Introduction of Research Study

Innovations in Dynamic Infrastructure Originated from Provided Value

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Hitachi Research Institute is conducting research on how information technology (IT) and data utilization in social and industrial infrastructures can lead to the creation of value. In this report, we introduce a research study on the creation of value in provided services, achieved by dynamically linking and coordinating social and industrial infrastructures to go beyond individual infrastructures. “Dynamic infrastructure” refers to a mechanism that enables infrastructures such as logistics, mobility, and energy to (1) connect and respond to diverse lifestyles and usage conditions of end users (service users), (2) absorb fluctuations in peak and bottom utilization rates to increase asset efficiency, (3) reduce disadvantages felt by users due to insufficient coordination between different infrastructures (waiting times, traffic congestion, etc.), and (4) facilitate the provision of services in response to unexpected situations such as large-scale disasters.

1. Dynamic coordination and adjustment between multiple infrastructures, as required by society and industry as a whole

Figure 1 summarizes the importance of dynamic operational coordination between infrastructures in the fields of logistics, mobility, and energy. It indicates the importance of expanding our perspective to include multiple infrastructures that comprise society and industry as a whole, as well as individual infrastructures in each sector.

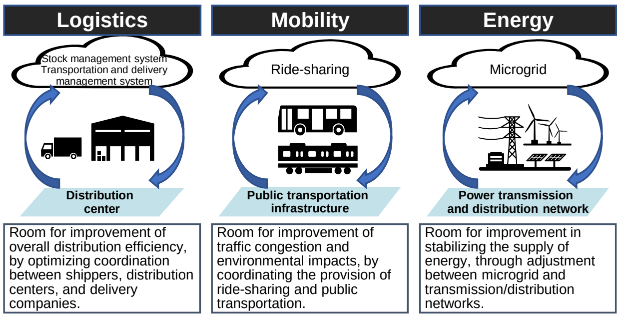

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Figure 1 Importance of Operational Coordination between Multiple Infrastructures

In logistics, for example, warehousing and distribution operations are aligned with predetermined cut-off times (times at which trucks leave warehouses) to create one-day operation plans. Then, times for transferring work from the upstream to downstream areas of logistics are decided, and operation procedures are established so that the work deadlines are followed. However, due to insufficient coordination between shipper inventory management systems, warehouse management systems at logistics centers, and transportation and delivery management systems of delivery companies, burdens related to the constantly fluctuating supply and demand conditions become concentrated at logistics centers, causing an increase in the waiting time of trucks at warehouses. On the other hand, if the time of delivery to the end customer is taken as the starting point, and the volume and deadlines are adjusted among the systems of the shipper, distribution center, and delivery company, the process can be streamlined by linking the delivery operations with the warehouse operations.

In the area of mobility, new services such as ride-sharing have enhanced mobility convenience for users, but as a result the volume of automobile traffic in urban areas has increased, causing traffic congestion and greater environmental impacts. In order to achieve more stable mobility and improve the living environment in urban areas, it will be important to optimize traffic flow by linking together elements such as ride-sharing and public transportation and utilizing dynamic fare pricing, in accordance with the supply and demand for mobility services.

In the area of energy, the introduction of decentralized power supply network systems using renewable energy sources such as solar and wind power generation is being promoted, primarily by local governments and business operators in individual regions. However, in order to further stabilize the supply of power, it will be necessary to make adjustments to the overall power supply process from generation to transmission and distribution, including transmission and distribution systems.

Dynamic infrastructure can link the operations of multiple infrastructures that make up social and industrial value chains, and can achieve overall optimization which includes greater efficiency, stability, and environmental load reduction, issues which have been difficult to solve by individual infrastructures alone.

2. Three cooperative measures to strengthen infrastructure operation across society and industry as a whole

Dynamic infrastructure assumes a high level of reliability and stability for each system. It collects information related to service operation and use from sources such as operators, end users, and equipment and facility manufacturers, to gain an understanding of the supply and demand conditions and achieve dynamic operational coordination between infrastructures. In order to accomplish this, it is important (1) to have operating status be mutually recognized between systems, preventing excessive chronological and regional concentration of operations, (2) to visualize the availability and reliability of each system and equalize their operations, and (3) to flexibly and automatically adjust and control the coordination targets and operation levels of systems, according to service supply and demand. Some companies are now working to realize dynamic infrastructure through these cooperative measures.

