Chapter 3 Response to Critical Issues Facing Japan

Section 1 Promotion of Measures for Solving Critical Issues

1 Assuring Safety, Affluence and High Quality of Life

Under the 4th Basic Plan, one goal is for Japan to become "a nation that affords its citizens safety, fulfillment and high quality of life". To assure safety, fulfillment and high quality of life for years to come, measures should be taken to enhance security by protecting people from large-scale natural disasters, serious accidents and terrorism, and by an ensuring stable supply of food and water. Additionally, efforts are needed to help people enrich themselves mentally and cultivate themselves in terms of sensibility.

(1) Enhancement of the safety and convenience of life

Authorities have been advancing the efforts described below, toward the following objectives: ensuring safety against natural disasters, accidents and crime; protecting human health and conserving ecosystems; and achieving a good balance between safety enhancements and increases in comfort and convenience.

1) The promotion of surveys and observations regarding earthquakes, volcanoes, tsunamis, high waves and tides, damage from wind and flooding, and landslide disasters: The advancement of R&D for improved capabilities of natural disaster forecasting, disaster prevention/mitigation and disaster response

Japanese around the country experienced large-scale natural disasters in FY2013, including from tornadoes in Koshigaya, Saitama Prefecture, in September, and from a landslide from Typhoon Wipha on Izu-oshima Island. Natural disasters caused great damage in many other parts of the world. Typhoon Yolanda caused storm-surge-related damage in the Philippines in November 2013. To mitigate damage caused by natural disasters, it is critical to advance R&D of science and technology (S&T) related to the prevention of various types of disasters.

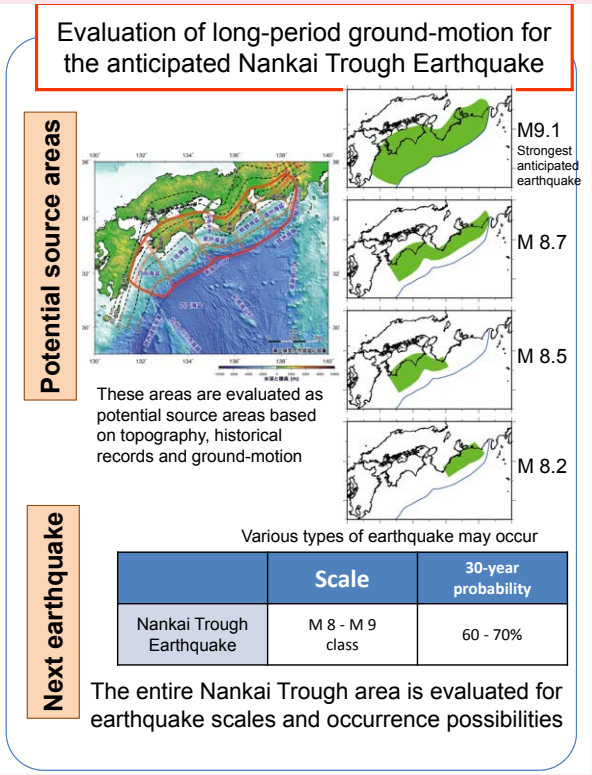
(i) Promotion of seismological R&D (MEXT)

Under the Headquarters for Earthquake Research Promotion (Director: the Minister of Education, Culture, Sports, Science and Technology), administrative agencies are working in close cooperation on seismological investigations and research. In the wake of the Great East Japan Earthquake (GEJE) of September 2012, the Headquarters for Earthquake Research Promotion reviewed the guidelines on Japan's basic policies regarding seismological investigations and research (i.e., the Promotion of a New Surveys and Research on Earthquake), which were formulated in April 2009. The headquarters decided to advance the steady development of observation networks in sea areas surrounding Japan, in order to improve the accuracy of real-time earthquake and tsunami forecasts.

Because the long-term evaluations conducted by the Headquarters for Earthquake Research Promotion did not cover massive multi-segment earthquakes such as the 2011 Off the Pacific Coast of Tohoku Earthquake, in terms of the probability and scales of earthquakes, conventional evaluation methods have

been reviewed for the formulation of new methods. In May 2013, a revised version of the *Long-term Evaluation of Nankai Trough Earthquakes (2nd edition)* was published (Figure 2-3-1).

Figure 2-3-1/ Long-term Evaluation of Seismic Activity in the Nankai Trough (2nd edition)



Source: MEXT

Seismological and volcanological observations and research at related institutions including universities were conducted according to the proposed "Promotion of Observation and Research Programs for the Prediction of Seismic and Volcanic Activity" (formulated by the Council for Science and Technology (CST), MEXR in July 2008; revised in November 2012). Under MEXT, CST developed a proposal called the Promotion of Earthquake and Volcano Hazards Observation and Research Program. That Helps Mitigate Disasters. CST submitted it to the Minister of Education, Culture, Sports, Science and Technology and other ministers November 2013. Based on the lessons learned from the 2011 Off the Pacific Coast of Tohoku Earthquake, this project is meant to be a five-year project starting in FY2014, focusing on research regarding the prediction of contributors to disasters, such as strong quakes, tsunamis, volcanic ash and lava extrusion, as well as regarding the prediction of earthquakes and volcanic eruptions. Seismological and volcanological observations and research at related institutions including universities were conducted according to the project(Earthquake and Volcano Hazards Observation and Research Program).

Under the Special Project for the Mitigation of Great Disasters which the Vulnerability of Cities Causes, the Research Project for Compound Disaster Mitigation on the Great Earthquakes and Tsunamis around the Nankai Trough Region and other projects, MEXT has been implementing investigations and research focusing on regions where social harm and economic damages could be significant in the event of assumed major earthquakes, such as earthquakes occurring directly beneath the Tokyo Metropolitan Area. Under the Research Project for Compound Disaster Mitigation on the Great Earthquakes and Tsunamis around the Nankai Trough Region, an earthquake source model covering an area extending from the Nankai Trough to the Nansei Shoto Trench was developed for estimating potential damage from earthquakes and tsunamis, and for examining measures to prevent and mitigate damage, as well as for recovery and reconstruction after such damage. Efforts for enhancing the use of research results specific to this region include research on the following: disaster prevention and mitigation measures, structural exploration, dense seismic observation, tsunamis in recorded history and simulations. In the Project for Investigations of Earthquakes and Tsunamis in the Sea of Japan, controlled-source surveying and investigations of tsunami deposits were conducted in order to advance research on an earthquake source

fault model and a tsunami source model that would be applicable to the Sea of Japan and its coast. This is because earthquake source faults and tsunami sources there are less understood that those in the Pacific Ocean and on its coastline. In the Research Project for Supporting Regional Disaster-prevention Measures, a database was developed based on research for disaster prevention measures from universities nationwide. Additionally, the utilization of research results in the formulation of regional anti-disaster measures was promoted.

After the Great Hanshin-Awaji Earthquake, earthquake observation networks were densely built in land areas. Although several sea-area observation networks have been built, including a Japan Meteorological Agency (JMA) cable network off of Tokai/Tonankai for submarine earthquake observation, the observation points in these networks are much fewer than those in land-based observation networks.

In light of this, MEXT started the full-scale operation of a dense submarine network equipped with seismometers and hydraulic gauges for real-time seismic observation in the hypocentral region of the assumed Tonankai Earthquake. A similar system was developed in the hypocentral region of the assumed Nankai Earthquake. A cable network for submarine earthquake observation has also been developed in and around the hypocentral region of the 2011 Off the Pacific Coast of Tohoku Earthquake, because large aftershocks and tsunamis are likely to occur (cf. Chapter 2, Section 1, 1(3)).

(ii) Promotion of S&T for disaster prevention (National Research Institute for Earth Science and Disaster Prevention)

National Research Institute for Earth Science and Disaster Prevention (NIED) engages in research on the following topics: seismic engineering utilizing E-Defense; accurate and precise prediction of rainfall based on next-generation high-performance radar; the prediction of damage from landslides, windstorms and floods; and potential damage from volcano and snowfall natural disasters. NIED is also advancing research on the development of systems for aggregating and utilizing information on diverse natural disasters. In FY2013, NIED detected a slow slip off the coast of the Boso Peninsula by utilizing its high-sensitivity seismograph network, and it detected the development of rain clouds by means of its X Band Multiparameter Radar prior to the tornadoes in and around the city of Koshigaya.

