Hitachi Review

Volume 65 Number 3 March 2016

HITACHI
Inspire the Next

Special Issue "Hitachi Technology 2016"

www.hitachi.com/rev

Hitachi Review
Volume 65 Number 3 March 2016

Hitachi Technology 2016

CONTENTS

Inspiring the World with Open Innovation

I would like to begin by thanking all of you for your ongoing support of the *Hitachi Review*.

With the rapid urbanization currently taking place around the world, especially in emerging economies, there is an urgent need for infrastructure to support ever-increasing populations, including the maintenance of energy security and the construction of transportation networks. Meanwhile, developed economies are searching for better ways to provide healthcare in order to cope with an aging population and to ensure that people enjoy long and healthy lives.

While environmental changes and other trends present challenges for societies throughout the world, they can also be seen as part of a broad movement that is shaping our future. Hitachi recognizes these developments as a major opportunity for innovation, and we are working to deliver solutions to the challenges faced by customers and communities around the world. Our Social Innovation Business, which combines advanced information technology (IT) with infrastructure technologies developed over many years, provides us with a strong foundation upon which to approach and try to solve these issues.

As more societies become globalized, these challenges broaden in scope and impact greater numbers of stakeholders. There are also many cases where it is beyond the capabilities of any one organization to find appropriate solutions. To achieve solutions that deliver greater value, it is essential to adopt an approach based on open innovation that transcends the borders and barriers between companies and industries, between industry, government, and academia, and between national and community levels. Hitachi calls this "collaborative creation" and is working in partnership with customers and other companies on projects in fields such as water, energy, and transportation.

The leading article in this issue of the *Hitachi Review* draws on the perspective of experts who are familiar with the true nature of open innovation. The content describes how Hitachi is implementing new service platforms using advanced data utilization technologies. Other articles focus on solution developments that anticipate reforms to the electricity system in Japan and on collaborative creation in the field of railway services, which is a key part of the transportation infrastructure. In addition, there are articles that demonstrate how Hitachi and a customer are combining their expertise to improve the efficiency of hospital management, and to make logistics smarter through tools that can be used to promote group-wide collaboration and collaborative creation with customers.

The explosive growth in the use of communications devices and sensors in recent years is ushering in a new era of the Internet of things (IoT) in which numerous different devices are connected by networks. With the IoT, which is expected to transform people's daily lives and business activities, there is the possibility of causing revolutionary changes, right now in the 21st century, that rivals the industrial revolution of the latter half of the 18th century. Hitachi's Social Innovation Business with its foundation in the advanced know-how in IT utilization that the company has developed over many years demonstrates its true value even more so in a time like this. Beginning with the case studies covered in this issue, we hope you will look forward to the challenges we plan to address in the future as well.

During this inspiring time in history when revolutionary changes are taking place, Hitachi is holding steadfast to its Mission of "contributing to society through the development of superior, original technology and products." Working closely with numerous partners, we will strive to live up to the expectations of the world.

T. Higashihara

Toshiaki Higashihara
President & CEO, Hitachi, Ltd.
(as of April 2016)

Visionaries 2016

After first touching on the viewpoints of experts with regard to open innovation, these articles describe five aspects of Hitachi's Social Innovation Business through the voices of the people involved.

Visionaries 2016

The 21st-century Industrial Revolution

— Creation of New Value through Open Innovation —

Chris Anderson, former editor of *WIRED* magazine and now CEO of 3D Robotics, presented a special lecture at the Hitachi SOCIAL INNOVATION FORUM 2015 –TOKYO– held in October 2015. Author of worldwide bestsellers, *The Long Tail, Free,* and *Makers,* Mr. Anderson is known for having proposed some of the key concepts for making sense of the web era. An extract from the lecture, this article looks at what is happening right now in the manufacturing industry and what companies should be doing in response, and presents a unique perspective that offers insights into the true nature of open innovation.

Historic Significance of the Three Industrial Revolutions

I have used the term maker movement to describe the third industrial revolution in which technology is driving a new model of innovation in manufacturing.

The first industrial revolution replaced muscle power with machine power, and in doing so achieved a three-to-fourfold boost in productivity. This led to the birth of the modern city as people began to cluster around factories. The low-cost production this made possible brought with it a better quality of life.

In the second industrial revolution, it was brain power that was replaced by machines. This involved the "democratization of computers," with "desktop" and "personal" being key words. However, this was not yet enough, and the missing piece was the democratization of tools for distributing information. This was achieved in 1995 with

the emergence of the World Wide Web (WWW) as a new concept. Whereas past technologies such as printing presses and the means of distribution have been the preserve of major corporations only, it is now possible to make information available to any number of people simply by clicking on a button in a browser.

The key words for the third industrial revolution are "mechanical" and "digital," symbolized by three-dimensional (3D) printers and cloud manufacturing. The practice of collaborating with other people on the web to build something by oneself is growing, with tools for manufacturing spreading to schools and the home. In other words, it is now possible to build physical objects for yourself.

Chris Anderson
CEO, 3D Robotics

2007 as a Turning Point

2007 was the year the maker movement really got started, with the release of a groundbreaking robot development kit and new home game consoles. It was also the beginning of the explosive growth in smartphones that continues to this day, and the year in which I began developing unmanned aerial vehicles. I was able to use the web to obtain the knowledge I needed to build them using toy blocks. This ability to use toys to build a flying robot felt to me like a major turning point in history. I went on to form an online community called DIY Drones and established 3D Robotics with a young colleague I met there. I chose him as my collaborator because of his extensive knowledge of factories.

The continued evolution of robots in the future will leave two paths open for human beings: you either program the robots, or you take out the trash. Humans will need to exhibit their creativity. On the other hand, things like access to skills or working through a community have become easier, making it possible to work as a team in which each participant contributes what they do best.

Answer to be Found in Open Innovation

While the economist Ronald Coase stated that the purpose of the company is to minimize transaction costs, that model of the company clearly belongs to the 20th century. In contrast, Bill Joy, co-founder of Sun Microsystems, said that, "No matter who you are, most of the smartest people work for someone else." The answer to this paradox is to be found in open innovation. If you create a platform or community, it will naturally attract talented people from around the world. Having already shifted from company-versus-company to product-versus-product, the nature of competition in the 21st century will be about ecosystem-versus-ecosystem, making it a battle between platforms. This phenomenon can be seen in the competition between major social networks taking place on the web. To own a platform or to participate in one: we need to look at these as the two pathways to success. It seems likely that such an era will give rise to corporate practices that allow others to be successful on the corporation's own platform.

Visionaries 2016

IT as a Platform for Interconnection

— Advanced Techniques for Using Data —

The growing use of digital and network technology has made it possible to obtain data on all sorts of real-world phenomena. How to handle large volumes of diverse forms of data is emerging as a determining factor in corporate value, with the potential to transform the way things are done in the future. Hitachi has been researching the corporate use of data from early on and supplies technologies for the collection and high-speed searching of large volumes of data. It also supplies various techniques for the realtime integration and consolidation of data and its analysis and other uses in the form of big data platforms. Hitachi is playing a leading role in the creation of new value through advanced solutions for the use of data based around open innovation.

Innovation through Tracking Status of People and Things

With information technology (IT) being used in a wide range of situations, from corporate business systems to industrial machinery, infrastructure, smartphones, wearable devices, and vehicles, today's networked society is constantly generating huge volumes of data. Furthermore, there are growing expectations for the achievement of initiatives such as social reforms and the development of business models that transcend conventional demarcations by putting these large and diverse volumes of data to use in the form of big data.

Since before the term "big data" was first coined, Hitachi has been engaged in research aimed at producing value from the large volumes of data generated by infrastructure and other industry. Makoto Yasuda (Senior Technology Evangelist,

and is used for applications such as encouraging greater activity at events or shopping centers. Human big data is a solution for measuring the level of activity in an organization by using wearable name tag sensors to measure people's activity. It can be thought of as one example of the IoT. Tracking the status of things has been implemented in systems with sensors attached to infrastructure or industrial machinery and process the operational data in realtime to detect signs of potential accidents or faults and to initiate preventive actions.

Makoto Yasuda

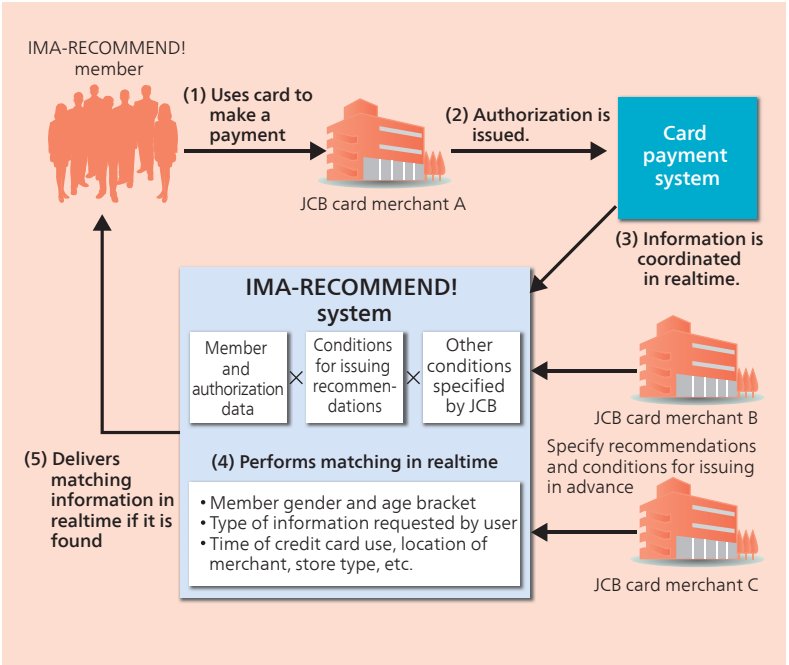
Enabling Realtime Use of Big Data

One example that represents a step forward in the use of big data is IMA-RECOMMEND! in which Hitachi is jointly engaged with JCB Co., Ltd., a credit card company. This service uses the authorization data generated by use of a credit card to trigger analysis and issue coupons for participating stores nearby. The analysis combines the promotional needs of participating merchants with information such as the customer's basic details and preferences to generate a recommendation that matches the needs of both the customer and merchants, and delivers a coupon to the customer's mobile device in realtime. A trial of the service ran for six months from October 2014 in the Shinjuku district of Tokyo, involving approximately 10,000

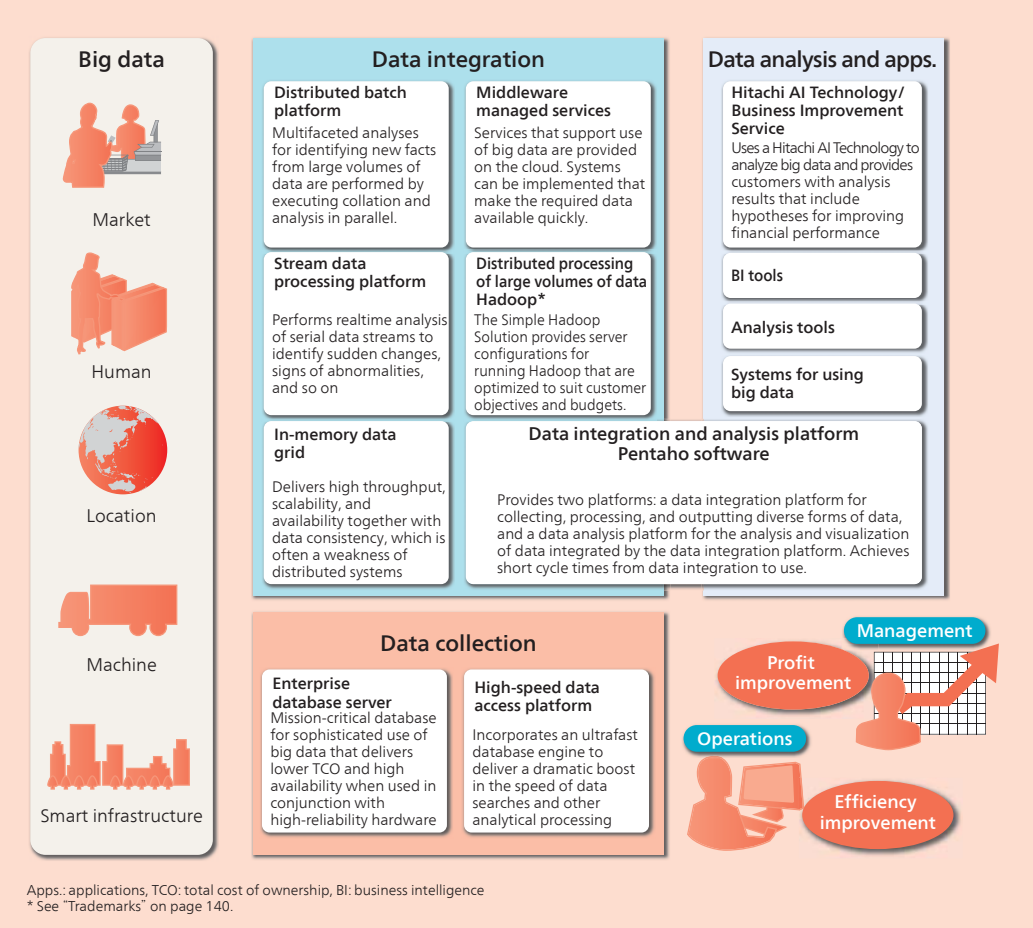
Systems & Services Business, Information & Telecommunication Systems Company, Hitachi, Ltd.), one of the key people engaged in big data applications, describes this work as follows.

"We have developed a variety of technologies for using data to track the status of the three elements of business, namely: people, things, and money, and for utilizing these for business innovation. In particular, we have put a lot of effort into techniques for tracking people, such as human big data and measuring the flow of people, and technologies for visualizing the status of things that can lead to solutions, including what has come to be known recently as the Internet of things (IoT), recognizing these as areas where Hitachi can put its strengths to good use."

Measuring the flow of people involves techniques for measuring how people move through specific areas while allowing for privacy concerns



Overview of the IMA-RECOMMEND! service for issuing coupons and information in response to card transactions. The service pays close attention to realtime performance and location, and issues information by obtaining an accurate assessment of customers' purchasing behavior and matching this with member attributes and preferences.



Apps.: applications, TCO: total cost of ownership, BI: business intelligence
* See "Trademarks" on page 140.

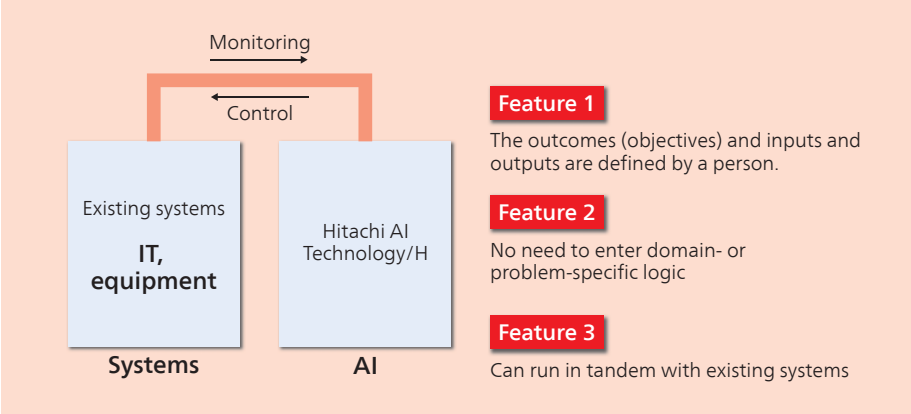
IT platforms supplied by Hitachi for using big data. Platforms cover a wide range of activities, including data collection, integration, analysis, and use.

JCB cardholders and 215 participating stores. It resulted in an increase in both visits to participating stores and in the value of purchases.

As Mr. Yasuda explains, IMA-RECOMMEND! is more than just a service for issuing coupons. "The key point is the execution of a sophisticated matching algorithm at high speed that links together data from different areas, namely marketing and the flow of people. This makes it possible to provide people with the information that they need at a particular instant and that is matched to their location, circumstances, and preferences." Widespread applications are expected for this innovative service model, which makes sophisticated use of data to present customers with what they are seeking in realtime and with a high degree of accuracy.

Supporting this sophisticated use of data are IT platforms that incorporate the technologies and know-how built up by Hitachi though its work as an IT vendor. One example is the high-speed data access platform*, which incorporates an ultrafast database engine that can perform searches and other analytical processing at high speed. Along with data matching for IMA-RECOMMEND!, its applications cover a wide range and include civil defense systems such as one that provides quick predictions of damage due to volcanic eruptions. The integration and consolidation of different types of data, meanwhile, enables the analysis and use of big data in realtime. Hitachi technologies are used in IMA-RECOMMEND! for realtime data integration, and also stream data processing, complex event processing (CEP), and in-memory data grids.

Mr. Yasuda states, "Use of big data extends from uncovering the useful elements contained in data to the point where they enable specific value-creation action. As in the project with JCB, we intend to expand our involvement in collaborative creation and collaboration in the future based on highly reliable IT platforms that Hitachi is uniquely equipped to provide, thereby helping achieve innovation and overcome challenges faced by customers."



Overview of Hitachi AI Technology/H, an AI developed by Hitachi. The AI can learn from data and grow in accordance with the conditions while producing results.

Kazuo Yano

* Utilizes the results of "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" (Principal Investigator: Prof. Masaru Kitsuregawa, The University of Tokyo/Director General, National Institute of Informatics), which was supported by the Japanese Cabinet Office's FIRST Program (Funding Program for World-Leading Innovative R&D on Science and Technology).

AI Makes the Leap from Data to Value

The use of big data is entering a new phase. To raise that level further, Hitachi has recently augmented its IT platforms with a new proprietary technology called Hitachi AI Technology/H, where AI stands for artificial intelligence. Kazuo Yano (Corporate Chief Scientist, Research & Development Group, Hitachi, Ltd.), who supervised development, looks back on that project as follows.

"Our research into world-leading uses for big data has involved considerable trial and error ranging from looking at individual items and collating widely scattered data to considering how we can create value in ways that generate corporate profit. The gap between data and value is wider than you might think. This led us to start AI development early in our research as a way to bridge this gap in an efficient manner."

Using golf as a metaphor for the relationship between data and value, whereas the only data that could be obtained in the past was the number of shots for each hole, the use of sensors and other technology means that it is now possible to collect tens of thousands of data points from each hole. It is then possible to analyze this data to identify correlations and generate hypotheses for how to achieve a better score, such as the fact that taking two practice swings results in longer drives. In other words, there is no point in collecting lots of big data that records actual events unless it leads to better results (small data). The techniques and methods for generating hypotheses for bridging this gap, by identifying correlations, lie at the core of big data applications.

Naturally, these hypotheses can also be generated by drawing on human intuition and rules of thumb. Unfortunately, there is a large cost in time and money associated with acquiring such experience and trying to make sense of large volumes of data.

Mr. Yano expresses his pride in his work by commenting, "Our development has targeted systems in which humans decide those matters that are best left to humans, such as defining the problem and choosing which data to use, while leaving the rest to be taken care of by AI. Such systems can jump directly to the value layer from the layer in which detailed actual data is collected, without human intervention. This is a key feature that currently only Hitachi AI Technology/H possesses."

Creating Value through Humans and AI Working Together

Hitachi AI Technology/H has been put to successful use in a variety of industries since the research and development stage. When used to issue picking instructions in a warehouse management system, for example, use of the AI shortened the time taken to complete the work by 8%.

Mr. Yano states, "Not only can Hitachi AI Technology/H respond flexibly to changing demand by selecting for itself which big data relating to warehouse management to use, it can also understand the workplace initiatives and improvements made by human staff, formulate hypotheses, learn from the results, and incorporate this into the work instructions it issues. That is, it can make process improvements in cooperation with

Wearable nametag sensors used for the collection of human big data. The sensors are used to measure data on the wearer's movements and to make improvements to things like workplace productivity and employee satisfaction.

human staff."

Since November 2015, the technology has been supplied as the Hitachi AI Technology/Business Improvement Service for resolving corporate management issues. This service formulates process improvement measures by using Hitachi AI Technology/H to identify elements in business big data that have a strong correlation with such objectives as improving financial performance or reducing costs. The advantages of using AI go beyond a reduction in workload. Its capabilities also extend to identifying correlations between data and business results deemed by human rules of thumb to be of little significance, or devising innovative measures from a different perspective to that adopted by people.

Hitachi AI Technology/H and human big data have also been combined to develop a service that helps overcome challenges by identifying the factors that influence the level of activity in an organization and evaluating the degree of influence. It is currently being used with The Bank of Tokyo-Mitsubishi UFJ, Ltd. in an initiative aimed at improving workplace productivity, and with Japan Airlines Co., Ltd. in a trial aimed at improving employee satisfaction. This technology is likely to be used in a wider range of industries in the future to make improvements in business efficiency and productivity with humans and AI working together.

Mr. Yano states, "What matters is that we can use Hitachi AI Technology/H regardless of the industry. It is able to learn from data and come up with ways of generating value without having first been supplied with specialist expertise. By speeding up the learning cycle across society as a whole, this has the potential to lead to breakthroughs that will provide a dramatic boost to economic productivity."

The use of big data and Hitachi AI Technology/H could bring major changes to the nature of business and society.

Incorporation of Advanced Technologies and Different Cultures

As noted earlier, big data means not only that the volume is large but also that it originates from a wide variety of sources. In the use of big data, the significance is in the integration of data of various different types for analysis and the identification of correlations. What matters here are the functions that enable data from different systems to be used together and the platforms that support them.

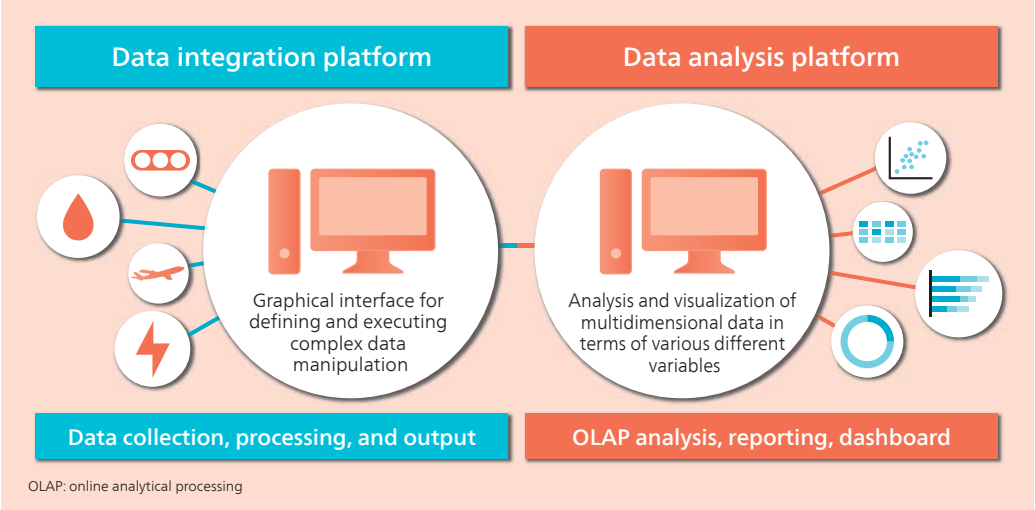
In June 2015, Hitachi acquired Pentaho Corporation, a US company that develops and supplies software for big data analytics. Pentaho's software supports a diverse range of data and provides advanced functions for integrating data from various business systems and other applications and for performing multifaceted analysis and visualization.

Another major feature of the software is that it is open source. Hiroyuki Kumazaki (President, IT Platform Service Innovation Management Division, Information & Telecommunication Systems Company, Hitachi, Ltd.), who manages the IT platform business, describes these features and the background to the Pentaho acquisition as follows.

"The open source Pentaho software is developed by a community of engineers from around the world. While the software itself is used by more than 1,500 companies, Pentaho has released an enhanced version for which it charges a royalty and which it has made better to use in ways that include conducting testing and adding functions. This business model of drawing on the open source community is new to Hitachi, and as we work on things like collaborative creation and open innovation with customers and partners, as Social Innovation, I see the open source concept and culture as things of great significance that will bring changes."

The Pentaho software is equipped with functions for everything from integrating data that is spread across systems to its analysis and use. As well as serving as the core of IT platforms that are essential to the use of big data, it is also seen as injecting new genes into Hitachi as the company experiences growing use of digital and network technology and a paradigm shift in business that is

Hiroyuki Kumazaki



Overview of Pentaho software. Pentaho provides two platforms: a data integration platform for data collection, processing, and output, and a data analysis platform for the analysis and visualization of the integrated data.

overturning past wisdom.

New Links Provide a Basis for Value Creation

While use of big data currently remains within the borders of individual companies, what will happen once it expands to encompass multiple companies in the form of a value chain?

The concept put forward by Mr. Kumazaki is large in scope. "In manufacturing, for example, by integrating corporate business systems that form a value chain, including the procurement of parts and materials, product assembly, and the logistics of market distribution, and by analyzing the resulting big data, it will be possible to optimize production by responding in realtime to things like demand fluctuations and changes in the material supply conditions. If we can combine business optimization solutions that utilize components for using AI or data from the Pentaho software or elsewhere by linking numerous different corporate systems together based on the symbiotic autonomous decentralized systems concept, and implement all of this as service platforms that generate a high level of value, it is likely to result in a transformation in the way various different industries operate." Nevertheless, this is no mere dream.

A recent trend that has attracted attention in the finance sector is that of "fintech," a term coined in the USA to mean a combination of finance and technology. Similar transformations are also likely to take place in many other industries in the future. The essence of this is that advances in IT enable data to be combined and enable companies and other organizations to work together in ways that were never envisaged in the past. These new links will bring major changes to existing industries and serve as a basis for things like paradigm shifts and value creation.

What are needed to encourage such new links are forums that make it easy for anyone to participate.

Mr. Kumazaki states, "Building service platforms that can provide these forums and deliver greater value throughout society is what we are seeking to achieve. Hitachi has built up know-how in a wide variety of working businesses, including industry, transportation, energy, and logistics as well as information and telecommunications, and we have the capabilities and the technology to support integration beyond organizational boundaries. In the future, we intend to take a global approach to accelerating the implementation of service platforms like these, while also dealing individually with issues such as data ownership and maintaining security."

Work has already started on initiatives that create forms of value that have never existed before from new links that encompass such things as data and organizations and that are enabled by open innovation and the symbiotic autonomous decentralized systems concept, as well as techniques for enhancing the integration and use of big data.

Visionaries 2016

New Era of Contestable Energy Markets

— Solution for Power Market Reforms —

The Japanese domestic market is seeking new energy services in anticipation of the full liberalization of retail markets and the separation of generation and transmission that will accompany power market reforms. Along with the entry of new players from a variety of different industries, these changes are also giving rise to numerous challenges, including reducing cost through management efficiencies, acquiring and retaining customers, and maintaining a security of supply that delivers a level of reliability among the best in the world. Hitachi already supplies a wide range of products and services, from generation to distribution and consumer markets. As customers and markets become more diverse in the future, Hitachi aims to contribute right across the value chain through solutions that draw on knowledge of IT.

Applying Strength in IT × OT in New Market

Power market reforms promoting the liberalization of the electricity market in Japan are making steady progress. The first stage of reform was the establishment in 2015 of the Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO). The OCCTO has already commenced business, with activities that include nationwide monitoring of supply and demand and management of grid interconnections. The second stage of reform (the full liberalization of retail markets, to commence in April 2016) is to be followed by a third stage involving the separation of generation and transmission.

The imminent full liberalization of retail markets includes complete deregulation of pricing and will permit even households and other small

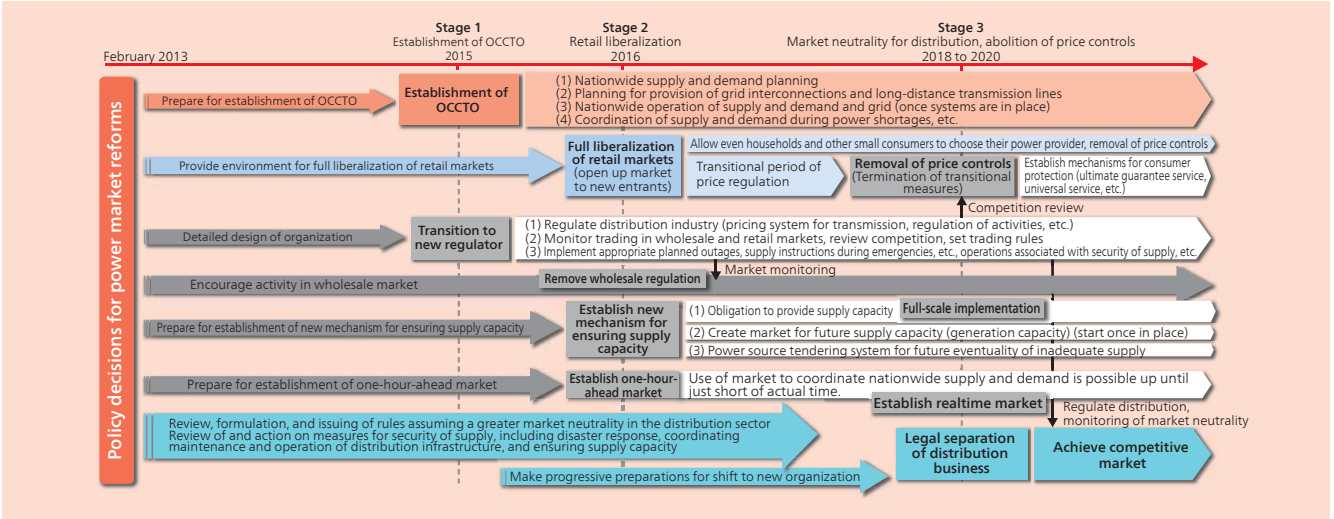
(low-voltage) consumers to choose their power company. The retail market of approximately 7.5 trillion yen will provide a level playing field open to both the general electric power providers (existing power companies) that already supply electric power in their respective regions of Japan and electric power providers that operate on a different scale (known in Japan as *shindenryoku*, meaning new power), both of which will be treated as power companies. In other words, the power market reforms will quickly lead to vigorous competition in the electric power market, presenting providers with a new business environment in which they need to consider competition as well as maintenance.

Shigetoshi Hayashi

Hitachi already supplies the electric power infrastructure market with mission-critical systems and other components that feature high reliability and performance. Hitachi is also involved in work related to the reforms, including winning an order from OCCTO for a nationwide coordination system. Recognizing the growing diversity of customers and markets, Hitachi has also established its Energy Solutions Company as part of a new organization that seeks to strengthen its sales engineering functions, which have adopted a "market in" approach.

Shigetoshi Hayashi (Senior Director, Service Platform, Smart Information Systems Division, Information & Telecommunication Systems Company, Hitachi, Ltd.) made the following comment about the background to these developments and Hitachi's activities associated with the power market reforms.

"Hitachi has largely dealt with the electric power industry on a 'product out' basis, meaning the supply of components and other products. Taking note of the upcoming changes in the electric power business, it is now looking to supply solutions that are better able to help customers overcome



Timetable for power market reforms (Source: Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry). The plan is for reform to proceed in three stages: the establishment of the OCCTO, the full liberalization of retail markets, and the separation of generation and transmission.

Teruo Ogata

Mitsuko Yoshimoto

challenges. To this end, Hitachi is undergoing an ongoing shift toward supplying solutions, with the entire company working together, and with "collaborative creation" as a key word. The Smart Information Systems Division will embed itself in customer workplaces to supply solutions that make sophisticated use of information technology (IT) and big data. Along with its involvement throughout the value chain that runs from generation to distribution and consumer markets, Hitachi as a whole intends to respond to the needs of the new market by utilizing its strengths in combining IT with control and operational technology (OT)."

Drawing on Accumulated Know-how

The three objectives of the power market reforms are to maintain security of supply, minimize electric power tariffs, and maximize consumer choice and business opportunities for providers. In the case of the full liberalization of retail markets, households and other small consumers are concerned with how much their power bills will fall, so the objective likely to be of most interest to them is that of minimizing electric power tariffs. Electric power companies, on the other hand, are interested in reducing costs by making their operations even more efficient.

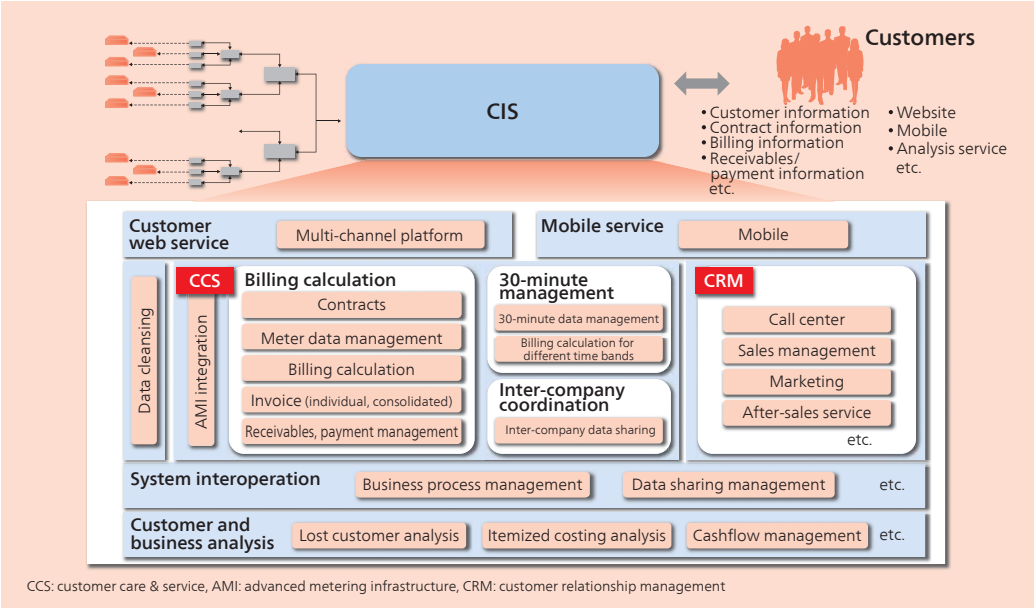
"Acquiring and retaining customers through the establishment of diverse tariff options and support structures for customers are important challenges, just as much for the new power companies. Hitachi is placing high hopes on IT for helping overcome these challenges."

This comment looking ahead to future changes was made by Teruo Ogata (Director of Energy Solution Department 2, Energy Information Systems Division, Energy & Transportation Information Systems Division, Information & Telecommunication Systems Company, Hitachi, Ltd.).

The customer information systems (CISs) used for customer management, billing, and revenue management in the retail sector are one such example. With a wide range of companies entering the electricity business, the CISs that form a vital part of their IT systems will require not only support for numerous different billing options, but also functions such as system integration with OCCTO that were not applicable in the past. This means that even existing power companies will need to reconfigure their CISs. The reality is, however, that the schedule for power market reforms leaves very little time for this system migration.

Mitsuko Yoshimoto (Director of SAP Business Solution Department, Enterprise Package Solutions Management, Enterprise Solutions Division, Information & Telecommunication Systems Company, Hitachi, Ltd.) describes as follows the strengths that Hitachi can offer companies in this predicament.

"Whereas system development for a retail CIS typically takes three or more years, these systems need to be up and running by April 2016 so the company is undertaking to complete the reconfiguration process in only 20 months. These difficult conditions will provide an opportunity for the company to show the strength of the know-how it has built up through past involvement in the implementation and maintenance of CISs for large power companies. The company is utilizing its experience in SAP*1 enterprise resource planning (ERP) implementation at more than 410 companies to reconfigure power company CISs using an



CCS: customer care & service, AMI: advanced metering infrastructure, CRM: customer relationship management

Overview of SAP solution supplied by Hitachi. The solution meets the diverse needs of new and existing power companies.

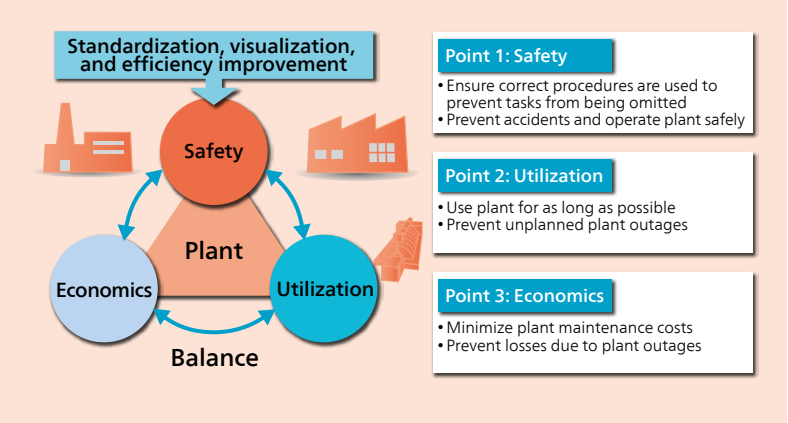
SAP IS Utility solution that is specifically targeted at the energy sector, and also intends to provide business intelligence (BI) tools and other utilities capable of analyzing customers in greater depth to deliver solutions that meet the needs of both new and existing power companies."

With the ultimate design of the market still unclear, along with the challenge of minimizing investment in the electricity business, the configuration of a CIS in a short time period is a major undertaking. Accordingly, Hitachi is providing each customer with tailored solutions, including expanding sales of packaged products designed for the Japanese market in addition to the SAP solution.

Generators, meanwhile, are seeking to boost their competiveness through measures such as maintaining power plant operation at a high level and adopting more advanced operation and maintenance practices while also helping ensure security of electric power supply.

Mr. Hayashi states, "These initiatives are another area where IT and OT are intimately intertwined. Even if sensors are used to collect data, it is only with the power of IT that advanced solutions become possible, meaning that an even closer fusion of IT and OT is required. Along with supplying an integrated enterprise asset management (EAM) solution for equipment maintenance, Hitachi has also started work on asset performance management (APM), in which the data on equipment condition and operation collected by EAM is utilized to ensure appropriate equipment maintenance."

*1 See "Trademarks" on page 140.



Overview of Hitachi Enterprise Asset Management, which provides company-wide optimization of assets by using EAM to standardize, visualize, and improve efficiency of plant and business processes and to strike a balance among safety, utilization, and economics.

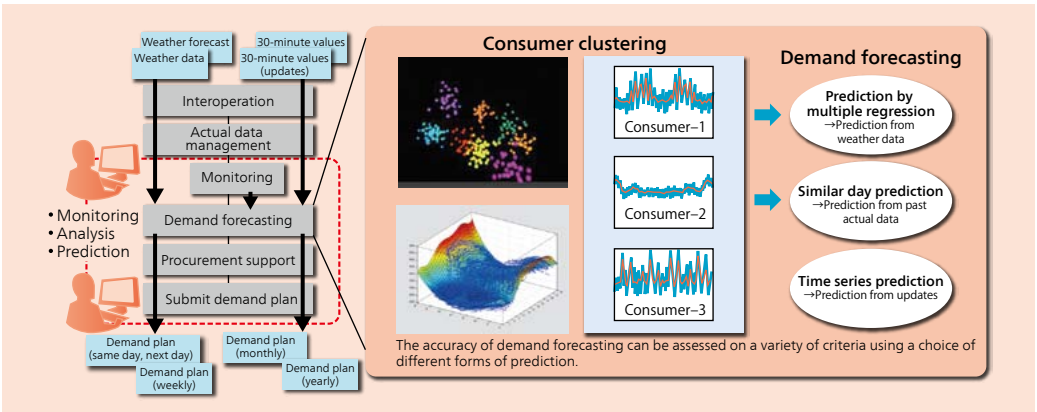
Advanced Supply and Demand Management to Help Ensure Stability of Supply

One of the objectives of the power market reforms, stability of supply, is also essential to society as a whole. Under the new regime, OCCTO will work with new and existing power companies to monitor and maintain the balance of supply and demand for electric power throughout Japan, issuing instructions to generate or reallocate power in the event of supply shortages. The power companies, meanwhile, need to produce supply plans for their generation and retail businesses. In this, the problem of managing supply and demand is an important consideration.

Ikuo Shigemori

Ikuo Shigemori (Director of Energy Solution Department 1, Energy Information Systems Division, Energy & Transportation Information Systems Division, Information & Telecommunication Systems Company, Hitachi, Ltd.), who is engaged in the development of a supply and demand management solution for new power companies, makes the following point.

"Power quality suffers when supply and demand get out of balance, with a worst-case potential to result in a major power blackout. As the effect of instability becomes greater when the number of consumers served by each company is relatively



Example solution for managing supply and demand. The solution comes with standard functions for core supply and demand management tasks, with useful functions being progressively added to keep up with ever-changing legal requirements and market needs.

small, more detailed management of supply and demand is required."

The greater the error in demand forecasting when power companies produce their supply plans, the more they are exposed to imbalance costs*2, inevitably leading to diminished profitability.

Mr. Shigemori further adds that, "In response to this challenge, Hitachi has developed solutions that can promptly and accurately manage supply and demand in response to ever-changing conditions, using a choice of different prediction techniques that include the use of air temperature, sunshine hours, and other weather data."

*2 Payment by power companies based on the difference between planned and actual power use.

Looking Ahead to Separation of Generation and Transmission

Further power market reforms are planned, with the separation of generation and transmission set for 2020. This is to occur through legal separation, whereby the distribution arms of power companies are to be spun off as separate entities. The administrative functions of accounting, procurement, and coordination will also need to change in response to these developments.

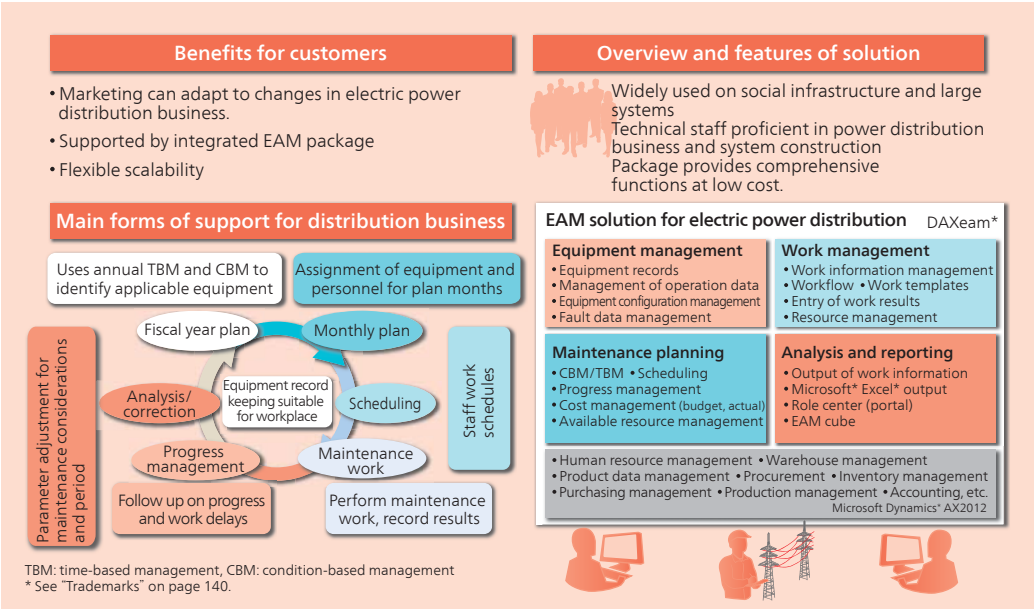
Mr. Ogata states, "As large power companies have a large investment in existing administrative systems, the key lies in finding efficient and effective ways of preparing for 2020. Hitachi has experience in upgrading customers' administrative systems through both the use of ERP systems and scratch development, which allows customers to choose the approach that best suits their own strategy."

Maintaining the reliability of the transmission and distribution infrastructure will be important once the separation of generation and transmission has taken place, with the large amount of equipment replacement that is to occur during this new era posing a major challenge. As the transmission and distribution infrastructure built in response to the rapid rise in demand during the 1960s is now all coming due for refurbishment or replacement, there is a need to reduce and spread the associated costs. The number of items to be dealt with is huge, with power poles in the region served by Tokyo Electric Power Co., Inc. alone numbering as many as six million, and with transformers, switchgear, and other transmission and distribution infrastructure also to be included.

Mr. Ogata states, "In terms of security of supply, the huge volume of distribution equipment coming due for replacement is a problem that cannot be put aside. In response to this problem, Hitachi offers solutions based on IT. Specifically, its aim is to help overcome the challenges by supplying an EAM for electric power distribution that utilizes information from smart meters, power sensors, and other sources for such purposes as monitoring loads and prioritizing maintenance based on the level of equipment deterioration."

Fusion of Energy and IT

What benefits can be expected from the power market reforms? Considering the objective of maximizing consumer choices and business opportunities for providers, the ability of consumers to choose their electricity provider will lead to differentiation among power companies on



Overview of EAM solution for electric power distribution. The solution uses an EAM and proven technical capabilities to support cost optimization and maintain the reliability of distribution equipment.

price, service, and added value. It is anticipated, for example, that companies will offer bundles that include such things as loyalty points, package discounts, and energy services.

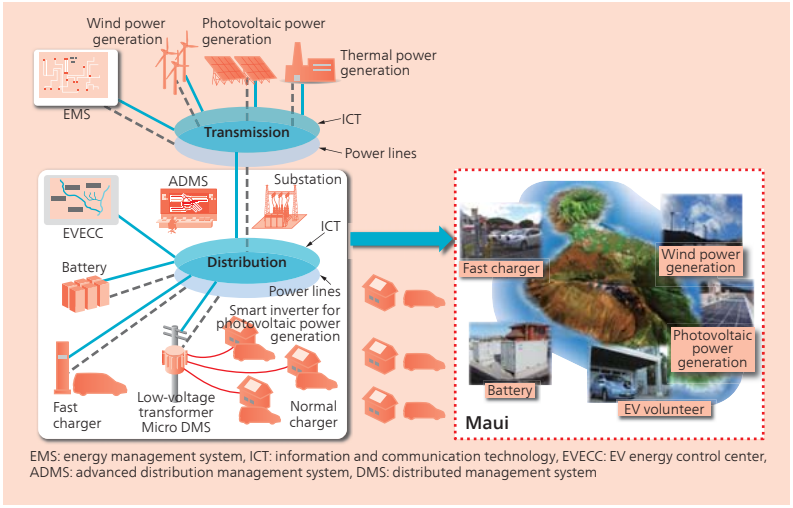
Ms. Yoshimoto states, "There will likely be some consumers who will base their choice of power company on a desire to use green power sourced from renewable energy. It should also become possible for consumers to obtain accurate energy consulting based on information such as data from the smart meters that are scheduled to be installed in all households by the end of FY2024. IT is seen as helping support consumers' ability to choose."

It is also highly likely that new markets for electric power business will emerge in Japan as they have in Europe and America. One example is "negawatt" trading, which the Japanese government expects to see broadly adopted. This involves the market trading of unused power, whereby consumers reduce their power consumption in response to requests. Typically, this is done by entities called aggregators acting as intermediaries and having consumers reduce their power consumption in response to requests from power companies. This reduction in power consumption when a request is received from a power company is called demand response (DR), with the consumers who make the savings being recompensed according to the amount by which they reduce their demand.

"While energy efficiency plays a central role in energy management in Japan, the USA in particular has a long history of DR, which has become a recognized means for utilities to cut costs. The establishment of a market for DR trading is being considered as part of Japan's power market reforms. If this proceeds, it is anticipated that energy management (including DR) will become an active field, including the emergence of new players such as aggregators who serve as intermediaries in the DR market."

This comment was made by Shinichi Kasai (Senior Manager, Infrastructure Solution Development Department, Energy Solution Systems Division, Solution Systems Division, Energy Solutions Company, Hitachi, Ltd.)

Hitachi has participated in demonstration projects in a number of countries where electricity liberalization has already taken place. One such is the Smart Community Demonstration Project in Greater Manchester, UK run by Japan's New Energy and Industrial Technology Development Organization (NEDO). This project includes trialing the viability of DR. Hitachi is also participating with NEDO and others in the Japan-U.S. Island Grid Project (JUMPSmartMaui Project) in the USA. Mr. Kasai was involved in both projects and comments as follows.



EMS: energy management system, ICT: information and communication technology, EVECC: EV energy control center, ADMS: advanced distribution management system, DMS: distributed management system

EV batteries are being used on the island of Maui in Hawaii to absorb excess energy and control frequency fluctuations. The trial involves more than 200 EVs and 40 households in the Kihei area, with the ultimate aim of establishing a virtual power plant made up of more than 500 EVs.

"The aim of the demonstration project in Maui is to use electric vehicles (EVs) to resolve the problems associated with installing a large amount of distributed power sources, such as photovoltaics and wind power. To mitigate frequency fluctuations and effects on grid voltage, the project links a central control system to control equipment installed around the grid and the consumer equipment used to control the use and charging of EVs to establish mechanisms for autonomous control in response to voltage or other abnormalities. This involves use of Internet of things (IoT) technology."

Mr. Hayashi states, "These demonstration projects provide an opportunity to test technology and build up various knowledge and other know-how about how to respond to the changes in the operational environment associated with power market reform. Both projects place an emphasis on economic assessment and the establishment and verification of the business models required for commercialization, and we intend to offer the results of this work as solutions for the Japanese market."

While the future remains an unknown with power market reforms having only just begun, a new era is beginning in which consumers can actively choose where they get energy. In the future, Hitachi intends to continue supplying solutions that help overcome challenges facing all of its customers along the energy value chain.


Shinichi Kasai

Visionaries 2016

Riding the Rails to the Future

— Expansion in Railway Systems Business —

The role of railway systems in the transportation infrastructure is attracting fresh interest, including major investments anticipated in the construction of high-speed railway systems in various parts of the world. Since it entered the UK railway market, Hitachi has been steadily expanding its operations in that nation, including enhancements to maintenance services, the winning of an order for a traffic management system, and the construction of a new production facility for rolling stock. Hitachi has also been striving in recent years to extend its activities to the global market, particularly countries in Asia, including taking action on standards compliance and developing advanced technologies. Hitachi is seeking to respond to increasingly diverse needs in its role as a general railway systems integrator with an extensive portfolio of technologies.

Achievement of Brand Presence in Europe

Hitachi's railway systems business in the UK, the birthplace of the railway industry, has progressed significantly since the 2000s. It is steadily establishing a foothold, including manufacturing and maintenance services for the Class 395 rolling stock that run on the High Speed 1 line connecting London and the Channel Tunnel, manufacturing and maintenance of rolling stock for the Intercity Express Programme (IEP), construction of a new production facility for rolling stock, and winning an order for a traffic management system.

The Class 395 rolling stock that entered service in December 2009 were Hitachi's first order in the UK. Development of the rolling stock faced numerous difficulties that arose because of the significant differences between railway standards in Japan and the UK. As the project included a requirement to use parts and consumables produced in Europe,

there were frequent problems with matching these against Japanese-made parts. Nevertheless, thanks to the research and development divisions and factory engineers joining forces to find solutions, the project was completed successfully, with operation commencing about half a year ahead of schedule. Looking back on this time, Akira Horie (COO, Rail Systems Company, Hitachi, Ltd.), who was responsible for the electrical systems on the Class 395, made the following comment.

"I believe this project had a positive impact on the people of the UK and elsewhere in Europe and provided an opportunity for them to gain a tangible appreciation of Hitachi. Overcoming difficulties, the project established brand presence for Hitachi in the European railway market."

The success of the Class 395 led to Hitachi winning the order for the IEP. A major project of the UK Department for Transport, the IEP will replace

The IEP involves the full replacement of aging rolling stock on the East Coast Main Line (ECML) and Great Western Main Line (GWML), the two main trunk lines in the UK.

Akira Horie

aging rolling stock on main trunk lines. In July 2012, Hitachi formally signed a comprehensive contract with the UK Department for Transport that included providing maintenance services for 27.5 years. Design of the rolling stock commenced in the autumn of that year.

Mr. Horie commented, "The knowledge we gained from the Class 395 fed through to the design of the rolling stock for the IEP. Firstly, we took great care in selecting locally sourced components, giving consideration to the compatibility between parts made in Europe and those made in Japan. Furthermore, to overcome the problem of the delays that would result from the swapping of rolling stock to deal with the fact that the line included both electrified and non-electrified sections, we chose to fit diesel engine generators to the Class 800 rolling stock for the IEP. To deal with the need to reduce noise and vibration when the diesel engine starts up on entering a non-electrified section, staff from Kasado Works and Hitachi Research Laboratory worked on countermeasures by conducting detailed measurements and analysis. Precise estimates of energy consumption were also produced, and the design engineers put a lot of effort into detailed studies of components to reduce their weight and achieve the required fuel consumption performance."

Thanks to the efforts of a large number of staff, the first pre-production rolling stock for the IEP were completed in January 2015. Operating trials are currently underway, including running on a section of the actual track, in preparation for the commencement of commercial operation in 2017.

The new Rail Vehicle Manufacturing Facility built in Newton Aycliffe, County Durham. The layout is optimized for the production of rolling stock.

Seeking to Achieve Efficient High-quality Production at State-of-the-art Facility

The rolling stock for the IEP will be produced at the new factory in Newton Aycliffe, County Durham. Completed in September 2015, the new factory features a layout that incorporates state-of-the-art just-in-time (JIT) production techniques. In addition to fitting the entire production line into a single building, it is also designed to allow rolling stock without production problems to overtake rolling stock with production problems. This enables production to continue without halting the line if a problem occurs, ensuring that work in progress completes each step fully before proceeding to the next one. Darren Cumner (Manufacturing Plant Manager, Newton Aycliffe, Hitachi Rail Europe Ltd.), who manages operations at the new facility, explained as follows.

Darren Cumner

"The plant is capable of high levels of efficiency and quality with a smooth flow of products through the single production line where quality management practices have been established for each step in the production process. Utilizing information technology (IT) systems, we are also managing manuals and other documentation such as work standards, quality management, and production records."

Nevertheless, achieving efficient high-quality production requires more than just a superior factory layout. Every effort is made to foster staff with a sincere approach to craftsmanship and reliable skills.

Mr. Cumner said, "We emphasize Hitachi Founding Spirit, which is based on the Values of "Harmony, Sincerity, and Pioneering Spirit", and observe the behavious of staff right from the beginning of the recruitment process. When I was first introduced to these values, I recognized it as something that sets Hitachi apart from everyone else by valuing the dignity of workers. Based on this belief, we provide staff with the opportunity to acquire a high level of awareness in areas like quality improvement and customer satisfaction."

In addition to nurturing steadfast attitudes, employees are acquiring and practicing advanced skills at a rapid pace, including the technical support from colleagues from the Kasado Works, which serves as a "mother factory." Pilot production is currently underway, with full-scale production scheduled to commence from April 2016 after process testing.

Hiroaki Koiwa

Rolling Stock Maintenance with Full Use of IT

It is standard practice in the UK for the rolling stock supplier to also handle maintenance. The duration of Hitachi's maintenance contract for the IEP is 27.5 years, which will have a very large impact in business terms.

This is another area where Hitachi is drawing on its experience from the Class 395. The key to this is use of IT, with progress having been made during the approximately six years since commencing maintenance of the Class 395 on "visualization," which involves the collection of a wide range of sensor data, including not only data from major equipment but also all sorts of detailed data from peripheral subsystems such as doors and vacuum-insulated switchgear, and its off-board analysis to attribute meaning. Hiroaki Koiwa (Head of Signalling Engineering, Technical, Hitachi Rail Europe Ltd.), who works on rolling stock maintenance in the UK, explained as follows.

Through maintenance work on the Class 395, Hitachi has built up know-how about using the data collected by various sensors in efficient work practices.

North Pole Depot completed in March 2015. The construction of four such rolling stock maintenance depots along the ECML and GWML is planned as part of the IEP.

"Status monitoring based on data collection has many benefits, such as identifying the warning signs of faults from the mean open and close times for doors, for example. This use of IT not only helps prevent accidents, it also leads to lower maintenance costs."

With the addition of bidirectional communications, the transfer of information such as reservations data from wayside to onboard systems is also planned in order to enhance services on the IEP rolling stock. Hitachi has also won an order from Abellio ScotRail of Scotland for the supply and maintenance of standard AT-200 commuter trains, and is looking in the future to build experience from the associated maintenance work and provide the resulting knowledge back to Japan. Predictive diagnostics, in particular, is seen as a key technology.

Mr. Koiwa commented, "Hitachi has a strength in big data analytics, identifying correlations with fault modes in large amounts of collected data and utilizing these in maintenance. I believe that the model whereby we use data analysis to create value by working as a group has applications in numerous fields, not just railways."

Traffic Management System Incorporating Experience from Lines with High Traffic Density

The UK has also launched a project to improve efficiency by introducing an automated system for traffic management, a function that has been handled manually in the past. Traffic management under the planned system will consolidate roughly 800 signals facilities around the country into 11 sites. As part of this, Hitachi won an order in July 2015 to supply a traffic management system for Thameslink, a main commuting line that runs through London from north to south.

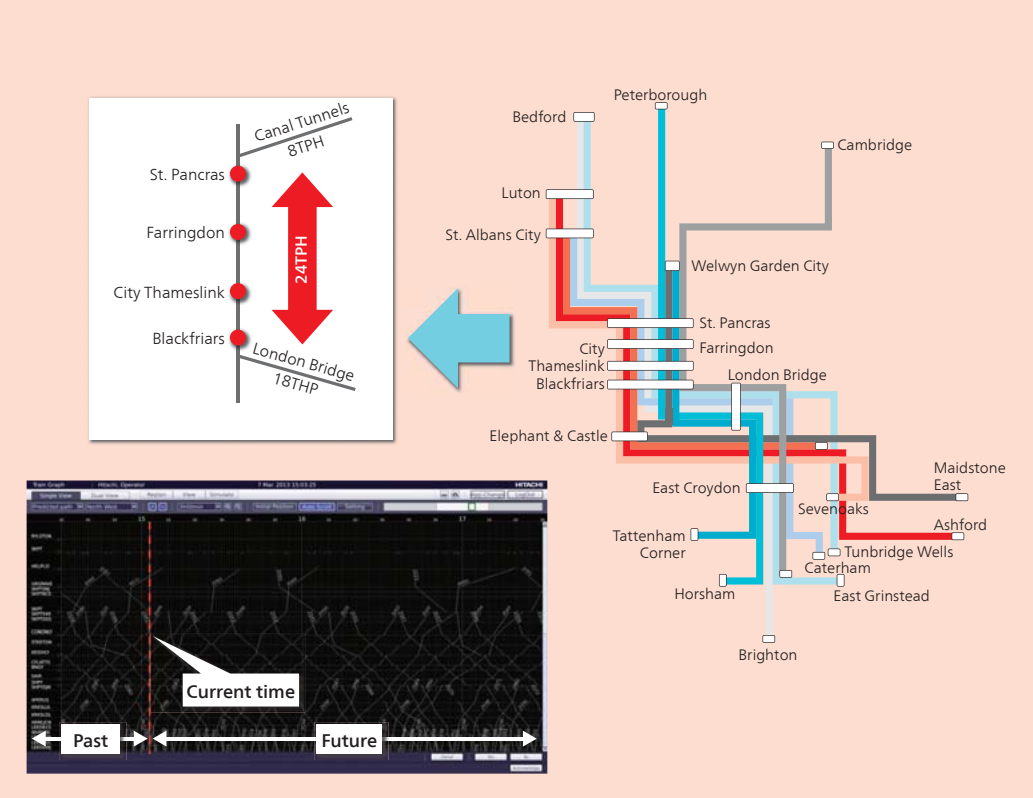
Hitachi supports the management of railway traffic in high-density networks such as those in the Tokyo and Kansai regions of Japan with a level of automation that is higher than anywhere else in the world. This latest order is the result of Hitachi working as a group to offer solutions based on these technologies developed in Japan. Susumu Hasegawa (Executive Chairman, Hitachi Information Control Systems Europe Ltd.), who works on the project, described it as follows.

"The line plans to increase train frequency to 24 trains per hour (TPH) in 2018. As Japan excels at managing the operation of open intercity railway lines with high traffic densities, and Hitachi has provided support for this. The customer recognized Hitachi for this experience and other capabilities."

As the Thameslink line includes a bottleneck where a number of lines converge, one of the challenges is deciding how to prioritize the routing of trains through this area when the schedule becomes disrupted. Hitachi was chosen for its extensive experience in solving such problems. Work is currently underway on finalizing the specifications, with one of the points at issue being how to adapt the Japanese system to the UK.

Mr. Hasegawa observed that, "The differences in thinking on safety are particularly important. Whereas the approach in Japan is to provide infrastructure to ensure safety based on a philosophy of prevention being better than cure, the tendency in the UK is to leave infrastructure as it is and ensure safety by establishing ways of dealing with it. Traffic management during schedule disruptions requires detailed consideration."

Susumu Hasegawa



Outline of operation of the traffic management system for the Thameslink line. The system features train graphs that display train status and scheduled movements over a wide area. While complex control is required for the Thameslink Core Area bottleneck, the train graphs support decision-making by operators and optimize operation of the entire line.

System delivery is scheduled for 2017, with operation to commence in stages. Based on its experience in the UK, Hitachi aims to expand into the entire European market and to deploy passenger service and other information systems that use the traffic management system as a core. By incorporating functions that integrate with the European Train Control System (ETCS) and other signaling systems, Hitachi is also looking to provide systems that improve energy efficiency and take greater account of the environment.

Expansion into Global Market

Hitachi's railway systems business has been expanding into Asia in recent years, including Singapore, India, and Myanmar. Mr. Horie recounted progress on developing the global market as follows.

"When work on developing the global market got underway in earnest from around 2008, there were two hurdles that we needed to overcome, namely catching up with the European wireless technology used for signaling and complying with Europe's strict safety certification. Obtaining safety certification was particularly difficult, with it taking several years just to understand the standards and acquire detailed design information."

One of the outcomes of overcoming these difficulties was signals business for a new freight line between Delhi and Mumbai in India funded through a yen loan. Hiroyuki Hara (General Manager, Rail Systems Company, Hitachi India Pvt. Ltd.), who worked on the project in India, explained as follows.

"While India is a major railway nation with a total length of track said to extend 64,000 km, poor efficiency due to freight, commuter, and long-distance services sharing the same track is a significant problem. To improve the situation, an efficiency improvement project is underway to expedite freight services by shifting them to a new line, with Hitachi supplying a complete signaling system."

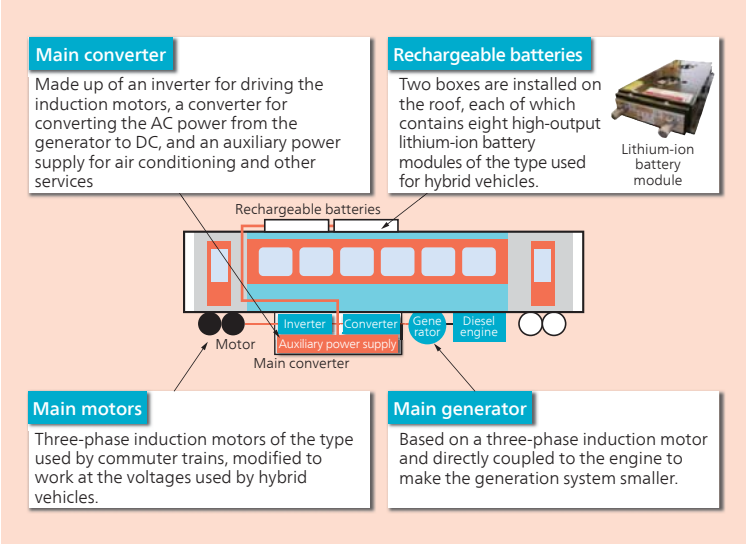
The aim is to perform train management, ensure safety, and boost the efficiency of operations by installing electronic interlock systems, automatic train control systems, and traffic management systems like those in Japan.

"We intend to use the project as a beachhead and also get involved in conventional lines," added Mr. Hara.

The problem with this is cost, and while the need is to build reasonable systems (in terms of cost) utilizing Indian-made components, subsequent global business opportunities are also in prospect. Hitachi has brought Ansaldo STS S.p.A, an Italian company with strengths in signaling technology,

Hiroyuki Hara

Planned route for new freight line between Delhi and Mumbai. Nearby, regional development schemes are being undertaken to provide predominantly privately funded infrastructure such as industrial complexes, distribution centers, and power plants.



Traction drive system and auxiliary power supply for hybrid rolling stock. The technology is seen as having widespread applications for reducing the environmental load of rolling stock that runs on non-electrified track.

into the group, and is seeking to expand its engineering business into other Asian countries from this base in India by utilizing its network and with participation by skilled Indian engineers.

The development of technology based on the diverse needs of the global market is also taking place for rolling stock. One example is how Hitachi has led the world in developing rolling stock with hybrid drive systems that combine lithium-ion batteries with diesel engines. Takashi Kaneko (Senior Engineer, Rolling Stock Electrical Systems Design Dept., Rail Systems Company, Hitachi, Ltd.), who was involved in this development, commented that, "We have been working on joint development with East Japan Railway Company and already have 29 units in operation in Japan running on non-electrified track. I believe it was Hitachi's having battery technology it had built up over time that made this possible."

Hitachi is also developing a battery-powered train (without a diesel engine) that runs on non-electrified track using power that is drawn from the overhead lines while on electrified track and stored in the batteries. All of these have widespread applications as technologies for reducing the environmental load of rolling stock that runs on non-electrified track.

Working toward Railway Systems that Satisfy Diverse Needs

One of the initiatives undertaken by Hitachi that demonstrates its role as a general railway systems integrator was the Ho Chi Minh City Urban Railway Construction Project for which the contract was signed in June 2013. The contract involves a total of 11 different subsystems and a five-year maintenance service, covering many different areas in addition to rolling stock, including signaling systems, communication systems, electric power systems, ticket gates and vending machines, and platform screen doors. The project demands close collaboration with other organizations, including local government agencies and the construction company responsible for the civil engineering work, and Hitachi was also assisted by a Japanese railway company.

Mr. Horie commented that, "Topics for future railway system development are likely to include extensive use of wireless technology, automatic operation, the elimination of catenaries, use of IT, and improvements to information services. Our aim is to pursue business throughout the world by supplying solutions that are finely tailored to the various conditions that apply in different countries around the world, while also making use of open innovation practices."

The value of railways has been under revision in recent years as a form of infrastructure for linking cities where there has been a rapid concentration of population, and as a means of transportation that places a low load on the environment. Furthermore, the more demand rises around the world, the greater the diversity of solutions sought by different regions. Hitachi's endeavors will continue, targeting the form that transportation infrastructure should take in the future.

Takashi Kaneko

Visionaries 2016

Plotting the Future of Mature Societies

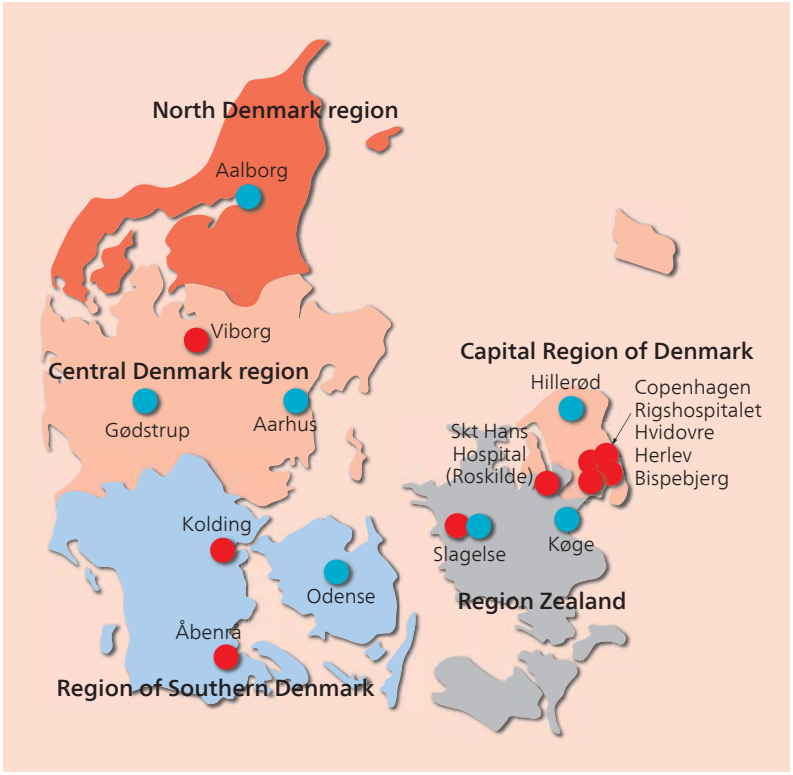
— Denmark's Super Hospital Concept —

The rising cost of social security is a challenge faced by all developed nations, with Denmark, a nation known for the extent of its welfare state, being no exception. Denmark is proceeding with a "super hospital" concept, whereby it is consolidating public hospitals across the nation into 16 sites to cover a broad range of activities. Hitachi is participating in this work, having reached an agreement to jointly develop solutions with Bispebjerg og Frederiksberg Hospital, which is responsible for healthcare in the municipalities around Copenhagen. This exercise in collaborative creation combines the hospital's healthcare data and its experience in hospital management and operation with Hitachi technology and other know-how to work on improvements in hospital management efficiency that will help realize a vision for the next generation of healthcare.

