Overview of Infrastructure Equipment R&D Supporting the Next-generation Networks

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Abstract

To support the next-generation networks, underground infrastructure equipment must have the capacity to handle with the widespread deployment of optical access systems in addition to long-term equipment stability. This article describes the overall approach to research and development of equipment management technology, equipment maintenance technology, and disaster prevention and security technology required for future infrastructure equipment.

1. Background

NTT's underground infrastructure equipment has been playing an important role in the rapid formation of optical networks for both the backbone and access systems and in the deployment of broadband services. Providing infrastructure equipment that will continue to provide enough underground space to ensure stable quality and support the required services in future is an important requirement of NTT's medium-term management strategy target of acquiring 30 million optical access subscribers by 2010. At NTT Access Network Service Systems Laboratories, we are conducting research and development (R&D) of equipment management technology to appropriately manage the quality and quantity of infrastructure equipment. We are working on technology that will contribute to the creation of a long-term plan for maintaining and managing equipment as well as supporting technologies that include inspection and repair technologies and disaster prevention and security technologies.

2. Current problems and needs

2.1 Tunnel/conduit capacity

NTT has at total of 600 km of cable tunnels, 630,000 km of cable conduits, and 840,000 utility holes for all of its carrier companies (**Fig. 1**). Although the average usage rate for conduit equipment is not high nationwide, there are concerns about a shortage of conduit facilities and an increase in required investment for them, especially in urban areas where demand for optical services is rapidly increasing. Accordingly, we need to develop a new planning method that will allow us to minimize new investment in equipment while effectively utilizing existing facilities. We also need effective techniques for managing underground spaces.

2.2 Equipment deterioration

Like other social infrastructure equipment, NTT's cable conduits were built intensively in the rapid-growth period of 1965 to 1985, so almost half of the equipment is more than 30 years old. Estimates show that the ratio will reach 80% in the next 10 years. Furthermore, most cable tunnels were constructed between 1970 and 1990, so cable tunnels are aging too (**Fig. 2**). Cases of obstacles to cable installation such as corrosion or earth intrusion are increasing in aged and degraded conduits. Trouble caused by cracks or water leakage as a result of deterioration of steel-reinforced concrete or reinforcing steel is increasing in cable tunnels. If such deterioration problems are not resolved, large-scale repair and reinforcement projects will probably be required, which will further increase the cost in the future. Therefore, we need an equipment management method that will ensure inspection and repair work are executed at the appropriate time and can provide

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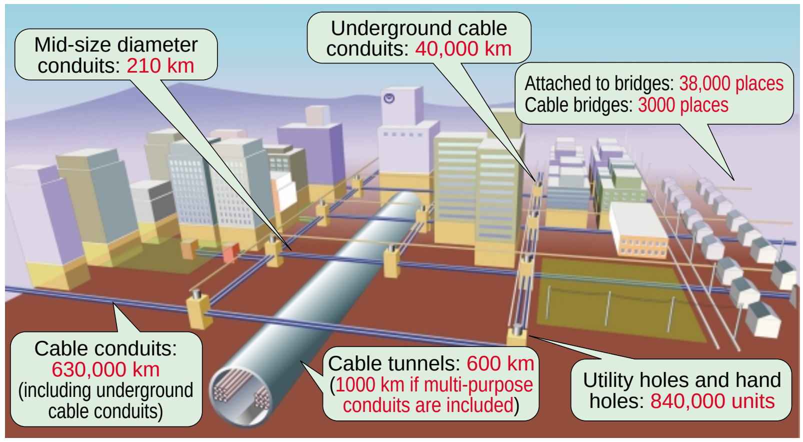

Fig. 1. Overview of NTT's infrastructure equipment.

