Digitalization of Onsite Work for DX in Social Infrastructure Maintenance

The social infrastructure that underpins people's lives needs to operate correctly at all times. Unfortunately, the equipment used in this infrastructure is aging, especially that installed during the high-growth post-war era. Moreover, while most maintenance inspections are conducted by workers onsite, there is a shortage of experienced staff and the workforce, too, is aging. One way to address these challenges is with solution services that use sensors to monitor the condition of social infrastructure and techniques like AI to analyze the collected data. These services can also help to reduce the load on the environment, including through rapid recovery from large natural disasters, enhanced national resilience, and the localization of work. This article presents examples of how Hitachi is working toward the digitalization of social infrastructure maintenance.

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1. Introduction

As much of the social infrastructure that underpins modern life was built during the high-growth post-war era, the rising proportion of aging equipment is a concern. Estimates indicate that the cost of inspecting and repairing this aging infrastructure is likely to exceed annual budgets by 2035. Estimates also indicate that roughly half of all experienced staff are coming up for retirement.

The Basic Plan for Life Extension of Infrastructure of the Ministry of Land, Infrastructure, Transport and Tourism presents an overview of the many infrastructure-related initiatives planned by central government and regional public agencies to address this situation. The plan instructs the agencies who manage this infrastructure to formulate Action Plans for Life Extension of Infrastructure that will enable serious measures to be taken to address this issue around Japan.

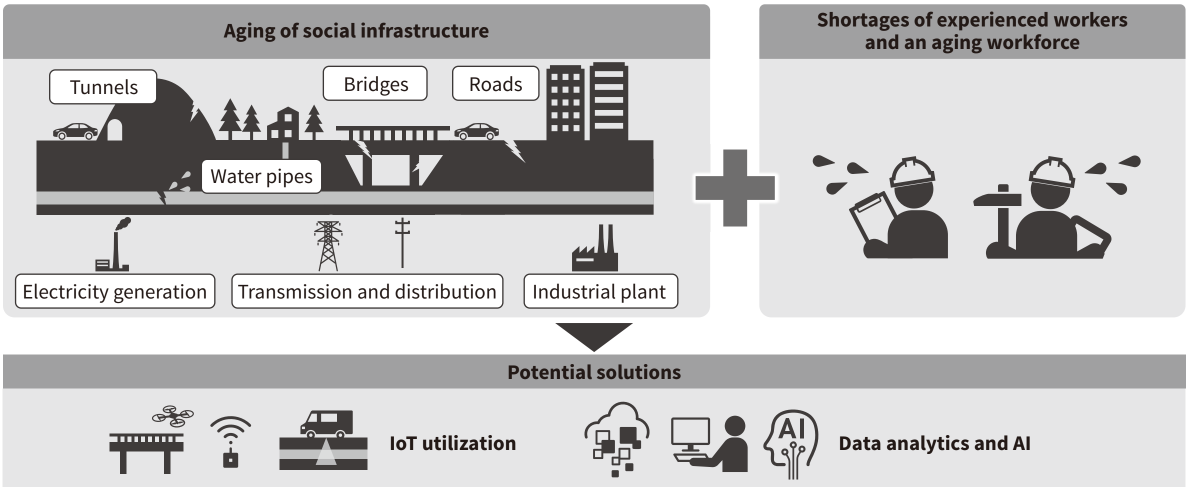
By collecting data from edge devices such as radar, cameras, and other sensors, then analyzing it using artificial intelligence (AI) to generate valuable data on the maintenance of social infrastructure, Hitachi is contributing to the digital transformation (DX) of inspection and repair work by the agencies responsible (see **Figure 1**).

2. Overview and Examples of Social Infrastructure Maintenance Work

This section gives an overview of social infrastructure maintenance and describes two of the services provided by Hitachi: a water leakage detection service and a subsurface visualization service. This includes an explanation of how

Figure 1 — Future Directions for Social Infrastructure Challenges and Solutions

As the social infrastructure built during the post-war era of rapid growth is coming toward the end of its life, the industry faces shortages of experienced maintenance staff and the aging of its workforce.