Happy Nation Benefiting from Reforms

Denmark has been called the world's happiest nation. It topped a United Nations survey of happiness indicators in 2013 and 2014, and placed third in 2015. Recognized as an example of the Northern European model of a welfare state and a leader in environmental matters, Denmark had the world's sixth highest per-capita gross domestic product (GDP) in 2014 and regularly appears near the top of international competitiveness rankings.

Underpinning this strong national performance are both a national character unafraid of change, and the benefits it is now reaping from past reforms. Further reforms are currently underway, one of those in the healthcare sector being the "super hospital" concept, a bold restructuring



Denmark is made up of five administrative regions. The super hospital concept aims to improve the operational efficiency of public hospitals by 25% by consolidating operations at 16 sites (blue: new construction, red: expansion or refurbishment).

aimed at improving the operational efficiency of hospitals by 25% by consolidating 40 existing sites around Denmark into 16 advanced medical facilities. Three specific targets have been set to help meet this objective: a 50% increase in outpatients, a 20% reduction in beds, and a reduction from 4.5 to 3 days in the mean length of a hospital stay. Specific activities aimed at achieving these are already in progress.

Hitachi is participating in the work, having reached an agreement in November 2014 with Bispebjerg og Frederiksberg Hospital, one of the super hospitals, to work jointly on the development of new healthcare solutions.

Shigeyuki Tani (Senior Researcher, European R&D Centre, Hitachi Europe Ltd.), who is involved in a research and development (R&D) capacity in the joint solution development project, used the following words to describe Hitachi's participation in these national reform activities in Denmark.

"Some two or more years ago, the government of Denmark issued an invitation to companies and other organizations around the world to participate in its reforms. The main thrusts of these are environment and energy, transportation, and healthcare. In response, Hitachi undertook about a year and a half of research involving consultation with a wide range of companies and other organizations, as well as the five administrative regions of Denmark, to identify where we could best focus our efforts. As a result of this work, we became involved in the super hospital concept because it had set the clearest objectives."

Innovative Capabilities Fostered by Appreciation of Social Sciences

Denmark is already known for its innovative capabilities as well as for its international competi-

Shigeyuki Tani

Hans Lindeman

Yukinobu Maruyama

tiveness. Hans Lindeman (Senior Vice President, Social Innovation Business Platform, EMEA-CIS, Hitachi Europe Ltd.), who is involved in business consulting for the project, explained the reasons for this as follows.

"Denmark is a relatively small nation, with a population of 5.6 million and a land area (excluding overseas dependencies) of only 43,000 km², and follows the Nordic model of investing heavily in areas like welfare and education. With the aim of improving the quality of life of its population, it is also proactive about adopting new technology and investing in its development, with the public-private partnership (PPP) being a common model for the provision of public services such as research, education, and healthcare. Collaborations like ours are also very common, and the nation has achieved numerous innovations through collaborative creation that involves the public and private sectors, with participation by the public as well as by corporations."

Yukinobu Maruyama (Chief Designer, Global Centre for Social Innovation — Europe, Hitachi Europe Ltd.), who is working on the project as a service designer, added the following noteworthy point about Denmark as a nation.

"Denmark is working on measures that treat not only natural science but also social science as being part of technology. Use is being made of social science in the study of public services intended to overcome societal challenges, including the service design process and drawing on knowledge of behavior modification research, a field that combines cognitive psychology with economics. This is another reason for the interest in Denmark."

For example, bicycles place a minimal load on the environment and the capital city of Copenhagen has increased the rate of bicycle use through changes in resident behavior brought about by policies that are designed in terms of both hardware and software to facilitate the use of bicycles so that they can play a central role in transportation in the city.

Mr. Tani also commented that, "The distinctive characteristics of Denmark that relate to information technology (IT) include a low level of resistance to participation in social innovations, with widespread adoption of new technology in daily life and a high level of IT literacy that includes regular use of electronic devices by the over-60 age group and public acceptance of data sharing with a national identity number system that has operated for many years. This has led Hitachi among others to see the country as an easy place to introduce new technologies."

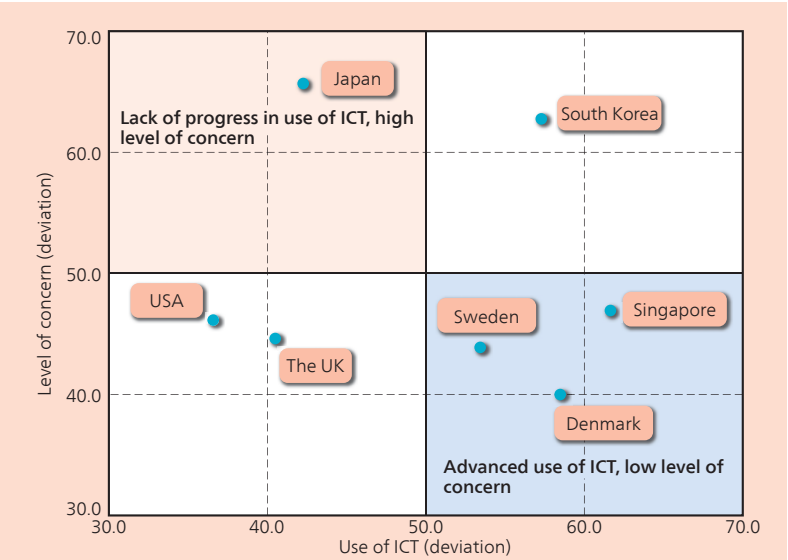
In other words, Denmark makes a good testbed for innovation.

Use of Big Data Analytics to Improve Efficiency

Denmark provides fertile soil for open innovation, and Hitachi established its Denmark Big Data Research Laboratory in Copenhagen as part of its participation in the super hospital concept. The laboratory serves as a base for working on the priorities identified by the government of Denmark, which include energy, environment, and transportation as well as healthcare, through the collaborative creation of solutions for overcoming challenges with partners such as local government and other public agencies and also local companies. Mr. Lindeman describes the role of the Denmark Big Data Research Laboratory as follows.

"We see the laboratory as a place where the business consulting unit can team up with R&D to show customers and partners the extent of our ability to contribute, and present an outline of how the Social Innovation Business will look in the future."

The initial example of collaborative creation is the joint development of healthcare solutions with Bispebjerg og Frederiksberg Hospital. Located in Copenhagen and formed from a merger of Bispeb-



Source: "International Comparison of ICT Trends and Survey of Advanced Uses of ICT in Japan and Elsewhere," Ministry of Internal Affairs and Communications, March 2009

ICT: information and communications technology

Relationship between use of and concerns about ICT in different countries. Denmark's success in assuaging concerns about ICT has led to its being well advanced in the use of ICT.

jerg Hospital and Frederiksberg University Hospital, the hospital has a staff of approximately 5,000 and provides medical services to approximately 450,000 people in the surrounding municipalities. Design and construction of a new hospital building commenced in 2014, with a major redevelopment scheduled for completion by 2025 to transform the facility into a super hospital.

While the merger on its own is expected to deliver some management and operational efficiencies, the aim is to achieve even greater management efficiencies and service quality improvements by augmenting these with Hitachi's capabilities that include big data analytics, service design, and business consulting methodologies.

Big data analytics will build on business improvement initiatives already undertaken by Bispebjerg og Frederiksberg Hospital. The hospital has installed monitoring sensors in temperature-controlled facilities at roughly 800 locations, including freezers and medical cabinets. When Hitachi conducted an analysis of roughly one year of this temperature data, it succeeded in identifying a number of trends and features. Mr. Tani commented on the work as follows.

"By identifying overall trends as well as determining the situation at the approximately 800 locations, we estimated that the potential savings from performing optimal control were more than 5% of the hospital's total cooling bill. Based on this result, we are now working with the hospital on ways of performing dynamic optimal control of numerous temperature-controlled facilities."

Another initiative involves measuring and analyzing data on the movement of people and goods at the hospital so that it can be used for purposes such as boosting operational efficiency or optimizing layouts. Mr. Tani explained that, "Along with this use of sensors to record people's movements and its combination with other data such as information on the work performed by each employee to analyze the causes of waste, the movement characteristics obtained through this work can be used not only to make improvements to existing processes but also to design efficient layouts such as for the wards at the new hospital building currently under construction." The aim for the future is to optimize the movements of patients as well as staff.

Eliminating unnecessary movement by people is an important consideration for management efficiency. By also attaching sensors to beds, lifts, and other medical equipment to provide information about their movements, it is possible to eliminate waste in the use of equipment and to implement systems that dynamically indicate the best location for bringing together staff, equipment, and other medical supplies. Through the use of big data analytics that combines sensor data with the various

Layout of Bispebjerg og Frederiksberg Hospital, one of Denmark's super hospitals, after the completion of its major redevelopment, which is scheduled to be finished by 2025.


Temperature-controlled cabinet (refrigerator) at Bispebjerg og Frederiksberg Hospital. An analysis of temperature data from approximately 800 sensors identified potential savings of more than 5% of the hospital's total cooling bill.

data generated in the operation of the hospital, Hitachi aims to support the efficient movement of people and goods at the integrated and enlarged super hospitals.

Designing Ideal Healthcare

The joint development of healthcare solutions is taking account of service design considerations and making use of ethnographic analysis. This is a methodology that can uncover latent issues by having researchers visit the work or living place being studied to make detailed observations of people's activities. Hitachi is conducting an ethnographic analysis of doctors, nurses, pharmacists, and other hospital staff in collaboration with Bispebjerg og Frederiksberg Hospital.

With an ability to identify underlying issues that are difficult to uncover through the quantitative study of measurements or other data, ethnographic analysis draws on social science to augment data-oriented efficiency improvement.

Mr. Maruyama emphasized the significance of incorporating service design methods by saying, "The tendency when designing a new hospital building, for example, is to focus exclusively on things like work efficiency and optimization. In this project, however, we were engaged in the development of a major social model, namely the super hospital concept, and the way in which Bispebjerg og Frederiksberg Hospital expressed what sort of hospital they wanted to create in the form of their initial model cases can be seen as an important determining factor in the overall success of the concept. Accordingly, we sought to develop a solution that indicated the direction that healthcare would take in the future by adopting an approach that involved a "vision design" describing what they wanted to achieve with reference to the underlying issues uncovered by ethnographic analysis as well as the trends and other issues going on in society as a whole."

Improving management efficiency is not the only objective of collaborative creation with Bispebjerg og Frederiksberg Hospital. Rather, it is an initiative that represents one vision for healthcare in relation to global society from a broader scope and long-term perspective. To achieve this, it is important that the development of new healthcare solutions continues as a business rather than ending once the demonstration project finishes.

Mr. Lindeman said, "Consequently, we embarked on measures for highlighting the factors that have an impact on hospital management, where the Social Innovation Business Platform and Hitachi Consulting Co., Ltd. are taking central roles. In addition to proposing management improvements based on this analysis, we also plan to establish a model for how Hitachi can earn revenue from the management improvement solution. I believe that moving from proof of concept to proof of value is essential if we are to make ongoing improvements and achieve social innovation."

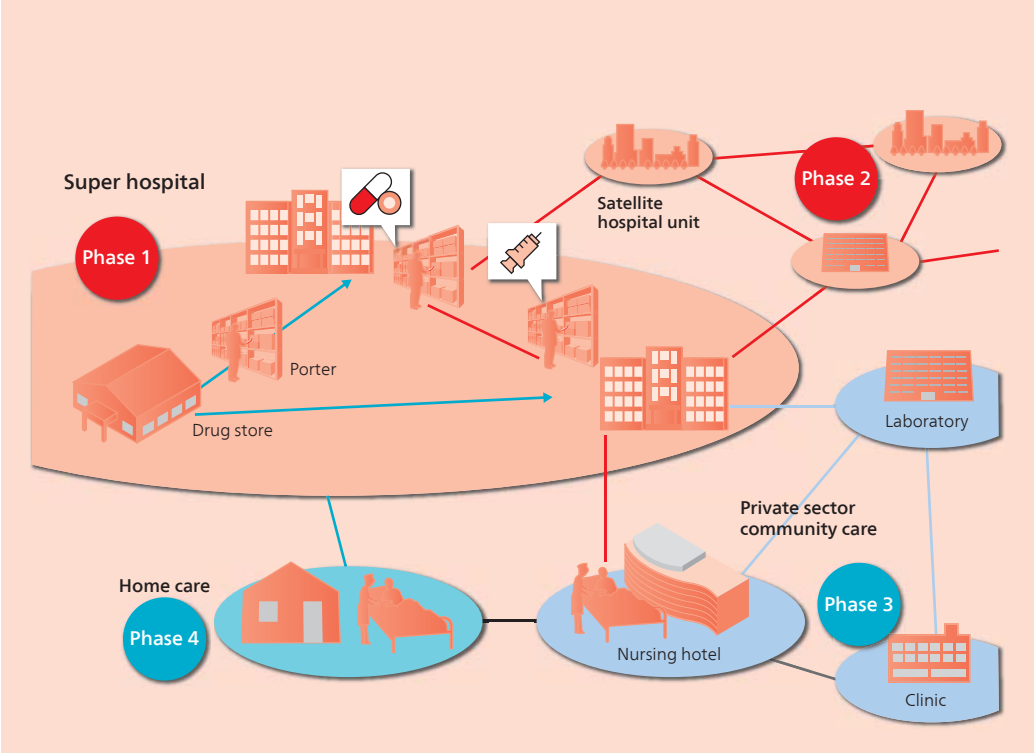
Ethnographic analysis in progress. Detailed observation of doctors, nurses, pharmacists, and other hospital staff can identify underlying issues that are difficult to uncover through quantitative study.

System-wide Optimization of Healthcare Using Symbiotic Autonomous Decentralized Systems

As noted above, the super hospital concept involves consolidating the regional base hospitals into 16 sites. To achieve this, it is necessary to build systems that allow not only for coordination and other information sharing among regional base hospitals and general practitioners (GPs), but also the future use of telemedicine.

As Mr. Maruyama said, "We see the key to this as being Hitachi's concept of symbiotic autonomous decentralized systems. Getting to the final stage of the super hospital concept will entail the staged integration of a variety of systems along with their expansion and growth, including the merging of multiple hospitals. It is in situations like this that involve links between different functions and the sharing of information under different rules that the concept of symbiotic autonomous decentralized systems can demonstrate its value."

Symbiotic autonomous decentralized systems



Overview of expansion and growth beyond the hospital itself under the "super hospital" concept. There is a need for integration with existing systems of different types operated by external organizations based on the symbiotic autonomous decentralized systems concept.

concept is a system concept for achieving overall optimization in a symbiotic manner by having multiple systems designed for different purposes share information while continuing to operate autonomously. I believe that this concept is always at work when achieving improvements in both the efficiency and quality of healthcare.

While the super hospital concept has only just got underway, there is much to do if its objectives are to be achieved and high expectations for Hitachi's technologies and ability to develop solutions.

Mr. Lindeman said, "There is much that Hitachi can provide, including improvements to management efficiency and the use of IT and other technologies to overcome challenges, particularly the prospect of using telemedicine in the future. I see three levels to how we can continue to build on this project we are undertaking in Denmark. The first is the successful completion of our joint development of solutions with Bispebjerg og Frederiksberg Hospital; the second is to roll out these solutions to other medical institutions in Denmark. The third level is then to take the know-how from Denmark and apply it in the global market."

Mr. Tani said, "The global deployment of solutions is likely to involve places such as China and the Middle East where healthcare will develop further in the future, and mature societies such as the nations of Europe that, like Denmark, are facing the challenge of rising social security expenditure. While keeping in mind the prospect of horizontal deployment, our initial aim is to contribute to healthcare reform in Denmark through our work with Bispebjerg og Frederiksberg Hospital on the collaborative creation of new solutions that tie in with their management strategy."

As maintaining the health of the public is an issue that bears directly on the nation's finances, the reforms being undertaken by Denmark can be seen as a bold strategy for taking on challenges faced by all mature societies. There is immeasurable potential for creating value through the combination of data and knowledge acquired through the operation of hospitals with Hitachi's IT and other technologies and its proprietary service design methodologies. The concept has started to make progress toward the achievement of global healthcare innovation that arises out of collaborative creation.

Visionaries 2016

Linking Manufacturing with Value

— Global Procurement Logistics Service —

As companies seek to strengthen their global competitiveness, manufacturers are being called on both to satisfy diverse customer needs and to achieve optimal production by making sophisticated use of IT, such as through the initiatives taking place under Germany' s Industrie 4.0 project. Key management challenges for achieving this include siting plants and establishing supply chains that are optimal at a global level, and establishing procurement strategies that take account of the TPP and other tax considerations. As part of Hitachi Smart Transformation Project, Hitachi is reforming its supply chains in sophisticated ways across the group. This provides support for comprehensive structural reform of the corporation, including, for example, the launch of the Global Procurement Logistics Service based on this know-how.

Kazuya Nakamura

Potential for Improvement in China

Along with economic globalization, Japanese manufacturers in particular are increasingly establishing operations overseas. What this tends to mean in practice is that functions such as management and research and development are retained in Japan while manufacturing is undertaken in China, Southeast Asia, or other countries that offer low-cost labor. Most notably, along with its transition from "global factory" to "global market," China, which has now grown into the world's second largest economy, has become the destination for growing investment from Japanese companies and the site chosen for the construction of a large number of factories.

Kazuya Nakamura [General Manager, Smart Logistics Business Group, Hitachi (China) Ltd.], who has moved to China to work on business operations there, offers the following analysis of this

situation.

"China's economy is said to be entering a new phase (a 'new normal') that will be different from the rapid growth of the past. Nevertheless, there remains considerable scope for improvement, with inefficiencies still present in how things are managed and distribution costs that are higher than in developed economies. Moreover, with the Chinese government having recently announced its Made in China 2025 plan aimed at lifting the level of manufacturing up to that of developed economies over the next 10 years, it is anticipated that work on development and enhancement of the manufacturing infrastructure will continue."

Other urgent issues include satisfying demand for higher levels of service quality and dealing with the rapid growth in the volume of goods being transported due to rising individual consumption. Against this background of challenges faced by companies manufacturing in China, Hitachi has launched its Global Procurement Logistics Service, which aims to help overcome them. As part of this, Hitachi's China subsidiary, Hitachi (China) Ltd., has also established its Smart Logistics Business Group.

Naohiko Gommori (General Manager, Industry Project Division, Business and Engineering Solutions Division, Social Innovation Business Promotion Division, Hitachi, Ltd.) describes the lead up to the launch of this service as follows.

"The sophisticated reforms that Hitachi is seeking to bring to supply chains through its Global Procurement Logistics Service are targeted at helping overcome management challenges that are common to all manufacturers, including reforming cost structures and improving cash flow. Having faced these same challenges itself, Hitachi has worked on ways of resolving them and achieved a certain degree of success. In other words, this service can be described as one that commercializes this problem-solving know-how."

Naohiko Gommori

China's economy is said to be entering a new phase (a "new normal"). (The photos show downtown Shanghai.) Steps are being taken to raise the level of the nation's manufacturing industry under the Made in China 2025 plan.

Atsushi Nabeshima

Based on Hitachi's Own Accumulated Know-how

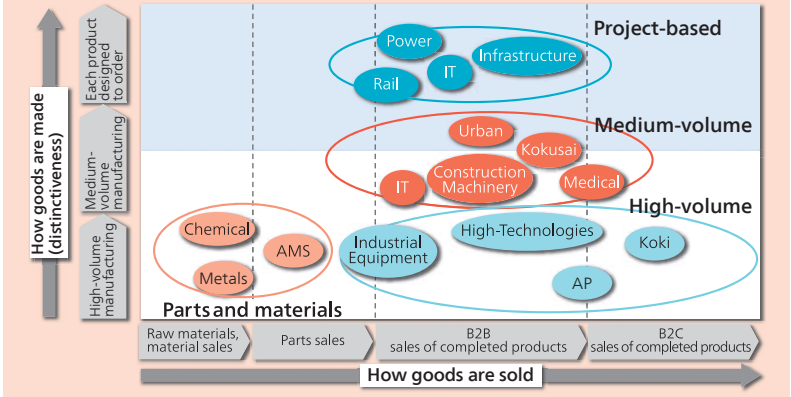
Hitachi launched Hitachi Smart Transformation Project in FY2011 with the aim of improving cost-competitiveness to achieve growth in global markets. The project includes activities for reforming cost structures through better global procurement and logistics and the use of shared services to reduce the manufacturing costs, direct material costs, and indirect costs that together make up the cost of sales and of sales management. To realize the benefits of reforms made in procurement and logistics respectively, policies were put in place for extending the network of procurement offices, making greater use of consolidated purchasing, and adopting joint shipping and delivery. Furthermore, responsibility for international procurement, previously handled by operational divisions, was reassigned to take advantage of professional capabilities within Hitachi, such as having Hitachi High-Technologies Corporation handle procurement and Hitachi Transport System, Ltd. deal with logistics, for example. This achieved cost reductions by economies of scale.

Tetsuya Uchiyama

Mr. Gommori comments, "To begin with, the idea of commercializing the business was prompted initially by the frequent consultations the company had as part of Hitachi Smart Transformation Project. No doubt the fact that Hitachi had achieved major cost reductions itself added a degree of credibility. Furthermore, Hitachi is engaged in all forms of manufacturing, from project-based work in the electric power, transportation, and other sectors; medium- and high-volume manufacturing; and also parts and materials businesses. As a result, being conversant with the challenges faced by manufacturers, the company saw itself as well placed to offer customers its know-how in a variety of different ways."

Atsushi Nabeshima (Deputy General Manager, Hitachi Group Smart Transformation & Business Development Center, Global Business Development Headquarters 1, Hitachi Transport System, Ltd.), who was involved in getting the project up and running, identified the benefits of reforms to supply chain management as follows.

"The company is working on reforms at companies throughout Hitachi, and one of the reasons for its success has been the different approach it has taken to optimization. Whereas the objective in the past has been to optimize individual plants, the company now seeks to optimize operations across business units and the entire group. This has enabled it to reap the benefits of synergies."



B2B: business to business; B2C: business to consumer; Power: Power Systems Company, Hitachi, Ltd.; Rail: Rail Systems Company, Hitachi, Ltd.; IT: Information & Telecommunication Systems Company, Hitachi, Ltd.; Infrastructure: Infrastructure Systems Company, Hitachi, Ltd.; Urban: Urban Planning and Development Systems Company, Hitachi, Ltd.; Kokusai: Hitachi Kokusai Electric Inc.; Construction Machinery: Hitachi Construction Machinery Co., Ltd.; Medical: Hitachi Medical Corporation; Chemical: Hitachi Chemical Co., Ltd.; AMS: Hitachi Automotive Systems, Ltd.; Metals: Hitachi Metals, Ltd.; Industrial Equipment: Hitachi Industrial Equipment Systems Co., Ltd.; High-Technologies: Hitachi High-Technologies Corporation; Koki: Hitachi Koki Co., Ltd.; AP: Hitachi Appliances, Inc.

Hitachi's business activities categorized according to how goods are sold and how they are made. As a manufacturer itself, Hitachi is involved in all different types of manufacturing.

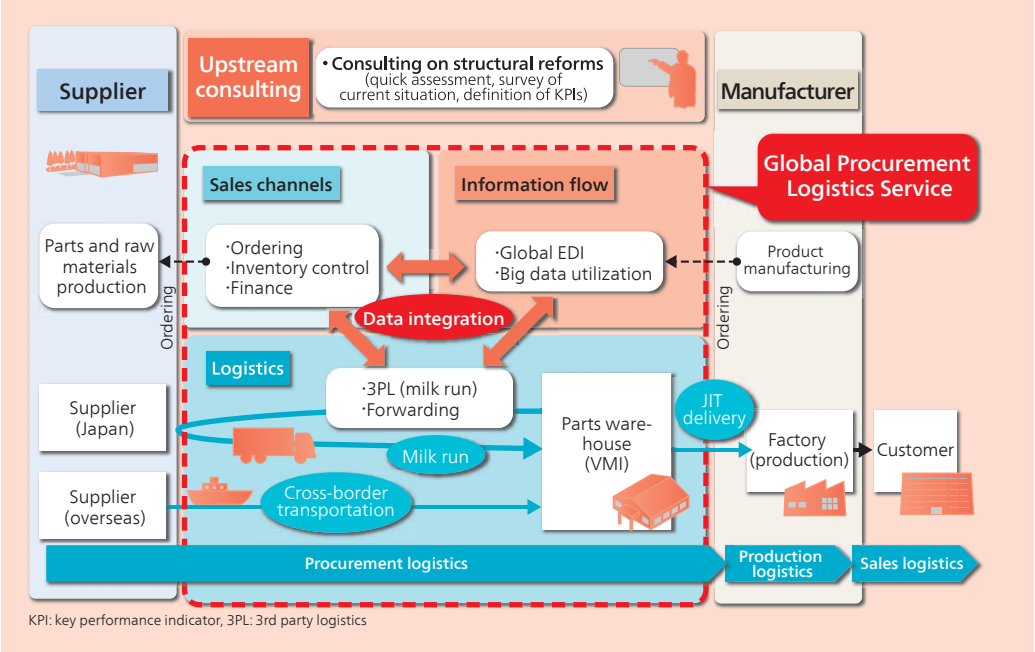
Integrated Service for Procurement, Logistics, and Information

What does the Global Procurement Logistics Service actually involve? The major feature is that it integrates procurement, logistics, and information. That is, it reforms supply chain management in terms of optimizing all of its aspects by providing integrated functions for trading, logistics, and information technology (IT). The service can be described as drawing on the comprehensive capabilities of Hitachi, with its experience in all three areas of activity.

The procurement service utilizes the trading company capabilities of Hitachi High-Technologies Corporation. It includes support for the procurement of parts and materials, inventory management at production plants and their associated warehouses, operation of vendor-managed inventory (VMI), and importing. It also covers financial services such as factoring (the purchase of trade debt owed to a company and its subsequent collection).

Tetsuya Uchiyama (General Manager, Functional Materials & Supply Chain Div., Hitachi High-Technologies Corporation) made this point as follows.

"Significant developments are underway in association with the formation of major economic zones, including free trade agreements (FTAs) and the Trans-Pacific Partnership (TPP). When the rise of a new economic zone excludes a nation



Overview of Global Procurement Logistics Service. Hitachi has platforms for all steps along the supply chain and supplies comprehensive services for dealing with complex challenges.

from which parts have been sourced in the past, it can result in the imposition of new tariffs or, depending on the nature of the parts, changes to the procedures for satisfying trade administration requirements. While Hitachi has know-how in how to deal with such situations, companies operating overseas find this difficult due to the limited availability of human resources in their overseas operations. To address this difficulty, Hitachi offers to reorganize their procurement operations on a global basis."

The logistics service utilizes the global network of Hitachi Transport System, Ltd. to reduce the costs of international logistics through the joint shipping of goods by sea or air. For transportation within Japan, the service provides a high level of added value by combining the distribution centers it operates at each of its facilities with practices such as milk-run and just-in-time (JIT) delivery.

Mr. Nabeshima states, "The logistics provided by this service go beyond simply the transportation of goods. Rather, the aim is to provide the same advanced logistics practices used in Japan by, for example, reconfiguring logistics so as to treat the company's warehouses as part of the production line. The intention is to establish optimized supply chain management practices by combining logistics and procurement and integrating transaction and other customer logistics data."

Underpinning these practices are IT platforms based on the use of electronic data interchange (EDI) in procurement. These information services utilize Hitachi's TWX-21 business media service to establish interconnections between production sites and suppliers that extend globally so that electronic practices can be adopted for procurement, and also to provide visibility in the supply chain and enable such things as coordination of supply and demand.

Recognizing that each customer has different challenges and objectives, Takeshi Ishizaki (Senior Director of Smart Business Department, Smart Information Systems Division, Information & Telecommunication Systems Company, Hitachi, Ltd.) describes the provision of the service as follows.

"One of the reasons that logistics in the emerging economies of Asia are so expensive is the extreme inefficiency of practices that results from the slow uptake of electronic methods. As well as providing shorter lead times, paperless operation, and lower labor costs, the service is based on lot-level traceability, meaning it can also cope with product recalls. The company starts by taking note of the customer needs identified during its marketing activities and incorporating these into the IT service."

As part of providing the Global Procurement Logistics Service, Hitachi undertook a preliminary demonstration project at a number of its sites in China. This involved trialing a shared milk run


Takeshi Ishizaki

for local Chinese suppliers (three new suppliers and seven existing suppliers with which neighboring factories already had dealings) and succeeded in reducing procurement and logistics costs by 12.7%. The demonstration project also achieved a 22.4% reduction in inventory levels thanks to the more frequent deliveries of smaller quantities that milk runs make possible.

Tools for Highlighting Value

Having confirmed these benefits, the Global Procurement Logistics Service was launched in FY2015. The service is initially targeting Japanese companies that manufacture transportation equipment, electrical machinery, parts, and other products for the Chinese market, with offerings that include warehouse management, transportation, procurement and other operational outsourcing, and also ways of helping with improvements and efficiency enhancements for operational management such as the visualization of information on procurement and logistics. Mr. Nakamura, who is coordinating the project at Hitachi (China) Ltd., describes it as follows.

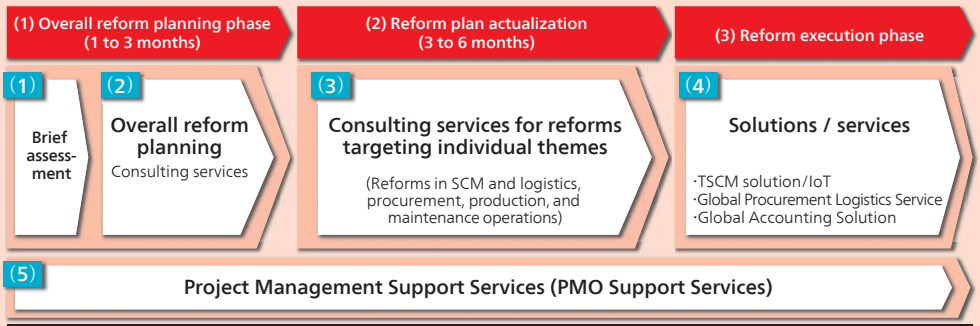
Example screens from NEXPERIENCE / Cyber-Proof of Concept, a simulation tool that is simple to use and can simulate a variety of hypotheses to highlight waste and help identify value through improvements.

"The project team started out with a staff of around 20 including members from the research and development division. The team covers consulting and engineering, sales, and project management, with its role being to design supply chain management practices that combine the procurement, logistics, and information services to cut the cost of logistics and reduce inventory levels. That is, it is the team's task to put together optimal proposals that will lead to the provision of specific services for overcoming the challenges faced by customers. Upstream consulting plays a vital role in this work. Because of the obvious need for a quantitative assessment of business viability, the team uses business value simulation tools to show customers the sort of improvements that can be made.

The service itself is provided in a series of steps: (1) preliminary assessment, (2) proposal of new models, (3) specific proposals, (4) system and operation preparations, (5) trial operation, and (6) full roll-out. The preliminary assessment involves two steps: a structural review of current logistics practices and an investigation of new models with quantitative simulation of the benefits. A business value simulation tool called NEXPERIENCE / Cyber-Proof of Concept (Cyber-PoC) is used in this latter step.

This tool simulates factors such as the cost-benefit of infrastructure construction projects in cyberspace. While reforming the supply chain includes demonstration projects and other trials as well as assessing potential improvements with reference to considerations like cost, cashflow, and lead times, these are costly in both time and money. NEXPERIENCE / Cyber-PoC utilizes techniques from big data analytics to help study the viability of improvements and reforms by simulating a wide variety of hypotheses and presenting their outcomes on a computer.

Mr. Nakamura states, "In addition to its obvious uses for presenting information about the current situation, the service can simulate what happens when conditions such as lead times or inventory are modified, and also initiatives that are desirable but difficult to implement in practice, such as teaming up with other manufacturers. Unlike existing logistics analyses that are difficult to understand, NEXPERIENCE / Cyber-PoC is a valuable tool for presenting customers with clearly intelligible opportunities for identifying value in quantitative form and with the sort of visual presentation that you would get from the results of an actual



Consulting options		Overview
(1)	Brief assessment	Quick estimate of potential for reforms, support for deciding whether to undertake full-scale study
(2)	Overall reform planning Consulting services	Formulation of macro measures in preparation for embarking on a full-scale project. These include measures for determining project objectives and challenges, prioritizing the challenges, and actualizing them.
(3)	Consulting services for reforms targeting individual themes	Assist with study to flesh out concepts associated with specific reforms, including reforms in SCM and logistics, procurement, production, and maintenance operations
(4)	Solutions / services	Provide Hitachi solution services required for reforms (Includes provision of service platforms established for Hitachi Smart Transformation Project)
(5)	PMO Support Service	Support smooth implementation of project, including management of diverse stakeholders

SCM: supply chain management, TSCM: total supply chain management, IoT: Internet of things,PMO: project management office

Structure and offerings of the Transformation Support Services, which utilizes practical know-how that Hitachi has built up through trial and error in its own reforms to help companies with global business operations to undertake fundamental structural reforms.

trial. Hitachi is also currently collaborating with its research and development division to present information on the efficiency of truck deliveries. The company believes these will also prove effective in the future for demonstrating its capabilities for using IT to companies from China or other overseas nations."

In the future, Hitachi intends to expand the service beyond Japanese companies to also target Chinese companies, with a view also to deploying and expanding the service into Southeast Asia.

Future Prospects for Corporate Structural Reform

Amid these developments, in December 2015, Hitachi commenced delivery of a new service. Called the "Transformation Support Services," it is targeted at Japanese companies with global business operations.

Mr. Gommori states, "With considerable demand from customers wanting to engage in corporate reform, Hitachi launched the Transformation Support Services to assist companies with comprehensive structural reforms.

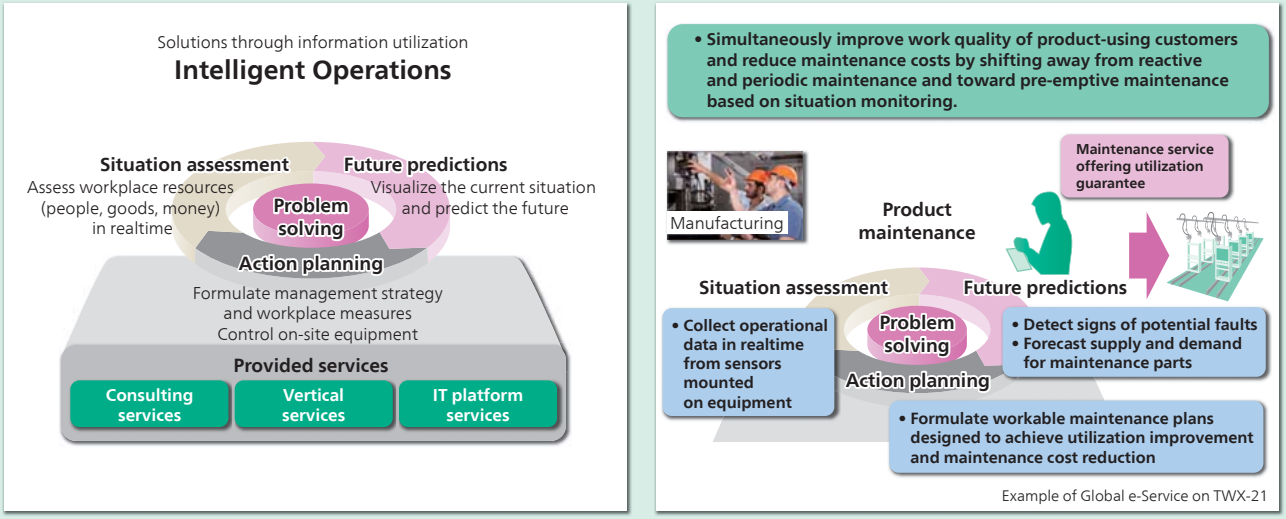
"The service provides solutions that have generated benefits and practical know-how that Hitachi has acquired through trial and error in Hitachi Smart Transformation Project. Because it can utilize various templates and ways of dealing with challenges that Hitachi used in Hitachi Smart Transformation Project, use of the service makes it possible to undertake projects in a short timeframe."

The service is designed to be provided in three phases: an overall reform planning phase, a reform plan actualization phase, and a reform execution phase. Along with the Global Procurement Logistics Service, the reform execution phase also extends to production reforms, global accounting, and maintenance reforms, making available solutions and services to support the operations of manufacturing businesses.

Mr. Gommori states, "Japanese companies are still behind the best overseas companies in terms of operating profits and cashflow margins. Hitachi wants to leverage its past successes and failures to assist with reforms by customers and support global growth strategies."

Initiatives such as Germany's Industrie 4.0 project and the Made in China 2025 plan that are aimed at utilizing IT to enhance competitiveness in manufacturing are attracting international attention. Hitachi is striving to provide services with a high level of added value to contribute to structural reforms that lead to greater manufacturing competitiveness.

IT Solutions and Services



1 Intelligent Operations framework for solutions through information utilization (left) and examples of operational innovation (right)

1 Operational Innovation through Use of Workplace Information Intelligent Operations

Along with increasing corporate globalization and the rapid commodification of products and services, companies are being called on to build more competitive businesses.

Responding to these developments, Hitachi is combining business knowledge built up in the workplace with various forms of data that can now be collected thanks to recent advances in the technology behind the Internet of things (IoT), and is using this to establish solutions for utilizing information to promote new innovations under the framework of Intelligent Operations.

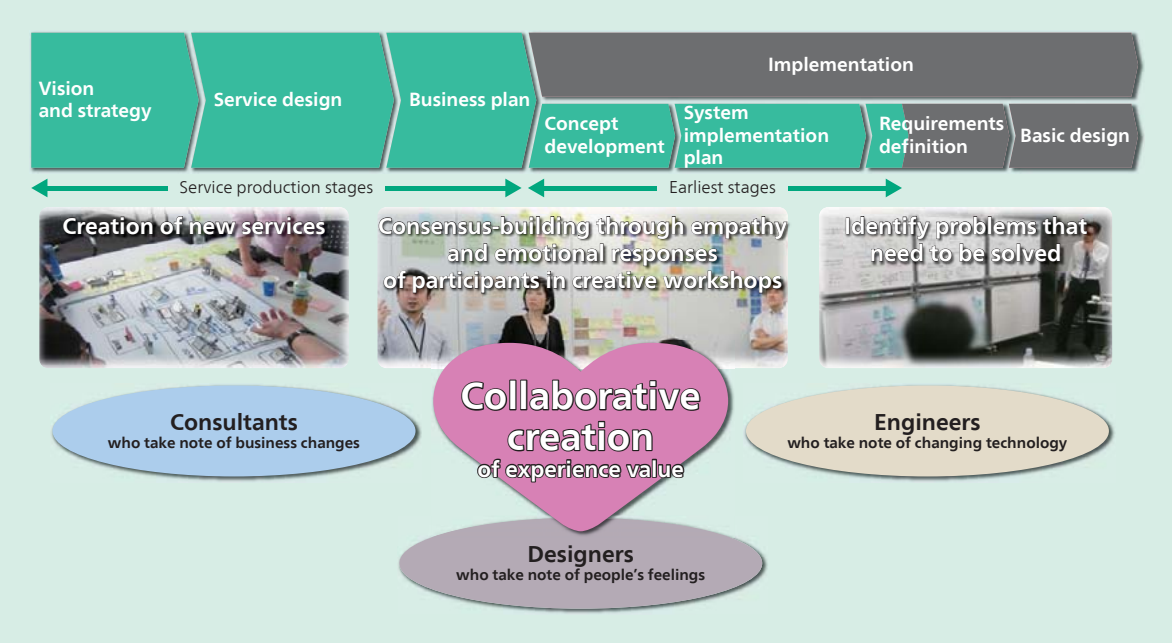
By acquiring and utilizing information in a multidisciplinary manner from a wide variety of business workplaces, including product manufacturing (equipment and work management), logistics (warehousing, distribution), sales and service delivery (customer, sales trends), and operation and maintenance (faults, claims), Intelligent Operations seeks to facilitate business innovation through more sophisticated decision-making on business improvement and development, activities that in the past have relied on the experience and intuition of numerous managers and other experts from each area.

Specifically, by acting as a one-stop provider of consulting services, vertical services (services for specific industries), and information technology (IT) platform services, Intelligent Operations implements a cycle of collecting workplace information (situation assessment), using this information as a basis for predicting what might happen next (future predictions), and providing timely feedback to the workplace or management in the form of decisions made based on these predictions (action planning).

Hitachi utilizes this Intelligent Operations framework to supply solutions to various different industries, including manufacturing, energy, and healthcare.

Examples include Hitachi Enterprise Asset Management, which optimizes corporate assets by improving the productivity of various maintenance tasks, such as the optimization of equipment inspection plans, status visualization, and the rationalization of inspection work, and the supply of Global e-Service on TWX-21, which adds value to products, including ancillary services, through the global management and sharing of information across the entire product life cycle.

In the future, through the supply of Intelligent Operations, Hitachi intends to contribute to the ongoing progress of society by providing the entire world with better living conditions and business environments.



2 Experience-oriented approach for collaborative creation with customers

2 Experience-oriented Approach for Collaborative Creation with Customers

The experience-oriented approach is a technique for collaborative creation that considers people's experiences to determine the system concept and requirements definition in the very earliest stages of a project, and can be used to formulate a new vision for the customer's business, develop strategy, and design services.

It provides a framework under which designers, consultants, and engineers can work together to conduct investigations from a variety of in-depth perspectives. It can deal with a diverse range of cases by combining assorted collaborative creation techniques developed by research institutions with extensive implementation know-how built up through involvement in actual projects. Through creative workshops coordinated by a facilitator, it creates a greater sense of ownership and promotes the building of a consensus on issues such as new services or how to solve problems by drawing on the empathy and emotional responses of the participants together with a mix of quantitative data and qualitative experiences. Proposals for new services or ways of solving problems for which people feel a greater sense of ownership have a higher level of viability because they make it easier to achieve consensus among participants in subsequent implementation processes, resulting in less rework.

3 Hitachi Enterprise Asset Management Solution

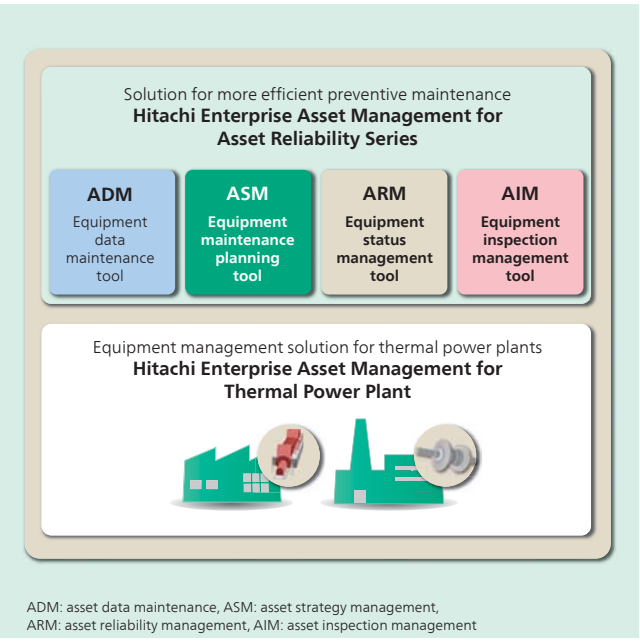
There is growing demand for solutions that maintain and improve equipment utilization through accurate and efficient preventive maintenance while also minimizing the cost of equipment management. Hitachi Enterprise Asset Management boosts the efficiency with which companies can manage maintenance of their manufacturing equipment and plants. It is available in the following two forms.

(1) Hitachi Enterprise Asset Management for Asset Reliability Series

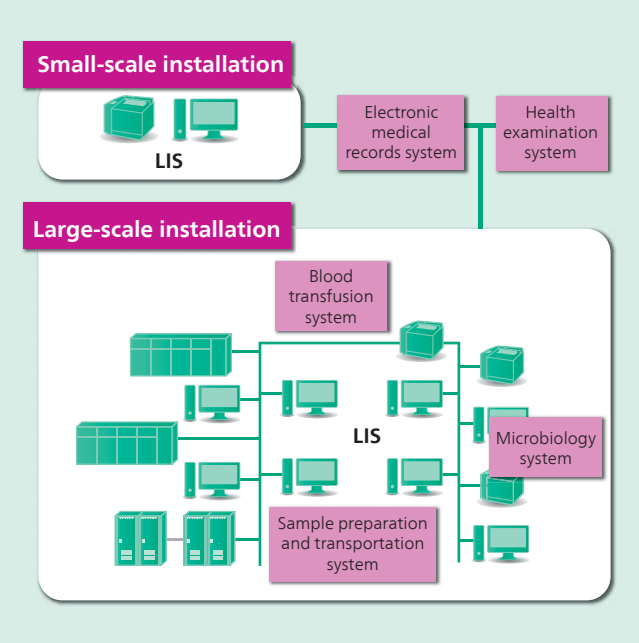
This solution for more efficient preventive maintenance provides four additional tools for use with existing equipment and asset management systems, supporting preventive maintenance planning, decision making, and inspection for manufacturing equipment and various plants.

(2) Hitachi Enterprise Asset Management for Thermal Power Plant

An equipment management solution for thermal power plants that supports the rapid installation of equipment management systems at thermal power plants by using templates that run on a SAP enterprise resource planning (ERP) module for plant maintenance.



3 Hitachi Enterprise Asset Management Product Lineup



4 Example LIS configuration

4 Clinical Testing System for Medical Institutions LIS

Hitachi has more than 40 years of history with clinical testing systems, with laboratory information system (LIS) being its most recent product. The product is mainly supplied to testing laboratories run by hospitals, medical associations, and external providers and its end users are the laboratory technicians who staff these facilities. The main steps in the workflow for clinical testing are checking the test order entered by the doctor into an electronic medical records system or other similar system; analyzing the content of the blood, urine, or other sample on an automated testing system; and promptly updating the results in the electronic medical records system. The LIS supports team-based healthcare by providing functions to ensure that this workflow is performed smoothly and safely, including interoperation with the electronic medical records system, automated testing systems, and other systems at the testing laboratory. It contributes to healthcare quality and better working practices through quality assurance that includes the managing analysis data accuracy and providing data on turn-around time (TAT) in terms of the entire process.

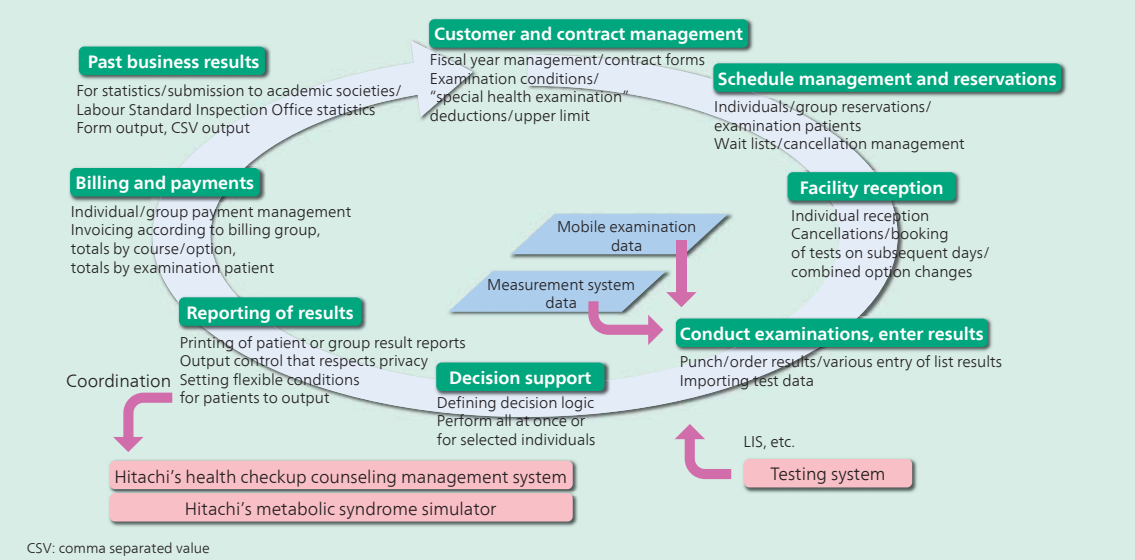
In the future, Hitachi intends to work hard to contribute to team-based healthcare and to help improve medical quality by adding additional functions to make the system safer and more secure.

5 Hitachi's Support System for Medical Examinations and Health Guidance

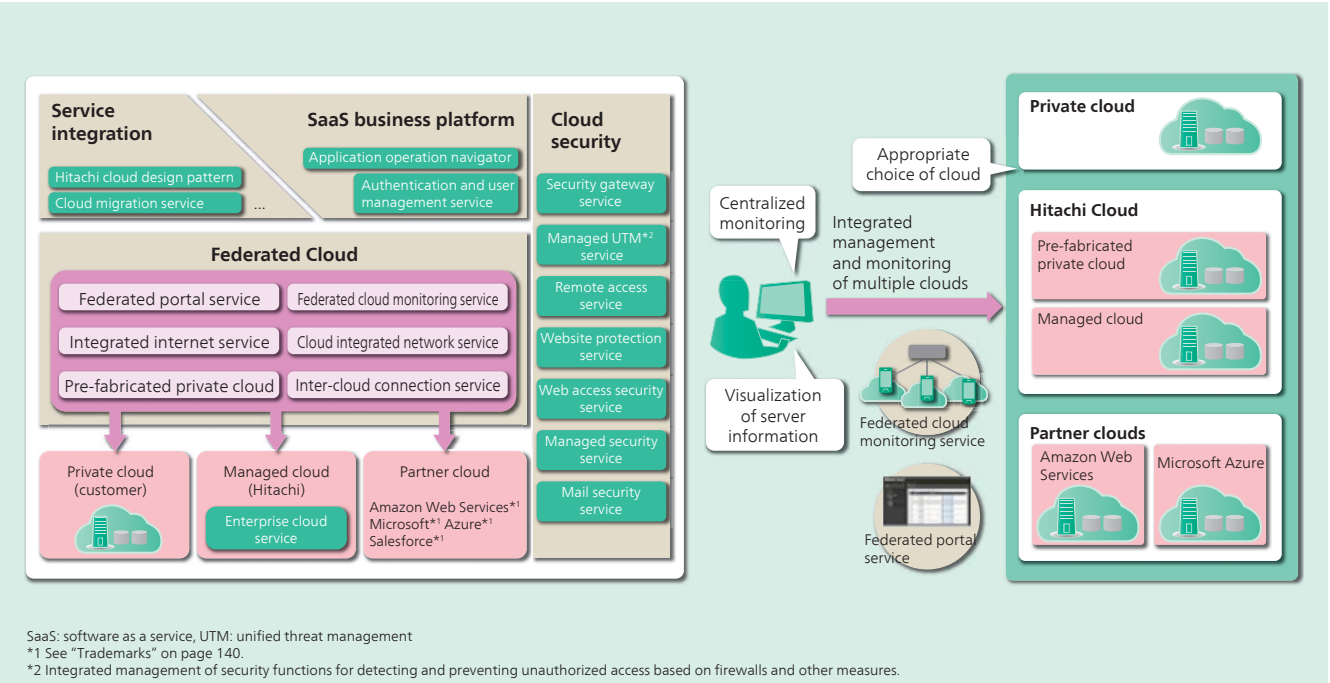
Hitachi's support systems for medical examinations and health guidance refers to three products that support preventive healthcare and promotion of health: Hitachi's health checkup system for medical examinations, Hitachi's health checkup counseling management system for giving specific health guidance in the form of a medical checkup for metabolic syndrome, and Hitachi's metabolic syndrome simulator, which provides lifestyle disease risk simulation. The core Hitachi's health checkup system product consolidates know-how acquired through extensive experience and outcomes in the medical examination business going back more than 40 years and provides support for a wide range of healthcare practices, including complete medical checkups and other on-site health checks, mobile examination programs such as routine or resident examinations, and special health examinations.

The product is increasingly being installed at large facilities in particular because of its support for operational activities ranging from contract and reservation management to reception, examination, results output, billing, and operational records; its extensive functions for performing this work; and its flexibility and expandability.

In the future, Hitachi intends to contribute to controlling healthcare costs and to creating a society of health and longevity by incorporating additional functions and greater added value, and by supporting the promotion of health.



5 Overview of Hitachi's health checkup system functions



SaaS: software as a service, UTM: unified threat management
*1 See "Trademarks" on page 140.
*2 Integrated management of security functions for detecting and preventing unauthorized access based on firewalls and other measures.

6 Overview of federated cloud services (left) and management portal and monitoring functions (right)

6 Federated Cloud Services

The cloud has been growing in importance in corporate and other IT systems in recent years as a means for deploying systems or making configuration changes in a short period of time with minimal upfront costs, with aims that include global business expansion and the establishment of new businesses as well as reducing the cost of development and administration, and of ensuring reliable operation. On the other hand, a high degree of know-how is required to make appropriate choices when introducing cloud computing based on such factors as operating costs and the objectives and purposes of cloud use, with various options available including the customer's own private cloud, a managed cloud operated and administered by Hitachi, or a partner cloud belonging to a third party.

Since May 2015, Hitachi has been rolling out its federated portal service and federated cloud monitoring service. These services provide centralized management of business systems that operate across a number of clouds. The federated portal service provides capabilities for displaying and administering virtual machines and other platform information spread across multiple clouds from a single management portal with standardized operation. Similarly, the federated cloud monitoring service provides centralized monitoring of alerts from business systems spread across a number of clouds. This achieves the overall optimization of IT investment by enabling the efficient management of the customer's business systems.

Hitachi intends to enhance the global capabilities of Hitachi Cloud while making ongoing enhancements based on customer requirements.

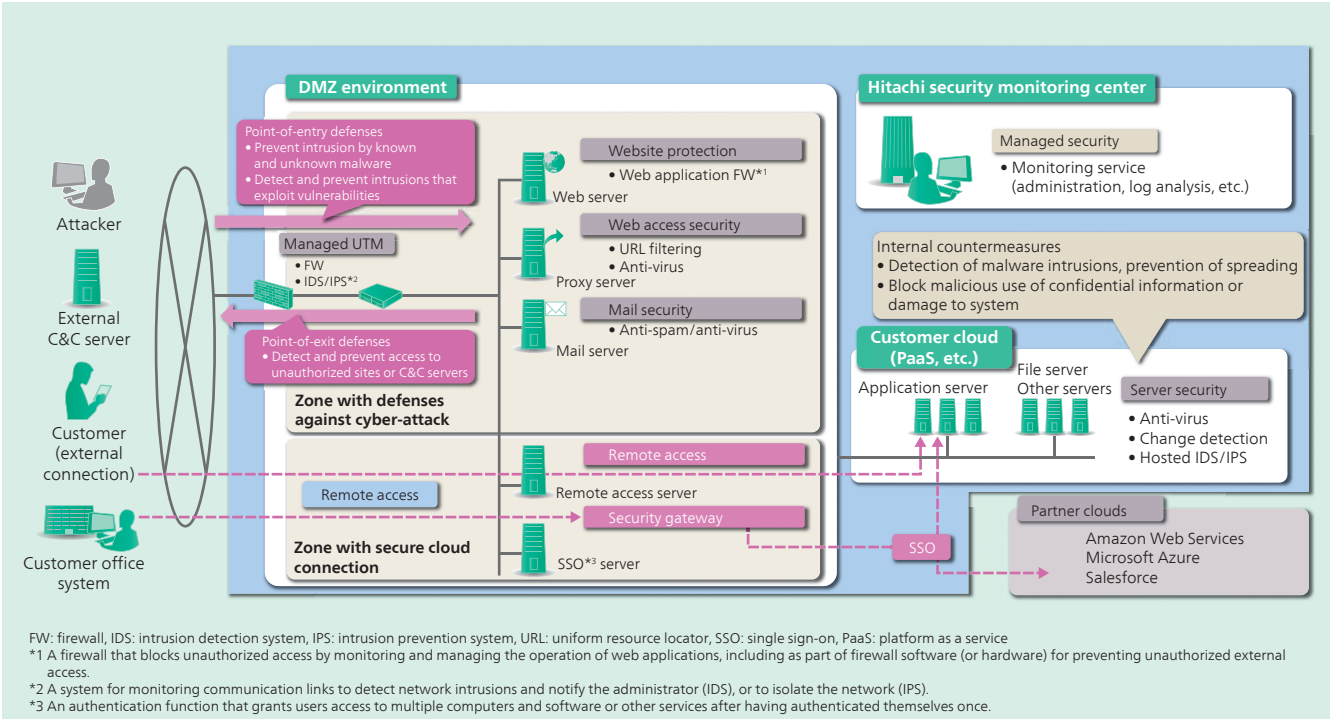
7 Cloud Security Service

Cyber-attacks such as zero-day attacks and increasingly sophisticated targeted attacks have become more advanced in recent years, with growing involvement from organized crime. In parallel with this, wider corporate use of the cloud is driving rising demand for more advanced functions for ensuring that this use is secure.

Hitachi Cloud supplies services that provide effective and timely security countermeasures against cyber-attack. Specifically, these provide defense-in-depth through an effective three-way combination of internal countermeasures and defenses at points of entry and exit. Defense at the point of entry means detecting and preventing malware or other intrusions that exploit vulnerabilities. Point-of-exit defenses detect and prevent access from within the network to unauthorized sites or command and control (C&C) servers*1. Internal countermeasures operate on the assumption that a malware intrusion has already occurred and act to prevent their spread, and to block leaking of confidential information or damage to the system.

Along with expanding the range of available security services, Hitachi will strive in the future to make customer systems safer and more secure by offering solutions with a high level of added value, such as comprehensive services for the secure defense of "demilitarized zones" (DMZs)*2, which are subject to high risks.

*1 In the case of cyber-attacks that work by an external party co-opting computers within an organization, a C&C server is a computer belonging to the attacker that issues instructions to the co-opted computers in order to carry out the cyber-attack.
*2 A network segment located between untrusted networks (such as the Internet) and trusted networks (such as an organization's in-house network). Servers such as those for the web or e-mail that need to access the Internet are located in DMZs.



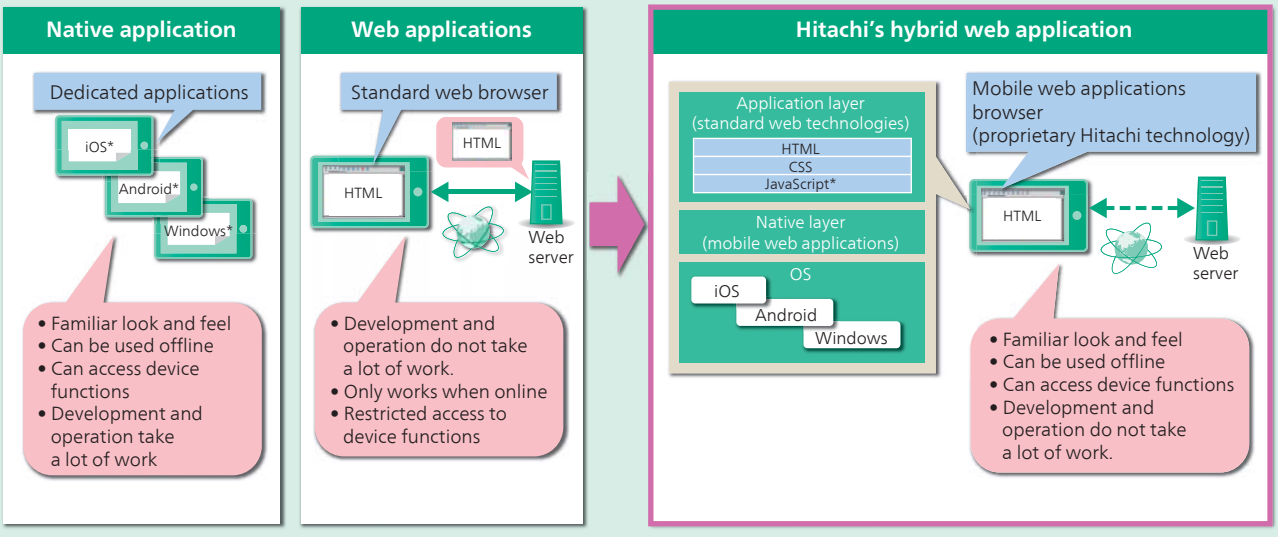
FW: firewall, IDS: intrusion detection system, IPS: intrusion prevention system, URL: uniform resource locator, SSO: single sign-on, PaaS: platform as a service
*1 A firewall that blocks unauthorized access by monitoring and managing the operation of web applications, including as part of firewall software (or hardware) for preventing unauthorized external access.
*2 A system for monitoring communication links to detect network intrusions and notify the administrator (IDS), or to isolate the network (IPS).
*3 An authentication function that grants users access to multiple computers and software or other services after having authenticated themselves once.

7 Overview of cloud security services

8 Hitachi Mobile Cloud Service for Financial Institutions

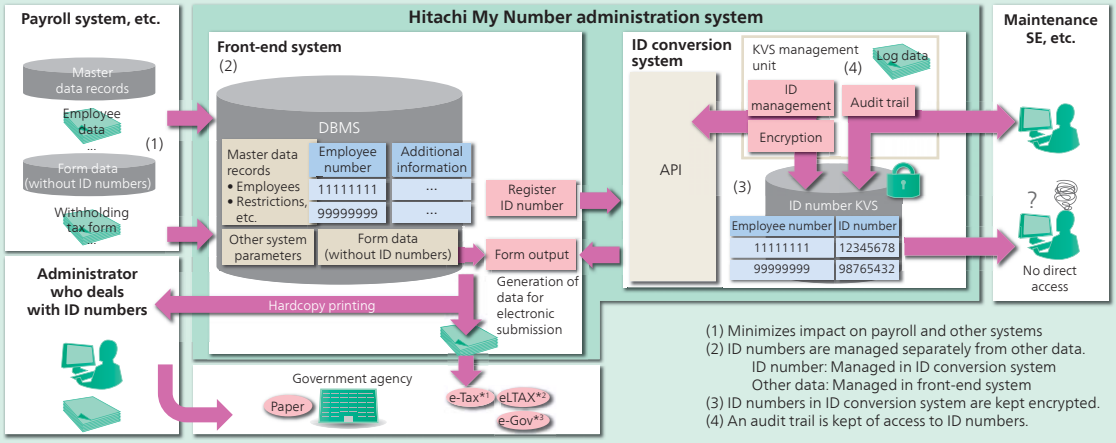
Financial institutions are making greater use of tablet computers to improve service quality, including the effective marketing of products to customers and the adoption of electronic application procedures.

Hitachi is pursuing a hybrid approach for its application architecture for smart devices that combines the use of standard web technologies for image display with the development of native applications for those aspects that need access to device functions or high performance, implementing the architecture in the form of a platform for executing mobile web applications from Hitachi Solutions Create, Ltd. Along with an execution environment for web applications that operates both on- and off-line, this platform provides device integration functions that make tablets a more practical option for business use, including using the camera to capture personal identification documents, using the touch panel for handwritten signatures, and printing application forms from a mobile printer. With the Hitachi mobile cloud service for financial institutions also available, customers can now introduce tablet systems more quickly.



HTML: hypertext markup language, CSS: cascading style sheets, OS: operating system
* See "Trademarks" on page 140.

8 Hybrid web application



DBMS: database management system, API: application programming interface, KVS: key-value store, SE: systems engineer
*1 Electronic national tax filing and payment system. *2 Local tax portal system. *3 Comprehensive point of contact for e-government.

9 My Number administration system

9 My Number Administration System for Private-sector Businesses

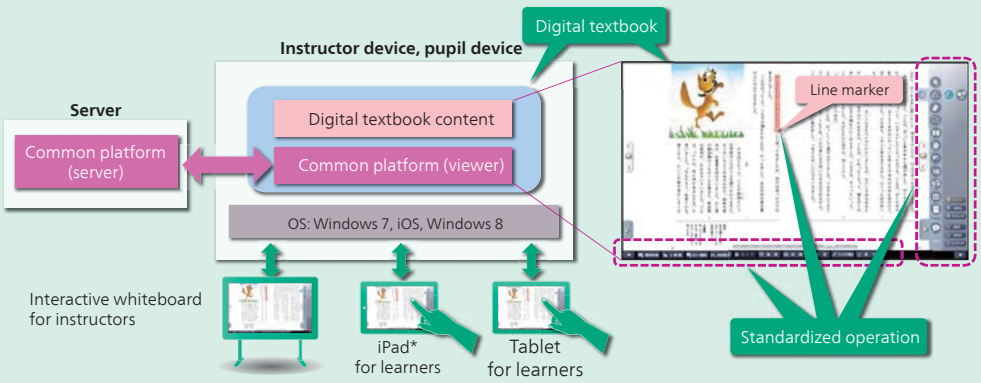
The Social Security and Tax Number ("My Number") System that entered use in January 2016 requires private-sector businesses to obtain ID numbers for staff and their dependents and to enter them on the official forms they submit to government agencies, such as those for income tax withholding payments in Japan. Because ID numbers are highly confidential, private-sector businesses are expected to handle them with care, and are criminally liable for leaks or other violations, with sanctions that include fines and prison sentences, including for top management.

Hitachi supplies a dedicated system (which it developed itself) for the secure management of ID numbers, including their storage and their entry and printing on official forms. The system incorporates ID conversion system (which Hitachi also developed itself) that uses techniques such as encryption and maintaining an audit trail to provide security measures for preventing leaks and other misuse of ID numbers.

The My Number and other ID number infrastructure has the potential to be extended to other sectors such as banking and healthcare in the future. Through the use of products and technologies such as the systems described here, Hitachi intends to help establish an environment in which ID numbers can be used securely.

10 Digital Textbook Business Targeting 21st-century Skills

The Ministry of Education, Culture, Sports, Science and Technology has formulated "The Vision for ICT in Education" aimed at instilling 21st-century skills. The consortium for the promotion of a digital text platform established by Hitachi and 12 textbook companies has developed a common platform for the digital textbooks that are at the core of this vision. Relying as they do on advanced IT, the development of digital textbooks posed difficult challenges that included supporting multiple operating systems (OSs), standardized operation, group learning, and distributing textbook content. The establishment of the consortium with support from the textbook companies came about after Hitachi proposed an approach that would consolidate these difficulties into a common platform made up of a viewer and server, and leave the textbook companies to focus on content development. The development process involved agreeing on specifications with the textbook companies and running a field trial to assess performance. The platform was introduced in elementary schools



* See "Trademarks" on page 140.

Source: *Gongitsune* (Gon, the Little Fox), a 4th-grade *kokugo* (Japanese) digital textbook published by Mitsumura Tosho Publishing Co., Ltd.

10 Role of common platform for digital textbooks and example screen

throughout Japan beginning in April 2015 and its use is still expanding. The adoption of a common platform has significantly improved the convenience of textbook use in the classroom by providing a standardized user interface in place of the diverse interfaces used in the digital textbooks published by individual companies in the past. It also includes the network distribution of textbook data and license management. Because the common platform looks after important IT components such as support for networks and multiple OSs, it has significantly reduced the development workload at textbook companies.

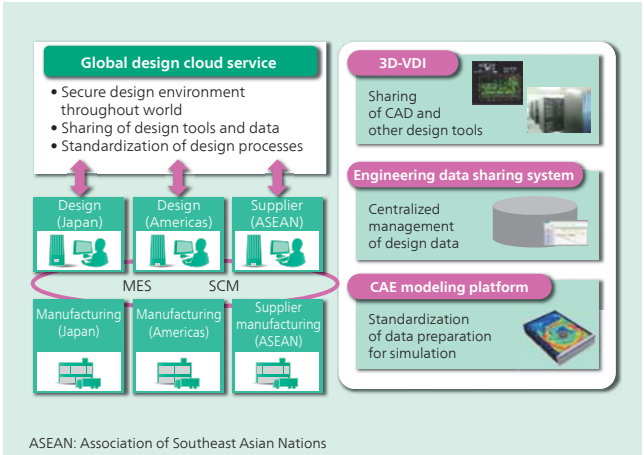
In the future, Hitachi intends to contribute to society in the form of educational and social infrastructure by making the common platform into a de facto standard and expanding its scope to include junior and senior high schools.

11 Global Design Cloud Service

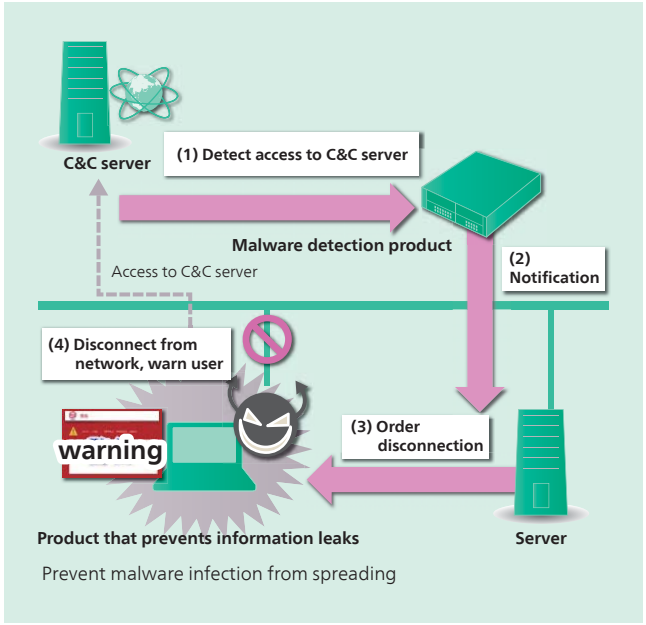
Differences in the quality of workmanship at different facilities are becoming a problem for manufacturers as they expand their operations globally. Design in particular is highly dependent on the skills and know-how of individuals, making the achievement of consistent quality through work standardization an issue of concern. This has created a demand for design environments that can be used securely from overseas offices, and that enable data sharing and the standardization of design tools.

