Hitachi's Vision of the Smart City

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HITACHI'S SMART CITY THEME

RECENTLY, the growing severity of global-scale environmental and resource problems together with changes in people's views and values have prompting a reevaluation of what form future cities should take. Hitachi approaches smart city development with the aim of creating a well-balanced relationship between people and the Earth. This means cities that remain in harmony with the environment while providing a lifestyle that is comfortable, safe, and convenient, without compromising people's quality of life.

To achieve this well-balanced ideal, Hitachi is seeking to achieve an advanced fusion of infrastructure with information and telecommunications by drawing on its total engineering capabilities and extensive experience built up over many years working in the field of public infrastructure, including the electric power and mobility sectors, and its capacity to deliver superior solutions in the information and telecommunications fields. These capabilities can be thought of as lying at the core of smart city development, and Hitachi plans to supply them globally in conjunction with real estate developers, construction companies, manufacturers, trading companies, and other businesses involved in urban development.

WHY THE CALL FOR SMART CITIES NOW?

Global Environmental Change and Adverse Effects of Urbanization

Behind the need for smart cities are the external factors that influence people's lives, namely the global environment and the society in which they live. Specific examples include climate change, resource depletion, population growth, demographic changes, the concentration of populations in cities, and the associated adverse effects of urbanization.

Changing Lifestyles

Another set of factors behind the need for smart cities are human considerations such as changes in people's views and values.

Specific examples include the change in the mode of consumption from ownership to sharing, such as when people rent products rather than own them, and consumers who are producers as well as users, such as when people publish their own blogs as well as browsing the Internet.

In broad terms, this represents a shift in values from "material goods" to "activities" and it is anticipated that emerging economies too will undergo a similar shift once they have completed their rapid growth in material terms.

HITACHI'S APPROACH TO SMART CITIES

What do Smart Cities Need?

A smart city can be defined as an environmentally conscious city that uses IT (information technology) to utilize energy and other resources efficiently. Furthermore, Hitachi also believes that it is important

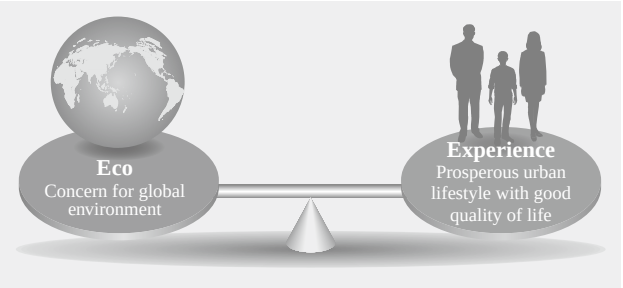

Fig. 1—Well-balanced Relationship between People and the Earth. This means establishing a well-balanced natural harmony between the "eco" value of reducing the impact on the environment and the human-centered "experience" values of comfort, safety, convenience, and well-being.

for smart cities to be attractive places in which people will want to live. In addition to concern for the global environment, smart cities also need to satisfy the wants and values of their residents.

Well-balanced Relationship between People and the Earth

Hitachi believes that smart cities that suit all stakeholders can be achieved through a well-balanced relationship between the "eco" perspective of the global environment and the "experience" perspective of the consumers who live in the city, where "eco" means environmentally conscious and "experience" means a prosperous urban lifestyle that offers a good quality of life (see Fig. 1).

Seeking to combine convenience with consideration for the environment will be essential if cities are to continue to grow in a sustainable way. It is also very important in terms of economic considerations such as improving cities' international competitiveness and the formulation of urban policy.

The following sections discuss each of these perspectives in turn.

(1) Eco: Environmentally conscious

This perspective is concerned with how to handle a changing global environment and reduce the future impact on the environment. The need to take account of the global environment exists in a variety of fields, including the creation of a low-carbon society in response to climate change, the efficient use of water resources to resolve the imbalances in its supply and demand, and effective use of energy in ways that take account of the depletion of mined resources such as fossil fuels.

(2) Experience: A prosperous urban lifestyle that offers a good quality of life

An extremely important factor when considering the sustainability of cities is how to enhance people's experience values, such as living, working, studying, and traveling. These concern people's way of life and require the creation of a prosperous urban lifestyle that offers a good quality of life in a way that is also balanced in economic terms, with a view to solving problems such as demographic changes as well as those faced by cities directly.

