Research & Development

Fundamental Technology

May 28, 2026

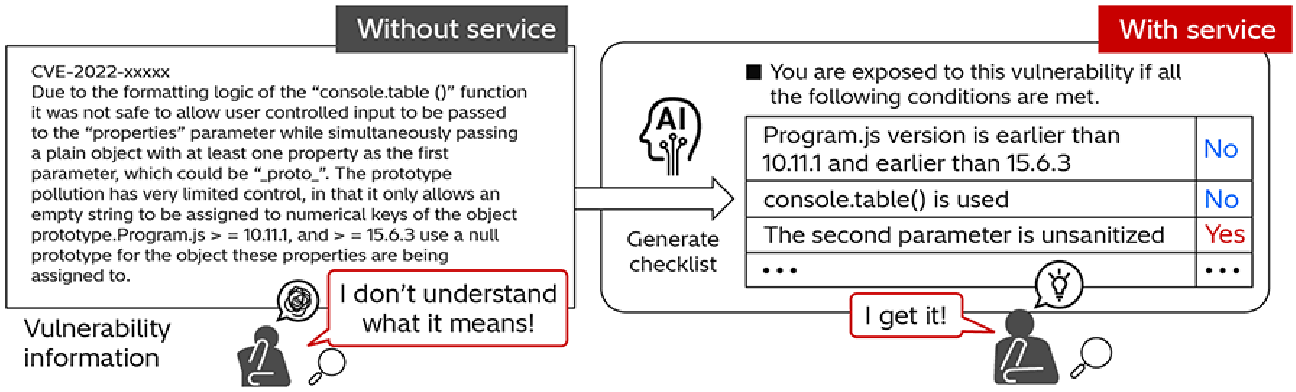
Innovation & R&D

1. AI for Ensuring Ongoing Security

An increasing number of cyberattacks in recent years have targeted vulnerabilities in Internet-of-Things (IoT) products, creating a need for manufacturers to consider the risk of attack and ensure security across entire product lifecycles. In particular, security regulations such as the European Union's Cyber Resilience Act (CRA) require manufacturers to take rapid and effective action on any vulnerabilities that exist in their products or services. Moreover, taking action on these vulnerabilities requires knowledge of the products and security measures so as to determine the conditions under which products may be impacted based on vulnerability information. Another problem is that investigating issues is time-consuming as many manufacturers lack knowledge and are short of personnel who can deal with product security. Exacerbating this, it can be difficult for employees with little experience of security investigations to even understand this vulnerability information.

In response, Hitachi has developed a vulnerability analysis service that uses generative artificial intelligence (AI) to supplement the security knowledge needed to take action on vulnerabilities in IoT products or systems. The service can provide checklists indicating the conditions under which products may be impacted by vulnerabilities. Use of the technology also enables an efficient response to vulnerabilities, being able to shorten the amount of time it takes to investigate their impacts by about 45% compared to past practice.

By making this technology available to enable prompt action on vulnerabilities, Hitachi is helping its customers strengthen their business continuity.