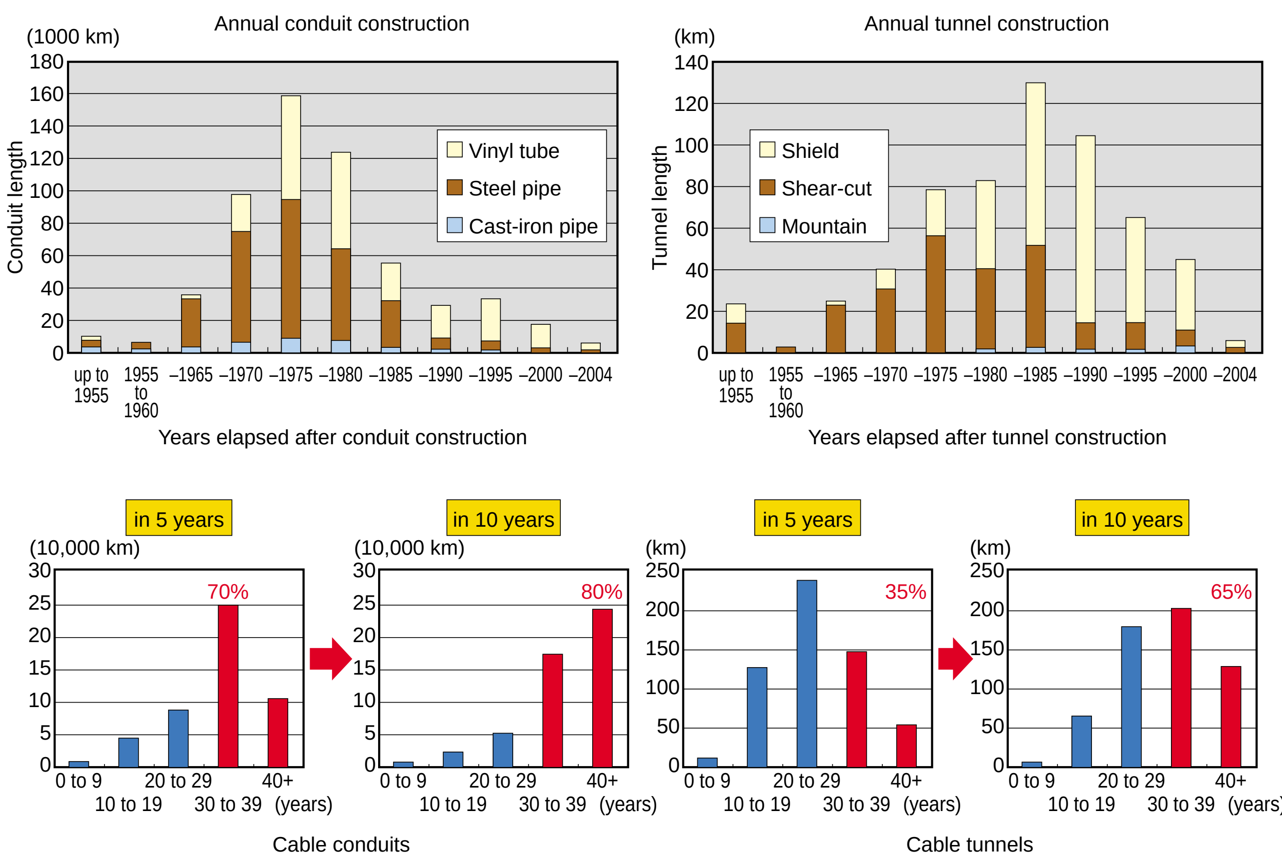

Fig. 2. Transition of equipment construction and deterioration issues. The numbers in red show the percentage of equipment that will be at least 30 years old.

long-term maintenance and minimize management costs while predicting equipment degradation. At the same time, inspection and repair/reinforcement technology must be upgraded and technology for achieving economical efficiencies is also needed.

2.3 Manpower

Although there are currently about 2000 engineers working on infrastructure equipment-related operations in the NTT Group as a whole, the number is expected to decrease greatly in the years to come because of pressure to hire fewer new employees while many engineers will be retiring (**Fig. 3**). In the future, it will be necessary to restructure equipment databases and upgrade operations technology to efficiently provide services with stable quality using vast amounts of complex infrastructure equipment with the minimum amount of human effort.