IoT: Internet of Things AI: artificial intelligence

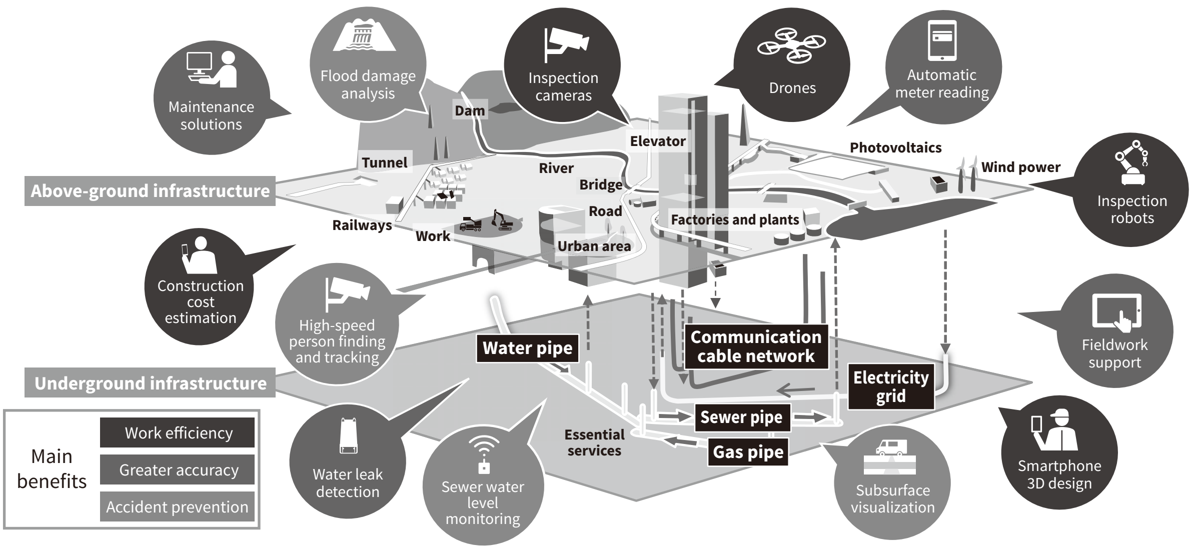
these services facilitate rapid recovery from major natural disasters and the work being done to reduce the load on the environment.

2. 1 Overview of DX in Social Infrastructure

Whether it be above or below ground, Hitachi provides solutions ranging from inspections to the optimization of repair planning for the social infrastructure belonging to a variety of industries (see **Figure 2**). Past practice was to develop systems for specific customers through a bespoke system integration (SI) business. More recently, having recognized commonalities in the challenges facing social infrastructure, Hitachi has begun providing solution services that transcend the boundaries between different customers and industries. By finding the best mix of solution services that focus on this commonality of challenges along with knowledge of customers and industries derived from many years of working together, Hitachi can provide the services they need quickly and at low cost (see **Figure 3**).