[1] Overview of Vulnerability Analysis Service

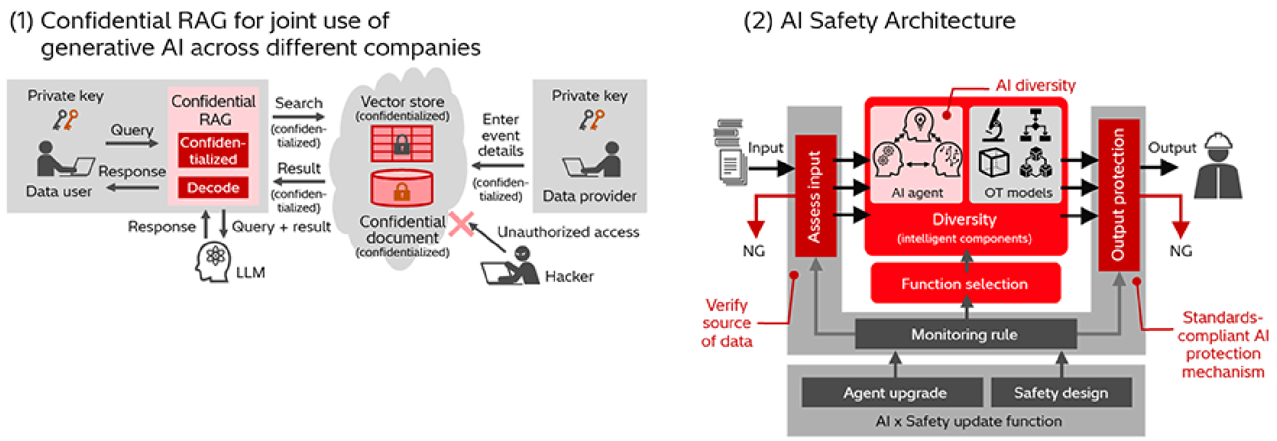
2. Security and Safety for AI

To facilitate the deployment of AI in mission-critical applications, Hitachi has developed two techniques for ensuring the secure and highly reliable use of AI without knowledge leaks or the generation of erroneous instructions.

(1) Confidential retrieval-augmented generation (RAG) technique for protecting confidentiality in joint use by different companies of sensitive data on past activities
The emergence of generative AI has facilitated the use of RAG to extract knowledge from data that companies hold on their past activities and to put this data to use in company operations. However, it remains difficult to collect instances of failures or other incidents in mission-critical activities given that these occur with a rarity that belies their significance. While the use of RAG to share such information between companies offers one way of overcoming this issue, the tendency of these incidents to be highly confidential is an obstacle to their disclosure to other companies. It is in response to this that Hitachi developed confidential RAG as a means of performing similar search on a vector store while keeping the knowledge in encrypted form.

(2) AI safety architecture
Hitachi has developed an architecture for the safe application of AI to mission-critical operations and a number of accompanying safety features. This implements a system configuration that minimizes erroneous outputs by excluding input data that fails an

authenticity check on the input information, utilizes a diversity approach that uses a redundancy system to improve decision-making reliability, and performs safety analyses using operational technology (OT). By doing so, it enhances the safety of AI-equipped systems.



[2] Overview of Security & Safety for AI

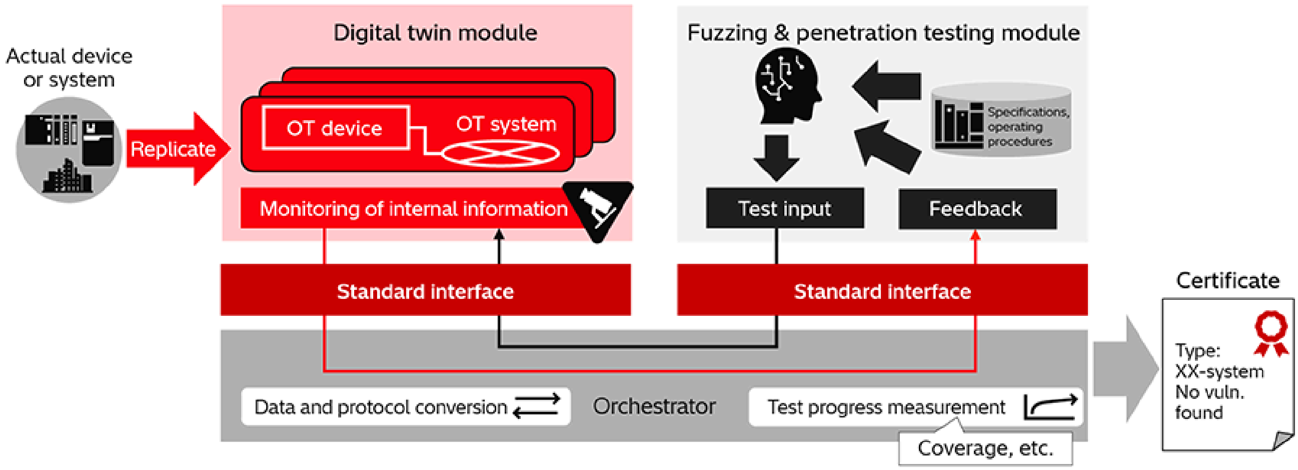
LLM: large language model

3. OT Security Test AI

The OT realm, which includes control systems and devices, has been targeted by a series of cyberattacks over recent years, with new security vulnerabilities being discovered all the time. This has made it increasingly vital that comprehensive and rigorous security tests are conducted prior to the shipment and commissioning of OT devices and systems. Unfortunately, the OT industry has poor knowledge of security issues compared to IT and the proprietary nature of the specifications and communication protocols used makes reliable testing difficult to accomplish.