In response to this demand, Hitachi supplies a global design cloud service that is made up of a three-dimensional virtual desktop infrastructure (3D-VDI) for three-dimensional computer-aided design (3D-CAD) and an engineering data sharing system for sharing drawings between offices. This provides global access to data and to 3D-CAD and other design tools on the same platform. Hitachi also supplies a modeling platform that standardizes the preparation of data using computer-aided engineering (CAE), making it possible to minimize the variability in accuracy resulting from differences in designer skill levels.

In the future, Hitachi intends to add services for sharing design processes between different offices and to make enhancements to manufacturing practices (such as shorter lead times) through integration with supply chain management (SCM), manufacturing execution systems (MESs), and other systems.



11 Cloud service for global design



12 Interoperation between product that prevents information leaks and malware detection product

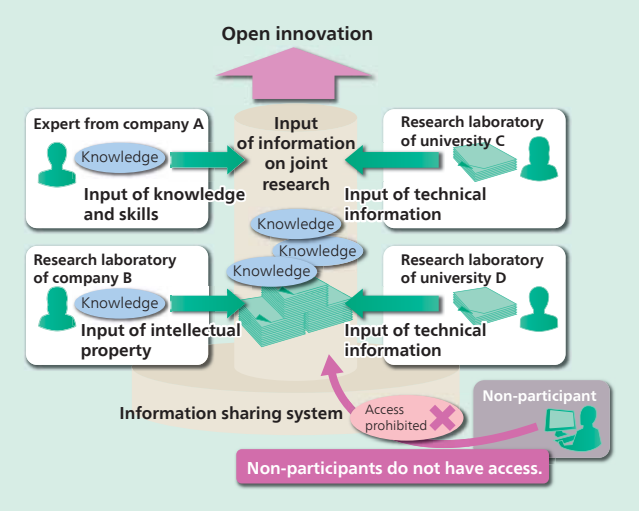
12 Solution that Prevents Information Leaks

While the measures being adopted by companies to prevent information leaks are becoming more diverse in response to changes in things like working practices and IT infrastructure, the potential information leaks that need to be countered are also becoming more complex, extending from the loss or theft of information to internal fraud and malware attacks.

In line with the objective of countering information leaks, this solution uses control of devices and networks, encryption, and information rights management (IRM) to provide the robust security demanded by corporations. Given the increasingly sophisticated malware attacks of recent years, what is important is not only to take pre-emptive steps to block attacks, but also to consider how to extend this to prevent the further spread of damage by quickly identifying and responding to malware infections when they do occur. The product that achieves this solution works with anti-malware products to take actions such as issuing warnings to infected devices or automatically disconnecting them from the network based on the severity of a detected incident. Disconnection from the network prevents the infection from spreading more widely across the internal network.
(Hitachi Solutions, Ltd.)

13 Information Sharing Platform that Supports Open Innovation at Companies

A rising number of companies are adopting open innovations that incorporate a wide range of high-level specialist knowledge and skills so that they can continue to supply products and services that deliver value in a highly competitive environment characterized by markets that are changing at an increasingly rapid pace. However, open innovation requires the sharing of important technical data, intellectual property, and other confidential infor-



13 Using open innovation in collaborations between industry and academia

mation with partners. Achieving this requires IT infrastructure that allows companies to be confident about sharing this confidential information with external partners.

Hitachi's information sharing platform supports open innovation by combining advanced IT with know-how built up over many years in different fields to provide flexibility in the use of business content, incorporating the management of access rights for content (including after it has been supplied to external partners); document protection that can block further access to documents if necessary; document management designed to let information be updated by a number of different people; high-speed transfer of large quantities of technical data up to several tens of gigabytes in size; and a corporate social networking service (SNS) suitable for sharing information held by the people involved in particular work.

This information sharing platform is recognized for helping invigorate and speed up the pace of research, having been adopted in joint research involving extensive open innovation between industry and academia as a way of sharing information throughout projects.

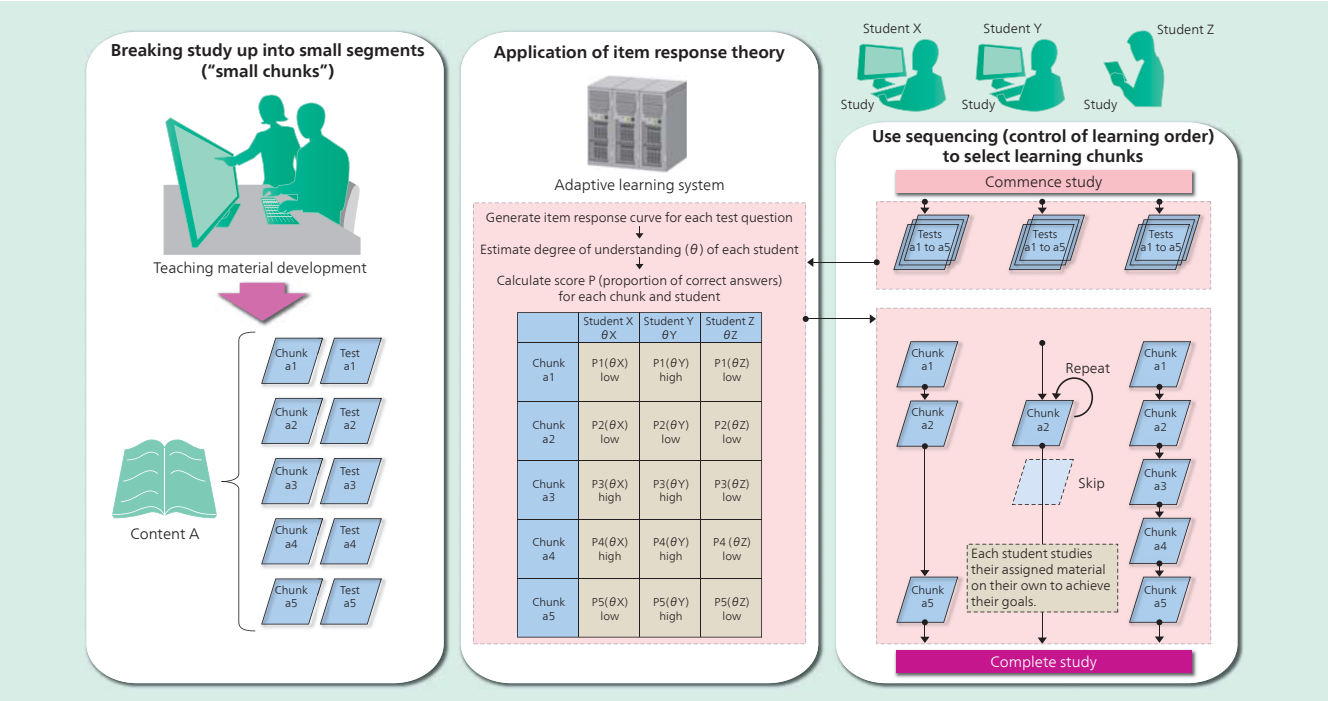
(Hitachi Solutions, Ltd.)

14 Adaptive Learning System Solution for IT Staff Training

While the spread of e-learning has made it possible to study regardless of time or place, the growing diversity of training in recent years is leading to rising demand for providing autonomous learning to students with different levels of experience and skill so that they can all reach certain goals. In response to this challenge, Hitachi has developed an adaptive learning system for determining the proportion of correct answers and selecting and recommending the required learning material based on the use of preliminary tests to obtain an accurate assessment of each student's level of understanding. This involved the service launch in December 2015 of "e-learning with navigation functions," a new e-learning system format that combines techniques such as "chunk learning" (breaking study up into small segments), sequencing (selecting the learning "chunks" based on degree of achievement of learning goals), and item response theory (calculation of preliminary test scores). Rather than following a fixed course of study, the system significantly improves the efficiency with which individual students can acquire their targeted skills by studying material that has been specifically selected for them.

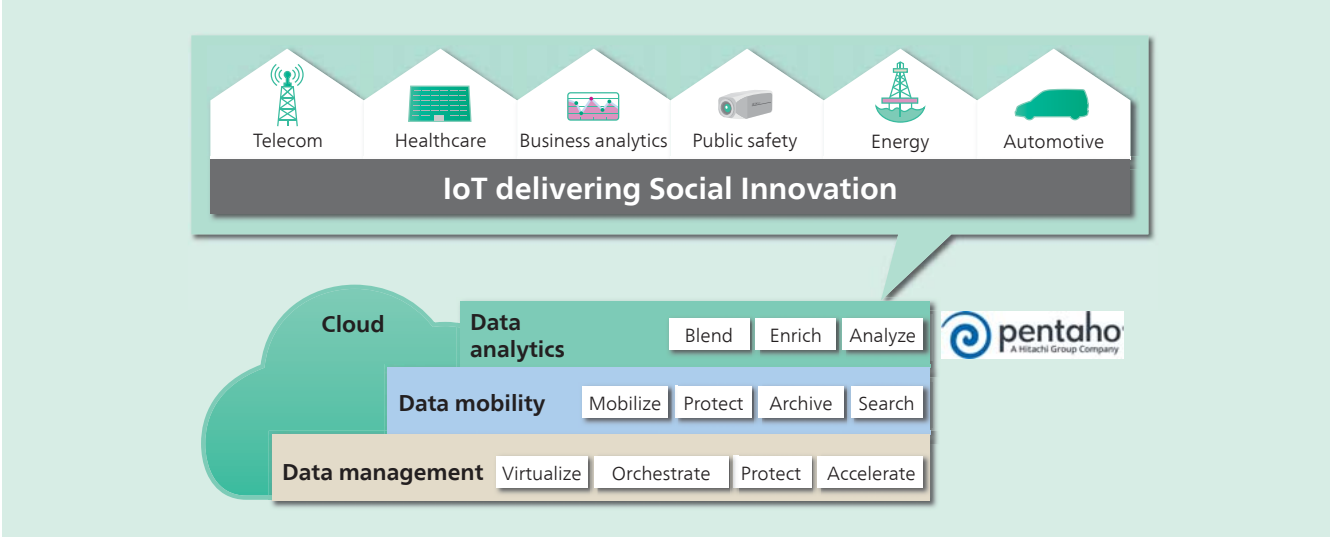
In the future, Hitachi plans to add a learning path recommendation function for utilizing big data collected on learning to provide individual students with recommendations on the mix of material they need to study based on the characteristics of the student themselves, their organization, or other factors.

(Hitachi Information Academy Co., Ltd.)



14 Adaptive learning practices

IT Platform



1 One Hitachi vision

1 IT Platform Solution Strategy

What makes smartphones "smart" compared to phones from previous generations is data. Data is the secret sauce for smart devices, smart cities and a smart planet. Hitachi has always believed that data and how it connects possibilities to outcomes is how people transform to thrive. Big data and the Internet of things (IoT) personify the explosion of possibilities. Hitachi has the proven expertise to deliver data-centric solutions to enable its customers to innovate and optimize. All of this is underpinned by the most comprehensive and integrated solution set in the industry.

(1) Data management

Hitachi has a flexible software-defined infrastructure that abstracts data better than anybody else and has the industry's broadest infrastructure automation to accelerate IT as a service.

(2) Data mobility

Hitachi's award-winning content mobility portfolio enables secure data access anytime, anywhere, and with any device, all the way to the cloud.

(3) Data analytics

Hitachi's growing analytics solutions enable customers to turn data into insight to make better decisions and gain competitive advantages.

Data is at the heart of everything. What Hitachi offers is an integrated and secure way to store it, access it, protect it, analyze it, and ultimately turn it into insight to drive better business outcomes.

And, Hitachi is one of the few companies in the world that can bring a wide breadth of expertise together to ensure holistic solutions with bigger outcomes: it builds many of the things, like sensors, that generate big data; it builds information technology (IT) solutions and manages data for 83% of the Fortune Global 100; and it has deep experience in core business processes, analytics innovation, and operational technology (OT). Furthermore, it aggressively collaborates within industry and throughout society. Combining mature innovation practices and proven delivery teams, Hitachi connects what works for customers now to what is coming next.

2 Hitachi's Framework for Analytics and Big Data Solutions

Hitachi has begun a transformation to become one of the leading companies in the market to provide solutions for big data and the IoT. Social Innovation is the unifying strategy across Hitachi businesses to deliver solutions that enable healthier, safer, and smarter societies.

The company is expanding from an IT systems business to an OT business, targeting markets where it sees competitive advantage. Its strengths come from its own data and information management expertise combined with expertise across all Hitachi product lines, including deep domain expertise in industrial markets, with data scientists in its big data laboratories (Hitachi Live Insight Center of Excellence). Using this combined expertise, the company is developing a shared analytics platform with reusable components and best practices that enable it to accelerate solution development.

Hitachi has developed a framework architecture for delivering

analytics and big data solutions. Designed to incorporate key technology components that combine Hitachi IT platform and essential open source technologies, it creates a solution development framework that offers software services at multiple levels to its customers, technology and channel partners; as well as different business units within Hitachi.

The company provides an open service-oriented framework and architecture that enables full end-to-end business solutions as well as services to be consumed at different levels. These include:

(1) Infrastructure as a service (IaaS)

These services are built on Hitachi's hyper-converged Hyper Scale-Out Platform (HSP) and converged Unified Compute Platform (UCP)—with automated provisioning, monitoring and reporting from individual computing elements [such as virtual machines (VMs)] to full clusters, while abstracting specifics of the hardware so these services can be provided either on-premises or in the cloud.

(2) Big data platform services (BDPS)

These provide big data componentry such as Hadoop, STORM* for realtime processing of stream data, Spark* for in-memory analytics processing, as well as NoSQL data stores such as Cassandra*, etc. BDPS builds atop IaaS and also features automated provisioning, monitoring, and reporting at a cluster level.

(3) Data services

Including search and indexing using Elasticsearch* and Solr*; data orchestration and workflow for designing and deploying analytics solutions; and extract, transform, load (ETL) functions that are built above the platform as a service (PaaS) layer.

(4) Analytics libraries

These will include open source analytics libraries like R and Weka using Pentaho data integration (PDI) server, as well as some Hitachi-built custom analytics for customer-specific or vertical-specific analytics solutions.

(5) Heterogeneous data

Connectors that support import of different data types that can be processed with different analysis techniques. Data types include streaming data (such as network time-series data), log data, performance data (from data center elements), and others. For time-series data, the company leverages the Hitachi Streaming Data Platform managed under a STORM framework. Besides streaming data, unstructured data from text to video can be imported and indexed for future analysis. Structured data from databases and data warehouses that are imported using ETL tools and connectors (via PDI) can be used to extract contextual information as needed for analyses of both realtime streaming as well as unstructured data.

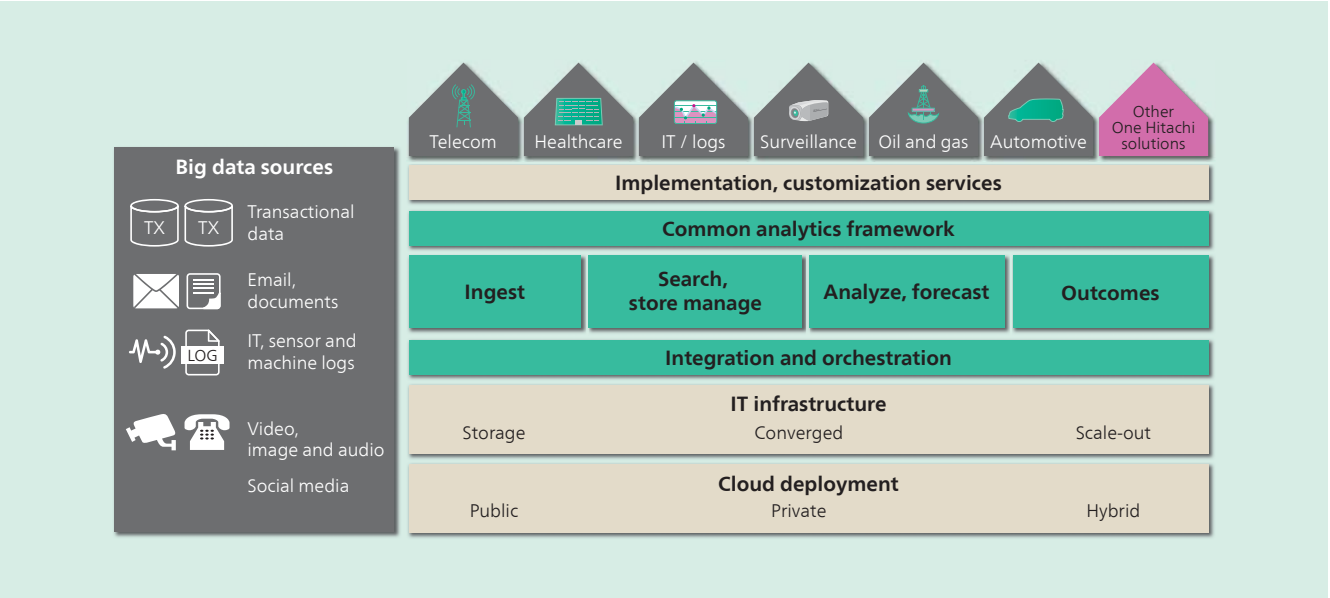
Hitachi is introducing this open framework for analytics and solutions to provide a set of complete technology solutions. With this framework, and the many IoT solutions that Hitachi offers, companies benefit through a greater ability to accelerate implementation of their big data and analytics strategies.

* See "Trademarks" on page 140.

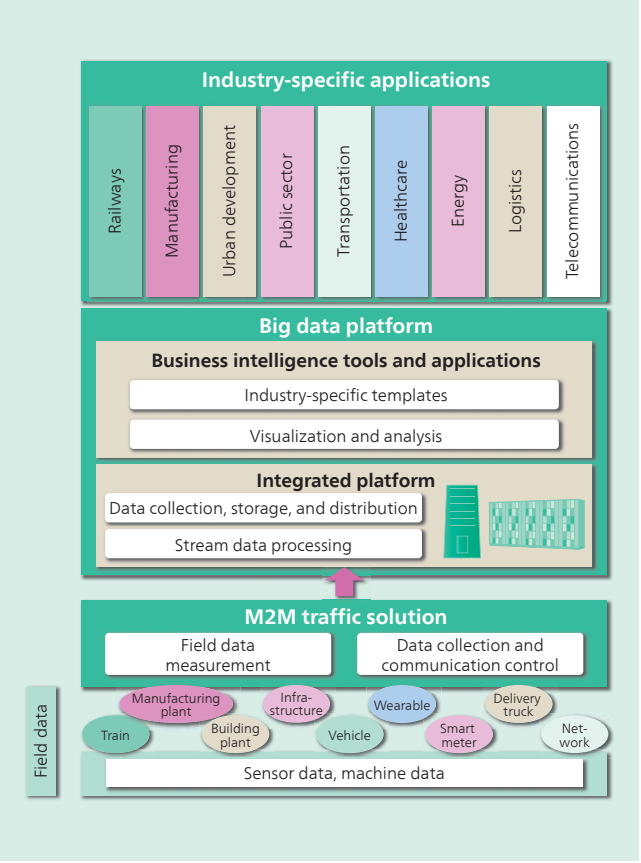
3 Hitachi's IoT Initiatives

The connection of computers, smartphones, and other devices to the Internet has made possible a series of new services—including online shopping, social networking services (SNSs), and video streaming—that have led to significant changes in how people live, making life richer and more convenient. New developments can also be expected in the future from the IoT, which connects a variety of different devices to the Internet, and the data collected from these devices will be used to create a society that is more comfortable, safe, and secure.

In response to these expectations, Hitachi is working on initiatives that combine the cloud, mobile systems, and other IT with equipment OT built up through the development of a wide variety of social infrastructure systems in sectors such as transportation and energy; using these to overcome the productivity improvement and other challenges faced by customers. One example is a machine-to-machine (M2M) traffic solution that utilizes mobile and other IT for the efficient collection of large quantities of data



2 Hitachi's framework for analytics and big data solutions



3 Block diagram of system for utilizing IoT

from workplace devices. Hitachi is also seeking to supply IoT solutions that utilize big data platforms for the storage and analysis of collected data, and industry-specific applications based on OT to boost maintenance efficiency in the railway industry and improve data center security.

Hitachi is using the IoT, which utilizes OT and IT as well as related know-how, to contribute to Social Innovation.

4 M2M Traffic Solution High-volume Data Transfer Service

Hitachi has launched a new M2M traffic solution high-volume data transfer service for IoT that uses mobile communications to provide a secure and reliable data transfer service for large quantities of collected data in situations where networking has not previously been available.

The main features are as follows.

(1) Large quantities of data can be securely transferred to the cloud. Data stored in the cloud is available to users wherever they are.

(2) A wide-area network (WAN) optimizer incorporating patented Hitachi technology obtains maximum performance from the mobile connection to transfer data reliably and at high speed.

(3) Gateway management and connection status monitoring can be performed remotely via the cloud.

(4) The gateway, which incorporates Hitachi communication technology, can be mounted on a vehicle to provide efficient and trouble-free collection of data from cars, buses, or other vehicles.

Typical applications are as follows.

(1) Image data recorded in a mobile clinic is automatically transferred to the office via the cloud. In addition to boosting productivity by shortening the time taken to transfer images to the data center for storage, it also reduces the risk of data being leaked or lost during transportation.

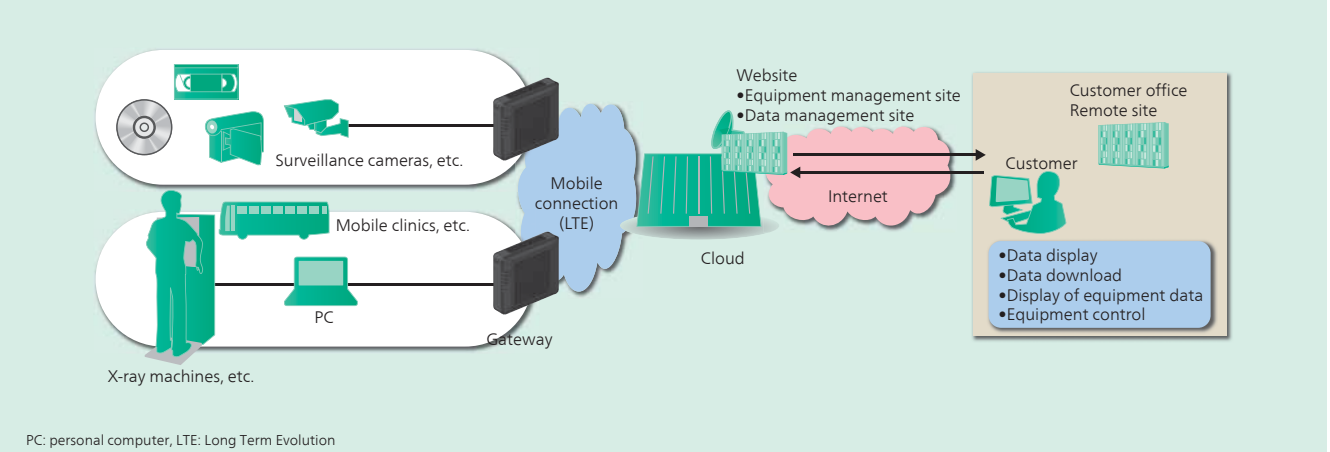
(2) Data from cameras or other surveillance devices is transferred to the cloud. Remote sites can download data from the cloud as required.

(3) Large quantities of data collected by vehicles or other remote workplaces that otherwise lack network connections are transferred to the cloud (data collection).

(Commencement of service: October 2015)

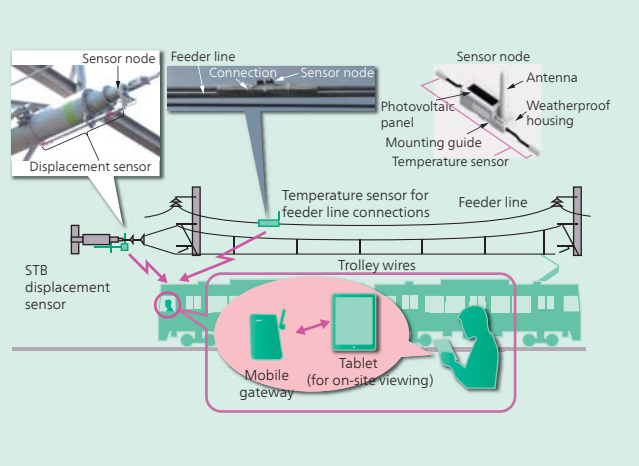
5 Railway Line Equipment Monitoring System for "Smart Maintenance Initiative" in JR East

The East Japan Railway Company (JR East) is seeking to establish smart maintenance practices that optimize maintenance decision-making based on an analysis of past and present equipment status data. Their railway line equipment monitoring system forms part of this initiative. The key devices of the system are wireless sensors (sensor nodes) and data collection units (mobile gateways) jointly developed by JR East and Hitachi. The solar-powered sensor nodes measure the temperature of compression joints on feeder lines*. Efficient data acquisition is achieved by having mainte-



PC: personal computer, LTE: Long Term Evolution

4 Overview of high-volume data transfer service (M2M traffic solution)



5 Railway line equipment monitoring system

nance staff on the train (maximum speed: 130 km/h) carry the mobile gateways and collect data wirelessly from the large number of sensors they pass along the railway line.

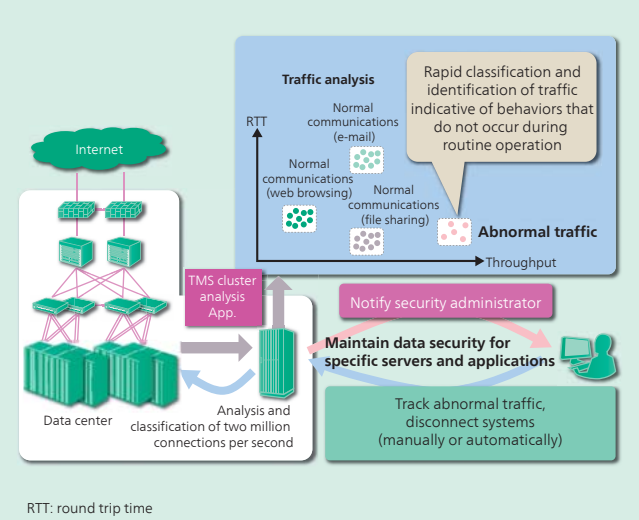
The system was initially installed by JR East on the Joban Line from Kita-Senju Station to Abiko Station in 2015. In addition to temperature, wireless sensors for measuring the spring displacement on the spring tension balancers (STBs) that tension the overhead lines are also being developed.

* A weak point in railway line infrastructure. The temperature is managed to prevent the train's load current from overheating the joints due to degradation with age.

6 Traffic Management Solutions for Data Centers

Growing dependence on use of the Internet has inevitably led to the increasing importance of data centers as part of the social infrastructure. In response, Hitachi supplies solutions that meet the need for security at data centers that control and store information. While intrusion defenses in the past have predominantly focused on the Internet, growing diversity of the form taken by attacks means that there is also a need to be concerned about internal traffic. To help maintain security, Hitachi utilizes cluster analysis techniques in traffic management solutions (TMS) to rapidly classify and identify traffic patterns that are indicative of behaviors that do not occur during routine operation (analysis and detection of abnormal traffic), and to invoke countermeasures automatically.

Similarities in the respective characteristics of telecommunications infrastructure and data centers include large networks, a high priority placed on reliability and security, the handling of different types of data, and integrated operation and monitoring. Hitachi intends to create robust data centers that form part of the social infrastructure by applying the know-how it has built up in its telecommunications infrastructure business.



RTT: round trip time

6 Example of TMS used for network security

7 Data Utilization as Opening for Collaborative Creation of Business

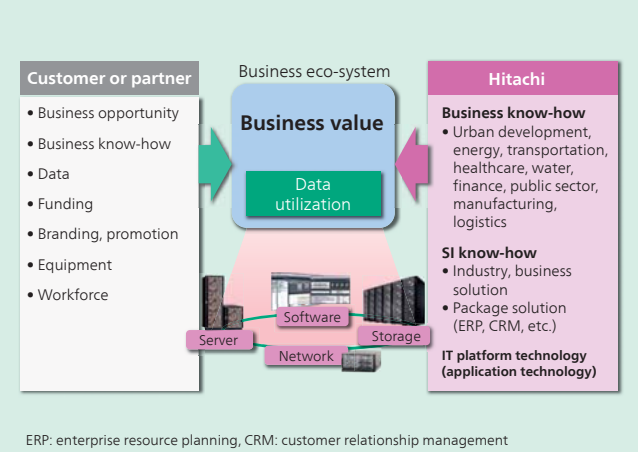
With greater use of digital technology in business, large quantities of data are being generated from all forms of business activity. To achieve innovation in this era of digital business, it is essential to utilize the generated data for business purposes to identify and create new value. Hitachi intends to supply services that promote innovation by providing a platform for collecting and utilizing the generated data and linking it to the business in order to achieve the collaborative creation of new value and new businesses with customers and other partners. This means Hitachi is seeking, along with its customers and partners, to establish business ecosystems* in which each party contributes its own business opportunities, know-how, and other resources, and that are based around the new business value generated through the use of data.

Hitachi already supplies know-how that it has acquired through experience from involvement in a wide range of sectors, such as urban development and energy; know-how in system integration (SI) acquired from the implementation and operation of systems for various business processes; and IT platform technology (application technology).

In the future, Hitachi intends to continue working with customers and partners on collaborative creation of business that generates new business value.

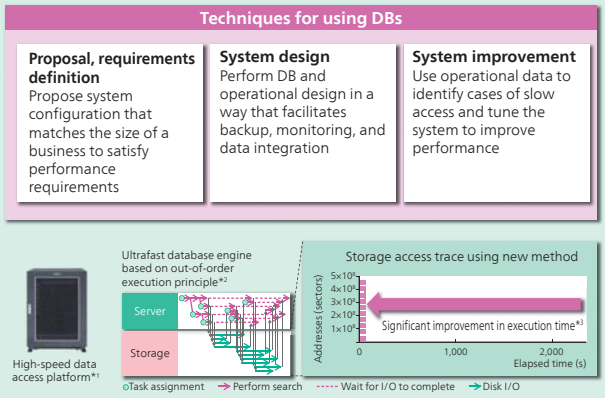
The following articles present three examples of data utilization and describe the technologies behind the IT platforms they use.

* A system that expands corporate and consumer markets through the creation of value in a value chain that includes Hitachi and its partners and customers.



ERP: enterprise resource planning, CRM: customer relationship management

7 Data utilization for collaborative creation of business



I/O: input/output
*1 Utilizes the results of "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" (Principal Investigator: Prof. Masaru Kitsuregawa, The University of Tokyo/Director General, National Institute of Informatics, which was supported by the Japanese Cabinet Office's FIRST Program (Funding Program for World-Leading Innovative R&D on Science and Technology).
*2 A principle devised by Masaru Kitsuregawa, Professor at The University of Tokyo and Director General of the National Institute of Informatics, and Kazuo Goda, Project Associate Professor at The University of Tokyo.
*3 Comparison with existing Hitachi product. Based on a standard benchmark for analytical DBs, it measures execution performance for various data analysis requests.

8 Techniques for using DBs and ultrafast DB engine

8 Example Use of Data for Collaborative Creation 1: Distribution Analysis Solution

The distribution and retail industry needs to deal not only with product sales and overcoming lifestyle challenges in a market beset by a falling birth rate and an aging population, but also with increasingly diverse lifestyles such as marketing based on things like family events or seasonal cuisine. Hitachi already markets a distribution analysis solution that takes a customer-specific approach to handling information held by retailers and offers products tailored to each customer to combine higher sales with greater customer satisfaction.

This solution combines data from such sources as point-of-sale (POS) systems and loyalty cards with companies' accumulated business know-how to enable the timely supply of products by analyzing purchases and customers to keep up with ever-changing customer preferences and other trends, and by linking products and customers together to identify new best-selling products.

The IT platform technology used to implement the system incorporates techniques for using databases (DBs) and an ultrafast DB engine.

Based on know-how that Hitachi has acquired through experience with hands-on involvement in a wide variety of industries, the techniques for using DBs involve offering customers system configurations that match the size of their business and ensure that performance requirements are satisfied; DB and operational designs that facilitate backup, monitoring, and data integration; and using operating conditions in performance tuning.

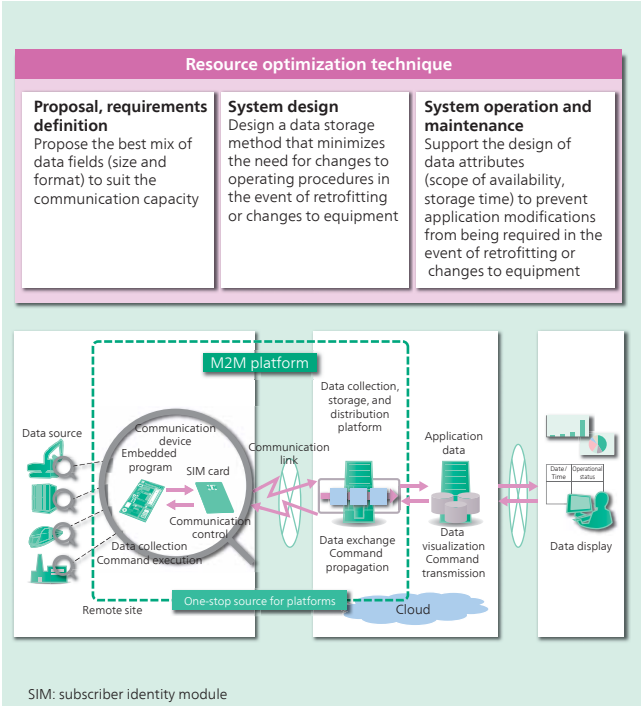
Rather than performing data access sequentially as in conventional DBs, the ultrafast DB engine uses parallel processing and rigorously improves the degree of concurrency by automatically splitting operations up into blocks that can execute in parallel. A search operation with complex search conditions that was performed on more than two billion data items that took 40 minutes using a conventional DB was completed in 20 seconds by the ultrafast DB engine.

9 Example Use of Data for Collaborative Creation 2: Equipment Lifecycle Management Solution

Hitachi supplies an equipment lifecycle management solution that helps increase sales and decrease costs through the timely acquisition of operational data from equipment at manufacturing plants. The solution involves attaching sensors and communication units to individual items of equipment to collect information such as operational data, position, and fault alarms to determine in advance when to replace parts, and to ensure that replacement occurs before the equipment fails by combining this with monitoring for warning signs based on factors such as actual data from past abnormalities and the know-how of experienced workers.

The requirements for implementing this solution are an ability to collect operational data from many different types of equipment in diverse locations, and an ability to support new models or specification changes at short notice in the event of operational changes or the replacement of machinery at a site.

The IT platform technologies used for this purpose are an M2M platform that serves as a one-stop source for data collection, storage, and distribution platforms together with the communication link to the site where the equipment is located, and a resource optimization technique for ensuring that the large quantities of data that are routinely generated can be collected without interruption in accordance with the nature of the equipment and the data being collected. The M2M platform supplies core functions, from data collection to storage and distribution, as a package that is priced in accordance with factors such as the number of machines and quantity of data. In accordance with customer requirements, the resource optimization technique includes



SIM: subscriber identity module

9 M2M platform and resource optimization technique

assessing the best mix of data fields to suit the communication capacity, and designing the data storage method so as to minimize the need for changes to operating procedures, applications, and so on in the event of changes to data formats or the addition or removal of data.

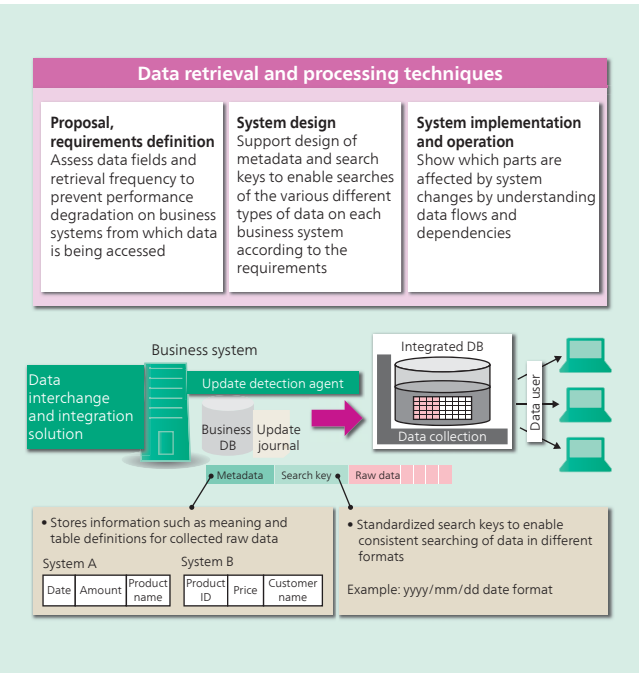
10 Example Use of Data for Collaborative Creation 3: Data Interchange and Integration Solution

Manufacturers that operate multiple sites around the world as a result of mergers and acquisitions (M&A) need timely and accurate access to production, sales, and inventory data that is managed separately by each site so that they can precisely plan production, sales, and inventory throughout the world. In response to this need, Hitachi supplies a solution that supports optimal planning by making production and sales data from sites in different parts of the world available quickly so that demand can be predicted based on sales performance and provided as feedback for production and inventory plans.

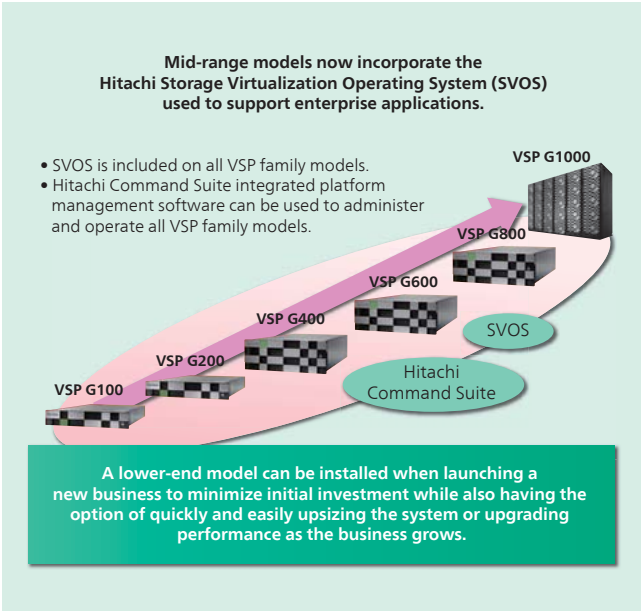
The solution provides techniques for retrieving the latest data without affecting the business systems operating at each site, data refining techniques that facilitate searching of the collected data, and services for designing, implementing, and operating the IT platform on which the solution runs.

Data retrieval prevents any performance degradation on the live business system by having an update detection agent monitor the database journal to identify the latest data. Data refining enables flexible data searching by managing the metadata that defines data meaning and the keys for consistent searching together with various types of data.

The services for designing, implementing, and operating the IT platform can show which parts are affected by system changes and help investigate ways of using data by understanding data flows and dependencies.



10 Data retrieval and processing techniques



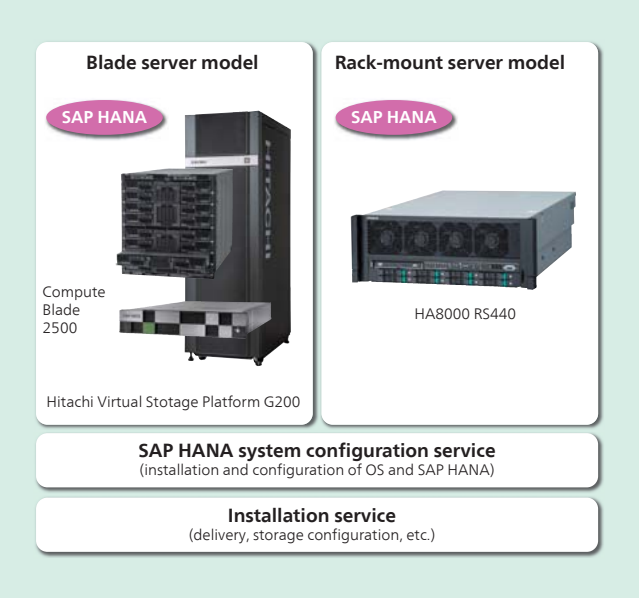
11 Hitachi VSP family

11 Hitachi Virtual Storage Platform G100, G200, G400, G600, and G800

Along with the spread of the IoT, which connects various different devices to the Internet, recent years have also seen an expansion in the use of big data analytics with the aim of creating new value by bringing different types of data together for analysis. The storage systems that provide the platforms for this activity are called on to deliver a high level of expansion and operational capabilities to keep pace with business growth and changes in strategy. The Hitachi Virtual Storage Platform (VSP) G100*, G200, G400, G600, and G800, launched against this background in April 2015, feature the advanced functions of the high-end VSP G1000 disk array system and the Hitachi Storage Virtualization Operating System (SVOS) core storage software, which ensures high reliability. By providing functions such as Hitachi's proprietary advanced virtualization in mid-range systems, these storage systems make the high-level expansion and operational capabilities of high-end systems available in small and medium-sized applications.

As all high-end to mid-range models incorporate SVOS, it is easy to upgrade to more advanced models without changing operation and administration practices. This makes it possible to minimize initial investment by installing a lower-end model when launching a new business, and then upsizing the system or upgrade processing performance quickly and easily as the business grows.

Furthermore, a new technology called "active flash" adopted by the new models increases the speed of data access by dynamically relocating frequently-accessed data on flash storage. As data is automatically relocated in an optimal manner based on data access frequency, it eliminates the past requirement for detailed preliminary system design that involved categorizing stored data, predicting likely increases in quantity, and moving data to accommodate retrofits. This not only makes it easy to add additional flash storage as data quantities grow, but it also enables the system



12 Hitachi Unified Compute Platform for SAP HANA

to adapt flexibly and quickly to changes in access frequency that are difficult to predict because they are influenced by factors such as changing market conditions.

* VSP G100 is only sold in Japan.

12 Hitachi Unified Compute Platform for SAP HANA

There is rising demand for realtime analysis of the large quantity of data being generated as a result of advances such as those in cloud computing and sensor technology, and its use to enhance corporate competitiveness. In response, SAP SE supplies SAP HANA*, a dedicated ultra-high-speed in-memory database for the realtime processing of large quantities of data. Hitachi, meanwhile, supplies an integrated platform optimized for SAP HANA that combines high-performance servers and storage called Hitachi Unified Compute Platform for SAP HANA (UCP for SAP HANA).

UCP for SAP HANA provides rapid configuration and operation of customer systems by supplying pre-tested optimal system configurations for SAP HANA. Furthermore, an extensive range of models and model upgrades ensures that the initial installation is an ideal match with the size of the customer's system, and enables flexible expansion as the business grows. UCP for SAP HANA also supports use of the Hitachi logical partitioning feature mechanism for the logical partitioning of servers, improving the ease of system administration and operation by allowing a number of SAP HANA systems to run on the same physical server. Along with routine operation, a proven disaster recovery function for Hitachi disk array systems for use in emergencies satisfies the customer requirement to minimize corporate losses due to downtime.

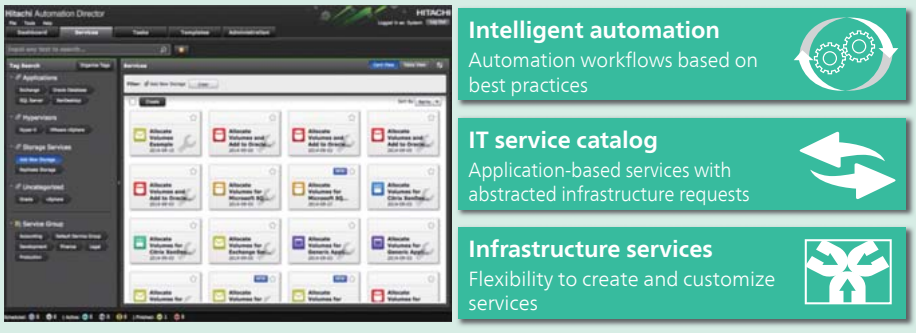
In the future, Hitachi intends to support the creation of new value and rapid management decision-making at companies by extending its range of integrated platform solutions like UCP for SAP HANA for use as platforms for the timely and flexible provision of highly reliable clouds, big data, and other applications.

* A high-speed in-memory platform from SAP SE.
See "Trademarks" on page 140.

13 Hitachi Automation Director for More Efficient and Automated IT Management

In the management of corporate IT infrastructure, implementation and use of cloud computing based on platform virtualization is undertaken to improve responsiveness to the business. On the other hand, common challenges include the operational costs of managing ever-increasing quantities of data appropriately, and the increasing workload being imposed on administrators with high-level skills.

Hitachi Automation Director reduces the administrator workload required for the efficient operation of IT infrastructure and overcomes these problems by abstracting the IT infrastructure and equipping products with the intelligence to select the IT resources that best match the application requirements. This makes it simple to optimize the cost of managing IT infrastructure by providing important applications with best practices in the form of a service catalog based on the characteristics of resource use by the application. Operational efficiency can be further enhanced by using the application programming interface (API) to integrate with the existing management environment, including modifying or adding to service catalog options in accordance with the specific operational requirements of each company.



13 Overview of Hitachi Automation Director

Energy Solutions

1 Outlook for Energy Solutions Business

Energy is one of the most fundamental and important parts of the social infrastructure. However, factors such as economic progress and the changing nature of society are making the requirements for energy more diverse. The following are five common challenges and customer requirements.

(1) The provision of reliable electric power in response to rising demand, particularly in emerging economies.

(2) Dealing with global warming

(3) Maintaining grid stability despite challenges such as the increased use of renewable energy

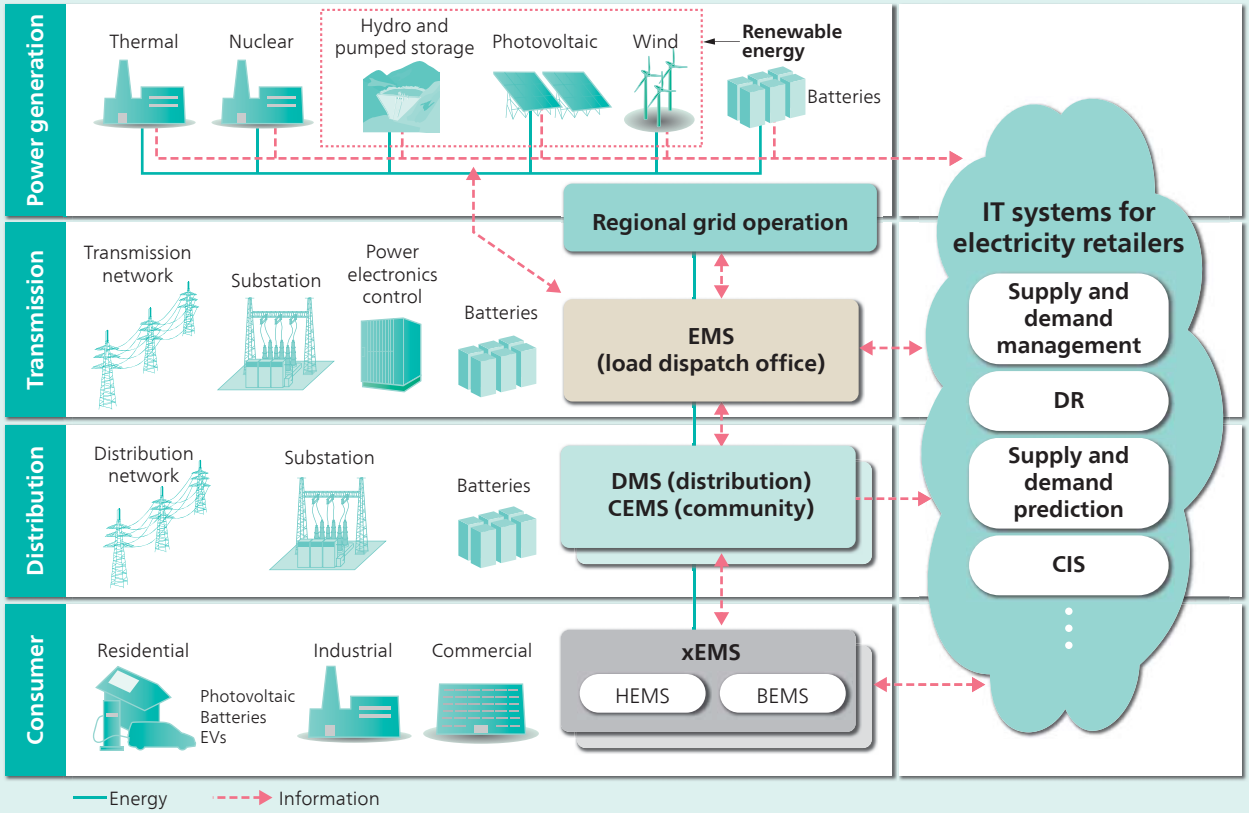
(4) Dealing with aging equipment

(5) Introduction of market principles to reduce electricity prices through competition

As the nature of these challenges and requirements vary widely depending on the customer's circumstances and other factors, the solutions lie not only in past business models based on the supply of equipment, but also demand open innovation involving the collaborative creation with customers and other external stakeholders of solutions to shared challenges, and thinking in terms of total solutions that combine operation technology (OT) with information technology (IT).

Hitachi established its Energy Solutions Company in April 2015 to engage in businesses in the electric power sector alongside its conventional equipment supply business.

Hitachi supplies total solutions from power generation to transmission and distribution as well as IT systems for electricity retailers.



EMS: energy management system, DMS: distribution management system, CEMS: community energy management system, HEMS: home energy management system, BEMS: building energy management system, EV: electric vehicle, DR: demand response, CIS: customer information system

1 Energy solutions from Hitachi

Power Generation Equipment and Systems

1 Chingshan Branch of Taiwan Power Company

1 Replacement of Four 96.13-MW/105-MVA Vertical-shaft Francis Turbines and Generators and Electrical Systems at Chingshan Branch of Taiwan Power Company

The Taiwan Power Company's underground Tachiachi Hydro Power Plant Chingshan Branch Power Plant, which commenced operation in 1973, was completely engulfed by landslides when Taiwan was struck by a devastating typhoon (Typhoon Mindulle) in July 2004. Redevelopment and reconstruction work on the power plant and surrounding area began in 2009, with Hitachi Mitsubishi Hydro Corporation being part of a consortium along with Taiwanese suppliers that won an order and contract in November 2011 for the replacement of four turbine and generator sets, including control and substation equipment. Although on-site work commenced in December 2012, because the plant is located in steep mountainous terrain in central Taiwan, this work was often interrupted due to landslides that made access roads impassable. Despite these very difficult conditions, site installation and commissioning staff worked assiduously and completed on-site testing well ahead of the initial schedule. All four sets completed on-site testing in September 2015 and are sequentially being brought back into commercial operation.

It is anticipated that this replacement project will help Taiwan enjoy a more reliable supply of electric power.

The project also won a superior construction quality award at the 15th Public Construction Golden Quality Awards, the highest distinction for public works in Taiwan.

(Hitachi Mitsubishi Hydro Corporation)

2 Commencement of Operation after S&B of 10.9-MW/12-MVA Vertical-shaft Pelton Turbine and Generator at Mibugawa 2 Power Plant of Mibugawa Power Company

A scrap and build (S&B) project for the 10,910-kW vertical-shaft, single-runner, four-jet Pelton turbine and 12,000-kVA synchronous generator at the Mibugawa 2 Power Plant of Mibugawa Electric Power Co., Inc. was completed in December 2014 and the plant is now operating reliably.

Mibugawa 2 is a run-of-the-river power plant located in the Hase district of Ina City in Nagano Prefecture and is powered by water from the headwaters of the Mibugawa River in the Tenryu River system.

The main features are as follows.

(1) The turbine runner is highly efficient, with the latest design.

(2) The vertical shaft of the turbine uses water-lubricated polymer bearings that do not require lubricating oil.

(3) The generator thrust bearing uses polyether ether ketone (PEEK) polymer bearings to reduce bearing losses and eliminate the need for cooling water.

(4) Electric and electromagnetic systems are used to operate the needle, deflector, and brake to eliminate the need for hydraulics.

In future new hydroelectric power plant and S&B projects, Hitachi intends to help take advantage of renewable energy, reduce environmental risks such as oil leaks, and improve maintenance.

(Hitachi Mitsubishi Hydro Corporation)

2 Turbine-generator (barrel type) (top) and electric drive mechanism for needle and deflector (bottom)

3 S&B and Electrics Upgrade to Two 2,860-kW/3,000-kVA Vertical-shaft Francis Turbines at Kakinosawa Power Plant of JX Nippon Mining & Metals Corporation

Hitachi has completed a full upgrade of the turbines, generators, distribution panel switchgear, and substation equipment at the Kakinosawa Power Plant of JX Nippon Mining & Metals Corporation, with the plant resuming commercial operation in June 2015.

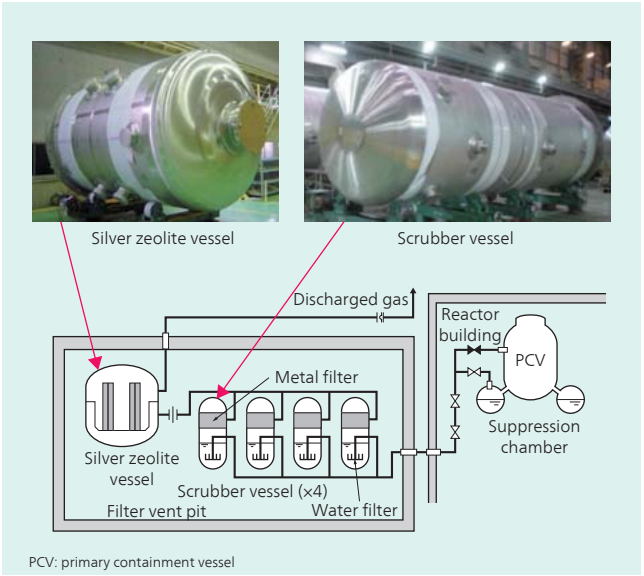
The upgrade of the generation system came roughly 60 years after the plant first commenced operation in 1955.

The upgrade has reduced environmental risks as well as improved maintenance by eliminating hydraulics and other auxiliary equipment using electric servomotors for the turbine hydraulics and air-cooled turbine bearings that do not require a water supply. To control the two turbine/generator units so as to make full use of the precious water energy resource and maximize electric power generation, the two units can be operated alone or together in response to the ever-changing water volume.

On-site work for the two turbine/generator units, which extended from dismantling and removal to assembly, was undertaken in parallel and completed in only 11 months. Hitachi anticipates that the upgrade will enable the plant to continue to operate reliably in the future.

(Hitachi Mitsubishi Hydro Corporation)

3 Kakinosawa Power Plant generator room (top) and turbine room (bottom)



4 Vent filter

4 Development and Deployment of Vent Filter

The purpose of a vent filter is to capture the radioactive material in a gas to prevent it from being released into the environment in large quantities when the gas needs to be vented into the atmosphere from the reactor containment vessel at a nuclear power plant, such as to prevent over-pressure failure of the vessel during a severe accident.

The vent filter for Unit 2 at the Shimane Nuclear Power Station of The Chugoku Electric Power Co., Inc. is made up of a stainless steel scrubber vessel (approximately 2 m in diameter and 8 m in height) and a silver zeolite vessel (approximately 3 m in diameter and 5 m in height). It was designed and developed by Hitachi using filter technology from AREVA GmbH that has already been deployed in Europe, and complies with Japanese standards and satisfies the space constraints for installation.

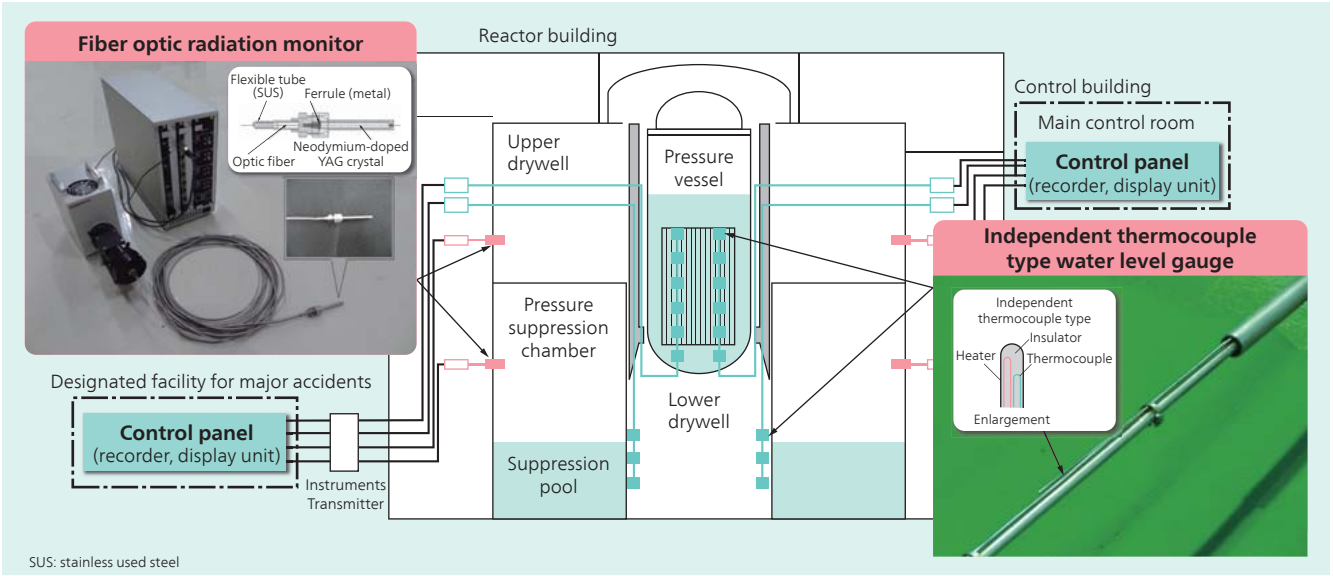
The scrubber vessel uses a water filter and metal filter to remove radioactive particles and inorganic iodine, and the silver zeolite vessel uses a silver zeolite filter to remove organic iodine.

[Installation: August 2014 (scrubber vessel) and April 2015 (silver zeolite vessel)]

5 Instrumentation System for Severe Accidents

To provide information about plant status in the event of a severe accident, Hitachi has developed an independent thermocouple type reactor water level gauge and a fiber optic radiation monitor that are able to operate under such conditions.

Unlike conventional water level gauges that use differential pressure, the thermocouple type reactor water level gauge (nuclear reactor, lower drywell) has a heated thermocouple arranged in a vertical direction (a thermocouple and a heater wire positioned inside the tip of a metal sheath) that detects the temperature rise in the sensor tip when a current is applied to the heater wire. From the temperature rise, whether the thermocouple is immersed in



5 Example of new instrumentation system able to operate during severe accidents

water or steam is detected and the water level is determined. In addition to water level, the gauge can also measure the temperature at the location of the thermocouple. The fiber optic radiation monitor works on a different principle to the ionization chambers used in the past. The radiation level is determined using a neodymium-doped yttrium aluminum garnet (YAG) crystal that serves as a long-wavelength light-emitting element, emitting light in proportion to the strength of incident radiation. This light passes along an optic fiber cable and is measured by an optical sensor.

Both systems have been tested to confirm their ability to operate under the harsh environmental conditions present during a severe accident and Hitachi intends to contribute to improving safety measures at nuclear power plants by installing them in the future.

The research results described in this article are a part of the results of research undertaken jointly by 11 Japanese electric power companies (Hokkaido Electric Power Co., Inc.; Tohoku Electric Power Co., Inc.; Tokyo Electric Power Co., Inc.; Chubu Electric Power Co., Inc.; Hokuriku Electric Power Company; The Kansai Electric Power Co., Inc.; The Chugoku Electric Power Co., Inc.; Shikoku Electric Power Co., Inc.; Kyushu Electric Power Co., Inc.; The Japan Atomic Power Company; and Electric Power Development Co., Ltd.) and three Japanese equipment suppliers and the research was undertaken as a project of the Agency for Natural Resources and Energy in the Ministry of Economy, Trade and Industry to develop safety technology for power-generating nuclear reactors and other plants.

6 300-kW Photovoltaic PCS for Medium-scale Photovoltaic Power Generation

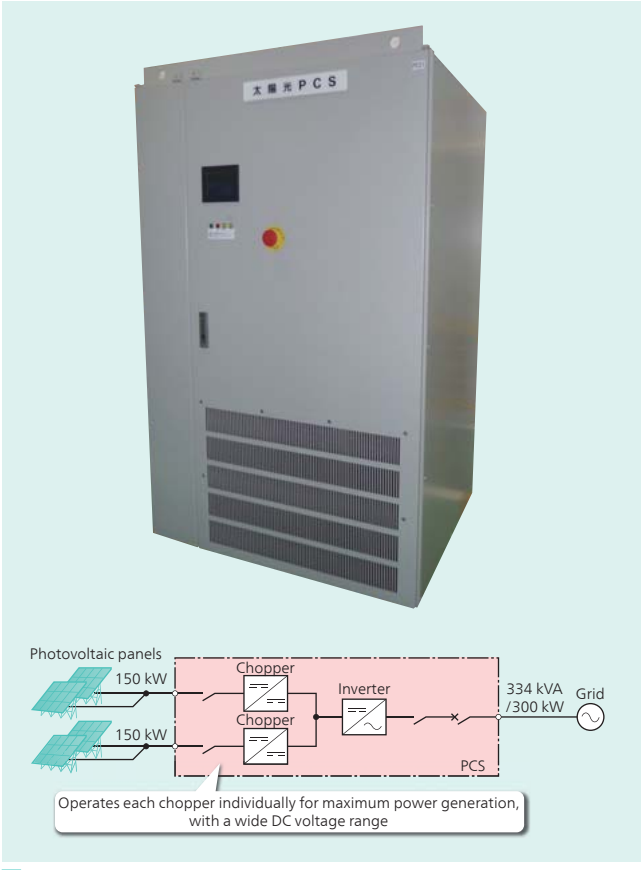
As part of the growing market for photovoltaic power generation systems in recent years due to rising environmental awareness, medium-scale systems intended to take advantage of roofs or unused land at shopping centers, factories, and schools are becoming more common. In response to the rising demand for such systems, Hitachi has developed a 300-kW power conditioning system (PCS) for medium-scale photovoltaic power generation to add to its existing 500-kW and 660-kW models for large-scale photovoltaic power generation.

The features of the 300-kW model are as follows.

(1) This model has two chopper circuits for boosting the direct current (DC) voltage from the photovoltaic panels. Having two such circuits maximizes the power from each chopper and expands the range of panel voltages at which power can be generated. That is, power can be generated even when the DC voltage is low due to low levels of sunlight.

(2) It achieves high power conversion efficiency (97.5% max.).

In the future, Hitachi intends to contribute to the building of photovoltaic power generation systems that meet customer needs by expanding its range of PCS products with high efficiency and wide operating range.



6 300-kW photovoltaic PCS (top) and photovoltaic PCS circuit diagram (bottom)

Parameter	Value	Notes
Rated capacity	630 kW	
Number of DC inputs	1	
Max. DC input	1,000 VDC	Over-voltage detection level
Rated AC voltage	300 VAC	50 Hz
Control functions	MPPT, FRT, islanding detection, etc.	FRT function complies with PEA requirements.

AC: alternating current, VDC: voltage direct current, VAC: volts alternating current, MPPT: maximum power point tracking, FRT: fault ride through

7 630-kW photovoltaic PCS for Thailand (top) and photovoltaic inverter specifications (bottom)

7 630-kW Photovoltaic PCS for Thailand

The installation of renewable energy sources such as wind and photovoltaic power is not limited only to Europe and America, these systems are also becoming increasingly prevalent in China and other parts of Asia. The photovoltaic power generation business in Thailand was expected to get underway in earnest during FY2015, underpinned by a new energy efficiency policy.

Hitachi has developed a PCS for photovoltaic power generation in Thailand and had it certified by that nation's Provincial Electricity Authority (PEA).

The main features are as follows.

(1) It achieves high power conversion efficiency (98.8% max.).

(2) It can operate with a wide range of panel voltages (520 to 900 V).

(3) It has environmental specifications that are suitable for installation in Thailand (upper limit on ambient temperature: 50°C).

Hitachi intends to use this development as a starting point for helping to build photovoltaic power generation systems that meet the needs of customers around the world by accelerating overseas deployment of PCS technology developed in Japan for achieving high efficiency and a wide operating range.

8 Increasingly Advanced Large-scale Photovoltaic Power Generation System

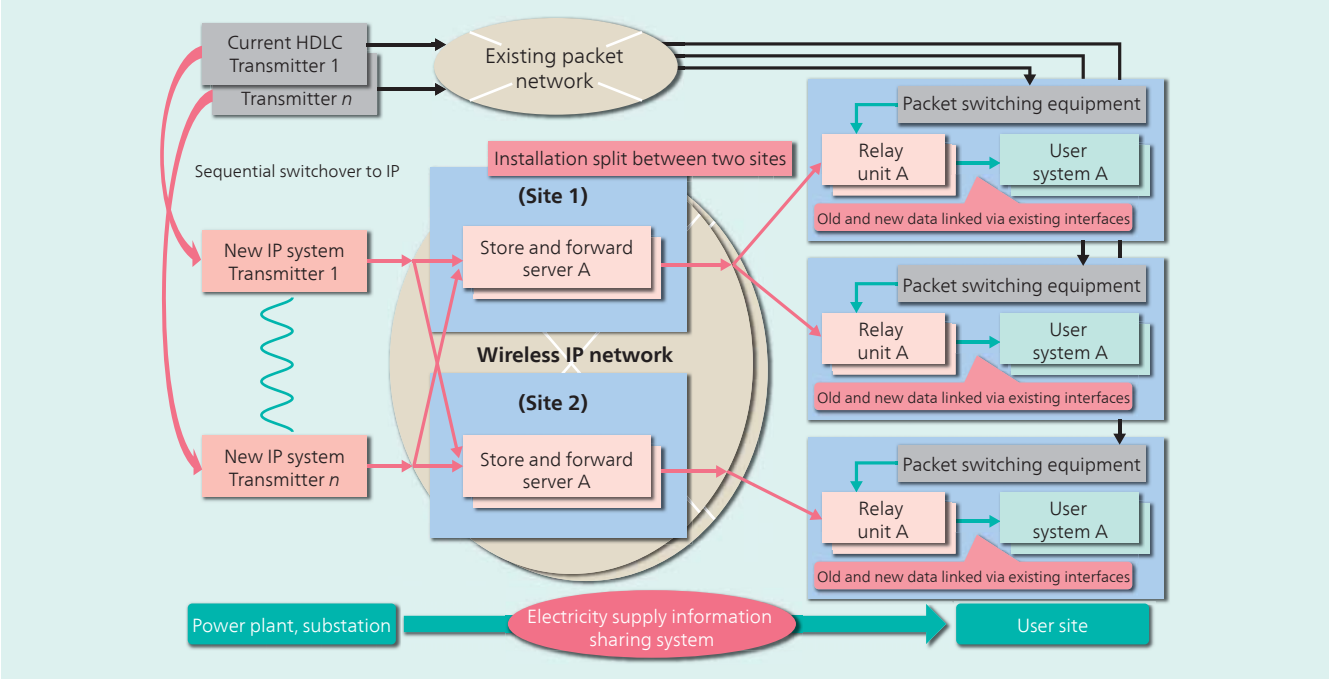
The Eurus Tenmyo Solar Park of Eurus Energy Group (rated output of photovoltaic modules: 18,757 kW, rated output of power conditioners: 14,000 kW) commenced operation in March 2015. The project, which commenced in March 2014 and was completed in 12 months, involved Hitachi working with new technologies. It included construction at a mountain golf course site (approximately 0.8 km^2), use of pile foundations to cope with upswelling due to frost, the construction of a regulating reservoir with a capacity of 35,000 m^3 of water, and the running of private transmission lines with a mix of pylons and undergrounding along municipal roads.

The 73,566 photovoltaic panels were installed along the centers of the fairways and located so as to leave the off-course topography unchanged as much as possible. The system has performed well, with power generation in April 2015 totaling 123 MWh and a capacity factor of 17%. Total annual power generation at the site will be equivalent to the consumption of approximately 5,000 households, representing an annual reduction in carbon dioxide (CO_2) emissions of 9,200 t. On the basis of each tree absorbing 14 kg of CO_2 each year, this is equivalent to a plantation of 660,000 Japanese cedar trees.

Photograph courtesy of Eurus Energy Holdings Corporation

8 Eurus Tenmyo Solar Park (top) and panel installations (with pile foundations) (bottom)

Electric Power Transmission Equipment and Systems



1 Configuration of electricity supply information sharing system

1 The Kansai Electric Power Co., Inc. Electricity Supply Information Sharing System

As part of an upgrade to communication equipment in its automatic electricity supply system, The Kansai Electric Power Co., Inc. converted its online electricity supply information network to support the Internet protocol (IP) in place of the previous system, which ran on packet switching equipment and used high-level data link control (HDLC) with a switched network on leased lines. However, because the system must be capable of remaining in operation during an earthquake or other emergency, the adoption of the existing IP system needed to be accompanied by a high degree of reliability.

