TECHNOLOGICAL RESEARCH AND DEVELOPMENT IN RELATION TO THE ROAD IN JAPAN
- THEIR TREND, RECENT CHANGES AND OFFICIAL ASSISTANCE TO THE RESEARCH -

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In Japan, research and development in relation to the road, 10 policy domains have been defined. They are designed to allow degrees of freedom to widely take in the wisdom of “academia” and technology of “industry”. In order to improve the quality of the road policy through close cooperation among industry, academia and government, it was publicly solicited to propose the tasks of technological research and development in the 10 policy domains.

As another method to cooperate among three parties, Public Works Research Institute (PWRI) actively promotes joint research, having two types of joint research scheme (that proposed by PWRI and that proposed by the private sector).

For the promotion of Intelligent Transport System (ITS), a related study has got underway, having established the “Smart Way Project Advisory Committee” in 1999 with academic experts, ITS specialists in the industrial circles, related government ministries as members, with a view to clarifying the significance, function, requirements, measures to realize the Smart Way. In addition, National Institute for Land and Infrastructure Management (NILIM) and 23 private enterprises have engaged in joint research since February 2005.

In order to enhancing application of new technologies, Ministry of Land, Infrastructure and Transport (MLIT) is constructing a mechanism for finding useful new technologies developed in the private sector and utilizing them in public works.

1. CIRCUMSTANCES SURROUNDING THE TECHNOLOGICAL RESEARCH AND DEVELOPMENT

The road penetrates deeply into the national life and economic activities as an important form of social and economic infrastructure. Alongside changes in social trends, such as internationalization, a dwindling birthrate and an aging population, a diminishing capacity for investment, informatization, increased leisure time and the broadening participation of local residents in politics, various needs for the road are emerging as stated below:

(1) A high-level road traffic service to secure punctuality, safety, amenity, etc.
(2) Road design, focusing on the streetscape, landscape and environment
(3) High-quality road structures with reduced maintenance and administration expenses incurred, taking lifecycle cost and durability into consideration
(4) Explanatory technique easy for citizens to understand

As for technological development policy at a government level, Japan set the “Nation based on the Scientific and Technological Creativity” as a national strategy in the fiscal year 1996, under which comprehensive measures have been vigorously promoted based on the Science and Technology Basic Plan. At present, various measures have been progressively implemented on the basis of the 3rd basic plan, which was started in the fiscal year 2006 as the 1st term. In the plan, the area of the social infrastructure is cited as a research and development promotion area, since it is basic for the viability of the nation and indispensable for the country to address. In relation to the road, long-term maintenance of the function, reduction in the lifecycle cost, and the further development of ITS technology and so forth are included in the plan as important research and development issues, which are currently being promoted.

In addition, Innovation 25, being promoted by the current Abe Administration inaugurated in September 2006, envisions the highly innovated Japanese society in 2025. Aiming to realize these social images, technological research and development need to be advanced in the field of the road, targeting the realization of a safe and intelligent road traffic society through the utilization of ITS technology, and more efficient and sophisticated social capital improvement and control technology, etc. .

2. TREND IN TECHNOLOGICAL RESEARCH AND DEVELOPMENT OF ROAD POLICY

In consideration of such circumstances as mentioned above, the Road Bureau of the MLIT, jointly with the NILIM and the PWRI (an incorporated administrative agency), has determined 10 policy areas relating to technological research and development for road policy, in which policy research is conducted. In addition, it has been decided to shift policy for technological research and development of roads to those in which cooperation among industry, government and academia is strengthened and the policies are properly responded to. This is intended to utilize various technologies developed in the industrial circles and basic research, as well as information available in universities, and to proceed with technological research and development fully in response to road policies.

2-1 Research System at the Government Level

In Japan, the NILIM of the MLIT and the PWRI serve as government-level institutions to promote technological research and development in relation to fundamental infrastructures,

such as the road and river.

The NILIM is a national research institute, conducting comprehensive survey, research and development closely related to the planning of the land and infrastructure management policy, for which the MLIT is responsible. Meanwhile, the PWRI, as an incorporated administrative agency engaged in research and development in relation to civil engineering technology, is elucidating the phenomena occurring to facilities/structures and their mechanism, conducting research and development of analysis, design, construction and management technique, and providing technical guidance and project assistance to local offices of the MLIT and local public entities.

