Infrastructure Maintenance, Renovation, and Management

Developing Technology to Support Long-Term Infrastructure Use
Safer, More 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. Number of other problems include the cost of paying for social capital repairs and maintenance across ten different segments (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 2023, and between ¥4.6 and ¥5.5 trillion in fiscal 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, 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 develop inspection, monitoring, and diagnostic technologies
Develop technologies that provide efficient, effective inspection and monitoring capabilities to assess infrastructure damage.

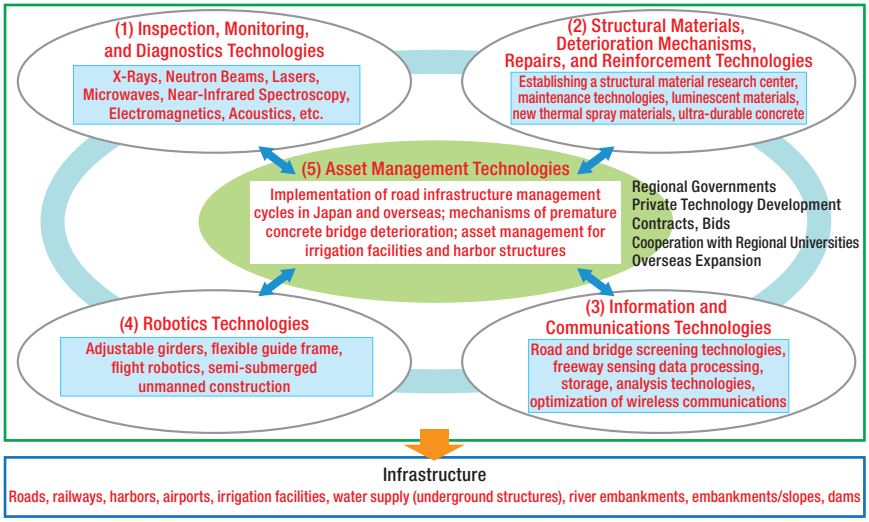
2. Research and develop structural material, deterioration mechanism, repair, and reinforcement technologies
Develop simulation technologies to assess the deterioration mechanism of structural materials; create a structural deterioration forecast system.

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., above. Develop asset management technologies for efficient operations management making the most of limited financial and human resources.

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



Exit Strategies

Active use of new technologies

Actively adopt and assess new technologies by the nation and demonstrate the outcome to regional public bodies resulting in eventual nation-wide roll-out. 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 roll-out; 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, the National Research and Development Agency, 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 (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 (ITS Technology Enhancement 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, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Agriculture, Forestry and Fisheries, Ministry of Economy, Trade and Industry, Ministry of Land, Infrastructure, Transport and Tourism, JST, NEDO

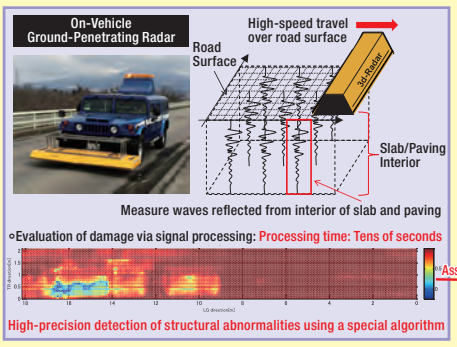
Project Promotion Council

[Research and Development Promotion]
Chair: PD
Members: Sub-PDs, advisory committee, Cabinet Office, Ministry of Internal Affairs and Communications, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Agriculture, Forestry and Fisheries, Ministry of Economy, Trade and Industry, Ministry of Land, Infrastructure, Transport and Tourism
Secretariat: JST, NEDO
Research units: Universities, the National Research and Development Agency, private enterprises, etc.

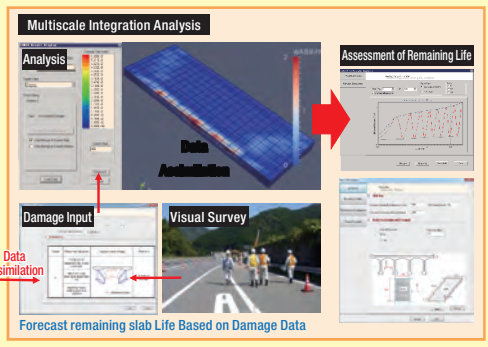
Progress to Date

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 in a bridge slab, while moving as fast as 80km/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 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 essential role to support functionality of modern society. Our research and development is designed to prevent the physical degradation of infrastructure from becoming a major accident, so that they 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. Yozo Fujino is in his third year overseeing the program as its PD. In this interview, Mr. Fujino looks back on the progress of this program and shares his renewed commitment for the future.

"This is an all-Japan effort, bringing in researchers from industry, academia, and government, and it is our first attempt to do everything from basic research to real-world implementation. I believe that I have developed a clear vision of our goals during the first two years of activity. In other words, I see how we can implement these technologies in society. At this point, we are asking ourselves again how to strategically reach our goals more quickly. We must do more to move our technologies toward practical implementation."