Achieving this high reliability by incorporating the following technologies, Hitachi developed the electricity supply information sharing system in a way that facilitated migration.

(1) The previous packet switching functions were consolidated into dual store and forward servers with installation split between two sites, and a wireless IP network with dual communication links was adopted to improve the disaster-tolerance of the network, to ensure that store and forward processing of electricity supply information functioned reliably, and to improve maintenance.

(2) The network was designed to facilitate migration, including avoiding the need to upgrade existing systems by installing relay units at each user site that can handle both old and new data and perform conversion and transmission of existing protocols and data formats.

2 Tohoku Electric Power Co., Inc. Regional NW Distribution Network Monitoring and Control System

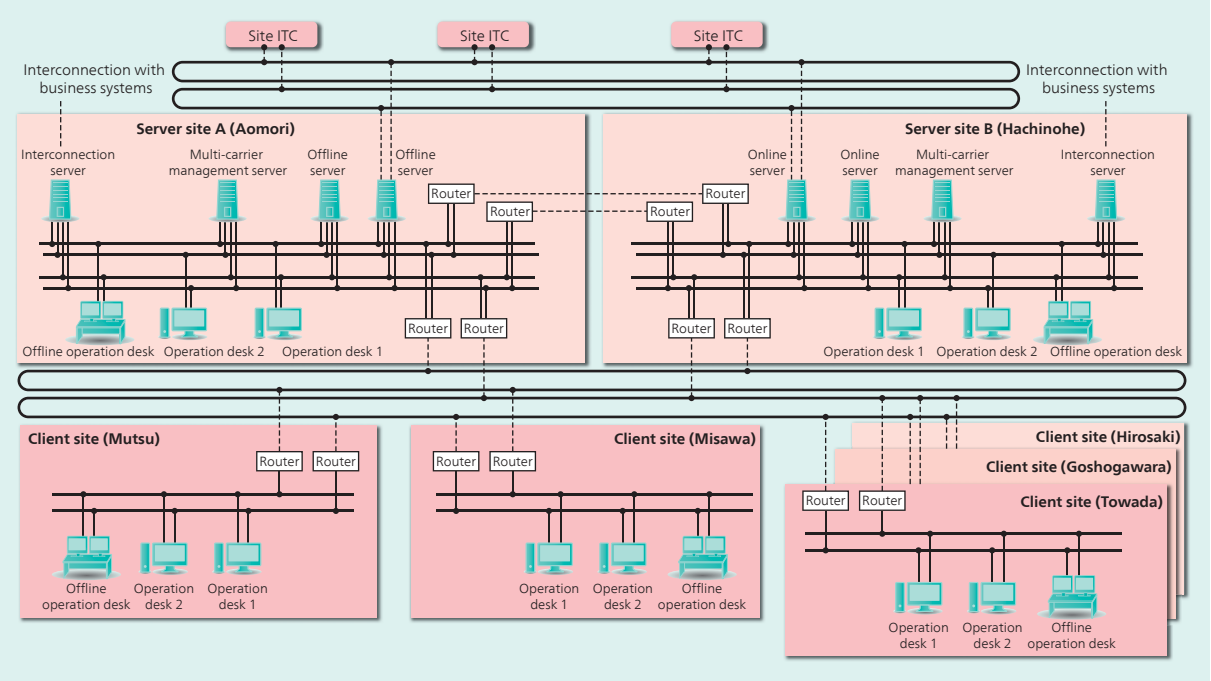
In an upgrade to the distribution automation system for the region administered by the Aomori Branch Office of Tohoku Electric Power Co., Inc., Hitachi has replaced an existing system made up of a single configuration spread across seven sites with an integrated system based on a redundant configuration.

The distribution network monitoring and control system for the regional network (NW) was implemented by splitting the sites into server and client sites, with active and backup servers located at the server sites (Aomori and Hachinohe) and thin client operation desks installed at the client sites.

The main features are as follows.

(1) By installing the active and backup servers remotely from each other and using thin clients for the operation desks at each site, sites can switch to backup operation in the event of a disaster. This is the first time a Hitachi distribution network monitoring and control system has been integrated at the site level.

(2) Whereas, in the past, each distribution automation system had its own grid and there was no automatic operation of the grids at the boundaries between sites, integration has enabled automation and improved security of supply.



2 Block diagram of regional NW distribution network monitoring and control system of Tohoku Electric Power

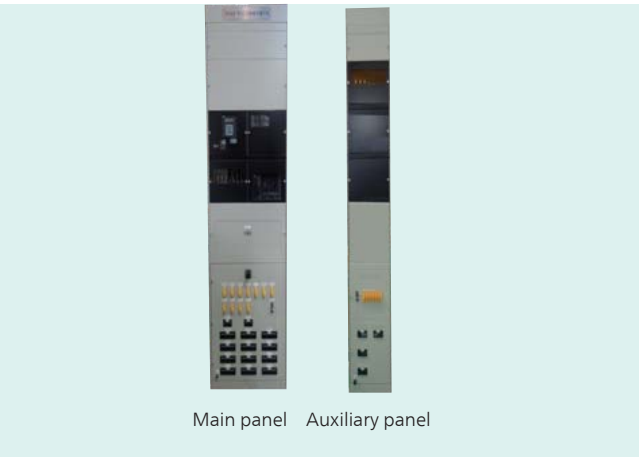
(3) Use of a virtualization operating system (OS) for the servers and thin clients for the operation desks reduced hardware requirements, minimizing installation space requirements and cutting the cost of hardware and software maintenance.

[Commencement of operation (five sites): March 2015 (the remaining two sites were integrated later during FY2015)]

3 Tokyo Electric Power Co., Inc. 500-kV Busbar Protection System Using Process Bus

In extra-high-voltage power systems of 275 kV or higher, standard practice in the past for busbar protection systems for double busbars has been a dual-panel configuration made up of check zone and discriminating zone protection. Hitachi has now developed a 500-kV busbar protection system using Process Bus that reduces the number of panels and facilitates the retrofitting of lines by using a shared central processing unit (CPU) for both check zone and discriminating zone protection.

The main features are as follows.



3 Busbar protection system using Process Bus

(1) Check zone and discriminating zone protection use the same CPU.

(2) Use of Process Bus enables precise synchronization of sampling across distributed panels and high-speed transmission (sampling synchronization error: 1 μs or less).

(3) Faster operation through direct control of auxiliary panel input/output (I/O) from main panel CPU.

Following acceptance testing of the main and auxiliary panel configurations involving type testing by Tokyo Electric Power Co., Inc., only the main panel configuration was supplied and is currently operating reliably.

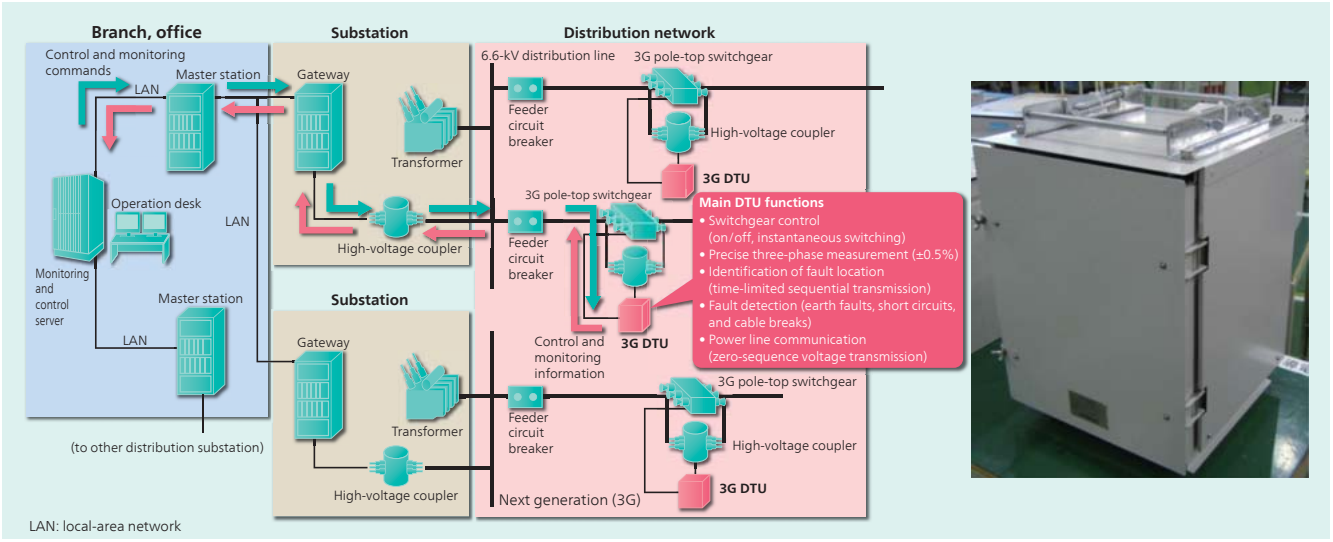
In the future, Hitachi intends to continue utilizing Process Bus technology to develop highly reliable products that meet diverse requirements.

(Commencement of operation: March 2015)

4 Shikoku Electric Power Co., Inc. Next-generation Distribution Terminal Unit (3G DTU)

Growth in the installation of renewable energy has been accompanied by a degradation of power quality, with electric power distribution networks suffering problems such as voltage fluctuations and voltage imbalances. It is anticipated that maintaining power quality using existing electric power distribution systems will be difficult. To overcome these problems, Hitachi is working on functional enhancements to distribution automation systems and has developed a next-generation distribution terminal unit (DTU) [third generation (3G) DTU] that is compatible with these new features.

Enhancements to the 3G DTU include precise three-phase measurement of various electrical quantities (±0.5% for voltage and current), better fault detection (detection of earth faults, short circuits, and cable breaks and recording of fault waveforms), and support for switchgear with instantaneous excitation (instanta-



4 Block diagram of distribution automation system (using power line communications) (left) and next-generation distribution terminal unit (right)

neous switching function). To allow for compatibility with existing equipment, the 3G DTU also uses an existing transmission method (zero-sequence voltage transmission).

The new DTU is expected to facilitate sophisticated power quality management by distribution automation systems and help improve maintenance efficiency.

(Commencement of deliveries: September 2015)

5 300-kV Standalone Gas DSs

The electric power distribution industry in Japan has been experiencing growing demand in recent years for the replacement of aging equipment. Experience with disasters that cause equipment damage or long-duration outages at open-air substations equipped with standalone equipment, in particular, has prompted calls for also making improvements to earthquake strength, reliability, and ease-of-maintenance when equipment is replaced. In response, Hitachi has developed a 300-kV standalone gas disconnecting switch (DS) to replace the air-insulated DSs with porcelain insulators used at open-air substations. The new DSs use tough lightweight composite insulator to improve seismic performance and feature reliability and ease-of-maintenance equivalent to gas-insulated switchgear (GIS).

Not only do the new gas DSs satisfy Japanese standards of JEC-2350 and JEC-2310 performance requirement (for insulation, conduction, seismic, and switching performance), but also their bus-transfer current switching performance gives them a recovery voltage of 600 V (JEC requirement is for a maximum of 300 V), meaning they can be used as busbar DSs at open-air substations with long busbars. This is anticipated to increase demand for upgrades because, if the feeder-side equipment is simultaneously replaced with an integrated GIS that combines gas circuit breakers, DSs, earthing switches, voltage transformers, current transformers, and lightning arresters, it provides a quick path for upgrading open-air substations using equipment that features earthquake strength, reliability, and ease-of-maintenance equivalent to a full-GIS installation.

Rated voltage	300 kV
Rated current	4,000 A
Rated short-duration current	50 kA for 2 s
Rated lightning voltage impulse	1,050 kV
Rated frequency	50/60 Hz
Rated gas pressure (guaranteed minimum pressure)	0.5 MPa (0.45 MPa)
Operation	Electrically-operated spring (coupled three-phase operation)
Standards	JEC-2350, JEC-2310
Bus-transfer current switching capacity	Switching current: 4,000 A Recovery voltage: 600 V Number of switching operations: 100

5 300-kV standalone gas DS (top) and target specifications and performance (bottom)

6 First Transformers Built by HFT

The factory of Hitachi Fortune Transformer, Inc. (HFT) commenced production in Taiwan in May 2015, making it the first facility outside of Japan for Hitachi's transformer business. HFT is a joint venture between Hitachi and Fortune Electric Co., Ltd. of Taiwan and was established on the basis of their strong existing relationship, the two companies having had technical collaboration since 1990.

The main features are as follows.

(1) Location

6 345-kV/265-MVA power plant transformer

Located in the Taichung Port Free Trade Zone, the factory is eligible for preferential customs treatment from Taiwan and the site is well placed for the maritime shipment of transformers for export.

(2) Factory equipment

Equipped with new production and testing equipment, the factory provides a highly efficient work environment with low labor requirements. Moreover, adoption of a one-way production line provides process directionality.

(3) Human resources

The factory, equipment, and products were commissioned by staff seconded from the two parent companies and recruited by HFT. Despite being a greenfields site, the factory satisfies Hitachi's technical standards.

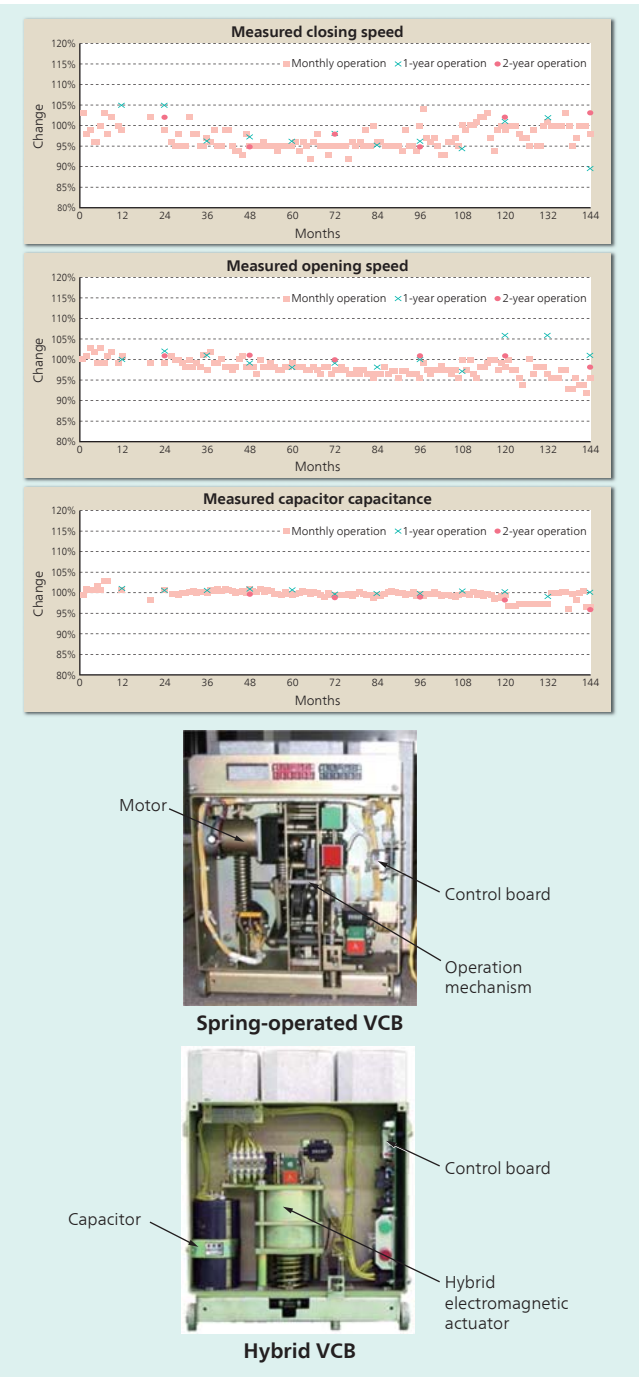
The first orders, for two 345-kV/265-MVA and two 415-MVA transformers, were received from Grand River Dam Authority (GRDA) in the USA in December 2014. They were completed in December 2015 and shipped to the USA from Port of Taichung.

7 Hybrid VCB Infrequent Operation Endurance Test Results

Hybrid vacuum circuit breakers (VCBs) have a simple mechanism and solid-lubricated bearings to enable them to operate without lubrication oil. By not using lubrication oil, hybrid VCBs remain free from mechanical defects caused by the drying out of grease, which are inevitable in spring-operated VCBs without maintenance. Moreover, as they do not need regular lubrication with grease, their maintenance interval is doubled compared to conventional VCBs. As a result, they have an advantage, not only in their reliability, but also in their maintenance cost. Since the product first went on sale in 2003, Hitachi has been conducting ongoing endurance testing (infrequent operation testing), one of the aims of which is to verify the longer inspection interval. The results for the 12-year mark (when a detailed inspection is due), are as follows.

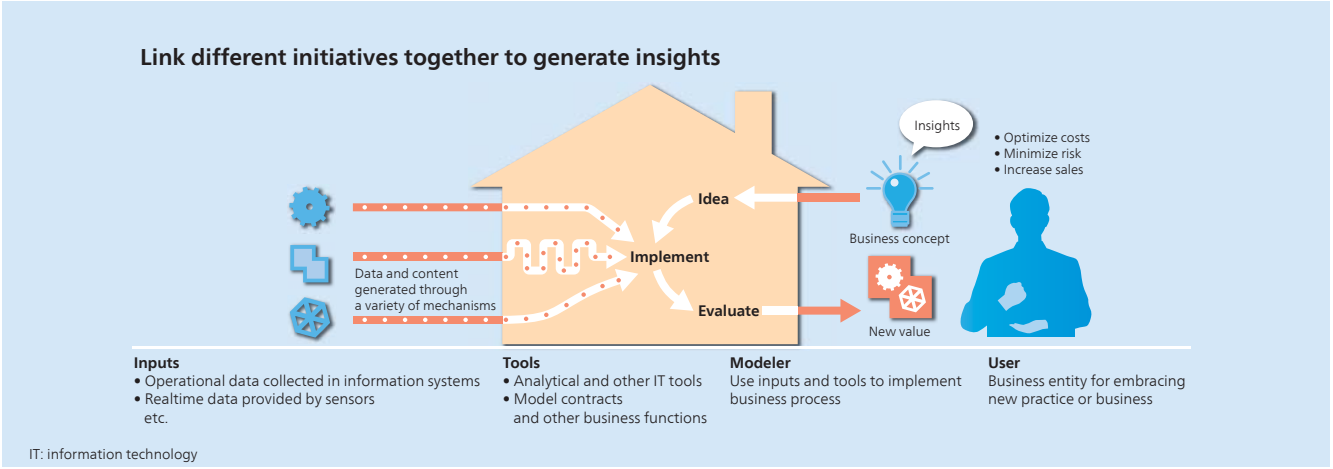
Three test VCBs are being used in infrequent operation testing. Each unit is operated once only every one-month, one-year, and two-year interval, and its speed and other characteristics are being measured. No maintenance is performed on the VCBs during the period of the infrequent operation test.

The test results for the 12-year mark indicate no faults in the operation mechanism or elsewhere, with all measurements being within the criteria and varying by no more than 10% since testing started. These results verify that performance is maintained during the 12-year period, after which a detailed inspection is due. Hitachi intends to continue with infrequent operation testing up to the VCBs' intended product life of 20 years.



7 Overview of infrequent operation endurance test results (change in closing speed, change in opening speed, change in capacitor capacitance) (top) and photograph of the VCB (bottom)

Symbiotic Autonomous Decentralized Systems



1 Concept of symbiotic autonomous decentralization

1 Concept of Symbiotic Autonomous Decentralization —Symbiotic Approach Opens up Potential for Open Innovation—

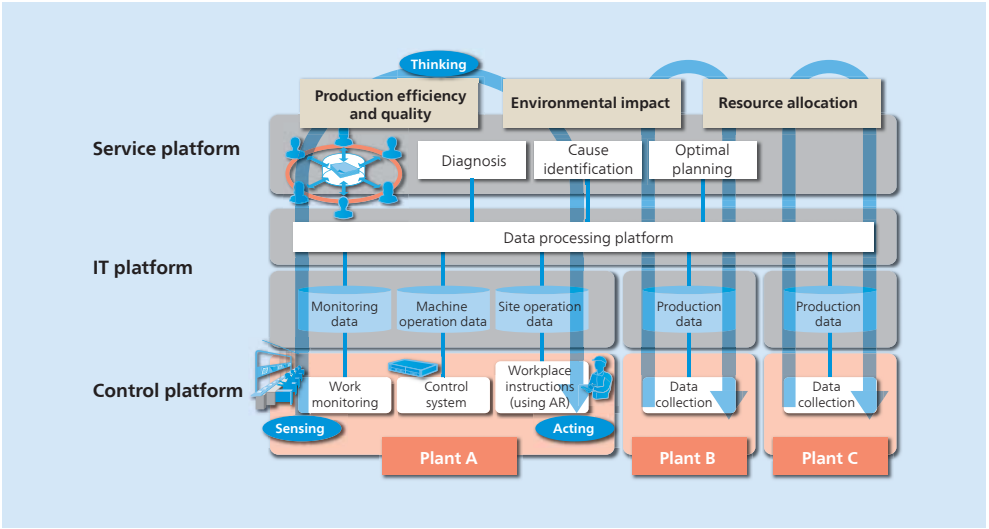
Due to social change and technological progress, new value is created in this current era of open innovation by linking different systems together. A typical example might be a service for calling a taxi at short notice that works by combining smartphone user location data with a vehicle dispatch system.

How this interconnection is achieved is key to the use of system interoperation to create innovative services, and it also requires secure processing via standardized interfaces based on defined data types. Also crucial is an environment that enables ideas to start small and then grow quickly through a process of trial and error.

The concept and methodology of symbiotic autonomous decentralization are proposed by Hitachi as a way of achieving such innovations through collaboration. Hitachi provides ways of working together to generate insights into how to improve the key performance indicators (KPIs) for a customer's business so that open innovation with customers and other partners can be achieved through the approach of symbiotic autonomous decentralization.

2 Symbiotic Autonomous Decentralized Systems Architecture

With growing use being made of the Internet of things (IoT), especially in manufacturing, Hitachi is seeking to generate customer value through systems that interconnect in accordance with the symbiotic autonomous decentralized systems concept.



2 Symbiotic autonomous decentralized systems architecture

Hitachi has a track record of developing highly reliable and scalable control systems using autonomous and decentralized designs and deploying them in such fields as transportation and industry. The symbiotic autonomous decentralized systems concept extends this to the system level and seeks to achieve system-wide optimization by collecting various types of real-world data (sensing), utilizing it in big data analytics and formulating measures based on systems and operational knowledge (thinking), and then providing these proposed measures back to the field as feedback (acting).

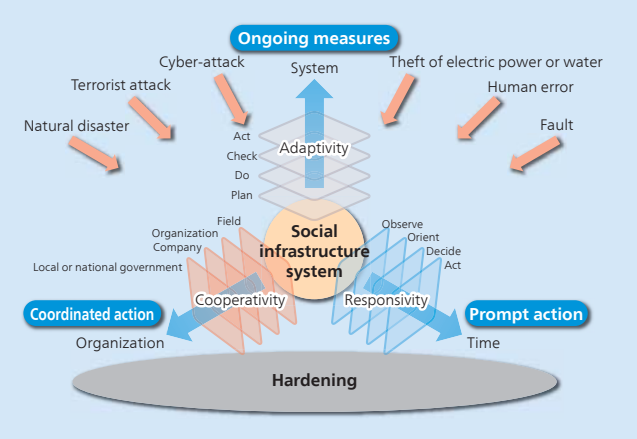
Achieving this involves integrating a wide range of technologies to satisfy customer needs, including the use of video and other new sensing techniques, big data platforms with the flexibility to handle diverse forms of data, big data analytics incorporating techniques such as artificial intelligence, and the use of augmented reality (AR) to provide feedback to the field.

3 Security in Symbiotic Autonomous Decentralized Systems

Along with relentless progress in industrial and social infrastructure systems, it is important that security also becomes more advanced.

To this end, Hitachi supplies a security solution for building symbiotic autonomous decentralized systems based on Hitachi system security concept. In addition to providing hardening (defenses) in compliance with IEC 62443 and other standards, the solution provides the adaptivity to implement the plan, do, check, act (PDCA) cycle for dealing effectively with ongoing change, the responsivity to implement the observe, orient, decide, and act (OODA) cycle for responding promptly to unexpected incidents, and the cooperativity for implementing security through interoperation between different systems.

In addition to engineering such systems, Hitachi also supplies such products as controllers with Embedded Device Security Assurance (EDSA) certification, security gateways (GWs), one-way routers, systems for the detection and forcible removal of unauthorized personal computers (PCs), and security monitoring and damage analysis services.

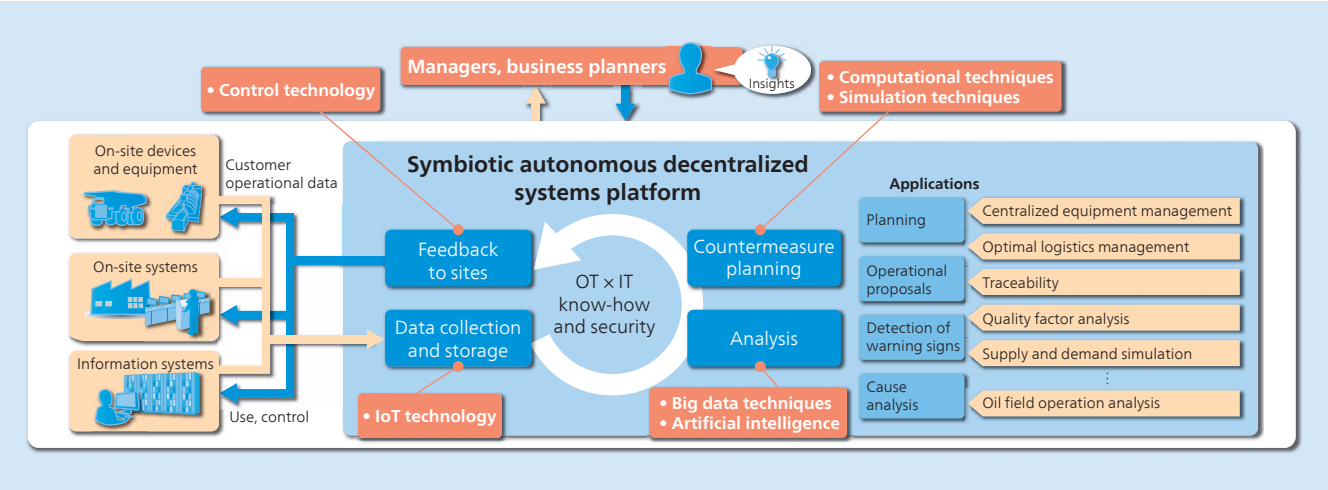


3 Security solution for social infrastructure systems (Hitachi system security concept)

4 Symbiotic Autonomous Decentralized Systems Technology

Hitachi uses its symbiotic autonomous decentralized systems concept as a basis for encouraging open innovation and the timely creation of customer value by connecting autonomous systems together. Data collection and storage, analysis, countermeasure planning, and feedback are all important factors in achieving this. Data collection and storage use IoT technologies, analysis uses big data analytics (such as Pentaho) or artificial intelligence (such as Hitachi AI Technology/H), countermeasure planning uses simulation and other computational techniques, and feedback uses control technologies.

To accelerate the growth of its social infrastructure business, Hitachi intends to build common platforms that will allow it to put solutions together quickly using these technologies, products, and services, and to deliver them securely based on a combination of operation technology (OT) and IT know-how.



4 Symbiotic autonomous decentralized systems platform

Transportation Systems

1 Series HB-E210 rolling stock

1 East Japan Railway Company Series HB-E210 Traction Drive System

On May 30, 2015, East Japan Railway Company opened the Senseki-Tohoku Line in conjunction with a comprehensive upgrade to the Senseki Line. The Senseki-Tohoku Line was created by linking the Senseki Line, which uses direct current (DC) power, with the Tohoku Line, which uses alternating current (AC) power, through an interconnecting line (non-electrified). It provides express services between Ishinomaki and Sendai using the Series HB-E210 of hybrid rolling stock, which can operate on all different forms of electrification.

Hitachi manufactured and supplied a hybrid drive system for the Series HB-E210 that is the latest version of the systems used on the Series Kiha E200 and HB-E300. In addition to combining the output of the engine and lithium-ion batteries to provide regenerative braking, optimal engine operation, and an idling stop function, the system also features the ability to continue operating as an electric locomotive even if the drive system batteries are unavailable. This new function is achieved by installing emergency batteries in the main converter that can be used to start the engine and generate power.

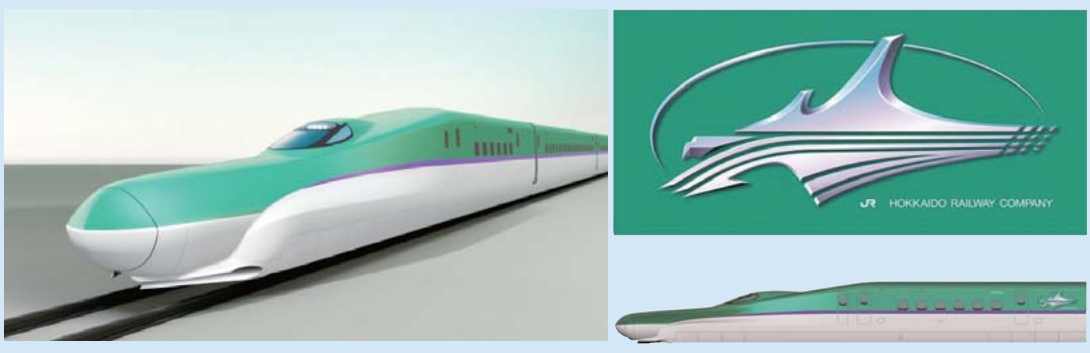
In the future, Hitachi intends to continue utilizing battery and engine-powered generator control technologies to satisfy the diverse requirements of railway operators.

2 Series H5 Shinkansen for Hokkaido Railway Company

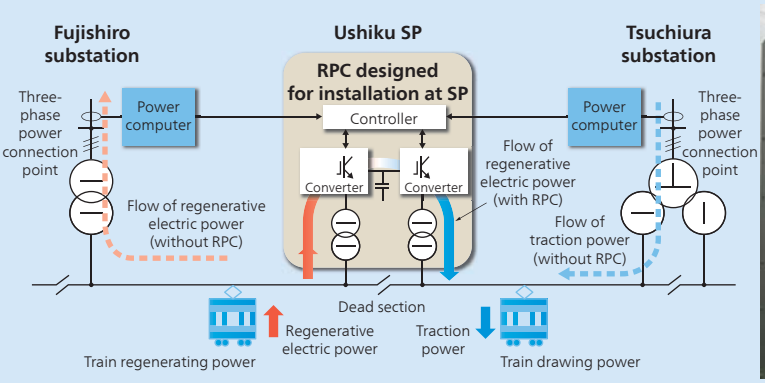
The Hokkaido Railway Company has introduced a Series H5 Shinkansen rolling stock (based on the existing Series E5) and is conducting operational trials in preparation for the opening in March 2016 of the Shin-Hakodate-Hokuto service of the Hokkaido Shinkansen.

The train will have a maximum speed of 320 km/h and operate at 260 km/h on the Hokkaido section and 140 km/h in the Seikan Tunnel. The exterior design of the rolling stock is based on the original Series E5 and incorporates features that are distinctive of Hokkaido, including the violet ("*saika* purple") color. Similarly, the symbol designed to represent the rolling stock is based on a bird of prey (gyrfalcon) motif. The Series H5 Shinkansen incorporates a wide range of technologies and leading-edge equipment, with light-emitting diode (LED) lighting in the passenger cabins and barrier-free features that include large wheelchair-accessible toilets and multi-purpose rooms.

As the route includes the Seikan Tunnel, which links Hokkaido to Honshu (Mainland of Japan), the technologies used in the rolling stock include a constant speed control system in the traction drive to suit the gradient in the tunnel.



2 Series H5 rolling stock for Hokkaido Shinkansen (image of completed train) and the Series H5 symbol design



3 Use of regenerative electric power by RPC designed for installation at an SP (left) and equipment in the RPC room at the Ushiku SP (right)

3 East Japan Railway Company RPC for Ushiku SP

A railway static power conditioner (RPC) developed and installed by Hitachi for the Ushiku sectioning post (SP) of the East Japan Railway Company's Joban Line entered service in March 2015. The purpose of the RPC is to take advantage of regenerative electric power.

As track sections fed by AC power are separated from each other by SP dead sections, it is not possible to transfer regenerative electric power between adjacent sections. Rather, to achieve this requires the installation of an RPC. The system is made up of the RPC and a power computer installed in the adjacent substation. Based on information sent via the power computer, the RPC reallocates excess regenerative electric power to other sections where rolling stock are drawing power. The RPC can transfer up to 5.3 MW (rated power: 1.3 MW) using a power converter equipped with insulated-gate bipolar transistors (IGBTs). It is also fitted with a reactive power compensator to cope with the fall in voltage when rolling stock are running on an extended section, thereby helping to keep trains operating reliably.

4 Central Japan Railway Company Upgrade to Nishi-Sagami FC Distribution Panel

The distribution panels supplied by Hitachi for the No. 2 Shinkansen frequency converter at the Nishi-Sagami frequency conversion (FC) substation of the Central Japan Railway Company entered service in April 2015.

Prompted by the aging of the previous equipment, the project involved a complete replacement of the control and protection systems on the No. 2 frequency converter.

The adoption of digital control and protection systems not only makes the equipment more compact, it also improves functionality and reliability thanks to a function for entering settings from a remote personal computer (PC) and the addition of monitoring functions that include continuous monitoring and automatic checking.

A data logging function stores data such as the voltages and currents during faults to make the causes easier to identify.

Hitachi intends to continue working with customers to help keep trains running reliably.

4 Upgraded protection relay panel

5 Dual 50-Hz/60-Hz control and protection system (left) and indoor GIS installation (right)

5 Hokuriku Shinkansen Shin-Joetsu Substation

Key wayside equipment supplied for the Shin-Joetsu substation of the Hokuriku Shinkansen between Nagano and Kanazawa entered service in March 2015.

As the power supply between Nagano and Kanazawa is supplied by Tohoku Electric Power Co., Inc. (at 50 Hz) and by Chubu Electric Power Co., Inc. and Hokuriku Electric Power Company (at 60 Hz), a feature of this section of line is that, as with the existing line between Takasaki and Nagano, it uses electric power supplied at these two different frequencies. The Shin-Joetsu substation that supplies power to rolling stock is itself supplied by Tohoku Electric Power Co., Inc. via a 154-kV/50-Hz line. It is also capable supplying rolling stock at 60 Hz using power drawn from adjacent substations. Accordingly, electrical equipment for the feeder sections is designed to operate at both 50 Hz and 60 Hz. The feeder protection system supplied as part of this project was designed to provide protection in the event of a fault, with a monitoring system able to work at both 50 Hz and 60 Hz that was developed jointly with the West Japan Railway Company and the Japan Railway Construction, Transport and Technology Agency. The Shin-Joetsu substation uses gas-insulated switchgear (GIS) to minimize equipment size and is installed indoors to prevent snow-damage.

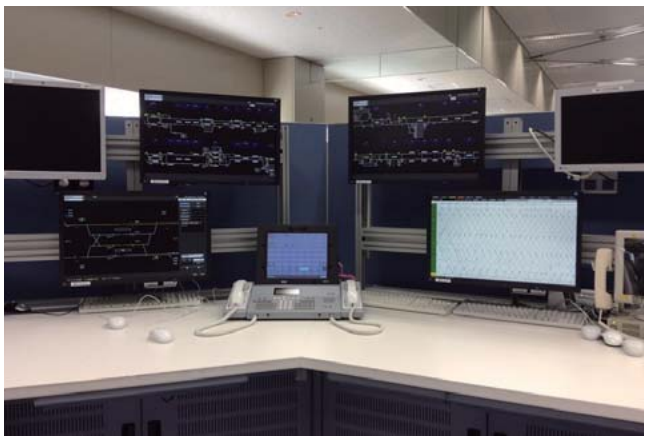
6 Adoption of ATOS on Yokohama Line and Commencement of Operation

The Autonomous Decentralized Transport Operation Control System (ATOS) of the East Japan Railway Company operates on high density railway lines in the Tokyo region.

The system was installed on the Yokohama Line from Hachioji to Higashi-Kanagawa Station in July 2015. As ATOS operation on the Chuo Line and Keihin-Tohoku/Negishi Line had already commenced when the system entered use at these terminal stations on the Yokohama Line, system migration involved a mix of existing and new stations, with a staged switchover being adopted for things like train scheduling to achieve a smooth transition without interfering with the existing system or railway operations. The adoption of ATOS on the Yokohama Line has further improved the safety and reliability of transportation in the Tokyo region.

Prior to the installation of ATOS, graphic displays* (GDs) were installed at Yokohama Line Hashimoto Station in June 2015. This improved the efficiency of station operations, including the entry of changes to incoming and outgoing schedules, by making it possible to input train schedules in timetable data in place of the previous operation, which used character-based screens.

* Terminals equipped with a function for entering schedule changes using timetable data like those used on the traffic supervision desks at a control center.



6 Control desk for Yokohama Line

7 East Japan Railway Company's onboard track inspection system

7 East Japan Railway Company Commencement of Operation of Onboard Track Inspection System (Yamanote Line, Chuo Line, and Keihin-Tohoku Line)

A track inspection system for installation on operating trains that was supplied for use on the Yamanote Line, Chuo Line, and Keihin-Tohoku Line, major lines in the Tokyo region operated by the East Japan Railway Company, commenced operation during FY2015.

A feature of the system is that it uses an inspection unit installed under the floor of operational rolling stock to make high-frequency measurements of track displacement at the same 0.1-mm degree of precision as the dedicated inspection cars used to make periodic measurements in the past. The measurement data is sent in realtime by a wireless communication system to a central management system that has connections to terminals located at the maintenance depots. This enables track monitoring to be performed from any depot. In addition to making a major contribution to ensuring the even safer operation of railway services, track monitoring using the new system also has the potential to help make track maintenance even more efficient than in the past.

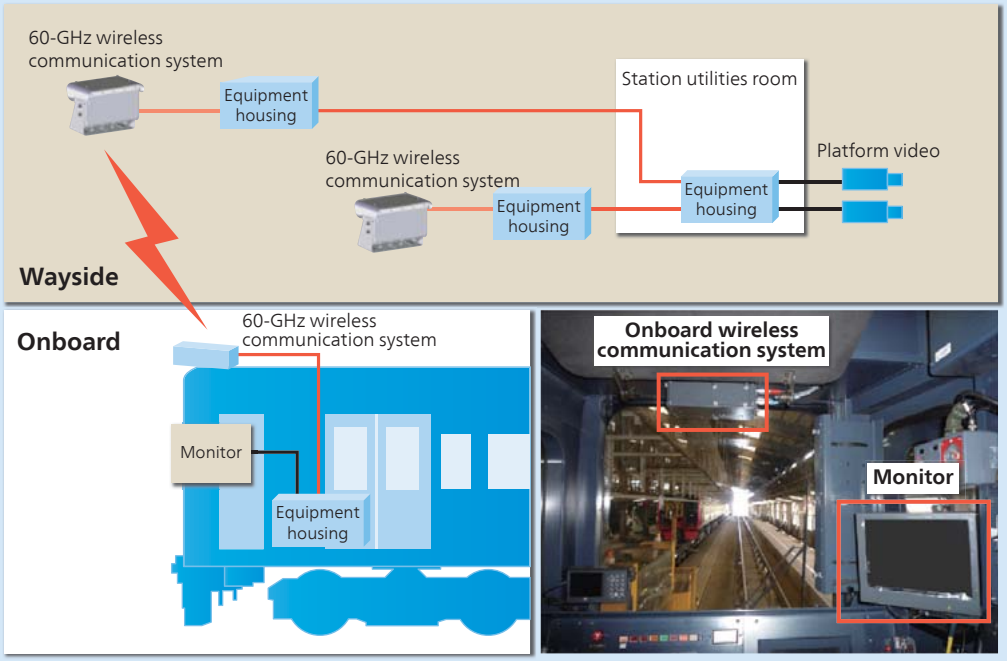
In the future, Hitachi intends to extend deployment of the system to major lines in the Tokyo region and to regional lines.

8 Kyushu Railway Company Support System for Single-driver Trains on Chikuhi Line

As part of an upgrade due to the aging of existing equipment, a system used by Kyushu Railway Company on its Chikuhi Line to support train operation by a single driver was switched from its current 2.4-GHz band communication system to a 60-GHz millimeter band system. The system ensures passenger safety and reliable operation of single-driver trains by displaying images of the platform to the driver on their onboard monitor screen.

To satisfy the system requirements, which included realtime image display and uninterrupted display until the rear of the train fully clears the platform, the support system was implemented in a way that ensured seamless display. This was done by upgrading to a video communication system with low-latency that provides realtime display, and works by polling multiple wayside wireless base stations to perform progressive handover from one station to another.

(Commencement of operation: April 2015)



8 Configuration of Kyushu Railway Company system for supporting train operation by a single driver on the Chikuhi Line

Public Sector Systems

1 Monitoring and control system for water treatment plant

1 Monitoring and Control System for Water Treatment Plant

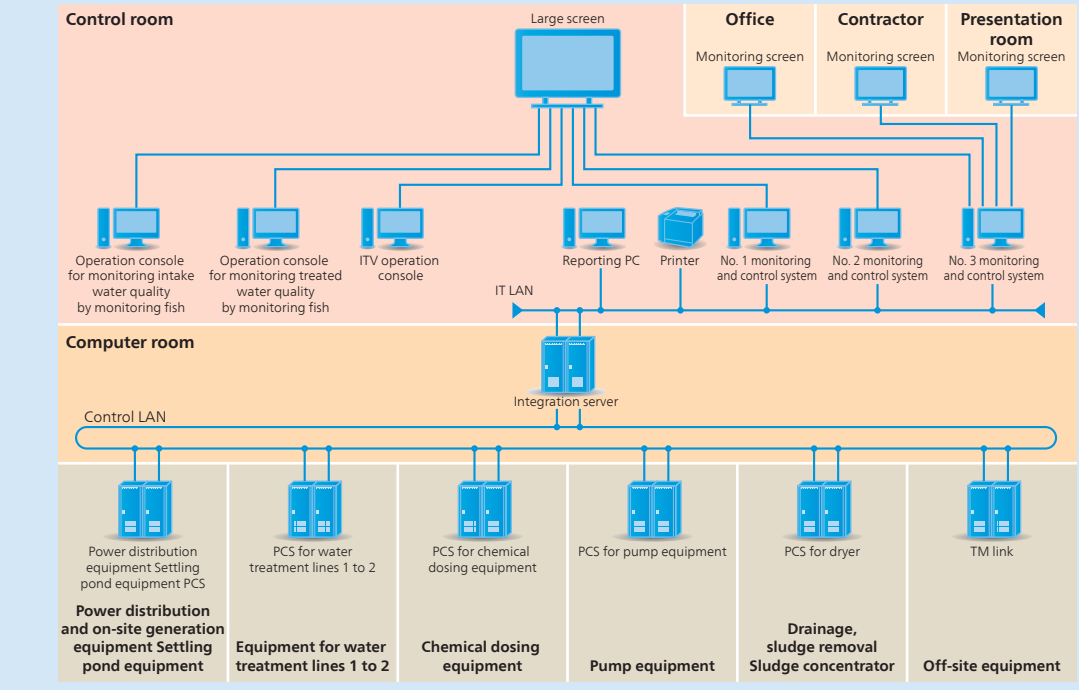
Hitachi has supplied a monitoring and control system for a water treatment plant that uses dual-configuration controllers for electric power distribution, water treatment, and water distribution equipment, and centrally located dual data servers, monitoring and control terminals, and large monitors. The system is configured to operate the plant and present an overview of its status by providing a separate control screen for each item of equipment and consolidating the display of calculation details and settings input.

The system is equipped with functions that support reliable and economical operation, including a water distribution planning system that uses demand prediction control based on actual past data and a quasi-optimal routing system (QRS) to plan flow settings both on and off site, as well as functions for sending settings to each controller, auto-generating water distribution plans 48 hours in advance, and simulation.
(Delivery date: March 2015)

2 Central Monitoring and Control System for Arai Wastewater Treatment Plant of Koriyama City Water Bureau

The Arai Wastewater Treatment Plant commenced operation in 1997 with a capacity of 21,000 m^3/d. It was the first such facility in Tohoku to adopt an advanced water treatment technique based on ozone and activated carbon. The plant capacity is now 42,000 m^3/d and it mainly supplies the eastern parts of Koriyama City in Fukushima Prefecture. Hitachi recently undertook a full replacement of the plant's central monitoring and control system.

The main features are as follows.
(1) The system uses a client-server architecture and a dual configuration for monitoring and control equipment (servers) to



ITV: industrial television, PC: personal computer, IT: information technology, PCS: process control station, TM: telemeter

2 Central monitoring and control system for Arai Wastewater Plant of Koriyama City Water Bureau

improve reliability.
(2) High-speed communication is provided by connecting controllers to a control local-area network (LAN).
(3) All of the operation consoles with mini-graphics panels were removed and replaced with liquid crystal display (LCD) monitors.
(4) The use of networking equipment allows monitoring to also be performed from offices or a presentation room.
(Commencement of operation: March 2015)

3 Central Monitoring and Control System for Izumi Water Treatment Plant of Fukushima Prefecture Development Bureau for Public Utilities

Iwaki City in Fukushima Prefecture has four industrial water supplies. With a maximum capacity of approximately 1,260,000 m^3/d, these are playing an important role in the recovery of industrial activity.

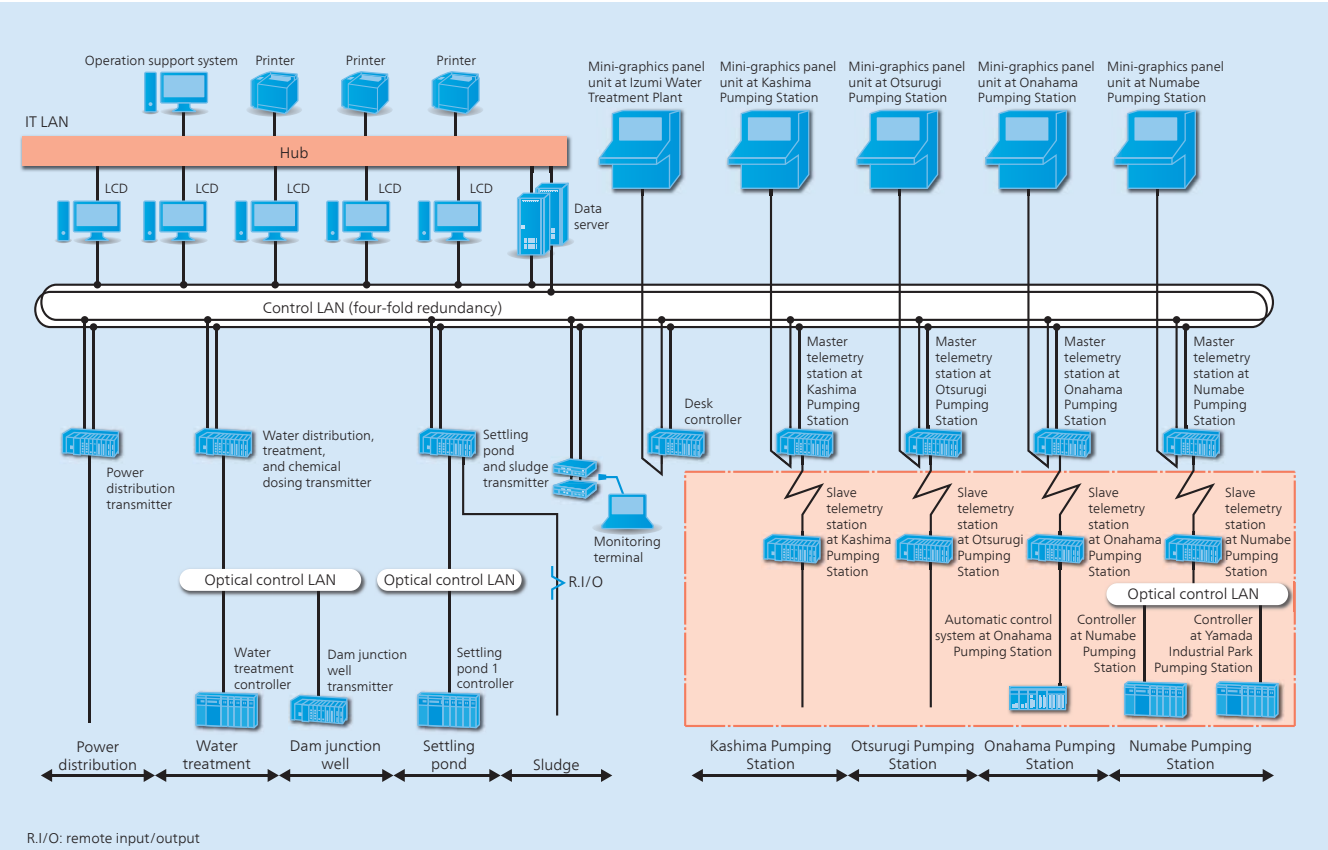
A system recently supplied by Hitachi to the Izumi Water Treatment Plant performs central monitoring and control of the industrial water supplies for the Iwaki, Nakoso, and Onahama districts. The main features are as follows.
(1) The system improves reliability using a client-server architecture, with a dual configuration for servers and four-fold redundancy for the control LAN (2 × dual rings).
(2) High-speed communication is provided by connecting controllers directly to a control LAN.
(3) It reduces space requirements through the removal of control room desk controllers, instead providing a human interface for monitoring and control of master telemetry stations for off-site equipment.
(4) It replaces the operation panels in the sludge processing building with notebook PCs (clients) for sludge equipment monitoring that are connected to the control LAN at two points in the sludge processing building.

4 Monitoring and Control System for Niwakubo Water Purification Plant of Osaka Municipal Waterworks Bureau

The Niwakubo Water Purification Plant of the Osaka Municipal Waterworks Bureau started supplying water to Moriguchi City in the north of Osaka in November 1957 with a capacity of 120,000 m^3/d drawn from the Yodo River. The current configuration is made up of three water intake and distribution systems (14 intake pumps and 13 distribution pumps), 64 filtration basins, and advanced water treatment systems, providing a capacity of 800,000 m^3/d. It was the second water treatment plant to commence operation in Osaka City.

Hitachi recently replaced the central monitoring and control system with an integrated monitoring and control system designed to improve reliability and optimize water distribution.

The main features are as follows.
(1) The system uses a client-server architecture and a dual configuration for servers to improve reliability.
(2) It achieves further improvement in reliability by using a three-way configuration for plant control equipment (dual main controllers and a single backup controller).
(3) The system achieves optimal operation of water distribution using demand prediction data generated by the integrated water distribution system at Kunijima Water Purification Plant.
(Commencement of operation: April 2015)



R.I/O: remote input/output

3 Central monitoring and control system for Izumi Water Treatment Plant of Fukushima Prefecture Development Bureau for Public Utilities

4 Control center of monitoring and control system for Niwakubo Water Purification Plant of Osaka Municipal Waterworks Bureau

5 Monitoring and Control System for Isaza Intake Pumping Station of Kitakyushu City Water and Sewer Bureau

The Isaza Intake Pumping Station has the important task of supplying water from the Onga River to various water distribution facilities in Kitakyushu City (Fukuoka Prefecture). As the monitoring and control system used to operate the station had been in service for more than 15 years and was becoming difficult to maintain due to problems such as age and spare parts availability, a project was undertaken to replace it.

Whereas the Isaza Intake Pumping Station had previously been operated manually based on the experience and judgment of the operators, the replacement project included installation of LCD monitoring and control units (industrial PCs) and controllers that perform automatic control of water intake in accordance with the quantity of water to be supplied to each water distribution facility.

Furthermore, the water intake station can be monitored remotely from the monitoring and control system at the Ano Water Purification Plant (supplied by a different vendor). As failure of communications with the Ano Water Purification Plant has a significant impact on operation, the configuration of the communication controller uses dual central processing units (CPUs). Also, the control network uses optical communications, including both input and output (I/O) devices, to ensure reliable communications without being vulnerable to lightning or electromagnetic noise.

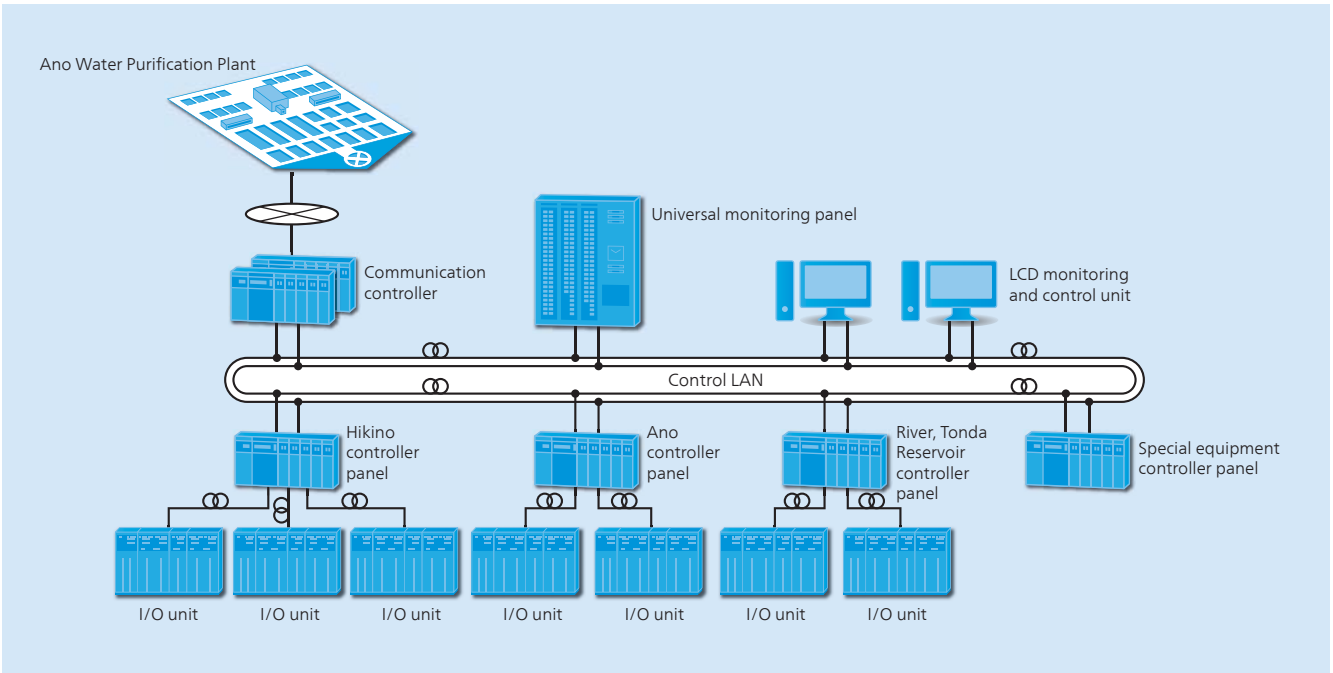
(Commencement of operation: March 2015)

6 Sea Level Reporting System

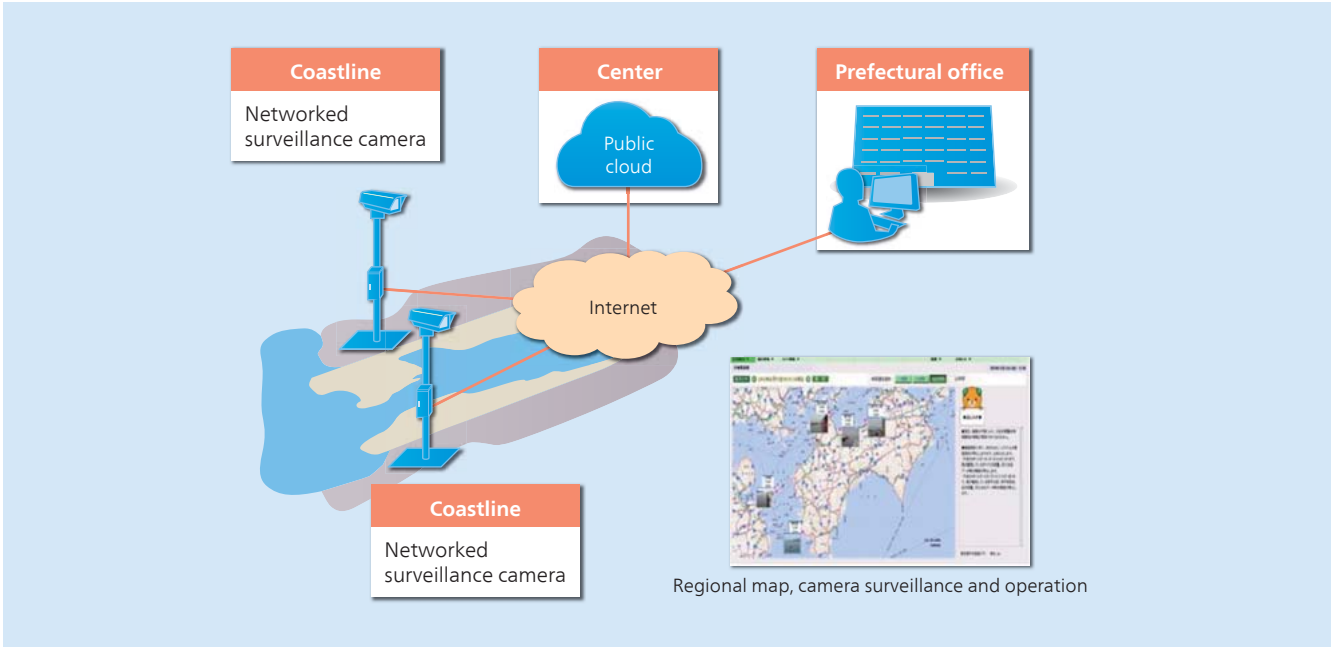
As the height of a tsunami when it strikes land tends to be higher than the wave height observed in open water, it is essential that information be provided in a manner that is timely and accurate for the region concerned. The requirement is to implement an information collection and distribution system with minimal installation and maintenance costs that can reliably collect data from the equipment being managed and deliver it to the community.

To meet this objective, the system uses cloud-based telemetry. Furthermore, because the height of a tsunami when it strikes land tends to be higher than the wave height measured out at sea, the system was designed to provide useful civil defense information by consolidating sea level sensors along the coast of the prefecture to collect and supply sea level information in realtime. As having people go out and visually confirm sea levels can be difficult, such as when high tides occur at night, providing web cameras, sea levels, and other information on a reliable and routine basis can make the information available for civil defense use.

In the future, Hitachi intends to draw on know-how from the implementation of this system to help ensure safe and secure communities while also satisfying a wide range of customer needs.



5 Block diagram of monitoring and control system for Isaza Intake Pumping Station of Kitakyushu City Water and Sewer Bureau



6 Overview of Ehime Prefecture sea level reporting system

7 Efficient Nitrification Control System Incorporating ICT (Technology Verification by B-DASH Project)

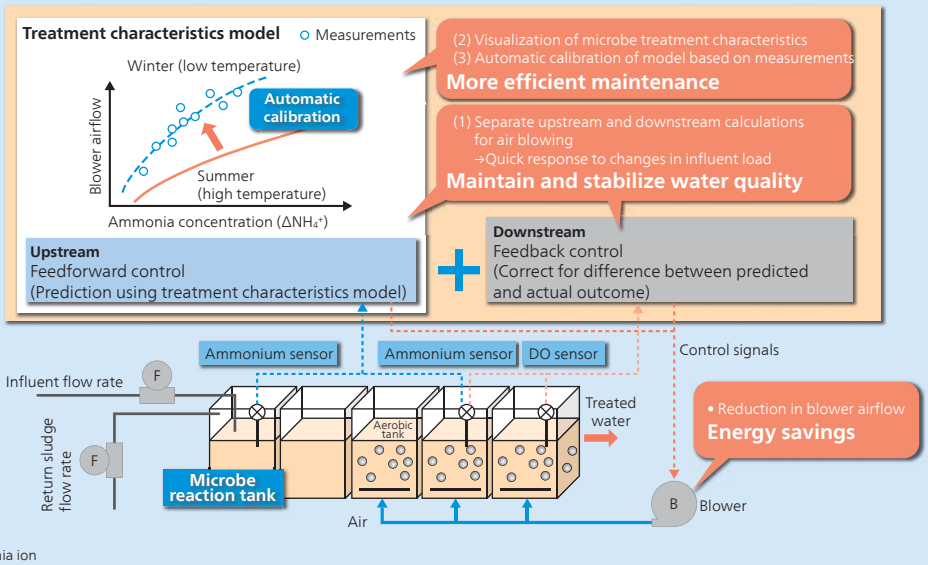
Since FY2014, as part of the Breakthrough by Dynamic Approach in Sewage High Technology (B-DASH) Project of Japan's Ministry of Land, Infrastructure, Transport and Tourism, Ibaraki Prefecture and Hitachi have been working on the "Demonstration of Efficient Nitrification Control with ICT," a contract research initiative of the ministry's National Institute for Land and Infrastructure Management. The research is trialing a nitrification control system that combines energy efficiency with the maintenance of good water quality at the Kasumigaura Sewage Treatment Plant in Ibaraki.

In addition to a downstream dissolved oxygen (DO) sensor, the control system also incorporates ammonium sensors located midway along and upstream of the aerobic tank. The system is designed to maintain water quality, improve energy efficiency by reducing air blowing, and enable more efficient maintenance, with functions that use these sensors to combine feedforward and feedback control, display process characteristics, and automatically calibrate control parameters.

The FY2014 trials demonstrated a 14% reduction in blower airflow compared to constant-DO control while achieving a mean ammonia concentration in the treated water of 0.3 mg-N/L (target: 1.0 mg-N/L or less). The trial is continuing in FY2015 to assess reliability over the long term, and is scheduled to end in March.

8 Precision Farming Demonstration Project in Australia Using Quasi-Zenith Satellite System

Along with Hitachi Zosen Corporation and others, Hitachi was



7 Overview of nitrification control system being trialed as part of B-DASH Project

8 Use of self-steering tractor to spread fertilizer on a crop farm in Australia

commissioned by the Ministry of Internal Affairs and Communications in FY2014 to conduct a study on the effective use overseas of advanced positioning signals from Japan's Quasi-Zenith Satellite System. This involved a demonstration project on the use of the Quasi-Zenith Satellite System for precision farming in Australia.

The demonstration project uses a new precision standalone positioning system to send highly accurate position corrections to farm tractors on the signals from the L-band experiment (LEX) quasi-zenith satellite. This succeeded in obtaining tractor locations to an accuracy of ±5 cm and driverless operation along rows of crops. The project also used the geographic information cloud service of Hitachi Solutions, Ltd. to collect self-steering data from the tractors and crop growth sensor data and present it on an on-screen map. Potential uses include providing this data to the farmer, or improving the efficiency of agricultural production and agricultural machinery management through the use of self-steering.

Along with use in commercial agriculture, in the future Hitachi intends to operate businesses that utilize precise positioning techniques in other industries and regions.

9 Iwanuma City Fatigue Measurement System

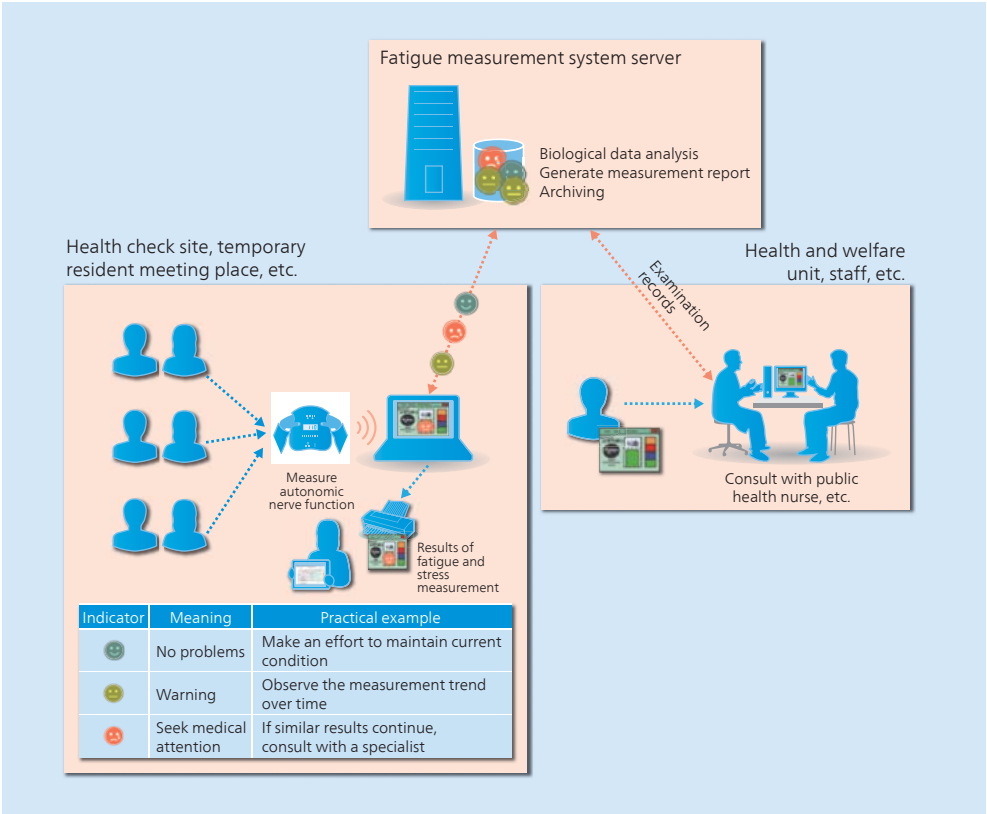
Iwanuma City in Miyagi Prefecture introduced a fatigue measurement system in April 2015. The system is used for resident health checks to measure levels of fatigue and stress. Made up of an autonomic nerve measurement device* and the fatigue measurement system server, the system performs analyses and generates reports using an analytical function from Fatigue Science Laboratory Inc. that runs on the server.

Measurement is simple to perform. The examinee inserts his/her left and right forefingers into the autonomic nerve measurement device for two to three minutes while it records the electrocardiogram and pulse waveforms that provide the basis for the analysis. The report gives the examinee's age in terms of their autonomic nerve function, heart rate variability, and the balance between their sympathetic and parasympathetic nerve, and provides a three-level assessment of either "OK," "Warning," or "Seek medical attention." This information can prevent mental health risks and assist with early detection.

In the future, Hitachi intends to continue deploying mental healthcare solutions like this to local governments, educational institutions, and companies.

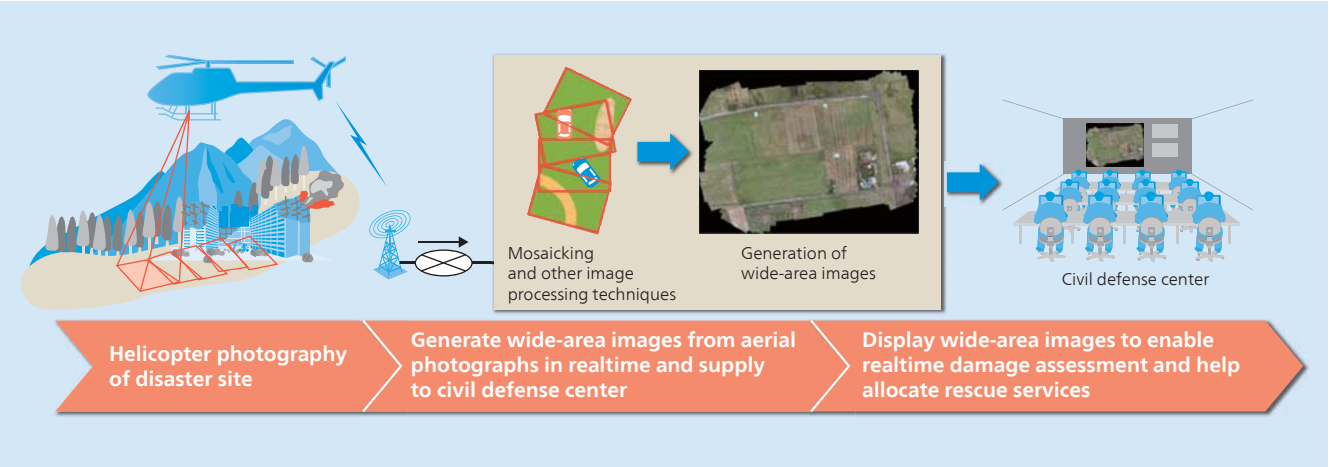
[Hitachi Systems, Ltd. (implementation of fatigue measurement system)]

* Developed by Fatigue Science Laboratory Inc.



9 Diagram of fatigue measurement system operations

Security Technologies for Social Infrastructure



1 Realtime aerial image analysis system

1 Realtime Aerial Image Analysis System

A rapid and appropriate first response to earthquakes and other large natural disasters is essential, including determining the level of damage in the immediate aftermath, sharing information, and allocating rescue services. While images from helicopters or small unmanned aerial vehicles are currently used for damage assessment, it can be difficult to quickly identify the physical location of an image and how it relates to the surrounding area. In response, Hitachi has developed a realtime aerial image analysis system that can generate wide-area images from photographs taken by helicopters and other sources.

