Developing Technology to Support Long-Term Infrastructure Use

——Toward Safe and Robust Infrastructure Systems

From roads to harbors, railways to airports, infrastructure is the fundamental element of modern society that supports our life and social activities. A sustainable economy, productivity, and the well being of a nation depend heavily on the reliability and sustainability of its infrastructure. A large portion of today's infrastructure was built during the period of our high economic growth three to five decades ago; and in recent years, numerous cases of infrastructure deterioration have surfaced, presenting the danger of devastating accidents and other serious related issues. Some experts predict that infrastructure-related maintenance and repair expenditures may escalate by as much as ¥190 trillion over the next five decades. In the face of such circumstances, many are looking toward infrastructure maintenance, renovation and management technologies as a strategy to prevent accidents and reduce the burden of repairs and maintenance.

Infrastructure Maintenance, Renovation, and Management

Program Director

Yozo Fujino

Distinguished Professor, Institute of Advanced Sciences
Yokohama National University

Profile

After completing the Master of Engineering program in the Department of Civil Engineering at the University of Tokyo, Yozo Fujino studied at the University of Waterloo, Canada and received his Ph.D. in civil engineering. He then returned to Japan in 1977 and served as a research associate at the Earthquake Research Institute of the University of Tokyo. In 1978, he joined the Department of Structural Engineering at the University of Tsukuba as an assistant professor. Fujino joined Department of Civil Engineering at the University of Tokyo in 1982 as an associate professor. In 1990, Dr. Fujino became a full professor of civil engineering at the University of Tokyo. In 2013, Professor Fujino was named as professor emeritus at the University of Tokyo, after which he took an appointment from the Yokohama National University in November 2014. In 2007, Professor Fujino was awarded the Medal with Purple Ribbon from the Emperor of Japan.

Yozo Fujino

How to Deal with an Aging Infrastructure?

From roads to harbors, railways to airports, infrastructure is the fundamental element of modern society that supports our life and social activities. A sustainable economy, productivity, and the well being of a nation depend heavily on the reliability and sustainability of its infrastructure. A large portion of today's infrastructure was built during the period of our high economic growth three to five decades ago, and in recent years, numerous cases of infrastructure deterioration have surfaced. Even more troubling is the risk of major infrastructure failure on the scale seen in the 2012 Sasago Tunnel collapse. Therefore, strategies to deal with the heavy burden of infrastructure maintenance and repairs serious needs in our society.

Japan is now looking at an enormous operations and maintenance budget with respect to our national infrastructure stock, which amounts to more than ¥800 trillion. For example, recent surveys suggest that upgrades and repairs to Japan's freeway infrastructure, which consists of about ¥45 trillion in related assets, will require as much as ¥3 trillion in the next 15 years. In total, it was estimated that infrastructure upgrades and repairs will cost about ¥190 trillion over the next 50 years. Adding to the problems are the strained government finances and the decline in the number of experienced engineers in Japan. Consequently, restraining infrastructure lifecycle costs through preventive maintenance and accident prevention is a critical issue facing our country.