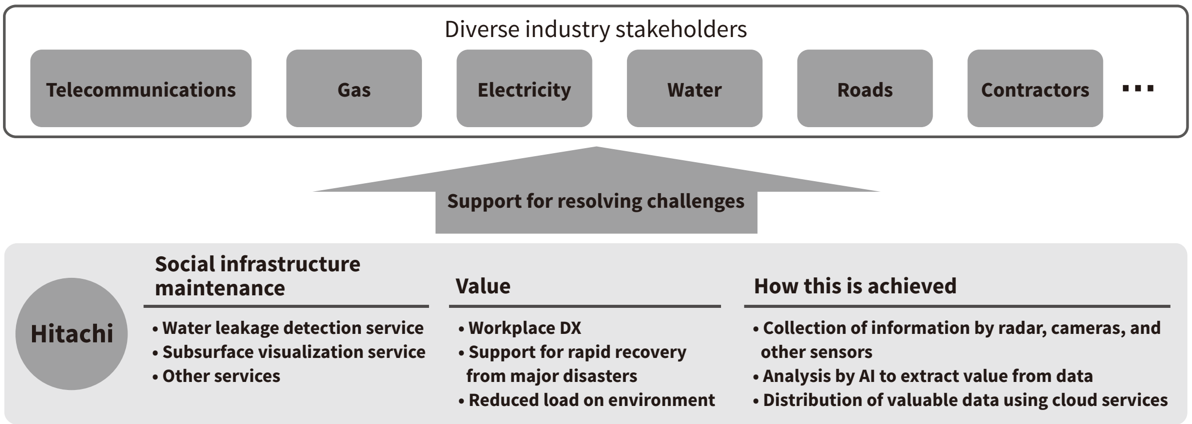
Figure 2 — Hitachi Social Infrastructure Maintenance Solutions

Hitachi provides total solutions for a range of social infrastructure.



3D: three-dimensional

Figure 3 — Industry-wide Workplace DX
Workplace DX is being pursued across the industry, involving a wide range of stakeholders.



DX: digital transformation

The goal is to deliver greater value while also equipping existing services to deal with the new risks that are likely to arise as progress is made on workplace DX. To achieve this, Hitachi intends to further expand and deepen its collaborative creation (co-creation) with stakeholders.

2. 2 Water Leakage Detection Service

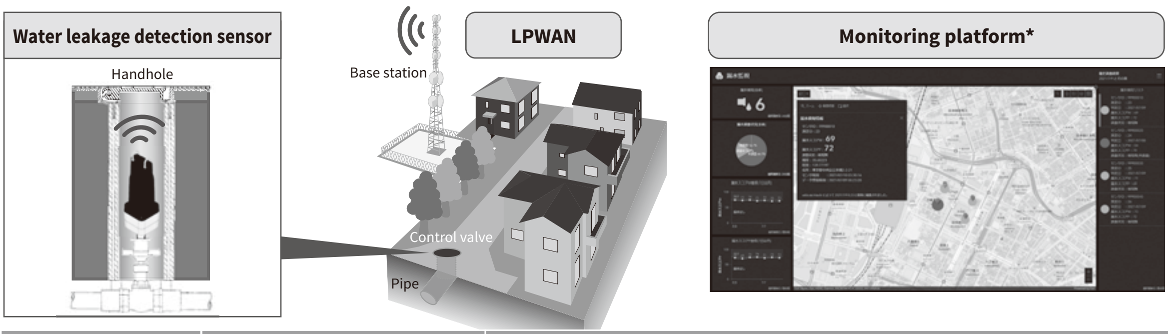
The water leakage detection service[(1), (2)] uses ultra-sensitive vibration sensors developed by Hitachi for the continuous monitoring of water pipes. It combines networked leak sensors with a cloud-based monitoring platform (see **Figure 4**).

The service works through sensors mounted on control valves in the pipe network that measure the vibrations emitted at sites where water is leaking. This data is then analyzed using an algorithm developed by Hitachi to calculate a leak risk score. A low-power, wide-area network (LPWAN) based on Long Term Evolution-machine (LTE-M) communications is used to send the scores to the monitoring platform where a map screen displays whether leaks are suspected and the locations of the sensors that are detecting them.

The service provides remote monitoring of the condition of underground pipes without having to visit the site. By narrowing down the areas where suspected leaks are located, it should also make the task of finding them more efficient.

The service was awarded the Minister of Education, Culture, Sports, Science and Technology Prize at the 51st

Figure 4 — Overview of Water Leakage Detection Service
Hitachi's water leakage detection service achieves high accuracy by using ultra-sensitive vibration sensors and algorithms developed in-house. Problems caused by water leaks can be minimized through continuous monitoring via an LPWAN.