The system generates precise images from aerial photography in realtime by using a mosaic technique along with distortion correction, techniques for minimizing position alignment error, and so on. The ability to convert large quantities of image data to compact image information means that civil defense agencies can share damage assessments among themselves to assist with achieving a rapid and appropriate first response.

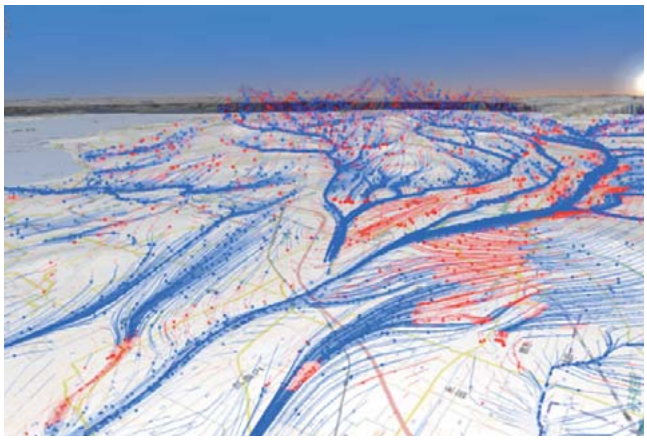
Hitachi intends to contribute to society by supplying disaster prevention solutions that keep people safe and secure, not only in Japan, but also in other disaster-prone regions.

2 Water Cycle Simulation Services

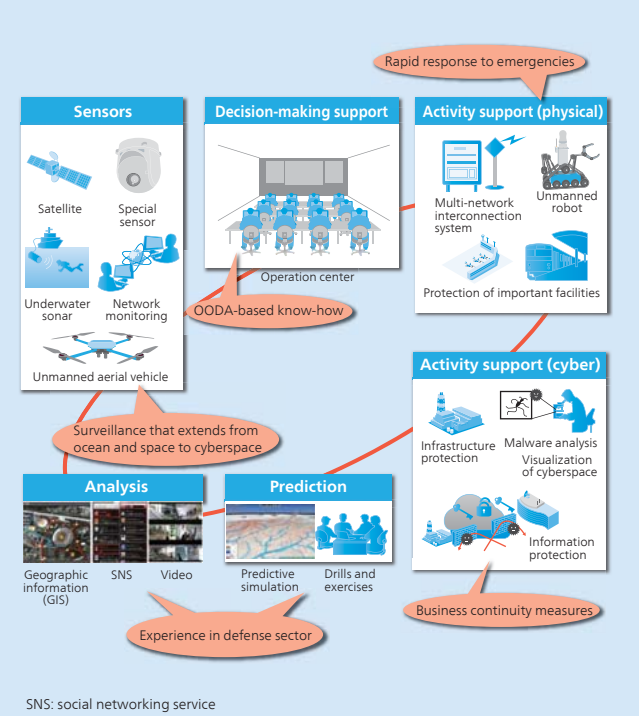
Following the Basic Plan on Water Cycle Policy cabinet decision of July 2015, national and local governments and other agencies are undertaking appropriate groundwater management for each river basin. In the future, Hitachi intends to supply water cycle simulation services that provide watershed analysis and visualization for use in implementing the Basic Plan on Water Cycle Policy. Hitachi is also working to supply services for appropriate groundwater management globally.

The water cycle simulation services include simulation techniques that fully combine and analyze both surface water and groundwater, and visualization techniques that provide quick and intelligible display of the analysis results. The simulation techniques consider interactions between surface water and groundwater and enable an analysis of mechanisms for the movement of pollutants and other substances. The visualization techniques can display large amounts of time-series data for above and below ground generated by the simulations, provide spatial totals, and plot data at high speed in accordance with the display scale.

With these features, it is anticipated that the service will provide even sophisticated assessments of the current situation and predictions of the future for water resources and the water cycle.



2 Visualizing surface water and groundwater flow (blue lines: surface water flow, red lines: groundwater flow)



3 Providing a security solution for the entire social infrastructure

3 Wide-area Surveillance and Security Solution

Hitachi uses Hitachi system security concept, which focuses on measures that are adaptive, responsive, and cooperative, to deal with security requirements for protecting social infrastructure from threats such as natural disasters, cyber-attacks, and terrorism, and supplies a wide-area surveillance and security solution that provides appropriate ongoing measures in accordance with the International Organization for Standardization (ISO) 22320 standard for emergency management.

Specifically, it performs multifaceted monitoring of social infrastructure by using satellites, unmanned aerial vehicles, network monitoring, and other sensors to assess the ever-changing situation in both the physical and cyber realms. Along with using unmanned vehicles, security gates, and so on to provide physical support for activities, this includes analyzing and predicting information using geographic information systems (GISs), analyzing image, and simulation techniques. It provides rapid and accurate decision-making support, including the provision of know-how based on the observe, orient, decide, and act (OODA) process.

It also supports prompt action through the automatic detection of warning signs identified by realtime processing of large amounts of collected monitoring data.

The system can be configured and installed quickly thanks to a flexible choice of hardware configuration based on the nature of the operation and existing equipment.

4 Multi-network Interconnection System for Use in Social Infrastructure Security

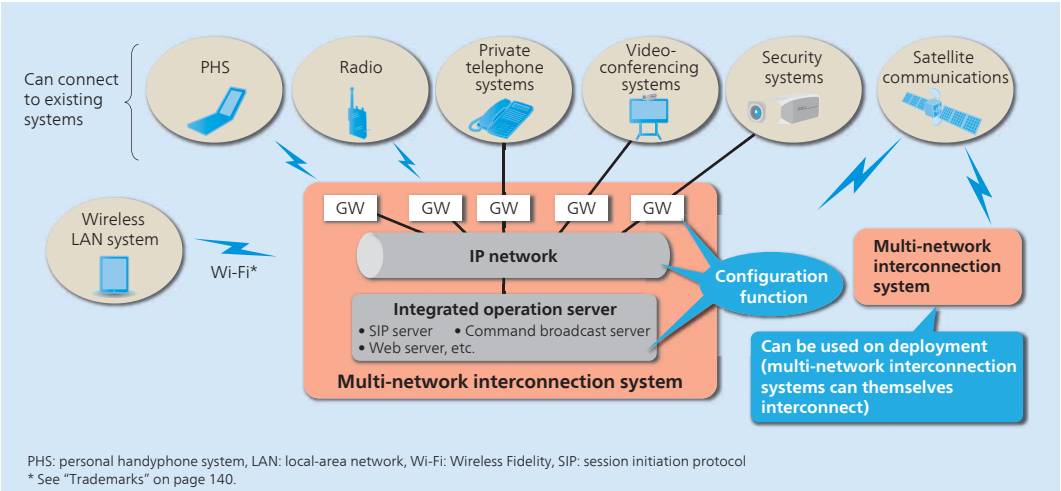
A breakdown in communications during a major disaster and the associated complications and confusion regarding information are obstacles to taking prompt action to limit damage.

This reaffirms the importance of ensuring that robust communication methods are available during a major disaster.

In response, Hitachi supplies a multi-network interconnection system that utilizes technology from the defense sector to provide means of communication that are suitable for use during a major disaster.

The system combines existing infrastructural communication equipment with other forms of wireless communication such as mobile phones and transceivers to make wide-area voice and data communications available simply and quickly. The system uses gateways that perform conversion to Internet protocol (IP) connections to provide seamless calls between telephones or over radios that do not normally support phone calls, including proprietary communication protocols like those used on transceivers for identifying devices from their frequency band.

Autonomous and portable for outdoor use, the system supports communications during a major disaster and at places that lack a communication network (such as at a worksite or inside a tunnel) by establishing a simple and proprietary communication infrastructure from a fragmented communication network or on mountains or remote islands.



PHS: personal handyphone system, LAN: local-area network, Wi-Fi: Wireless Fidelity, SIP: session initiation protocol
* See "Trademarks" on page 140.

4 Image of using the multi-network interconnection system to connect existing communication infrastructure

Elevators

1 Elevator car (top) and image of different types of internal lighting (white light versus the color produced by an incandescent light bulb) (bottom)

1 New Model Attuned to Human Behavior in Keeping with the Core Concept of Hitachi Elevators

In September 2015, Hitachi announced a conceptual model for elevators that was developed to implement its new core concept that was formulated for its elevator and escalator product services with the aim of supplying systems that are compatible with human behavior.

In addition to conventional functions for safety, security, and comfort, this elevator uses comforting elevator car designs with minimal corners and rounded lines so as not to discourage passengers from leaning against them. It also uses liquid crystal displays (LCDs) with a portrait orientation for ease of viewing to display information in a way that makes it easier for passengers to visualize the movement of the elevator to their intended floor by giving an intuitive indication of the current location. Another function adjusts the lighting color to suit the time of day to provide a sense of comfort in the elevator car by conveying impressions such as crispness or warmth.

In keeping with this concept, Hitachi intends in the future to develop functions and services with a high degree of added value so that users can feel confident about making regular use of elevators, and to deploy products throughout the world that incorporate these functions and services.
(Hitachi Building Systems Co., Ltd.)

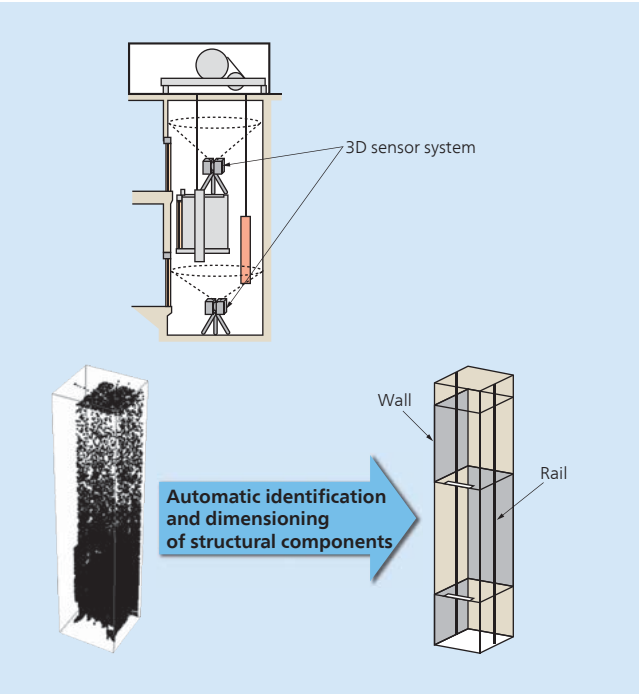
2 3D Site Survey System for Elevator Overhauls

Hitachi has developed a three-dimensional (3D) site survey system that significantly reduces the time taken from the site survey to the design work stage of elevator overhaul projects, and shortens the lead time for preparing work quotations. The system entered full-scale operation in April 2015. This significantly reduces the amount of time elevators have to be shut down to perform a site survey and shortens by 80%* or more the total survey and design time required to prepare a work quotation, while also improving measurement accuracy and design quality.

The main features of the system are as follows.

(1) Adopts a 3D sensor system to eliminate the need for manual dimension measurements, improves accuracy by eliminating measurement errors while also causing less user disruption by significantly shortening the time the elevator needs to be shut down (from 90 to 30 minutes).

(2) Enables the dimensions of walls, rails, and beams to be determined automatically by using a newly-developed algorithm that automatically identifies these structural components from 3D



2 Image of elevator shaft being measured using a 3D sensor system (top) and a depiction of the automatic calculation of dimensions from measurements (bottom)

measurements. This has shortened the time it takes to prepare drawings on a computer-aided design (CAD) system from four hours to about 30 minutes.
(Hitachi Building Systems Co., Ltd.)

* Sum of the reduction in time an elevator is shut down for survey and the reduction in design time.

3 Advances in Remote Maintenance System and Wider Range of Models Covered by Remote Maintenance

Launched in April 2015, a new remote maintenance system was developed by Hitachi in tandem with the commencement of operation of the new 2014 models of its standard elevators.

The new remote maintenance system has undergone rigorous improvements in maintenance quality, featuring more accurate measurement and a wider range of measurements than the previous remote intelligent diagnostics unit, and has been enhanced to the point where it can detect small changes that occur in equipment such as brakes or door open/close mechanisms, etc. prior to problems. The new remote maintenance system is made up of products and services that improve elevator toughness, while also helping achieve a quick recovery in the event of a major disaster through its use in conjunction with an automatic diagnosis and recovery system, which uses a Long Term Evolution (LTE) communication link to intervene in operation in response to emergency earthquake warnings and performs automatic elevator diagnosis and recovery after seismometer operation halts.

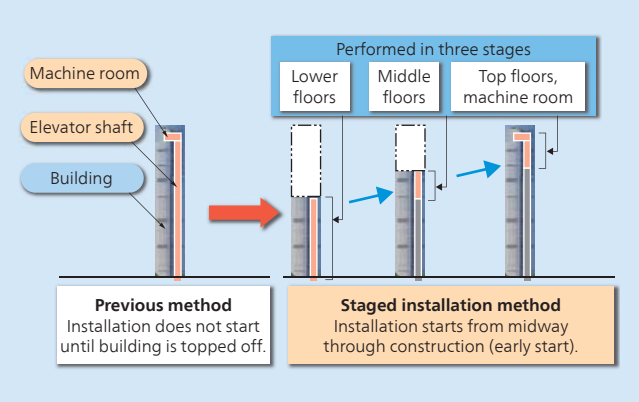
In the future, Hitachi intends to use this technology to expand the coverage of remote maintenance through deployment in other products such as high-speed custom elevators or Hitachi's modernization package elevator overhaul offering. Hitachi also intends to continue providing safety and security to all building users, with the aim of being the world leader in maintenance quality, by expanding the use of the new remote maintenance system to China and other Asian markets.
(Hitachi Building Systems Co., Ltd.)

4 Technique for Staged Installation of Elevators in Ultra-high-rise Buildings

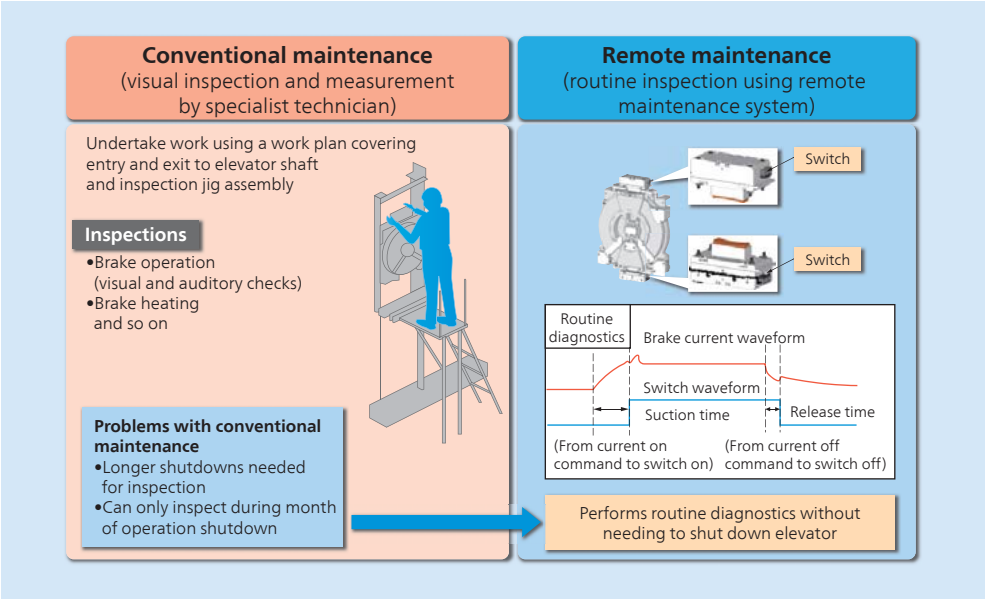
Hitachi is working to improve the quality of installation and maintenance by overseas escalator and elevator companies. Particular effort is going into quality improvement and shorter work times for the installation of elevators in ultra-high-rise buildings in China. Hitachi Elevator (China) Co., Ltd., the company that manages Hitachi's escalator and elevator business in China, has introduced a technique it developed for the staged installation of ultra-high-rise elevators.

The new technique involves starting installation in the lower part of the building from an intermediate floor prior to construction reaching the top floor. By starting the work earlier and shortening the installation time, elevator installation is completed at an earlier stage than with previous methods. This is appreciated by customers because it makes the elevator available for transporting construction materials and workers several months earlier than otherwise. In addition to improving the safety and quality of installation work, it also reduces worker workload.

Hitachi intends to adopt the new staged installation method for elevators as standard practice in buildings that are constructed to a height of 200 m or more (about 40 floors).

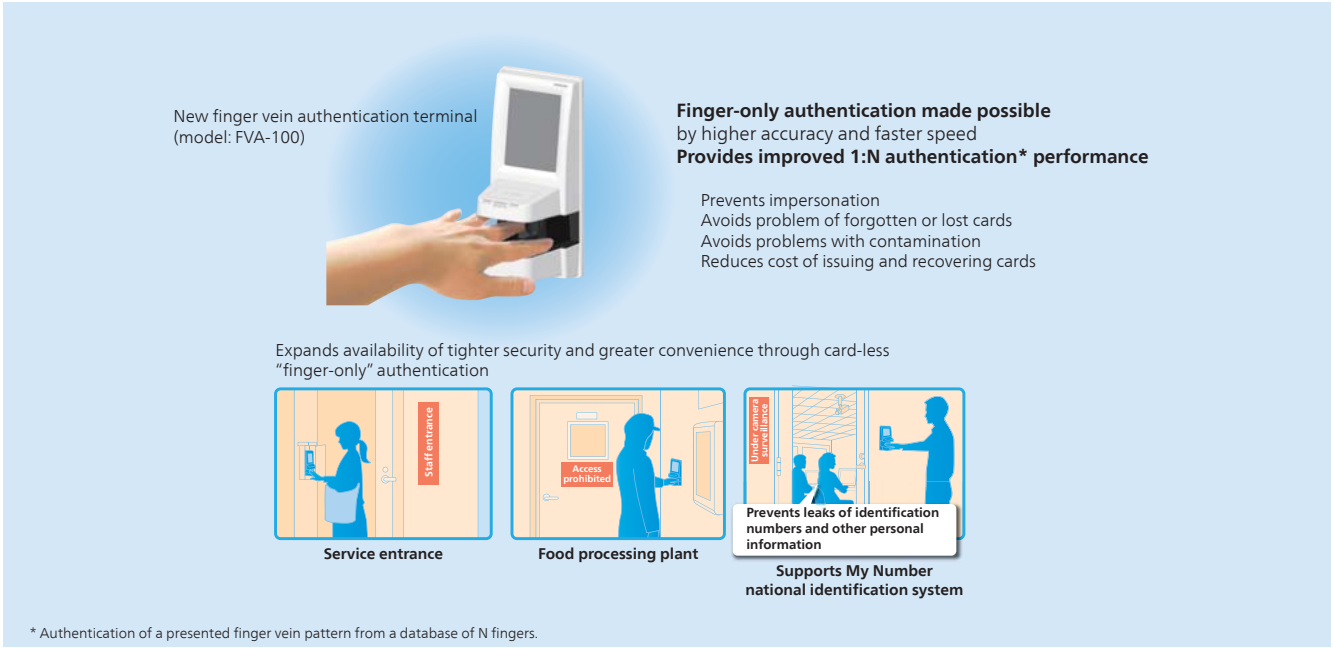


4 Overview of technique for staged installation of elevators in ultra-high-rise buildings



3 Brake inspection

Industrial Equipment and Systems



1 New model FVA-100 finger vein authentication terminal

1 Access Control System Using New Finger Vein Authentication Terminal

Finger vein authentication is mainly used for access management in situations such as server rooms that demand a high level of security. However, because of the inconvenience of having to issue and recover cards, the risk of their being forgotten or lost, and, in the case of factories, the potential for them to be a safety hazard or source of contamination if worn around the neck, recent times have seen growing demand for authentication based on the user's finger alone.

In response, Hitachi has developed the new model FVA-100 finger vein authentication terminal that features significantly improved authentication performance using only a user's fingers, reducing the number of instances of incorrect acceptance to 1/15 of the previous method*1 when used for successive authentication*2 and a high authentication speed of 10,000 fingers/s (three times previous method*1). The first access control system fitted with the new terminal is used to control between one and 256 doors and is already on sale.

In the future, Hitachi intends to satisfy growing demand for tighter security and greater convenience, and to make an even greater contribution to creating a safe and secure society, by using the new terminal in applications such as cloud-based building facilities management solutions and integrated large scale access control systems.

*1 Compared to previous model (FVTC720).
*2 Users record patterns for two fingers. If the person is not identified by the first finger, authentication is repeated for the second finger. This significantly improves authentication performance.

2 Video Surveillance Solution for Large Systems

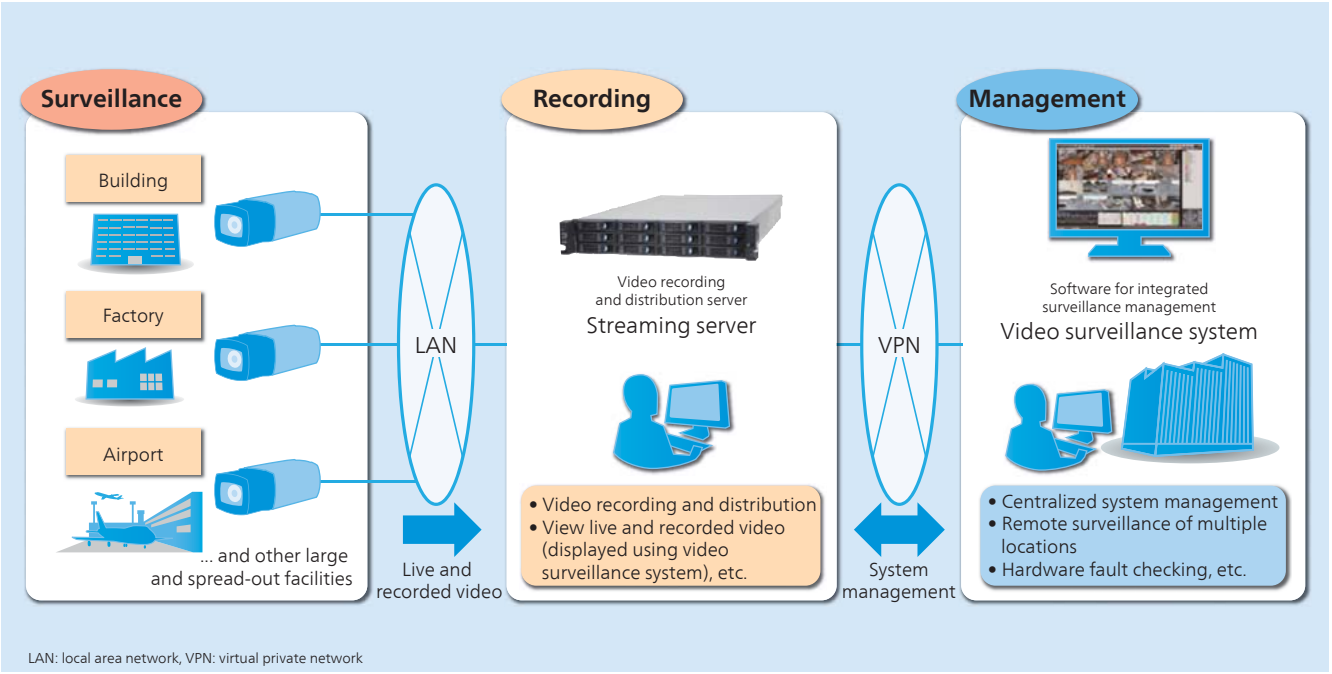
Surveillance systems are growing in size and diversity in order to provide tighter security and more convenient video surveillance at companies, public facilities, and other sites, including increases in the number of cameras and centralized management from headquarters or a data center of camera images from multiple sites. Hitachi has introduced a new video surveillance solution for large systems that can seamlessly integrate its video surveillance system software for integrated surveillance system management of up to 32,000 cameras and 2,000 recording devices with its streaming server video recording and distribution servers, which can handle a large volume of video data (64 or more cameras) on a single server.

The main features are as follows.

(1) It can connect network cameras* from other vendors as well as Hitachi.

(2) It provides high performance and high quality video recording and distribution that enable systems to be configured at low cost.

(3) It provides efficient video management through a wide range of management functions and user interfaces.



LAN: local area network, VPN: virtual private network

2 Video surveillance solution for large systems

In the future, Hitachi intends to work on video solutions that combine collected video data with image analysis to provide video solutions that can be used not only to prevent crime, but also to help customers make operational improvements.

(Hitachi Industry & Control Solutions, Ltd.)

* Restrictions apply as to which models and settings can be used when connecting network cameras from other vendors.

Parameter	Specification
Voltage	13-kV class
Frequency	60 Hz
No. of poles	4
Output	13 MW

Note: A starting current of 300% is also available.

3 Photograph and specifications of the new 13-MW induction motor

3 Large Three-phase Induction Motor

Recent years have seen greater use of high-capacity induction motors. In the oil and gas industry in particular, the demand is for robust induction motors that are compact and lightweight while still providing high capacity. These features make a major contribution to increasing flexibility and reducing the cost of transporting and installing new motors. Hitachi has recently developed a 13-MW class induction motor that is the highest rated model in its new development series that features modular and optimal design.

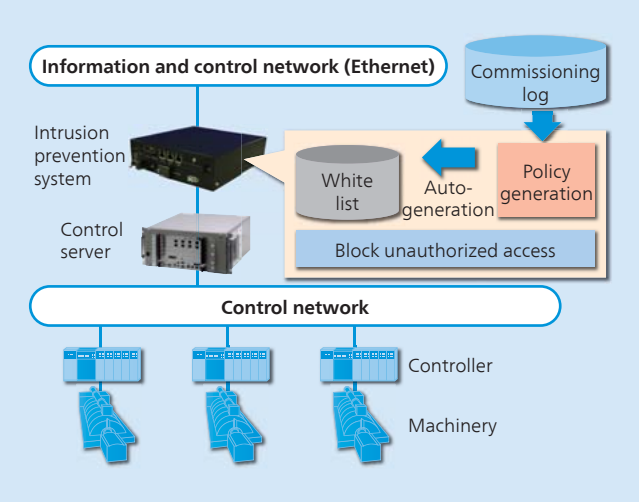
The new model expands the potential uses for induction motors, also providing the low starting current required by floating production, storage, and offloading (FPSO) systems.

4 Security Gateway Intrusion Prevention System for Control Systems

The year by year increase in cyber-attacks on control systems is creating a need for security measures. Unfortunately, there has been a lack of progress on such measures because of difficulties associated with the use of existing security products, which have short product support periods and require specialist knowledge to specify the security settings. The issues include the fact that control systems do not allow configuration changes that impede reliable operation over the long term, and that the people who operate these systems do not have security expertise.

In response to this situation, Hitachi has developed an intrusion prevention system with the following features to prevent unauthorized access to control systems.

(1) Unauthorized data packets that do not satisfy predefined policies (a white list) are blocked, without the need to modify network settings for control system equipment when installing



4 Example use of intrusion prevention system

the intrusion prevention system.

(2) There is no need for specialist security expertise because the policies can be auto-generated based on the packet traffic that passes through the intrusion prevention system during commissioning.

In the future, Hitachi intends to expand use of the system beyond the nuclear power industry, where use of the system is already planned, to also include other industries and the public sector.

5 Intelligent L2 Switch for Industrial Use

Developed by Hitachi, Intelligent L2 Switch is a small 10-port intelligent L2 switch for industrial use that combines long life (a 10-year design life) and advanced functions with excellent reliability and durability. In addition to more than 40 routine functions, including support for the simple network management protocol (SNMP) and spanning tree protocol (STP), the switch also uses a proprietary ring topology based on the core technology from the control network [International Electrotechnical Commission Publicly Available Specification (IEC PAS) 62953]. In configurations of up to 64 devices, functions for improving reliability include automatic recovery from network faults in less than 500 ms, route switching in response to intermittent as well as persistent faults, and duplication of blocking locations.

The switch also provides the following features thanks to a component mounting design and metal housing specially optimized by Hitachi.

5 Intelligent L2 Switch

(1) The switch can operate in ambient temperatures from −10°C to 60°C.

(2) It is resistant to dust thanks to a housing that does not include a fan or ventilation slots.

(3) It has 4 G resistance to vibration [and also complies with class 1 of Japanese Industrial Standards (JIS) E3014].

These three features make the switch suitable for installation on machinery that is exposed to harsh environments.

Along with use in water, sewage, railways, and electric power systems, Hitachi also plans to expand its applications to include power generation systems in the future.

6 New UX Series Industrial Inkjet Printer

Industrial inkjet printers are widely used in industries such as the food, beverage, cosmetics, and pharmaceuticals industries for the direct printing of date of manufacture, use by, lot number, and other quality management data. They are in high demand throughout the world, especially in countries where there is a strong awareness of quality such as Japan, Europe, and America.

Hitachi developed its new UX series of industrial inkjet printers based on the key concepts of reliability, simplicity, and environmentally conscious performance.

The main features are as follows.

(1) Ink and makeup fluids are supplied in cartridges produced by Hitachi that are simple to insert, minimizing problems such as users getting dirty hands. They also use near field communications (NFC) to prevent insertion of the wrong fluid.

(2) A proprietary system for minimizing solvent volatility reduces solvent use by approximately 50%*.

(3) High-quality printing at high speed is achieved using new print control (reverse scan control, ink particle usage irregularity control).

(4) Easier operation using new screen designs with simple layout on a 10.4 inch (about 26.42 cm) thin-film transistor (TFT) liquid-crystal display (LCD).

(5) Easier connectivity to host system, with Ethernet provided as

6 New industrial inkjet printer designed for greater reliability, simplicity, and environmentally conscious performance

a standard feature (on the UX-E and UX-D).
(Hitachi Industrial Equipment Systems Co., Ltd.)

* When comparing the UX-E to the previous Hitachi model (based on Hitachi's measurements at 20°C using 1067K ink).

7 Variable-speed Oil-free Scroll Compressor with Inverter Control (3.7/5.5 kW)

Hitachi has developed a variable-speed oil-free scroll compressor with inverter control (3.7 and 5.5 kW) to improve the energy efficiency of these machines, which are characterized by being clean and quiet.

The main features are as follows.

(1) Unwanted pressure rises are minimized by varying the electric motor speed in accordance with how much air is being used to maintain constant pressure. This reduces power consumption by approximately 10% compared to previous oil-free scroll compressors controlled by a pressure switch*.

(2) Can supply approximately 15% more air than conventional models* using pressure quantity (PQ) wide mode, which can increase the amount of air being supplied in accordance with the operating pressure.

(3) Due to lower load during compressor operation, the maintenance cycle has been lengthened* from the four years (10,000 hours) of conventional models to five years (12,500 hours).

(4) A single model covers two different pressures (0.8 MPa or 1.0 MPa) and can operate at different mains voltage frequencies (50 Hz or 60 Hz), each of which required separate conventional models.

(Hitachi Industrial Equipment Systems Co., Ltd.)

* For a pressure setting of 0.65 MPa.

7 New V-type oil-free scroll compressor (5.5 kW-output)

8 New amorphous transformer series ultra-efficient transformer

8 Advances in New Amorphous Transformer Series

Growing demand is anticipated for the replacement of buildings constructed during Japan's economic bubble in the 1980s and, prompted by the recovery in capital investment, companies' aging electric power distribution equipment. In many cases, these replacements require transformers that are as small or smaller and as light or lighter than those they are replacing.

Hitachi has launched its new series of amorphous transformers to coincide with the April 2014 transition to level 2 standards of Japan's Top Runner Program* in which achieving 115% or more of the standard is rated as ultra efficient. The latest enhancements are intended to improve suitability for the replacement market by making the transformers smaller (installation footprint reduced by up to 21%) and lighter (reduced by up to 11%), while still maintaining the same energy efficiency performance as the new series, which feature significantly lower losses. A three-phase 500-kVA transformer, for example, has the same installation footprint as a transformer from 30 years ago but 53% lower losses.

In addition to energy efficiency, Hitachi intends in the future to make new amorphous transformer series more compliant with societal requirements.

(Hitachi Industrial Equipment Systems Co., Ltd.)

* Level 2 criteria for transformers designated as special equipment under the Act on the Rational Use of Energy.

9 New V-type Hoist

The performance of overhead and other cranes is maintained by performing periodic inspections and replacing parts that have reached the end of their lifetimes. As the electrical hoists widely used in overhead cranes need to be inspected and maintained, their maintenance requirements include being easier to inspect and having fewer and lighter spare parts. Hitachi has developed an electrical hoist that is easier to maintain thanks to features that include sharing parts wherever possible in the reduction gear,

9 New V-type hoist

which is rated for loads up to 3 t.

The main features are as follows.

(1) Sharing of reduction gear parts between the 2-t and 3-t models reduces the number of spare parts from 56 to 36 (a 36% reduction).

(2) The speed of the 3-t model has been increased from 0.125 m/s to 0.14 m/s (at 50 Hz) by increasing its motor output.

(3) The operator can press emergency stop in the event of a problem using the on/off button provided as a standard feature.

(Hitachi Industrial Equipment Systems Co., Ltd.)

10 Use of Hitachi Positioning System for Materials Handling

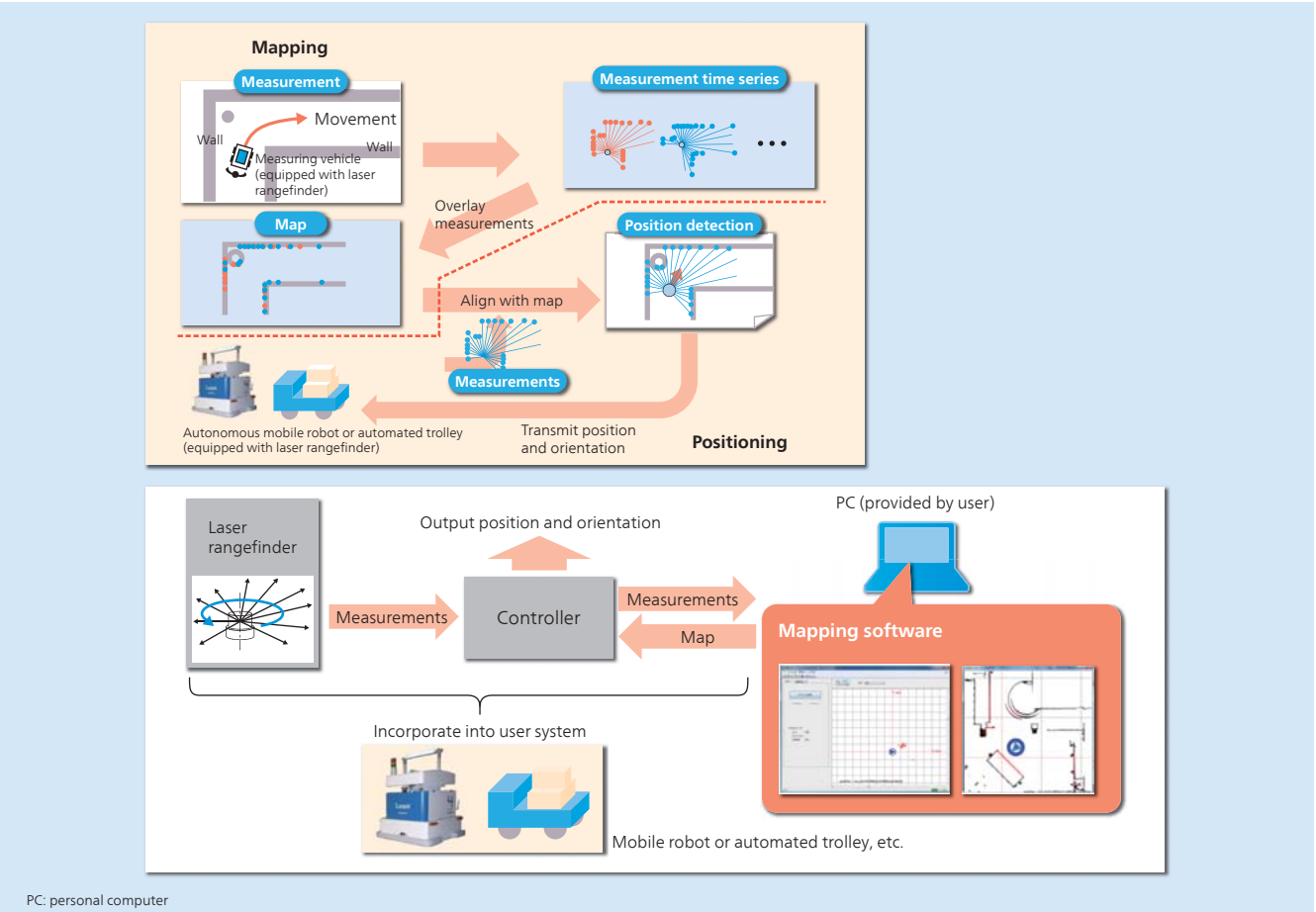
Services and other solutions that utilize positioning information have attracted attention in recent years. Recognizing this, Hitachi developed and commercialized Hitachi positioning system, which uses laser rangefinders to perform positioning.

Hitachi positioning system uses a proprietary algorithm to generate position information at 25-ms intervals with an accuracy of ±50 mm and an orientation accuracy of ±3°. Because Hitachi positioning system does not require any sensors other than its laser rangefinders, when used to control the movement of a vehicle, for example, it can provide reliable positioning regardless of the vehicle's design and characteristics.

Hitachi has also developed an automated materials handling system that includes autonomous mobile robots equipped with Hitachi positioning system. In recognition of this success, Hitachi positioning system won a FY2015 Technical Innovation Award from The Robotics Society of Japan.

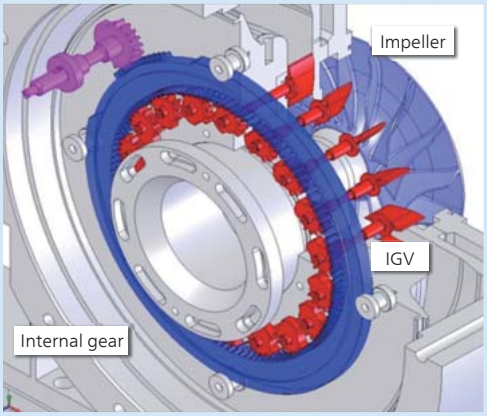
In the future, Hitachi aims to utilize Hitachi positioning system in the materials handling and service robot sectors (which are expected to grow), especially by incorporating functions that assist with specifying travel routes for use in the control of vehicles.

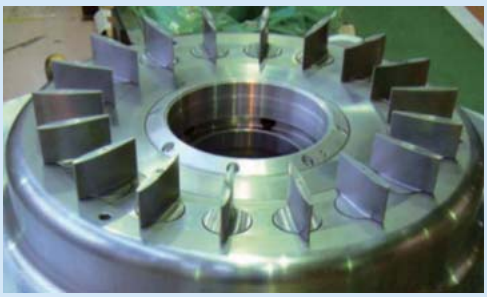
(Hitachi Industrial Equipment Systems Co., Ltd.)



PC: personal computer

10 How Hitachi positioning system performs mapping and positioning (top) and Hitachi positioning system block diagram (bottom)





11 Compressor with IGV for Rosneft (top) and IGV mechanism (center and bottom)

11 Completion of Centrifugal Compressors with IGV for Rosneft (Russian Government-owned Oil Company)

Hitachi has completed and delivered two compressors with inlet guide vanes (IGVs) ordered by Heurtey Petrochem for Rosneft, an oil company owned by the Government of Russia.

The main product features are as follows.

(1) The compressors are for installation at a hydrogen production plant that uses steam methane reforming (SMR). The main component of the process gas is methane. The compressors have a required capacity of 2,600 kW and operate at 10,879 min^{-1}.

(2) Although the two compressors have the same design and rated operating points, IGV angle control allows them to be routinely run at different operating points.

(3) The compressors have a single shaft with 10 impeller stages and use a rotor stabilization technique to ensure highly reliable rotor dynamics.

The second and third of these features ensure that the compressors provide excellent cost-performance and have a wide operating range, combining IGVs with a single-shaft/10-impeller-stage configuration.

12 First Installation of New High-speed, Single-stage Turbo-blower with Magnetic Bearings

In an example of a next-generation product that contributes to society by being environmentally clean and energy efficient, Hitachi has added a new high-speed, single-stage turbo-blower with magnetic bearings to its existing range.

Three units ordered for the final treatment plant of Iizuka City Water and Sewer Bureau in Fukuoka Prefecture in 2013 commenced operation in December 2014.

The main features are as follows.

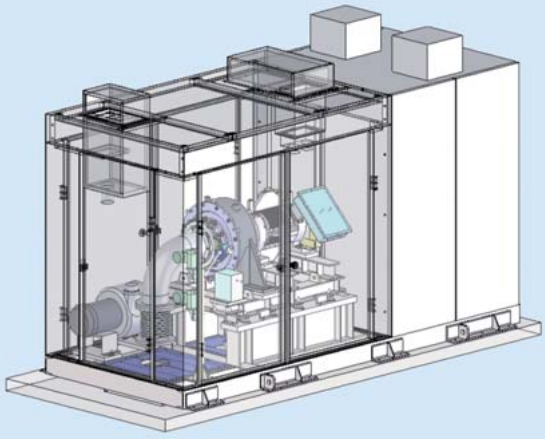
(1) Mechanical contact is eliminated by using bearings that work on the principle of magnetic levitation, whereby the rotor is supported by magnetic force.

(2) Use of the latest three-dimensional impeller allows the turbo-blower to be small and highly efficient with a wide operating range.

(3) Use of a floating shaft improves energy efficiency by minimizing mechanical losses.

(4) The oil-free design is environmentally clean and eliminates the need for a lubrication system.

(5) The integrated design combines the blower unit and electrical control unit (control panel), with a touch panel for operation and monitoring.



12 Design and photograph of high-speed, single-stage turbo-blowers with magnetic bearings

13 Energy-saving Solution Using Oil-free Screw Compressor with Waste Heat Recovery Heat Exchanger

Recent years have seen growing interest in reducing carbon dioxide (CO_2) emissions and saving energy, with various proposals and developments relating to the air compressors that are used as a power source at factories. Hitachi has recently devised a waste heat recovery solution and undertaken the system design to build an oil-free screw compressor with a waste heat recovery heat exchanger.

The waste heat recovery technique used on the compressor involves using a heat exchanger to recover the heat generated when compressing air so that it can be used for purposes such as preheating the water supplied to a boiler or as a heat source for air conditioning (water at 35°C or higher can be used for hot water recovery at 45 to 80°C, for example).

The main features are as follows.

(1) The proposed energy efficiency solution comprises a complete system (450-kW and 400-kW units in this case).

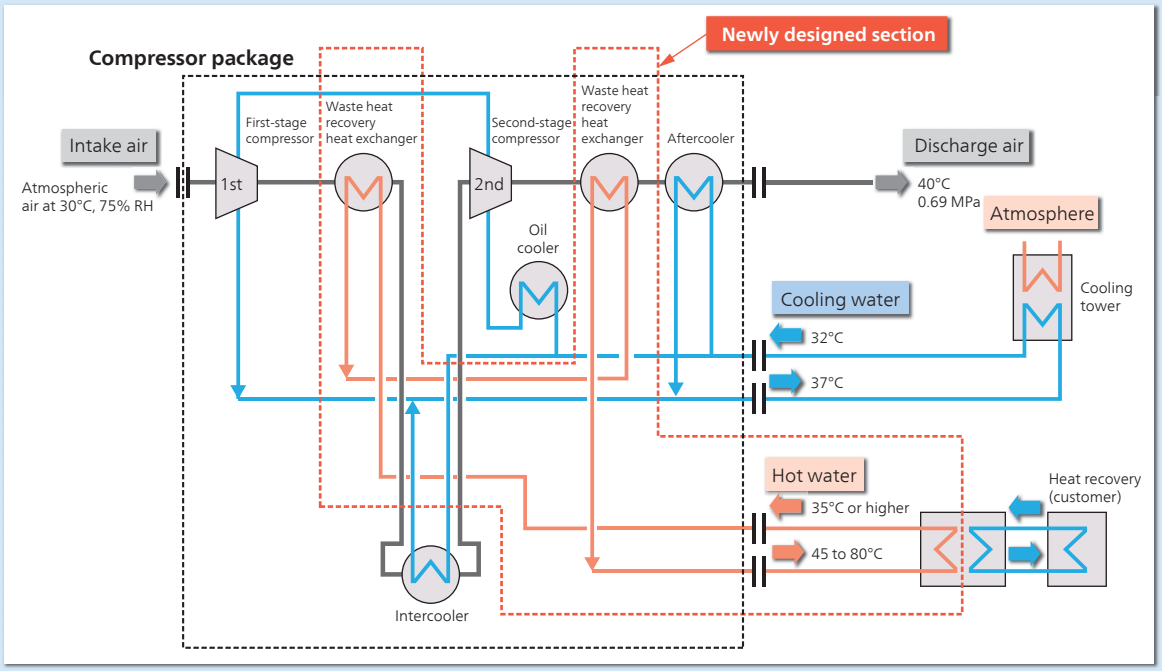
(2) An oil-free screw compressor was developed that incorporates two heat exchangers for better waste heat recovery.

(3) It has the same dimensions as the existing model (SDS-U series oil-free screw compressor).

In anticipation of rising demand for reducing CO_2 emissions and saving energy, Hitachi intends to expand its product range and offer refurbishment of existing units.

14 One-stop Maintenance Enhancement Service for Drastically Reducing Risk of Equipment Outages

In recent years, factors such as difficulties in staff recruitment due to the falling working population and improvements to service



RH: relative humidity

13 Flow diagram when using the waste heat recovery heat exchanger and photograph of SDS-U series oil-free screw compressor

quality, including offering same-day delivery, mean that outages on materials handling equipment used to automate delivery services can have a major impact on customer operations. Recognizing this situation, Hitachi operates a one-stop maintenance service incorporating the following maintenance enhancement services with the aim of drastically reducing the risk of equipment outages.

(1) Engineering service for maintenance planning based on risk assessment

Based on a risk assessment for each equipment component, this service formulates long-term maintenance plans and periodic inspection plans that take account of cost optimization.

(2) One-stop enhancement service that coordinates maintenance with equipment vendors

This service achieves faster problem recovery by working with materials handling equipment vendors, not only on Hitachi products, but also on responding to problems across the entire materials handling system.

(3) Prompt onsite arrival service that draws on Hitachi's extensive network of operations

Shorter onsite arrival times are achieved through 24 hours a day, 7 days a week maintenance service network operated from approximately 300 sites around Japan.

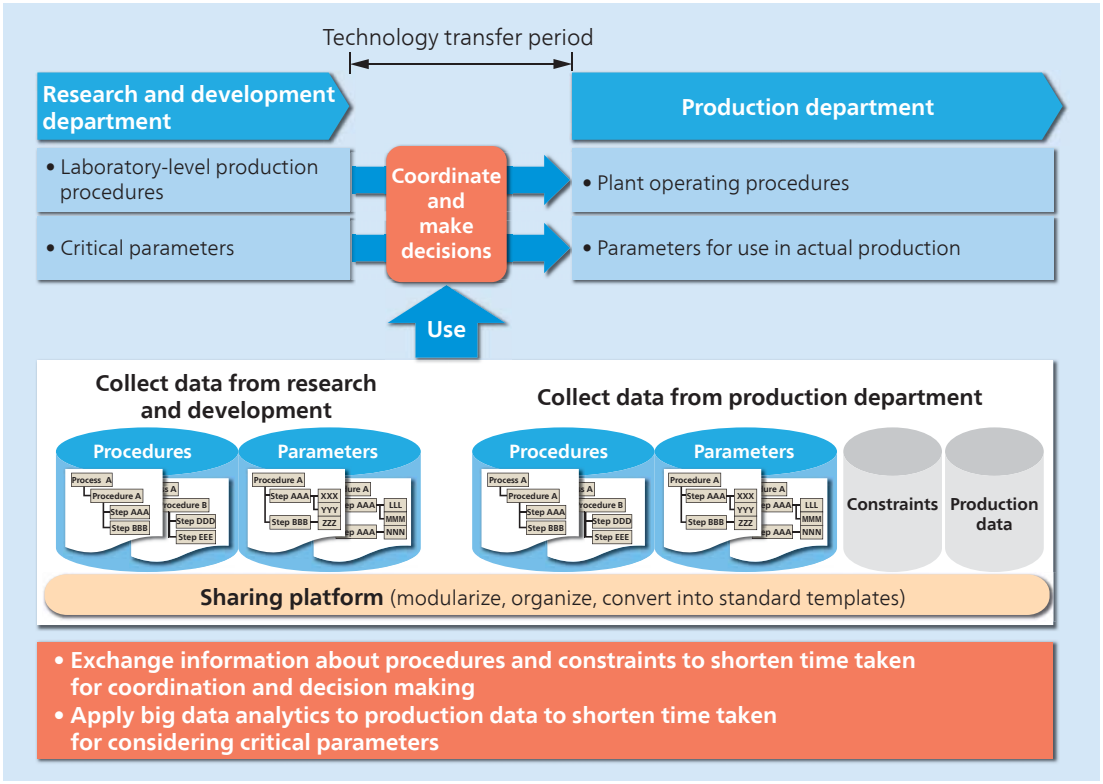
In addition to these services helping customers maintain more reliable equipment operation, Hitachi also intends to enhance maintenance services further using advanced information technology (IT) such as big data analytics.

15 Solutions and Services for Faster Market Entry by Manufacturers

In process manufacturing, technology transfer (the handing over of production practices) from research and development to the departments responsible for actual production is one of the challenges to speeding up the bringing to market of new technology and new product developments. At pharmaceutical companies, for example, two stages of technology transfer are required, one for the transition from research and development to production for clinical trials, and another to commercial production. Speeding up this process is a source of competitive advantage. The underlying cause of the challenges of technology transfer lies in the coordination required between the provider and recipient of the technology, with the former holding information about production practices and the latter being subject to equipment-based constraints. In response, Hitachi provides solutions and services to standardize ways of expressing production practices developed by the research and development department by breaking them down into procedures and parameters and then organizing them as more structured production practices. It is also able to shorten the time for technology transfer using the same platform for sharing and investigation by organizing the constraints associated with the equipment used by the manufacturing department in a similar manner.

Furthermore, by applying big data analytics to collected production data to determine critical parameters, Hitachi further reduces the time taken for technology transfer by making faster decisions about the choice of parameters.

The actual implementation involves incorporating this function into a manufacturing execution system (MES) that is one of the most widely used in the pharmaceutical industry in Japan. Starting in the pharmaceutical industry, Hitachi intends to contribute to the progress of manufacturing around the world by extending its use to other manufacturers who need to perform similar technology transfers.



15 Solution for achieving faster market entry

Plant and Factory Equipment

Parameter	Specification					
Circuit type	Two-level inverter					
Motor type	Three-terminal				Six-terminal	
Number of converter panels	1				1 × 2 banks	
Number of cell unit rows	1	2	3	4	3 × 2	4 × 2
Rated output (kVA)	1,040	1,840	2,740	3,630	5,480	7,260
Rated output voltage (Vrms)	1,155					
Cooling system	Air cooled					
Overload specification	150% for 1 minute					
Conversion efficiency	98% or higher (converter + inverter)					

1 Photograph and specifications of medium-capacity IGBT inverter (third generation)

1 Medium-capacity IGBT Inverter (Third Generation)

Hitachi has been involved in new installations and replacement projects for medium-capacity insulated-gate bipolar transistor (IGBT) inverter drives in Japan and elsewhere for roughly 20 years since releasing its first generation in 1996, with the second generation following in 2003. Hitachi has now gone on to develop a third generation with a new design intended to satisfy more global user requirements. The new generation has been fully revised, including different device dimensions and range of capacities.

The main product features are as follows.

(1) 3.3-kV/1.5-kA (3.0-kAp) IGBT devices (global standard) are used to ensure long-term product availability and larger output capacity*.

(2) Smaller size achieved by simplifying the circuit design (the panel width dimension is 60% narrower than the equivalent previous 2,750-kVA model).

(3) To provide the best drive system to suit user needs, a series of different capacities are available by connecting the drive circuits in parallel.

(Commencement of production: October 2015)

* Maximum capacity is 3,630 kVA (or 7,260 kVA in a two-bank configuration).

2 Commissioning of Cold Rolling Mill Using New Controller

Hitachi has been commissioning a number of plants that use its new controller, including both new and retrofit projects.

In South Korea, a continuous pickling line and tandem cold mill (PL-TCM) supplied to Hyundai Steel Company commenced production in May 2015 and has been operating reliably. This was the first plant where Hitachi replaced existing controllers with the new model. The electrical equipment upgrade provides higher reliability and improves maintenance, including through the introduction of sophisticated analytical tools.

The new controller features a more efficient implementation, faster processing, and higher reliability. Thanks to the experience and know-how that Hitachi has built up in the replacement of electrical equipment, commissioning of the upgrade was completed in just one month.

Hitachi expects to install more of the controllers in the future in response to rising demand from both new and retrofit projects. To achieve this, Hitachi aims to make progress on further standardizing on-site commissioning to achieve a faster plant startup and supply more valuable systems.

2 Cold rolling mill at Hyundai Steel Company in South Korea

3 Delivery-side operator's desk at No. 2 CAL of CSC in Taiwan

3 Projects to Replace Electrical Equipment from Other Vendors at Processing Lines Outside of Japan, and Commencement of Commercial Operation

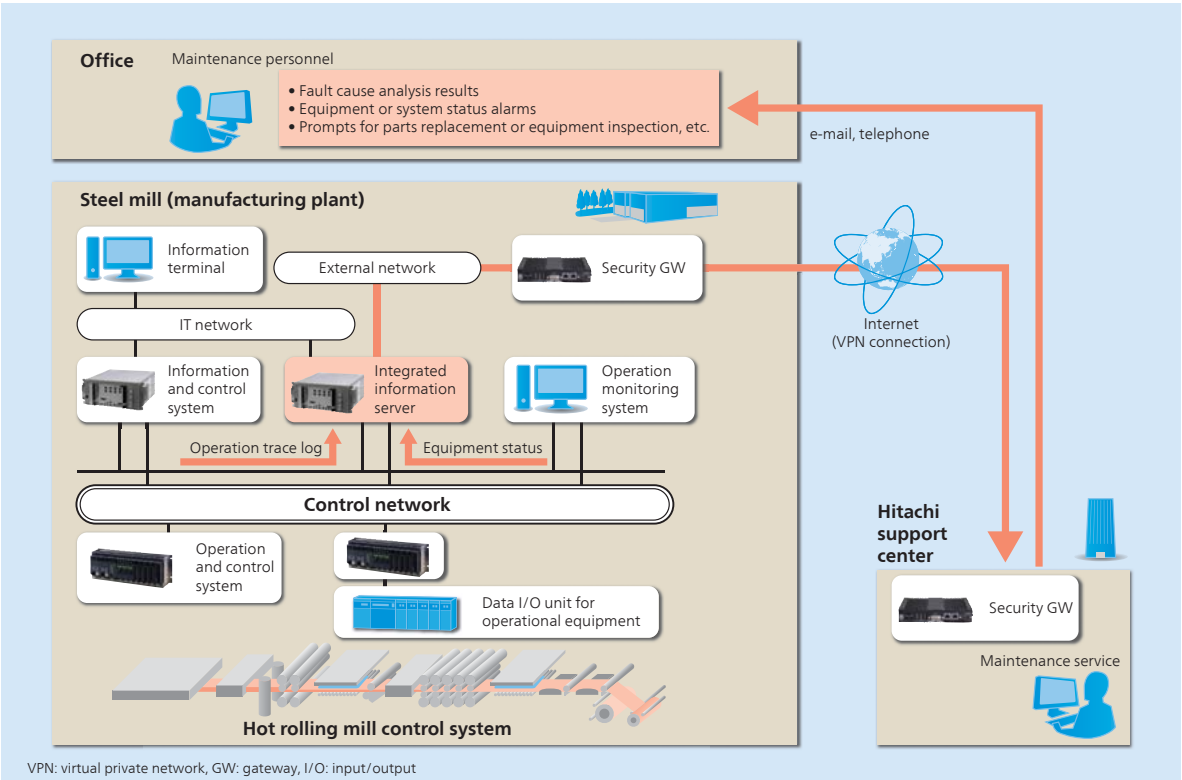
Hitachi received an order to replace electrical equipment from other vendors at the No. 2 continuous annealing line (CAL) at China Steel Corporation (CSC) in Taiwan and the No. 2 continuous galvanizing line (CGL) at Tata Steel Limited in India. The on-site work and commissioning were completed on schedule and the plants are operating reliably.

The CSC project involved replacing the line motors, line drives, programmable logic controllers (PLCs), process input/output (PIO), and writing new software to work with the existing equipment. Thanks to Hitachi's extensive technologies and project management capabilities, the on-site work and commissioning were completed within the schedule proposed by the beneficial existing equipment supplier. This was a major result in the context of future growth in orders for the replacement of electrical equipment from other vendors. The project also included the use of line drives from Hitachi Hi-Rel Power Electronics Pvt. Ltd. in India, thereby providing an opportunity to establish a reference site at a large plant outside of India. The Tata Steel order was a locally supplied project handled by Hitachi India Pvt. Ltd., with design, manufacturing, and a short on-site commissioning being undertaken by local staff with technical guidance from Hitachi. The plant commenced operation without any major problems, making it an auspicious start to the expansion of business in India.

In the future, Hitachi intends to work toward increasing orders for processing lines by strengthening collaboration with subsidiaries in India and China so that it can have an active involvement in similar projects.

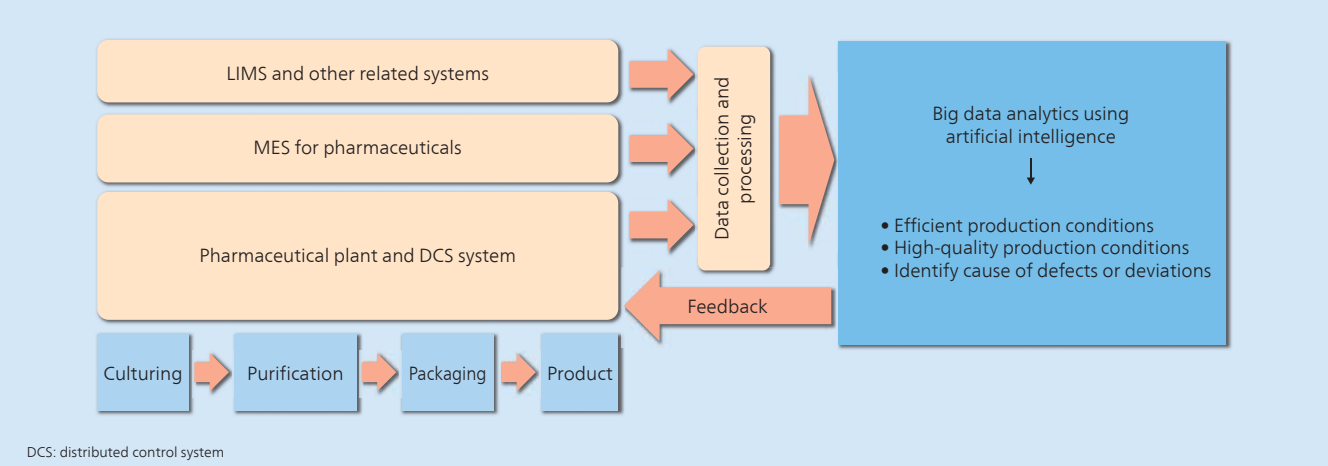
4 Integrated Information Platform for Advanced Maintenance Services at Steel Hot Rolling Mill in India

Advances in steel industry control systems mean that maintenance staff require ever-higher levels of knowledge and skills year-on-year, with suppliers being expected to provide more advanced maintenance support to ensure reliable system operation. Hitachi has developed an integrated information platform that is intended to provide rapid identification and resolution of fault causes and better preventive maintenance for a system supplied to a steel hot rolling mill in India. The platform enables centralized management of the status of system equipment (whether or not equipment is operating or has a fault), operation trace logs [including for the central processing unit (CPU) and communications], alarms, event logging, and other information. This can reduce downtime by utilizing multiple data sources to perform cause analysis before equipment faults occur, and warn of situations with the potential to result in system faults. It also supports remote maintenance to



VPN: virtual private network, GW: gateway, I/O: input/output

4 System block diagram of remote maintenance support service



DCS: distributed control system

5 Overview of big data analytics solution

provide high-quality maintenance support to customers or global plants with limited maintenance personnel.

In the future, Hitachi intends to expand the scope of information managed by the integrated information platform to include things like sensor and control data, and to link it to external analysis systems to provide advanced maintenance services that use big data (such as predictive diagnostics or advanced analytics).

5 Big Data Analytics Solution for Pharmaceutical Plants

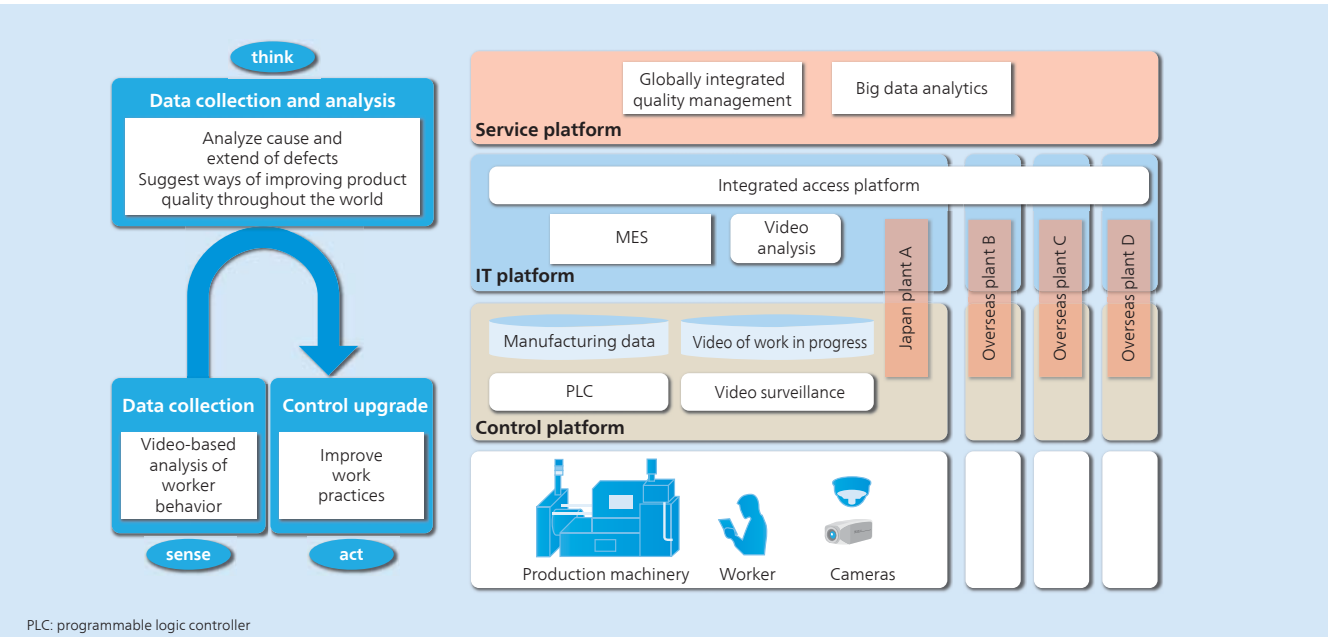
Hitachi has contributed to improving production efficiency and introducing stricter manufacturing and quality management processes for pharmaceutical companies by promoting the use of information technology (IT) such as plant automation, manufacturing execution systems (MES), and laboratory information management systems (LIMS).

In recent years, based on new technology factors such as big data analytics, the demand for using information collected by these IT systems is increasing. Hitachi is seeking to achieve high quality and highly reliable manufacturing through the analysis of data from both equipment on the pharmaceutical shop floor and from MES/LIMS, to identify new correlations between process data and data such as volume and quality of finished goods especially for the growing biopharmaceutical industry.

The strength of Hitachi is that it can deliver total solutions ranging from plant design and plant construction, to computer systems such as LIMS and the Hitachi pharmaceutical manufacturing execution system, which has the top market share in Japan. Based on current solutions that collect and process manufacturing data, Hitachi is striving to provide new solutions that combine existing data with big data analytics using Hitachi artificial intelligence technology.

6 Next-generation Global Manufacturing Management Using Sensing Technology and Practical Know-how

Hitachi has utilized its sensing technology and practical manufacturing know-how to develop a next-generation manufacturing management system. It is possible to use images to track manufac-



PLC: programmable logic controller

6 Improvements to product quality throughout the world using next-generation manufacturing management system

turing performance in terms of people, machines, and material by installing cameras of various different types (fixed, omnidirectional, distance image, and so on) at an assembly plant and collecting images of the plant and linking them to an MES that contains accumulated practical know-how. This prevents large-scale recalls by facilitating analysis of the extent of the problem when a defect occurs.

Hitachi is currently working to implement functions that use realtime analysis of images to prevent defects from proceeding to downstream processes by detecting changes that influence quality before starting the next cycle, such as the behavior of workers who deviate from standard practices (people), supervision by supervisors (people), abnormal operation by equipment (machines), and component supply (material).

Hitachi is also making improvements to product quality globally by integrating information (processing data, work video, and so on) from plants located around the world and using big data analytics to analyze the causes when a defect occurs or to suggest improvements and provide feedback to the plant.

7 Completion of All-weather Environmental Test Facility for Obayashi Corporation

Hitachi Plant Mechanics, Co., Ltd. completed an all-weather environmental test facility for Technical Research Institute, Obayashi Corporation in June 2014. This facility is composed of twin high/low temperature test rooms.

7 Test room when the solar simulator lights are on (top) and test room after continuous operation of the snow simulator (bottom)

These test rooms are able to simulate all kinds of global climate conditions aimed at conducting several seasoning tests for environmental materials, to be combined with several environmental parameters such as temperature, relative humidity, rainfall, snowfall, wind force, and sun-light intensity, respectively.

These twin rooms are compatible for concurrent testing of architectural materials under indoor and outdoor conditions simultaneously, by removing internal wall in between the test rooms, and setting different climate conditions for each room independently.
(Hitachi Plant Mechanics Co., Ltd.)

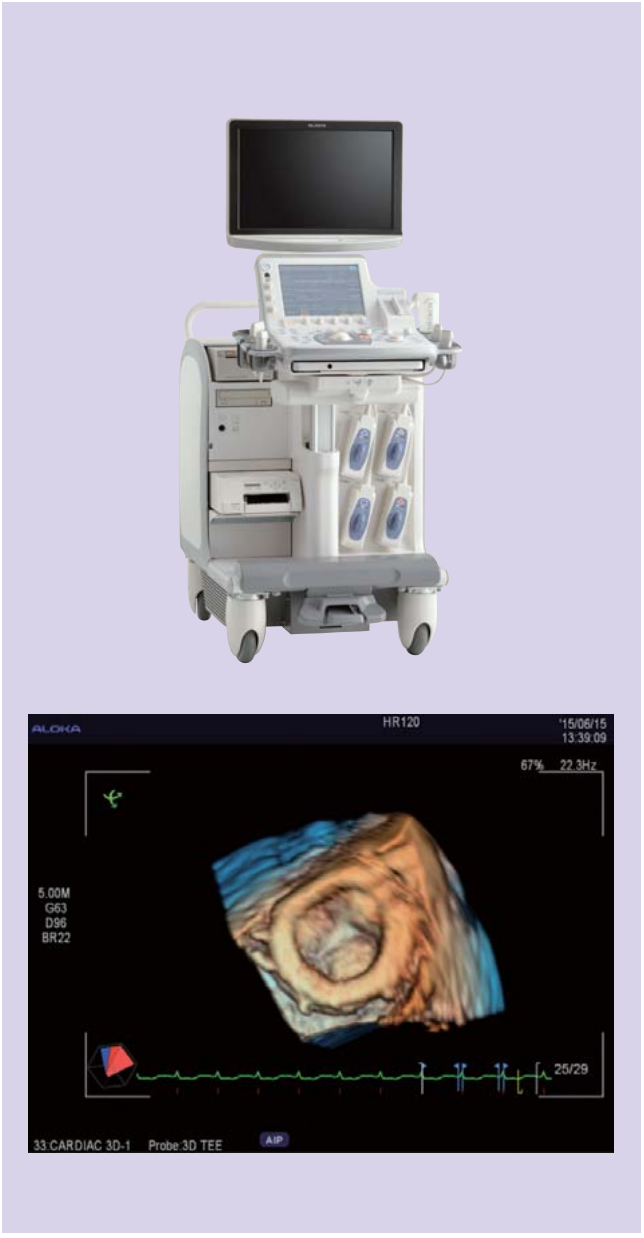
8 Factory-assembled Contaminated-wastewater Storage Tanks

The first shipment of contaminated-wastewater storage tanks for Fukushima Daiichi Nuclear Power Station started on November 24, 2014, which had been ordered by Tokyo Electric Power Co., Inc. via Hitachi-GE Nuclear Energy, Ltd.