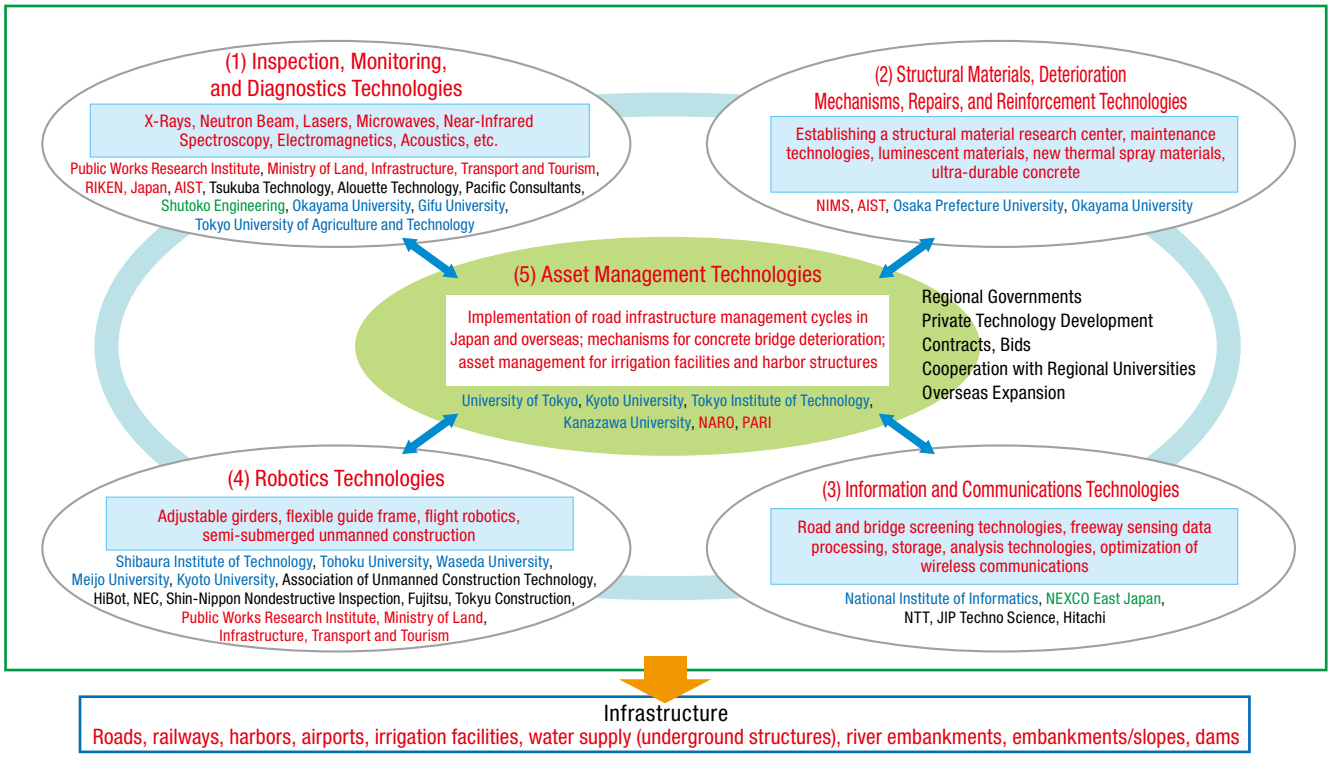
Given these circumstances, many are looking toward the adaption of ICRT in infrastructure management. ICRT is an integration of advanced information and communications technology (ICT) with information and robotics technology (IRT).

Dr. Yozo Fujino, Distinguished Professor at Yokohama National University, serves as the program director for this research and development plan. "Our infrastructure is aging rapidly," Fujino says. "Now is the time for us to systematize infrastructure management by adapting advanced technologies. If we fail to address this issue, then we could be leaving serious problems for future generations."

He continues, "Creating a more robust infrastructure using advanced ICRT may not only reduce the costs, but also present a significant business opportunity as the maintenance industries both at home and across Asia are facing the same issues. I hope that this research and development program will create a 'year one' for infrastructure maintenance."

Sustainable Infrastructure

As a young boy, Program Director Fujino idolized Torahiko Terada, a famous physicist who worked during the late Meiji and early Showa eras in Japan. Following in his idol's footsteps, he pursued the study of geophysics, eventually choosing civil engineering as his main course of study. After graduating from Department of Civil Engineering at the University of Tokyo, Fujino sensed that he was on the verge of changing times in Japan. He decided to further his academic studies, approaching a wide range of research fields from the perspective of civil engineering. Fujino's studies took him to the University of Waterloo in Canada, the Earthquake Research Institute at the University of Tokyo, the University of Tsukuba, and back to the University of Tokyo, this time as a member of the Faculty of Engineering.



