



1 Creating innovation through collaborative creation with customers and other partners



2 Lumada Alliance Program concept

The program will transcend the boundaries between different companies and industries by serving as a forum for collaborative creation with partners addressing the same issues. It will be a place for innovative value creation that leverages the assets of Lumada and takes advantage of the different strengths of the companies involved. By accumulating and deploying the value that is created, it will also deliver sustainable growth across all stakeholders.

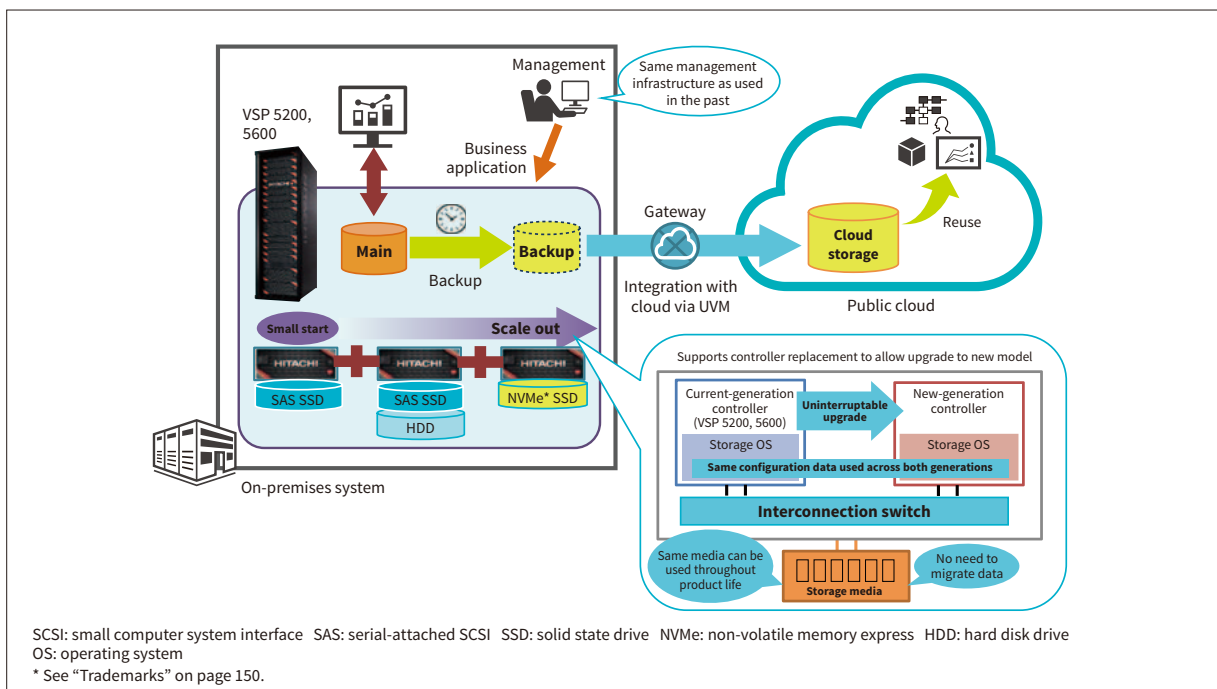
Now that companies and organizations from a wide range of industries, including global companies and startups, have already joined this program, meetups and discussions on collaborative creation between participants are being conducted on a daily basis.

[Technologies and Services that Provide a Platform for Data Utilization]

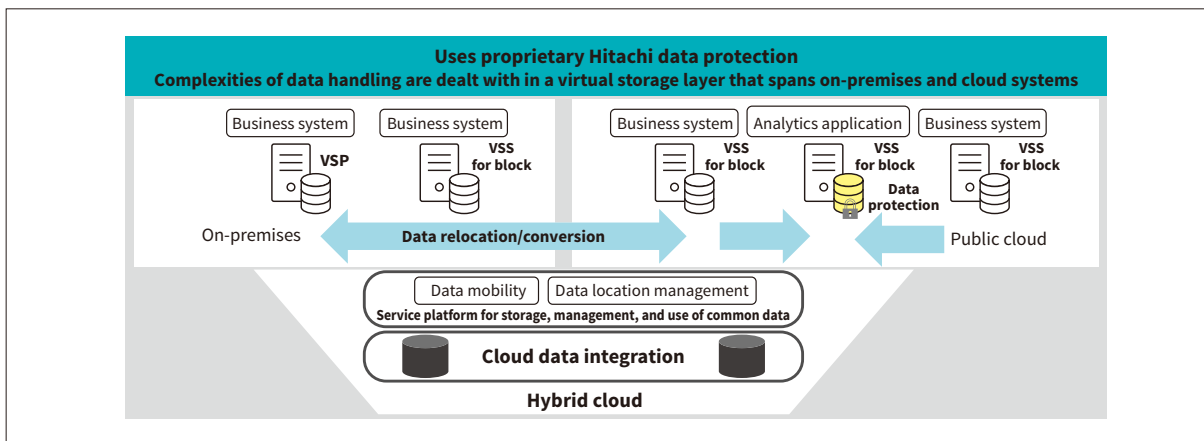
3 New Hitachi Virtual Storage Platform 5200 and 5600 with Cloud-compatible Virtualization to Enable Data Integration

While recent years have brought greater use of the cloud for IT infrastructure, an increasing number of companies are finding that their migration to the cloud is being made more difficult by a lack of configuration and operation expertise.

Hitachi Virtual Storage Platform 5200 and 5600 (VSP 5200 and VSP 5600) went on sale in October 2021.



3 Use of Hitachi Virtual Storage Platform 5200 and 5600 in a cloud environment



4 Operation of hybrid cloud linked to Hitachi storage (VSP) (under development)

These fast and highly efficient enterprise storage systems reduce the amount of work required for data migration, providing transparent interoperability for data across both on-premises and cloud systems.

Universal Volume Manager (UVM) is a proven external storage virtualization function. By expanding UVM's scope to also encompass the cloud, VSP 5200 and VSP 5600 simplify the management of data across hybrid cloud environments that combine on-premises and cloud systems, thereby accelerating companies' future migration to fully cloud-based operation.

The new storage systems feature a scale-out architecture and support upgrading of the storage controller to a newer model to allow for changes in the system environment that occur over long-term use.