Parameter	Conventional leakage inspection	Water leakage detection service
Inspection frequency	Once every three to five years	Continuous monitoring of sensors via LPWAN
Features	Time-consuming manual work	Installation of sensors improves work efficiency by a factor of 16 (Hitachi's estimate)

LPWAN: low-power wide-area network
*Artist's impression

Japan Industrial Technology Awards organized by Nikkan Kogyo Shimbun, Ltd.[3] It is widely used in Japan, helping to make social infrastructure safe, secure, and resilient.

Municipal utilities are the main customer base for the water leakage detection service and large parts of their pipe networks are now coming due for upgrading, having largely been built during the post-war high-growth era. It is because this work has fallen behind that leaks continue to occur.

Instead, water utilities conduct regular inspection surveys to address the problem of leakage. Onsite inspection is the main method in current use, involving an engineer going out into the field and listening for the distinctive sound of a water leak. Unfortunately, there is a limit to how well this approach can detect changes across wide areas of piping. As detection also relies on experience and know-how, retaining staff with the requisite skills is another challenge.

The primary benefit of the water leakage detection service is that the remote monitoring it provides enables the early detection and repair of water leaks. Combining the service with existing onsite inspection allows leak monitoring practices to be put in place that improve the efficiency of this work.

Investigation is also underway into extending the service to cover pipe network management (upgrade planning), one of the broad-based challenges facing water utilities[4]. That is, the task of upgrading pipe networks can be made more efficient by using data collected for leak detection to inform decisions on how long particular pipes will be able to remain in service and when they will need to be upgraded.

By integrating water leakage detection with other services and data rather than only supplying it on a standalone basis, Hitachi is also aiming to expand the service into something that will help utilities improve their operational efficiency.

2. 3 Subsurface Visualization Service

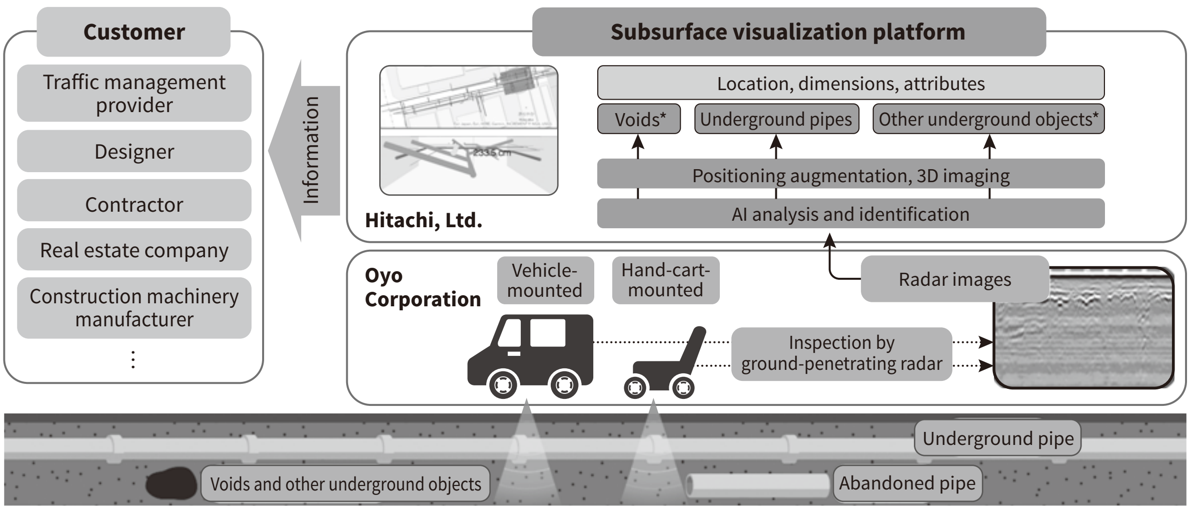
Among the issues to be dealt with when laying or upgrading underground piping is the amount of design work required, including collation and coordination of the separately managed drawings held by different utilities. Discrepancies between drawings and the actual situation are also a problem, with the resulting design changes, work delays, and pipe damage being an impediment to the planned and efficient progress of this work.