These tanks are categorized as middle- and low-level contaminated water storage tanks among the purification facilities at the Fukushima site. These tanks are known as some of the biggest factory-assembled tanks, and are cylindrical in shape (approximately 12.5 m in height, 12 m in diameter), with a capacity of approximately 1,220 m^3, dry weight of approximately 90 t, and are made of SM400C carbon steel similar to ASTM A283. The inside and outside surfaces are painted. Hitachi Plant Mechanics, Co., Ltd. and its cooperating manufacturers have produced the tanks within a short delivery time using their advanced welding and fabricating techniques, covering the required earthquake and pressure resistance. Fabrication has been ongoing since August 2015 for the next delivery, and marine and land shipments are being processed for subsequent installation at the Fukushima site.
(Hitachi Plant Mechanics Co., Ltd.)

8 Tanks that were shipped in November 2014

Medical Equipment and Systems



1 Diagnostic ultrasound system (top) and clinical example of artificial valve (bottom)

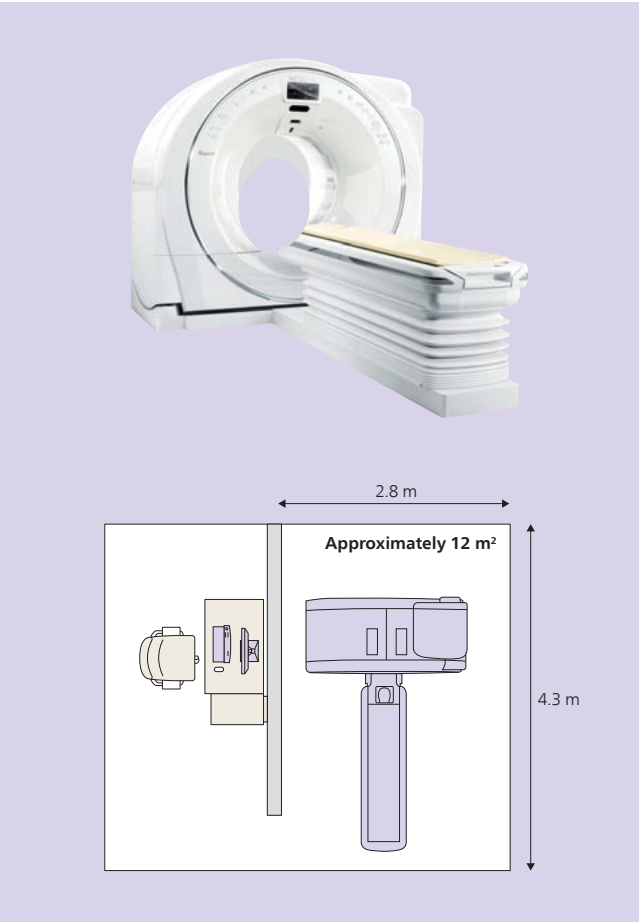
1 Product Development Targeting Circulatory Organs —Diagnostic Ultrasound System and 3D Transesophageal Probe—

The aging of Japan's population has led to rising rates of circulatory organ disease in recent years. In the circulatory disease market, use of three-dimensional (3D) transesophageal probes has been increasing year after year as a way of improving communication between surgeons and physicians before and after surgery. The first such device from a Japanese supplier* designed to be used with a 3D transesophageal probe, a diagnostic ultrasound system, was developed to provide ease-of-use that will enable routine examinations to be performed efficiently, with high quality imaging and an extensive range of functions to suit different circumstances. Along with the light weight of the probe operation unit, even when performing 3D echoes, and the high-quality images and 3D rendering achieved by processing data from a matrix array 3D probe at high speed, it is also capable of a higher level of assessment, with a variety of functions provided for this purpose, such as Active 3D mode for evaluating a particular area of concern.

It helps with early detection and treatment of arteriosclerosis by performing accurate three-dimensional imaging of heart structures, using cardiac function analysis software to assess heart muscle movement, and using the unique functions of the circulatory system to identify changes in blood vessels. It is also suitable for use in a wide variety of examinations, with flexible portability made possible by its natural ergonomics that reduce operator fatigue.

(Hitachi Aloka Medical, Ltd.)

* As of September 2015, based on research by Hitachi Aloka Medical, Ltd.



2 Supria 64-slice CT scanner (top) and example layout (bottom)

2 New Concept 64-slice CT Scanner Supria 64

Most of the computed tomography (CT) scanners currently being installed in regional hospitals are models that capture fewer than 64 slices. The installation of 64-slice or larger models involves a large upfront cost and requires changes to management policies because of strict equipment requirements that include installation space, power supply, and infrastructure, and cost constraints that include running costs that must be funded directly by the hospital. In response, Hitachi has developed the Supria 64, a new concept in 64-slice CT scanners that provides a compact design and high cost-performance along with high speed, a wide field of view, and image quality.

The Supria 64 has a large 75-cm bore that makes things easier for the elderly or patients with severe curvature of the spine and a compact scanner gantry that has been miniaturized to less than 2 m wide and 1.85 m high. The system is made up of three units*, one less than previous 64-slice scanners, to make the best use of available space in even very confined CT rooms. When used in tandem with a standard bed, the system is capable of being installed in a CT room as small as 12 m^2 (approximate area), equivalent to the requirements of a conventional single-slice CT scanner.

(Hitachi Medical Corporation)

* In case the power supply voltage is 200 V.

3 Compact open MRI (top) and example scanner room layout (bottom)

3 Compact Open MRI

The new compact open magnetic resonance imaging (MRI) model features the latest system equipped with a variety of imaging techniques that expand the scope of examination and diagnosis, while still incorporating the same transverse table configuration for ease of operation and use of minimal design to facilitate installation that were features of the previous models.

Positioning the patient in an MRI system is important when imaging shoulders, knees, or other off-center parts of the body in order to perform the scan in the center of the magnetic field where the best image quality is achieved. Unlike many other MRI systems, the table on the compact open MRI model has a transverse configuration as well as a floating mechanism for adjusting the location of the table in the gantry (forward or backward, left or right) that enables centering of the patient when scanning off-center parts of the body.

Compared to MRI systems with a superconductor, the extent of magnetic field leakage from a permanent magnet MRI system is smaller. It also takes up less space because it does not require auxiliary equipment such as routine cooling. This makes it a good choice for replacement installations when it is not practical to enlarge the scanner room or there is a desire to minimize the cost of additional equipment.

Hitachi intends to continue developing distinctive permanent magnet MRI systems using proprietary technology.

(Hitachi Medical Corporation)

4 Optical Topography System

Optical topography systems use near-infrared light to measure the relative concentration of hemoglobin in blood flow through the brain and changes in this concentration. In addition to optical topography, another technique for imaging brain activity from changes in blood flow is functional magnetic resonance imaging (fMRI). However, because fMRI uses an MRI system, scanning takes a long time and can only be performed within the space of the scanner aperture. Optical topography systems, on the other hand, work by attaching near-infrared sensors to the patient's head. This means that scanning can be performed with the patient in a seated position, and it is possible to conduct scans that involve a considerable amount of movement or a patient who is uncomfortable in confined spaces.

Hitachi Medical Corporation first commenced sale of optical topography systems in Japan in April 1998, and the systems are used at numerous overseas institutions in more than 10 different countries, including in North America, Europe, and Asia. The systems are also used in medical practice, and the procedure is approved for health insurance purposes for use in neurosurgery and mental health.

In October 2015, Hitachi commenced sale in Japan of the new ETG-4100 model that incorporates functions that support clinical research as well as improved ease of use in clinical settings in anticipation of the wider medical use of optical topography

4 ETG-4100 optical topography system

scanning.
(Hitachi Medical Corporation)

5 Glycohemoglobin Analyzer cobas c 513

Glycohemoglobin analyzers are used to measure hemoglobin A1c (HbA1c), an indicator of diabetes. HbA1c is glycated hemoglobin (glucose molecules attached to hemoglobin) in the blood and is used for the diagnosis and monitoring of diabetes in terms of the average blood sugar level over a period of one to two months.

The cobas*1 c 513 analyzer improves testing productivity and safety by providing high-speed measurement, automated sample preparation, and a low risk of infection. It was developed in response to the rising demand in recent years for HbA1c testing. The primary market is testing centers or large hospitals in Europe that have a large number of samples to be tested. The cobas c 513 is the fastest special-purpose analyzer in the world*2 to be purpose-designed for HbA1c testing.

The main features are as follows.

(1) High-speed measurement (500 tests/hour, world's fastest*2)

(2) Uses closed-tube sampling (CTS) in which a special probe is inserted into the sealed sample tube to dispense the test samples. By eliminating any need for the operator conducting the analysis to open samples, this minimizes the risk of droplet infection.

(3) Reporting of the HbA1c value complies with international standards specified by the National Glycohemoglobin Standardization Program (NGSP) and International Federation of Clinical Chemistry and Laboratory Medicine (IFCC).

In the future, Hitachi intends to expand sales throughout the world and provide connectivity to sample testing automation systems.

(Hitachi High-Technologies Corporation)
(Product release date: October 2015)

*1 See "Trademarks" on page 140.
*2 For glycohemoglobin analyzers with a CTS function. As of September 2015, based on research by Hitachi High-Technologies Corporation.

5 cobas c 513 glycohemoglobin analyzer

Measurement/Analysis Equipment

1 NX2000 FIB-SEM and FIB-SEM-Ar Triple Beam System

1 FIB-SEM and FIB-SEM-Ar Triple Beam System NX2000

Focused ion beam scanning electron microscope (FIB-SEM) is used for cross-sectional analysis and transmission electron microscope (TEM) sample preparation in various fields such as electronics, nanotechnology, materials, and life sciences. Especially in the analysis of latest shrinking devices and advanced nanomaterials, where uniformly thin high quality TEM samples are required for the analysis of fine structures and the characterization of composition or defects, FIB-SEM plays an important role.

The new NX2000 is designed for the preparation of high-quality TEM sample, combining high-performance FIB optics and high-resolution SEM optics with a micro-sampling system and argon (Ar) beam optics. It features significant improvements to analysis throughput, including site-specific sample preparation and FIB-induced damage reduction, which traditionally required a substantial amount of skill.

NX2000 enables high quality sample preparation without high skill requirements to contribute to the development of the latest devices and advanced nanomaterials.

(Hitachi High-Technologies Corporation)

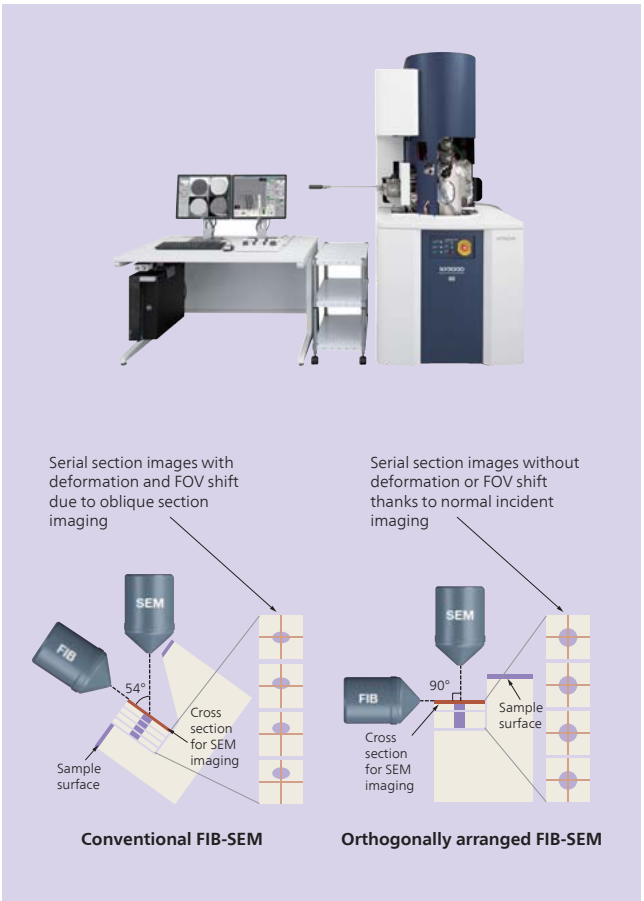
2 Realtime 3D Analytical FIB-SEM NX9000

The evaluation of advanced materials and devices requires the analysis of internal structure as well as SEM observations of surface topography. In recent years, the use of FIB-SEM for three-dimensional (3D) structural analysis has attracted increasing attention. FIB cross-sectioning and cross-sectional SEM imaging are automatically repeated to collect serial section images. Collected images can be reconstructed to analyze the 3D structure of the region of interest.

The newly developed NX9000 realtime 3D analytical FIB-SEM employs a column layout optimized for 3D structural analysis. SEM columns and FIB columns are orthogonally arranged to eliminate aspect deformation, foreshortening of cross sectional images, and shifting of field of view (FOV) during serial section imaging, which cannot be avoided by conventional FIB-SEM, to realize high-fidelity imaging. Also, the combination of precise FIB and a highly stable, high precision sample stage allows highly reproducible serial sectioning even with very small cutting interval. Together with energy dispersive spectrometry (EDS) and electron backscatter diffraction (EBSD), a 3D distribution of elemental composition and crystal orientation can be analyzed.

NX9000 enables high-precision 3D structural analysis, which is difficult with conventional systems, for a wide range of areas relating to advanced materials, electronic devices, biological tissues, and a multitude of other applications to contribute to the development of novel materials and new devices and the elucidation of vital functions.

(Hitachi High-Technologies Corporation)



2 NX9000 realtime 3D analytical FIB-SEM (top) and comparison of conventional FIB-SEM and orthogonally arranged FIB-SEM (bottom)

3 FT-150 series fluorescent X-ray coating thickness gauge

3 Fluorescent X-ray Coating Thickness Gauge

Hitachi has commenced sales of the FT150 series fluorescent X-ray coating thickness gauge for the advanced measurement of plating thicknesses on the very small electronic components used in smartphones and other mobile devices.

The target application for the FT150 is the measurement of plating of 10 nm or less that cover an area of less than 50-µm square. To achieve this, Hitachi has succeeded in doubling the detection sensitivity for fluorescent X-rays from the specimen compared to the previous model, while retaining the same 30-µm irradiation spot size.

The system is designed for routine use at production facilities, including both its software and hardware, with consideration given in all areas to ensure easy operation at every step, from inserting the specimen to positioning it for measurement, performing the measurement, and processing the results.

Hitachi intends to proceed with development along the two axes of technology and design. On one axis, it will proceed with development of technologies for advanced measurement. On the other axis, it will forge ahead in creating easy-to-use product designs that take account of customer feedback. Through this dual-axis approach, Hitachi will supply leading-edge coating thickness gauges for the cutting edge of plating technology.
(Hitachi High-Tech Science Corporation)

4 Coherence Scanning Interferometer VS1000 Series

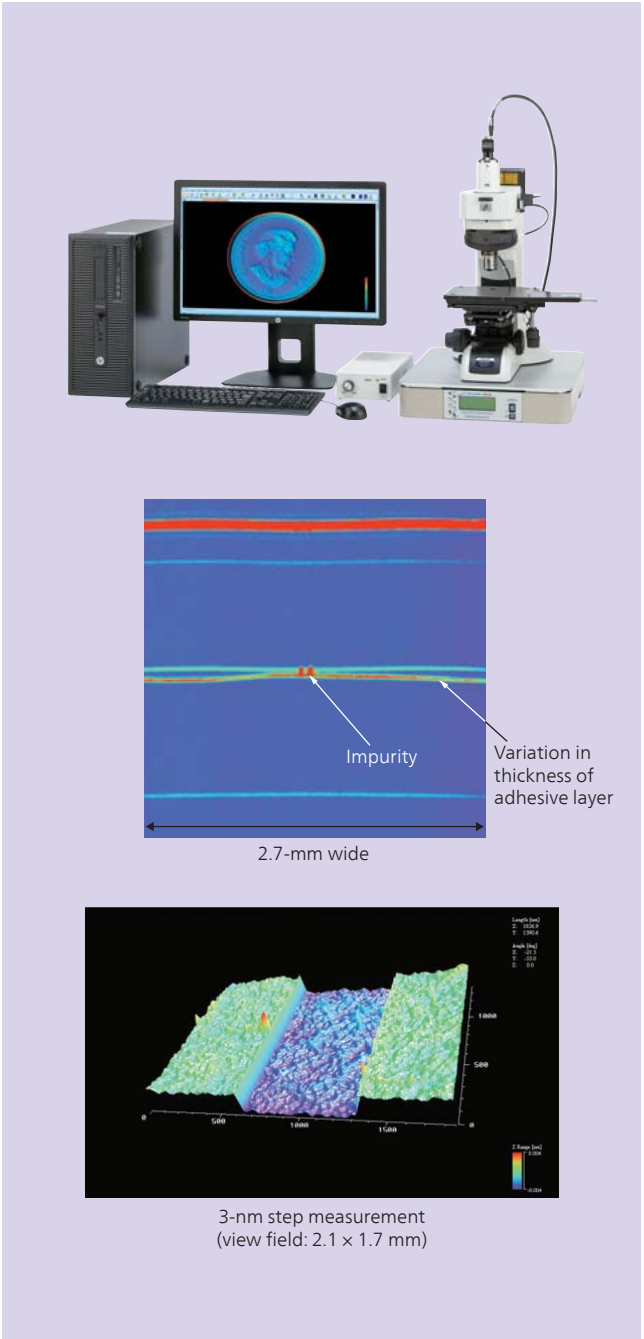
In the development, manufacture, and quality assurance of electronic components, advanced materials, precision-machined parts, and so on, there has been demand in recent years for measurement of micro roughness or features with sizes in the range of several nanometers to several tens of nanometers.

The newly introduced VS1000 series coherence scanning interferometer is a surface inspection instrument for the three-dimensional non-contact and non-destructive measurement of micro roughness, features, and film thicknesses.

The main features are as follows.
(1) Non-contact three-dimensional (surface and height) measurement of micro roughness and other features in a short amount of time (from several seconds to around 10 seconds) and 0.01-nm vertical resolution (Sq resolution) using optical interference measurement that combines a wide measurement field and high Z-axis resolution.
(2) It supports the extension of evaluation procedures from lines to surfaces by providing surface roughness measurements that comply with the ISO 25178 standard for surface texture.
(3) It identifies things like impurities or peeling at the boundaries between layers by measuring the thickness of transparent multi-layer films.

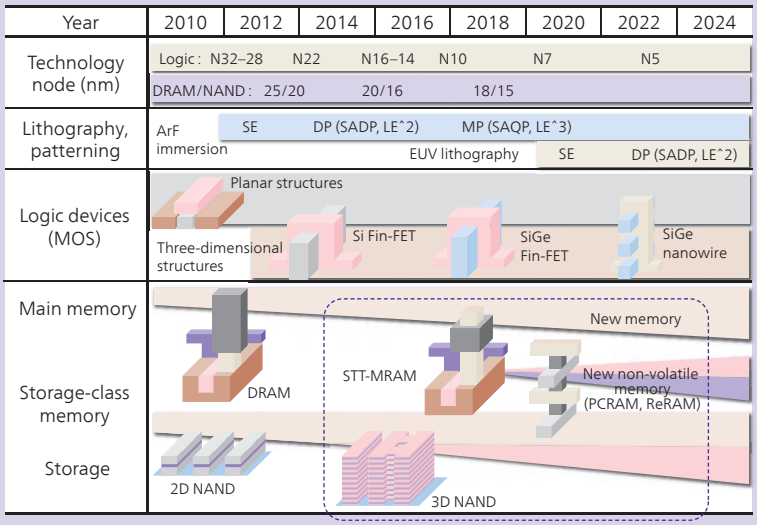
By adding this new coherence scanning interferometer to the other surface inspection instruments marketed by Hitachi High-Tech Science Corporation [scanning probe microscopes (SPMs) and SEMs], Hitachi intends to continue supplying surface inspection solutions that take advantage of synergies.
(Hitachi High-Tech Science Corporation)

* VS1000 series is only sold in Japan.



4 VS1000 series coherence scanning interferometer (compact model) (top), cross-sectional analysis of polarizing film (center), and measurement image of 3-nm step (bottom)

Semiconductor Manufacturing and Inspection Equipment



MOS: metal on silicon, DRAM: dynamic random access memory, NAND: not AND, Ar: argon, F: fluorine, Si: silicon, Ge: germanium, SE: single exposure, DP: double patterning, MP: multi-patterning, SADP: self align double patterning, SAQP: self align quadro patterning, LE: litho etch, STT: spin transfer torque, PCRAM: phase change random access memory

1 Developments in the field of advanced devices

1 New Developments in Advanced Devices and Increasingly Diverse Customer Requirements

Advances intended to improve the performance of the semiconductor devices that underpin the widespread use of products such as smartphones, tablets, and cloud computing servers are being made on a variety of different fronts, including not only miniaturization but also the adoption of three-dimensional structures and new types of memory. In the case of miniaturization, development is progressing on 10-nm nodes and smaller using techniques such as multi-patterning and extreme ultraviolet (EUV) lithography. In the case of three-dimensional structures, vertical stacking of a number of memory transistors and the use of fin-shaped field effect transistors (Fin-FETs) in logic devices and processors have both become mainstream practice. Meanwhile, various companies are developing new types of memory such as magnetoresistive random access memory (MRAM) and resistive random access memory (ReRAM).

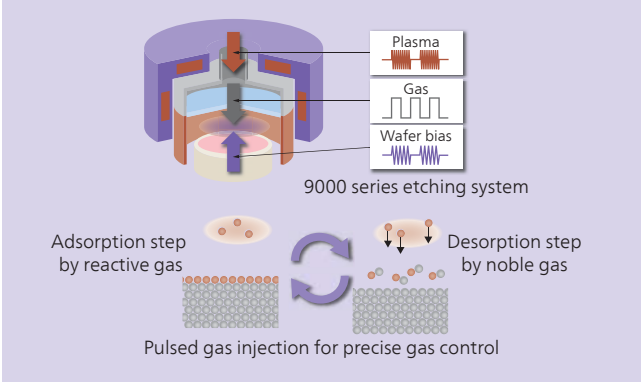
Customer requirements are also changing in response to these developments. In addition to the precision fabrication and measurement of nano-scale patterns, these increasingly diverse demands include process module techniques that improve transistor reliability, measurement techniques that quantify fabrication execution, techniques for the fabrication and measurement of three-dimensional structures such as deep trenches or holes, and support for new materials.

In the future, Hitachi intends to continue supplying technology and other solutions that satisfy these diverse customer requirements.

(Hitachi High-Technologies Corporation)

2 Atomic-level Etching Control Technology Tri Time-Modulation

Along with miniaturization, devices with three-dimensional structures are becoming the norm for semiconductor generations with minimum dimensions of 10 nm or less. Hitachi has been a leader in the use of microwave electron cyclotron resonance (ECR) plasma etchers for microfabrication in the manufacture of semiconductors, and three-dimensional fabrication for these sub-10-nm generations demands control of variation to the level of individual atoms or molecules and ultra-high selectivity to prevent the formation of a damaged layer on the device surface during etching.



2 Tri time-modulation system

Tri time-modulation is a plasma etching control technology with atomic-level precision that can meet these requirements. The dual time-modulation technology used in the past precisely controls plasma densities and ion energies. The new technology augments this with the ability to precisely control gases using pulsed injection of the reactive gases used for etching. Furthermore, by optimizing each of these processes, the technology enables microfabrication with atomic-level precision in a way that works with three-dimensional structures.

This technology is being incorporated into Hitachi's flagship 9000 series and can be retrofitted into systems that have already been delivered. As a result, it is expected to play an active role as a production solution that supports the next generation of device manufacturing.

(Hitachi High-Technologies Corporation)

3 CG6300 High-resolution FEB Measurement SEM

Focused electron beam (FEB) measurement scanning electron microscopes (SEM) are used to measure the dimensions of circuits fabricated using semiconductor manufacturing processes. Hitachi's products have provided behind-the-scenes support for the semiconductor industry, advancing in step with increasing semiconductor miniaturization since the first model was launched in 1984. A total of 4,600 units have been shipped to date. The new CG6300 is designed for use in mass production of the 10-nm generation of semiconductors and beyond, featuring updated electron optics, control, and mechanical mechanisms for improved resolution and dimension measurement repeatability.

The main features of the CG6300 are as follows.

(1) In addition to the existing imaging of pattern formation using secondary electrons, the CG6300 can also perform imaging of material structure using backscattered electrons.

(2) Less noise results in clearer edges. Noise is reduced by doubling the electron beam scanning rate compared to previous models to minimize the effect of residual charge on the wafer surface.

(3) Can process at least 20% more wafers per hour than previous models thanks to a new stage design.

3 CG6300 high-resolution FEB measurement SEM

(4) Long-term reliability with inter-device variation minimized to facilitate use at large semiconductor fabrication plants.

(Hitachi High-Technologies Corporation)

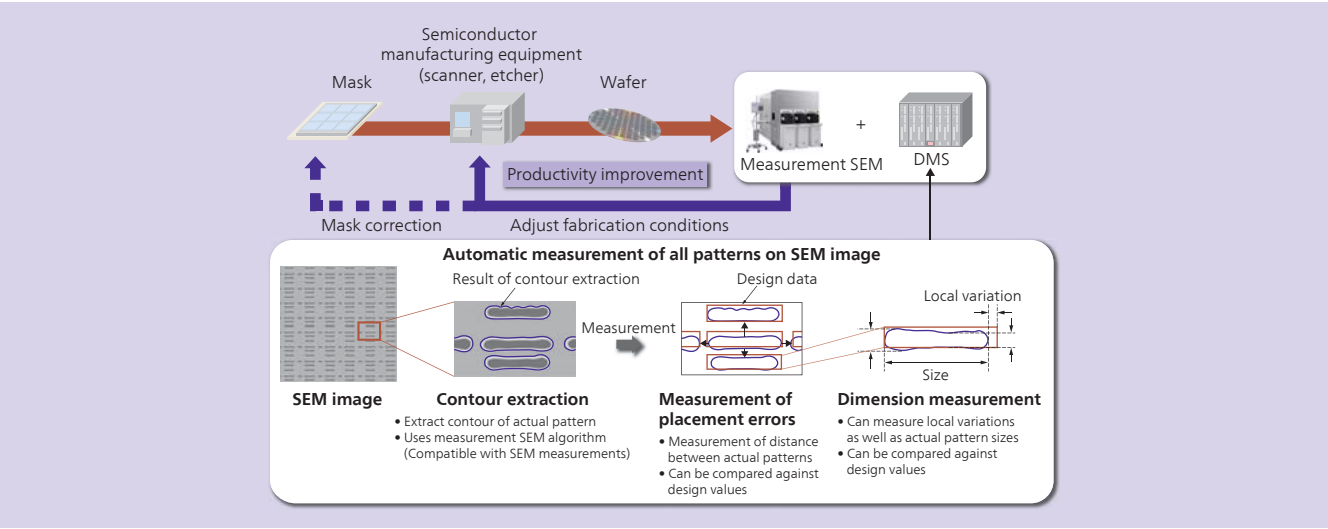
4 Two-dimensional Measurement Solution for Semiconductor Patterns that Helps Increase Yield

As semiconductor devices become increasingly miniaturized, it becomes more difficult to determine the best production conditions for forming the pattern in accordance with the design. Achieving a faster startup of high volume manufacturing and cutting labor costs require fully automated measurement procedures that are precise enough to perform quantitative evaluations of how well patterns have been formed under volume manufacturing conditions and to provide feedback to the fabrication process.

A defect metrology system (DMS) is solution for improving yield that performs precise two-dimensional measurements based on contour extraction, a core technology of Hitachi High-Technologies Corporation. It uses 24 different measurements to make a quantitative evaluation of how well fabrication has been performed, including placement errors, and fully automatic measurement of all pattern dimensions on the SEM image.

In the future, Hitachi intends to improve the performance of the solution and expand its use to include defect inspection as well as measurement.

(Hitachi High-Technologies Corporation)



4 Overview of DMS

Electronic Equipment and Power Tools

1 SK-UHD8060B UHD-2 broadcast camera in recorder configuration (top), with the optical transmission unit and UHD-1 view finder (bottom)

1 UHD-2 Camera System for Next Generation of Broadcasting

The broadcasting market is starting to take major steps toward the implementation of the upcoming UHD-1 and UHD-2 generations. Hitachi's new UHD-2 broadcast camera (SK-UHD8060B) was jointly developed with the Japan Broadcasting Corporation. This groundbreaking broadcast camera system is suitable for a wide variety of different uses. Along with the development of a built-in recording unit, the camera and optical transmission unit have been made smaller to facilitate the production and transmission of UHD-2 video.

The main features of the SK-UHD8060B are as follows.

(1) The ways in which the system can be used have been significantly improved, with a dockable design that enables the camera head and optical transmission unit or camera head and recording unit to be combined.

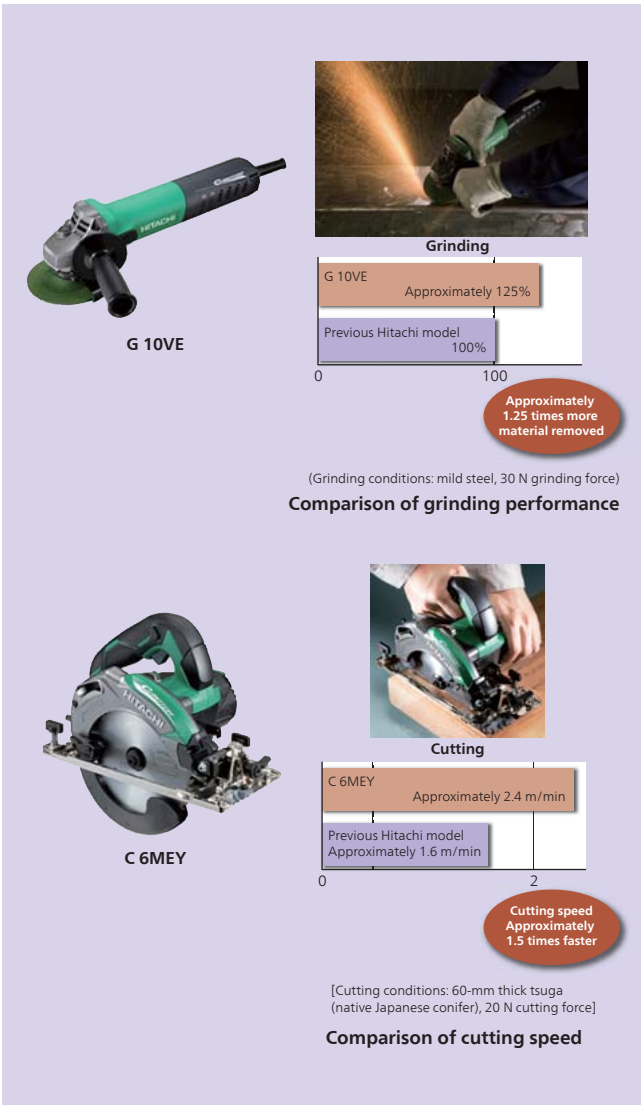
(2) UHD-2 video recording has been significantly enhanced by the recording unit, which can record 40 minutes of video on a solid state drive (SSD) slot with 2-Tbyte capacity.

(3) Can operate as a system camera by connecting the optical transmission unit. A range of peripherals are available, including a UHD-1 view finder, and the system can be fitted with a large lens and used as a studio camera.

(Hitachi Kokusai Electric Inc.)

2 Power Tools with Brushless AC Motors G10/13VE, G10/13YE2, G15YE2, C6MEY/UEY

While the past requirements for power tools have been for their underlying performance, namely high work efficiency, small size, and light weight, new functions that make the tools more convenient for users have also become important in recent years. In response, by using proprietary technology to drastically shrink the size of the inverter circuits, Hitachi has developed products that incorporate new functions as well as being designed for high



2 Power tools with brushless AC motors

work efficiency, small size, and light weight by using highly efficient brushless alternating current (AC) motors in disk grinders and circular saws, an industry-first for hand tools[*1, *2].

The main features of the power tools are as follows.

(1) Class-leading work efficiency[*1,*2] [G10VE: 1.25 times higher grinding capacity (material removal) than previous model, C6MEY: 1.5 times faster cutting speed than previous model]

(2) Smallest and lightest in class[*1,*2], and well balanced for excellent maneuverability to reduce user fatigue

(3) A kickback minimization system that works by monitoring for changes in the motor speed and momentarily stopping the motor whenever a sudden deceleration occurs

(4) A function for preventing the power tool from starting unintentionally avoids accidents by preventing the tool from starting when the power is plugged in with the switch in the ON position.

(5) A small, highly efficient inverter developed by Hitachi enables the tools to be used with engine generators

(6) Monitoring of the power supply and load ensures reliable operation when using an extension cord, despite the associated voltage drop

(Hitachi Koki Co., Ltd.)

*1 Among Japanese power tool manufacturers. As of May 2015. Based on research by Hitachi Koki Co., Ltd. (100/125/150-mm class electronic disk grinders)

*2 Among Japanese power tool manufacturers. As of April 2015. Based on research by Hitachi Koki Co., Ltd. (deep-cut electronic circular saws with 165-mm blades)

3 Cordless Impact Drivers WH14DDL2 and WH18DDL2

Cordless impact drivers can be used for different tasks such as tightening screws, tightening bolts, and drilling holes by changing the tool bit. Their primary use, however, is for fastening building materials in timber home construction. While there has been a notable increase in characteristics like torque and screw tightening speed in recent years for use with hard materials such as laminated timber or with long screws, these changes have brought with them an increase in problems such as the screwdriver bit slipping off the screw head or the oversinking of short screws. The new models have been made easier to use by using a triple-hammer mechanism (three hammer claws compared to two on previous models) that reduces problems like slipping out or oversinking by increasing the number of small-force impacts (three impacts per rotation). In contrast, power mode (1.5 impacts per rotation) increases the hammer impact energy to provide faster screw tightening. This is achieved in tandem with Hitachi's proprietary active control system (ACS) function for optimal control of the motor speed, impact timing, and other parameters, providing ease of use and higher performance in the same tool.

The main features of the cordless impact drivers are as follows.

(1) New industry-first* triple-hammer impact mechanism delivers both ease of use (fewer problems with screwdriver bit slipping off screw head or oversinking) and higher performance (leading screwing speed and tightening torque than previous models).

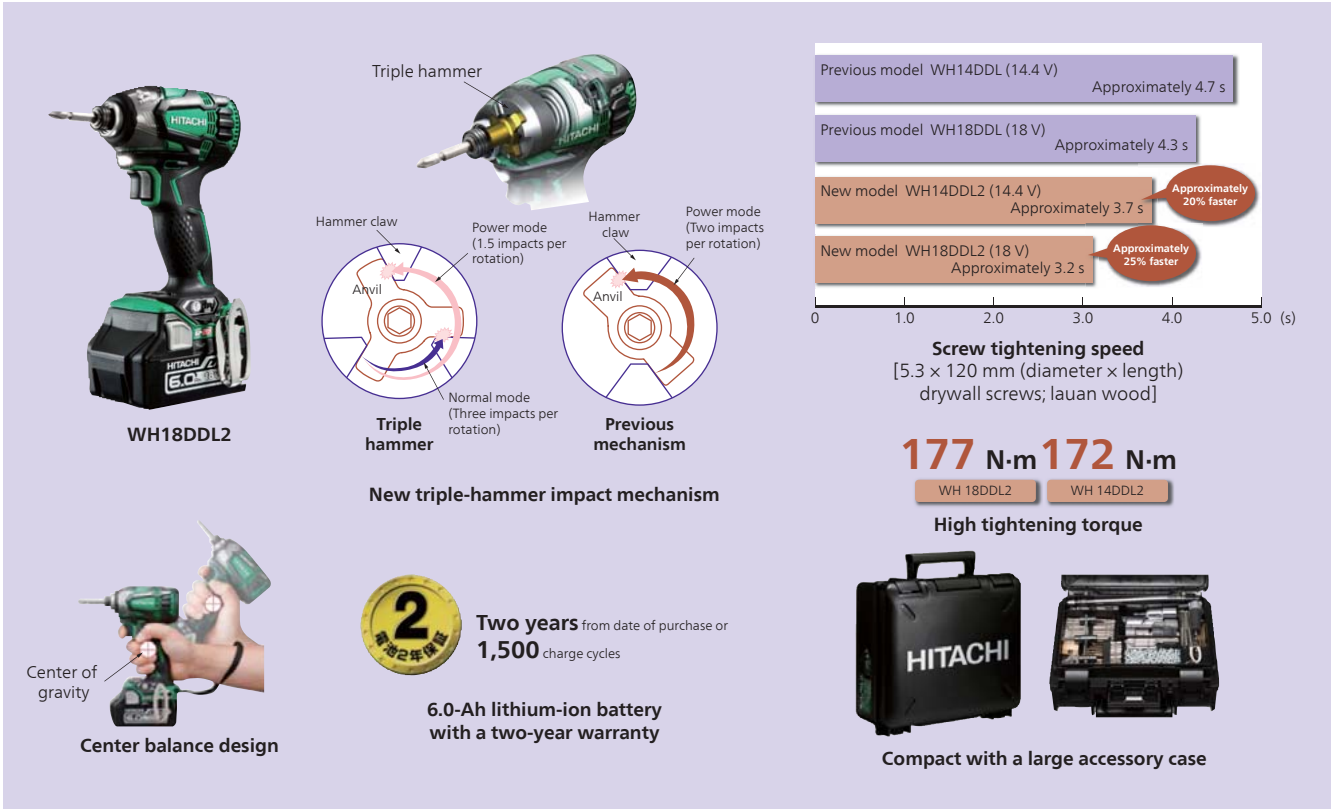
(2) Center balance design reduces user fatigue.

(3) Supplied with a 6.0-Ah lithium-ion battery with a two-year warranty (delivers approximately 1.2 times more work than a 5.0-Ah battery).

(4) Compact case with a large accessory holder

(Hitachi Koki Co., Ltd.)

* Among Japanese power tool manufacturers. As of July 2015, based on research by Hitachi Koki Co., Ltd.



3 Features of cordless impact drivers

Construction Machinery

1 ZX75US-5B (top) and ZX75UR-5B (bottom) hydraulic excavators

1 Hydraulic Excavators ZX75US-5B and ZX75UR-5B

The ZX75US-5B and ZX75UR-5B are hydraulic excavators that comply with Japan's 2014 Act on Regulation, Etc. of Emissions from Non-road Special Motor Vehicles. Features include an automatic idling stop function that shuts down the engine if the machine remains idle, and functions for reducing carbon dioxide (CO_2) emissions to help the global environment.

Compared to previous models, improvements to the efficiency of the hydraulics have reduced the amount of fuel consumed to perform a given amount of work by approximately 15% on the ZX75US-5B and 20% on the ZX75UR-5B, combining energy efficiency with a high level of work performance.

Safety features include a cab that complies with the International Organization for Standardization (ISO) standard for roll-over protective structures (ROPSs) that protect the operator in the event that the hydraulic excavator overturns, and a rear view monitor (included as a standard feature) that improves peripheral visibility by displaying the view from behind the machine that the operator would otherwise have trouble seeing. The machines are also fitted with a delay function that keeps the working lights turned on for 60 s after the engine is turned off to ensure safety at the end of nighttime operation.
(Hitachi Construction Machinery Co., Ltd.)

2 Rotary Mini Excavators ZX30UR-5B, ZX40UR-5B, and ZX55UR-5B

The ZX30UR-5B, ZX40UR-5B, and ZX55UR-5B are mini excavators that comply with either the Ministry of Land, Infrastructure, Transport and Tourism criteria for construction machinery with emission controls (level 3) (ZX30UR-5B and ZX40UR-5B) or Japan's 2014 Act on Regulation, Etc. of Emissions from Non-road Special Motor Vehicles (ZX55UR-5B), and feature electronically-governed engines and improvements to hydraulics efficiency to significantly reduce fuel consumption compared to previous models (ZX30UR-5B: 16%, ZX40UR-5B: 14%, and ZX55UR-5B: 16%).

2 Canopy models of new ZX55UR-5B (top) and ZX30UR-5B (bottom) mini excavators

The main features are as follows.

(1) Excellent operation and work performance

A boom height limiter system is provided as a standard feature to help avoid power lines and other obstacles. The speed can be adjusted smoothly when using the blade thanks to the inclusion of a switch on the blade lever for selecting the travel speed.

(2) Comfortable workspace

Multiple liquid crystal display (LCD) monitors with bright and clear display make it easy to view the current machine status. Modifications to the shape of the right-side canopy panel have improved visibility on the right side of the machine.

(3) Easy maintenance

An engine cover that slides vertically and a front radiator cover with a wide opening make routine inspections easier to perform. Easier access to important components is provided via a floor that tilts upward.

(Hitachi Construction Machinery Co., Ltd.)

3 Wheel Loader ZW80-5B

The ZW80-5B is a wheel loader that complies with Japan's 2014 Act on Regulation, Etc. of Emissions from Non-road Special Motor Vehicles. To reduce the need for operator maintenance, it is fitted with a muffler that does not use a ceramic filter. It is also fitted with controllers for the engine and driving operation that improve driving and other operations, resulting in a 6% increase in productivity compared to previous models. Another standard feature improves product attractiveness by providing a switch for reducing the engine speed to lower noise when needed for operating conditions such as those associated with snow clearing, livestock, or industrial waste.

The main features are as follows.

(1) Muffler does not use a ceramic filter.

(2) A throttle limiter switch for minimizing noise is included as a standard feature.

(3) A hi-lo selector switch for limiting speed in confined workspaces is included as a standard feature.

(4) Reminders for replacing filters are displayed on the monitor (standard feature).

(5) Sliding windows on both sides and a sun visor are standard features on the optional cab design.

(Hitachi Construction Machinery Co., Ltd.)

3 ZW80-5B wheel loader

4 Vibratory Rollers ZC35C-5, ZC50C-5, ZC35T-5, and ZC50T-5

Vibratory rollers are used for compaction in road construction and at various other work sites. The ZC35C-5, ZC50C-5, ZC35T-5, and ZC50T-5 are a new range of models designed to be better for the environment and feature improvements to maintenance, safety, and operation.

The main features are as follows.

(1) Better for the environment

Fitted with an 18.2-kW direct injection engine that complies with the Ministry of Land, Infrastructure, Transport and Tourism criteria for construction machinery with emission controls (level 3), the ZC35C-5 and ZC50C-5 achieve approximately 11% lower fuel consumption than previous models when performing the same work. They also comply with the ministry's criteria for ultra-quiet construction machinery.

(2) Ease of maintenance

4 ZC50C-5 (top) and ZC35C-5 (bottom) vibratory rollers

The rollers are designed to be easy to maintain, with fully opening engine covers and water spray and fluid nozzles that can be inserted or removed at a single touch.

(3) Safety

The rollers have a low floor and stair to make them easy to get on and off. New hazard lights have been added as a standard feature.

(4) Ease of operation

In addition to the existing hi-lo mode, the ZC50C-5 and ZC50T-5 have a super-low mode for hill climbing, providing equal or better performance on slopes than previous models.

(Hitachi Construction Machinery Co., Ltd.)

5 ZX250LC-6 Hydraulic Excavator Compliant with European Emission Standards Stage IV

Emission standards for construction machinery have been tightened internationally in recent years along with other initiatives aimed at reducing the load on the environment that have been undertaken on a variety of fronts. It is based on this background that Hitachi developed the ZX250LC-6 hydraulic excavator to comply with new emission standards.

In addition to complying with engine emission standards, the systems for the ZX250LC-6 have also been designed to achieve lower fuel consumption. One of the new technologies adopted to make the engine compliant with emission standards is selective catalytic reduction (SCR) using urea. The system works by spraying an aqueous urea solution into the hot exhaust gases inside the catalytic converter to form ammonia. With the aid of the catalyst, this ammonia then reacts with nitrogen oxides (NO*x*) to break them down into harmless nitrogen and water.

Hitachi has also made improvements to the existing new hydraulic system to further reduce fuel consumption, by approximately 10% compared to the previous model (ZX250LC-5B) when performing equivalent work. Furthermore, for greater safety during maintenance, handrails at the top of the cab have been provided as a standard feature. Hitachi has also set out to make the most of information technologies, including enhanced functions for monitoring machine condition and functional improvements to the Global e-Service to shorten the time it takes to respond to faults.

(Hitachi Construction Machinery Co., Ltd.)

5 ZX250LC-6 hydraulic excavator compliant with European emission standards Stage IV

6 Dump Trucks EH3500AC-3 and EH4000AC-3

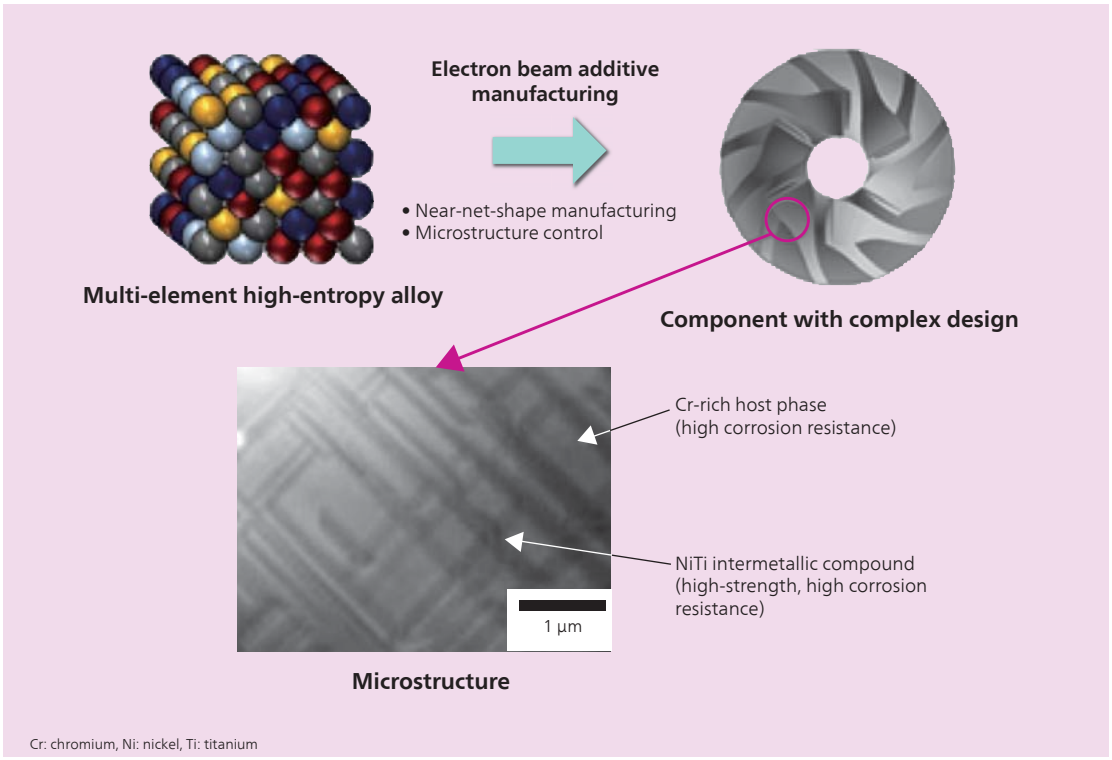
The EH5000AC-3 dump truck went on sale in March 2013. Drawing on technologies used on the EH3500AC II and EH4000AC II, its standard features include Hitachi Drive Control System (a stability control system) and an alternating current (AC) drive system developed jointly by calling on the comprehensive capabilities of Hitachi. These same functions were also deployed in the EH3500AC-3 and EH4000AC-3, both of which went on sale in December 2014.

While retaining the same highly-regarded acceleration and electrical braking performance, the EH-3 series delivers even better driving stability than previous models thanks to its stability control system. Hitachi has also made the dump truck more competitive by offering a choice of engines to suit customer requirements, with the same truck frame able to be fitted with either the standard Cummins Inc. engine or an optional MTU engine. Furthermore, it has an augmented vision system extending all around the truck that is designed to help reduce worksite collisions.

(Hitachi Construction Machinery Co., Ltd.)

6 EH3500AC-3 (top) and EH4000AC-3 (bottom) dump trucks

High Functional Materials & Components



1 Use of electron beam additive manufacturing to fabricate components from multi-element high-entropy alloys

1 High-strength, Corrosion-resistant Alloy Components Produced by Electron Beam Additive Manufacturing

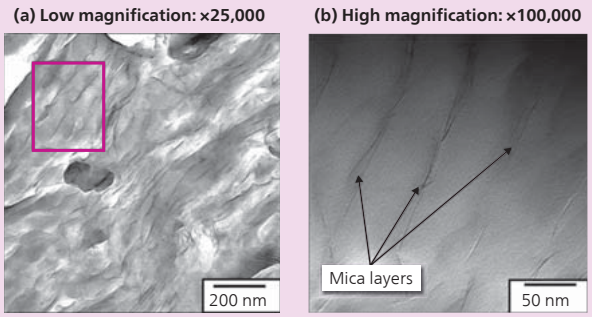
Fields such as resources and energy that require tolerance of harsh environments have a need for alloys with characteristics that surpass the stainless steel widely used in the past. Now, Hitachi is seeking to develop ways of utilizing high-entropy alloys in products. Unlike conventional alloys made by adding alloying elements to a metal, high-entropy alloys ("multi-element high-entropy alloys") are formed from a large number of different elements. While the new alloys feature excellent mechanical properties and corrosion resistance, it is difficult to use them to make large components with uniform properties. Electron beam additive manufacturing has attracted attention for its potential to overcome this problem by manufacturing complex shapes using a repeated process involving selective melting by an electron beam of a uniformly-spread layer of metal powder. Hitachi has developed new alloy components by taking advantage of the local melting and rapid solidification that is characteristic of electron beam additive manufacturing to form a microstructure that is strengthened by precipitated phases. These new alloy components have been demonstrated to provide approximately twice the strength of existing corrosion-resistant dual-phase stainless steel together with equal or better corrosion resistance.

In addition to making further improvements in the properties of these alloys, Hitachi intends to develop applications for them in components that are used in harsh environments.

2 Epoxy Composite with High Insulation Voltage Produced with High Dispersion of Mica

As part of the trend toward smaller size and higher output, automotive, industrial, and other electrical and electronic equipment are increasingly expected to deal with higher voltages. However, as higher voltages are accompanied by thicker insulation, combining this with smaller size is difficult. Accordingly, there is a need for insulators that are able to withstand higher voltages.

Epoxy composites are made from epoxy resin and inorganic powder. They are widely used as insulators in electrical and electronic equipment because they offer an excellent balance between insulation, heat-resistance, adhesion, and mechanical properties performance. While it has been known for some time that dispersing insulator nanoparticles through the epoxy resin increases the insulation voltage, and because of the large surface area of the nanoparticles, simply adding such material is very detrimental to productivity due to problems such as higher viscosity and thixotropy (tendency to become less viscous when shaken or otherwise stressed). In response, Hitachi and Kansai



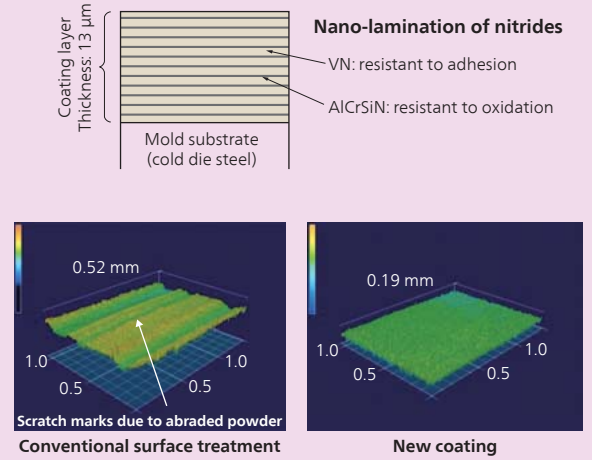
2 Transmission electron microscope (TEM) image of cured epoxy resin composite containing highly dispersed mica

University have jointly developed a technique that uses micrometer-size mica particles with a small surface area that cause less of an increase in viscosity, and achieves a high degree of dispersal through the epoxy resin by separating the mica layers from each other during the curing process to form nanometer-thick flakes. This produces an excellent epoxy resin composite with three or more times the insulation life of previous materials, without compromising productivity.

3 PVD Coating for High-tensile Steel Sheet Press Molds

The use of higher tensile steel sheet in components such as vehicle frames is resulting in increasingly harsh operating conditions for the molds used in press-forming. The very high surface pressures to which molds are subjected in the forming of high-tensile steel sheet result in heating of the forming surfaces and localized wear.

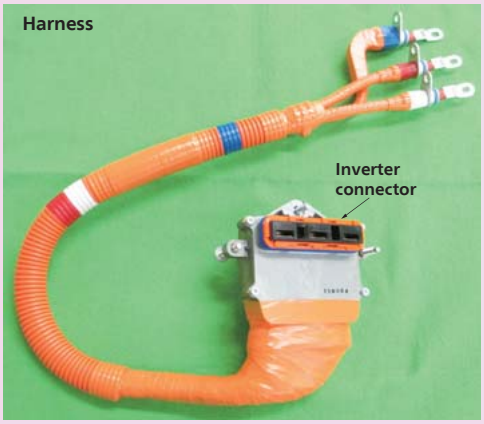
Based on the concept of improving wear performance under high-surface-pressure conditions, Hitachi has developed a physical vapor deposition (PVD) multi-layer coating "vanadium nitride (VN)/aluminum-chromium-silicon nitride (AlCrSiN) coating" for high-tensile steel sheet press molds formed from the nano-level lamination of oxidation-resistant AlCrSiN and VN which has excellent resistance to adhesion (metal sticking). In addition to inhibiting excessive wear of the coating due to oxidation at high temperature, the vanadium in the coating prevents adhesion with the steel being pressed by forming vanadium-based oxide on the coating surface. Furthermore, by reacting with the iron (Fe) oxide that forms as the surface of the steel slides during pressing, the vanadium oxide acts to lower the eutectic point of the vanadium-iron oxides. This suppresses the formation of abraded particles that cause abrasive wear. Hitachi has demonstrated that the new coating can significantly extend mold life relative to conventional surface treatments.
(Hitachi Metals, Ltd.)



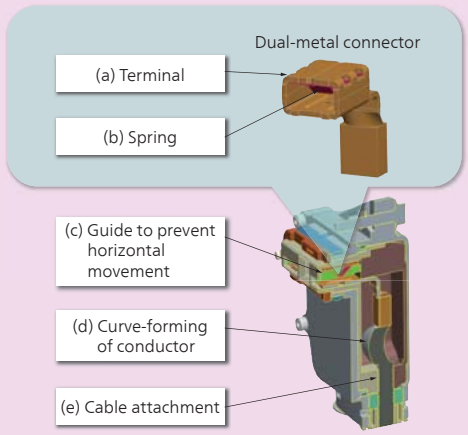
3 Coating structure and condition of mold surface after press-forming

4 Heavy-current Harnesses for HEVs

Heavy-current harnesses for hybrid electric vehicles (HEVs) are used to connect power electronics units such as those for the drive motor, inverter, and batteries. In the case of the inverter connection, harness contact terminals are used for easy assembly via connectors. Harness contact terminals are dual-metal, meaning they are made of two different metals. The terminals themselves are made of a copper alloy with conductivity of 90% or better in terms of the International Annealed Copper Standard (IACS) to minimize conductor heating when carrying a heavy current, while the harness uses a stainless steel with good stress relaxation characteristics to stabilize the contact pressure even at an ambient

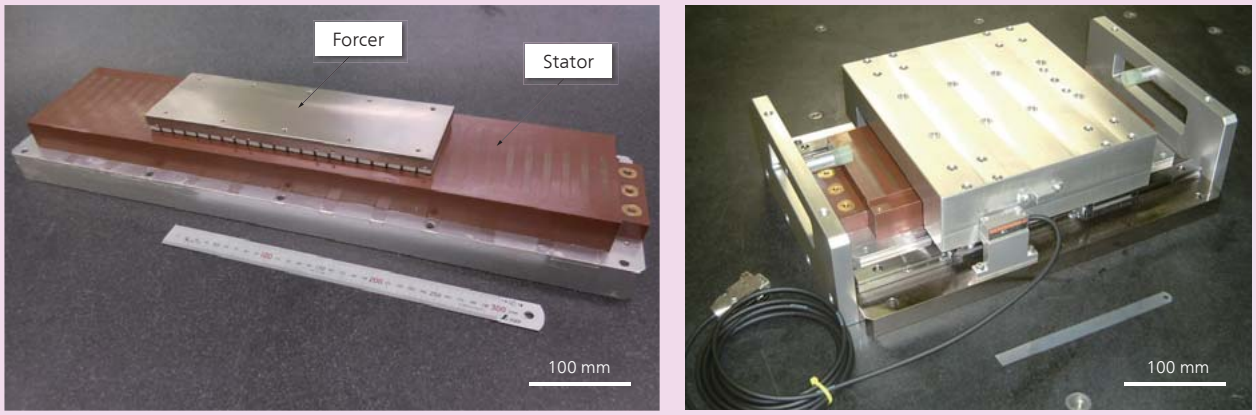


Heavy-current harness for HEV



Cutaway drawing of inverter connector

4 Harness (top) and cutaway drawing of inverter connector (bottom)



5 Moving magnet linear motor capable of high acceleration (left) and single-axis linear motor stage (right)

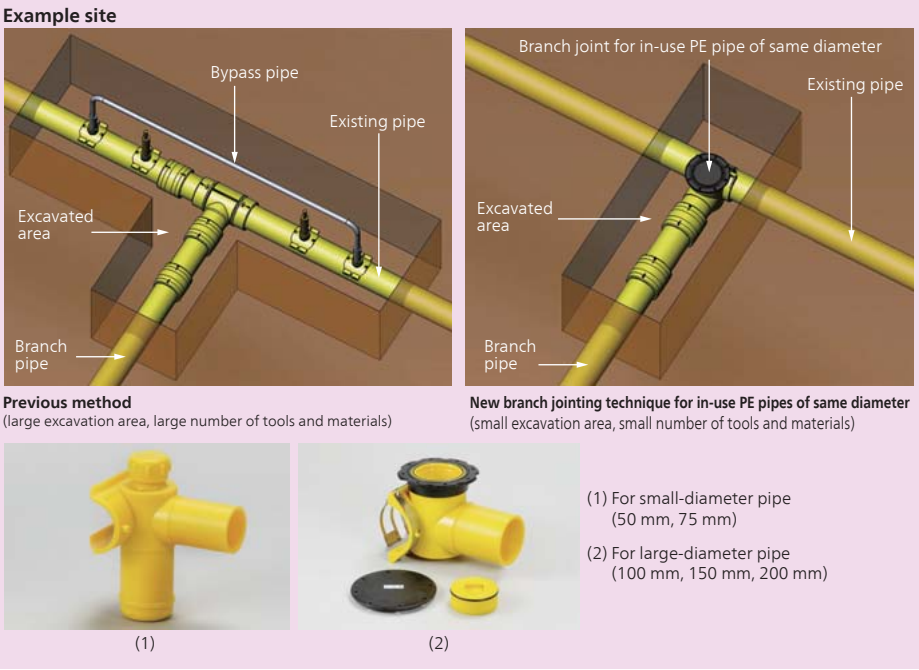
temperature of 85°C. Other features include the provision of guides to prevent horizontal movement of the terminals, forming of curved conductors, and structures for holding cables in place to maintain a reliable connection even when subjected to vibration.
(Hitachi Metals, Ltd.)

5 Moving Magnet Linear Motor Capable of High Acceleration

While the key objectives for past linear motors have been limited to propulsive force and maximum speed, the emphasis in applications such as component mounting machines where the work head requires a fast response is on how to deal with high acceleration by seeking to reduce the weight of the forcer (moving part) of the linear motor.

Linear motors can be broadly categorized according to whether or not they incorporate a core, with core-less configurations being adopted in high-acceleration applications in order to satisfy the requirements by reducing the weight of the forcer. Unfortunately, maximum propulsive force places a limit on the extent to which this approach can be used. Conventional linear motors with a core, on the other hand, are not suited to achieving high acceleration because of their heavier forcer. In response to this problem, NEOMAX ENGINEERING Co., Ltd. has developed a moving magnet linear motor, which is capable of a mean acceleration of 98 m/s² (10 G).

By adopting a forcer made up of only a magnet and ferromagnetic material (low-carbon steel), the weight of the forcer on the new linear motor has been reduced to 40% or less of that on previous moving-coil linear motors that incorporate a core. By adopting a low-impedance design for the stator, this combines propulsive force step response performance equivalent to a core-less design with a maximum propulsive force that benefits from the presence of a core.
(NEOMAX ENGINEERING Co., Ltd.)
(Scheduled commencement of production: March 2016)



6 Comparison of new branch jointing technique for in-use PE pipes of the same diameter with the previous method (top) and special-purpose joint used by the new method (bottom)

6 Branch Jointing Technique for In-use PE Pipes of the Same Diameter

With the rapidly growing use of polyethylene (PE) pipes in the underground gas pipe market, there is rising demand for a way of installing branch joints in existing PE pipes that have the same diameter without interrupting the flow of gas. Past practice for branching off a new pipe of the same diameter from an existing PE pipe required considerable work and the excavation of a large area to allow the fitting of bypass piping to avoid the need to turn off the flow of gas, with localized blocking of gas and cutting of PE pipe.

A new technique developed by Hitachi uses a special-purpose saddle-shaped branch joint and a dedicated tool. It eliminates the need for a bypass pipe and significantly reduces both the area to be excavated and the time required for the job. The technique has been adopted by a large number of gas operators as a means of cutting costs and Hitachi believes it will continue to make a major contribution to the gas business in the future.
(Hitachi Metals, Ltd.)

7 Semiconductor Packaging Film

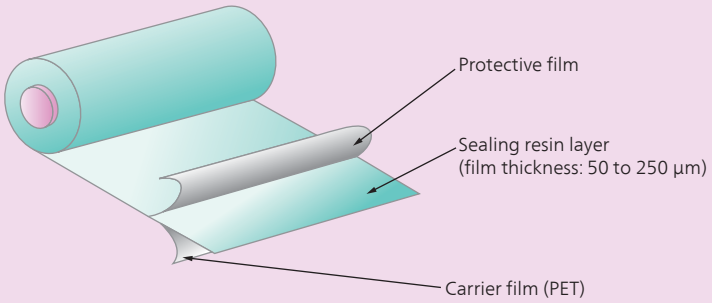
The spread of smartphones and other mobile devices has created a need for semiconductor packages that are smaller and slimmer, and that can be manufactured at low cost. To ensure that sealant coverage is not too thin and to improve ease of production, small quantities need to be supplied uniformly to a large surface area of unsealed package.

To produce packages that are both slim and low-cost, Hitachi has developed a semiconductor packaging film that has low thermal expansion and excellent fluidity during thermoforming.

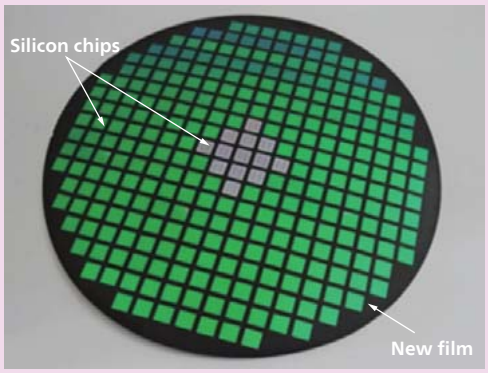
Features of the new film include its fluidity, its flexibility (essential for maintaining ease of handling), and its reduced thermal expansion (achieved by incorporating a high level of inorganic filler). These were achieved by using a resin with high fluidity and a technique for improving the filler surface quality.

Being a film, the new product can be used not only in conventional molding, but also in thermal laminators that make it easy to seal large surface areas. While ultra-thin packages are difficult to seal using existing sealants, selecting the correct film for the desired thickness of seal makes it possible to seal a large surface area in a single operation. The new film also helps reduce the load on the environment by producing much less dust than powdered sealants.

In the future, Hitachi intends to expand its range of products that take advantage of film forming to suit different types of packages, and to market them both in Japan and elsewhere.
(Hitachi Chemical Co., Ltd.)



Structure of new film



Sealed package produced using new film
(size: 200 mm)

PET: polyethylene terephthalate

7 Structure of new film and example sealing

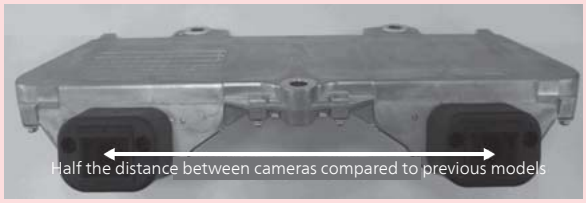
Automotive Systems

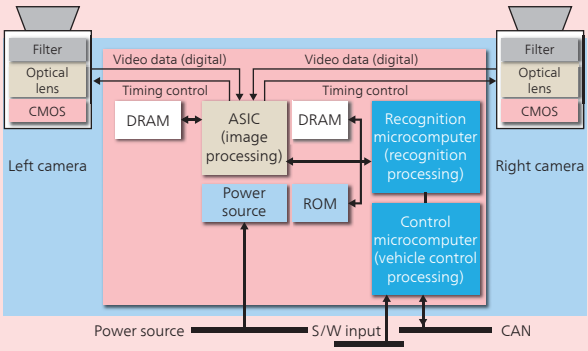
1 Compact Stereo Camera

Hitachi Automotive Systems, Ltd. supplies stereo cameras to automakers as sensors for advanced driver assistance systems that are able to recognize the outside world and the vehicle's driving conditions. These systems are intended to prevent car accidents and mitigate damage by detecting pedestrians and bicycles, etc. and controlling the brakes.

The latest compact stereo camera developed by Hitachi only requires about half the distance between the left and right cameras (baseline length) compared to previous models. This enables the stereo camera to be installed even in restricted layout conditions, such as in compact vehicles, yet achieves almost the same performance as before in terms of accident prevention and damage mitigation.

In the future, Hitachi will continue to enhance performance and promote further adoption by reducing costs and developing sensors that will help make automatic driving a reality.
(Hitachi Automotive Systems, Ltd.)

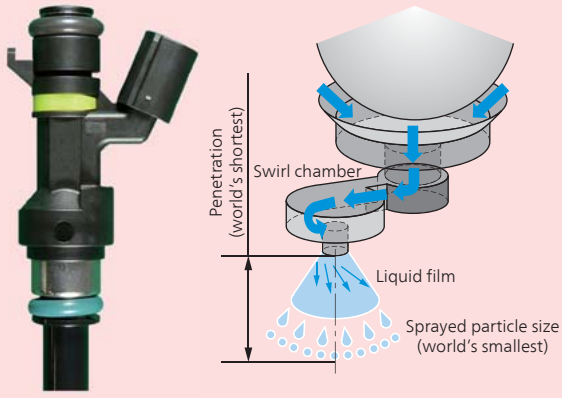




Item	Specifications (developed product)
Size	Width: 270 × Depth: 130 × Height: 40 (mm)
Weight	650 (g)

CMOS: complementary metal oxide semiconductor, DRAM: dynamic random access memory, ASIC: application specific integrated circuit, ROM: read only memory, S/W: switch, CAN: controller area network

1 Compact stereo camera exterior (top), structure (middle), and specifications (bottom)



2 Multi-swirl injector for PFI and spraying system

2 Multi-swirl Injector for Port Fuel Injection

The multi-swirl injector for port fuel injection (PFI) is a gasoline injector used in PFI systems. To achieve greater atomization of the injected gasoline particles and low penetration (low spray speed), it employs the world's first*1 swirl spraying system.

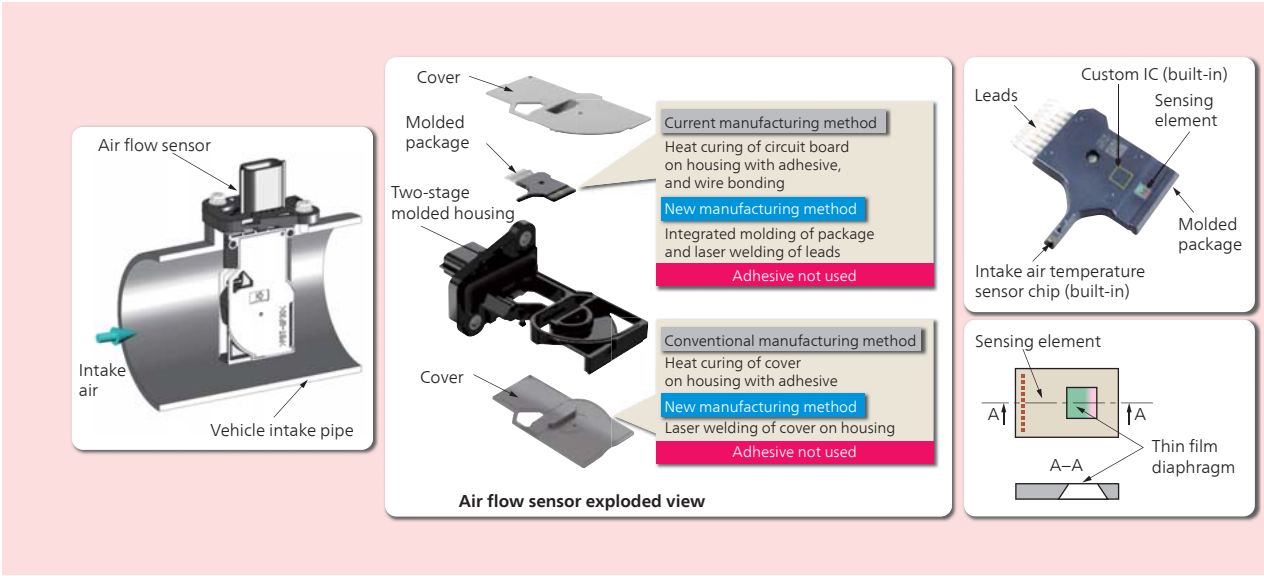
In this swirl spraying system, energy is gained by swirling the gasoline in a swirl chamber located in the fuel passage, and this energy is converted efficiently into atomization energy for spraying. To enable the adoption of this spraying system, Hitachi developed spray control technology using its proprietary simulation technology and precision processing technology. The result was a spraying method that achieves both the world's smallest*2 particle size and the world's shortest*2 penetration. This spraying system improves fuel efficiency and reduces exhaust gas emissions.
(Hitachi Automotive Systems, Ltd.)
(Start of mass production: November 2013)

*1 As of October 2013, research by Hitachi Automotive Systems.
*2 As of October 2015, research by Hitachi Automotive Systems.