The following section considers what is meant by and what is required for well-balanced relationships in the natural environment, urban lifestyles, and the economy.

(i) Well-balanced relationship between natural environment and economy

The more priority is given to the economy, the more it tends to cause environmental problems. Overcoming this requires initiatives such as the reassembly of public infrastructure and advanced control of the balance between supply and demand.

To obtain an urban structure that can achieve a better balance between the natural environment and the economy at a low cost, it is necessary to consider the city in terms of its component parts using the concept of the smallest unit of urban infrastructure.

(ii) Well-balanced relationship between urban lifestyle and economy

Placing too much emphasis on considerations like economics and efficiency results in a loss of consumer convenience and comfort. To give an extreme example, the most economically efficient way to build a city, in which the distance people need to travel is kept short, thermal efficiency is high, and infrastructure management costs are low, would be to construct a single huge building capable of housing all homes, workplaces, supermarkets, schools, and hospitals along with waste management, entertainment, sports, and other facilities. However, this would not make for an attractive place to live.

If urban consumers do not find a city to be attractive, they will go somewhere else. Being a consumer-oriented city that considers ways of providing attractive lifestyles is also an important factor.

(iii) Well-balanced relationships in urban living

Many people acting to maximize the benefit to themselves will not necessarily maximize overall welfare. For example, traffic congestion occurs when large numbers of people choose to use cars so that they can benefit from getting to where they want to go quickly and efficiently, resulting in longer travel times and the loss of that benefit they hoped to gain. What is needed to resolve this fallacy of composition is sophisticated control of demand and supply, including ways of making information visible.

This involves not only eliminating energy wastage to reduce the impact on the environment, but also improving the utilization of infrastructure and other equipment to reduce overall costs and reduce resource wastage.

(iv) Well-balanced human values

Establishing a well-balanced relationship between ownership and sharing of tools, facilities, and other equipment is essential for responding to changing consumer values. For example, if services were provided that allowed cars or other products to be

used by those people who really need them, when they need them, sharing between large numbers of people would bring savings such as in the overheads of ownership and the dead time when the products are not being used. It would also minimize energy use and reduce the impact on the environment by allowing city managers to provide their services without the need to maintain excess resource or equipment capacity.

Smart City Stakeholders

The stakeholders in a city can be broadly divided into the following three groups. Hitachi believes that realizing smart cities will require well-balanced relationships in which the needs of each group of stakeholders are satisfied.

(1) Consumers

This group includes the people who live, work, study, or visit the city. They represent the people who act (live, work, study, or travel) within the city while also seeking their own fulfillment and a better quality of life.

(2) City managers

These are the organizations such as local government, real estate developers, and infrastructure operators who manage and execute the planning, design, construction, operation, and growth of the urban environment that supports consumer activity. They represent those stakeholders who seek to ensure the ongoing growth of the city.

(3) World opinion

This group represents those stakeholders who seek to reduce the impact on the global environment. Their priorities include reducing carbon emissions, making effective use of natural resources, and maintaining biodiversity.

Although they all share the same actual problems, these three groups of stakeholders can come into conflict because of differences in their priorities and the directions in which they seek to move.

For example, railway passengers would each like to travel seated in an uncrowded train, but if a city manager increased the number of trains to satisfy this demand, the result would be higher costs for the railway company as well as rises in fares and energy consumption.

On the other hand, if the number of trains were cut to reduce the impact on the environment, consumers would suffer from longer travel times and the discomfort of traveling in crowded trains.

That is, the comfort, convenience, safety, and security demanded by consumers conflict with the city manager's desire for efficient urban services, industrial vitality, and a symbiotic society, while both conflict with the prevention of global warming, effective use of natural resources, maintenance of biodiversity, and reduced impact on the environment demanded by world opinion. What is required is a sustainable approach that achieves a balance between the many conflicting demands of each group without compelling any of them to endure more than their fair share.

Hierarchical Structure of Smart Cities

Smart cities consist of two infrastructure layers for public services built on top of the national infrastructure, together with urban management infrastructure that uses IT to link these together (see Fig. 2).