Developed through co-creation with Oyo Corporation to enable more advanced and efficient maintenance of underground infrastructure, the subsurface visualization service[5] provides information about such infrastructure to the utilities responsible for it (see **Figure 5**). Instead of relying on human expertise, the information is generated by using a vehicle equipped with non-destructive ground-penetrating radar to scan the region of interest and then using AI analytics to present this visually. The information is collected on a central platform from which it can be viewed on a web browser in the form of accurate and intuitive two- and three-dimensional (2D/3D) images that show what is below the surface, including relative positions. Hitachi's goal in making this service available is to transform existing maintenance processes.

The service was launched commercially in May 2021 and access to information on the platform became available in December of that year. As of November 2022, trials and

Figure 5 — Overview of Subsurface Visualization Service

Positional information about piping, voids, and other underground objects that has been converted into visual form by the analysis of ground-penetrating radar images is managed centrally on a platform and made available to customers on demand. Scanning can be done at a speed of 45 km/h using vehicles equipped with radar, a global navigation satellite system (GNSS), an inertial navigation system (INS) to maintain accuracy in locations where GNSS does not work well, and a mobile mapping system (MMS) for collecting 3D data on road surfaces and the surrounding area.



*Hitachi plans to make information about voids and other underground objects available on the subsurface visualization platform in the future.

service delivery are underway with 28 organizations (seven gas companies, 13 central or local government agencies, and eight manufacturing companies). When a joint study with Sendai-city Sewer Division (from November 2021 to May 2022) estimated the benefits of using information provided by this service in design work, it found that, by improving the accuracy of design information prior to exploratory digging, it could be expected to deliver a 70% reduction in additional digging or design changes (rework) resulting from discrepancies between drawings and what is underground. A joint study into improving the efficiency of onsite and other work commenced in July 2022. The aim is to utilize knowledge gained in this work to further enhance service functions, establish a service model that is compatible with the needs of local government, and to make the services available to private-sector companies.

Hitachi is also looking at the potential for using the service platform as a place for infrastructure operators to share information, thereby smoothing communications and helping to achieve operational efficiency gains and other advances across the entire industry. The sharing of upgrade plans, for example, currently takes place at venues such as conferences. If simple ways were available to submit and share such information on the platform in a standardized format, and to improve the frequency with which the information is updated, it should be possible to facilitate the sharing of detailed and timely information, reduce the amount of work that utilities put into coordinating with one another and making on-site visits, and lead to greater work efficiencies. By consulting with infrastructure operators about their needs and how best to address them, Hitachi intends to put plans in place and get to work on implementing them.

3. Added Value from Social Infrastructure Maintenance Business

The platforms described above that form part of Hitachi's social infrastructure maintenance business also provide valuable functions in terms of preparedness for major natural disasters. This is in line with the Cabinet Secretariat Fundamental Plan for National Resilience.