2-2 State of Priority Areas for Research

Research and development in relation to the road have been advanced, aiming to improve the efficiency of research and clarify targets by formulating the 5-Year Program for Road Technology (fiscal years from 1993 to 1997) and the new 5-Year Program for Road Technology (fiscal years from 1998 to 2002). From the fiscal year 2004 onwards, 10 policy domains have been defined, as shown in Table 1, to conduct the research with increasing priority placed on coordination between policy and research.

In sharing the work specifically, the Road Bureau puts in order the “Present Status and Basic Direction of the Policy” in relation to the road and sets out individual themes for technological research and development for realizing policy through consultation with the NILIM and the PWRI. Then, these two institutes conduct technological research and development on each theme in cooperation. In comparison to the previous state, research on construction has been reduced, while the emphasis of research has been shifting to matters related to asset management, risk management, information service and environmental conservation.

The NILIM is conducting research on traffic management, ITS, traffic safety, road disaster prevention and road environment, while mainly engaged in technological research and development in relation to (1), (2), (3), (5) and (6) within the 10 policy domains.

The PWRI is conducting the research on designing, construction and maintenance and control technologies for road structures (bridge, pavement, tunnel, earth structure, etc.), asset management and risk management, while mainly engaged in technological research and development in relation to (4), (7), (8), (9) and (10) within the 10 policy domains referred to in Table 1.

Table 1 - Ten Policy Domains in Technological Research and Development for Road Policy

	(10 Policy Domains)	(Research Underway)
Reform	(1) Create a new administrative system.	- To support the practice of the road administration management.
		- To support the administrative operation based on data.
Vitality	(2) To form a road network capable of generating vitality in the economy and life, targeting its effective utilization.	- Optimal use of the road network.
		- A new technique for road design, introducing service levels.
	(3) To create a new information service to raise the user satisfaction level.	- Smooth passage through every gate.
		- A regional guide appropriate for the area and needs.
		- To realize a timely drive assistance service.
		- To utilize the vehicle ID and accumulated information.
		- To improve the collection and provision of road-related information.
	(4) To reform the cost structure and form (produce) the road asset efficiently.	- A design / construction / quality control management system, responding reasonably to external forces such as earthquake.
		- A competitive and highly transparent procurement system such as CM.
		- To forecast the external diseconomy of the road construction etc.
Life	(5) To create a beautiful landscape as well as a pleasant and high-quality road space.	- Techniques of assessment and project promotion for the development of a beautiful country to be passed on to future generations.
		- Formation of road-side landscape with the participation of citizens.
Safety	(6) To protect the human life from traffic accidents.	- To reduce accidents through the optimal utilization of the road network.
		- To improve the project effect by safety measures at accident black spots.
	(7) To provide speedy and accurate responsive actions for assistance during disaster.	- Research of the domain of pre-disaster measures.
		- Research of the domain of response at the time of disaster.
		- Reasonable winter-time road control based on a clear control standard.

	(8) To scientifically conserve important road assets.	- Reasonable replacement investment strategy.
		- Performance and health inspection and an assessment system for road structures etc.
		- Development of an efficient repair/reinforcement technique.
Environment	(9) To improve the environment along the road, and create a favorable living environment.	- Further improvement and enhancement of the roadside environment.
		- Technique for designing the roadside green space.
		- To reduce the environmental burden in the urban space and overall society.
	(10) To conserve the natural environment and global environment.	- To contribute to the countermeasures against global warming.

2-3 Cooperation with Industry and Academia in Relation to Research and Development as Well as Support

1) *Public solicitation type contract research system*

Ten policy domains relating to technological research and development for the road policy referred to above are designed so as to allow degrees of freedom to widely take in the wisdom of “academia” and technology of “industry”. In order to improve the quality of the road policy through close cooperation among industry, academia and government over a wide range by making use of this merit, it was publicly solicited, in fiscal year 2005, to propose the tasks of technological research and development in the above 10 policy domains, and a mechanism allowing the three parties to proceed with research in cooperation was constructed. As shown in Table 2, there are three types of proposal solicitation methods, which differ in terms of annual limit amount and screening standard. The screening is conducted from the perspectives of creativity, viability and research structure in the Committee on Advanced Road Technology (CART), comprising academic experts and representatives of the organizations of construction-related industries, and determines the tasks to be adopted. The research period for each task is scheduled to be within three years. In each fiscal year, the CART assesses research conducted over multiple fiscal years, to discontinue those assessed to be not promising for achievements, and study whether those recognized as having generated significant achievements should be continued, even beyond the initial research period. Researches adopted for the fiscal years 2005 and 2006 are shown in Table 3. In this table, the transportation demand management is listed as an example of tripartite cooperation among industry, academia and government. This is a research proposed and applied for by a research group in which a university, private enterprise and local public entity cooperate, and the research and development are being implemented involving a tripartite structure of cooperation among

industry, academia and government, including the regional development bureau concerned and the NILIM.