4 Seamless Data Integration Functions for Distributed Data Realized by Hitachi Virtual Storage Software for block

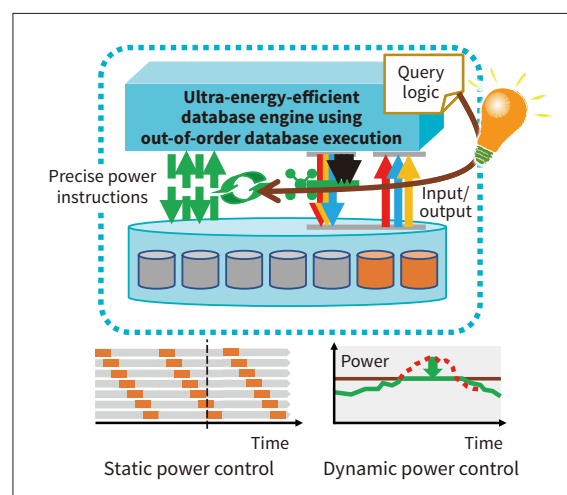
A growing number of customers have driven the DX business over recent years utilizing constantly generated data and various applications. This brings out more demand for "lift & shift" from critical IT systems to public cloud, and more demand for a hybrid cloud that seamlessly integrates systems of record (SoRs) and systems of engagement (SoEs).

Featuring data integration functions based on superior compatibility with existing Hitachi storage solutions and public cloud support (under development), Hitachi Virtual Storage Software for block (VSS for block) expands services to cover customer requirements that cannot be satisfied with existing core storage solutions. VSS for block solves the problem of data distribution by eliminating the complexities of data handling through a virtual storage layer that extends from on-premises to cloud systems.

Along with the basic capabilities of a software-defined storage (running on common servers, with flexible scale-out), VSS for block is equipped with a unique data protection technology called Hitachi Polyphase Erase Coding that provides larger usable capacity than a conventional mirroring, maintaining data access in the case of failure in multiple storage nodes. As a result, VSS for block realizes more secure and more efficient management of customers' data, accelerating data utilization with high-speed data read processing.

5 Energy-efficient Database Engine Using Out-of-order Database Execution

In collaboration with the Institute of Industrial Science, the University of Tokyo, Hitachi has developed an energy-efficient database engine technology that uses out-of-order database execution*. This technology features fine-grained parallelism and works by identifying high levels of parallelism in database processing. It also reduces power consumption through tight integration



5 Overview of energy-efficient database engine technology

with the power management of HDDs, SSDs, and other storage devices and the scheduling of fine-grained parallel execution. In evaluation testing on an Internet of Things (IoT) traceability task that simulated the operation of open pit mining, the technology achieved up to 200 times the energy efficiency of previous methods.

Work on standardizing indicators for measuring the efficiency of software energy usage in IT systems culminated in the publication in June 2021 of International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 23544:2021 Information Technology – Data Centres – Application Platform Energy Effectiveness (APEE), to encourage the improvement of energy efficiency using software.

* Using results from the study “Development of the Fastest Database Engine for the Era of Very Large Database and Experiment and Evaluation of Strategic Social Services Enabled by the Database Engine” (Core researcher: Masaru Kitsuregawa, University Professor at the University of Tokyo and Director-General of the National Institute of Informatics), which was supported by the Funding Program for World-Leading Innovative R&D on Science and Technology (Cabinet Office, Japan).

6 Next-generation Information and Control Systems for Mission-critical IoT

Hitachi has a track record of supplying mission-critical information and control systems that underpin the reliable operation of key infrastructure. Meanwhile, the requirement in recent years has been for mission-critical IoT systems that advance customer operations through the use of big data and AI for sophisticated analysis and to uncover insights that can be used as feedback for real-world control systems.

Accordingly, Hitachi draws on the operational technology (OT) know-how that it has acquired across a wide range of fields to supply customers with next-generation information and control systems that implement

mission-critical IoT applications in which the three elements of reliability, open and seamless operation, and evolution represent the key forms of value.

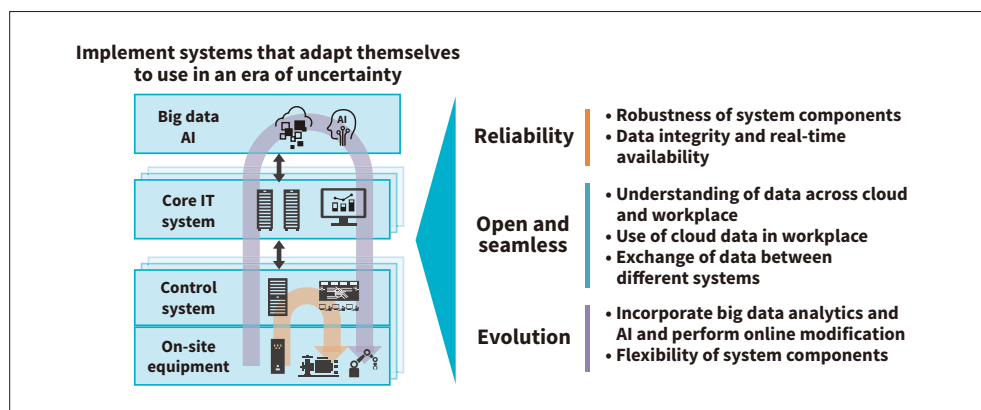
(1) Reliability: Maintain system-wide robustness extending from control systems to big data and AI applications running in the cloud, while also ensuring the integrity and real-time availability of the data used in these systems.

(2) Open and seamless: Maintain the understanding, distribution, and usability of data that enables interoperation across the fifth-generation (5G) telecommunications and other networks that link the workplace to the cloud as well as between different types of systems, including control systems.

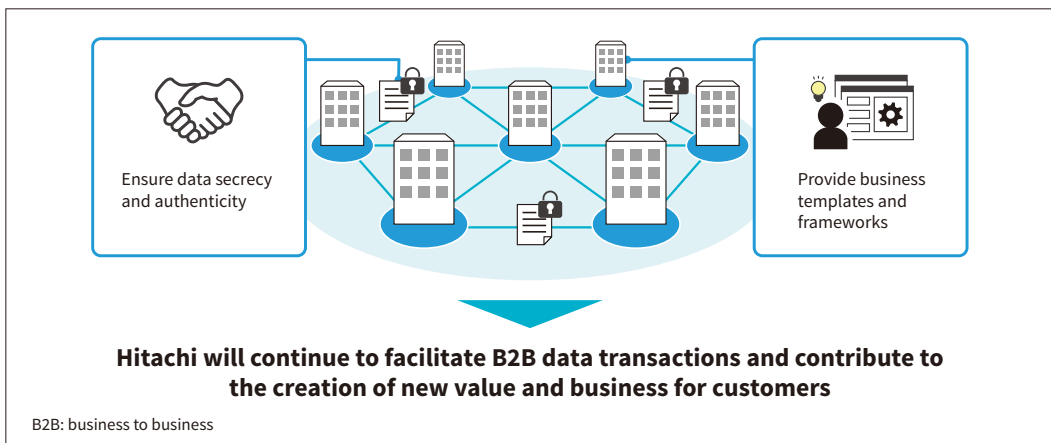
(3) Evolution: Orchestration of control systems and other functions so that their evolution can take place online. This encompasses both enhancements to edge functionality and functional evolution driven by the output of big data analytics and AI.