In response, Hitachi is researching and developing the use of AI for automated security testing in OT. This involves creating a digital twin of the system or device under test and acquiring details of internal states such as memory. Next, an AI is trained on the system's specifications or operating procedure documentation to generate and execute test cases. By repeatedly regenerating the test cases while keeping track of changes in the internal state of the system, this achieves comprehensive test coverage without human intervention. The technique will help to improve the safety of key infrastructure such as electricity and railways.

Note that this work was based in part on the results of the Economic Security Critical Technology Development Program / Enhancement of Advanced Cyber Defense Functions and Analytical Capabilities project (JPNP24003) commissioned by the New Energy and Industrial Technology Development Organization (NEDO).



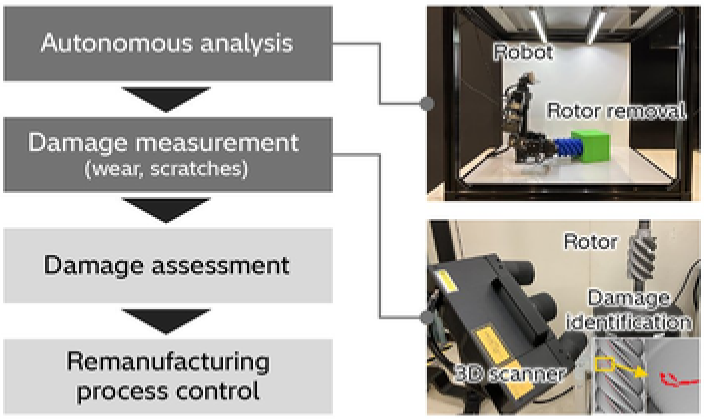
[3] OT Security Test AI Framework

4. Manufacturing and the Circular Economy: Disassembly and Remanufacturing Process Driven by Physical AI

Achieving economic viability for resource circulation is vital to realizing a circular economy. This requires efficient disassembly and remanufacturing processes to retain the value of remanufactured parts. Hitachi has developed two technologies. One is robot disassembly that can take products apart carefully and efficiently. The other involves optimizing the remanufacturing process through measurement and assessment of the disassembled parts.

As the condition of used products varies, the disassembly process needs to adjust the force it applies accordingly. Hitachi has expertise in physical AI that is capable of complex and intricate automation using multi-modal data and plans to utilize this in disassembly robots in the future. To determine whether removed parts are able to be reused, Hitachi has developed a technique for applying three-dimensional (3D) measurement to identify scratching or other damage with a resolution of 5 μm. As heavily damaged parts can be restored to function by re-plating, the goal wherever possible is to remanufacture items with minimal energy use as highly valuable parts rather than treating them as no more than a source of materials.

In the future, Hitachi intends to develop and implement remanufacturing technologies for actual products and the use of physical AI for their autonomous disassembly and value assessment. In doing so, it will help to establish resource circulation that delivers both economic and environmental benefits.