(iii) Research on earthquake monitoring/forecasting, tsunami forecasting and earthquake early-warning (JMA)

JMA processes and analyzes the monitoring data collected at its earthquake monitoring facilities and related institutions, and provides the analysis results to those institutions. JMA collaborates with NIED in conducting R&D for further advancing technologies for the earthquake early warning system.

The JMA Meteorological Research Institute engages in research on the following topics: the development of tsunami forecasting technologies for mitigating damage by tsunamis on the basis of offshore tsunami monitoring data and real-time earthquake intensity estimations after massive earthquakes; technologies for seismic intensity estimation that help improve the accuracy of earthquake early warnings; and technologies for monitoring and analyzing crustal movements that help improve the accuracy of predictions for the assumed Tokai Earthquake.

(iv) Improvement of technologies for monitoring and analyzing crustal movements (the Geospatial Information Authority of Japan: GSI)

GSI engages in R&D on technologies for the observation and analysis of crustal and plate movements

through continuous GNSS observation at electronic reference stations[1], through Very-Long-Baseline Interferometry (VLBI[2]) and through SAR Interferometry[3]. Detailed monitoring of crustal movements in and around volcanoes has been implemented through integrated analysis of GNSS volcanic observation data, which have been collected in and around volcanoes by the JMA (since FY2009), NIED (since FY2010), the National Institute of Advanced Industrial Science and Technology (AIST) (since FY2012) and the Hot Springs Research Institute of Kanagawa Prefecture (since FY2012).

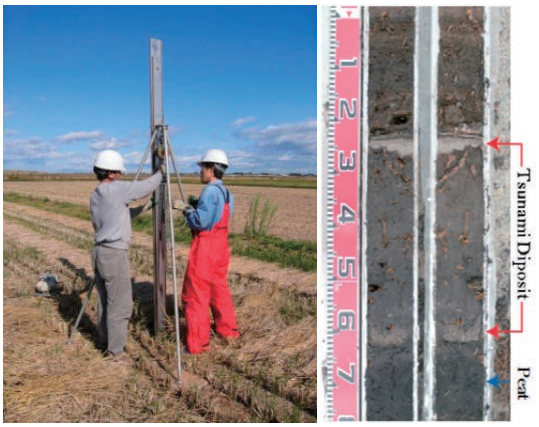
(v) Enhancement of surveys and observations of crustal movements on the seafloor (Japan Coast Guard)

The Japan Coast Guard (JCG) has been advancing observations of crustal movements on the seafloor[4] by means of GPS and echo ranging, as well as advancing surveys of submarine topography and active faults. In light of the 2011 Off the Pacific Coast of Tohoku Earthquake, the JCG has reinforced its system for observing crustal movements on the seafloor in the Nankai Trough.

(vi) Geological surveys of volcanoes, active faults and tsunami deposits (AIST)

AIST performs geological surveys of active volcanoes, active faults and tsunami deposits in order to collect geological information useful for disaster prevention and publishes the results of these surveys.

The AIST conducted geological surveys at six major fault zones on land and three major fault zones in nearshore seas in order to elucidate fault distributions and the history of fault activity. Regarding the Fukaya Fault and the Ayasegawa Fault on the Kanto Plain, seismic reflection surveys were conducted and existing data were reanalyzed in order to estimate the subsurface structure. For short-term predictions of Tokai/Tonankai earthquakes, the AIST increased the number of integrated groundwater observation points and continued measurement of groundwater levels, groundwater temperatures, crustal strains and seismic waves. The AIST also performed geological surveys for the purpose of understanding the history of large-scale tsunamis and of the seismic activity that causes such tsunamis in the following areas: the Shimokita Peninsula, the Sendai Plain, Northern Ibaraki and the Boso Peninsula, which are located along the Japan Trench; and Shizuoka Prefecture, the Kii Peninsula, and the coastal area of Shikoku, which are located along the Nankai Trough.



Survey of tsunami deposits on the Sendai Plain (left); Collected deposits (right)

courtesy of AIST

To make volcanic eruption scenarios more sophisticated, the AIST has continued observations of ashfall and petrological analyses regarding Mt. Shinmoe (a volcano in the Mount Kirishima cluster of volcanoes), which erupted in 2011, and the Sakurajima volcano, which has become more active. Investigations on the

1 Electronic reference points numbered 1,276 as of the end of March 2014.
2 Very-Long-Baseline Interferometry: Technology that uses radio waves from quasars billions of light years away to obtain precise long-distance (i.e., several thousand kilometers) measurements on the Earth's surface within a tolerance of several millimeters.
3 Synthetic Aperture Radar: A form of radar hosted by satellites for monitoring the Earth's surface topography and its deformation. (The Advanced Land Observing Satellite "Daichi" stopped operating in May 2011.)
4 The location of each reference point on the seafloor is measured first by determining the precise location of a survey ship at sea through the use of GPS technology, and then by using sound waves to measure the distance between the ship and each reference point.

history of eruptions were conducted for Mt. Kuju, Mt. Zao and Hachijo-jima, because improvement of monitoring/observation systems was necessary for these volcanoes.

(vii) R&D for the prevention and mitigation of damage from natural disasters as well as for the observation of waves and tidal levels (Ministry of Land, Infrastructure, Transport and Tourism: MLIT)

MLIT has been developing and operating the Nationwide Ocean Wave Information Network for Ports and Harbours (NOWPHAS) in cooperation with the Port and Airport Research Institute and other institutes. Data on waves and tidal levels observed across Japan are collected through this network and are published on MLIT's website in real time. In FY2013, MLIT increased the use of GPS wave gauges, which also help in observing tsunamis after earthquakes.

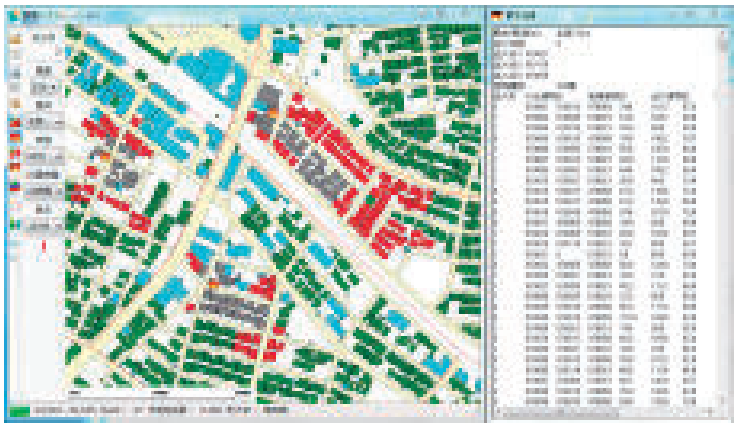
The National Institute for Land and Infrastructure Management (NILIM) of MLIT has been cooperating with related departments and bureaus of MLIT in advancing research for formulating technical standards necessary for securing citizens' safety during and after disasters, as well as in advancing research that is useful for the planning of anti-disaster measures. For example, details of disaster forecasting and anti-disaster planning are studied toward preventing or mitigating damage caused by natural disasters (e.g., earthquakes, tsunamis, floods, landslides) to infrastructure such as roads, rivers, ports and harbors and to houses and residential areas. In FY2013, based on the experience of the GEJE, the NILIM conducted research on the structure of sea dikes and breakwaters that would be able to control tsunamis even for peak wave heights that exceed the design wave height and for sea water overtopping the crown of the dikes/ breakwaters. To provide technical support to local governments regarding measures against liquefaction for residential land, the NILIM developed and published software for simplified calculation of the probability of liquefaction damage.

(viii) Research on prevention, mitigation and early restoration in relation to natural disasters that have become increasingly severe and diverse (Public Works Research Institute: PWRI)

PWRI conducts R&D that contributes to the prevention and mitigation of damage caused by natural disasters (e.g., earthquakes, tsunamis, eruptions, windstorms, floods, landslides, and snow and ice) and to early restoration after these disasters. In FY2013, for example, the PWRI engaged in research on technology for protecting river levees by combining measures for improving water resistance and measures for enhancing aseismic capacity.

ix) The collection and analysis of disaster information: The development of disaster drill systems (Fire and Disaster Management Agency)

Based on an understanding of problems with information gathering that were identified after the GEJE, the Fire and Disaster Management Agency (FDMA) experimentally developed a wide-area earthquake damage estimation system for test operation. This system helps officials responsible for emergency response to make



Oscreen display of simulated fire spreading
Courtesy of the National Research Institute of Fires and Disasters

appropriate decisions about the dispatch of emergency fire response teams and the like. To make use of experience gained in emergency response after the GEJE and large-scale flood disasters, the FDMA also developed an emergency response support system and a drill system for multiple simultaneous fires. These systems are useful for response team deployment in severe-disaster drills and for giving evacuation instructions to citizens.

