Overview

Information and Control Systems and Component Technologies for Social Infrastructure

Naohiko Irie, Dr. Eng.
Akitoshi Shimura, Dr. Eng.
Minoru Koizumi, Dr. Eng.
Takayuki Takezawa

CHALLENGES FACING SOCIAL INFRASTRUCTURE

THE challenges facing social infrastructure, including population growth, urbanization, and environmental problems, continue to grow year after year. The United Nations estimates that the global population will reach 8.3 billion in 2030, of which 60% will live in cities. Supporting this growth will require the provision of energy (including electric power and gas), transportation (including roads and railways), and other social infrastructure (such as water supply and sewage systems). As the expansion of social infrastructure places an increasing load on the global environment, including environmental degradation and warming, there is a need for the efficient construction and operation of social infrastructure that can reduce the resulting social costs. Against this background, total investment in social infrastructure was approximately $US2 trillion in 2010, and is forecast to rise by a factor of about 1.5 by 2020 (see Fig. 1).

The construction of new social infrastructure is anticipated in emerging economies as their populations grow and as they become more industrialized and urbanized. In the energy sector, for example, there is growing demand for liquefied natural gas (LNG), oil synthesis, gas-based chemical plant, resource development, and power systems(1). Also needed are the provision of transportation systems to relieve congestion, and water supply and sewage systems to alleviate water shortages and resolve sanitation problems. Issues associated with this rapid provision of infrastructure, including how to reduce investment and operating costs and give proper consideration to the environment, are a concern for all parts of society.

Developed economies, meanwhile, need to deal with a growing awareness of environmental problems, aging infrastructure, and societal problems such as aging populations and falling birth rates. In the energy sector, the generation and supply of electric power from renewable energy is expected to grow at an annual rate of about 8%(1), posing challenges that include the construction of reliable power grids and the establishment and operation of flexible billing schemes. In the transportation sector, the important issues include not only ensuring reliable transportation services but also providing efficient passenger and freight transportation by utilizing data such as that from commuter smartcards. In the industrial sector, the needs are for the use of information to make production more efficient and for the optimization of logistics, including global supply chains, as recommended by Germany's Industrie 4.0(a)(2) project.

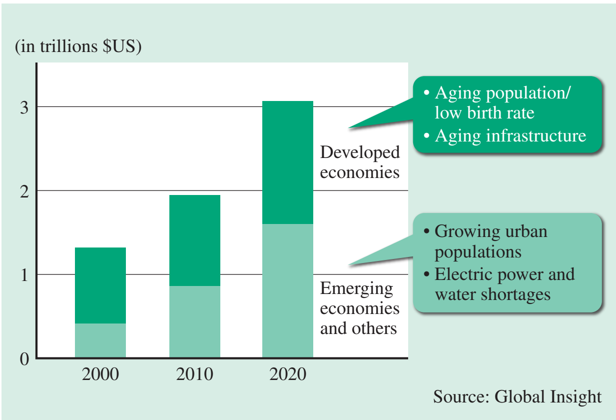


Fig. 1—Forecast of Global Investment in Infrastructure.
Investment in social infrastructure is growing, especially in emerging economies, and is expected to expand by about 1.5 times between 2010 and 2020.

In Japan, meanwhile, a plan for national resilience that incorporates lessons learned from the Great East Japan Earthquake and the selection of Tokyo to host the 2020 Olympic and Paralympic Games have helped prompt moves to upgrade the aging infrastructure. However, the need to balance these against financial considerations means that efficiency is essential for both upgrades and operation.

With reference to these trends, this issue of *Hitachi Review* describes information and control platforms and component technologies for extolling and realizing value in social infrastructure, and also Hitachi's work on building advanced social infrastructure for the energy, transportation, water, industrial, and other sectors.