*(1) Inspection, Monitoring, and Diagnostics Technologies include the following research institutes working in coordination with the Committee for Reviewing and Promoting Usage of Social Infrastructure Monitoring Technologies, overseen by the Ministry of Land, Infrastructure, Transport and Tourism
Research Institutes: PASCO Corporation, Osaka City University, Sumitomo Mitsui Construction, Taisei Corporation, Omron Social Solutions, NEC Corporation, OYO Corporation, Chuo Kaihatsu Corporation, Aero Asahi Corporation, Japan Institute of Country-ology and Engineering, Infrastructure Development Institute-Japan, Research Association for Infrastructure Monitoring System, Penta-Ocean Construction, Kawasaki Geological Engineering, Tohoku University, Alpha Product, NTT Advanced Technology Corporation, the University of Tokyo

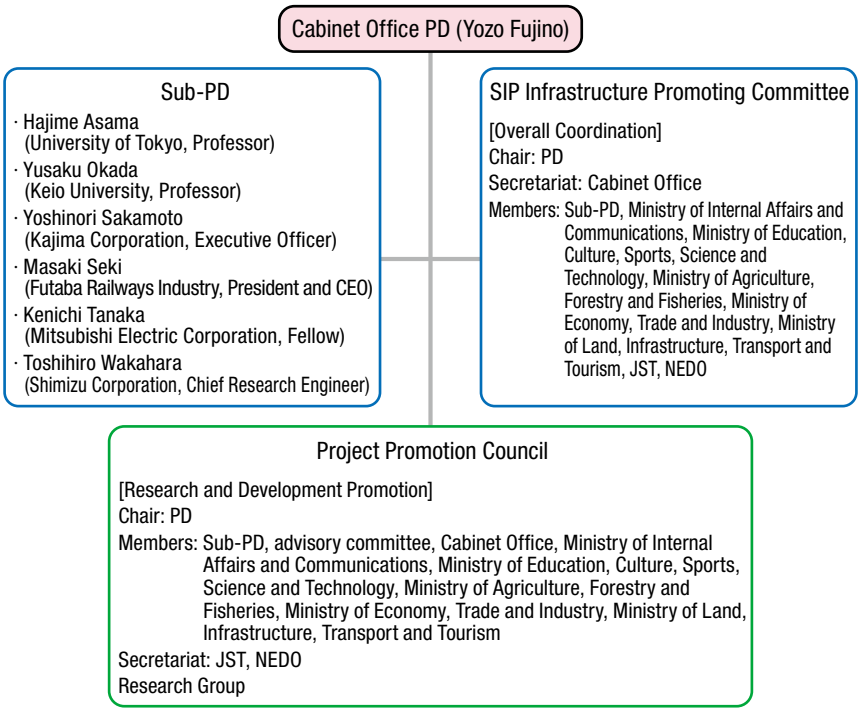
●**Research and development topics relationship diagram (participants as of May 21, 2015)**

Yozo Fujino

Fujino says, “When I was younger, Japan’s construction industry was in its heyday; there were hundreds of major projects throughout the country. But, I could see that this period of amazing growth was coming to an end. In other words, I believed we were seeing a transition from a period of building infrastructure to a period of maintaining infrastructure for the long term. This is where I focused my research: How do we go about protecting the infrastructure we have already built?”

The concept of infrastructure preventive maintenance extends beyond the boundaries of engineering, encompassing other fields such as the natural sciences, the social sciences, and many others.

Program Director Fujino continues, “Through my work and research, I worked closely with a number of researchers from different field of studies. I believe that we need to create this same environment for our current project. It is critical for us to take a holistic approach to these issues from a wide range of perspectives, coordinating work among different groups and individuals.”