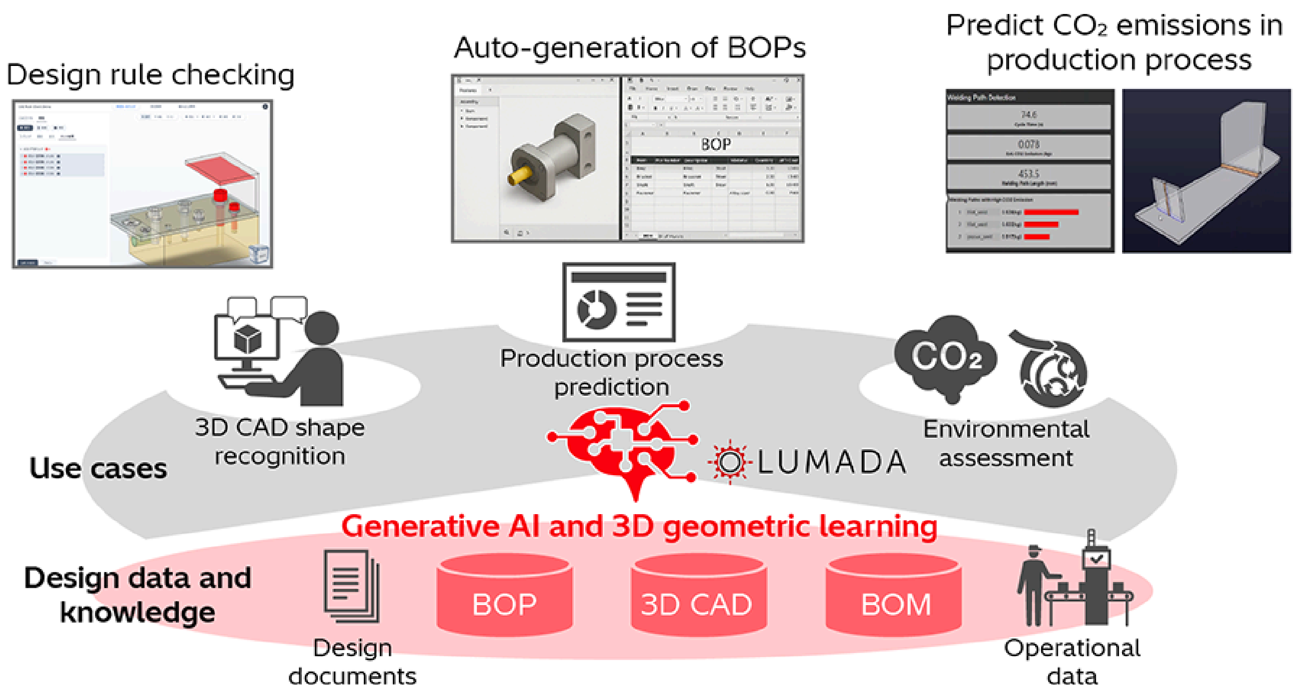


[4] Remanufacturing Process for Screw Compressors Driven by Physical AI

5. Innovation in Design for X Using Generative AI

As the environment in which manufacturing operates becomes increasingly complex, the industry is being called on to satisfy a wide range of requirements. In the product design process, for example, the requirement is for “design for X” whereby, rather than just product functions and performance, a wide range of other factors (Xs) need to be considered at the design stage. Examples include environmental performance and ease of manufacturing and maintenance. Accordingly, Hitachi has developed a way to accomplish this much more efficiently using generative AI and 3D geometric learning.

Design rule checking is one use case. This involves, for example, checking that 3D computer-aided design (CAD) models satisfy a geometry rule whereby holes in a plate must be separated from its edges by a distance at least twice the plate thickness. This uses generative AI, first to extract the design rules from the design documentation and then to auto-generate a program for performing the check. To ensure that the system can deal with reasonably complex design rules, it also uses a proprietary library of 3D geometry functions. In this way, it can implement design by X in a variety of forms while also improving manufacturing productivity. It can, for example, generate a bill of process (BOP) or predict CO_2 emissions in the production process by using a learning model of 3D geometry trained on past CAD data to identify the features of a 3D CAD model.



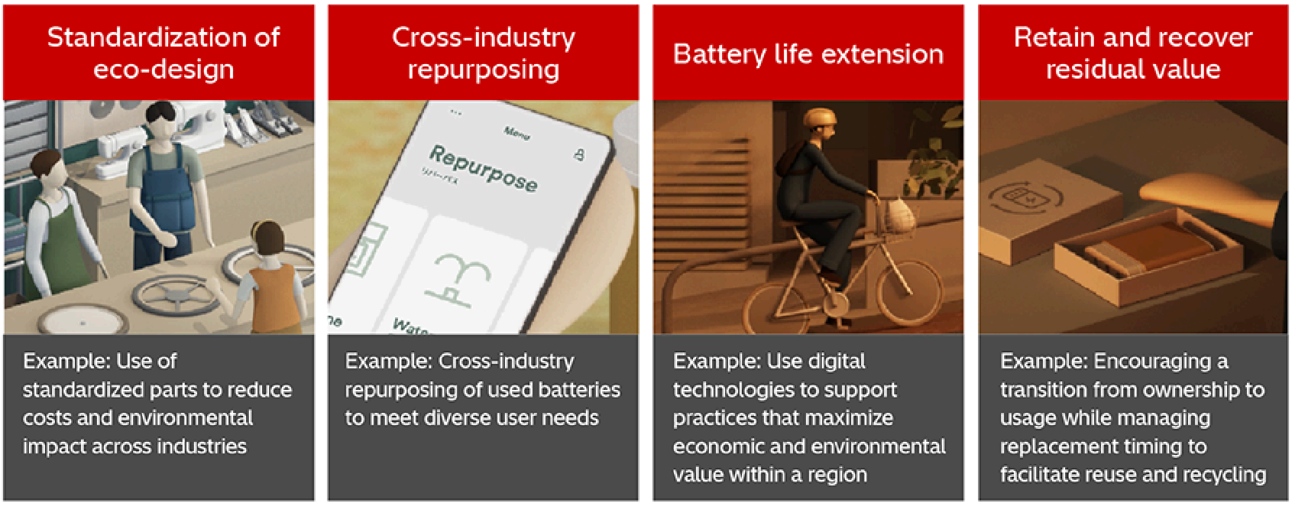
[5] How Design for X is Implemented Using Generative AI and 3D Geometric Learning