Through the implementation of mission-critical IoT applications, Hitachi is not only ensuring system reliability, but it is also contributing to the sustainable development of control systems by equipping them with the dynamic capabilities to cope flexibly with uncertain times, including new rules and regulations such as those associated with decarbonization or changes in user demand driven by societal changes such as the emergence of COVID-19.

The Hitachi CE50-10 Industrial Edge Computer was developed to provide just this kind of next-generation information and control system. Being equipped with the technologies required for mission-critical IoT at the network edge (close to the point of application), the CE50-10 is ready for use in DX of information and control systems in applications such as proof-of-concept (PoC) projects intended to put these next-generation information and control systems into use.



6 Next-generation information and control systems for mission-critical IoT



7 Application Service for Blockchain

7 Faster Implementation of Blockchain Systems for Ensuring Trustworthiness of Commercial Transactions

Currently, achieving Society 5.0 will require the realization of “Data Free Flow with Trust”^{*} as free data distribution to ensure the validity of the objects passed between people, organizations, and networks, and the integrity of data.

Hitachi has devised a development support service for blockchain systems that links business data held by different companies together to ensure the trustworthiness of commercial (business-to-business) transactions. The service speeds up the development and deployment of business applications that take advantage of the highly tamper-resistant nature of blockchains (distributed ledgers). Equipped with all the necessary functions, including a blockchain platform, development environment,

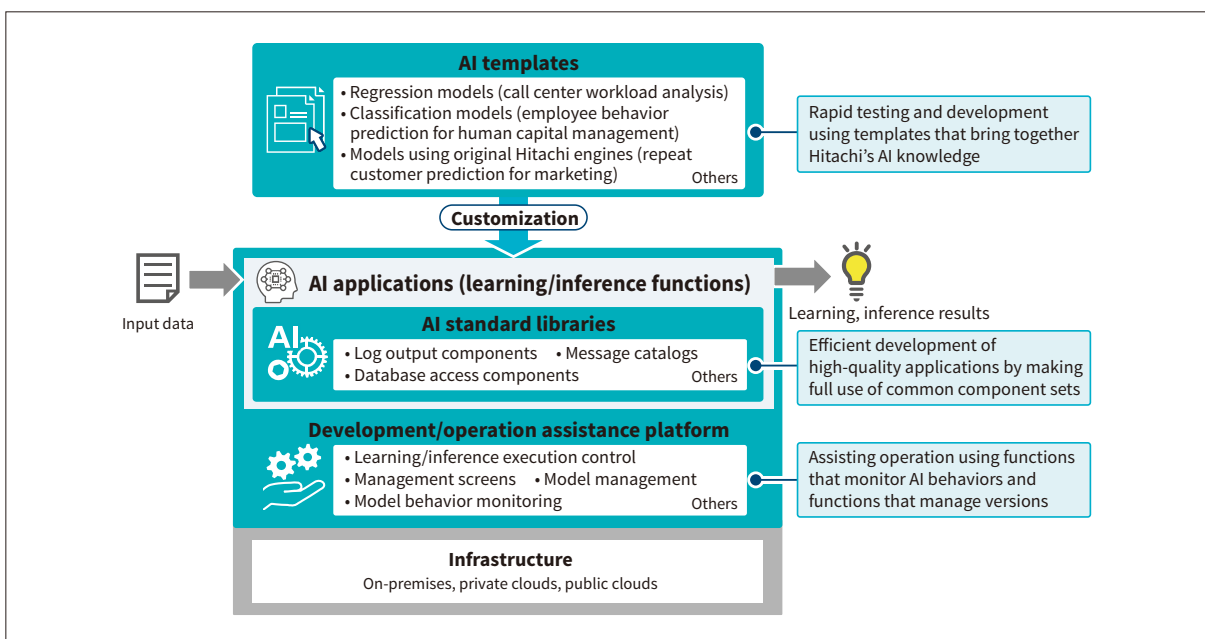
and application templates for things like electronic signatures, the service provides total support for blockchain system implementation, from provision of the core system environment to design consulting, application development, and operation.

* A concept put forward by the Japanese government at the January 2019 World Economic Forum annual meeting in Davos.

[Technologies and Services that Create Value through Use of Data]

8 Hitachi AI Application Framework for Faster AI Implementation

The use of AI in enterprise applications that support companies and other social infrastructure includes



8 Block diagram of Hitachi AI Application Framework

requirements for things like learning performance monitoring and the ability to adapt to ongoing changes to data. In practice, these requirements make the development of AI systems more difficult and present an obstacle to their deployment.

In response, Hitachi has developed the new Hitachi AI Application Framework, which supports the efficient and high-quality development and operation of AI systems to speed up AI implementation. The main features are as follows:

- (1) Use of generic “AI templates” for more efficient development
- (2) Use of “AI standard libraries” (common component sets) to improve quality and development efficiency
- (3) Use of “Development and operational support platform” to automate operation and monitoring of AI systems

In the future, Hitachi intends to continue its support for the use of AI in enterprise applications through further improvements to the efficiency of AI system development, including by expanding the range of available AI templates.

9 Anomalous Sound Detection Solution Using AI to Overcome Dependence on Skilled Staff in Equipment Maintenance and Product Inspection

Faced with a shrinking workforce, the manufacturing industry is making use of sensors and the IoT for digitalization and to improve the efficiency of its operations. This DX has only been accelerated by the COVID-19 pandemic, and in the case of equipment maintenance

and product inspection, tasks that in the past have relied on human senses such as sight and hearing, the requirements are for automation, labor saving, and the ability to perform this work remotely.

Using the presence of anomalous sound as a means of identifying potential equipment faults or quality issues, for example, has in the past relied on the experience and expertise of skilled staff. How to pass on these skills or capture them in digital form has become a major challenge that is not made any easier by the shortage of younger workers who can take the place of experienced staff.