2) The promotion of R&D on measures against fires, severe accidents and crime

The National Research Institute of Police Science specializes in research that helps to enhance criminal investigations, crime prevention and investigations of the causes of accidents. The following research subjects were dealt with in FY2013: improvements to methods for scientific examinations in cannabis-related criminal investigations; the development of a system for visualizing age-related changes in facial appearance; Individual identification of biological data through haplotype analysis[1] for supporting criminal investigations; behavioral science regarding techniques for interviewing suspects and crime victims; the practical application of simulation techniques used for fire appraisal that is implemented to identify the causes of fire accidents as well as to establish the finding of arson; and the development of techniques for appraising crashes by vehicles against roadside structures to identify the causes of such crashes.

In collaboration with ministries and agencies concerned, MEXT has been implementing the R&D Program for Implementation of Anti-Crime and Anti-Terrorism Technologies for a Safe and Secure Society, for the purpose of advancing R&D on S&T that helps to establish anti-crime and anti-terrorism measures and for the purpose of translating R&D results into applications based on the needs of public agencies as users of the developed S&T. This program was supported by Special Coordination Funds for Promoting Science and Technology between FY2010 and FY2012, and it has been a part of integrated implementation of social system reforms and R&D since FY2013.

3) The promotion of R&D toward human health protection and ecosystem conservation

PWRI has been engaging in the research on risk assessment and management of, and measures against, water pollutants, with the aim of protecting human health and conserving ecosystems.

For the purpose of preserving the maritime environment, the National Maritime Research Institute has been conducting research on key technologies that are useful for formulating environmental regulations which are socially rational and help to significantly reduce the environmental impacts of emissions, through efforts for attaining zero emissions.

4) The promotion of R&D for balancing enhanced safety with increased comfort and convenience

(i) R&D on the advancement and safety evaluations for transportation systems

Because the safety of transportation systems, on which citizens depend every day, needs to be enhanced urgently for restoring the public confidence in these systems, priority should be given to the promotion of the use of new technologies that help to ensure traffic safety and accident prevention. These technologies should be developed on the basis of expected increases in the demand for air traffic, as well as on the

1 Analysis of a collection of specific alleles, or particular DNA sequences

knowledge about human factors associated with operators and with driver performance, including their responses to what they see while driving.

The National Police Agency (NPA), the Ministry of Internal Affairs and Communications (MIC) and MLIT have been promoting efforts for the practical application of the Driving Safety Support Systems (DSSS), which utilizes bidirectional communications between vehicles and infrastructure, and vehicle-to-vehicle communications.

To put the DSSS into practical use, MIC made it possible to introduce vehicle-to-vehicle and vehicle-to-infrastructure communications in the 700-MHz band across the nation in April 2013. MIC also completed R&D for the advancement of 79-GHz high-resolution radars in FY2013. Amendments to rules and regulations necessary for securing pedestrian safety were made in December 2012.

MLIT installed about 1,600 ITS spots[1], mainly along expressways, and started ITS spot service nationwide in 2011.

MLIT has also been enhancing R&D that helps to improve the safety of railway traffic, including by developing platform screen gates that are available to various train door positions relative to the platform and help reduce construction cost.

The National Maritime Research Institute has been implementing research that helps to realize a safe and secure society. Specifically, for the purpose of ensuring the safety of marine transportation, this institution is formulating safety regulations that are socially feasible and that help to substantially reduce accidents at sea. Research is also being conducted on promoting modal shifts, increasing the efficiency of maritime transportation for better logistics, and developing transportation systems.

For the purpose of ensuring safety and timely operation of air traffic, the Electronic Navigation Research Institute is focusing on the following R&D: the expansion of air traffic capacity and improvement of operation efficiency; the expansion of air traffic capacity at congested airports; and the development of technologies that connect air and ground for safe, efficient navigation.

In FY2013, as part of efforts to prevent drunk driving, the National Research Institute of Police Science pursued research on the medical and psychological determination of drivers who are likely to drive drunk repeatedly.

1 Intelligent Transport Systems

Column 2-1

Portable Mass Spectrometer for the Detection of Illegal Drugs

Japan has been facing serious drug problems: Annual arrests for drug-related crimes have exceeded 10,000 in recent years, and the amount of confiscated drugs has continued to increase. Additionally, various illicit drugs that are similar in chemical composition to stimulant drugs and cannabis are trafficked. Thus, it is critical to develop and introduce drug detectors that are available to drug investigators, are easy to use and detect drugs quickly and reliably.

Mass spectrometers have been widely used for identification and analysis of illegal drugs, but each of these spectrometers weighs more than 100 kg and requires technical knowledge to operate. It has been impossible for drug investigators to use these spectrometers. A portable mass spectrometer developed by the National Research Institute of Police Science in cooperation with industry and academia[1] is small (35 cm x 39 cm x 17 cm), weighing only 11 kg. The internal battery ensures operation for one hour. Drug detection is possible from five minutes after the device is turned on. The special sample container makes it possible to easily detect dry cannabis or drugs in urine.

This mass spectrometer enables tandem mass spectrometry[2]. By checking against the drug database in the spectrometer, an analysis result of drug types and compositions is displayed within 5 minutes after the start of analysis. Because of these characteristics, this spectrometer is expected to be widely used by drug investigators for drug screening. Although the portable mass spectrometer was developed for use by Japanwese organizations investigating drug-related crimes, it is likely to be exported to other countries where problems of illegal drugs are more significant than in Japan, thereby contributing to the creation of a safe, secure society in each of these countries. Furthermore, the technology that was developed for this spectrometer is a core technology applicable to the monitoring and screening of water, soil, food items and farm products. This technology will help to promote technological and industrial development in Japan.

Portable mass spectrometer (top)
Display of a detection result (bottom)
Courtesy of Hitachi High-Technologies Corporation

(ii) The promotion of R&D for the improvement of housing and social infrastructure that are aging, as well as for longer service life

PWRI is developing technologies for the efficient maintenance of aging social infrastructure and for the service life extension of social infrastructure while enhancing its function based on advances in materials technology.

In December 2013, MLIT and Ministry of Economy, Trade and Industry (METI) specified priority areas for the development and introduction of robots for next-generation infrastructure, with the aim of advancing the development and utilization of robots that will support the enhancement of disaster response efficiency and effectiveness and of the maintenance of social infrastructure. To identify these priority areas, an investigative commission was organized in July 2013 for examination of the needs for robots that infrastructure administrators and officials in charge of disaster responses had, as well as for investigating the technological seeds in various fields in Japan and abroad.

1 R&D Program for the Implementation of Anti-Crime and Anti-Terrorism Technologies for a Safe and Secure Society which is integrally promoted through social system reforms and R&D

2 A mass spectrometry technique that uses the mass spectral pattern of fragment ions for substance identification. Ionized molecules are selectively extracted on the basis of a specific mass-to-charge ratio (m/z), and ionic dissociation is induced by an electric field for producing fragment ions.

(2) R&D for securing stable supply of food, water, energy and other resources

Ministries and institutions concerned are engaging in the R&D described below for ensuring the stable, uninterrupted supply of food, water, energy and other resources that are indispensable for the lives of the nation, as well as engaging in the R&D described below for enhancing the safety of these supplies.

The Ministry of Agriculture, Forestry and Fisheries (MAFF) is conducting research on the development of super-high-yielding crop varieties, crops suitable for harsh environments, high-biomass crops, breeds of pigs with high feed utilization efficiency and highly reproductive breeds of cow. To help achieve Japan's food self-sufficiency target, the MAFF also works on developing food and feed crops that have novel features in terms of quality and processing, and on techniques for producing high-quality meat and other livestock products by using domestic feed.

Other R&D subjects that the MAFF has been dealing with include the following: enhancement of accuracy and efficiency in communicable disease control with the aim of lowering the risk of spreading of avian flu, foot-and-mouth disease and other livestock diseases, and with the aim of reducing farmers' economic losses; technologies for reducing the risk posed by hazardous microbes and chemicals during the production, distribution and processing of farm products; techniques for finding scientific evidence of disease-prevention benefits in functional ingredients in farm/forestry/marine products and other food items and, thus, for supporting healthy longevity; the development of crop varieties containing functional ingredients in larger quantities, and techniques for culturing these varieties; and systems for supplying functional food items and farm/forestry/marine products to individuals according to their health conditions.