3 Molded Package Air Flow Sensor

An air flow sensor measures the flow of intake air into an internal combustion engine. With the goal of supplying high-precision sensors at low cost, Hitachi has developed a new type of air flow sensor based on a molded plastic package instead of the printed circuit board that was previously required.

Specifically, the following four areas were developed for product application.



3 Molded package air flow sensor

(1) A custom integrated circuit (IC) that internally integrates the external electronic components that were previously required
(2) A sensing element formed from a thin film diaphragm a few micrometers thick that is partially exposed and integrated and sealed in a molded plastic package together with the IC and intake air temperature sensor
(3) A two-stage molded housing that fixes the package to the housing without using adhesive
(4) Technology that joins the plastic cover using a laser, without using the adhesive that was previously required

As a result, element mounting accuracy is improved, achieving higher sensor precision. In addition, the number of components has been greatly reduced, and the manufacturing time has been shortened through the elimination of processes such as adhesive heat curing process.

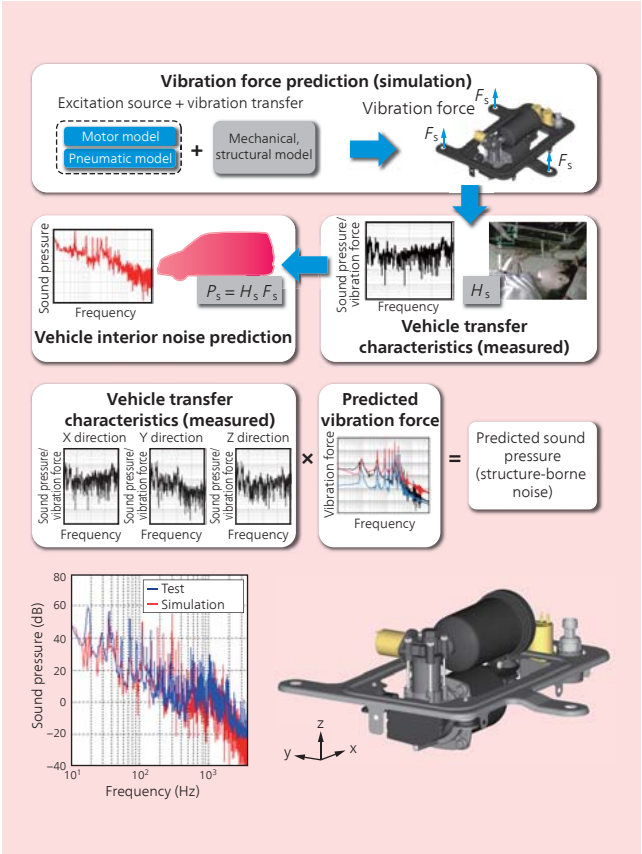
In the future, Hitachi will continue to improve performance and further integrate components to develop optimum sensors for high performance engines.
(Hitachi Automotive Systems, Ltd.)
(Start of production: April 2014)

4 Vehicle Interior Noise Prediction Technology

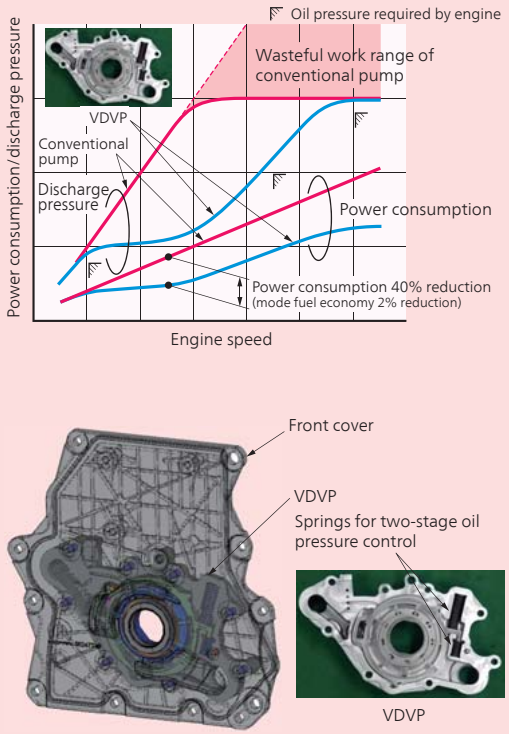
In recent years, there has been growing need to reduce the noise of components to make vehicles more quiet. However, even if the noise is reduced for a component alone, the noise level may not be satisfactory once the component is actually mounted on a vehicle. In response to this issue, Hitachi is developing a method for predicting, at the development stage, what the noise level of components will be when they are mounted on a vehicle. This kind of approach is called analysis lead design.

Applying this method to the air suspension compressor, the vibration of the compressor itself during operation was analyzed to calculate the force of vibration that would be applied to the vehicle. By multiplying this by the vehicle transfer characteristics, the vehicle interior noise (sound pressure) can be predicted. The vehicle transfer characteristics can be calculated by applying vibration force to a mass-produced vehicle or development vehicle and measuring the sound pressure inside the vehicle. As long as the vehicle transfer characteristics are available, the vehicle interior noise when a component is mounted can be predicted in the analysis.

In the future, Hitachi will continue to improve the accuracy of this technology to enable application in a wide range of products.
(Hitachi Automotive Systems, Ltd.)



4 Overview of vehicle interior noise prediction method (top), results of vehicle interior noise simulation (bottom)



5 Characteristics of VDVP oil pressure and power (top), VDVP integrated into front cover (bottom)

5 Variable Displacement Oil Pump for Engine Lubrication

In recent years there has been growing demand for variable displacement oil pumps for engine lubrication to improve fuel efficiency in response to stricter environmental and fuel efficiency regulations. To meet such demand, Hitachi has developed the variable displacement vane pump (VDVP), a variable displacement oil pump that is integrated into the front cover.

In conventional pumps with a constant discharge capacity, the discharge capacity and discharge pressure both increase as the engine speed increases. In high engine speed ranges, more oil pressure is generated than is required by the engine. The oil pressure must be controlled to an appropriate level by releasing excess oil to the oil pan via a relief valve. In other words, the problem with this method is that wasteful work is performed.

The newly developed VDVP can vary the discharge capacity, eliminating the excess oil that needs to be released in conventional pumps. In addition, the use of two springs enables the oil pressure to be controlled in two stages from low engine speeds. This improves fuel efficiency by 2% compared with conventional pumps in the mode fuel economy range (40% power consumption reduction).

In the future, Hitachi will continue to enhance its product lineup to meet global customer needs.

(Hitachi Automotive Systems, Ltd.)

(Start of mass production: October 2014)

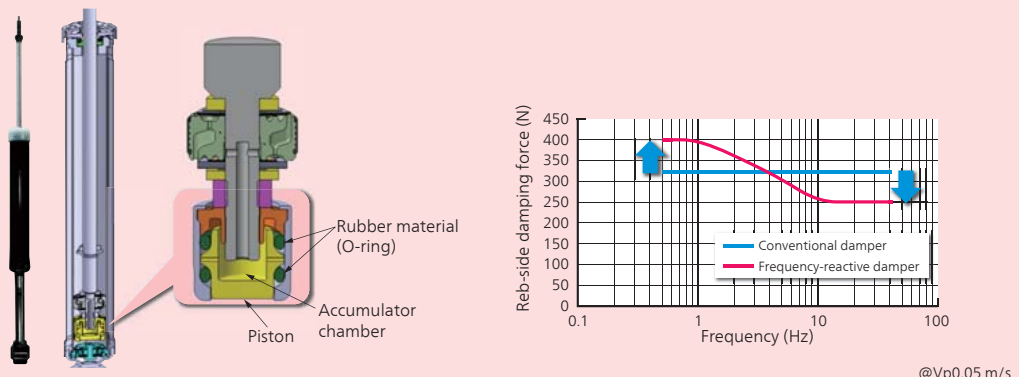
6 Frequency-reactive Damper

A recent trend in vehicles is the adoption of tires with larger diameters and lower profiles, and environmentally conscious tires with higher rigidity. This has resulted in reduced ride comfort due to the uncomfortable vibrations (harshness) that are transmitted to the vehicle when driving on variable road surfaces. However, it is difficult for conventional dampers to restrict the large low-frequency bouncing movements of the vehicle (by increasing the damping force) and to stop the uncomfortable high-frequency vibrations that are transmitted from the road surface (by reducing the damping force) at the same time.

Hitachi has started to mass produce frequency-reactive dampers that can both restrict and stop vibrations by changing the damping force according to the vibration frequency. This is achieved using a mechanical structure, without using electronic control. A piston-type accumulator chamber is installed within the oil passage of the damper, and both spring and sealing functionality is provided with a simple rubber material. This achieves variable damping force characteristics with minimal discomfort, and enables the mechanism to be made more compact.

In the future, Hitachi will meet customer needs by further improving performance, enhancing the product lineup and applying the technology to more vehicle types (expand to compact vehicles).

(Hitachi Automotive Systems, Ltd.)



6 Frequency-reactive damper

Item	Specifications
Size (mm)	120×80×12
Weight (kg)	0.24
Average voltage (V)	3.7
Capacity (Ah)	5.2
Power density (W/kg)	5,000
Energy density (Wh/kg)	80

7 Prismatic lithium-ion battery cell and specifications

7 Prismatic Lithium-ion Batteries for Hybrid Vehicles

Hitachi Automotive Systems, Ltd. will supply prismatic lithium-ion battery cells with a high power density of 5,000 W/kg for the new model Chevrolet Malibu Hybrid to be sold by General Motors Company in 2016. The batteries are manufactured by Hitachi Vehicle Energy, Ltd.

These prismatic lithium-ion battery cells conform to high safety standards while achieving a high power density of 5,000 W/kg by using a heat-resistant separator that ensures ion conductivity between the positive and negative electrodes of the battery cell. Evaluations have also shown that these batteries maintain their high power density even under cold conditions of -30°C, which was a reason for their adoption in this model.

In the future, Hitachi will further expand the global presence of these prismatic lithium-ion battery cells to respond to customer needs, as well as strengthen its electric power train products to contribute to the development of electric vehicles.

(Hitachi Automotive Systems, Ltd., Hitachi Vehicle Energy, Ltd.)

8 Android Onboard Device for Commercial Vehicles

Clarion Co., Ltd. released its new series of onboard devices for commercial vehicles in November 2014. These devices use the Android operating system (OS), which enables a wide range of applications to be added depending on the type of business, and are installed on a platform that is tough and durable. Clarion responded to strong demand from the market for commercial vehicle onboard devices with such features.

The main features are as follows.

(1) Supplies accurate positional information using external navigation control and multiple sensors, and a tough and durable design can withstand continuous use 24 hours a day, 7 days a week.

(2) A software development kit is provided to simplify the development of third-party applications.

(3) Can be used for communicating data with a center that uses the driving log acquisition function (positional information, time, vehicle data, etc.) required for safe driving analysis and movement management, and to support business management by storing driving logs in universal serial bus (USB) memory.

(4) The car navigation and Internet protocol (IP) wireless functions are integrated by connecting a USB stick-type data communication device and a push-to-talk (PTT) microphone.

In the future, Clarion will continue to apply its know-how in business-use car navigation to develop onboard devices for commercial vehicles that support safe and economical driving, as well as business efficiency.

(Clarion Co., Ltd.)

8 Android onboard device for commercial vehicles

Consumer Appliances

1 Top-loading washer dryer [BW-D11XWV (N)]

1 Top-loading Washer Dryer

Hitachi has released the top-loading washer dryer (BW-D11XWV), which is equipped with the high flow rate rinse program that completely removes detergent using a plentiful amount of water and centrifugal force.

The main features of the BW-D11XWV are as follows.

(1) Comes equipped with the high flow rate rinse program that completely removes detergent from fibers through high speed rotation (approximately 1,000 revolutions per minute), which produces a strong centrifugal force and a powerful shower flow with a circulating flow rate of approximately 50 L/min.

(2) Comes equipped with a warm high flow rate circulation wash cycle with enhanced washing capability that fully utilizes the enzyme power of the detergent by adding a warm mist function for warming up garments for the high flow rate circulation wash. This ensures that even laundry with stubborn stains comes out strikingly white. Selecting the 120-minute warm mist course completely removes even yellowing from garments.

(3) Parts inside the washing tub have been slimmed down and the top part of the tub has been redesigned to achieve a washing capacity of 11 kg without changing the size of the unit. In addition, the glass top design includes a lid made from tempered glass that is free from scratching, and is flat for easy cleaning.

(Hitachi Appliances, Inc.)

2 High-power Cyclonic Cleaner, Paper Bag Vacuum Cleaner

Hitachi has released the high-power cyclonic cleaner (CV-SC700) equipped with the "Jet Suction Smart Head" and the paper bag vacuum cleaner (CV-PC500).

The main features of the CV-SC700 are as follows.

(1) Using a newly developed "Jet Suction Smart Head" it achieves both strong suction power and light, smooth operation.

(2) Achieves strong power with a suction work rate*1 of 430 W through a compact and lightweight high-power fan motor and a high-power cyclone structure.

(3) Comes equipped with various unique functions that make the vacuum cleaner easy to use, such as a "One-Touch Zoom Pipe" which makes the pipe length easily adjustable.

The main features of the CV-PC500 are as follows.

(1) The newly developed high-performance compact motor achieves strong power with a suction work rate*1 of 360 W, while maintaining a low operating sound of 57 dB*2.

(2) Components such as the advanced dust collection filter and airtight motor case ensure clean exhaust (99.999% collection efficiency*3).

(3) The vacuum cleaner has been made compact and lightweight

2 High-power cyclonic cleaner [CV-SC700 (R)] (top), paper bag vacuum cleaner [CV-PC500 (N)] (bottom)

by giving the unit a compact design and using a proprietary lightweight material.
(Hitachi Appliances, Inc.)

*1 The maximum value for the suction work rate is given, under the guidelines for suction power specified by JIS standards. The dust collection performance during operation depends not only on the suction work rate, but also on differences in terms of factors such as the type of suction tool, the degree of dust accumulation, and the flooring material.
*2 Operating sound measured under JIS C 9108.
*3 Test dirt: air cleaner (AC) test dust (fine), test organization: SLG Prüf-und Zertifizierungs GmbH (Germany), test method: measured amount of discharged dust with size of 0.3 to 10 μm, test result: 99.999% collection efficiency (average).

3 Superheated Steam Microwave Oven

Hitachi has released the health conscious superheated steam microwave oven (MRO-RY3000), equipped with a double scanning system that measures both the food temperature and weight (including the dish). This reduces heating unevenness when heating or defrosting*1.

Previous products*2 heated automatically after measuring the food weight (including the dish) with three weight sensors, but this product is also equipped with a center infrared sensor that measures the food temperature. This reduces heating unevenness when heating or defrosting caused by differences in the initial temperature of the food. In terms of ease of use, a large window is used, and the inside of the microwave is white and lit with an light-emitting diode (LED) to produce a bright interior where the stewing condition or roasting color of the food is clearly visible. The oven design also makes cleaning easy. The white interior oven surface is treated so that adhering grime is easy to see and wipe off, and the table plate at the bottom of the oven can be removed and washed.
(Hitachi Appliances, Inc.)

3 Superheated steam microwave oven [MRO-RY3000 (R) (top), (S) (bottom)]

*1 Cooking results vary due to factors such as the shape of the food, interior temperature, and dish.
*2 Previous Hitachi product MRO-NY3000 (2014 model).

4 "Vacuum Compartment" Large Capacity Refrigerator

Hitachi has released the "Vacuum Compartment" refrigerator series (such as the R-X7300F with rated interior capacity of 730 L). This series uses a platinum catalyst that breaks down odors and generates carbon dioxide in a vegetable compartment that preserves vegetable nutrients and freshness, and in a vacuum-chilled compartment that minimizes food oxidation and preserves freshness through vacuum power.

The main features of the R-X7300F are as follows.
(1) A platinum catalyst jointly developed with Hokkaido University for home-use refrigerators breaks down ethylene gas and odors, and generates carbon dioxide. This raises the concentration of carbon dioxide around the vegetables, reducing their respiration activity. As a result, wherever the vegetables are stored in the vegetable compartment, the "Photocatalyst Preservation" function preserves the vegetables as if they are sleeping, protecting their nutrients.
(2) The platinum catalyst is also used in the vacuum-chilled compartment, which breaks down odors from meat and fish and increases the carbon dioxide concentration inside the compartment. This reduces the effects of enzymes on the surface of meat and fish. As a result, the "Photocatalyst Preservation" function preserves the food as if it is sleeping, and the nutrients and freshness of the meat and fish are protected by storing them in a vacuum pressure of approximately 0.8 atmospheres.
(3) When using the refrigerator model with the industry's largest rated interior capacity of 730 L, there is ample space to store food

4 "Vacuum Compartment" large capacity refrigerator [R-X7300F (ZT) (left), vegetable compartment (top right), vacuum-chilled compartment (bottom right)]

bought in bulk on the weekend or received by a delivery service, and even large items can be stored whole.
(Hitachi Appliances, Inc.)

5 LED Ceiling Light for Home Use

Hitachi has released four models of LED ceiling lights equipped with a new additional light function*1 that brightly illuminates all corners of a room from the ceiling to the walls, making the room feel more spacious.

The main features of the spacious light models are as follows.

(1) Comes equipped with a new additional light function that brightly illuminates all corners of a room from the ceiling to the walls, in addition to a wide lighting function that uses a lens to maximize the range of brightness to suit the size of the room*2. The LED light at the top of the fixture shines toward the ceiling and walls, giving bright light to locations that are difficult to reach for conventional lights. This reduces imbalances between light and dark in the room and makes the room feel more spacious.

(2) When the easy viewing function button on the remote controller is pressed, the brightness increases by approximately 1.2 times compared to a fully lit room, and the easy viewing function LED also illuminates*1. Blue and green light components, which are slightly lacking in conventional LED lights, are added to the fully lit LED lights to produce wavelengths closer to natural sunlight. This makes small text appear more clearly, and the color of photographs seem more vivid and with higher contrast.

(3) The lineup includes products with the industry's highest light intensity*3 of 10,000 lm (for 33-m² or larger*4 rooms). The three models for 13-m², 20-m², and 23-m² rooms deliver the maximum standard brightness for each room size*2. In terms of energy saving performance, 137.7 lm/W*5 or higher is achieved in all models.

(Hitachi Appliances, Inc.)

*1 Power consumption higher than normal fully-lit (rated) level.
*2 Under the "Residential Catalog Applicable Room Size Standards" (Guide 121:2011), issued by the Japan Lighting Manufacturers Association.
*3 As of September 2015, compared with LED ceiling lights sold in Japan.
*4 Standard for 33-m² or larger room type model, set by Hitachi Appliances, Inc.
*5 The energy saving performance expresses the energy consumption efficiency. The energy consumption efficiency is calculated as rated luminous flux divided by rated power consumption.

5 LED ceiling light equipped with additional light

6 Inverter Pump for Home Use

Hitachi has released an inverter pump (WM-P250X) for shallow wells and pressurized water supply that uses a bladder tank system*1. Through the use of components such as a pump head and high performance motor, this delivers high energy savings and minimizes noise.

The main features of the WM-P250X are as follows.

(1) Comes equipped with components such as a high efficiency pump head with newly-designed flow channels that reduce water flow resistance, and a high performance interior permanent magnet (IPM) motor dedicated to the pump. This delivers energy saving performance of 350-W power consumption, and low noise performance of 40-dB operating sound.

(2) Comes equipped with Hitachi's proprietary Karman vortex ultrasonic flow sensor, which monitors the water flow in the internal flow channels of the pump. This enables the new adoption of smart controls to detect cavitation*2 that causes reduced efficiency and water supply fluctuations, and adjust operations to the optimum level. This reduces wasteful power consumption and achieves stable water supply.

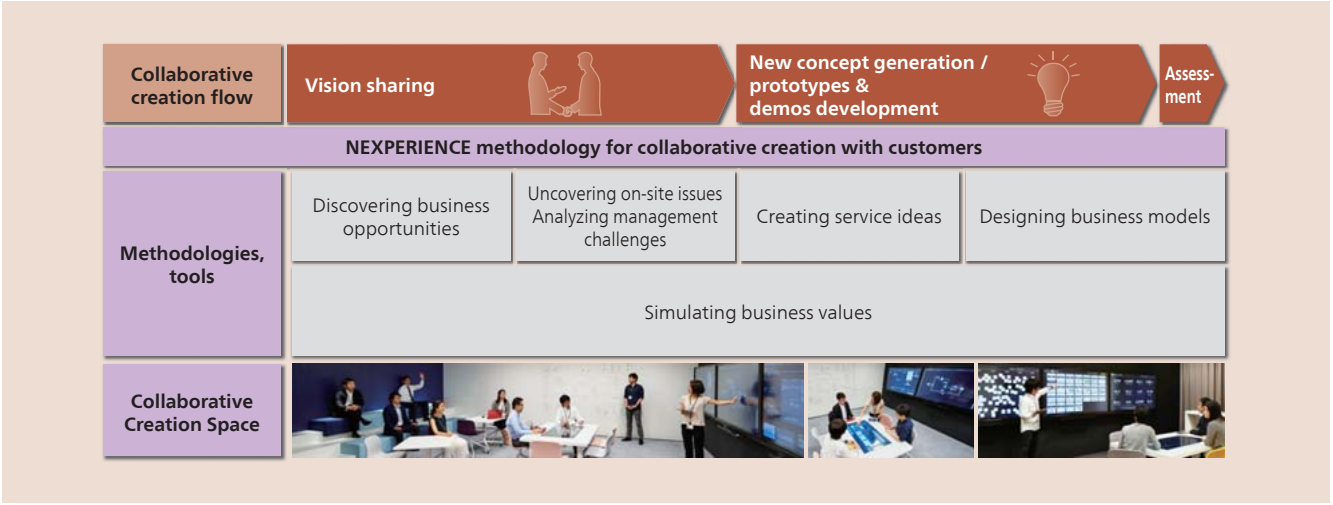
(3) Operational wear is greatly reduced because the high pressure area inside the casing of the pump head is equipped with a wear-resistant and elastic casing made from a new elastic elastomer material that is resistant to sediment wear.

(Hitachi Appliances, Inc.)

*1 A pump using a pressure tank with a structure that seals nitrogen between the outer shell and a movable rubber film (bladder).
*2 Phenomenon when bubbles occur in intake pipes or intake flow channels when the water flow resistance is high and the flow speed is fast. This reduces the water supply volume and causes vibration and noise in the pump.

6 Inverter pump for shallow wells and pressurized water supply (WM-P250X)

Collaborative Creation with Customers



1 Methodologies, tools, and Collaborative Creation Space that form part of the NEXPERIENCE collaborative creation methodology

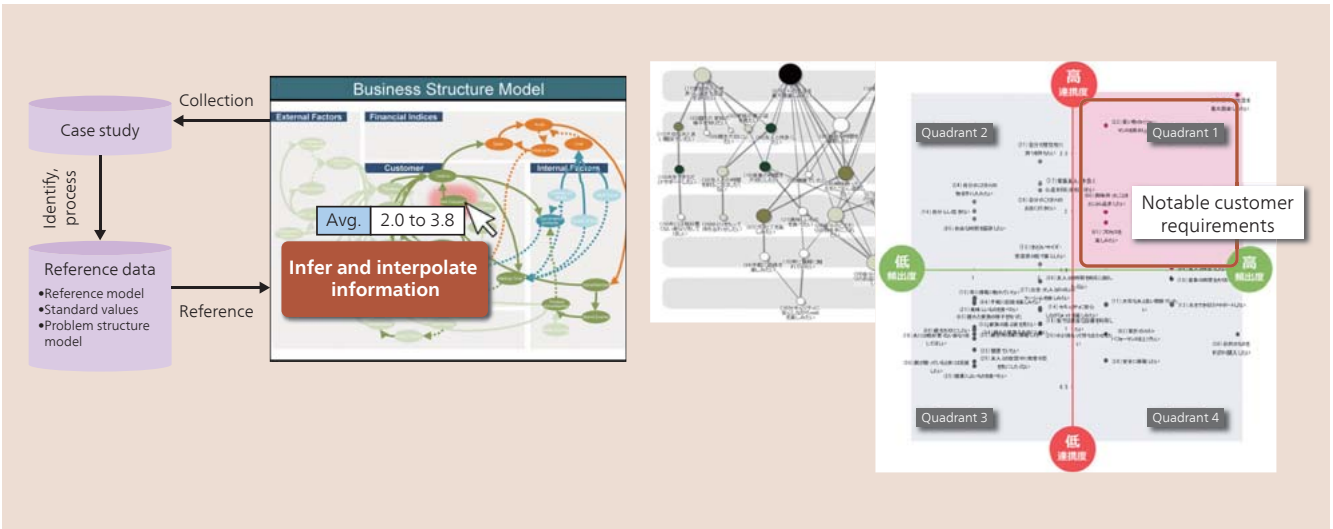
1 Collaborative Creation with Customers Establishment of NEXPERIENCE

The transformation of manufacturing into a service industry is growing. In its Social Innovation Business, Hitachi is required to create acceptable service businesses by analyzing and evaluating the profitability and feasibility of multiple stakeholders. However, a holistic investigation of complex issues is difficult with conventional methodologies and tools.

Therefore, NEXPERIENCE has been systematized and information technology (IT) tools have been developed to conduct collaborative creation for service businesses while visualizing ideas in multiple perspectives based on knowledge from customers and partners.

NEXPERIENCE covers a wide range of phases from discovering business opportunities and designing business models, to simulating business value in order to satisfy customers' goals. And Hitachi has built the Collaborative Creation Space in Akasaka (Tokyo) that supports NEXPERIENCE activities. Through methodologies, tools, and a Collaborative Creation Space that promote a series of collaborative creations, it is capable of accelerating the Social Innovation Business and increasing the ratio of promising service businesses by carrying out intensive and high-quality discussions in a short period of time.

It is essential to increase the number of people able to use them, and apply them on actual business projects. Furthermore, expanding NEXPERIENCE to locations outside Japan has been planned to foster the Social Innovation Business globally.



2 Screens used for identifying business challenges and structured analysis of user requirements

2 Methods for Visualizing Customer Value from Individual and Management Perspectives

The era of the Internet of things (IoT) will make it possible to collect data from a wide variety of devices at a level of granularity that was inconceivable in the past, and many companies see this as increasing the scope for business improvement and new business opportunities. In this current period of transition, however, not only are there few cases in which sufficient data can be collected and stored to enable its use for management and business analysis, but workplace analysis is also made difficult by the complications of human factors, such as people's values and emotions, which are not available as electronic data. Whereas past practices have included workplace analysis techniques for observing business workplaces and identifying the sort of problems that are otherwise prone to being overlooked, as well as methods for the visualization of issues in all parts of the organization and their impact on operations, the burden that this data collection places on the customer is a problem.

In response, Hitachi has developed and implemented a method for identifying business challenges that facilitates the obtaining of information about business conditions from the customer, even from a limited amount of information, and a structured analysis method for user requirements that uses questionnaires as a basis for collating customer requirements and identifying which requirements have the highest priority.

In the future, Hitachi intends to further enhance practices for the collaborative creation of services and other solutions that satisfy customers from the perspectives of both workers and management.

3 Collaborative Creation with Customers of Smart Branch Solution for Banks

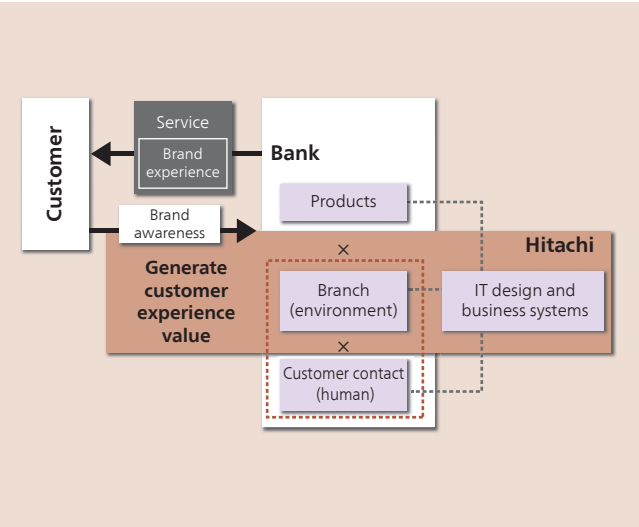
Along with the growth of "Internet finance," the banking industry is under pressure from the increasing pace at which the industry is opening up and interest rates are being deregulated. Banks have come to place an emphasis on using business innovation to improve customer service and profitability. Working with partners in the finance sector in China, Hitachi has developed a smart branch solution for banks through joint innovation with its customers in the industry.

The solution utilizes branch design and an IT solution to provide self-service tools, security plans, and precision marketing plans. In addition to improving the bank's brand image, the efficiency of branch (outlet) operation, and marketing, these features also increase customer satisfaction.

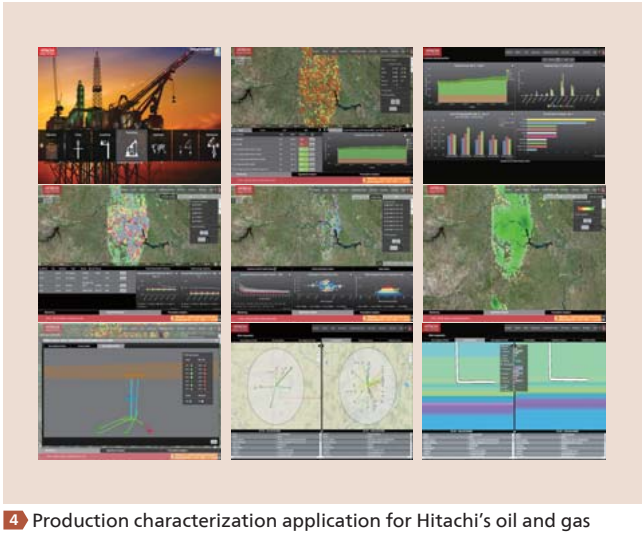
4 Customer Collaborative Creation Activities at Digital Oil Field

Disruptive innovation in an unconventional oil and gas industry such as the shale industry offers a promise to change the world's economies. Advances in technologies including horizontal directional drilling and hydraulic fracturing technologies have fueled growth in the industry. However, oil and gas industry operators are facing tough business challenges. Shale sub-surface geology presents challenges in terms of proper characterization. Operators want to maximize production output from their acreage through assembly-scale operations. The orthodox approach of modeling the shale upstream operations has proven inadequate. Big data technologies can augment traditional methods in developing a deep understanding of the shale oil and gas operations to address the challenges faced by operators in a holistic way.

Hitachi has evolved an approach to prioritizing and understanding such customer challenges through voice-of-customer surveys. Collaboratively creating and collaboratively evolving the lifecycle of the solution with customers as the focus has been championed by Hitachi's oil and gas analytics technology. Hitachi's oil and gas analytics solution is uniquely positioned to address the ability to incorporate data from across the entire suite of upstream processes and provide a full suite of descriptive, predictive and prescriptive analytics to its customers. The robust architecture allows scalable solutions to be deployed securely. Working closely with Hitachi's partners and business units, Hitachi's Big Data Laboratories are rapidly furthering the development of Hitachi's oil and gas analytics solution as well as engaging multiple customers to enhance the solution.



3 Concept behind smart branch solution for banks



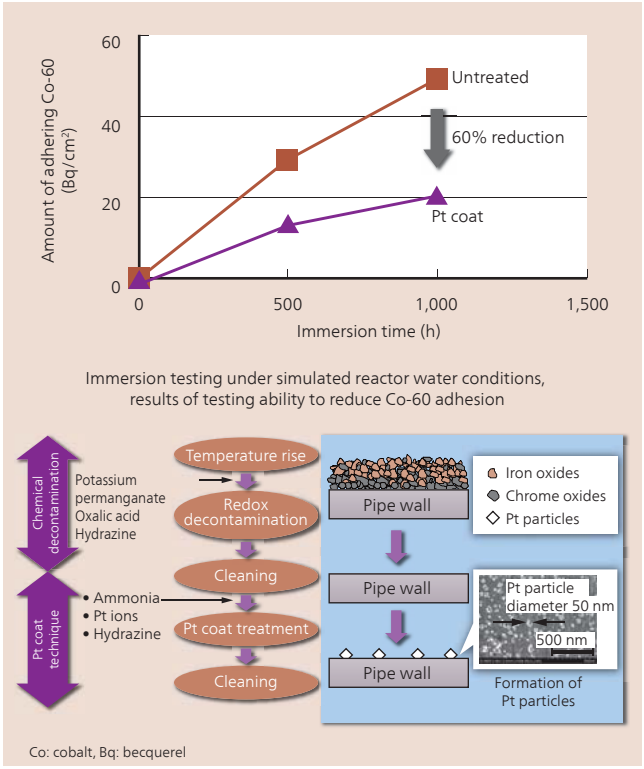
4 Production characterization application for Hitachi's oil and gas analytics solution

Technology Innovation

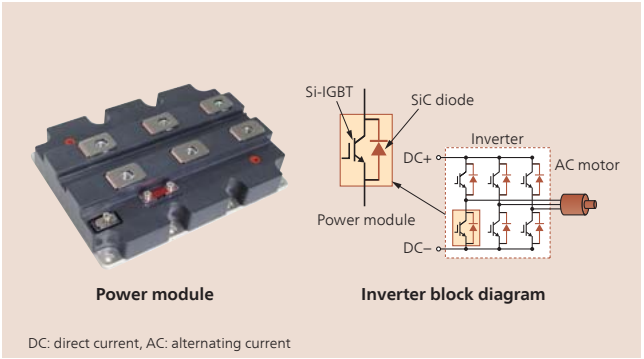
1 Pt Coat: Pt Coating Technique for Inner Surface of Pipes at Nuclear Power Plants

Reducing worker exposure to radiation is one of the obligations of a nuclear power plant. The formation of an oxide layer on the inner surface of the pipes that circulate hot reactor water can trap radioactivity from the water, resulting in the emission of radiation from the pipes. The practice adopted in response to this is to use chemical decontamination to remove this layer prior to major maintenance work. Unfortunately, because the oxide layer reforms and the radiation level around a pipe rises once more after operation resumes following chemical decontamination, the decontamination process needs to be repeated. A study into techniques for slowing the formation of the oxide layer to reduce the frequency of decontamination found that tiny particles of platinum (Pt) acted as a catalyst for dissolving the oxides. Accordingly, Hitachi has developed Pt coat, a technique for coating the inner surface of pipes with these Pt particles prior to restarting operation after decontamination. Laboratory testing demonstrated a reduction in the adhesion of radioactivity, and the practical viability of Pt coat was confirmed in a 1:20 scale model.

In the future, Hitachi intends to help reduce worker exposure to radiation by deploying the technique in actual plants.



1 Results of testing to demonstrate the ability of Pt coat to reduce the adhesion of radioactivity (top) and overview of Pt coat treatment procedure (bottom)



2 3.3-kV/1,800-V SiC/Si hybrid power module

2 3.3-kV/1,800-A Hybrid Power Module for Rolling Stock

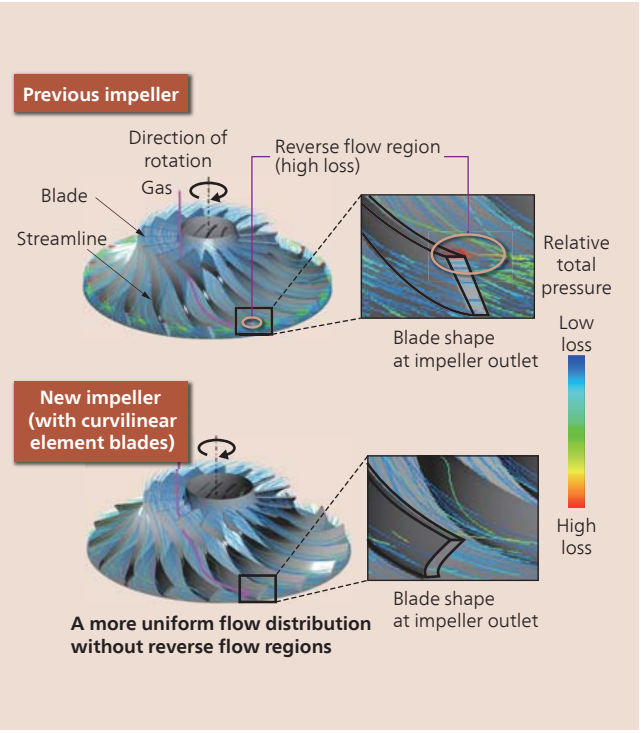
Hitachi has developed a heavy duty 3.3-kV power module for rolling stock that uses silicon carbide (SiC) semiconductor devices. Power modules are used as components in electric power conversion systems such as inverters. Conventionally, they have been built using insulated-gate bipolar transistor (IGBT) and diode switching devices made from a silicon (Si) semiconductor.

Hitachi jointly developed SiC diodes rated for 3.3 kV with Hitachi Power Semiconductor Device, Ltd. and used them to build a SiC/Si hybrid power module. As SiC/Si power module is lower energy loss compared to Si power module, it can carry a heavier current density with minimal heat generation. This made it possible for a 1,800-A module to have the same size as a previous 1,500-A module (20% improvement). It has also halved switching losses compared to inverters built using previous Si modules. Use of these technologies has succeeded in providing highly efficient motor control together with an approximate 40% reduction in power use by rolling stock compared to previous models.

3 Curvilinear Element Blade Design Technique for More Efficient Centrifugal Compressors

Improvements to the efficiency of the centrifugal compressors used in industrial plants to pressurize and pump gas are needed to cut operating costs. The key components of a centrifugal compressor are its impeller blades. Hitachi has developed a design technique for improving efficiency by stabilizing the flow through the impeller blades up to the point where flow separation occurs.

The technique combines a multi-objective optimization algorithm capable of optimizing a large number of design parameters at high speed with a method for defining curvilinear element blade shapes in centrifugal turbomachinery that uses only 10 parameters and provides detailed control of blade surface



3 Comparison of streamlines in impeller and blade shape at impeller outlet

curvature. This combination enables the rapid design of highly efficient blade shapes that minimize reverse flow through the impeller blades.

This has resulted in the development of centrifugal compressors with curvilinear element blades that have 2.4% higher efficiency than previous models.

Hitachi plans to apply the technology for a wide range of different centrifugal compressors in the future.

4 Use of X-ray Phase Imaging for Realtime Analysis of Ion Concentration during Charging and Discharging of Lithium-ion Batteries

Hitachi has developed a technique for the realtime analysis of the distribution of electrolyte ion concentration during charging and discharging of lithium-ion batteries. The technique uses X-ray phase imaging, an effective imaging technique for light elements that uses phase changes to measure the distribution of ion concentration in the electrolyte resulting from the flow of lithium ions during charging or discharging. The measurements found that the distribution of ion concentration in the electrolyte sandwiched between the cathode and anode is inclined toward the cathode while charging, and that this non-uniformity does not immediately disappear after charging is complete. While a lack of appropriate design methods in the past has made the dynamic behavior of ions in the electrolyte during charging and discharging an entirely "black box" process, the knowledge of the associated inclining of the ion concentration distribution obtained by these measurements will be important for the development of batteries for automotive applications that feature repeated rapid charging and discharging.

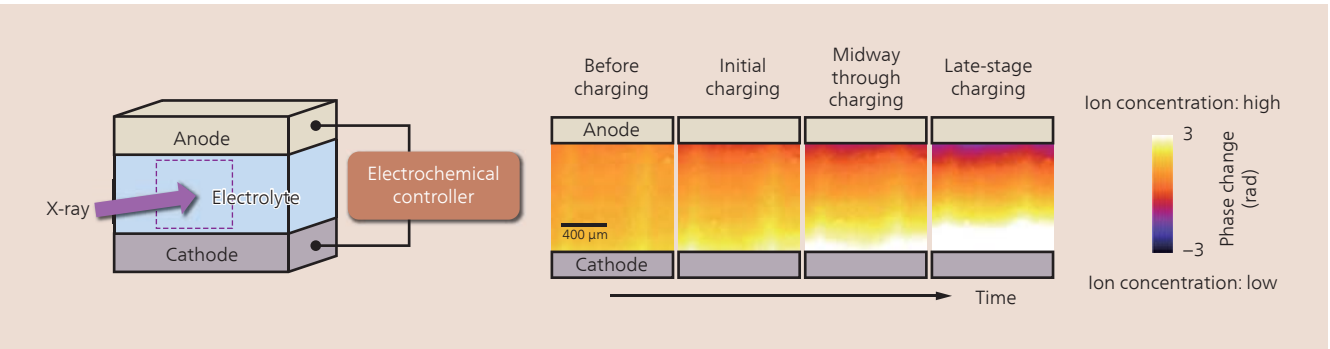
In the future, Hitachi intends to use the technique to help develop high-output batteries by analyzing the movement of ions in lead-acid batteries as well as lithium-ion batteries.

5 Platform Technology for Realtime Data Analysis for the Internet of Things

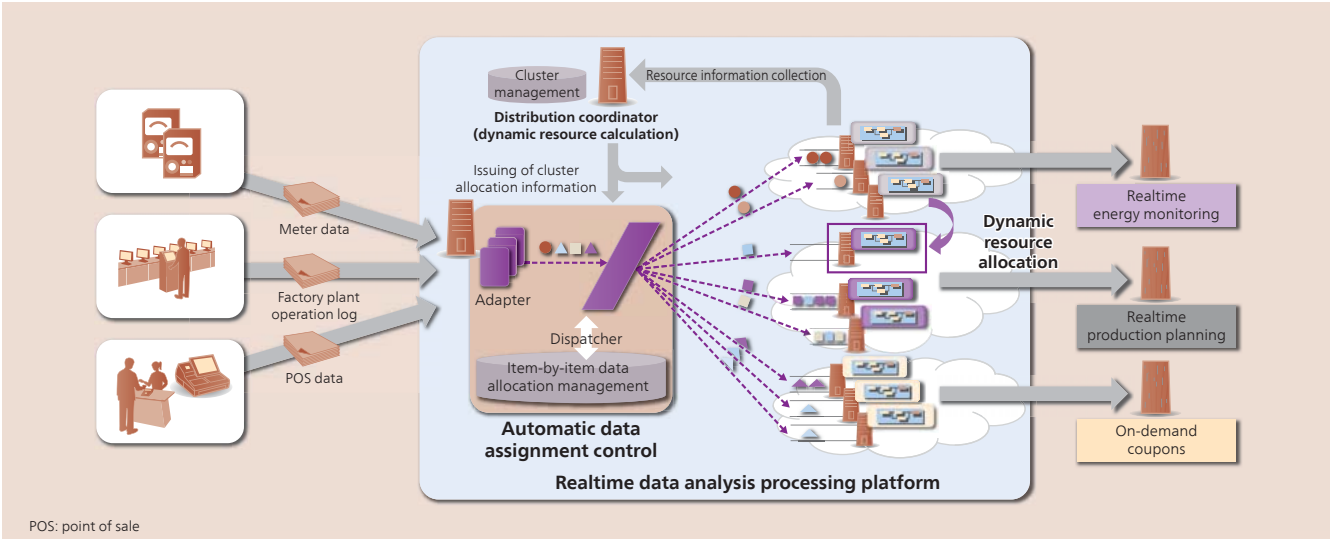
The growing uses in business for data from the Internet of things (IoT), such as sensors and other devices, are creating increased demand for a focus on individual movements and the realtime analysis of data to prompt business actions. Along with business changes that occur on a daily basis, realtime data analysis is subject to frequent changes to the processing design (the quantity and type of data collected and the modification or augmentation of analyses) and to system resources in response to the processing requirements. However, because the required resources and data allocation for individual items are complicated by increases in data and processing workloads, making rapid changes to system resources is difficult.

In response, Hitachi has developed a platform technology for realtime IoT data analysis that dynamically calculates server resources based on the level of load, such as the quantity of data held for each analysis, and automatically determines where to assign the data for each item based on the extent to which allocated resources are being used. The technology automates resource allocation and data assignment in the system design (which is more complex) in accordance with the processing requirements, and makes it easy to expand the system by adding servers.

In the future, Hitachi aims to implement solutions that speed up every step along the value chain from processing design to system configuration by developing modeling design methods that use flowchart representations to facilitate changes to the analysis as well as system expansion.



4 Use of X-ray phase imaging for realtime analysis of ion concentration



5 Realtime data analysis platform

6 UPS for Long-duration Backup with Hot Swapping of Batteries

The progress of the information society has increased the importance of ensuring that information technology (IT) equipment has a reliable supply of electric power. There is demand for uninterruptible power systems (UPSs) that prevent loss of data from power outages to deliver higher reliability and longer backup times. Responding to these demands requires the development of highly reliable UPSs that allow batteries to be replaced without halting the supply of electric power (hot swapping).

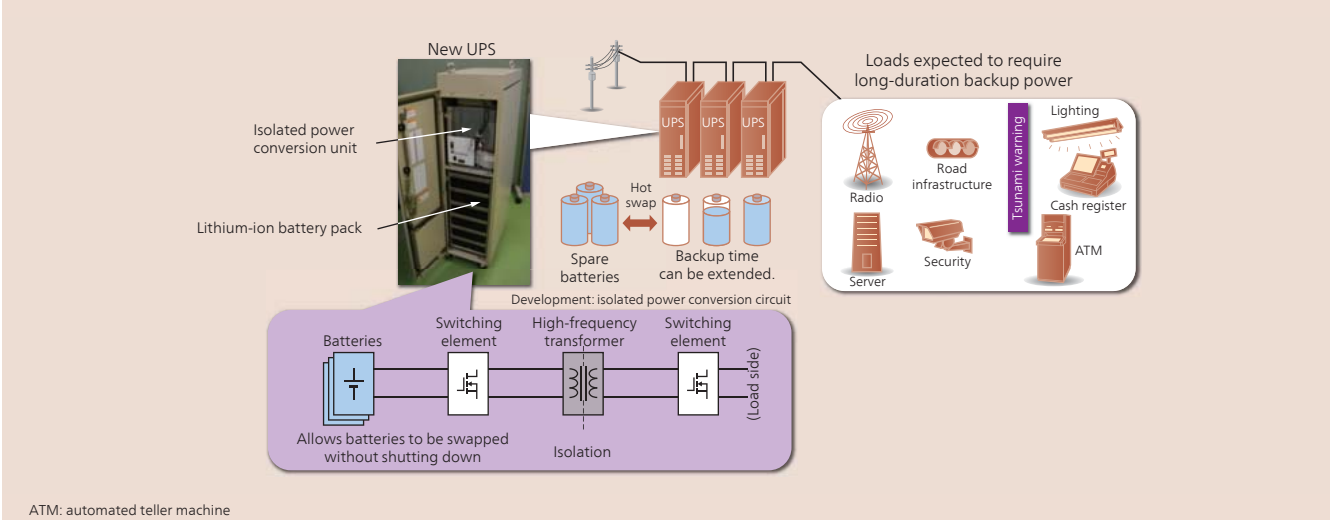
Hitachi has recently developed a UPS that uses an isolated power conversion technique to isolate the mains power grid and batteries from each other. The isolated power conversion circuit achieves its hot swapping capability by using a high-frequency transformer and incorporating a control algorithm for initiating battery discharge as soon as a power outage occurs. By using a number of UPSs to supply power in turn, the backup power supply can be maintained for a long period of time by progressively swapping batteries.

In the future, Hitachi intends to utilize the features of the new isolated-battery UPS to deploy it in applications such as commercial buildings or for wireless base stations and other communication infrastructure.

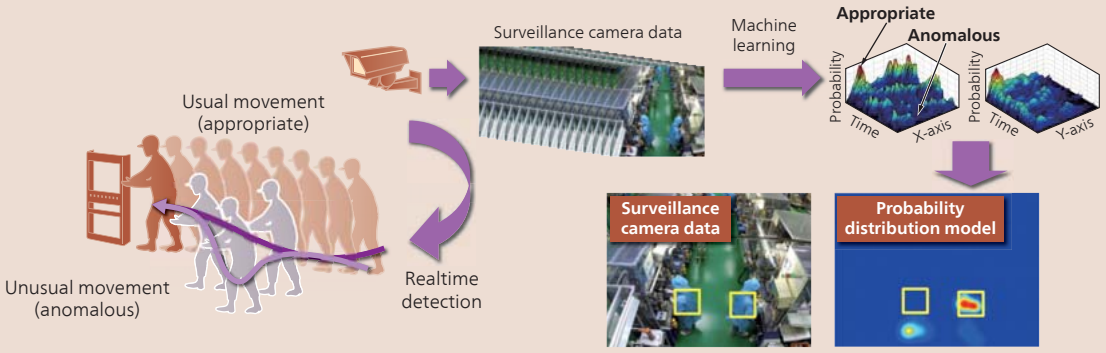
7 Worker Activity Monitoring and Anomaly Detection Technique Based on Big Data Analysis of Surveillance Camera Data

The growing use of close-to-market production means that improving the quality of locally produced products has become an urgent challenge. In particular, there are concerns about the thoroughness of education, instruction, and monitoring of workers at assembly plants in emerging economies where use of manual labor to minimize capital expenditures is common practice.

In response, Hitachi has developed an anomaly detection technique for monitoring work-flow-line and movement of assembly workers with the aim of preventing the outflow of defects caused by work. The technique uses statistical analysis to generate a probabilistic model of appropriate worker movements based on big data from assembly work captured on camera, and then uses this model to detect anomalous work in realtime. In



6 Long-duration UPS that enables hot swapping of batteries



Work anomalies are detected by comparing worker location against a probability distribution.

7 Concept behind technique for worker activity monitoring and anomaly detection

addition to providing the detection results to workers and supervisors as feedback, they are also utilized in analyses that include product quality data to help improve the quality of local products.

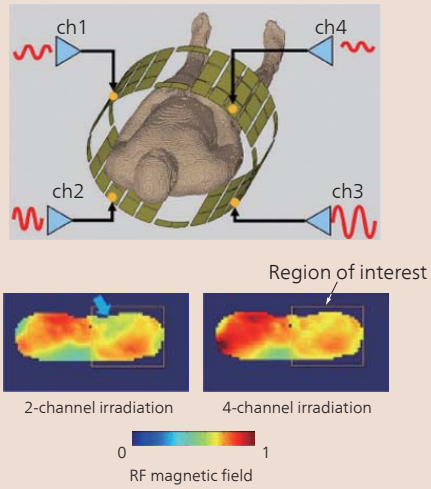
Along with extending use of the technique to in-house manufacturing divisions in the future, Hitachi also intends to commercialize it in the form of a product quality cloud service for external customers in the automotive, precision machinery, and other industries.

8 RF Transmission for High-magnetic-field MRI with Four Independent Channels

Higher magnetic field strengths have been a feature of magnetic resonance imaging (MRI) system development over recent years. The improved image signal-to-noise (SN) ratio on MRI system with a field strength as high as 3 T has the potential to provide better image quality and a wider range of functions. However, because the radio frequency (RF) is proportional to the magnetic field strength, this brings problems such as image distortion due to poor uniformity in the RF magnetic field distribution, and an increase in the specific absorption rate (SAR) (a measure of how much RF is absorbed by the body).

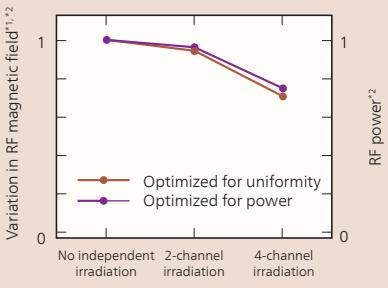
To overcome these problems, Hitachi has developed a technique for RF transmission with four independent channels. It features independent control of the amplitude and phase of the RF waveforms applied to each channel of the RF transmission coil. The technique improves the uniformity of the RF magnetic field in the region of interest. It also has the potential to reduce the SAR by reducing the transmitted RF power.

Hitachi intends to continue contributing to the development of core technologies for various types of imaging using high-magnetic-field MRI, including ongoing work on image evaluation.



Simulation of RF magnetic field distribution cross-section of shoulder joint and surrounding area. In a diagnostic scan of a shoulder joint, use of four channels improved the RF magnetic field strength in the region where it was low (indicated by blue arrow).

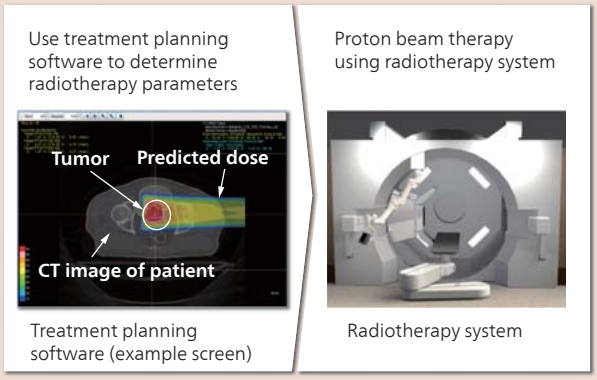
The system splits the RF transmission coil into four independent channels. The distribution of the RF magnetic field inside the body is controlled through independent control of the amplitude and phase of the RF waveforms sent to each channel. This provides greater flexibility in the generated RF pattern (combination of amplitude and phase) than the previous two-channel method.



Changing from two to four channels improves RF magnetic field uniformity and enables the power to be reduced.

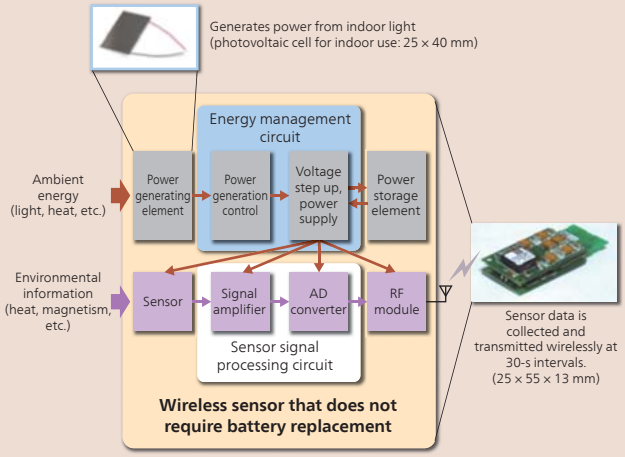
*1 Standard deviation/mean value of RF magnetic field
*2 Normalized, with variation when no independent control used = 1.0

8 RF transmission system with four independent channels



CT: computed tomography

9 Treatment planning software for proton beam therapy system



AD: analog-to-digital

10 Wireless sensor that does not require battery replacement

9 Faster Dose Distribution Calculation for Treatment Planning Software Used with Proton Beam Therapy System

Hitachi is able to provide precise radiotherapy thanks to the development of a technique that concentrates the dose on the tumor by scanning a narrow beam over its shape, and by combining it with a tumor-tracking technique that tracks the movement of the tumor during therapy. As the treatment planning system (TPS) software uses simulation to optimize the beam scanning path and dose, two important parameters for this scanning radiotherapy method, it requires accurate calculation of the dose distribution inside the patient's body. While the Monte Carlo (MC) method, which achieves precise calculation by simulating the behavior of individual proton beams, is one way to calculate the dose distribution, general-purpose MC tools are impractical for TPS use because they take several hours to complete the calculation for a single patient.

Hitachi has now developed a high-speed dose distribution calculation that uses an enhanced MC method. The new method shortens the calculation time to a few minutes without compromising accuracy by restricting the MC analysis to the scattering that determines accuracy, using modeling for other physical processes such as nuclear reactions. It will be incorporated into the TPS in the future.

10 Wireless Sensor that Uses Ambient Power to Eliminate Battery Replacement

The collection and use of sensing data have potential applications in overcoming a variety of societal problems. Unfortunately, battery replacement and other maintenance take a lot of work and are obstacles to the wider use of systems that collect data wirelessly from large numbers of installed sensors. In response, Hitachi has developed wireless sensors that can operate using the small amounts of energy available in the environment.

While solar-powered wireless sensors that do not require battery replacement are already available, they are restricted to outdoor use. By developing an ambient energy management circuit that can efficiently collect small amounts of energy from the environment and sensor signal processing circuits that operate on low levels of power without losing their high accuracy, Hitachi has made it possible to operate wireless sensors using indoor light (with only 1/500 the brightness of sunlight).

Hitachi has used the technology to build a prototype sensor for measuring the current drawn by industrial machinery and tested its ability to take measurements inside factories.

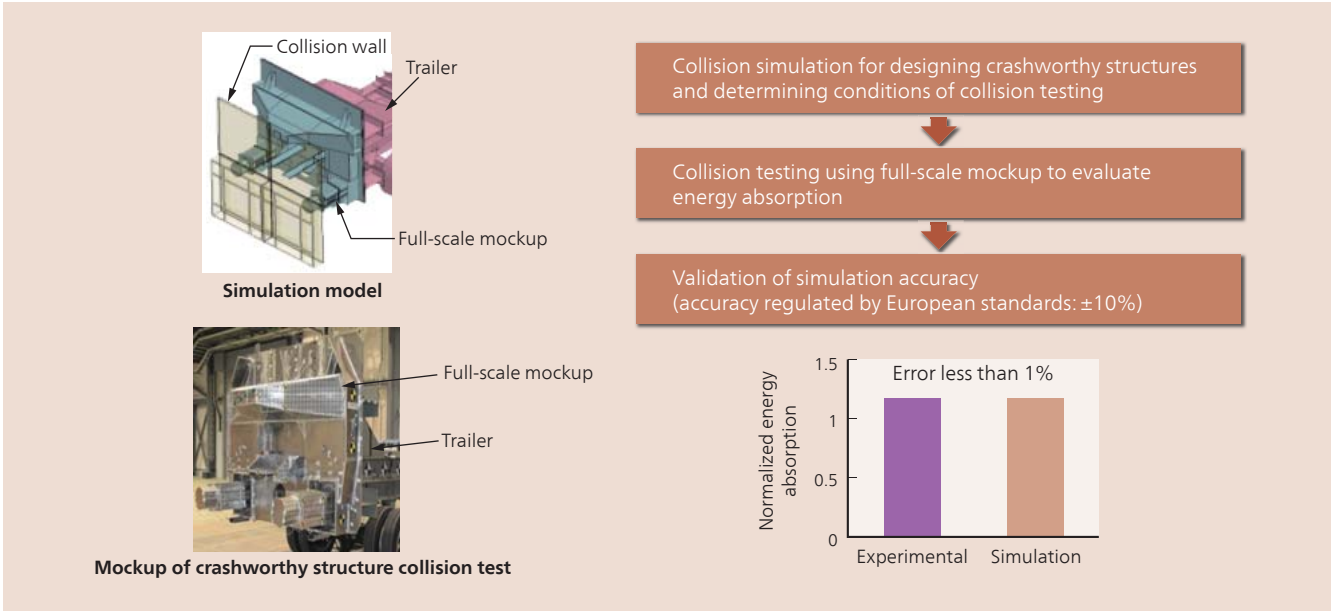
In the future, Hitachi intends to contribute to the provision of sensor solutions by utilizing the technology in applications such as the monitoring of industrial machinery and the use of beacons to monitor the movement of people.

This research was undertaken as part of a joint "The Sensor System Development Project to Solve Social Problems" by the New Energy and Industrial Technology Development Organization (NEDO).

11 Crashworthiness Assessment of Railway's Rolling Stock for Europe Using Full-scale Collision Test

In railway systems in Europe, a structure specified for absorbing collision energy by plastic deformation, called a "crashworthy structure," is deployed at the ends of the railway's rolling stock to comply with European standards that regulate the crashworthiness of rolling stock. For designing a crashworthy structure, the structural energy absorption must be evaluated by a collision test using a full-scale mockup of the crashworthy structure, and a collision simulation is required to validate its prediction accuracy with an error of less than 10%.

Accordingly, Hitachi developed a testing procedure in which the crashworthy structure is attached to a trailer and collided with a rigid wall, and also developed a collision simulation model that includes the test equipment. The collision simulation was performed prior to the testing to determine appropriate measurement points that would secure the collection of test data required to verify the simulation accuracy. Prediction accuracy with an error of less than 1% was validated with respect to energy absorption, which satisfied the accuracy regulated by European standards. It also succeeded in shortening the time taken for testing and reduced its cost by eliminating the need to repeat trial-



11 Use of full-scale collision testing to evaluate energy absorption performance

and-error testing.

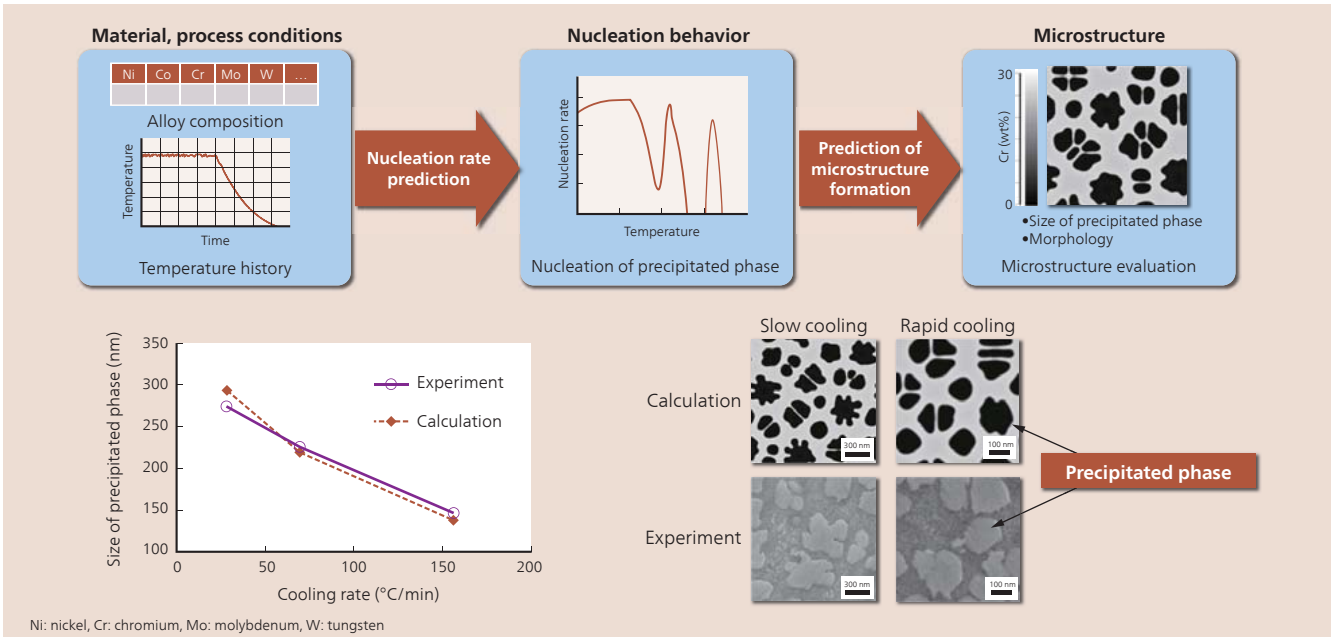
Hitachi is applying this testing method to the development of crashworthy structures of high-speed and commuter trains for Europe.

12 Microstructure Prediction Technique for Faster Alloy Design

As super heat-resistant alloys for use in turbines for aircraft engines or generators operate at high speed and are exposed to harsh environments with severe temperature changes, there is a need to improve their characteristics, including high temperature strength, creep strength, and low cycle fatigue strength. These characteristics are strongly correlated to the microstructure of the metal, as represented by parameters such as grain diameter and the size of precipitated phases. As microstructure varies significantly depending on factors such as material composition and manufacturing process, the design of alloys can be expedited considerably by using simulation to conduct preliminary studies prior to experimental testing.

The newly developed technique couples prediction of nucleation rate and microstructure formation to provide a visualization of the formation of the metal microstructure during heat treatment, something that is difficult to observe experimentally, enabling evaluation of factors such as the size and morphology of precipitated phases that influence mechanical properties. Calculations of precipitated phase size under different heat treatment conditions made using this technique agree with experiment to within 10%.

In the future, Hitachi intends to help shorten the time taken to design alloys by using microstructure parameters to predict mechanical properties.



Ni: nickel, Cr: chromium, Mo: molybdenum, W: tungsten

12 Method for predicting formation of microstructure under different heat treatment conditions

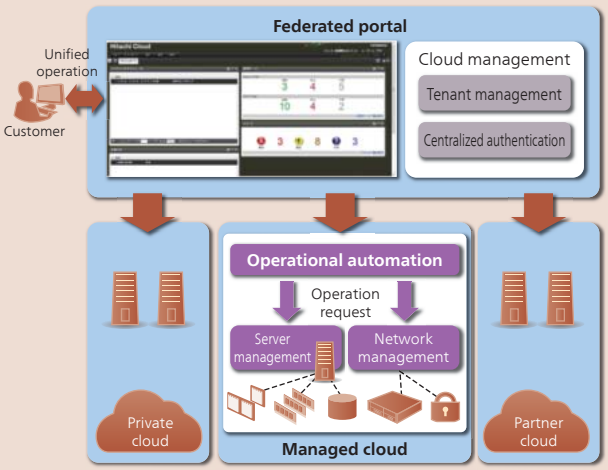
13 Next-generation Warehouse Incorporating AI and Robotics

Factors such as the expansion of the electronic commerce (EC) market on a global scale and more diverse consumer needs are making flexibility an important consideration for future distribution operations, along with efficiency. While there are problems with the flexibility of automated warehouses that use special-purpose equipment, placing an emphasis on manual labor limits efficiency.

In response, Hitachi has developed an artificial intelligence (AI) technique that provides both flexibility and efficiency by using big data collected from the workplace to control people and robots, and has set up a model for the warehouses of the future in collaboration with Hitachi Transport System, Ltd. This includes control techniques for manual work performed by an AI that updates its task model on a daily basis, control techniques for coordinating the work of people and automated guided vehicles, control techniques for autonomous mobile dual-arm robots that can perform picking in a similar manner to a person, and a cockpit that helps present details with an overview of operational and physical information for the large space controlled by these AIs and robots.

In the future, Hitachi intends to integrate these newly developed techniques to make further improvements to efficiency and flexibility, and to deploy them in other fields such as production and retail.

13 Operation of autonomous mobile dual-arm robot (top) and cockpit (bottom)



14 Overview of federated cloud technology

14 Technology for a Federated Cloud

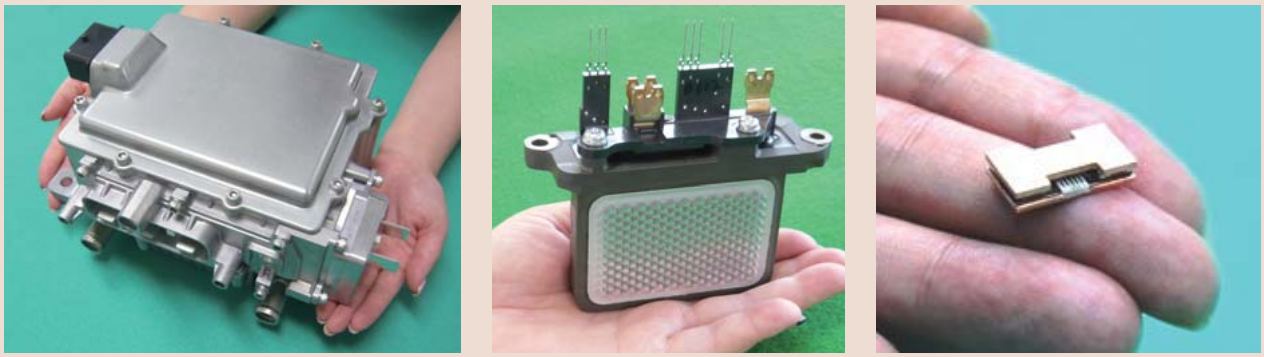
The use of various clouds provided by different cloud providers depending on customers' demands is becoming important for introducing cloud services in their business systems. For business systems that are dispersively built in multiple clouds, unified monitoring and management are required.

Hitachi has developed federated cloud technology that enables resources from the customer's private cloud, the managed cloud provided by Hitachi, and partner clouds such as that provided by Amazon Web Services to be logically partitioned and allocated for each customer system, with monitoring and administration of these resources by a single account. It also integrates with individual administrative functions, such as server and network management, to provide automatic allocation of server memory, disk, networking, and other resources required to configure business systems in response to customer resource operation requests entered via a federated portal. This significantly improves convenience by allowing the customer to monitor and modify the distributed servers that constitute a business system in a single pane view.