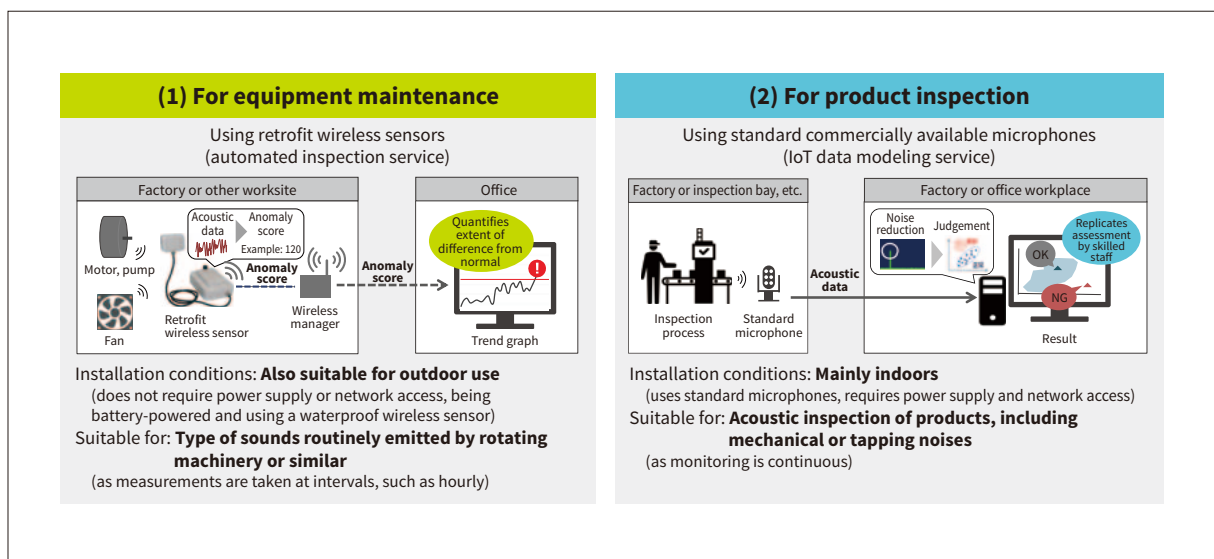
In response, Hitachi has developed a solution for use in equipment maintenance and product inspection that automatically identifies anomalous sounds in acoustic data. The following two services are available to suit different uses.

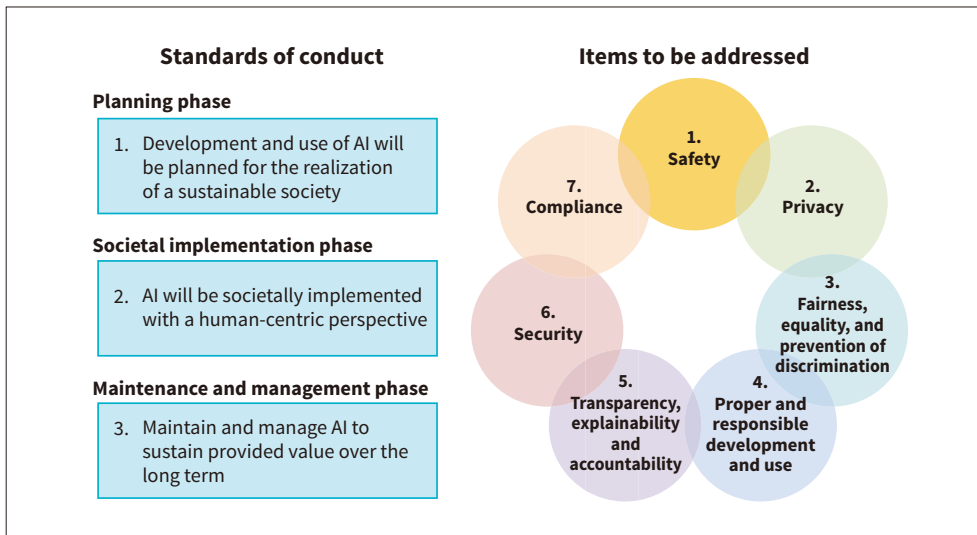
- (1) Automated inspection service for equipment maintenance

This service uses a microphone-equipped wireless sensor developed by Hitachi that is retrofittable and can detect anomalous sounds by recording and analyzing the sound of equipment operation. The sensor is suitable for outdoor installation and can rapidly highlight anomalous sounds by learning what normal equipment operation sounds like.

- (2) IoT data modeling service for product inspection

This service performs real-time analysis of the sounds made by a product or by equipment operation that is recorded using a standard commercially available microphone suitable for the type of sound and plant environment. It uses AI for precise acoustic detection, even when the sound varies over time and despite operating on a noisy factory floor.





10 Hitachi Principles Guiding the Ethical Use of AI

10 What Hitachi is Doing about AI Governance in Digital Business

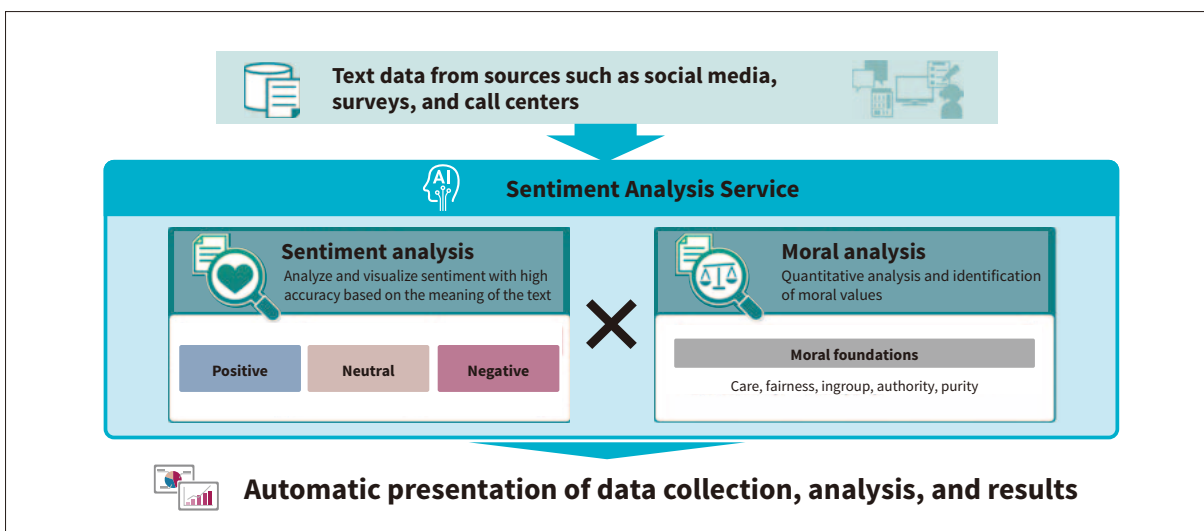
In order to achieve the human-centric development and societal implementation of AI, Hitachi has formulated its Principles Guiding the Ethical Use of AI in its Lumada-driven Social Innovation Business. These principles specify three standards of conduct and seven items to be addressed that are based on considerations such as safety, fairness, and privacy protection. The Lumada Data Science Laboratory is a hub for the collaborative creation projects of Hitachi’s Social Innovation Business and is playing a central role in this work. Specific activities include risk assessments and the establishment of countermeasures based on the Principles Guiding the Ethical Use of AI, with risk assessment and action planning for the societal implementation of AI having already got underway. Hitachi is also actively pursuing

technological initiatives in support of this work, one of which is the development of an AI application framework that includes explainable AI (XAI).