With the aim of ensuring a stable supply of marine resources, MEXT has been promoting R&D for enhancing technologies for exploring ocean minerals and securing marine biological resources (cf. Chapter 3, Section 1, 4(2)). Toward the realization of a low-carbon society, MEXT is also promoting R&D on innovative technologies for distributed energy systems and renewable energy that substantially help to create "green innovation" (cf. Chapter 2, Section 2, 1 (1) and (2)).

The National Maritime Research Institute is conducting research on the development and advancement of techniques for the safety evaluation of marine structures as well as for reducing their impacts on the marine environment, as these techniques underlie key technologies used for the development of marine resources and energy.

METI is promoting the establishment of recycling systems for used products, aiming at developing a sustainable recycling-based society that is environmentally sound and unaffected by resource constraints. Specifically, for enhancing the recycling of tungsten contained in cemented carbide tools that are indispensable for car manufacturing, grants were provided for the development and system demonstration of technologies for increasing the efficiency and reducing the cost of tungsten-derived alloy material production; and expansion of the recovery of used tools. To enhance the recycling of the lithium-ion batteries that are used in next-generation bicycles, grants were also provided for the development and demonstration of technologies for reducing the cost of cobalt extraction and recovery, and the development of systems for collecting spent lithium-ion batteries.

(3) Increase of the affluence of lives of the nation

To use science and technologies for improving quality of life, increasing affluence and helping to enrich people's minds and cultivate their sensibilities, efforts described below have been advanced by various

ministries and institutions.

1) Efforts for improving quality of life and for increasing affluence

With the aim of promoting the use of information and communications technologies (ICT) at schools, MIC collaborated with MEXT in implementing the Future School Promotion Project, an empirical study that identified and analyzed issues related to the use of ICT at schools. For the purpose of this project, ICT devices such as tablet PCs and interactive whiteboards were provided to 8 junior high schools and 2 schools for students with special needs, for developing information and communications networks. Regarding R&D that benefits welfare, grants have been provided to R&D projects in order to defray the costs of R&D on technologies necessary for delivering more convenient communications and broadcasting services to elderly and/or disabled citizens. In medical care and nursing care, research has been conducted for verifying the usefulness and effectiveness Ubiquitous Net Technology[1], and demonstration tests have been implemented regarding a medical information linkage platform that is being used for facilitating the safe sharing of medical information by each local community. In the field of public administration, MIC has been promoting efforts to improve public services by utilizing ICT across Japan. MIC is also studying and verifying data items, data links and linkage methods for facilitating data linkages among public service authorities through cloud computing services.

2) Efforts toward helping people to enrich their minds and cultivate their sensibility

MIC has been promoting efforts to facilitate the handling of secondary-use rights, with the aims of developing an environment that supports the creation and distribution of broadcast content, and of promoting the export of Japan's broadcast content.

Table 2-3-2 / Key Measures Taken for Realizing a Safe and Affluent Society That Guarantees High Quality of Life for Citizens (FY2013)

Ministry /Agency	Implemented by	Research Subject
NPA	NPA	The development of infrastructure for post-disaster traffic information services based on data from probe vehicles
	National Research Institute of Police Science	Improvement of methods for scientific examination in cannabis-related criminal investigations
		The development of a system for visualizing age-related changes in facial appearance
		Individual identification of biological data through haplotype analysis
		The practical application of simulation techniques used for fire appraisal
		Behavioral science regarding techniques for interviewing crime suspects and victims
		The medical and psychological determination of drivers who are likely to drive drunk repeatedly
		The development of techniques for investigating vehicle crashes against roadside structures to identify the causes of the crashes
MIC	MIC	R&D on technologies for next-generation satellite communications used for marine resources exploration
		R&D on technologies for recovering the energy in electromagnetic waves

1 Ubiquitous Net Technology is being used for automatically identifying and recording the medical practice of health-care professionals and patients' conditions by utilizing electronic tags and sensors attached to patients, medicinal products and medical devices.

	National Institute of Information and Communications Technology	R&D on key technologies for universal communication
MEXT	MEXT	The mitigation of damage caused by disasters which becomes serious due to the vulnerability of urban areas
		Seismic and tsunami investigations in the Sea of Japan
		Research on compound disaster mitigation for large-scale earthquakes and tsunamis around the Nankai Trough region
		Research on support for regional anti-disaster measures
		The comprehensive promotion of surveys on active faults
		The comprehensive evaluation of information on faults in sea areas
	NIED	Scientific research focusing on monitoring and prediction
		Scientific research focusing on disaster mitigation experiments
		Scientific research focusing on social systems for disaster prevention
		The development of Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench
MAFF	MAFF	The creation of new demands by capitalizing on farm/forestry/marine resources
		The realization of significant reductions in the production costs of domestic farm products
		The development of next-generation key production technologies for farm and livestock products by utilizing genome information
		The improvement of food safety and animal health
		The promotion of research on S&T for agriculture, forestry, fisheries and the food industry
	National Agriculture and Food Research Organization	The promotion of basic research for innovation (supported by competitive funding)
		The urgent development of innovative technologies for aggressive agricultural, forestry and fishery management
METI	METI	The development of systems for responding to social issues, such as the maintenance and renewal of infrastructure
	AIST	Geological survey and research in urban and coastal areas, and the optimization of geological and environmental information
		Improvement in the accuracy of earthquake forecasting through surveys of active faults and seismic observation
		Improvement in the prediction accuracy of volcanic eruptions
MLIT	MLIT	The cost of developing a social infrastructure information platform
		Study on the development and use of monitoring technologies
		The promotion of the development and introduction of robots for next-generation social infrastructure
	NILIM	Research on techniques for determining strategic priorities in applying seismic retrofitting to sewerage facilities
		Research on new port and harbor planning techniques for enhancing the efficiency of international bulk shipping
	JMA	The technological advancement of earthquake early warning and tsunami monitoring information
	Meteorological Research Institute, JMA	The development of technologies for the ultrafast monitoring of localized torrential downpours and tornadoes using phased array radar

2 The strengthening of Japan's Industrial Competitiveness

(1) The reinforcement of shared infrastructure, toward increasing Japan's industrial competitiveness

Japanese manufacturing is more globally competitive than other domestic industries, has major ripple effects on other industries and drives economic growth. Thus, the government of Japan has been taking measures to actively enhance manufacturing technologies. However, in the wake of the GEJE, R&D and production activities in the private sector have stagnated, thereby significantly affecting the supply chains of products, parts and materials. The recent rapid appreciation of the yen coupled with constraints on the procurement of raw materials, including rare earth elements, has encouraged businesses to move their production bases abroad, and the business environment in Japan has deteriorated. Consequently, people are

increasingly worried about the hollowing of domestic industry and reductions in investment in R&D. In response, the government has been taking measures to enhance the competitive edge of Japanese industries, to achieve sustainable economic growth and to rebuild robust systems and infrastructure that can support manufacturing.

With the aim of creating new industries that utilize radio waves, MIC is conducting R&D on technologies that enhance the use efficiency of radio waves and that enable the use of higher frequencies, in order to meet the demand for newly available radio frequencies.

MEXT has been collaborating with industries and universities in promoting the development of the most advanced, unique technologies and instruments for measurement and analysis that serve the needs of world-leading researchers and manufacturers (cf. Chapter 3, Section 1, 5(1)).

Toward enhancing Japan's industrial competitiveness, METI has been promoting R&D on the topics stated below, to support the creation and growth of new industries by developing shared infrastructure for manufacturing.

1) The development of key technologies for manufacturing processes

The demand for light, high-strength carbon fiber, which is useful as a structural material for aircrafts and automobiles, is expected to expand significantly. In light of this, METI collaborated with universities and carbon fiber manufacturers to develop key technologies that are used in unconventional manufacturing processes. Through these processes, the production efficiency has significantly increased and CO_2 emissions and other environmental impacts have been reduced.

Research was also conducted for translating these key technologies into basic manufacturing technologies.