BOM: bill of material

6. Deep Dive into Possible Circular Economy Scenarios and Exploration of Desirable Futures

The Hitachi-AIST Circular Economy Cooperative Research Laboratory has identified "possible futures" and "desirable futures" as part of the grand design for realizing a circular economy. In the initial phase, future scenario simulations were utilized to analyze the cause-and-effect relationships among factors that play a role in the circular economy. This process led to the identification of nine "possible future" scenarios. From these, scenarios were selected that offered a good balance among rules, technologies, and people in promoting circularity, and in which the efforts of those engaged in circular economy initiatives are appropriately aligned with the benefits they receive.

Next, discussions were held with experts to identify the prerequisites for the rules and technologies that will be crucial to realizing these scenarios. Based on these discussions, the desirable future that people would feel motivated to pursue was defined as a society that functions in a manner inclusive of a diverse range of viewpoints and that encourages circular practices. To provide more concrete vision, examples of social mechanisms supporting the desirable future were articulated. Ongoing work will seek to clarify the specific requirements for making the transition to a desirable future, including incentives to promote this transition and a roadmap for achieving it.

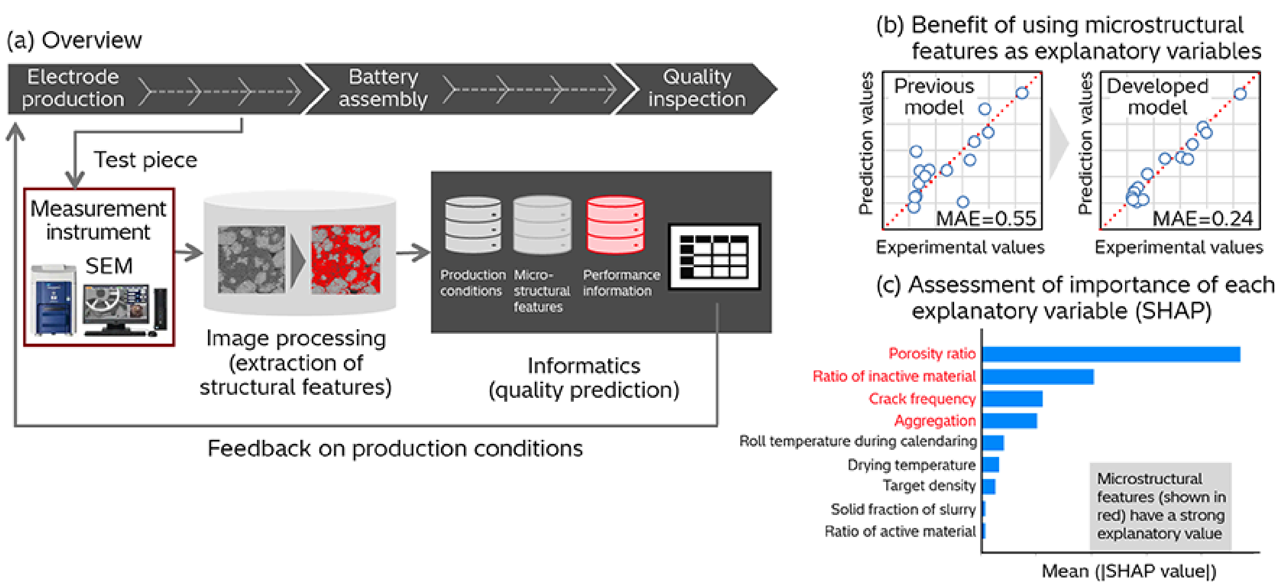


[6] Examples of Social Mechanisms Supporting the Desirable Future

7. Measurement and Informatics Technology to Support Frontline Manufacturing Workers

Faced with the need to respond rapidly to changing markets, the manufacturing industry needs ways of ramping up production lines quickly and improving production yield. To address this, Hitachi, Ltd. and Hitachi High-Tech Corporation have been investigating a process improvement solution that combines AI with a production process database to support frontline workers.

