Infrastructure Maintenance, Renovation, and Management

Developing Technologies to Support Sustainable, Safe and Secure Infrastructure Systems, Driven by Five Research Projects

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 wellbeing 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 high economic growth. In recent years, numerous cases of infrastructure deterioration have surfaced, leading to major accidents. Many other problems include the cost for social capital repairs and maintenance across ten different sectors (roads, flood control, sewage systems, harbors, public housing, parks, seashores, airports, sea marks, and government facilities). Estimates suggest these costs will reach between ¥4.3 and ¥5.1 trillion in fiscal year 2023, and between ¥4.6 and ¥5.5 trillion in fiscal year 2033. 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.

Program Director

Yozo Fujino

Yokohama National University
Institute of Advanced Sciences
Distinguished Professor

Profile

After completing the Master of Engineering program in the Department of Civil Engineering at the University of Tokyo in 1974, Yozo Fujino studied at the University of Waterloo, Canada and received his Ph.D. in civil engineering in 1976. 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 the 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. Professor Fujino took an appointment from the Yokohama National University in November 2014. Professor Emeritus, the University of Tokyo. Among other honors, Professor Fujino was awarded the Medal with Purple Ribbon from the Emperor of Japan in 2007 and the Hokokai Award (Hattori Hokokai Foundation) in 2015.

Research and Development Topics

1. Research and development on inspection, monitoring, and diagnostic technologies

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

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

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

3. Research and development on information and communications technologies

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

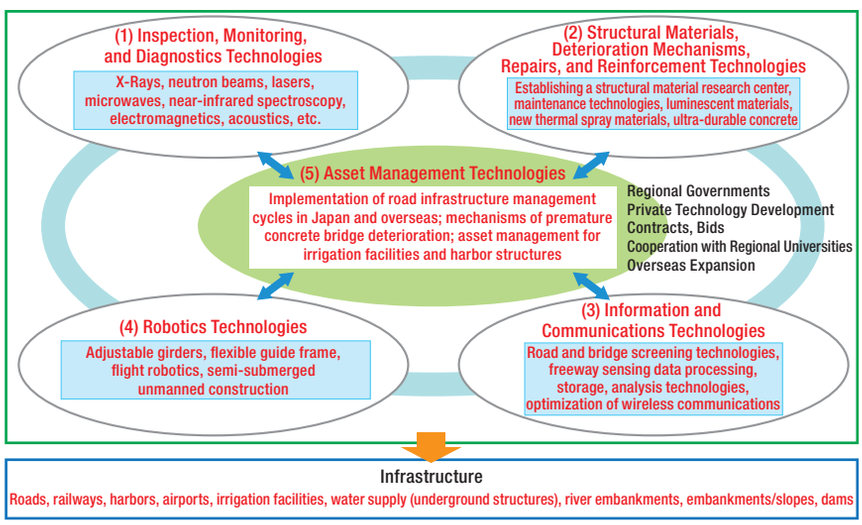
4. Research and development on robotics technologies

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 development on asset management technologies

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

•Conceptual Overview of R&D on Infrastructure Maintenance, Renovation, and Management Technologies



Exit Strategies

Active use of new technologies

National government will actively adopt and assess new technologies; demonstrate the outcomes to regional public bodies that will eventually generate nationwide rollouts; build a support and management structure; train and educate human resources.

Standardization of useful new technologies for international expansion

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

Implementation Structure

The SIP Infrastructure Promoting Committee is led by the Program Director (PD) and Cabinet Office, with participation by sub-PDs, concerned government ministries and agencies, the Japan Science and Technology Agency (JST) and the New Energy and Industrial Technology Development Organization (NEDO). Project Promotion Council meetings are held in cooperation with universities, national research and development agencies, private enterprises, and others as the main research units. The PD, sub-PDs, advisory committee members, and concerned government ministries and agencies advise research units on research and development. At the same time, they examine intellectual property strategies, including standardization strategies for developing nations and other foreign countries.

Cabinet Office PD (Yozo Fujino)

Sub-PDs:
- Hajime Asama (The University of Tokyo, Professor)
- Yusaku Okada (Keio University, Professor)
- Yoshinori Sakamoto (Kajima Corporation, Managing Executive Officer)
- Masaki Seki (Futaba Railways Industry, President and CEO)
- Tadayuki Tazaki (Japan Construction Machinery and Construction Association, President)
- Kenichi Tanaka (Mitsubishi Electric Corporation, Fellow)
- Toshihiro Wakahara (Shimizu Corporation, Chief Research Engineer)

SIP Infrastructure Promoting Committee

[Overall Coordination]
Chair: PD
Secretariat: Cabinet Office
Members: Sub-PDs, Ministry of Internal Affairs and Communications (MIC), Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Agriculture, Forestry and Fisheries (MAFF), Ministry of Economy, Trade and Industry (METI), Ministry of Land, Infrastructure, Transport and Tourism (MLIT), JST, NEDO