SOCIAL INFRASTRUCTURE SYSTEMS THAT HITACHI SEEKS TO PROVIDE

Hitachi has extensive experience and system implementation technologies that it draws on to support highly reliable, high-quality large-scale systems, particularly in Japan. In addition to this track record, Hitachi also aims to deliver new value by utilizing the latest information technology (IT) to overcome the challenges facing social infrastructure throughout the world. Accordingly, in FY2014, Hitachi reorganized its infrastructure systems business domains into urban & energy solutions, water & environment solutions, industrial plant solutions, and components in order to establish a framework that can deliver one-stop solutions for societal challenges.

The social infrastructure systems like those for the sectors mentioned above have many different stakeholders, including the end users of the infrastructure; the operators who build, run, and maintain it; and the governments that impose regulatory oversight. In the future, Hitachi intends to deliver the values of social infrastructure to these stakeholders in three forms, namely "smart & smooth," "sustainable growth," and "security & resiliency" (see Fig. 2). The following sections explain what each of these values mean.

(1) Smart & smooth: Eliminating what is "unreasonable, wasteful, and uneven"[3]

This means the efficient control of social infrastructure using IT through improving the efficiency of energy use and relieving congestion, and reducing the overall cost to society including the environmental load, while also improving convenience for end users. It also means reducing the total life cycle cost to operators by analyzing operational data to optimize operation and maintenance, and by providing new services that enhance the convenience of social infrastructure for end users.

(2) Sustainable growth: Social infrastructure that can continue to grow

Social infrastructure that needs to remain in service for decades or more requires the flexibility, expandability, and ease of improvement to adapt to changes in society that cannot be foreseen at the time of its construction. In addition to expanding along with the development of the city, it should also provide a platform for growth that increases capital value for end users, operators, and others.

(3) Security & resiliency: Ensuring that infrastructure is safe, secure, and resilient

In addition to being reliable enough to operate continuously, 365 days a year, infrastructure must also maintain security and privacy; these issues have also become concerns for control systems in recent years. Infrastructure must also have the resiliency to continue delivering essential functions even in the event of extensive damage caused by unforeseen incidents such as faults or disasters, and to be able to recover quickly.

(a) Industrie 4.0
A high-tech strategy of the German government that anticipates the fourth industrial revolution. It aims to make all aspects of wide-scale industrial processes smarter, including logistics, through the use of information and communication technology (ICT), including machine-to-machine (M2M), big data analytics, and the integration of industrial and business systems.

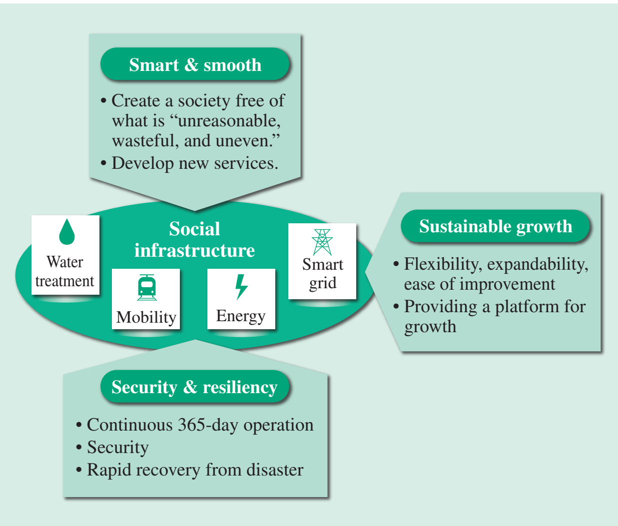


Fig. 2—Values that Hitachi Seeks to Provide to Social Infrastructure.
Hitachi seeks to provide "smart & smooth" infrastructure systems that are capable of "sustainable growth" and "security & resiliency."

INFORMATION AND CONTROL PLATFORMS THAT DELIVER NEW VALUE FOR SOCIAL INFRASTRUCTURE

Social infrastructure consists of the equipment installed at energy, transportation, water, industrial, and other sites; the information and control platforms that control these plants; and the information platforms that handle operation and management at a supervisory level. Hitachi supplies the functions needed for each of these platforms in order to deliver value for social infrastructure in terms of "smart & smooth," "sustainable growth," and "security & resiliency" (see Fig. 3).