2) The development of semiconductor technologies

R&D on the following semiconductor technologies has been implemented: key evaluation technologies necessary for a next-generation extreme ultraviolet (EUV) lithography system that realizes semiconductor microprocessing and manufacturing process at the 10-nm level; technologies for ultra-low-power semiconductors that utilize new materials and structures; and key technologies for "normally-off computing" (i.e., nonvolatile elements are embedded in semiconductors to ensure that power is consumed only when data processing is necessary). Other R&D topics that are dealt with by METI include the following: technologies for integrating next-generation semiconductor devices that help to advance next-generation vehicles, PCs and servers, and that help to reduce their power consumption; and technologies for creating hybrid circuits consisting of light and electrons and for building these circuits into systems (part of the "Pioneering Research for the Future" Project).

3) The development of information-processing technologies

Manufacturers of embedded systems are required to assure product reliability and safety by ensuring product quality, and to meet accountability for their efforts to secure product reliability and safety. METI has supported the development of a tools platform that is used for ensuring the traceability of documents created in the process of product development. This platform helps to enhance accountability for product quality.

4) Support for reductions in the use of rare-earth elements

Rare-earth elements are vital to high-value-added industries, such as the manufacture of hybrid and electric cars. METI has been addressing the supply risk posed by resource nationalism overseas through projects that aim to develop technologies for producing alternative materials and for reducing the use of rare-earth metals.

The Development of Magnetic Materials for High-efficiency Motors Used in Next-generation Vehicles was started in 2012. It was the first project selected under the "Pioneering Research for the Future" Project, which promotes the practical application of innovative technologies through industry-university-government cooperation. The project was continued in 2013. In response to the increasing demand for high-performance magnetic materials used in the motors of next-generation vehicles and wind power generators, magnetic materials that are more powerful than conventional one are developed in this project, without the use of rare earth elements such as dysprosium[1], whose geographical distribute is uneven. Additionally, with the aim of manufacturing high-performance motors without using rare-earth elements, prototypes with enhanced performance are designed and manufactured.

In a project for developing materials to replace rare metals, METI developed technologies that use abundantly available resources for manufacturing substitutes for rare metals, as well as technologies for significantly reducing the use of rare metals. Support was provided by METI for the recycling of rare metals in the motors of vehicles and air conditioners.

5) Efforts for promoting R&D at small and medium-sized enterprises

Necessary measures were implemented for the Project for Strategic Promotion of Advanced Basic Technologies under the budget for FY2013. METI supported R&D projects that were accredited pursuant to the *Act on the Enhancement of Small and Medium-sized Enterprises' Core Manufacturing Technologies (Act No. 33, 2006)* and that were conducted by small and medium-sized enterprises (SMEs) in collaboration with research institutions, including universities and public research organizations.

Regarding the Specific Core Manufacturing Technologies specified on the basis of the *Act on Enhancement of SME's Core Manufacturing Technology*, 22 technological fields were reviewed for the strengthening of manufacturing industries according to the Japan Revitalization Strategy approved by the Cabinet in June 2013 and also by the Headquarters for the Growth of Small Businesses established by the Small and Medium Enterprise Agency. The review results shoed the need to facilitate entry by SMEs into growing fields such as medical and environmental businesses. In light of the review results, the Specific Core Manufacturing Technologies were redefined according to the needs of health, medical, environmental, energy and other industries. Additionally, the *Guidelines on the Enhancement of SME's Specific Core Manufacturing Technologies (METI notification No.97, 2012)* were drastically revised.

6) The development of innovative technologies for semiconductor manufacturing

METI has been conducting R&D on basic technologies applicable to a minimal fabrication semiconductor production process. This innovative process is suitable for high-mix, low-volume

1 It is a rare-earth element added to high-performance magnets to improve the heat resistance of motors used in hybrid/electric cars and air conditioner compressors.

manufacturing. The devices used in this process are small; thus, no large investments in equipment are necessary. A large part of the energy that would otherwise be necessary for manufacturing semiconductors is saved, because clean rooms are not used in this process.

7) The promotion of regional open innovation

In each strategic field specified by regional industrial competitiveness councils, platforms for supporting R&D conducted by small and medium-sized companies are created by introducing R&D facilities into public experimental research institutions and universities.

8) Efforts for creating small and medium-sized venture companies specializing in R&D

Although many technological seeds are available in Japan, small and medium-sized venture companies that specialize in R&D for utilizing these technological seeds have not been fully developed. Thus, to facilitate innovation, the development of venture companies engaging in R&D has been promoted. For this purpose, a comprehensive support system was established in the New Energy and Industrial Technology Development Organization (NEDO) to provide support to development of technologies for practical application and commercialization with the help of specialists.

(2) The creation of industrial infrastructure by leveraging Japan's strengths

Against the backdrop of intensifying international competition in the markets for end-products such as machinery, automobiles and electrical/electronic equipment, the government has been promoting R&D on integrated systems consisting of smart grids, next-generation transportation systems and network infrastructure, as well as R&D on integrated services for the maintenance and operation of these systems. R&D on these systems and services aims at the creation of new added value. Demonstration experiments and international standardization of the R&D results are also promoted for the application of these results abroad. For increasing the productivity of service industries, R&D for more effective use of science and technology is being enhanced. Furthermore, with the aim of creating new industries and of improving the efficiency of the nation's socioeconomic system, the government has been promoting R&D on technologies for next-generation information and communications networks and R&D on ICT for highly reliable cloud computing. The use and application of these technologies are encouraged in a broad range of areas.

MIC has been promoting R&D on key technologies for realizing flexible network control and for increasing the network capacity in response to the diversification of network services and the expansion of wide-area cloud computing services. Toward the operation of the Driving Safety Support System, MIC made it possible to introduce vehicle-to-vehicle and vehicle-to-infrastructure communications in the 700-MHz band across the nation as of April 2013. MIC also completed R&D for the advancement of 79-GHz high-resolution radars in FY2013. Amendments to rules and regulations necessary for securing pedestrian safety were made in December 2012. To realize optimal energy management at the regional level in connection with the operation of smart grids, MIC has been promoting R&D and the international standardization of communications platform technologies for the remote control of various devices in multiple buildings in an accurate and reliable manner. MIC is also promoting R&D and demonstration experiments of new-generation network technologies and their applications, for the purpose of supporting the development of human resources that specialize in ICT, industrial revitalization and the enhancement

of Japan's international competitiveness, as well as for the purpose of cooperation with other countries. The R&D and demonstration experiments are conducted by utilizing the Japan Gigabit Network-eXtreme (JGN-X[1]), a new-generation network testbed that was developed and is operated by the National Institute of Information and Communications Technology (NICT).

METI has been promoting R&D on technologies for increasing the efficiency of the nation's socioeconomic system. Specifically, the development and demonstration of technologies for creating smart communities are being enhanced. Large-scale demonstration tests are conducted in four regions. By utilizing technologies and ideas that complement these demonstrations, demonstration tests are also implemented in nine other regions where the local energy situation is taken into consideration toward solving technical and institutional problems specific to each region (cf. Chapter 2, Section 2, 1(1)).

METI has also implemented development projects that aimed at creating new added value and industries by utilizing IT and data. The projects include those for the development of a diagnostic support system based on medical information, and an effective crop cultivation system that uses environmental and ecological information.

Table 2-3-3 / Key Measures Taken for Strengthening Japan's Industrial Competitiveness (FY2013)

Ministry /Agency	Implemented by	Research Subject
MIC	MIC	R&D on technologies for using real-time information as part of the G-spatial platform development project
		ICT innovation (the "I-Challenge!" program)
		The demonstration of ICT for a next-generation ITS
		The establishment of ICT infrastructure for smart infrastructure management and maintenance
		R&D on increasing the available radio frequencies
		Technical examination of measures to cope with the shortage of available radio frequencies
	NICT	R&D on key network technologies
		R&D on key technologies for universal communication
MAFF	National Agriculture and Food Research Organization	The urgent development of innovative technologies for aggressive agricultural, forestry and fishery management
METI	METI	The development of technologies for an ultraprecise 3D modeling system
		The development of technologies for a software-controlled cloud computing system
		The development and promotion of a hub for safety evaluation of critical IT infrastructure to support restoration of the disaster-stricken Tohoku region
	AIST	Materials that are functional on the nano level: multifunctional materials
		Measurement standards that support the globalization of industries
	NEDO	Platform for supporting the creation of new R&D-based business
		IT integration-based system development
		The development of systems for addressing social issues related to the infrastructure maintenance, management and renewal
	Government-funded project	Funding to venture companies through the Innovation Network Corporation of Japan (INCJ)
MLIT	NILIM	Measures for internationalizing techniques, standards and the like related to port and harbor infrastructure

1 JGN-eXtreme

3 Contributions to Solutions to Global Issues

As a country with a relatively high S&T level, Japan has been focusing on R&D on technologies and measures for addressing various global issues, in cooperation with universities, public research institutions, industries, international organizations and other countries.