Table 2 - Types of Solicitation Method

I. Policy realization type	Research expected to contribute to a priority issue of the current road administration.
II. Technological breakthrough type	Research targeting an innovative solution to a technical issue.
III. New policy domain creation type	Research to propose a new policy domain for road administration from the inter-policy viewpoint.

Table 3 - Adopted Researches

Fiscal Year	Number of Tasks for Contract Research	Contract Research Expenses	Main Examples of the Contract Research
2005	8 tasks	131 million yen	Mobility management Public Involvement Technique to assess the health of road structures Technique to reinforce the fill against earthquake
2006	11 tasks	176 million yen	Mechanism of beneficiary liability Transportation Demand Management

2) *Joint research with industry and academia at the PWRI*

The PWRI actively promotes joint research in cooperation with industry and academia, having two types of joint research scheme (that proposed by PWRI and that proposed by the private sector).

The joint research proposed by the PWRI is that in which a researcher for the joint work, based on a theme specified by the PWRI, is publicly sought from private enterprises and so forth or designated by the PWRI. On the other hand, the joint research proposed by the private sector is a system in which a technological proposal for the research area presented by the PWRI is publicly sought, and joint research is conducted with the private enterprise having proposed the task concerning the proposed technology. The latter system was created in the fiscal year 2001 and opened the way for actively harnessing the originality and ingenuity of the private enterprise etc.

In road-related areas, 30 joint research programs are underway in the fiscal year 2006. The

heat shield pavement (Figure 1), rapid construction technology for the construction of a grade separated intersection etc. can be cited as achievements of the joint research conducted so far.

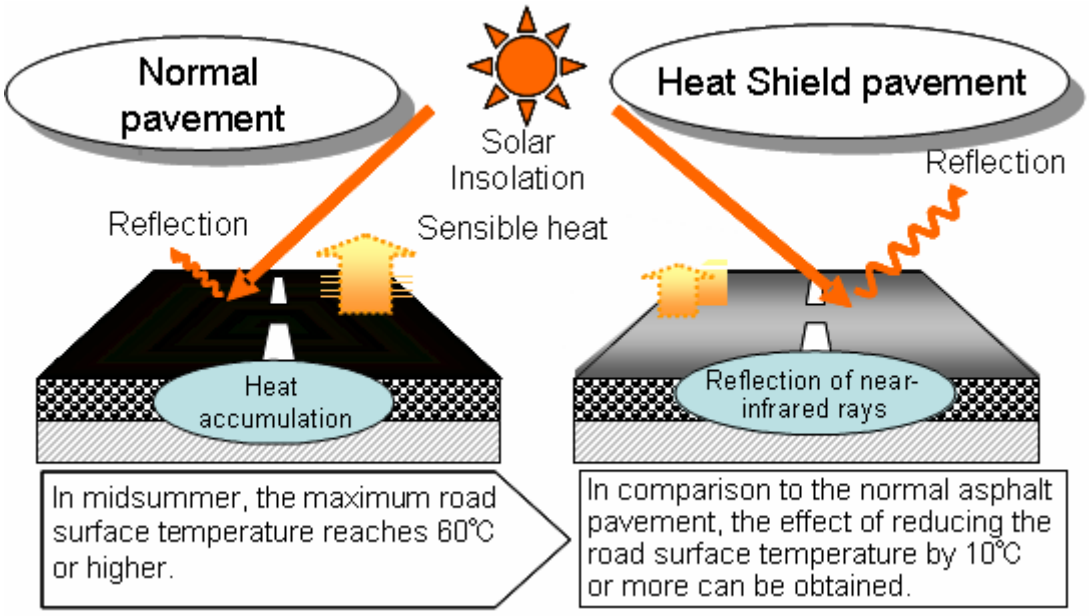


Figure1 - Heat Shield Pavement

2-4 Cooperation with Overseas Entities

The NILIM and the PWRI promote activities including joint research based on a bilateral/multilateral cooperation agreement and participation in international conferences, as cooperation with overseas entities for technological research and development.