While the large amount of training data needed to make accurate predictions has been a problem in the past, Hitachi has succeeded in improving the prediction accuracy using small amounts of data by focusing on intermediate products and combining informatics with microstructural feature extraction derived from measurements. One example involved using machine learning to reduce mean absolute error (MAE) in the production of lithium-ion batteries. This improved on a previous method that was based on production conditions by instead treating microstructural features obtained by the analysis of scanning electron microscope (SEM) images of electrode sheet surfaces as explanatory variables. By providing an indication of the relative importance of each explanatory variable, this also improved model explainability. It is expected that this technology will reduce workloads and the amount of trial and error involved in the commissioning of production lines.



[7] Example Application of Measurement and Informatics to Production of Lithium-ion Batteries

SHAP: Shapley additive explanations

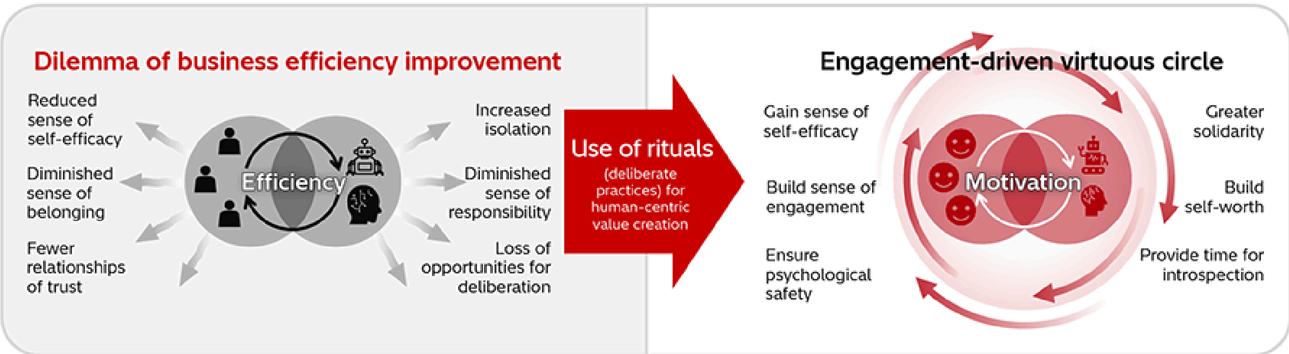
8. Use of Ritual in Redesigning Motivation for Era of Collaboration with AI

While collaboration with AI or robots can improve work efficiency and quality, it also denies people opportunities for learning by trial and error and risks undermining the motivation and self-worth they derive from the process. In response, the Research &

Development Group at Hitachi is seeking to go beyond the simple pursuit of efficiency and define work in a way that places people's motivation at its core.

Hitachi has already established methodologies for human-centric value creation, including ethnography that factors in what people value, vision design that envisages desirable futures, and behavior design that changes how people think and act.

While future collaboration with AI will boost individual efficiency, it is also expected to diminish opportunities for gaining a sense of self-efficacy or belonging, and for forming relationships and building consensus. In response, Hitachi is seeking to adopt rituals (deliberate practices) that encourage introspection and boost engagement with the organization, and to design experiences that encourage overlap between what individuals want and the vision of the organization. By doing so, the goal is to create business processes in which everyone can make full use of their individuality and creativity and feel motivated in an environment where collaboration with AI is the norm.



[8] Transcending the “Efficiency” Dilemma by Designing for Motivation in the Era of Collaboration with AI