(1) Mutual recognition of operating status: Kyyti is a ride-sharing service operation company in Finland. It has established a ride-sharing service management system that uses APIs to obtain data from systems for public transportation such as trains and buses, on service conditions such as vehicle locations, destination information, and delay information. It then analyzes transportation supply and demand from the destination information of ride-sharing service users, and varies its ride-sharing fares to disperse users to other forms of transportation in order to avoid localized concentrations of traffic. By sharing data among different types of transportation, the supply and demand conditions of local transportation services can be understood in real time, and transportation services can be operated with high stability.

(2) Visualization of availability and reliability for individual systems: Walmart and IBM have built a system that reads tracking codes attached to food products at each stage of distribution, including production, warehousing, transportation, and sales, and registers them in a blockchain. By referring to the merchandise distribution information stored in the blockchain, each business operator can identify the status of delivery in just a few seconds. This includes the quantity of products handled and their retention time over the entire supply chain, including the distribution stock of handled products. These companies accumulate and analyze actual data on the rate of transition to unacceptable products (due to decay or defects) and the required processing time at each stage of distribution, to visualize the processing capacity of each business partner company. Each company's allowed processing capacity is then simulated according to increases or decreases in volume, and order amounts are distributed and adjusted to equalize the level of operational quality throughout the supply chain.

(3) Automation of connection destinations, and operating level adjustment and control: Schneider Electric is developing an application that can link systems for managing data on the operation and power consumption of facilities in factories and buildings, with systems for managing data on the amount of private power generation such as by solar power. It can predict changes in the power consumption of entire facilities in response to the constantly changing facility operating rate of factories and buildings, and controls private power generation supply systems through APIs to stabilize supplies of power between private power generation and distribution by power companies. By providing groups of APIs for linking each system of facility management, private power generation, and the main power distribution network, and an automatic code generation function for easily changing software settings, the company has achieved a flexible means of coordinating operations across multiple systems.

3. Promotion of dynamic infrastructure policies by the ITRC in the UK

The United Kingdom is promoting policies to realize greater efficiency and stability, and reduce environmental impacts, by dynamically coordinating the operation of respective infrastructures from a social and industrial perspective. Specifically, the ITRC (Infrastructure Transitions Research Consortium), a consortium for industry-government-academia collaboration, has been formed to build mechanisms and implement solutions to achieve standardized data and system coordination between society and industry. The ITRC has developed the NISMOD (National Infrastructure Systems MODel) framework (Figure 2). This framework consists of three functions: an “infrastructure database”, which collects real-time data from social and industrial infrastructures; an “infrastructure coordination system model”, which provides an environment for simulating operational coordination between infrastructures; and an “infrastructure strategy”, which provides API groups and automatic software code generation functions. Participating infrastructure operators and system vendors are using the NISMOD framework to develop and implement dynamic infrastructure solutions to achieve operational coordination of infrastructure across various industry types.

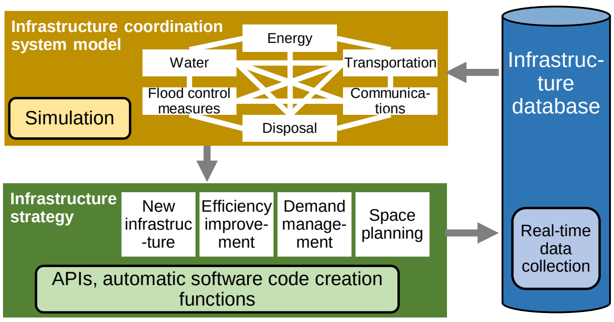

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Figure 2 Main Functions of the NISMOD National Infrastructure Model Framework

4. Future prospects for maximizing the value provided by social and industrial infrastructures

With the future spread and expansion of AI and 5G, the application of social and industrial infrastructure data will advance in each country or region. Hitachi Research Institute intends to continue carrying out research on this subject, paying close attention to the trends for policy and technology development by various countries, regions, and companies toward the realization of dynamic social and industrial infrastructure.