Prior to this, another initiative for ensuring that due consideration is given to privacy protection in the use of data was the establishment in July 2014 of a privacy protection advisory committee to oversee privacy protection measures. The committee has assisted with risk assessment and action planning on a wide variety of projects that involve the use of data.

11 Sentiment Analysis Service for Business that Assesses Customer Feedback in Terms of Sentiment and Morality

Amid rising public interest over recent years in “environmental, social, and governance” (ESG) considerations



11 Block diagram of Sentiment Analysis Service augmented with moral analysis

and the Sustainable Development Goals (SDGs), many companies are being called upon to go about their business activities in ways that take account of moral factors like social responsibility, corporate ethics, and human rights. In areas like marketing, it is becoming important to develop new products and services that consider the diverse moral values of end users to better meet their needs. Also vital is to be able to quickly identify and take action on things like social media flaming or infringements on human rights. The problem with this, however, is that addressing the moral values of end users is dependent on the sensitivities and experience of the people to whom the task is delegated, making it difficult to achieve a quantitative analysis and timely response.

Hitachi is helping to improve future business activities that encompass both proactive forms of marketing such as product planning and reactive marketing practices that include detecting and responding to social media flaming, incorporating a moral analysis function that is based on academically compiled dictionaries of moral foundations* and can quantitatively identify the moral values that underpin the emotional expression of things like delight, surprise, or dissatisfaction.

* The Moral Foundations Dictionary (MFD) and Japanese Moral Foundations Dictionary (J-MFD) were used.
MFD: <https://moralfoundations.org/other-materials/>
J-MFD: <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0213343>

12 Empathy Monitoring Service for Assessing Employee Buy-in with Corporate Mission or Vision

With the rapid spread of remote working encouraging a wide variety of different working practices, an increasing number of companies are concerned that this will

diminish employees' motivation and performance as well as their sense of belonging to the organization. In order to create a greater sense of belonging and to build a strong organizational culture based on a shared vision, communication between companies and staff is now more important than ever.

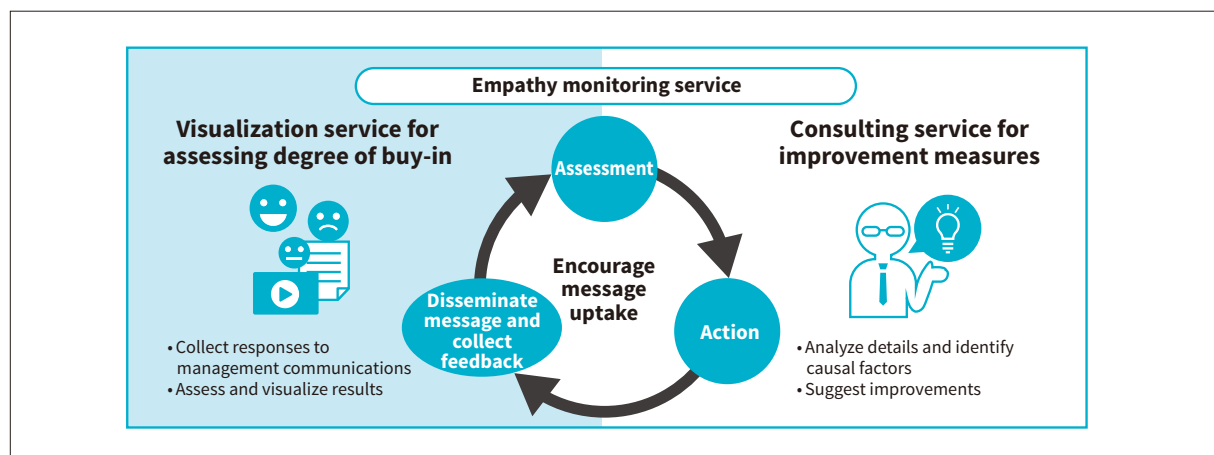
Hitachi has developed an empathy monitoring service that collects employee responses to management communications and assesses whether they achieve buy-in. This can include mission or vision statements that companies make to their staff as well as other messages from senior management. By using the collected data to identify and highlight the degree of buy-in with such messages and where any problems lie, the service can show how to communicate in ways that achieve greater engagement from staff. Companies that have adopted the service use the results it uncovers as base data in work on DX and to find ways of communicating their mission more effectively.

In the future, the service will contribute to progress on DX at a wide range of different companies and to the building of strong organizations in which staff have a positive attitude and feel enthusiastic about their work.