●Implementation Structure

Five Factors for Moving Preventive Maintenance Forward

As shown in the Infrastructure Operations and Maintenance Overview diagram, this research and development program consists of five different focus areas: (1) Inspection, monitoring, and diagnosis technologies; (2) structural materials, deterioration mechanisms, repairs, and reinforcement technologies; (3) information and communications technology; (4) robotics technology; and (5) asset management technology.

In connection with focus (1), this program intends to develop robot, sensor, and non-destructive inspection technologies for efficient, effective inspection and monitoring of infrastructure damage.

Meanwhile, under focus area (2), the program will also develop simulation technologies for a variety of deterioration mechanism patterns for structural materials, creating a structural deterioration forecast system. Under this same heading, the program plans to develop new materials and repair techniques, promote reinforcement technologies to prolong infrastructure lifespan and restrain life cycle costs, and develop materials to improve performance of infrastructure components.

Under focus area (3), the program will develop data management technologies for utilizing the enormous amounts of information generated by inspection results, management work, renovation, and repairs. Here, development work will include technologies for retrieving data (wired or wireless) from sensors embedded in infrastructure elements, while other technology will operate to collect infrastructure information wirelessly from mobile sources.

Under focus area (4), the program plans to develop robotics technologies to inspect, diagnose, operate, manage, and repair infrastructure elements efficiently and effectively. The program will also develop robots to perform surveys and excavation in dangerous situations such as disaster areas.

Asset Management is the Key to Success

Program Director Fujino emphasizes that focus area (5), research and development of asset management technology, is the most important part of the overall program. Under this focus area, the program plans to devise mechanisms and technologies for putting the results of (1) through (4) into actual use, providing efficient maintenance of infrastructure and associated technologies.

Fujino stresses, “It is critical that we combine all technologies developed by our researchers from areas (1) through (4) and create management technologies that will effectively cycle each technology to make it available in practice. It’s not an overstatement to say that the entire success of our project will rely on asset management.”

It is expected that this project can deliver a structured management system to minimize infrastructure lifecycle costs and provide research and development for asset management technologies to be adopted first by regional public bodies and then nation-wide. At the same time, the program aims at establishing an organization to exchange technologies among infrastructure owners, experienced professionals, and academicians in Japan and overseas, providing a foundation to roll out advancements to other countries around the world.

As mentioned earlier, Program Director Fujino hopes to create a “year one” for infrastructure maintenance as a concept. “I certainly hope that we will be able to put these leading technologies into practical use. We hope to enhance the infrastructure management technologies to make engineers feel like using, through feedback and testing.”

Research and Development Topics

1. Research and develop inspection, monitoring, and diagnostic technologies

Develop technologies that provide efficient, effective inspection and monitoring capabilities to assess infrastructure damage.

2. Research and develop structural material, deterioration mechanism, repair, and reinforcement technologies

Develop simulation technologies to assess the deterioration mechanism of structural materials; create a structural deterioration forecast system.

3. Research and develop information and communications technologies

Develop data management technologies utilizing enormous volume of information generated by infrastructure maintenance, management, renovation, and repair systems.

4. Research and develop robotics technologies

Develop robotics technologies to inspect, diagnose, operate, manage, and repair infrastructure elements efficiently and effectively; develop robots to perform surveys and excavation in dangerous situations such as disaster areas.

5. Research and develop asset management technologies

Implement infrastructure management for the technologies produced from topics (1) through (4). Develop asset management technologies for efficient operations management making the most of limited financial and human resources.

Exit Strategies

☑ Active use of new technologies

Actively adopt and assess new technologies by the nation and show the outcome to regional public bodies resulting in eventual nation-wide rollout.
Build a support and management structure; train and educate human resources.

☑ Standardization of useful new technologies for international expansion

International standardization of useful new technologies through domestic use and evaluation for global rollout; create an integrated system for introduction and localization for target countries.

Our goal is to renovate infrastructure systems by developing technologies attractive to engineers , and to become a role model for the rest of the world.

Development and active use of new technologies and globalization