Information Platforms

Information platforms play an important role in making social infrastructure "smart & smooth." This includes supporting the formulation of optimal operating plans for control systems and the development of new services by collecting sensor and other operational data from control systems and by utilizing big data analytics, modeling, and simulation for analysis and prediction. Hitachi offers information platforms as the "Intelligent Operations Suite." This includes IT platforms, various industry-specific "vertical services," and early-stage consulting. The IT platforms consist of applications for big data, highly reliable clouds, and security platforms developed in fields such as finance, the public sector, and industry[4].

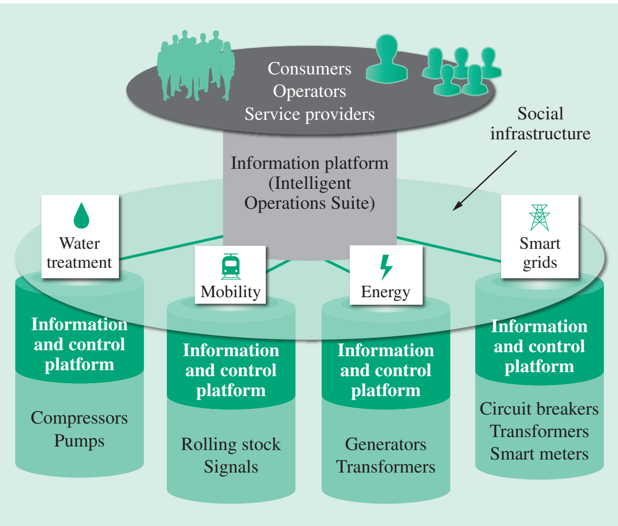


Fig. 3—Platforms that Support Social Infrastructure.
Social infrastructure is underpinned by information platforms that link the infrastructure with consumers and businesses, key plant machinery, and the information and control platforms that control them.

Information and Control Platforms

Information and control platforms are implemented with information and control systems that seamlessly comprise components like control servers and controllers. The various technologies incorporated into these components help deliver the social infrastructure value described earlier in this article (see Fig. 4).

Another article on page 71 of this issue describes the latest work on these platforms.

(1) Smart & smooth

The interoperation of control systems and information platforms is critical to making infrastructure "smart & smooth." To achieve this, Hitachi supplies functions that support the flexible collection of data from information platforms while also ensuring the realtime performance and reliability demanded of control systems.

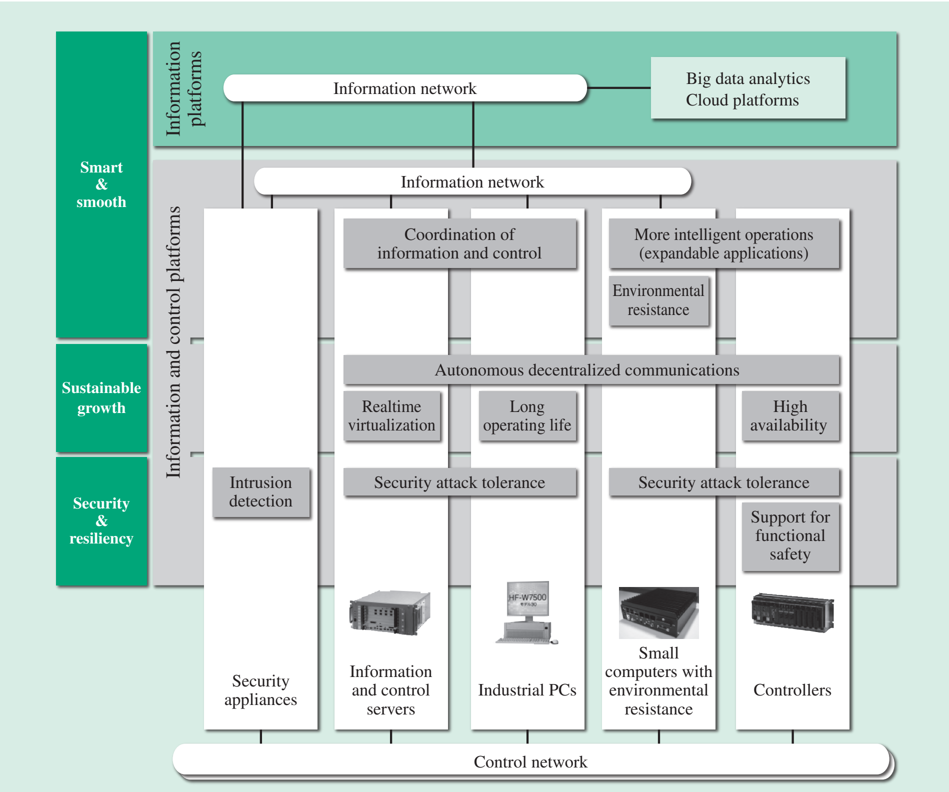
In the case of social infrastructure, the development of new services also requires greater "intelligence" so that the outputs of information platforms can be utilized as feedback to the infrastructure. Power system monitoring control devices designed for outdoor use and used in smart grids are one example. To satisfy these needs, Hitachi is developing small computers suitable for long-term operation in harsh environments, while also ensuring that applications are expandable.