3. Direction of R&D on infrastructure equipment technology

In response to the above issues, we are developing the following technologies as part of our R&D strategy for the future telecommunications infrastructure for the coming ubiquitous broadband age (**Fig. 4**).

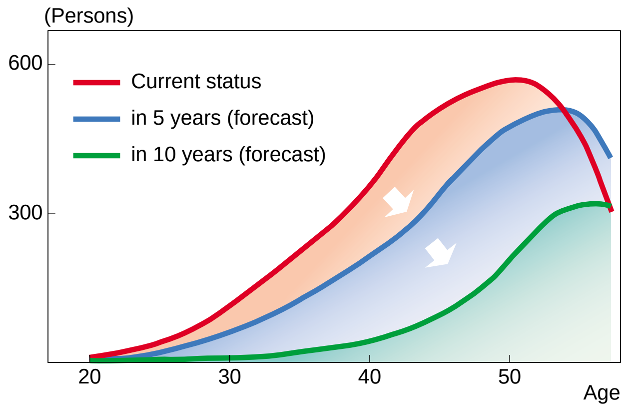

Fig. 3. Transition of NTT's infrastructure equipment engineers.

3.1 Equipment management technology

3.1.1 Quantitative management of infrastructure equipment

We are working to establish equipment management technology that includes equipment planning techniques for the period in which metallic and optical cables will coexist and decision-making techniques for investing in equipment.

3.1.2 Management of maintenance and repair technologies for infrastructure equipment

We are investigating techniques for creating long-term maintenance and repair plans by diagnosing the quality of equipment and evaluating the lifecycle cost.

3.1.3 Upgrading of the infrastructure equipment database technology

We are working on upgrading infrastructure equipment database technology to allow precise identification of the amount of equipment, its location, and its quality using the latest GIS (geographical information system) and GPS (global positioning system) technologies and to allow efficient management of equipment.

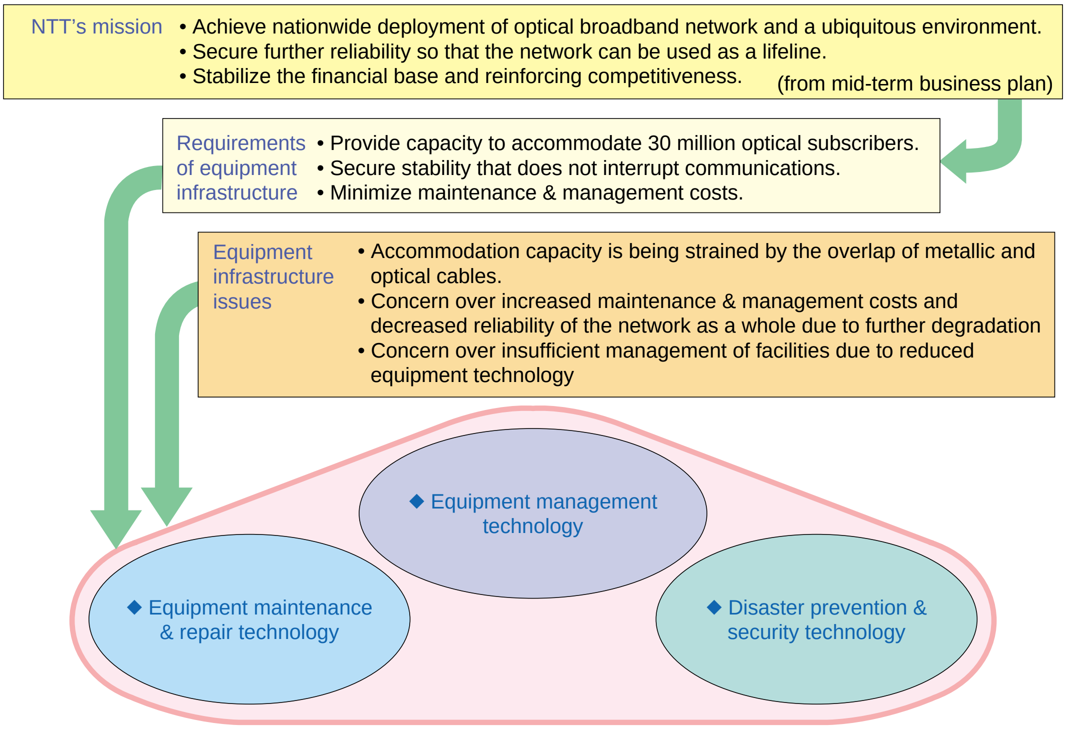

Fig. 4. Directions of infrastructure equipment R&D.