Toward adaptation to global climate change, Japan has been observing and predicting climate change globally and conducting impact assessment. R&D on measures against large-scale natural disasters has also been promoted. Additionally, Japan has been enhancing R&D on the following topics: the exploration of new resources, including energy sources, and the cyclical use of such; the creation of alternative resources; the identification of pathogeneses of emerging and reemerging infectious diseases; and the prevention, diagnosis and treatment of these diseases.

1) R&D on climate change

(i) The promotion of earth observation

To understand current global warming trends, many countries and organizations worldwide have been observing the earth by satellite, ground-based and maritime observation systems. To enhance the effectiveness of global efforts for tackling climate change problems, earth observation data should be integrated and analyzed through international collaborations, in order to accumulate useful scientific knowledge as a basis for policymaking in each country. It is also critical to develop the Global Earth Observation System of Systems (GEOSS), which consists of multiple systems that facilitate access by many countries and institutions to observation and other scientific data. The intergovernmental Group on Earth Observations (GEO) was established as an international framework for promoting the development of GEOSS. It has 167 countries and institutions as members. Japan has been playing a leading role on the GEO Executive Committee.

a) Satellite-based observation

Satellite-based earth observation is effective in that it allows continuous collection of extensive information in a repeatable manner. Towards solving global environmental problems, Japan has been comprehensively promoting satellite-based observation in cooperation with domestic and overseas organizations.

The Greenhouse Gases Observing SATellite "IBUKI" (GOSAT) was launched in January 2009 to help promote measures against global warming. This satellite has been used for collecting observation data on global GHG concentration distributions and changes. The data are necessary for improving the estimation accuracy of GHG absorption and emission. GOSAT has been successfully clarifying the global concentration distributions of carbon dioxide and methane, as well as seasonal changes in these distributions. Based on GOSAT data, absorptions and emissions of CO_2 and methane are estimated by month and by subcontinent, and three-dimensional CO_2 distribution data are estimated. These estimation results are made available to the public. The National Institute for Environmental Studies has been continuously processing GOSAT data and making the processing results available. In FY2012, the development of a successor to the GOSAT satellite started, with the aim of further improving the observation accuracy. Multi-point observation data collected by the successor satellite will contribute to the science of climate change, global environmental monitoring and the formulation of measures against

climate change. This satellite will be also used for collecting data on CO2 emissions for each large city or each large-scale emission source.

In May 2012, "SHIZUKU"(GCOM-W[1])was launched for the purpose of elucidating the global mechanisms of climate change and water cycle. This satellite has been collecting data on changes in the global water cycle. The data have been provided to the numerical prediction systems of the JMA and are used for improving the accuracy of precipitation estimates. The data are used not only for research on climate change but also for various other purposes, including weather forecasting and fishing ground detection.

The JMA verified that the use of GCOM-W data has helped to increase the accuracy of precipitation estimates in numerical weather prediction as well as the accuracy of analyses for sea surface temperature and sea ice. Since FY2013, the JMA has used the data from GCOM-W for a numerical weather prediction system that the JMA operates routinely and for analyzing sea surface temperatures and sea ice.

The SHIZUKU water cycle observation satellite (GCOM-W)
Courtesy of JAXA

The Japan Aerospace Exploration Agency (JAXA) has performed observations with the Advanced Land Observing Satellite "DAICHI" (ALOS[2]) for research on the reduction of greenhouse gas emissions, which are increasing due to deforestation and forest degradation in developing countries (i.e., REDD+[3]). (The operation of this satellite ended in May 2011.) JAXA also processes and provides the data obtained from Japan's Precipitation Radar (PR[4]) loaded on the U.S. satellite Tropical Rainfall Measuring Mission (TRMM[5]) and from Japan's Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E[6]) loaded on Aqua, a U.S. earth observation satellite. (The operation of the AMSR-E ended in October 2011.) JAXA continues to use satellite-based earth observation to further enhance the accuracy of climate change prediction and to elucidate the mechanism of changes in the global hydrological cycle. For example, JAXA is supporting the measurement operations of a core satellite launched in February 2014 for Global Precipitation Measurement (GPM), operated by NASA. JAXA is also conducting R&D on GCOM-C[7], which will be launched in FY2016.

In cooperation with other ministries, agencies and organizations, the MOE has been promoting observations of the global carbon cycle, in order to deepen our understanding of climate change and its impacts. Specifically, the MOE has been continuously monitoring CO_2 and methane levels by using aircrafts and ships by taking readings in forests. In addition, MOE is developing technologies for observing global CO_2/methane levels by GOSAT.

b) Observation by electromagnetic wave sensing

MIC is conducting R&D on a cooperatively controlled radar system that consists of multiple transceiver,

1 Global Change Observation Mission-Water
2 Advanced Land Observing Satellite
3 Reducing Emissions from Deforestation and Forest Degradation - Plus
4 Precipitation Radar
5 Tropical Rainfall Measuring Mission
6 Advanced Microwave Scanning Radiometer for EOS (Earth Observing System)
7 Global Change Observation Mission-Climate

receiver and transmitter stations. This radar system enables high-accuracy 3D observations without the use of additional frequency bands. MIC and the NICT have been promoting R&D on an airborne polarimetric and interferometric synthetic aperture radar system (Pi-SAR2) that can detect ground surface situations in disaster-stricken areas as needed, regardless of weather conditions. In collaboration with JAXA, MIC developed the Superconducting, Submillimeter-Wave, Limb-Emission Sounder (SMILES[1]), and it was attached to a port of the Exposed Facility of the Japanese Experiment Module (KIBO) on the International Space Station. MIC has been analyzing the scientific data on atmospheric composition collected by SMILES, so as to continuously disclose the analysis results to the public[2]. MIC has implemented R&D regarding the electromagnetic environment and the use of radio waves in geospace, and has collected, managed, analyzed and distributed space/earth observation data in an integrated manner. Additionally, the development of space environment informatics technology[3] has been promoted, with the aim of enhancing technologies for observation, sensing and numerical calculation and for the processing of large amounts of data.

c) Ground and oceanographic observations

Continuous oceanographic observation is necessary, because oceans are closely involved in environmental changes, such as global warming. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been promoting oceanographic observation throughout the world by utilizing buoys developed by JAMSTEC for observation. The observation results are used for research on environmental forecasts and simulations. In FY2013, JAMSTEC became the first organization in the world to obtain long-term observation data from profiling floats in the deep waters of the Antarctic Ocean. Until then, the deep-sea environment under the sea ice in winter had not been well known, due to the lack of sufficient observation data. JAMSTEC's success helped to greatly advance research on long-term changes of deep waters in the Arctic Sea, as well as on their warming mechanism, which significantly affects the global environment. MEXT and JMA are working on the maintenance of an advanced marine monitoring system (the Argo program) that continuously observes oceans around the world through international cooperation. The Argo program aims at real-time monitoring and evaluation of oceans worldwide. In the Argo program, a system for continuously observing oceans is being developed by deploying Argo floats globally. Currently, about 3,600 Argo floats have been deployed.

The JMA has been conducting observation and analysis of GHGs in the atmosphere and oceans, aerozols, ground-based emissions, the ozone layer and ultraviolet radiation. By collecting and analyzing various observation data from ships, Argo floats and satellites, the JMA provides information related to the global environment (cf. Chapter 2, Section 2, 1(3)).

(ii) The promotion of research that contributes to adaptation to climate change

The Meteorological Research Institute of the JMA has developed an earth system model for global

1 The Superconducting, Submillimeter-Wave, Limb-Emission Sounder: It observes ozone and other minor constituents by means of the most sensitive low-noise submillimeter receiver, which uses a superconducting sensor. The antenna is directed toward the edge of the atmosphere for receiving submillimeter waves emitted by trace gases. Submillimeter waves are radio waves with frequencies from 300 to 3,000 GHz. SMILES uses submillimeter waves with frequencies from 624 to 650 GHz.