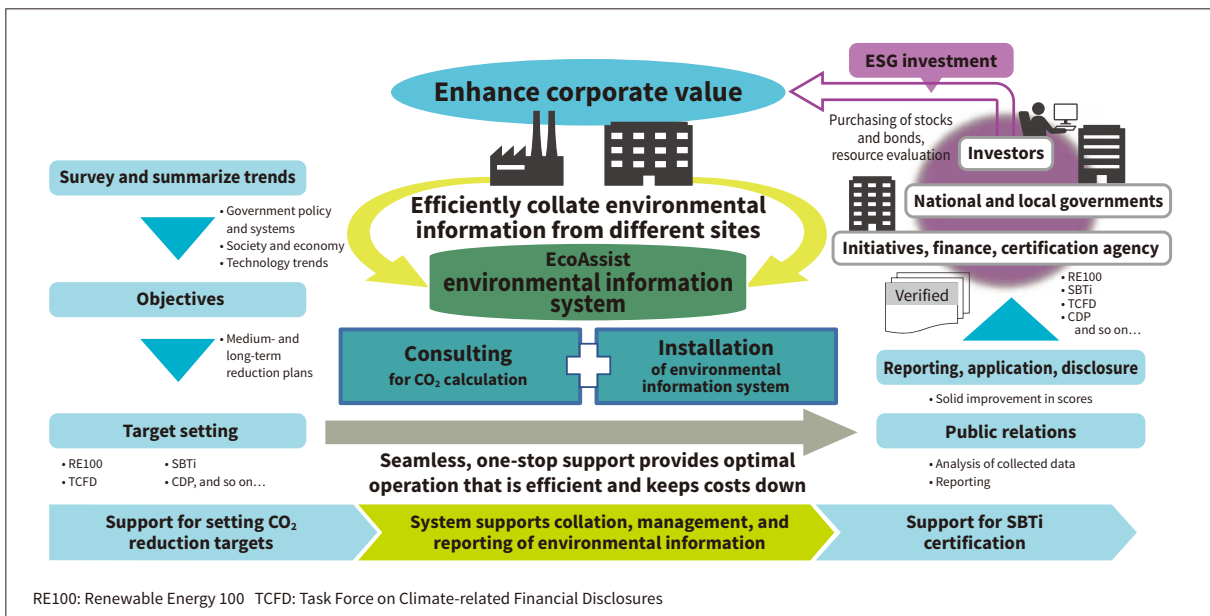
13 New CO₂ Calculation Support Service Available in EcoAssist

As institutional investors around the world pay increased attention to "environmental, social, and governance" (ESG) considerations, companies have begun working on roadmaps for achieving effective decarbonization and greater use of renewable energy.

The EcoAssist carbon dioxide (CO₂) calculation support service combines a greenhouse gas (GHG) calculation support service for decarbonization and the use of



12 Block diagram of empathy monitoring service



13 New CO₂ calculation support service available in EcoAssist

renewable energy operated by Hitachi Consulting Co., Ltd. with Hitachi's EcoAssist environmental information system that has been widely adopted by companies in manufacturing, distribution and retail, electric power, and a variety of other industries. The service provides support for non-financial disclosures such as those used as ESG investment indicators, including reporting for the Carbon Disclosure Project (CDP)^{*1} and certification under the Science Based Targets initiative (SBTi)^{*2}.

With this service, Hitachi can offer a one-stop solution for enhanced efficiency, collecting and collating the data to calculate supply chain emissions, tasks that in the past required a lot of time and effort, while also assisting with the preparation of CDP disclosure statements and obtaining SBT certification. In doing so, EcoAssist helps

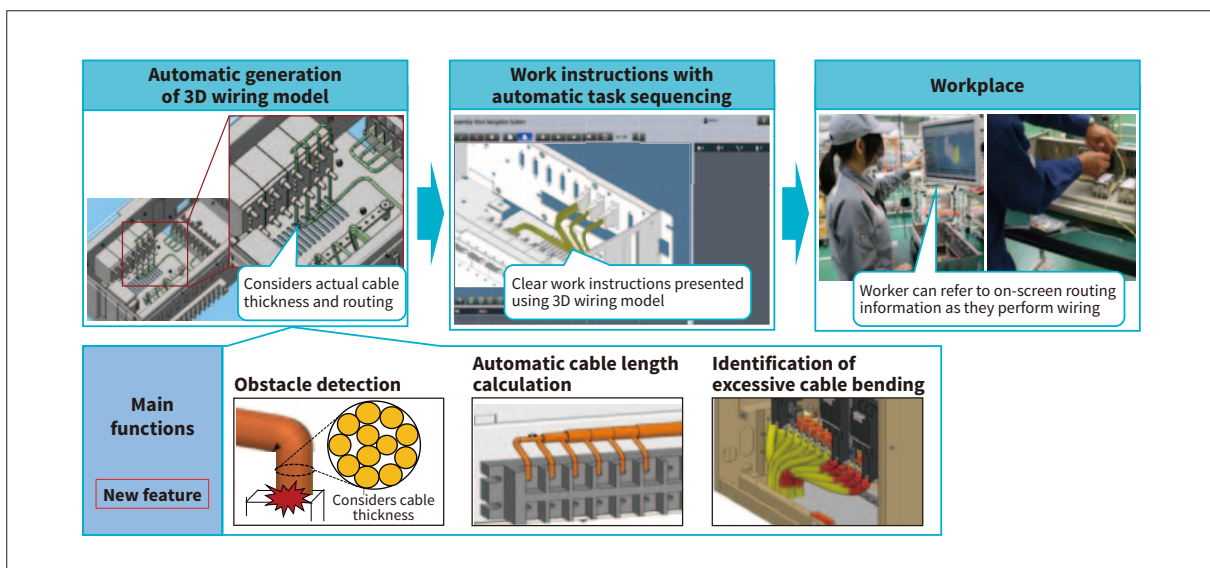
companies to improve ESG indicators and manage the decarbonization transition.

*1 An independent non-profit organization based in the UK that surveys corporate reporting on matters relating to climate change on behalf of international investors and publishes its assessments. The resulting database is used by financial institutions, investors, and research companies.

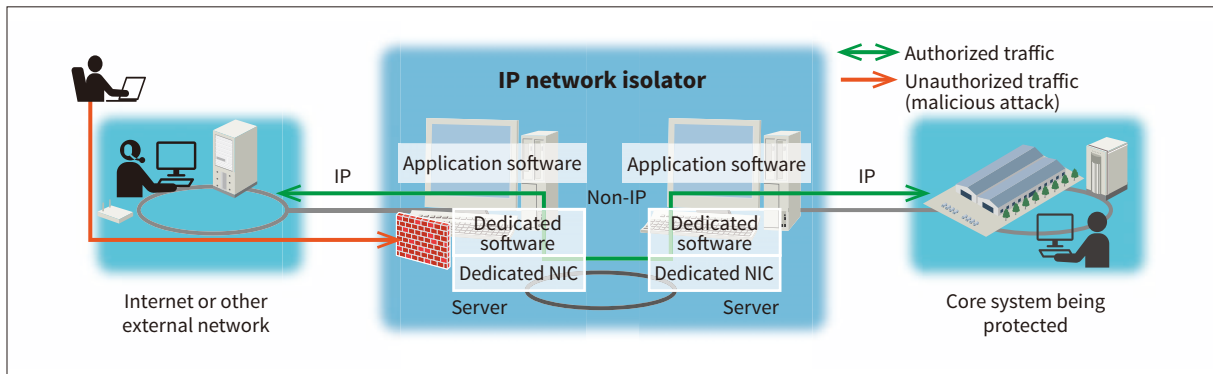
*2 An international initiative for the certification of companies that have set ambitious targets for keeping global warming to 2°C.