(2) Sustainable growth

Hitachi proposed the concept of an "autonomous decentralized" system for achieving sustainable growth in social infrastructure in 1977, and has been involved in the implementation of control systems with excellent expandability. In the case of information and control platforms, Hitachi supports the implementation of systems based on the autonomous decentralized systems concept by supplying autonomous decentralized communications middleware for devices such as information and control servers and controllers. Autonomous decentralized communication is incorporated into international standards such as ISO 15745[b] to improve interoperability between systems from different vendors.

Achieving sustainable growth requires that all of the components used in information and control platforms are themselves capable of long-term operation. However, hardware devices such as processors and microcontrollers are becoming commodities, and

(b) ISO 15745
An international standard for industrial automation networks. It specifies standardized rules for describing specifications and takes the form of an application framework for devices that are connected to a network.



PC: personal computer

Fig. 4—Overview of Information and Control Platforms.
The three values are underpinned by the distinctive technologies incorporated into the information and control servers, controllers, and other components of information and control platforms.

increasing year-on-year pace of technical innovation in software and services. To combine this situation with long-term operation of social infrastructure is a challenge. In response, Hitachi is using virtualization technology on information and control servers to ensure that proven operating systems (OSs) and applications can have a long operating life. While virtualization is already commonplace in information systems, Hitachi is seeking to deploy it on information and control servers in ways that also satisfy control system requirements for realtime performance, high availability, and ease of on-site maintenance.

(3) Security & Resiliency

While interoperation with information platforms is essential to making social infrastructure smart & smooth, this raises concerns about the resulting increase in security vulnerabilities. Furthermore, the increasing risk of attacks specifically targeted at control systems, such as the Stuxnet[(c)] incident, has created a need for the strengthening of cybersecurity in information and control platforms. Internationally, development of security standards for control quipment and systems, such as IEC 62443, is now ongoing, and vendors need to supply platforms that comply with these standards. Hitachi has been involved with the Control System Security Center since its formation and participated in activities such as security drills and joint research into enhancing control system security.

The first step in strengthening control system security is to raise the attack tolerance of the individual components. Hitachi is developing controllers that comply with international standards for certifying the security of control equipment, particularly ISASecure* EDSA (Embedded Device Security Assurance). Meanwhile, maintaining security at the system level requires the ability to detect intrusions such as unauthorized connections or access. Hitachi has released a node monitoring server for detecting unauthorized network connections. In addition to supplying appliance products that are designed to perform intrusion detection under a wide range of circumstances, Hitachi is also seeking to build more robust security systems through interoperation with security monitoring services that have been developed for information systems.

(c) Stuxnet
A form of targeted attack malware. Stuxnet attacks the control systems of industrial equipment and is known to have been responsible for attacks on control systems at Iranian nuclear facilities. Part of its threat is that, as well as spreading via the Internet, it can infect standalone networks via devices such as universal serial bus (USB) flash memory.