(1) National infrastructure

These are infrastructures that cover areas larger than single cities. In addition to providing the foundational layers of energy, water, transportation,

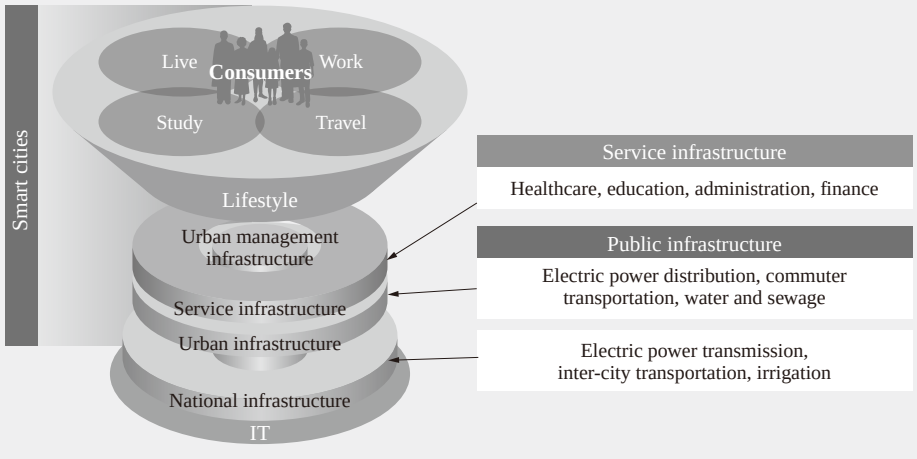

Fig. 2—Hierarchical Structure of Smart Cities.
Smart cities consist of urban management infrastructure and two infrastructure layers for public services built on top of the national infrastructure.

and communications that protect people's lives and support their day-to-day activities at a national or regional level, this is also the level at which coordination between different cities is managed.

(2) Urban infrastructure

The urban infrastructure layer is formed by linking together the smallest units based on the geographical and physical characteristics of individual cities. Most of the sectors handled by the urban infrastructure layer, including energy, water, mobility, communications, and waste, are closely integrated with the national infrastructure layer. It also represents the lowest level at which demand balancing can be considered, and the level at which interoperation, expansion, and reduction are handled in an autonomous and decentralized(a) way.

(3) Service infrastructure

This layer contains a city's facilities and other services including medicine and healthcare, education, administration, and finance. Built on top of the urban infrastructure, this layer can be considered from a consumer's perspective as being the layer in which they obtain services, and from a city manager's perspective as being the layer in which services are supplied to consumers.

The aim in this service infrastructure layer is to create a next-generation way of life by dividing the different services of the city into their smallest component parts, such as the ability to receive medical services or the provision of places of study, making the individual functions smarter, and then reassembling them in accordance with consumer needs.

This means making services multi-functional where this is needed or, alternatively, coordinating together under common services those that can be shared so as to eliminate waste and achieve greater efficiency and convenience. This can be thought of as the application to cities of the "object-oriented(b)" concept used in fields like software engineering.

(a) Autonomous and decentralized
A system architecture concept in which the overall mechanism and the associated functions are formed by combining a number of component elements from an autonomous system and having them work together.

(b) Object-oriented
A technique used in design, development, and other areas of software engineering whereby the data to be manipulated and the methods (procedures) that perform the manipulation are treated and managed as a single entity (an "object"). An object-oriented approach means putting systems together from the interactions between these objects.