With respect to the bilateral research cooperation, the U.S.-Japan Cooperative Program in Natural Resources (UJNR) have been held on a regular basis since 1969. In addition, under research cooperation agreements entered into with many European, American and Asian countries, research exchanges and joint research on civil engineering technology developments, including that in the road area, are underway. Examples are the international workshop on the ITS technology with the United States, China, South Korea, France and EU countries and organizations, and the cooperative study of the advanced construction technology based on the Agreement between the Government of Japan and the Government of French Republic on Cooperation in Science and Technology.

Cooperation activities are promoted, not only under this kind of bilateral agreement but also under multilateral agreements. For instance, the Conference on Public Works Research and Development in Asian with directors of civil engineering research institute and executive engineers in the departments in charge of technological development as their members has been held once a year in Japan since the first session in February 1993. The

conference is contributing to increasing awareness of the necessity to improve social infrastructure and the importance of research and development into civil engineering technology, fostering researchers and constructing the network for technological exchange in the Asian region. In addition, cooperation through international organizations, such as the Organization for Economic Cooperation and Development, is also implemented.

Furthermore, international joint research with overseas research institutes is promoted. For instance, joint research concerning measures to deal with soft ground was started in 2005, in cooperation with the Road Research Institute of the Ministry of Public Works of Indonesia, the Development Department of the Road Bureau of the Ministry of Transport and Telecommunications of Thailand and the Road Bureau of the Ministry of Public Works of Laos, constructing test banking in Bangkok, Thailand and conducting an assessment of the applicability on the spot at present with a plan involving the proposal of a designing and construction method suited to the construction conditions found on site. (Photo 1)

Photo 1 - Test Banking Construction

3. SPECIFIC EXAMPLES OF TECHNOLOGICAL RESEARCH AND DEVELOPMENT

With respect to specific measures used to promote research and development, two areas are taken up for introduction, namely the trend of research and development for the ITS, which is an infrastructure to support change in the industrial/social structure of the 21st century, and for asset management, which is becoming important to efficiently ensure the safety of road structures entering the period of renewal.

3-1 Intelligent Transport System (ITS)

In Japan, four ITS-related ministries and agencies, namely the MLIT, National Police Agency, Ministry of Internal Affairs and Communications and the Ministry of Economy, Trade and Industry, are intensively promoting the development of an Intelligent Transport System (ITS) as a new social infrastructure of the 21st century, positioning it as a national

project and designating the development areas shown in Table 4. The Road Bureau of the MLIT has been working on the promotion of the “Smart Way” that realizes high-level road traffic by integrating and incorporating leading-edge ITS technologies, and the Vehicle Information and Communication System (VICS) and the Electronic Toll Collection (ETC) System have been already practically implemented. In promoting the Smart Way, a related study has got underway, having established the “Smart Way Project Advisory Committee” in February 1999 with academic experts, ITS specialists in the industrial circles, related government ministries and agencies as members, with a view to clarifying the significance, function, requirements, measures to realize the Smart Way and seeking to realize the same. In August 2004, the Committee announced a proposal entitled “ITS Enter the Second Stage – Smart Mobility for All”. Following this proposal, a working group was established under the Smart Way Project Advisory Committee, in which studies were cumulatively advanced to realize the particulars of the proposal, including assistance for safe driving through vehicle infrastructure cooperative systems.

Table 4 - Nine Development Areas of ITS and Related Matters

Development Area	Main Particulars	Summary
Advances in navigation systems	VICS (Vehicle Information and Communication System)	Spread of VICS-responsive navigation: 15.84 million cars (June 2006)
Electronic toll collection systems	ETC (Electronic Toll Collection System)	Rate of ETC utilization: 65.5 %; Number of cars duly equipped: 15.14 million cars (December 2006)
Assistance for safe driving	AHS (Advanced Cruise-Assist Highway System); ASV (Advanced Safe Vehicle)	
Optimization of traffic management	Optimization of the traffic flow; Provision of traffic restriction information in case of incident	
Increasing efficiency in road management	Management of specially permitted commercial vehicles. Provision of roadway hazard information.	
Support for public transport	Provision of public transport information. Assistance for public transport operations and operations management	
Increasing efficiency in commercial vehicle operations	Assistance for commercial vehicle operations management	

Development Area	Main Particulars	Summary
Support for pedestrians	Pedestrian route guidance. Vehicle-pedestrian accident avoidance	
Support for the emergency vehicles operations	Automated emergency notification. Route guidance for emergency vehicles and support for relief activities	

Currently, with a view to realizing a full-scale ITS society and starting the full-fledged ITS service, 1) the development of the platform for the next-generation road services, 2) the development of new vehicle infrastructure cooperative systems, 3) the integration of the data structure, and 4) upgrading of the digital maps are being addressed.