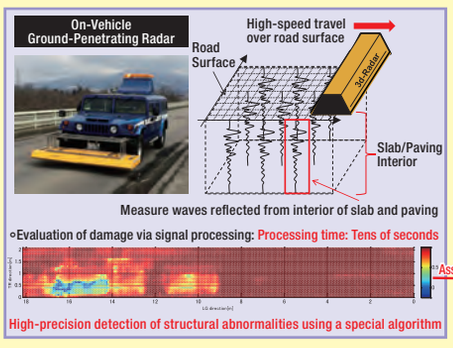
Project Promotion Council

[Research and Development Promotion]
Chair: PD
Members: Sub-PDs, advisory committee, Cabinet Office, Ministry of Internal Affairs and Communications (MIC), Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Agriculture, Forestry and Fisheries (MAFF), Ministry of Economy, Trade and Industry (METI), Ministry of Land, Infrastructure, Transport and Tourism (MLIT)
Secretariat: JST, NEDO
Research units: Universities, national research and development agencies, private enterprises, etc.

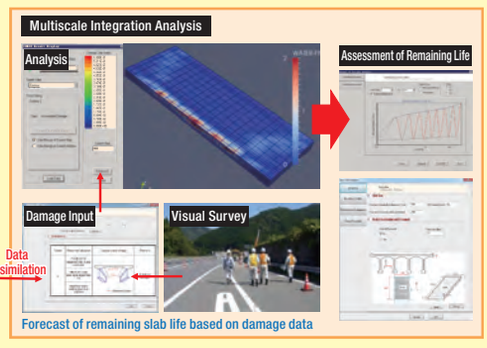
Progress to Date

On-vehicle Ground-penetrating Radar for High-speed Degradation Detection A Major Step toward Practical Application

This project is responsible for a major step forward in the practical application of on-vehicle ground-penetrating radar. With this technology, engineers can inspect, monitor, and detect damage to important infrastructure. One such example is multiscale integrated analysis. In this system, a vehicle equipped with ground-penetrating radar, detects faults inside a bridge slab, while moving as fast as 80 km/h. Engineers can use the results of this inspection to forecast the remaining life of the section in question. Other examples include technology that integrates diagnostic systems with high-speed non-contact radar to detect defects on tunnel linings. Development is also proceeding rapidly for flying robot systems that perform acoustic inspections. These systems would perform tests on pillars, tunnels, and other elevated locations that are difficult for human workers to access.



●On-Vehicle Ground-Penetrating Radar



●Multiscale Integration Analysis

Program Director **Yozo Fujino** Interview

Promoting Implementation by Regional Governments, which Account for 80 Percent of Infrastructure

Civil infrastructures, including roads, railways, airports and harbors, play an essential role in supporting functionality of modern society. Our research and development is designed to prevent the physical degradation of infrastructure from becoming a major accident, so that it can be passed onto future generations. These efforts are consistently producing results that can be put into practice in the real world.

Validating Innovative Diagnostic Technologies

Infrastructure maintenance, renovation, and management technologies are the way to keep the aging of civil infrastructure from becoming major sources of accidents, while reducing the cost of repairs and maintenance. With less than two years of the development period left to run, Program Director Yozo Fujino shares his renewed commitment for the future.

"Last fiscal year was the third year of the program, and marked the halfway point. Following a Stage-Gate process in order to select and focus on development topics with a view toward practical implementation, we narrowed down our topics and direction for the future. Leveraging the steady progress made in onsite verifications in cooperation with MLIT and the new Regional Implementation Support Team, we will step up efforts to refine the development into technologies that businesses can use, and will actually want to use, in the real world."

Let's look at the current results of the program in each of its focus areas.

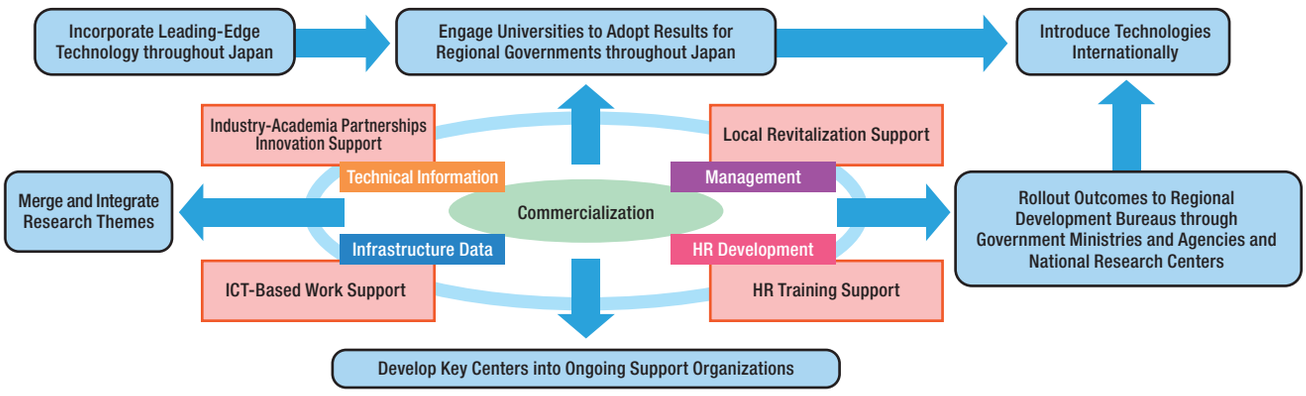
In the course of research and development for inspection, monitoring and diagnostic technologies, we have produced more than 30 technical developments. These successes provide efficient and effective inspection and monitoring capabilities to capture infrastructure damage as data. A number of these developments are nearly complete for real-world implementation. One example is a system that uses non-contact radar while traveling at high speeds through tunnels and similar locations to diagnose internal defects. Another technology uses on-vehicle ground-penetrating radar to find deteriorations on bridge slabs. This technology, too, works while on the move at relatively high speeds. The program has also achieved developments of outstanding convenience and simplicity, including completion of a compact device capable of detecting thickness and cracks concealed under a coating of paint using ultrasensitive magnetic nondestructive testing; as well as development of less labor-intensive technology capable of detecting internal defects in concrete by using lasers to vibrate the surface of the concrete. To date, Japan is the only country in the world that explore these technologies. In the future, we would be introducing these technologies to the rest of the world.