14 Wiring Guidance System for DX of Electrical Wiring Work

Hitachi has released an optional function for its Assembly Work Navigation System that extends support to the complex task of wiring industrial machinery.



14 New optional function for Assembly Work Navigation System that assists with wiring work



15 Example application of IP network isolator

Past practice for workers engaged in such wiring work was to use text-based wiring tables that specify how to connect parts and wiring, augmenting these with paper-based assembly drawings indicating where parts are located. A problem with these wiring tables and assembly drawings was that they did not specify how the wiring was to be routed, meaning that different workers would route cables differently. This approach also resulted in rework by designers to fix problems that only became apparent after the work commenced, such as a lack of space or other parts impeding wiring.

The newly added wiring guidance function facilitates the preparation of work instructions by generating a three-dimensional (3D) model that takes account of the actual cable thicknesses and routing. This 3D model is then incorporated into the assembly instructions. As the model is displayed along with the work instructions, the worker does not have to figure out the routing for themselves, eliminating worker variation. Furthermore, the ability to view the wiring on computer-aided design (CAD) drawings allows for third-party checking such as design reviews by other design and production personnel.

In this way, the system provides a solution for improving the quality of assembly and wiring work, enhancing the design efficiency of production engineering, and supporting optimal procurement.

15 IP Network Isolator that Protects against Communication-based Intrusions and Attacks on Core Systems

While the Internet Protocol (IP) has long been used for a wide range of applications, it is also subject to numerous security threats. Meanwhile, DX initiatives over recent years have also resulted in many industrial and infrastructure networks being connected via IP to the Internet or other external networks, thereby making these core systems a more frequent target of intrusions and cyberattacks. This has led Hitachi to develop an IP network isolator for protecting against such intrusions by using non-IP communications to handle the exchange of data at the entry and exit points to these systems.

Along with dedicated control software, the IP network isolator is made up of two servers with dedicated network interface cards (NICs) that connect them together in a non-IP network that operates using the same basic technology as Hitachi's $\mu\Sigma$ NETWORK-1000 control network. To exchange data via non-IP communications, the application software programs on the servers read and write data to the memory-mapped NICs. Dedicated software (proprietary macros) is required to read and write data to the NICs that are partitioned into separate areas for each system, thereby making intrusions or other forms of cyberattack more difficult. In the future, Hitachi plans to offer this technology in appliance form to facilitate wider use.

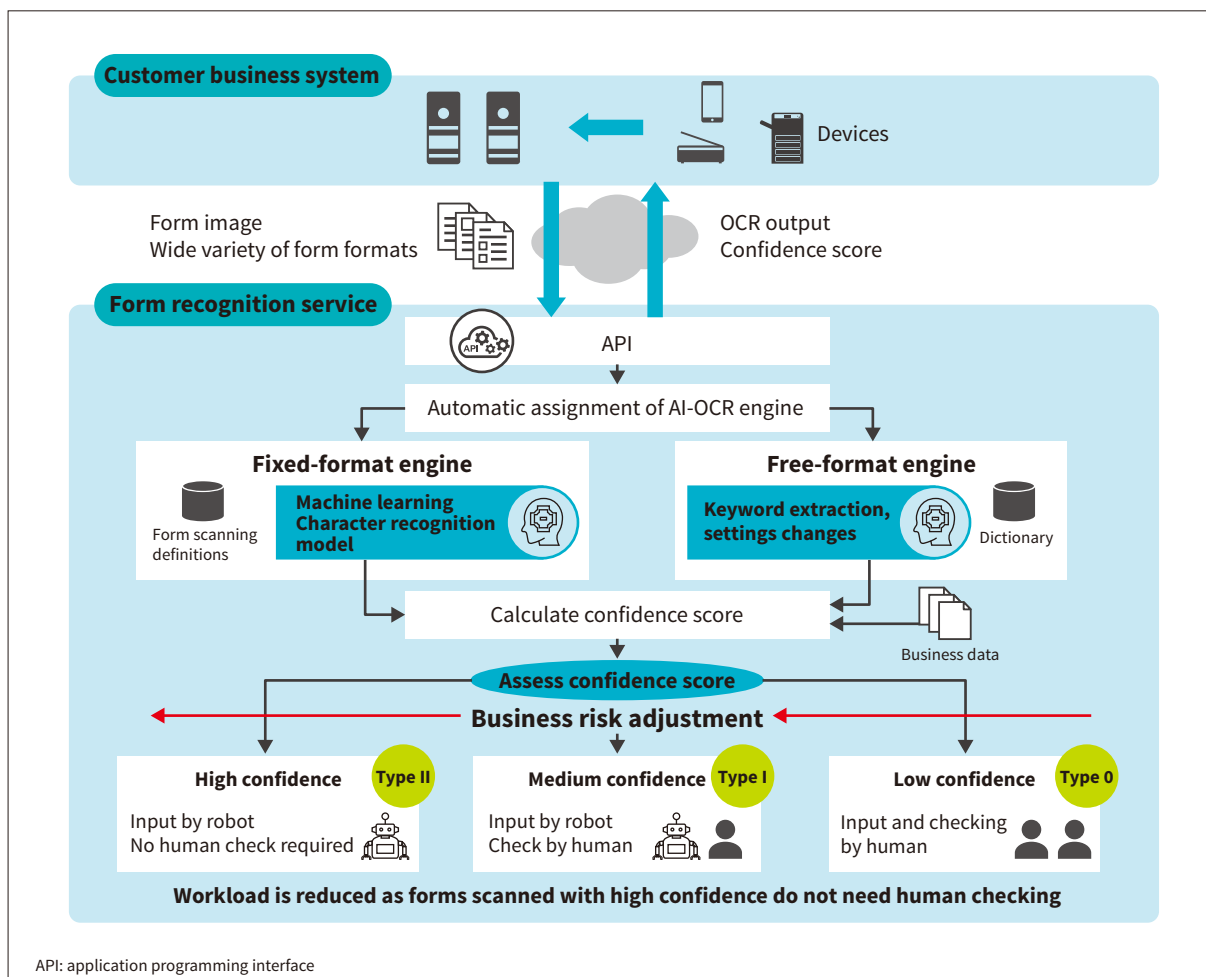
Solutions and Value Created through the Cloud and Digitalization

16 AI-OCR-based Form Recognition Service for More Efficient Processing of Forms

Digital solutions are currently being adopted to boost operational efficiency across a wide range of activities.