3.2 Equipment maintenance and repair technology

3.2.1 Non-destructive inspection and analysis technology

This is technology for performing non-destructive inspection and analysis using electromagnetic or ultrasonic waves to identify the exact status of degradation of concrete or steel structures. We have already put to practical use technology for measuring cracks in concrete and measuring concrete thickness and are currently developing further advanced technology for measuring the status of reinforcing steel corrosion and concrete strength degradation.

3.2.2 Metal conduit repair technology

Pipe-cameras and various lining technologies have been put to practical use for inspecting and repairing vacant conduits. At present, we are developing repair technology for cable-accommodating conduits and bridge conduits.

3.2.3 New infrastructure equipment construction technology

We are currently investigating new construction methods to reduce the lifecycle cost by improving durability and new structures such as free-space conduits or new utility hole iron covers. We are also working on environmental technologies that utilize waste material from optical cables.

3.3 Disaster prevention and security technology

3.3.1 Quake resistance technology to support infrastructure equipment

To ensure the reliability of networks against disasters, especially earthquakes, we have been conducting R&D of quake resistance technologies. That includes efforts to make existing cable tunnels and conduits resistant to earthquakes. At present, we are investigating simulation and evaluation technologies for evaluating the quake resistance of underground equipment as a whole, including cables, and looking at technology to reinforce cable bridge equipment against earthquakes.

3.3.2 Optical sensing technology

Using optical sensing technology for measuring distortion in structures utilizing the characteristics of reflected light in optical fibers, we are currently conducting R&D in disaster prevention technology for various types of social infrastructure such as tunnels, road slopes, and bridges [1]. We are using that technology in actual business via NTT group companies.

4. Future of infrastructure equipment business

By conducting the R&D mentioned above, we are aiming to establish a business style where equipment management technology and the hardware technology that supports it are unified so that it can function smoothly in a cycle that includes maintenance and management planning, inspection and repair, and history management of infrastructure equipment (**Fig. 5**).