* ISASecure is a Trademark of ASCI.

Support for functional safety is a requirement for information and control platforms so that they can provide public systems with the resiliency needed to cope with unexpected events. Hitachi develops and supplies R800FS/HSC800FS functional safety controllers that comply with the IEC 61508 standard for functional safety. These controllers can operate two types of applications: functional safety applications ensuring safety for equipment and general applications used for ordinary control systems and information processing. These two types of applications can provide highly flexible control functions by complementing each other. They also contribute to greater resiliency in control systems by providing mechanisms that allow control to continue functioning safely when a fault occurs, rather than simply shutting down control outputs.

ACTIVITIES AIMED AT BUILDING ADVANCED SOCIAL INFRASTRUCTURE

The following section describes the work Hitachi is undertaking to build advanced systems that can deliver the three forms of social infrastructure value described above in the energy, transportation, urban development, water infrastructure, and industrial sectors.

Smart & Smooth

(1) Island smart grid model

A smart grid demonstration project is being run on the island of Maui under the leadership of the New Energy and Industrial Technology Development Organization (NEDO) to encourage the use of renewable energy in the state of Hawaii in the USA. The system, which commenced operation in December 2013, controls electric vehicle (EV) charging to resolve problems such as frequency fluctuations caused by the variable output of renewable energy. In the future, we are planning to extend this system by using EVs as virtual power plants[(d)], whereby they operate as a distributed generation system (see p. 23).

(2) Smart grid demonstration project using PV power generation

Installations of large amounts of photovoltaic (PV) power generation will require more considerations, for example, power quality, efficient operations of existing equipment, PV output prediction, and battery utilization. Hitachi has been working with Kyushu Electric Power Co., Inc. since March 2013 on joint research into developing and testing power system control technology using a demonstration smart grid. In the case of supply and demand control, the project will test the coordination of consolidated and region-specific supply and demand plans and optimal methods for battery control based on these plans. In the case of voltage regulation, the project will identify the issues associated with voltage management on distribution grids and test optimal voltage control techniques by using test load systems to induce fluctuations in the grid load and by collecting and analyzing transmission line voltage, current and other data (see p. 28).

(3) Condominium energy management systems

Since the Great East Japan Earthquake in 2011, electric power consumers in Japan have been installing energy management systems (EMSs) to achieve more energy efficiency, save power consumption, and ensure sufficient amounts of energy during periods of tight supply. However, small-scale consumers and others on low-voltage supplies are not motivated to install the EMSs because of small economic benefit. Condominiums represent one category of such consumers, and Hitachi has developed a "condominium energy management system" (condominium EMS) that consolidates management of each residence in the building. The condominium EMS helps encourage energy efficiency and power saving by presenting information on energy use, remotely controlling appliances and other equipment, and providing notification of times when electric power is in short supply (see p. 41).

(4) Power conditioners for renewable energy

Grid instability is recognized as a problem that results from the installation of renewable energy sources such as PV modules and wind power. These grid instabilities can be broadly divided into two categories, namely the instability caused by a large number of power conditioners disconnecting at the same time in response to a grid fault, and variations in the grid voltage and frequency due to fluctuating output caused by changing weather conditions. Hitachi is developing power conditioners that can deal with these problems, along with control techniques for using these systems (see p. 35).

(5) Video surveillance systems

With the spread of digital technology and broadband networks, application of video surveillance is now

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(d) Virtual power plant (VPP)
A networked system of distributed power sources, the technology for which is being commercialized in the USA. The system performs integrated control and management via a communication network of multiple distributed power sources, which may include companies' in-house power generators, home-generated renewable energy, and EV batteries as well as power plants operated by power companies.

expanding beyond crime prevention to business uses such as monitoring what is happening at remote sites or using and analyzing images to support customer operations and business management. Hitachi currently supplies the video surveillance solution to business users and has plans for deploying cloud services that use image analysis techniques combined with high-resolution image transmission and image enhancement to support customer operations and monitor equipment operation (see p. 66).