2 http://smiles.nict.go.jp/pub/data/index-j.html

3 Space environment informatics technology: Technology for extracting information by processing large amounts of diverse data obtained through simulations and observation of the space environment.

warming prediction that can simulate the effects of aerosols on clouds, changes in the ozone layer and the carbon cycle. Using this model, this institute is making near-future (i.e., about 10-year lead time) climate change predictions and long-term predictions based on IPCC emissions scenarios. The institute has also developed a sophisticated cloud-resolving regional climate model that has sufficient resolution to simulate Japan's unique local climatic phenomena. The aim is spatially detailed regional climate warming prediction.

The Ministry of the Environment (MOE) has been using the Environment Research and Technology Development Fund[1] and other funds for comprehensively advancing research on elucidation of phenomena, future predictions, impact assessment and countermeasures, for the purpose of assembling a picture of global warming and implementing adequate administrative measures based on scientific knowledge. The Environment Research and Technology Development Fund was used for the following research:

- "Comprehensive research on the development and dissemination of techniques for planning, predicting and evaluating medium- to long-term policy options toward a low-carbon society in Asia" (implemented from FY2009 through FY2013). This research aimed at developing a road map to a low-carbon society envisioned for the Asian region, on the basis of the attainment of a goal of keeping the global temperature rise within 2°C of the pre-industrial temperature.
- "Comprehensive research on policies for impact assessment of and adaptations to global warming" (implemented from FY2010 through FY2014). This research aimed at realizing a safe, secure society that is adapted to climate change, by estimating the effects of global warming on Japan and other Asian nations in detail, and by taking measures to avoid or mitigate adverse impacts.
- "Comprehensive research on the development of global strategies for managing risks posed by climate change" (implemented from FY2012 through FY2016). This research is conducted with the aims of 1) understanding the risks posed by global warming to Japan and the whole world and the uncertainties associated with these risks, and 2) informing citizens and international society of the concept of scientifically and socially rational strategies and options for the management of risks imposed by climate change.

In FY2012, the MOE, MEXT and the JMA worked together in preparing and publishing the Integrated Report on the Observation, Prediction and Impact Evaluation of Climate Change, by collecting Japan's latest scientific knowledge about the impacts of global warming. This report aimed at supporting steady progress of measures for adapting to climate change in Japan. In July 2013, the Expert Committee on Climate Change Impact Assessment was established in the Global Environmental Subcommittee of the Central Environmental Council toward the development of an adaptation plan as a government-wide, integrated effort. This expert committee has been using existing studies for summarizing climate change projections and impact assessment, and has been deliberating on the assessment of impacts on and risks for Japan. The deliberation results will be organized into supplementary recommendations by the end of February 2015. Based on the supplementary recommendations and other sources, an adaptation plan will be formulated around the summer of 2015.

To establish recycling-based food production systems in response to climate change, MAFF has

1 In the light of the grave, significant effects that environmental problems can have on human survival, this policy-oriented, competitive fund was established for comprehensively promoting the investigation, research and development of technologies by uniting the capabilities of researchers in diverse fields from interdisciplinary and global perspectives. This fund aims at contributing to environmental conservation necessary for the realization of a sustainable society.

promoted the following: the development of technologies for reducing GHG emissions and increasing GHG absorptions; production techniques that help realize low-input recycling-based agriculture; systems for supporting measures against deforestation and degradation in tropical forests in Asia; and technologies for creating new breeds and for the stable production of farm/forestry/marine products adapted to the progression of global warming.

With the aim of reducing the risks of large-scale water-related disasters resulting from climate change, NILIM has been studying risk analysis techniques that are applicable to the formulation of specific adaptation measures, while taking into account the uncertainty that is inherent in future predictions and that cannot be avoided with current S&T. An interim report was published in August 2013.

2) R&D on the stable supply of energy and resources

Toward the stable supply of energy and resources, the Japanese government has been promoting R&D that is useful for the exploration and cyclical use of new resources, including energy resources, and for the creation of alternative resources (cf. Chapter 2, Section 2, 1(1) & (3), and Chapter 3, Section 1, 1(2)).

3) Research on emerging and reemerging infectious diseases

MEXT and the Ministry of Health, Labour and Welfare (MHLW) have been promoting research on the identification of the pathogenesis of emerging/reemerging infectious diseases, and the prevention, diagnosis and treatment of these diseases (cf. Chapter 2, Section 3, 1(1)).

Table 2-3-4 / Key Measures Taken for Contributing to Solutions to Global Issues (FY2013)

Ministry /Agency	Implemented by	Research Subject
MIC	NICT	R&D on key technologies for electromagnetic wave sensing
Ministry of Foreign Affairs	International Cooperation Agency	Cooperation in S&T toward addressing global issues
METI	AIST	The evaluation of potential resources in the geosphere
		The strengthening and promotion of international research cooperation
MLIT	NILIM	The development of key technologies that support the formulation/selection of a set of measures against large-scale water-related disasters resulting from climate change
MOE	MOE	Marine environment research for assessing CCS under the seabed

4 Foundations of the State

To maintain Japan's leadership position in the world and the safe livelihood of the Japanese public, the government should take a broad, long-term perspective in continually promoting R&D that helps to sustain and advance the foundations of the nation's existence, as well as in accumulating the R&D results.

(1) Enhancement of national security and critical technologies

The government has been advancing R&D on technologies that help to enhance national security and the safe livelihood of the people. These included technologies for information collection, telecommunications, space transportation, satellite development and utilization, early detection of

earthquakes and tsunamis, and world's most advanced high-performance computing.

In relation to nuclear power, R&D has been implemented regarding nuclear decontamination and reactor decommissioning, toward promoting recovery from the nuclear disaster caused by TEPCO's Fukushima Daiichi Nuclear Power Staion. The government is also promoting R&D on technologies for highly reliable information security systems.

1) The development and utilization of space technologies for space transportation and satellites

Space transportation technologies are essential for the utilization of space, because these are integral parts of technologies for satellite launches. Technologies for sending satellites to their designated altitudes whenever needed are vital for autonomy of Japan's space activities. The active use of satellites for telecommunications, broadcasting and weather forecasting is expected to play a significant role in bringing more affluent living to citizens. The Basic Plan for Space Policy (determined by the Strategic Headquarters for Space Policy, in January 2013) states that projects involving space transportation systems and satellites should be implemented by the government in a comprehensive and planned manner, because these systems and satellites are part of the social infrastructure that helps expand use of space and ensure Japan's autonomy.

(i) Space transportation systems

The H-IIA, the H-IIB and Epsilon are Japan's flagship large-scale launch vehicles. The successful launch of H-IIA launch vehicle No.23 in February 2014 marked the twenty-first consecutive success in launching. With the success of 26 out of 27 launch vehicles, success rate of over 96% has been achieved. In response to the demand for small launch vehicles, the Epsilon, which utilizes Japanese solid-fuel rocket technology, was launched successfully in September 2013. The full-scale development of a new flagship launch vehicle will start in FY2014, toward the first launch in 2020. This rocket development aims to maintain and enhance Japan's capability of autonomous space activities, as well as to secure Japan's international competitiveness.

Launch of H-IIA launch vehicle No.23 (left) and the Epsilon test launch vehicle (right)
Courtesy of JAXA

(ii) Satellite-based systems for communications/broadcasting and observation/monitoring

MIC and MEXT have been collaboratively using the Engineering Test Satellite-VIII, KIKU No.8 (ETS-VIII[1]), in experiments for developing and demonstrating technologies for large-scale satellite buses, large-scale deployable reflectors, and mobile satellite communications. Wideband Inter-Networking

1 Engineering Test Satellite-Ⅷ

engineering tests and the Demonstration Satellite KIZUNA (WINDS[1]) are also used for experiments conducted for developing and demonstrating satellite-based gigabit-class Internet communications technologies.

Regarding global positioning satellite systems, MIC, MEXT, METI and MLIT have been mutually cooperating in demonstration experiments that utilize the Quasi-Zenith Satellite-1 MICHIBIKI, which is available for high-precision positioning that is unaffected by mountains or tall buildings. The Cabinet Office launched the development of a practical positioning satellite system in FY2012.