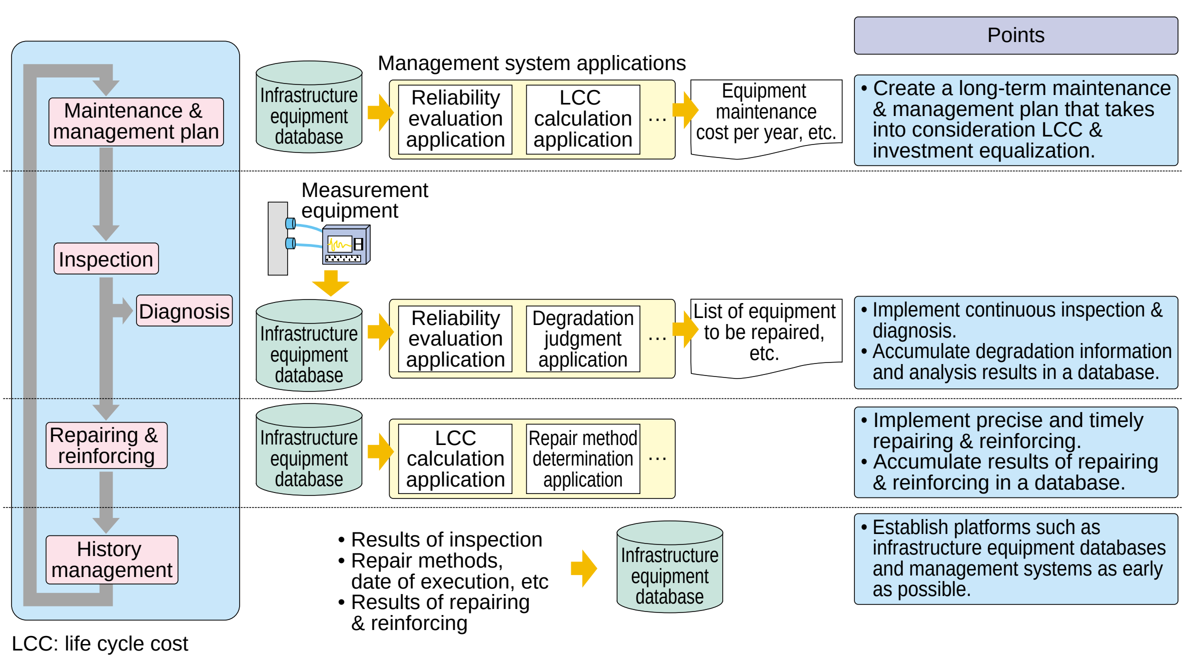

Fig. 5. Concept of future infrastructure equipment business.

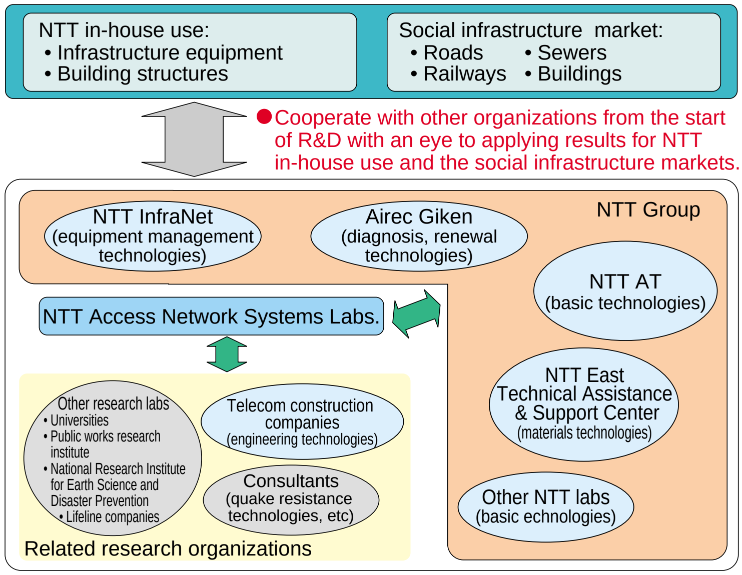

Fig. 6. Infrastructure equipment R&D framework for application to in-house use and the social infrastructure market.

In this cycle, the following points are important.

- Creation of long-term maintenance and management plans, taking into account the lifecycle cost and equalization of investment based on the results of inspection and analysis
- Continuous implementation of inspection and equipment diagnosis and accumulation of a database including degradation status and diagnosis results
- Implementation of precise and timely repair and reinforcement and records showing the history of the results
- Early establishment of platforms for constructing infrastructure equipment databases and management systems

5. Deployment in the social infrastructure market

Refining the equipment maintenance and management technologies described above is also related to Japan's social infrastructure as a whole, including roads, railways, and sewers. People have become more concerned in recent years about the safety and reliability of the social infrastructure after several incidents involving concrete falling from the ceilings of railway tunnels, landslides occurring after heavy rain, and inadequate earthquake resistance being discovered in recently constructed buildings. NTT Access Network Service Systems Laboratories is looking at deploying its technology in the social infrastructure market in addition to applying it for NTT in-house use. From the early stages of R&D, we coordinate with other NTT group companies as well as related research organizations to conduct product development that makes the most of NTT's strengths (**Fig. 6**).

Reference

[1] K. Fujihashi, H. Uehara, M. Okutsu, and K. Komatsu, "Development of a Road Disaster Monitoring System Using Optical Fiber Sensing Technology," NTT Technical Review, Vol. 1, No. 9, pp. 48-52, 2003.

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