Adapting Research Results for Recovery in Tohoku and Kumamoto

The next focus area is research and development of technologies for structural materials, deterioration mechanisms, repair, and reinforcement. In particular, the program has seen positive results in the development of precast components using ultra-durable concrete. Fujino says, "We have concrete that is five times as durable against salt and frost damage. It will be extremely effective when repairing and upgrading concrete, which makes up 80% of the structural materials in Japan's infrastructure."

The project is also developing a variety of robots that can

•Basic Aspects of Infrastructure Maintenance, Renovation and Management Exit Strategies



Infrastructure Maintenance, Renovation, and Management

inspect bridges, tunnels and other social infrastructure safely and economically. This includes a flying robot system that uses acoustics technology to perform inspections. Semi-submerged work robots are also being developed and improved for remote control operation. At the same time, the project is building systems that manage the information from these civil infrastructure robots through a central system.

The research results discussed above are already being implemented in actual infrastructure management. The program is also seeing specific results from asset management technologies, which provide systems for efficient maintenance and management. One such research result relates to enhancing the durability of concrete structures. This technology has been implemented in the Tohoku region of Japan for roads reconstruction and reconstruction of support roads. This development will reportedly be studied for use in infrastructure recovery support for the regions affected by the Kumamoto earthquakes of April 2016.

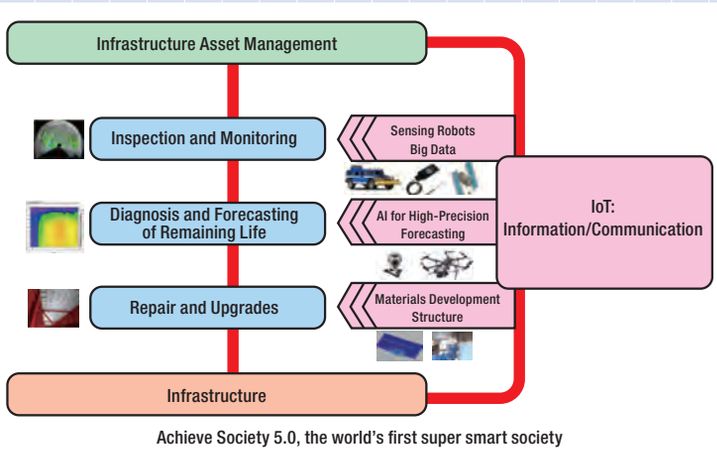
New Technologies for Society 5.0

Dr. Fujino says, “Regional governments manage 80% of all infrastructure. The question is how to get them to adopt our project results. To get there, we’ll need completely new types of partnerships. Therefore, we will be working to provide technologies with local universities acting as the hubs for regional development, moving from there to developing businesses.” To accomplish this, Fujino plans to devise a technical strategy plan based on reputation management. His program will be preparing the business environment while realizing business models that will support local revitalization. Some new technologies will not meet conventional standards. So from this fiscal year, the program will also launch an initiative for technology certification in cooperation with MLIT. Fujino stresses, “certification from MLIT will provide reassurance in using the new technologies.” Looking further into the future, Fujino anticipates that this program will introduce new technologies internationally, including to Asian countries where infrastructure development is very active.

Stressing the future prospects of this program, Fujino says, “development of infrastructure maintenance, renovation, and management technologies is a perpetual issue. Even after this program is over, building systems to ensure continuous progress based on a medium- to long-term vision will be crucial. And looking at the coming Society 5.0, I’m also hopeful that this program will develop into a service platform that advances spontaneously and leads to the creation of more new technologies.”

Future Plans

Leading up to the final year of the program, Fujino will focus on producing results under each R&D theme that can be implemented in the real world. He will study and validate real-world implementation models, working to develop businesses in local administrative areas, while publicizing and coordinating R&D results for international adoption.



Achieve Society 5.0, the world’s first super smart society

Healthy local infrastructure is the foundation for stronger local communities. We are working to develop infrastructure maintenance, renovation, and management technologies, promoting their implementation to regional governments through partnerships with industry, academia, and government.