This is also true of paper-based tasks, for which Hitachi has launched a form recognition service for automating forms processing and making it more efficient.

The service is able to scan a wide variety of forms in both fixed and free-format forms. As well as displaying



16 Technology for using form recognition service to boost operational efficiency

the text of scanned forms read by optical character recognition (OCR), it can also calculate a confidence score that indicates the reliability of the OCR result. When this confidence score is high, the information from the form can be recorded automatically without the need for human checking, thereby improving the efficiency of operation while reducing the risk of mis-recognition. Moreover, because the service is equipped with a number of different AI-based OCR systems (AI-OCR) for different customer business practices and can automatically assign whichever best suits a particular form, users implementing form recognition do not need to worry about how many different types of forms they use. Along with its use to process transactions at Hitachi's own accounting departments, the service is also helping to make forms handling more efficient for a wide range of customers.

17 DX with Cybersecurity: Protecting Smart Factories from Security Threats

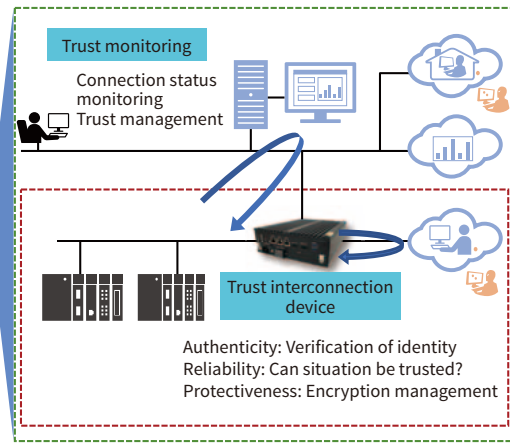
The use of DX to provide smarter ways of doing things at factories is accelerating as companies seek to maintain

competitiveness through the launch of new businesses or reforms to production practices. However, with DX comes a need for interoperation with internal and external systems and the adoption of equipment with standard interfaces, and this brings greater security threats to business continuity and to “security, quality, delivery, and cost” (SQDC).

In response these new security threats, Hitachi supplies a wide range of solutions for DX that take account of factories' needs for business continuity and SQDC. These solutions extend from strategic planning to support for system implementation, operation, and human capital development.

- (1) Strategic planning: Support extends from risk assessment to security strategy formulation, enabling smarter practices that are closely coupled with business strategy.
- (2) System implementation support: Hitachi supplies products and services to support DX system implementation from both a business and plant perspective.
- (3) Operational support: Supports the maintenance of trust in DX systems.
- (4) Human capital development: Training and drills that cover the security skills needed at different areas

| Category | Solution |
|-------------------------------|--|
| Strategic planning | Formulation of security strategies for DX |
| | Situation assessment and risk analysis for specific DX initiatives |
| | Trust and security planning for specific DX initiatives |
| System implementation support | Assistance with implementing security systems for DX |
| | Provision of trust-aware equipment and packages for control applications |
| Operational support | Assistance with trust operation (issuing and management of certificates) |
| | Integrated monitoring (control, security, and trust) |
| Human capital development | Equipping “plus security” staff needed for DX |
| | DX drills (security and control) |



17 DX with Cybersecurity solutions

and levels of the organization to make the smart factory transition.

Hitachi intends to continue supporting advances at smart factories based on the pursuit of DX.

18 Hitachi's SOC Service that Detects Actual or Suspected Cyberattacks on Vehicles and Related Systems

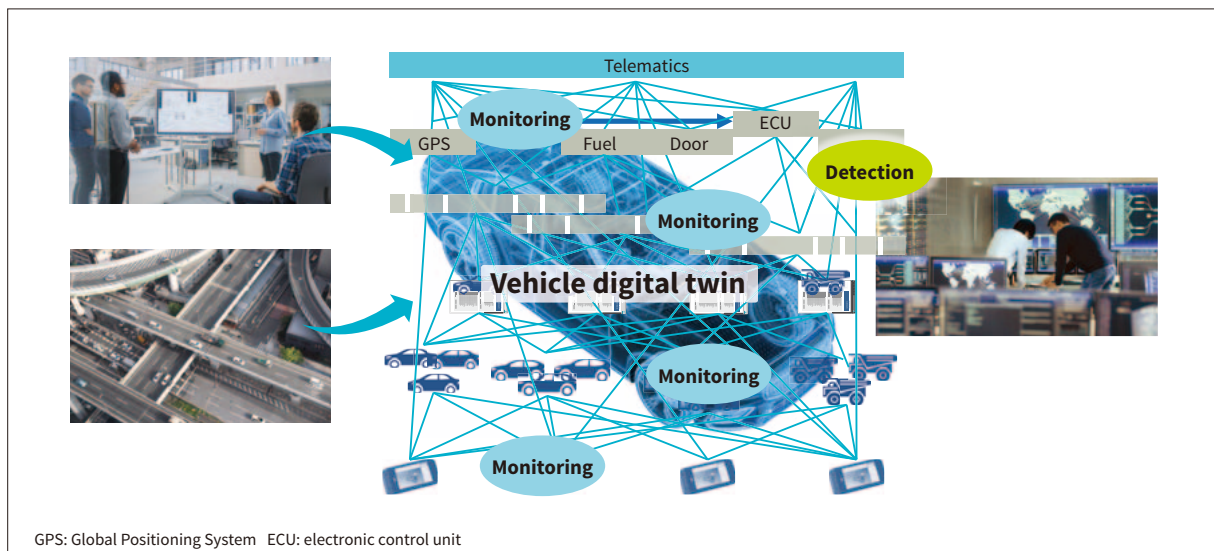
The spread of connected cars has brought a heightened risk of cyberattacks. As the forms of cyberattacks are continually evolving, this calls for ongoing security measures, with legal protections also being put in place around the world.

Hitachi's security operation center (SOC) service for vehicles draws on Hitachi's experience and know-how from the development of automotive products and its

operation of factory security and SOCs to provide a security monitoring service for automobiles that provides real-time monitoring of logs and other data collected from vehicles and related systems. This enables early detection and a rapid response to both actual cyberattacks and the warning signs of possible attacks.

The service uses vehicle “digital twins technology” that combines design information on vehicle functions and behaviors with actual operation to provide security monitoring in a way that takes account of the vehicle's context. It works by comparing actual and anticipated operation for the early detection of both known and previously unknown threats that cause a deviation from normal behavior.

* Technology that collects information in real (physical) space such as IoT and recreates the real space in cyber space based on transmitted data.



GPS: Global Positioning System ECU: electronic control unit

18 Security monitoring using vehicle digital twin