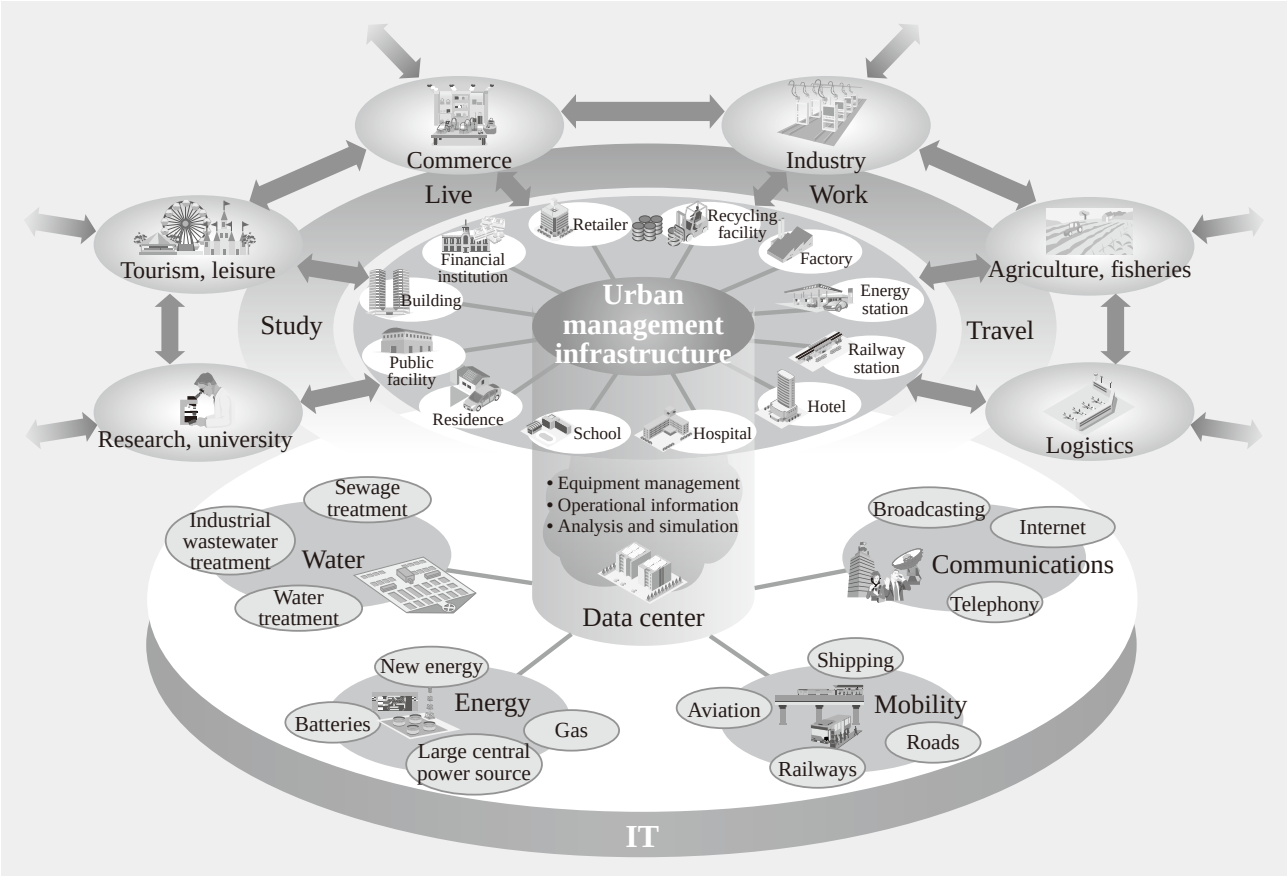

Fig. 3—Relationship between Smart Cities and IT.
IT links together and coordinates the infrastructure, services, and other elements that make up a city.

(4) Urban management infrastructure

This layer provides comfort to consumers and efficiency to city managers by reducing the impact on the environment at the same time as coordinating operations within and between different infrastructure using urban management infrastructure with functions that include using IT to manage city information, administer operations, and operate equipment. In the energy sector, for example, urban management infrastructure will be used to coordinate smart grids (which are currently a subject of interest). In the mobility sector, they will coordinate navigation systems and facilitate green mobility by using EVs (electric vehicles). In the water sector, they will coordinate advanced water management systems using water from rain and recycling.

(5) Lifestyle

This layer represents the "consumer's way of life," which means living, working, studying, and traveling. Hitachi's vision for smart cities seeks to improve QoL by understanding consumers' genuine needs and then disassembling and reassembling the functions of the service infrastructure layer accordingly.

IT SUPPORT FOR SMART CITIES

Hitachi's vision for smart cities involves using IT to combine the various elements of the hierarchy described above so that they work together. Hitachi is aiming to build a platform that can act as a foundation for achieving this coordination by utilizing the information technologies and control technologies it has built up over time (see Fig. 3).

Fusion of Information and Control

There are significant differences between the IT used in information systems and control systems.