(1) *Measures for the promotion of ITS*

Since cooperation among the industry, academia and government is important for research and development as well as the spread of ITS, organizations such as “The DSRC Forum Japan (DSRC: Dedicated Short Range Communication)”, “The Study Committee on the Use of ETC Related Technologies” and “The VICS Probe Colloquium” have been established, where the industry, academia and government are cooperatively conducting studies.

In addition, following the proposal of the Smart Way Project Advisory Committee, the MLIT has publicly sought participants in the “Joint Research for the Next-Generation Road Service Provision System”. Consequently, the NILIM and 23 private enterprises have engaged in joint research since February 2005 and held the the Smart Way Open Trial “Demo 2006” in February 2006, as part of joint research. To approximately 1,000 participants including those publicly sought, they carried out service demonstrations such as the road safety and traffic information services via voice or still images and the fare payment service at public parking spaces or gas stations. Putting these achievements in order, the “Report on the Joint Research for the Next-Generation Road Service Provision System” was published in March 2006.

The joint research was conducted, based on the specification of 5.8 GHz DSRC used in ETC, in order to realize the next-generation road services, including VICS and ETC, with a single on-board unit, by combining the common functions necessary to realize individual services. In addition, future linkage with various communication media was taken into consideration, and attention was also focused on how to secure safety while driving. Currently, studies for putting the service into practice and detailed examination for carrying out the experiment on public roads are underway, with a view to actually providing the full-scale service in the fiscal year 2007.

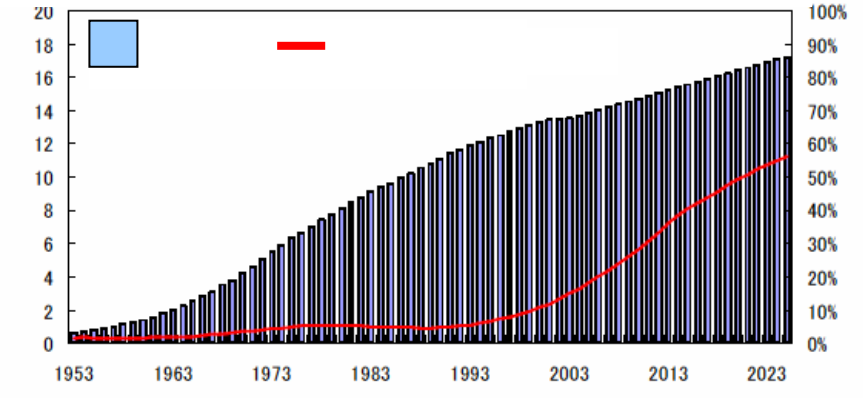
In terms of international cooperation, Japan is actively promoting international collaboration through its participation in the “ITS World Conference” and other meetings. In addition, Japan is holding annual bilateral conferences with the United States, China, EU, South Korea and other countries on the occasion of the World Conference, to exchange information with each country and organization.

Moreover, standardization is underway in 12 working groups under TC204, which is the committee dealing with international standardization in the field of ITS at the International Organization for Standardization (ISO). Japan is also actively participating in the activities of TC204.

3-2 Asset Management

(1) *Summary of the research*

In Japan, road facilities, composed mainly of many bridges constructed during the period of high economic growth from 1960 to 1980 or thereabouts, are rapidly entering into the period of aging (Figure 2). In order to maintain the function of the roads currently being provided and seek the rationalization of replacement investment, research and development to implement asset management, mainly focusing on the preventive maintenance shown in Tables 5 and 6, are underway.



Source: “Report on the Degree of Achievement of the Road Administration in the Fiscal Year 2005”

Figure 2 - Transition of the Number of Bridges (National Highways; Local Roads)

Table 5 - Asset Management Mainly Focusing on the Preventive Maintenance

Measures	Particulars (Supplementation)
Study/development of the indicators of the life prolongation effect through preventive maintenance	Including the study of the life of structures for the future, based on inspection results, actual repair records etc.