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

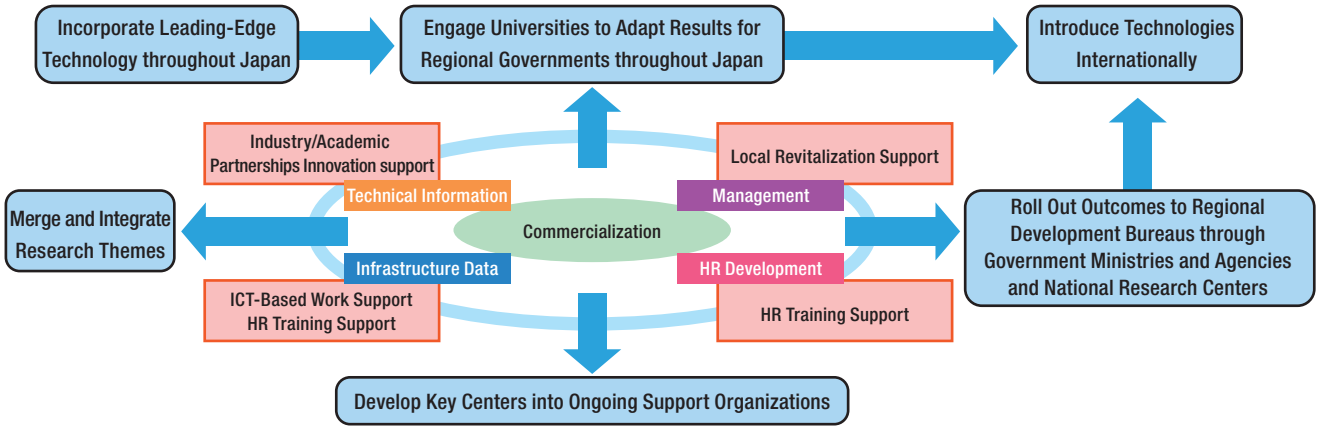
In the course of research and development for inspection, monitoring, and diagnostic technologies, we have produced more than 30 technical developments. These successes provide efficient and effective inspection and monitoring capabilities to capture infrastructure damage as data. A number of these developments are nearly complete enough 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 faults bridge slabs. This technology, too, works while on the move at relatively high speeds. To date, Japan is the only country in the world to explore these technologies. In the future, we could be introducing these technologies to the rest of the world.

Adapting Research Results for Recovery in Tohoku, 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 freezing damage. It would be extremely effective for the repair and upgrading currently used concrete, which makes up 80 percent of the structural materials in Japan's infrastructure."

The project is also developing a variety of robots that can inspect bridges, tunnels, and other social infrastructure safely and economically. This includes a flying robot system that uses

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



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acoustics technology to perform inspections. Semi-submerged work robots are 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 and recovery support roads for the Tohoku area. This development will reportedly be studied for use in infrastructure recovery support for the regions affected by the Kumamoto earthquakes of April 2016.

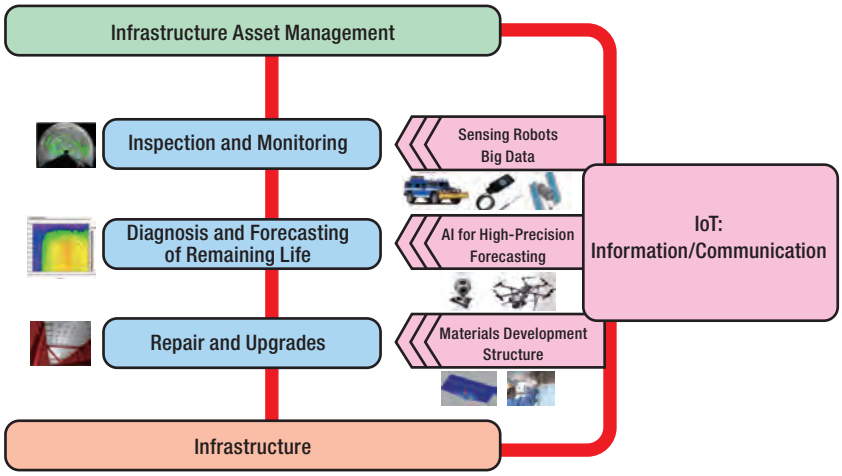
New Technologies for Society 5.0

Entering his third year as program director, Mr. Fujino says, "Regional governments are responsible for 80 percent of infrastructure. The question is how to get them to adopt our project results. To get there, we'll need completely new types of partnerships. This is why we will be working to provide technologies through regional universities, 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 aid with local revitalization. Looking further into the future, Fujino sees this program introducing new technologies internationally, including Asian nations where infrastructure development is very active.

Stressing the future prospects of this program, Fujino says, "The 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 grows spontaneously and leads to the creation of more new technologies."

Future Plans

In his final year with 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.