Rapid progress is being made on increasing the speed and expanding the capacity of information systems in order to process the explosive growth in information, particularly on the Internet and mobile networks. Also, many information systems work on the "best effort(c)" principle and use horizontally demarcated, open system configurations to handle the steady stream of new services.

Control systems, on the other hand, because they are used for the reliable and safe operation of physical equipment, are designed to prioritize safety, reliability, and real-time performance. They also tend to be designed to remain in operation for decades and most adopt a vertically integrated system configuration.

Many information systems are what are called "mission-critical systems," designed for real-time performance and requiring the reliability for 24-hour non-stop operation, such as financial systems. Even in such systems as these, however, the approach to a system's reliability requirements is significantly different. For example, whereas information systems are often designed with an emphasis on average execution speed, such as throughput under normal conditions, the emphasis in control systems is on what is known as "hard real-time performance," which means that processing is guaranteed to complete within the allowed time with 100% certainty.

Hitachi believes that what will be important in the future will be to aim for overall optimization to deal with the various issues faced by a city in a comprehensive way through the fusion of information and control, whereby the two types of IT (information and control systems) interoperate much more closely than in the past.

Advanced Control for Balancing Supply and Demand

By coordinating the urban infrastructure and service infrastructure layers, urban management infrastructure gives access to more information on supply and demand than was available in the past. They also allow management of the supply and demand balance to be performed instantaneously and with high precision.

(1) Control of demand

It is possible to smooth the utilization ratios of urban infrastructure equipment, without changing total demand, by guiding and controlling demand-side needs. For example, by extending this mechanism, it is possible to reduce traffic congestion by controlling the peak in demand for road use or to guide and control demand in ways that can cope with situations where supply-side control is difficult, such as the output of photovoltaic power generation.

(2) Control of supply

It is possible to take account of demand-side considerations and control the level of supply appropriately in accordance with individual demands, such as supplying electric power based on public

(c) Best effort
A term used for communication networks and services that do not guarantee communication quality, such as the Internet in its present form. As communication speed depends on factors such as the extent to which lines are being used and the performance and settings of software and hardware, it is possible for communication speeds and other aspects of service quality to fall below designated levels. In contrast, the term "guaranteed" is used for networks and other communication services that guarantee communication quality.

priorities in situations when adequate supply cannot be obtained.

(3) Risk mitigation

When controlling supply and demand during disasters or other emergencies, it is possible to specify and handle these independently based on geographical and physical characteristics. Minimum guidelines can be set for the smallest units of the urban infrastructure layer such as shared energy or other resources so that, by linking and coordinating these with other systems in an autonomous and decentralized way, things like the supply and demand balance and load distribution are controlled appropriately, even during an emergency. This secures service infrastructure appropriately unless they are physically damaged.

Non-stop Autonomous and Decentralized Operation of Urban Infrastructure

Hitachi considers city infrastructure in terms of its smallest units and builds the infrastructure based on an autonomous and decentralized system concept. By designing each system to function autonomously, service outages can be prevented when abnormal situations arise without any local malfunctions spreading to the entire system. These can then be enhanced further to become "symbiosis autonomous decentralized systems" that are more easily able to interoperate, even between different communities and different systems, and can adapt to a dynamically changing city for long into the future without interruptions to 365-day, 24-hour functions.

Adapting to Geographical Characteristics

By dividing infrastructure and other city functions into small units and combining only those that are needed by the community, it is possible to satisfy the requirements of islands or other small or geographically isolated areas by providing autonomous infrastructure consisting of only those elements that are required by the community. Meanwhile, to satisfy the requirements of arid areas where catchment management is a priority, it is possible to provide, in a limited way, some of the functions available in cities, such as Hitachi's intelligent water system(d).

By separating non-location-dependent services from their locations, it is possible to respond in a fine-tuned way to the requirements perceived by the administrators who formulate city policies, including improving both convenience and efficiency, reducing operating costs by sharing those services that are best shared, and cutting energy use by eliminating unnecessary functions.

Adapting to Changes that Come with Different City Life Stages

Cities can be differentiated on the basis of the series of life stages they go through over time, such as the rapid progress in emerging economies, the renewal taking place in the mature cities of developed nations, and the renewal stage when the national infrastructure layer and service infrastructure layer become separated. The smart cities envisaged by Hitachi will be able to adapt to these changes in an extremely flexible way.