To strengthen the management of preventive repair for the three major causes of damage (fatigue, chloride induced damage and alkali-silica reaction)	Operation of the priority projects support system, based on the forecast of future degradation
System design of the scientific asset management of bridges, based on the data	Putting in order bridge management record, etc.

Table 6 - Research and Development for Conducting Asset Management

Issues		Research Items
Upgrading and rationalization of the maintenance/control system	• Construction of a scientific road asset management system based on the data • Realization of reasonable management based on the forecast of future conditions	・Construction and improvement of the system ・Creation of the manager supporting tool ・Establishment of the degradation forecast technique
Assessment of the performance of existing structures	• Accurate and reasonable acquisition of the data required for diagnosis • Establishment of the technology to correctly assess the condition (safety) of existing structures	・Acquisition of necessary information (from “see” to “diagnose”) ・Rationalization, improvement of efficiency and sophistication in obtaining data ・Technology to assess health ・(Assessment of the current condition and assurance of safety as well as the judgment of the necessity for repair and reinforcement)
Establishment and enhancement of the repair and reinforcement technologies	• Reduction of LCC by the efficient repair and reinforcement method	・Development of a new technology and construction method ・Design criteria for repair and reinforcement

(2) *Cases of recent technological development in relation to asset management*

Case 1 Preventive maintenance-type health diagnosis technology for the concrete structure

Of all the degradation mechanisms of concrete structures, the corrosion of reinforcing steel induced by chloride ions has caused the most significant damage in Japan. To maintain the

chloride induced corrosion of concrete structures, it is important to detect the corrosion of re-bars in its early stage by periodic inspections and apply preventive countermeasures. The PWRI, has developed the modified half-cell potential method. This new inspection method that uses this half-cell potential survey, non destructive test methods, combined with the measurement of chloride ion content would be used in the principal inspection for highway concrete structures.

Case 2 Coating film removal technology used to prolong the life of the steel bridges (Photo 2)

In Japan, to prolong the life of steel bridges, there are plans to shift to heavy-duty anticorrosion coating film, which has superior durability compared to the traditional coating. This will involve removing the old coating film, however, it is difficult to delaminate the multi-layer coating all at once with a traditional remover, and there are also problems of prevention in coating film dust dispersion and of the processing of the dust when the mechanical method is used. As a result, a safer and more efficient removal method has been desired. The newly developed remover, of which the main ingredient is higher alcohol, is an innovative material that penetrates into softens the coating film and can be removed and collected securely and safely. Since the certainty of application has been demonstrated on several highway bridges, its use is expected to increase in future.

Photo 2 - Coating Film Removal Technology

(3) *Measures for finding and utilizing the technologies developed by the private sector*

The MLIT is constructing a mechanism for finding useful new technologies developed by the private sector and utilizing them in public works (utilization system of new construction technology for public works etc.) (Figure 3).

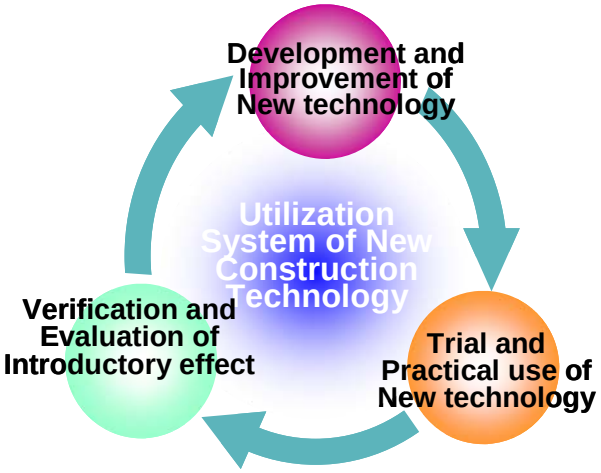


Figure 3 – Utilization System of New Construction Technology

In this system, new technologies are registered by private companies to be accumulated on the MLIT developed system called the New Technology Information System (NETIS). The MLIT will try each of the technologies, put them into practical use for verification and evaluation on the actual effects and put the results back onto the NETIS database. The results are reflected in the further technical improvement and development.

The full-scale operation of this system was started in August 2006, and over 4,500 new technologies have been registered to this day. While this system deals with overall technologies related to projects under the jurisdiction of the MLIT, it is expected that many technologies relating to asset management will be registered in the future.