Sustainable Growth

(1) ATOS Chuo Line upgrade

The purpose of the Autonomous Decentralized Transport Operation Control System (ATOS), which was installed by the East Japan Railway Company (JR-East) and commenced operation in 1996, is to provide optimal railway traffic management throughout the Tokyo region. Taking advantage of its autonomous decentralized architecture, JR-East has been progressively rolling out ATOS to additional lines over time, with the system now covering 20 lines with a combined length of about 1,270 km. The requirements for railway systems have been changing in recent years. This includes the need to adapt to operational changes such as the increase in train operations over multiple lines, minimize the duration of timetable disruption, and utilize IT to improve passenger services. To satisfy these requirements, Hitachi is supporting the sustainable growth of railway systems by upgrading to optimal system configurations, providing efficient command infrastructure, expanding information services, and ensuring seamless system upgrades (see p. 45).

(2) System for planning, operation, and maintenance of water supply and sewage

Water supply and sewage are core parts of the social infrastructure and need to satisfy a diverse range of requirements, including not only safe, secure, and trouble-free use, but also sustainable operation and awareness of biodiversity and other water-related environmental considerations. Hitachi considers the entire water supply and sewage lifecycle, supplying information and control system technologies that help operate services over wider areas, operate in ways that take account of energy and the water ecosystem, and build maintenance and upgrade schedules (see p. 52).

(3) Steel industry control systems

Steel industry control systems tend to be large, comprising motors, drives, programmable logic controllers (PLCs), and process computers among other components. In addition to reliability, they require the quick responsiveness to perform realtime electrical and mechanical control. They also need to satisfy demands for efficient equipment operation and improvement in the quality of steel strip. Hitachi is addressing these needs by adopting the latest computing technology and IT, and by working on innovations in control technologies and system technologies. To satisfy the demands of the global market, Hitachi is also actively adopting standard technologies and is developing operational support techniques and remote maintenance techniques that can be used to supply added-value after-sales services (see p. 60).

Security & Resiliency

Hitachi focuses on the concepts of adaptiveness, responsiveness, and cooperativeness to supply solutions to cities and companies. These encompass solutions for disaster prevention, physical security, and cybersecurity. The July 2014 issue of *Hitachi Review*, entitled "Social Infrastructure Security," contains articles on all aspects of Hitachi's work in security[5].

BUILDING SMART SOCIETIES AND SMART INFRASTRUCTURE

This article has looked at current trends in social infrastructure, Hitachi's business environment and the value it provides, developments in the information and control platforms that help deliver this value, and leading-edge initiatives in the field of social infrastructure.

While current work is limited to delivering value to specific sectors such as energy and transportation, the requirement for the future will be to achieve optimization across these sectors and to deliver value to cities, societies, and the entire world. This will require further advances in information platforms and information and control platforms, and the establishment of business models that include a wide range of stakeholders.

Hitachi is working steadfastly to satisfy the increasingly diverse requirements of social infrastructure and is contributing to overcoming a variety of challenges that exist on a global scale.

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ABOUT THE AUTHORS

Naohiko Irie, Dr. Eng.
Control System Platform Development Division, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in the development of control servers for information and control platforms. Dr. Irie is a member of the Information Processing Society of Japan (IPSJ).

Akitoshi Shimura, Dr. Eng.
Social Infrastructure Systems Research Department, Information Service Research Center, Yokohama Research Laboratory, Hitachi, Ltd. He is currently engaged in the research and development of information and control systems designed for railway systems. Dr. Shimura is a member of The Society of Instrument and Control Engineers (SICE).

Minoru Koizumi, Dr. Eng.
Information Platform Research Center, Yokohama Research Laboratory, Hitachi, Ltd. He is currently engaged in the research and development of information and control systems and networks. Mr. Koizumi is a member of the SICE, The Institute of Electrical Engineers of Japan (IEEJ), the IPSJ, and The Institute of Electronics, Information and Communication Engineers (IEICE).

Takayuki Takezawa
System Engineering Development Department, Control System Platform Development Division, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in the development of middleware for information and control systems.