In the stage of rapid progress, for example, the national infrastructure layer and urban infrastructure layer are developed in an integrated way, with the service infrastructure layer and lifestyle provision added as they become needed.

The situation in the renewal stage is that the national infrastructure layer remains in good condition but there is a loss of urban infrastructure layer and service infrastructure layer, with provision of these undertaken rapidly, starting with those parts that are needed.

In the mature cities of developed economies, it is possible to operate cities in a sustainable way that suits even societies such as Japan's, with a diminishing population, by allowing the conversion of facilities, for example, such as taking schooling functions that are no longer necessary due to a falling birth rate and redeploying them in rest homes for the elderly.

HITACHI'S CAPABILITIES

Hitachi boasts extensive experience and total engineering capabilities built up over many years of involvement in public infrastructure sectors such as electric power, mobility, water and sewage, and industrial systems. It also has the capabilities to achieve an advanced fusion of infrastructure with information and telecommunications, being equipped with excellent solution capabilities in the information and telecommunication sectors along

(d) Intelligent water system
Hitachi's proposal for a water infrastructure that integrates water treatment systems with information and control systems. The system uses information on water use (collected from sensors and other sources and then stored) to predict water demand and coordinates the operation of the water supply, recycled water, and industrial wastewater treatment systems in an optimum way to maximize energy efficiency and make effective use of water resources. The system also supports the coordination of water infrastructure over a wide area using an integrated management system.

with advanced technologies and know-how, including autonomous decentralized technology. By utilizing these capabilities, which are seen as essential for the development of smart cities, and undertaking projects in partnership with real estate developers, construction companies, manufacturers, trading companies, and others involved in urban development, Hitachi believes that it can design smart cities that exhibit a higher degree of completeness.

Hitachi is currently involved in many smart city projects being undertaken around the world where it is verifying specific practices and building experience. Not just in three or five years' time, but 30 years from now and beyond, Hitachi intends to be involved in supporting smart city development and will continue supplying solutions for a wide range of areas as one of the essential participants in the industry.

Current and Future Activities

Hitachi, Ltd. established its Smart City Business Management Division (currently Social Innovation Business Project Division) on April 1, 2010 to serve as a coordinating organization that spans a range of sectors involved with smart cities, including electric power, mobility, public and industrial infrastructure, urban development, telecommunications, information, and control. The mission of the new division is to participate in smart cities from the concept stage, offering a one-stop service that acts as a powerful driver for the business while also adding new value.

Currently, Hitachi is engaged in the following three major initiatives associated with smart city development.

(1) Packaging of Japan's advanced infrastructure

Japan is an environmental leader and this initiative involves packaging the strengths of its advanced infrastructures so that they can be deployed globally through collaboration with local partners. Rather than acting on its own, Hitachi is working with corporations and other entities with strengths in the various components that make up the package in order to cover all aspects of infrastructure construction, from planning to operation and maintenance services.

(2) Participation through collaboration between public and private sectors from the concept stage, and participation as a primary contractor

This initiative involves expanding Hitachi's business into services such as operation and maintenance, and taking part in activities such as central and local government policies and the consulting and planning work undertaken at the concept stage of projects by expanding its PPP (public-private partnership) business. This will sometimes mean Hitachi acts as the primary contractor. In such cases, if adequate capital cannot be raised for smart city development, Hitachi will support urban progress by having a comprehensive involvement in everything from investment in the infrastructure to its operation and maintenance.

(3) Technology and system development

This involves utilizing the strengths of Hitachi, with its extensive experience and success in the public infrastructure sector, to develop and supply the new technologies and other systems required by smart cities. Examples include plans for energy management systems that can reduce the impact on the environment while maintaining security of supply through the flexible adjustment of the balance of regional energy demand and supply, charging management, vehicle information management, and other systems that allow EVs to play their part in a city's mobility infrastructure.

APPLYING JAPANESE INGENUITY TO URBAN DEVELOPMENT

The ingenuity of the Japanese people that gave rise to the term "mottainai," which has now spread around the world, has expanded to encompass every aspect of urban infrastructure and lifestyles, and Hitachi wants to use the term "smart city" to refer to such cities when creating a well-balanced relationship between people and the Earth through advanced technology and other know-how.

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