The new technology is applied to the federated cloud services provided by Information & Telecommunication Systems Company of Hitachi, Ltd.

15 Highly Efficient Inverter for Environmentally Conscious Vehicles Incorporating Full SiC Power Module with Double-sided Cooling

Environmental regulations that require a reduction in the emission of carbon dioxide (CO_2), nitrogen oxides, particulate matter, and other pollutants are being progressively tightened in the USA, Europe, and elsewhere, creating a demand for reducing the power consumption of hybrid electric and other environmentally conscious vehicles and improving their performance as a



15 Prototype inverter (left), full SiC power module with double-sided cooling (middle), and parallel connection design for chips (right)

means of transportation. If these requirements are to be satisfied, improvements of the efficiency and output of the inverters and other components used in electric vehicles will be essential.

Hitachi has recently developed a power module with double-sided cooling and balanced wiring impedances so that the current through each chip is the same. The power module uses previously developed techniques for the parallel mounting of power semiconductors and double-sided cooling that provides a high level of cooling performance, as well as small silicon carbide metal-oxide-semiconductor field-effect transistors (SiC-MOSFETs) mounted in parallel. These technologies have led the new power module to achieve roughly twice the current capacity of the Si-IGBTs used in the past.

Furthermore, Hitachi has developed a prototype inverter for environmentally conscious vehicles incorporating the new power modules. This inverter has reduced power loss by 60% by taking advantage of the low resistance and high switching speed of SiC-MOSFETs.

16 Supply Chain Simulation for Optimizing Business Resource Allocation

The rapid revision of supply chains over a wide area has become an important challenge for manufacturers over recent years, including the reorganization of sites and improvements to inventory management, so that they can respond quickly to things like market globalization and changing business conditions, and achieve ongoing profits and cashflow.

In response, Hitachi has developed techniques for supply chain simulation that enable the rapid assessment of changes to the supply chain.

These techniques facilitate the creation of a simulation model by pre-defining templates representing the companies that make up the supply chain.

Furthermore, the production planning and dispatch instruction functions at each company are implemented as agents and the simulation can handle a variety of products and supply chain configurations by combining assorted different logic based on Hitachi's own know-how.

Along with expanding use by in-house production divisions, Hitachi also intends to continue developing the techniques as a solution for use by external customers.

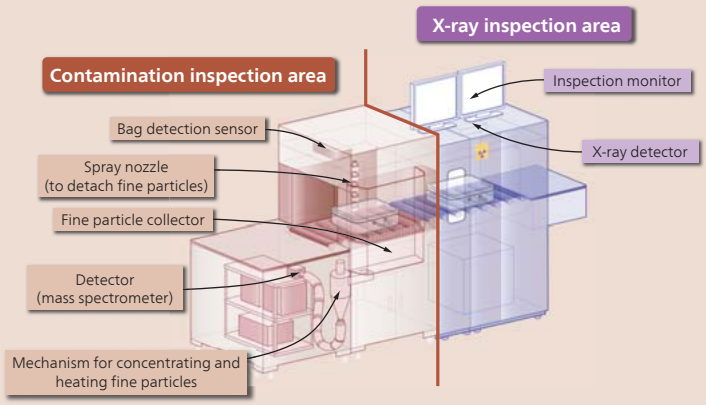
16 Key performance indicators assessment screen for supply chain simulator

17 Automatic Explosives Detection System

One method for detecting concealed explosives is to test the bag or other item for contamination by traces of explosive material. Unfortunately, past inspection of such contamination has required the operator to swab the surface of the bag, meaning that each inspection takes about 20 s.

In response, Hitachi has developed a high-throughput explosives detection technique that automates the swabbing procedure. This involves spraying compressed air at the person or item being inspected to detach any adhering contamination and then recovering it for immediate composition testing. The inspection process is fully automated, taking about 3 s for a person or 5 s for a bag. A prototype explosives detection unit was coupled to an X-ray baggage inspection machine to create an integrated system that can test for contamination at the same time that it performs X-ray scanning, without increasing the operator workload.

Note that this research was conducted under the "Funds for integrated promotion of social system reform and research and development" program of the Ministry of Education, Culture, Sports, Science and Technology (MEXT).



Placing a bag in the machine automatically checks for contamination and performs an X-ray scan.

17 Explosives detection system (for baggage inspection)

18 Decommissioning Support System for Drastically Reducing Volume of Waste and Dismantling Workload

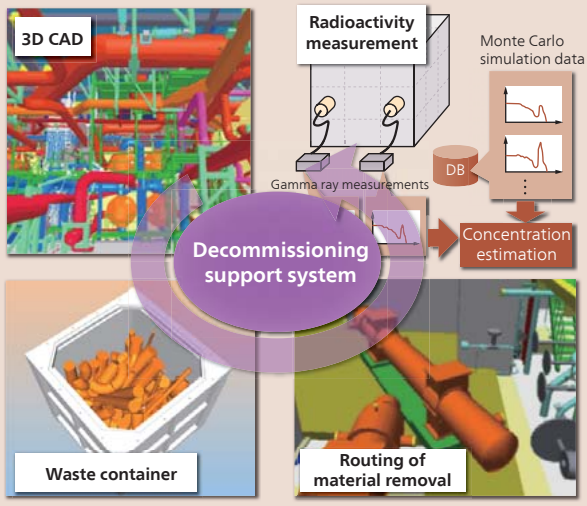
Hitachi has developed a decommissioning support system for safe handling of the several thousand tons of radioactive waste that results from the decommissioning of a nuclear power plant. The system dismantles and cuts up the waste, then places in waste containers for transportation.

After studying past methods based on design drawings for dismantling and cutting up waste, placing it in waste containers, and determining the transportation route, Hitachi developed a technique for calculating parameters such as how to pack the waste into the containers and the number of containers required based on a three-dimensional computer-aided design (3D-CAD) model that includes information on weight and radioactive materials using a calculation that optimizes these with respect to a variety of constraints, and a technique that uses a Dijkstra's algorithm route search and multibody dynamics to automatically determine the transportation route that minimizes the cumulative dose for the radioactive waste while also preventing collisions between machinery, pipework, structural parts of the building, and fittings. Hitachi also developed a technique that can predict the radioactivity concentration in the containers to an accuracy of ±20% from multiple gamma ray measurements and Monte Carlo simulation data using maximum a posteriori probability estimation to calculate the distribution of concentrations in the containers.

In the future, Hitachi intends to use these techniques to help perform decommissioning in a safe, reliable, and rational manner.

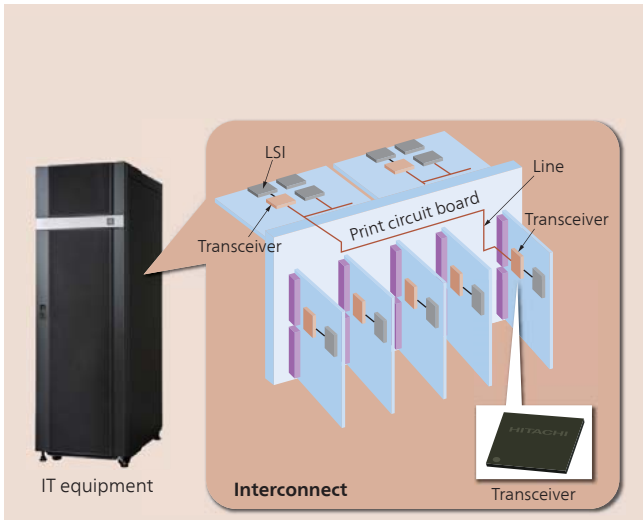
19 25-Gbit/s Transceiver for IT Platforms

In recent years, with the analysis of explosively generated data, brand new businesses and services are being created. To deal with this huge amount of data analysis, there is demand to upgrade the data rate per channel of IT platforms from 10 Gbit/s to 25 Gbit/s. However, this upgrade still has a critical issue due to channel loss



DB: database

18 Decommissioning support system



LSI: large-scale integration

19 High-speed interconnect

increases. For example, the signal amplitude changes from 1.0 V in the transmission signal to 10 mV in the received signal through a 40-dB channel loss. This means that the 10-mV received signal might be smaller than the power supply noise. To achieve long transmission at 25 Gbit/s, Hitachi developed a transceiver with a printed circuit board that achieves channel loss of more than 40 dB and cable transmission for 25 Gbit/s applications that is more than the 35 dB IEEE 802.3bj specification. The key technique is the proposed decision feedback equalizer. It can accurately compensate for deteriorated received signals due to its over 40 dB long channel transmission capability.

The proposed transceiver can achieve a bit error rate of less than $1E^{-14}$. The developed high-speed transmission technique including this transceiver is a key technique for next-generation IT platforms.

20 Reliability Analytics

The life of an infrastructure product that operates outdoors, such as a wind turbine or construction machine, is strongly influenced by how and where it is used. This means that, in order to supply highly reliable products, there is a need to collect and analyze operational data from a variety of sites to assess how and under what conditions they are used, and then to utilize this information in reliability design.

Hitachi has recently developed a reliability analysis technique that combines measurements and product knowledge to make maximum use of operational data by estimating those items that cannot be measured. To minimize the amount of work required to perform an analysis, Hitachi has also developed an analytics platform that provides a wide range of users with shared access to the analysis technique.

This platform, which is cloud-based and operates 24 hours a day, includes libraries of sophisticated analysis techniques and a database with functions for the high-speed analysis and transfer of data. Users can access the cloud from anywhere using a web browser graphical user interface (GUI) to produce highly-reliable product designs using methods verified by reliability design specialists for data analysis and visualization.

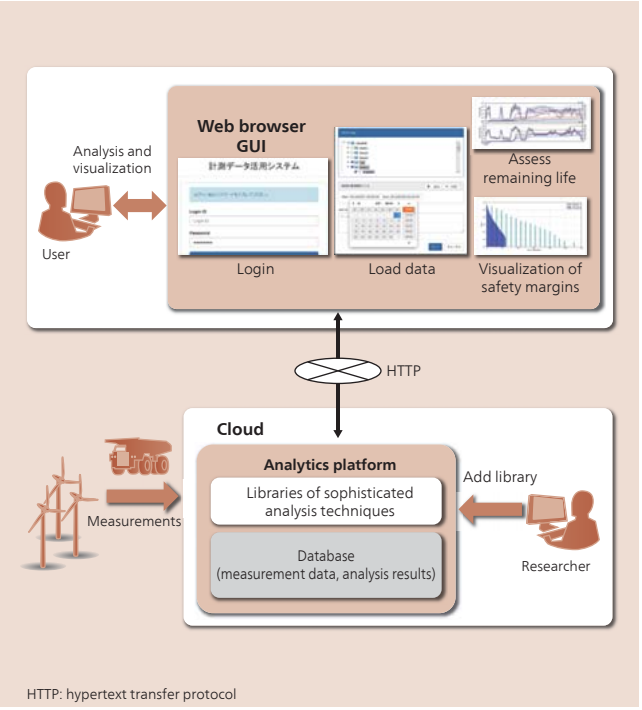
21 Elucidation of Solid Lubrication by Molecular Simulation to Reduce Wear in Resin

Hitachi has developed a technique based on molecular simulation for the efficient screening of low-wear resin-metal interfaces that enables materials design to help improve the reliability of industrial machinery.

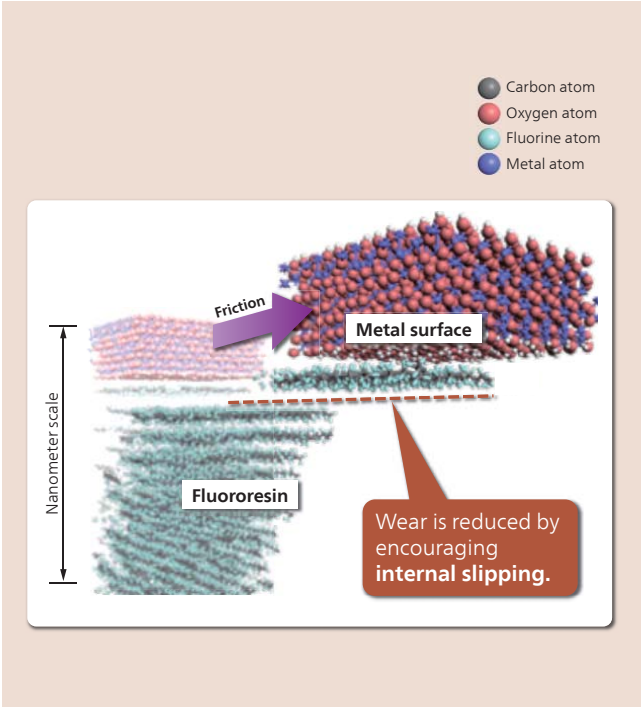
Fluororesins act as a solid lubricant for metal components that does not require oil, thereby enabling longer intervals between maintenance of air compressors and other industrial machinery. Unfortunately, the tendency for fluororesins to wear more quickly in low humidity can shorten equipment life.

With the aim of reducing fluororesin wear, Hitachi adopted molecular simulation to analyze wear for fluororesin on metal. This analysis found that solid lubrication worked by encouraging slipping in the resin, thereby resulting in lower wear. Humidity in the atmosphere acted to strengthen the adhesion between the fluororesin and metal and to encourage internal slipping. On the other hand, because internal slipping was less able to occur under conditions of low humidity, a metal that adhered more strongly to the fluororesin was required to reduce wear. Utilizing this strategy, Hitachi was able to improve the wear durability of compressors by designing a metal that would reduce fluororesin wear.

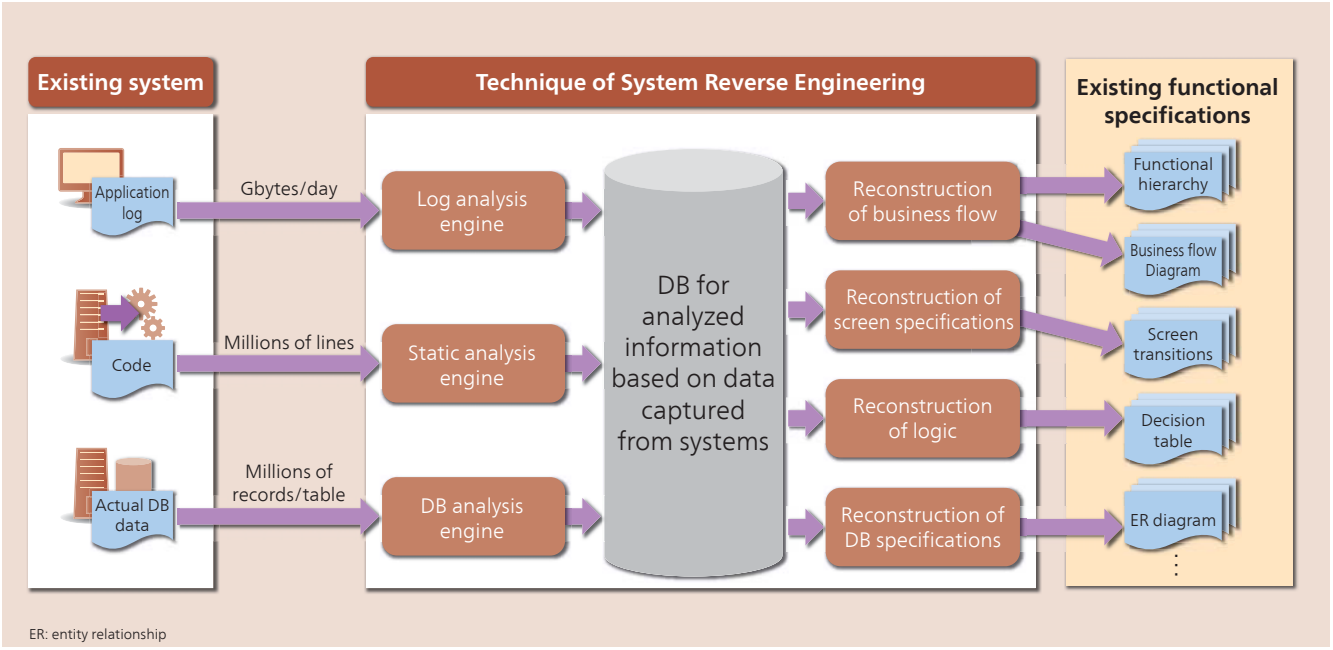
In the future, Hitachi intends to use the technique for the design of composite resins to save energy and improve the efficiency of products such as automotive parts and home appliances.



20 Analytics platform for utilizing measurement data in design



21 Molecular simulation on fluororesin-metal interface



22 Technique of system reverse engineering

22 Technique of System Reverse Engineering

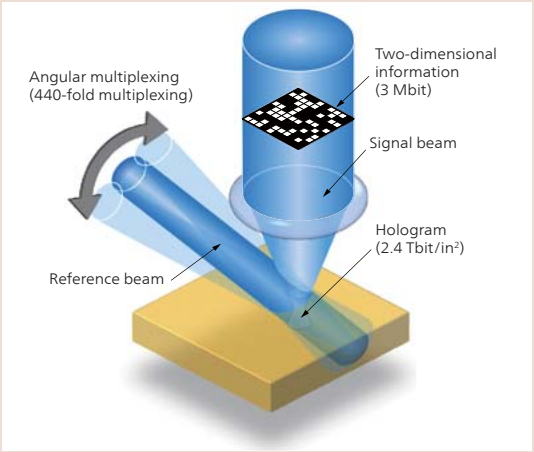
It is said that nowadays 90% of enterprise information system developments engage system migration. In a migration project, the existing system's functions are quite important for the customer's business continuity because the existing system runs the customer's current business. However, a lack of the existing system's specifications makes it difficult to migrate perfectly. Unfortunately, through unrenewed and/or lost documents, and also the resignations of experts, those specifications are often unclear.

To overcome the problems above, Hitachi developed a technique of System Reverse Engineering. This technique reconstructs functional specifications from the capturable data of the existing system. At first, analysis engines analyze and store large amounts of information, which includes system logs, source code, and actual data. Then the functional specifications are reconstructed by combining that analyzed data. This process is automated. The reconstructed specifications are based on data captured from the customer's system in operation. Therefore, our technique enables the customer to make the existing system's specifications clearer than just following the experience and assumptions of developers.

Hitachi is using this technique to improve the quality of our system development and deliver migrated systems by the due date.

23 Large-capacity Holographic Memory

It has been predicted that the total quantity of data produced worldwide will reach 40 Zbyte in 2020*. There is increasing demand for utilizing this large amount of data that is growing at an astonishing rate, with IT systems needing low-cost ways to store this data securely for the long term.



23 Holographic memory system

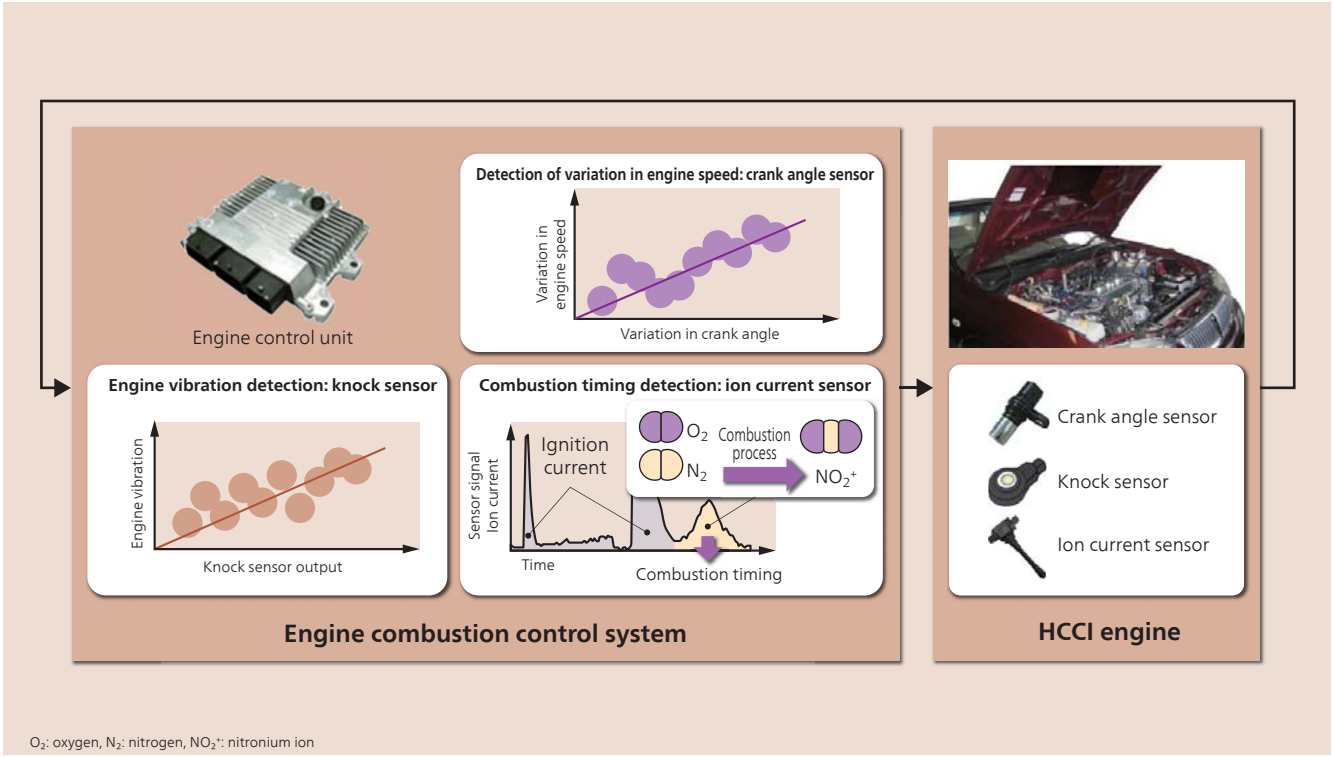
Optical storage is characterized by long life and low cost per bit, and it is seen as having significant potential as a way for data archives to store data in the era of big data. A large-capacity holographic memory developed by Hitachi uses angular multiplexing to store the interference patterns (holograms) formed by the interference of a signal beam carrying two dimensional data and a reference beam in a recording medium.

A prototype achieved a recording density of 2.4 Tbit/in^2 with 440-fold multiplexing. The new technology is recognized as having the potential to provide large-capacity optical storage with each disk having a storage capacity in the terabyte range.

* From"The Digital Universe in 2020: Big Data, Bigger Digital Shadows, Biggest Growth in the Far East," John Gantz and David Reinsel, Proc. IDC iView, December 2012.

24 Next-generation Engine Combustion Control System

Research into homogeneous charge compression ignition (HCCI) as an alternative to spark ignition has led to interest in its use as a



O_2: oxygen, N_2: nitrogen, NO_2^+: nitronium ion

24 Next-generation engine combustion control system

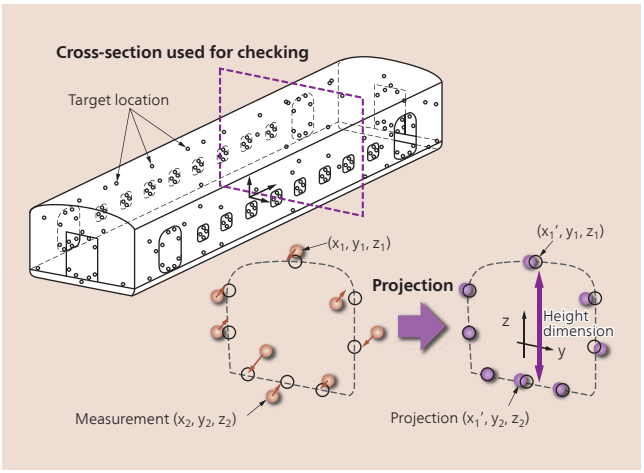
way to improve the thermal efficiency of gasoline engines so that they can comply with future regulations on emissions of CO_2. It is estimated that use of HCCI can increase the thermal efficiency of gasoline engines to about 40% from their present level of around 35%. One of the challenges to the practical adoption of HCCI is that the associated combustion has a low level of robustness with respect to changes in the operating conditions (such as temperature or fuel).

In this current development, Hitachi looked at how a deterioration in combustion results in increased vibration or variations such as in engine speed or combustion timing, and considered different methods for sensing this, namely using a crank angle sensor to detect variations in engine speed, a knock sensor to detect engine vibration, and an ion current sensor to detect the combustion timing. A key feature of the work was that it used existing sensors to minimize any cost increases due to combustion conditions detection.

Hitachi has established a way forward toward the commercialization of HCCI engines by building a next-generation engine combustion control system that uses the technique and achieving highly robust HCCI combustion.

25 Technique for Measuring Structural Dimensions of Rolling Stock Using Three-dimensional Measurement System

In response to growing demand for rolling stock from outside Japan, Hitachi is expanding overseas production at sites that are close to customers. Ensuring that overseas production achieves the same quality and productivity levels as production in Japan requires the establishment of manufacturing practices that are not dependent on worker skills. Rolling stock is produced by using welding to assemble the car body and then installing the internal

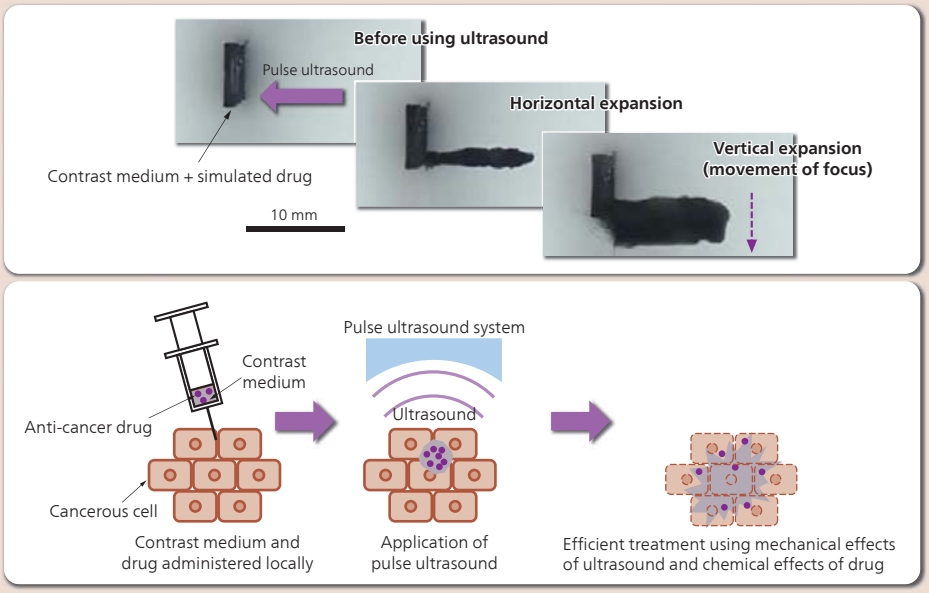


25 Automatic technique for determining dimensions

fittings, electronics, and other parts. The step involving the installation of parts requires that workers make adjustments based on their experience.

To eliminate this adjustment step, Hitachi has developed techniques for the precise and efficient measurement of structural dimensions and for providing work instructions to install parts based on these measurements.

The technique developed for measuring structural dimensions uses a contact-based three-dimensional measurement system. It achieves precise measurements by using a function for determining a measurement location that prevents incorrect measurements by checking the deviation between the actual location and the pre-defined target location, and a function for determining the actual dimensions by projecting the measurements onto a cross-section used for checking. Hitachi has also developed a work guidance function that processes the measurements automatically and issues measurement work instructions, and is using the system to check car body dimensions.



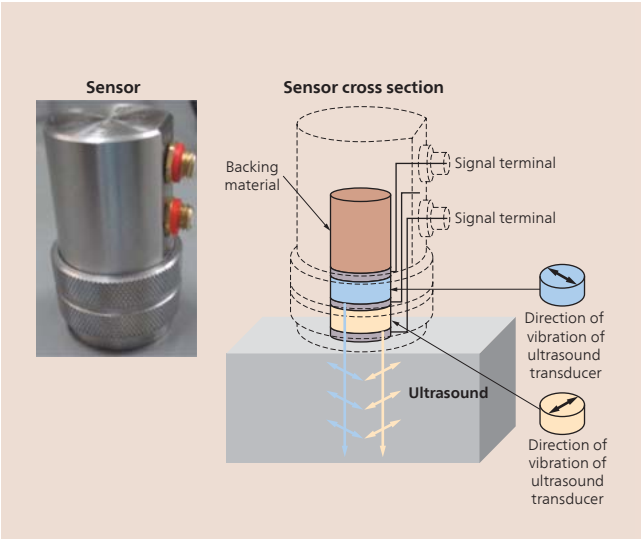
26 Control of drug distribution using pulse ultrasound and a contrast medium in a transparent gel (top) and concept behind new cancer treatment (bottom)

26 New Cancer Treatment Using Ultrasound to Control Distribution of Medication

Hitachi has verified the principle behind a minimally invasive treatment for cancer based on a new mechanism. It works by locally administering an anti-cancer drug into tumorous tissue and then using the mechanical effects of ultrasound to activate the drug throughout the tumor.

In the past, the technique has been difficult to use in practice because it required ultrasound at very high intensity. Hitachi has now demonstrated that its newly-developed method can work at intensities similar to existing ultrasound treatment systems using pulse ultrasound together with a contrast medium formed from minute droplets that can be administered in high concentration.

It has also confirmed that, in a transparent gel, the application of ultrasound changes the drug distribution by causing the gel structure to break down, with the drug moving in the direction of the applied ultrasound. It is anticipated that this will enable treatment at low-dose concentrations while also minimizing side effects from the anti-cancer drug.



27 Ultrasound sensor with two directions of vibration

27 Dual-axis Ultrasound Inspection Technique for Detecting Sub-millimeter Defects

Hitachi has developed an inspection technique that uses two ultrasonic waves with vibrations that are perpendicular to each other. Some metals, such as those produced by rolling, have a crystalline structure in which the speed of propagation of ultrasound varies depending on whether the vibration is parallel to or perpendicular to the crystal axis. As a result, the different directions of vibration produce defect signals that indicate different locations. The identification of defect signals is also complicated by the presence of reflection noise generated at crystal boundaries. As a result, previous techniques have only been able to detect defects in the order of several millimeters.

Hitachi's new technique uses two ultrasound transducers (each of which transmits and receives ultrasound with a different direction of vibration) and acquires signals for these two directions independently. When the defect data is corrected for the different speeds of propagation, it results in a consistent defect signal with a higher signal to noise (SN) ratio. This enables the detection of sub-millimeter defects.

In the future, Hitachi plans to use the technique in applications such as acceptance inspections.

28 Recording and Playback on Quartz Glass with Storage Density Similar to Blu-ray Discs

Quartz glass has excellent resistance to heat and water. Hitachi has developed a technique for the long-term storage of digital data in this material that uses a laser to write the data and an optical microscope to read it. This joint research with Kyoto University

28 100-layer sample (left), quartz glass carried on *Shin-en 2* (middle), and sample included in British Museum exhibition (right)

has devised a technique for using a femtosecond laser to record multiple layers of data in quartz glass. This involved creating a 100-layer sample in quartz and achieved recording and playback with a storage density similar to a Blu-ray Disc* (approximately 1.5 Gbyte/in^2). This sample was able to withstand a temperature of 1,000°C for two hours, equivalent to a fireproof safe, and was shown to have a room-temperature life of 300 million years or longer in accelerated temperature testing.

The technique can be used for the quasi-permanent archiving of valuable data such as historically important cultural material or public documents. A quartz sample produced using the technique is carried on the *Shin-en 2* spacecraft developed by Kyushu Institute of Technology and Kagoshima University, and another was exhibited at Kobe City Museum from September 2015 to January 2016 as part of the 'A History of the World in 100 Objects' exhibition of the British Museum, appearing as the "101st object" selected by the host museum.

* See "Trademarks" on page 140.

29 Simulation of Movement of People in Railway Station

Hitachi has developed a simulator for predicting the movement of people in railway stations with the aim of making them more convenient and pleasant places through initiatives such as the optimal layout of facilities, the modification of train schedules in response to passenger trends, and the provision of passenger information to help avoid congestion.

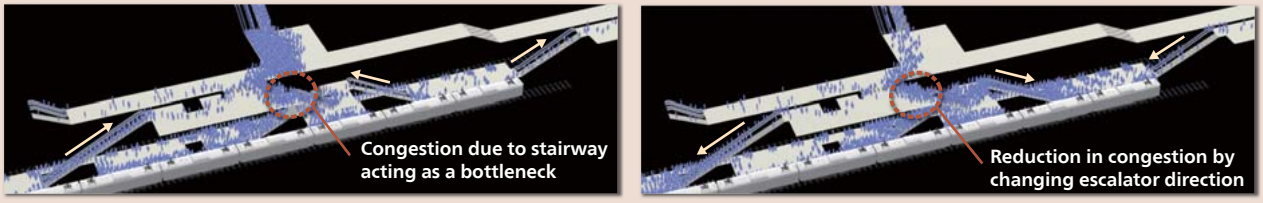
The new simulator incorporates general-purpose modeling that uses an agent-based technique for simulating the behavior of people at railway stations based on knowledge obtained from on-site surveys at a number of railway stations. For example, the behavior when getting on or off a train at the platform varies from station to station, depending on factors such as where the train stops, the number of doors, and how people wait in line. The model developed by Hitachi can reproduce this behavior flexibly by splitting these into three levels based on train arrival and departure and specifying detailed parameters such as where people wait in line for each stage. Hitachi also developed a 3D display function to provide a more intuitive presentation of the predictions.

The simulator can be used to determine in advance how changes such as upgrades to existing railway stations or the construction of new lines and stations will influence the movement of people.

30 Cost-benefit Analysis and Control Strategy for Battery Systems

The massive introduction of renewable energy sources in electric power grids has significantly increased the need for fast-ramping resources to continuously balance power demand and power supply and thereby to stabilize the grid frequency. Battery Energy Storage Systems (BESSs), with their flexible and fast-ramping capabilities, have the potential to become a key solution for grid stabilization issues. In the USA, grid utilities have recently created an ancillary service market that compensates by providing resources as regulating reserve to help maintain the frequency at its nominal value. And, several initiatives have been taken to foster the deployment of energy storage.

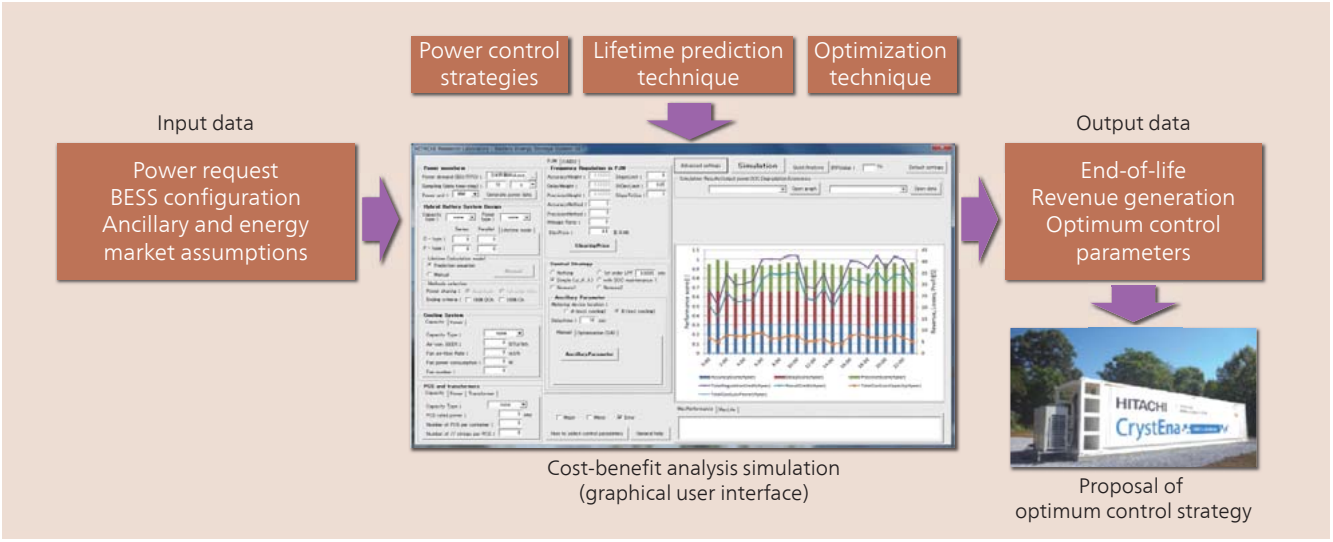
With the aim of entering the North American ancillary market with BESSs, Hitachi has developed a cost-benefit analysis simulation tool to assess stationary BESSs and overcome the challenging



(1) Interval between trains: 6.4 minutes, up escalator only

(2) Interval between trains: 6.4 minutes, down escalator only

29 Example prediction by railway station people movement simulator



30 Concept of the cost-benefit analysis simulation tool

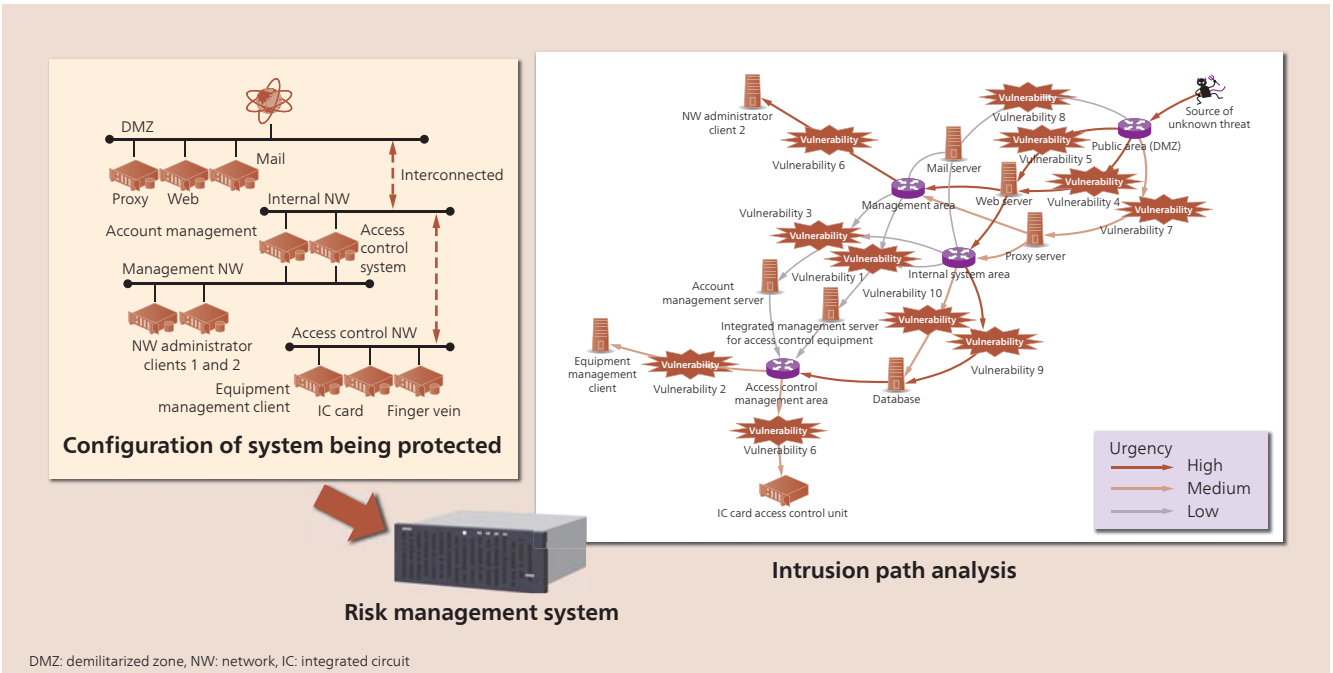
task of designing and controlling a BESS. The cost-benefit analysis simulation tool relies on battery lifetime prediction, on power control strategies design, and on optimization techniques developed by Hitachi Research Laboratory. Simulation and optimization are performed to support the selection of an optimum control strategy to maximize both the performance and the lifetime of a BESS.

Hitachi has installed a 1-MW/450-kWh containerized lithium-ion battery system in New Jersey, USA, and started a demonstration project aimed at verifying the effectiveness of the developed techniques, the commercial viability, and testing the system's performance for providing frequency stabilization service.

31 Security Risk Assessment Technique that Takes Account of Cyber-attack Intrusion Path

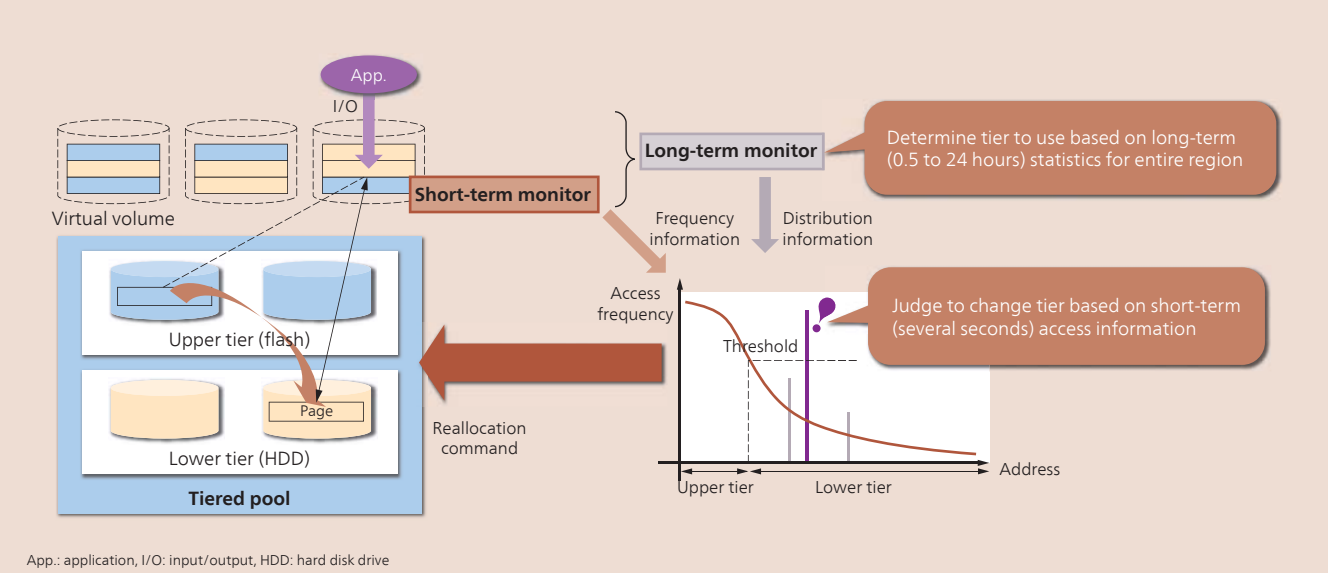
The number of reports of IT system vulnerabilities continues to grow year after year, with the US National Institute of Standards and Technology (NIST) making approximately 8,000 such reports during 2014. One such vulnerability that has attracted a high level of concern is the Heartbleed vulnerability. There was a sudden rise in the number of attacks exploiting this vulnerability after its details were made public, meaning that information system departments at companies and other organizations need to adopt prompt countermeasures. Cases like this call for a high level of information security skills due to the need to prioritize and decide which of the many vulnerabilities to take action on. Unfortunately, it is difficult for individual organizations to retain or train such specialists.

In response, Hitachi has developed a technique for rapidly identifying system vulnerabilities, determining all the possible routes (intrusion paths) by which predicted cyber-attacks can come, and prioritizing which vulnerabilities to address. This enables a uniform and rapid response to vulnerabilities by providing an



DMZ: demilitarized zone, NW: network, IC: integrated circuit

31 Prioritization of countermeasures by predicting cyber-attack intrusion paths



32 Overview of active flash

easy way to clarify the relative priorities of countermeasures, even at organizations that lack the relevant specialists.

To counter cyber-attacks that are becoming ever more complex, Hitachi intends to utilize security risk assessment techniques and expand services that support security activities by organizations, including their information system departments and Computer Security Incident Response Teams (CSIRTs).

32 Data Access Acceleration Technology for Hitachi Virtual Storage Platform Mid-range Family

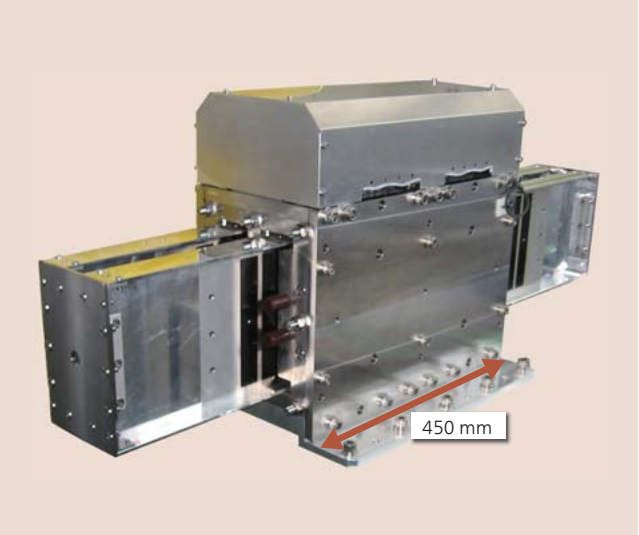
A variety of applications work on IT systems. The behavior of applications varies moment by moment. Therefore, it is extremely difficult and complicated for a system administrator to tune the configuration of the IT system following the changing behavior.

The Hitachi Virtual Storage Platform Mid-range family relieves this difficulty and complexity using "active flash." "active flash" is a new feature that provides automated tuning through rapid data detection and migration for frequently-accessed data onto high-speed flash media.

Through automated tuning, the system administrator can start and operate applications without a strict system design, and agilely expand the capacity of the system to keep up with business growth.

33 High-speed Linear Motor with Fast Acceleration

The use of linear motors has been growing in recent years in response to rising demand for drive mechanisms with higher speed and acceleration to improve the throughput of semiconductor production equipment, machine tools, etc. Making linear motors with faster speed and acceleration requires higher thrust and strength while also reducing the weight of the forcer (moving part). In response, Hitachi has developed a prototype linear motor with a novel design that can operate at higher speed and acceleration.



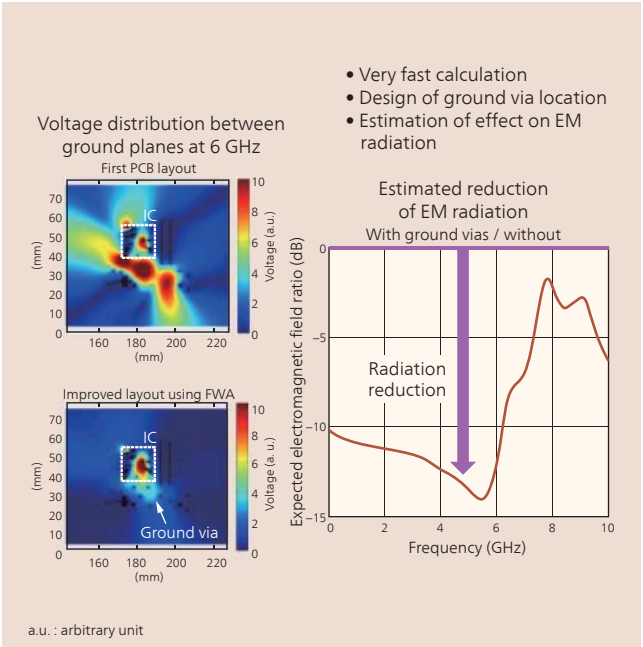
33 Prototype linear motor with acceleration of 1,670 m/s^2

The design of the linear motor reduces the weight of the forcer relative to the thrust by using opposed magnetic poles with the moving magnet located between them to make effective use of the magnetic flux on both sides of the magnet. To achieve a lightweight and strong forcer, it also uses a two-stage design that reduces deflection by having two forcers coupled together. In prototype testing, these features were able to reduce the weight of the forcer significantly (one-third previous model), with a maximum speed of 14.0 m/s and acceleration of 1,670 m/s^2, 4.3 times that of Hitachi's previous model.

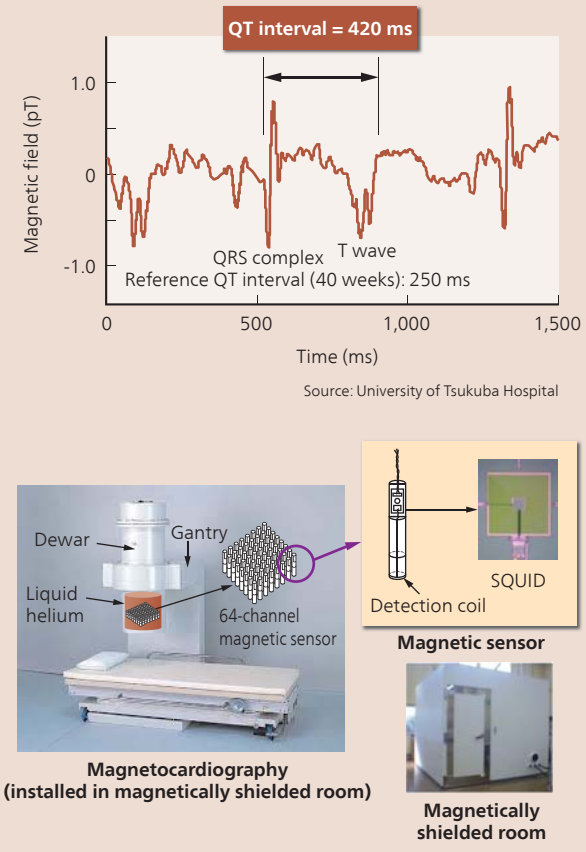
34 Fast Analysis Technique for Electromagnetic Compatibility Design of Printed Circuit Boards

Hitachi has developed the forward wave analysis (FWA) technique to improve the electromagnetic compatibility design of printed circuit boards (PCB) above 1 GHz.

The simultaneous switching of large-scale integrated circuits generates noise that propagates among the power supply planes of PCBs and radiates electromagnetic (EM) waves from the edges, creating interference with other electronic equipment. In order to



34 Improvement of layout design using FWA and reduction of EM radiation



35 Magnetocardiogram of a fetus with long QT syndrome and congenital 2:1 ventricular block (top) and magnetocardiography manufactured by Hitachi High-Technologies Corporation (bottom)

reduce the radiated noise, bypass capacitors, ground vias, and other current bypass devices can be used.

The design challenges are the calculation time of EM simulations and the lack of accurate component models above 1 GHz.

FWA achieves an approximate solution with very fast simulations (50-100 times faster than whole board simulations) and only a moderate amount of layout information, which is an advantage because simulations can be conducted before the design is completed. This is possible because above 1 GHz the radiation is strongly affected by a large number of resonances with moderate quality factors, making statistical quantities a more suitable target of the analysis. Simulations are made only on a local area close to the noise source integrated circuit and assuming infinite power supply planes, but they can be used to select the suitable location for current bypass devices, to estimate their effect on the radiated EM field, and also to analyze the vertical distribution of the noise among the power supply planes.

35 Use of SQUID Magnetocardiography for Fetal Arrhythmia Diagnostics

Obtaining electrophysiological information from fetal hearts has been difficult in the past. Now, Hitachi, in collaboration with University of Tsukuba Hospital and the National Cerebral and Cardiovascular Center, has established a diagnostic technique for fetal arrhythmia based on electrophysiological information collected using magnetocardiography that incorporates superconducting quantum interference devices (SQUIDs).

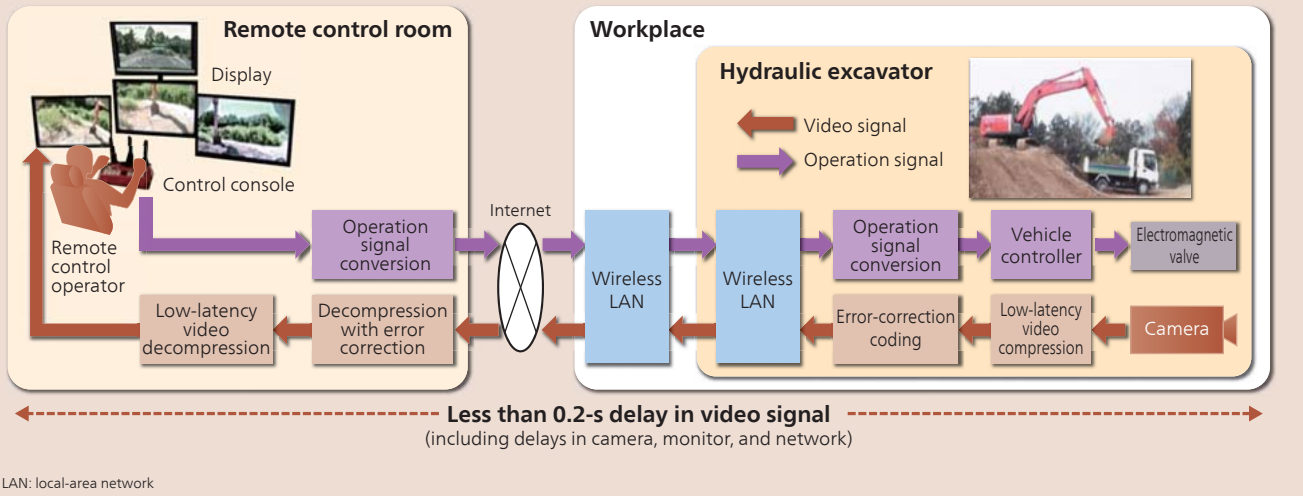
Magnetocardiography incorporates a number of SQUIDs and can record the faint magnetic signal from the fetal heart (less than one-millionth the strength of the Earth's magnetic field) with a good SN ratio from the top of the mother's abdominal wall. Magnetocardiography has been used to record more than 1,000 examples of normal fetal magnetocardiographic signals and obtain reference values with respect to the number of weeks of pregnancy for temporal indicators that are important for the diagnosis of fetal arrhythmia, including the atrioventricular conduction time and the QT interval [the time between the start of ventricular depolarization (QRS complex) to the end of ventricular repolarization (T wave)], for example. These reference values can be used for diagnosing conditions such as congenital long QT syndrome, which is suspected of involvement in intrauterine fetal death from unknown causes, due to life-threatening arrhythmia from the fetal stage.

It is anticipated that the establishment of this diagnostic technique will contribute to perinatal care, including both prenatal treatment and the planning of postnatal treatment.

36 Long-distance Remote Control System for Construction Machinery

The remote control of construction machinery has attracted attention as a key technology for ensuring operator safety and implementing more advanced working practices in situations such as disaster recovery sites and large overseas mines.

Remote control involves an operator operating a construction machine remotely with the aid of video images sent from the site via a network. Its technical challenges include poor visibility due to low image resolution or distortion caused by data transmission



LAN: local-area network

36 Long-distance remote control system for construction machinery

errors and cumbersome operation due to transmission delays.

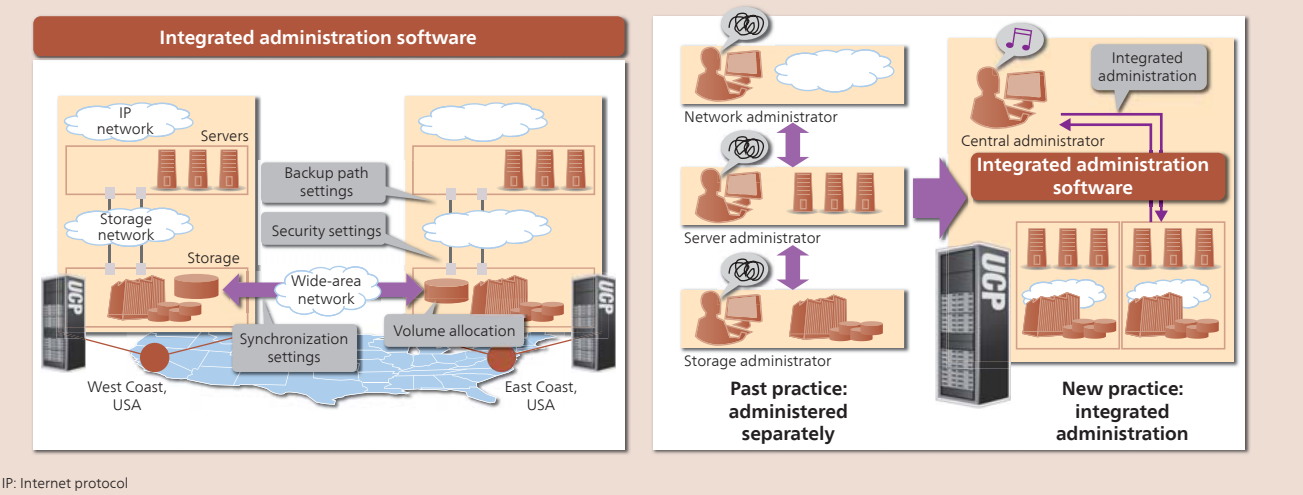
In response, Hitachi has developed a video transmission technique that corrects data errors caused during transmission and compresses and decompresses site video with low latency while still maintaining full high definition (HD) image quality. It has also built a long-distance remote control system for construction machinery that ensures efficient operation by using this technique to transmit highly realistic site video. A trial demonstrated that the system could perform remote control by transmitting video signals with a delay of 0.2 s or less over a network link approximately 800 km long.

Hitachi intends to enhance the performance of the technology further in the future.

37 Technique for Simplifying DR Setup on Hitachi Unified Compute Platform

With corporate information systems making greater use of virtualization in recent years, there is demand for virtualization platforms that are easy to manage and that have high availability and reliability, with disaster recovery (DR) being another important requirement. A problem with the configuration of DR environments in the past has been that setting up storage systems has required storage administrators with specialist knowledge, increasing the administrative workload due to factors such as these administrators needing to coordinate with each other. In response, to provide a simpler way to set up DR on integrated platforms for virtualization systems, Hitachi has developed automated techniques based on best practice and DR setup based on information about the virtualization environment. By reducing the number of settings required for DR setup by 86% and eliminating hardware-level settings altogether, these enable DR setup to be performed by one central administrator.

Hitachi believes that the proposed techniques will reduce administration workloads by eliminating the need for administrators to coordinate with each other and by making it possible for DR setup to be performed using a minimal number of settings.



IP: Internet protocol

37 Simplified DR setup function for Hitachi Unified Compute Platform (left) and simplified administration using Hitachi Unified Compute Platform (right)

Exploratory Research

1 New Wearable Sensor for Happiness (Level of Organizational Activity) that is Correlated with Workplace Productivity

Improving the productivity of service and knowledge work (which account for 70% or more of employment in developed economies) is an important challenge for society, despite being more difficult than for routine tasks. Based on a million or more days of human activity measurements spanning 10 years, Hitachi has developed a wearable sensor for measuring the level of happiness in groups, an index that is correlated with the organization's productivity.

The sensor uses a built-in accelerometer to detect the presence of small body movements and quantify the diversity of movement within a group. It has been shown that this index agrees to a high level of accuracy with the results of happiness surveys. It has also been shown that this measure of the level of group "happiness" is correlated with workplace productivity. For example, it has been found that the rate of orders taken by a call center on days when staff had a high happiness score was 34% higher than on days when the score was low, and that per-customer sales at a retailer were 15% higher. It has also been found that work by research and development projects with a high happiness score makes a higher contribution to sales.

The sensor has already been adopted in a wide range of sectors, including finance, aviation, telecommunications, the automotive industry, and logistics.

(Hitachi High-Technologies Corporation)

1 Wearable sensors in use

2 Atomic-resolution holography electron microscope

2 Atomic-resolution Holography Electron Microscope

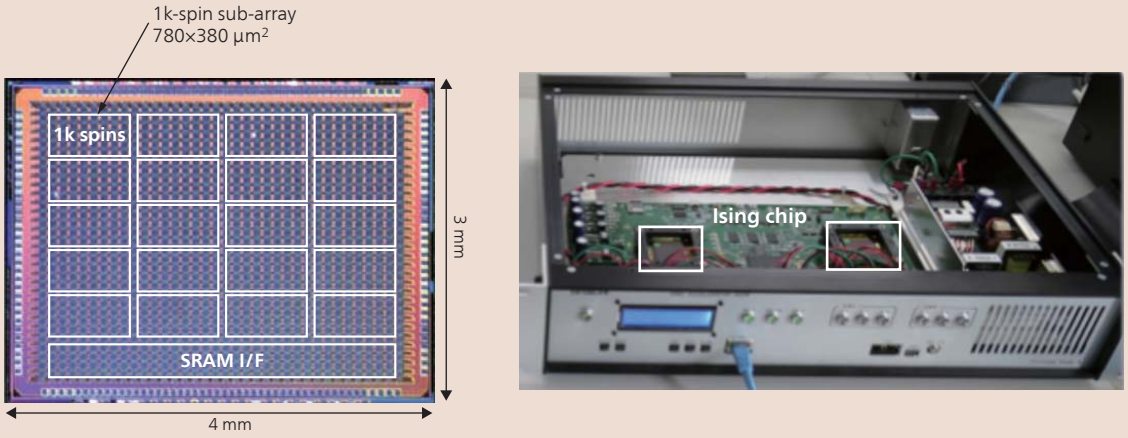
With the aim of developing materials with groundbreaking functions and properties, work is progressing on the development of techniques for atomicresolution measurement of the internal electromagnetic fields that govern these material properties. The atomic-resolution holography electron microscope has been developed, with assistance from the Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program), a national project. It is the world's first ultra-high-voltage electron microscope equipped with a spherical-aberration corrector. The highly stabilized electron microscope system enabled the equipping of the corrector. In this development, a number of new technologies (as follows) were successfully applied to improve the stability of the electron microscope system.

(1) A 1.2-MeV electron beam with suppressed energy dispersion

(2) An electron gun emitting high-brightness electron beams with long-term stability

(3) Development of facility technologies to eliminate degradation factors of resolution

Performance testing succeeded in transmitting structural information from a crystal to a camera with a world-record resolution of 43 pm. Hitachi intends to use the microscope to help develop the new materials that will underpin a sustainable society by studying the quantum phenomena responsible for the functions of such things as magnets, batteries, and superconductors.



SRAM: static random access memory, I/F: interface

3 CMOS Ising chip at the heart of the Ising computer (left) and the Ising computer itself (right)

3 New Computing Paradigm for Analyzing Increasingly Complex Social Systems (CMOS Ising Computer)

In the future, Hitachi's Social Innovation Business will necessarily involve the control of social systems, and this will require parameter optimization. This in turn requires the solution of combinatorial optimization problems to determine the optimal combination of parameters.

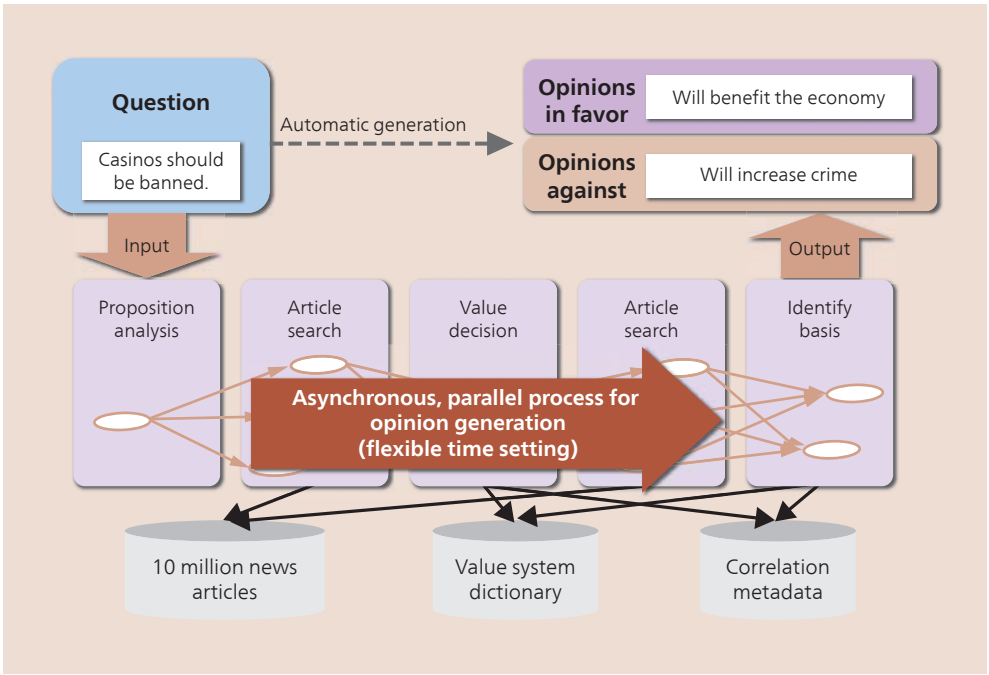
Hitachi has devised a computing technology based on a new paradigm that is capable of solving combinatorial optimization problems efficiently by simulating an Ising model on a complementary metal oxide semiconductor (CMOS) circuit, and has built a prototype 20,000-spin CMOS Ising computer using a 65-nm process. An Ising computer represents a combinatorial optimization problem by mapping it onto an Ising model of spin behavior in magnetic materials, and then uses convergence to solve the problem. This convergence is achieved by the operation of the CMOS circuit and randomness introduced by noise.

The prototype computer can operate at 100 MHz and has demonstrated its ability to solve actual combinatorial optimization problems. Furthermore, it consumed 1,800 times less power to obtain the solution than would have been required by a conventional von-Neumann architecture computer running an approximation algorithm.

4 Core Technology for AI Capable of Rational Interaction

Hitachi has developed a technique that analyzes large amounts of text data to present opinions for and against a question on which opinions are divided in a way that indicates their basis or rationale.

The technique identifies bases or rationales with a higher degree



4 Process for automatic generation of opinions for and against accompanied by justifications

of certainty by focusing on the values associated with subjects like health, economics, and public order that are considered important by people and communities when expressing opinions, and analyzing how a question relates to these values based on a large quantity of news articles and other material.

Whereas information based on objective facts has been provided in the case of past artificial intelligences (AIs) that operated on a question-and-answer basis, this technique can also provide information accompanied by a rational explanation in accordance with the values of the person conducting the interaction. Another advantage of the AI is that, by using a number of different values as reference criteria, it can present bases and rationales that are not biased toward any one particular aspect.

This new technique represents a core technology for use in developing AIs that can enable rational interaction between people and computers. In the future, Hitachi intends to utilize the technique in systems that analyze information such as corporate documents, published reports, or electronic medical records at hospitals to generate opinions that underpin operational activity.

5 Automated Cell Culture Technique

Hitachi has developed an automated cell culture technique for the reliable supply and large-scale production of safe and viable cells for regenerative medicine. It has also been working on the development of a system for closed culturing that provides the high level of sterility demanded by medical applications, and features a technique for parallel culturing using multiple culture vessels.

This system, called Automated Cell Culture Equipment 3 (ACE3), forms a circuit that links the liquid feed tube to the culture vessels that are in contact with the cells and culture medium. It also uses gamma rays to fully sterilize the interior prior to use. To prevent cross-contamination between patients, the circuit is fitted with an insertion and removal mechanism that enables single-use. ACE3 automates seeding, the maintenance of constant temperature and humidity, gas exchange, and culture medium replacement, and also provides for both automatic observation of the cells at designated points and manual observation as required.

Hitachi is currently engaged in joint research with Tokyo Women's Medical University on its use for regenerative medicine treatment of esophageal cancer. The aim is to use these techniques as a basis for encouraging the wider adoption of regenerative medicine through the future deployment of automated cell culture technology for different types of cells or diseases.

The research described in this article was undertaken as part of the Cell Sheet Tissue Engineering Center (CSTEC) under the Creation of Innovation Centers for Advanced Interdisciplinary Research Areas Program, a Project for Developing Innovation System Establishment Project of the Ministry of Education, Culture, Sports, Science and Technology.

* CellSeed Inc.

5 ACE3 automated cell culture system (left), closed culture vessel (top right), and cell sheet after automatic culture in an ACE3 (bottom right)

INDEX & TRADEMARKS

Index

Trademarks

Page	Name and explanation
10	Hadoop is a trademark of The Apache Software Foundation.
16	SAP is the trademark or registered trademark of SAP SE in Germany and in several other countries.
18	The Daxeam trademark is the property of UXC Eclipse Pty Ltd.
	Microsoft, Excel, and Microsoft Dynamics are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.
42	Amazon Web Services is a trademark of Amazon.com, Inc. or its affiliates in the United States and/or other countries.
	Microsoft and Azure are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.
	Salesforce is a trademark of Salesforce.com, inc.
43	IOS is a trademark or registered trademark of Cisco in the U.S. and other countries and is used under license.
	Android is a trademark of Google Inc.
	Windows is either a registered trademark or trademark of Microsoft Corporation in the United States and/or other countries.
	JavaScript is registered trademark of Oracle and/or its affiliates.
44	iPad is a trademark of Apple Inc., registered in the U.S. and other countries.
48	Spark, Cassandra and Solr are trademarks of The Apache Software Foundation.
	STORM is the trademark of Tokyo Broadcasting System Television, Inc.
	Elasticsearch is a trademark of Elasticsearch BV, registered in the U.S. and in other countries.
53	SAP HANA is the trademark or registered trademark of SAP SE in Germany and in several other countries.
75	Wi-Fi is a registered trademark of Wi-Fi Alliance.
92	COBAS is a trademark of Roche.
128	Blu-ray Disc is a trademark of the Blu-ray Disc Association.

• Other company and product names in this booklet may be trademarks or registered trademarks of their respective owners.