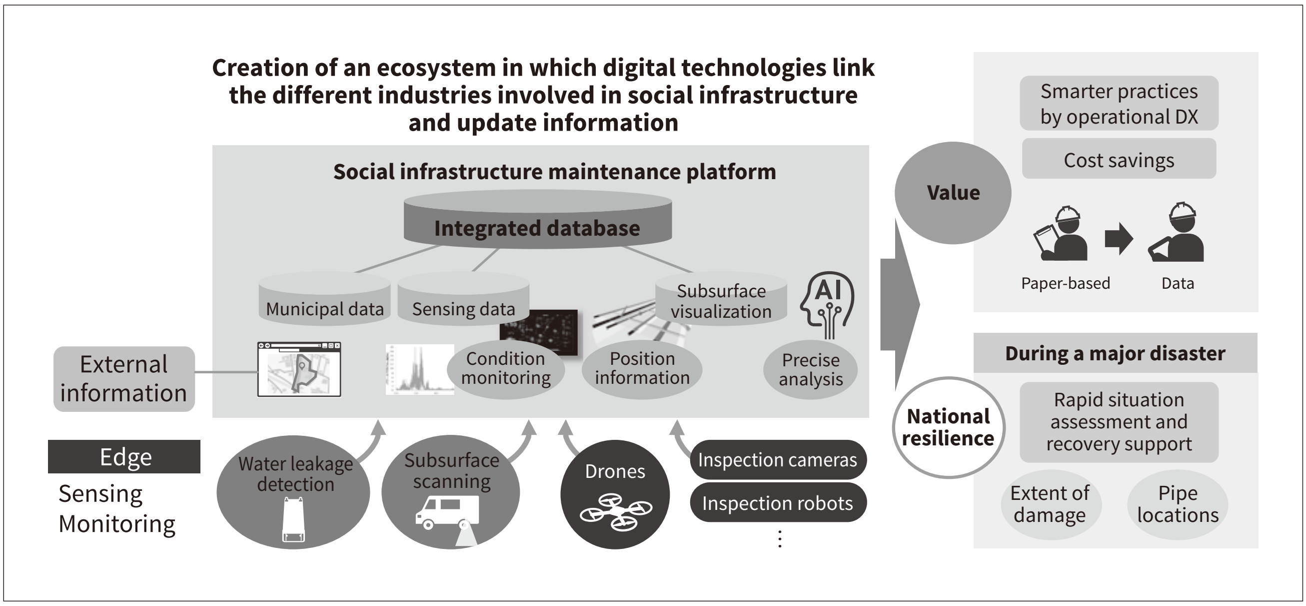
For example, large disasters such as earthquakes or landslips can result in leaks from aging water pipes. As many leaks can occur at the same time, in the past it has taken a lot of time and effort to assess the overall situation. In contrast, the continuous monitoring provided by Hitachi's water leakage detection service allows the locations of suspected leaks to be identified while the disaster is happening, thereby facilitating a rapid recovery.

Another example is the undergrounding of power cables as a disaster prevention and mitigation measure. While a lot of work goes into design tasks such as coordinating installation and determining where existing piping is located, Hitachi's subsurface visualization service can help make this work more efficient.

These services also help to lighten the load on the environment. Early detection by the water leakage detection service, for example, prevents the waste of valuable water. Likewise, by reducing the amount of exploratory digging required to make inspections, the benefits of the subsurface visualization service include less waste soil and use of machinery and reduced traffic congestion due to shorter work duration. More broadly, the integrated management on Hitachi's proposed social infrastructure maintenance

Figure 6 — Overall Concept behind Social Infrastructure Maintenance Business

Hitachi is creating an ecosystem for achieving DX in the operations of infrastructure businesses. To be prepared for major disasters, the company is also contributing to national resilience through platforms that remain available during emergencies.



platform of information from many different infrastructure businesses should help to build an ecosystem that transcends the boundaries between organizations, boosting efficiency across all social infrastructure maintenance.

By putting digital technologies such as AI and the Internet of Things (IoT) to work in social infrastructure maintenance so that this work can be conducted appropriately both during routine operations and in times of disaster, Hitachi's goal is to utilize large-scale DX and ecosystem building across many different infrastructure businesses as a solution for strengthening national resilience (see **Figure 6**).

4. Conclusions

This article has presented examples of how Hitachi is working toward the digitalization of social infrastructure maintenance.

In addition to playing its part in digitalization, Hitachi also intends to contribute to the creation of a safe and secure society by developing technologies and services to address the rising concerns of recent years about improving national resilience and reducing the load on the environment.

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