Regarding satellite observation and monitoring systems, the Advanced Land Observing Satellite "DAICHI" (ALOS) was used for observing areas damaged by the GEJE and other large-scale natural disasters, and for providing captured images of afflicted areas to disaster-prevention agencies. The DAICHI satellite was decommissioned in May 2011. R&D on the Advanced Land Observing Satellite-2 "DAICHI-2" (ALOS-2) has been advanced for launch in FY2014. The DAICHI-2 satellite has dramatically better radar performance than its predecessor. For ensuing the stable operation of Japan's satellites, MEXT is working with the Cabinet Office and the Ministry of Defense (MOD) on research directed toward the development of a space monitoring system that will be used for the ground-based monitoring of space debris. MEXT and the MOD will jointly study the application of sensitive infrared sensors to satellites. MEXT will also implement demonstration experiments of technologies for operating satellites at very low altitudes.

(iii) Efforts for enhancing the use of space

Although citizens are familiar with use of space in terms of satellite-based weather forecasting, telecommunications and broadcasting, space is not used sufficiently for other purposes or for people's livelihoods. In light of this, MEXT created a project for promoting the use of space through financial aid to industry-academia-government initiatives in FY2009. This project aims at capitalizing on the expertise of industries, universities and governments for expanding the use of space as well as for generating new demand for, and potential users of, satellites. In this project, R&D for enhancing the use of space has been continued, with the aim of creating markets for businesses in the fields of disaster prevention, agriculture, forestry, fisheries, medical science, education, and more.

For the purpose of strengthening the infrastructure of Japan's space industry, METI has been promoting R&D on small ground systems and small high-performance satellites that provide performance comparable to that of large satellites but are built at lower cost in a shorter period of time. METI is also advancing the development of technologies for utilizing satellites, including satellite-based technologies for data processing and analysis, as well as for remote sensing useful for the exploration of mineral resources.

2) Technologies for seafloor observation/monitoring directed toward the early detection of earthquakes and tsunamis

MEXT has been advancing the construction and operation of cable network systems for submarine earthquake/tsunami observation in the assumed hypocentralregions of the Tonankai/Nankai earthquakes and the hypocentral region of the 2011 Off the Pacific Coast of Tohoku Earthquake. MEXT is also

1 Wideband Inter-Networking engineering test and Demonstration Satellite

working on improving technologies for the early detection of earthquakes and tsunamis by utilizing submarine observation network systems. (cf. Chapter 2, Section 1 (3), and Chapter 3, Section 1 (1)).

3) The development of Innovative, High-Performance Computing Infrastructure (HPCI)

Supercomputer simulations have become the third S&T approach, following theorization and experiments. They are indispensable for the most advanced S&T, for enhancing industrial competitiveness and for building a safe, secure nation. A supercomputer is capable of performing large amounts of calculations at great speed for various purposes, and of simulating results that cannot be estimated by experiments, including damage caused by earthquakes, tsunamis and vehicle collisions.

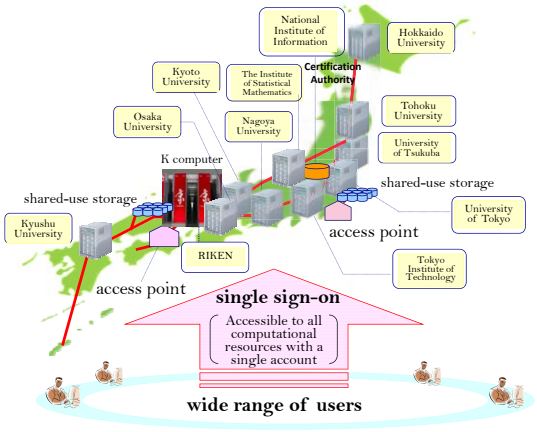
MEXT has been advancing the development of High-Performance Computing Infrastructure (HPCI), a computational platform realized by connecting the K computer to other major supercomputers and storage units owned by universities in Japan via high-speed networks. The aim is to accommodate the computational needs of diverse users. The computational performance of Japan's K computer is among the world's highest. MEXT aims at optimizing the use of the HPCI for (i) achieving breakthrough results, (ii) developing scientists/engineers who can master advanced computational science and technology and (iii) establishing a hub for research and education of advanced computing. In connection with this, R&D on systems for promoting computational S&T are being advanced in five strategic areas: 1) medical care and drug discovery, 2) materials and energy, 3) disaster prevention and mitigation, 4) next-generation manufacturing and 5) the origin and structure of matter and the universe.

The K computer was officially made available for use by researchers in September 2012. Pursuant to the Act on the Promotion of Shared Use of Specified Large-Scale High Technology Research Facilities (Act No. 78, 1994), the K computer is operated by the RIKEN Advanced Institute for Computational Science (in Kobe) in cooperation with the Research Organization for Information Science and Technology (RIST), which is designated as the registered institution for supporting k computer users, and with the HPCI Consortium, consisting of organizations that represent user communities and other organizations. The k computer has helped to produce breakthrough results in the abovementioned strategic areas.

For example, heart muscle movement was simulated on the molecular level for precisely reproducing cardiac motion. This simulation has contributed to the elucidation of the pathological condition of hypertrophic cardiomyopathy, an intractable cardiac disease, and to rational therapies and drug efficacy evaluation for various cardiac diseases. A severe earthquake in the Nankai Trough was simulated in order to estimate the travel distance of the tsunami generated by that earthquake, with an accuracy of 5 meters. This computational result is expected to facilitate the creation of hazard maps that are useful for regional disaster prevention. Expectations are high that the k computer will continue to produce world-leading, groundbreaking results in various fields and will help to advance new drug development processes, innovating manufacturing and the elucidation of the origin of matter and the universe.

To strategically promote R&D from a long-term perspective toward advancing computational S&T in Japan, in April 2012 an expert panel started research on the ten-year promotion of the HPCI program. The panel published an interim report in June 2013 and a final report in March 2014. Universities have also been commissioned to conduct research for obtaining technical expertise necessary for advancing the HPCI.

In addition to the efforts mentioned above, MEXT aims at realizing exascale computing[1] that will help to solve the social and scientific problems facing Japan and to strengthen Japan's industrial competitiveness. For this purpose, a project will starts in FY2014 for developing a successor to the k computer by FY2020. In this project, the development of software and hardware will be implemented in an integrated manner, with the aim of developing a computer that can produce the best results in the world.



Concept of the Innovative High-Performance Computing Infrastructure (HPCI)
Courtesy of MEXT

Supercomputer "K computer"
Courtesy of Riken

4) R&D on nuclear power and fusion

In FY2013, R&D was implemented regarding nuclear decontamination and reactor decommissioning, to promote recovery from the nuclear disaster caused by TEPCO's Fukushima Daiichi Nuclear Power Station. MEXT also engaged in R&D and development of human resources which support nuclear technology and safety.

Regarding Monju, the Monju Research Plan was formulated in September 2013, and the role of Monju was clearly defined in the Strategic Energy Plan. Necessary measures were implemented for R&D on technologies for fusion, nuclear nonproliferation and nuclear security. (Refer to Chapter 2, Section 2, 1 (1) for R&D on FBR cycle technologies and fusion, and to Chapter 3, Section 3, 2 (2) for R&D on technologies for nuclear nonproliferation and nuclear security.)

5) The promotion of R&D on information security

The Information Security Policy Council (ISPC, chaired by the Chief Cabinet Secretary), which was established to enhance information security measures through the united, cross-sectoral efforts of the public and private sectors, formulated the Cybersecurity Strategy in June 2013. Based on this strategy, R&D on technologies for active and dependable information security systems have been implemented, and scientists/engineers have been fostered for R&D on these technologies.

According to the Cybersecurity Strategy, MIC has created international networks to gather intelligence on cyber attacks and malware with the help of Internet service providers and universities at home and abroad. MIC is also working on R&D and demonstration tests of technologies that enable the prediction of,

1 1 exa = 1,000 peta = 10^{18}

and prompt response to, cyber attacks in collaboration with other countries. In response to recent increases in the numbers of cyber attacks targeting confidential information kept by government offices and companies, R&D has been implemented regarding technologies for detecting cyber attacks early based on analyses of communications on intranets and Internet user characteristics.

At the Control System Security Center, which has been operating since April 2013 in the City of Tagajo, Miyagi Prefecture, METI has been working on R&D, international standardization, the development of evaluation/accreditation systems, human resources development and promotional/educational activities. These efforts are continued for the purpose of evaluating and accrediting control equipment and technologies for enhanced security of control systems.

6) The development of technologies associated with the exploitation of ocean resources and energy

The growing global demand for energy has resulted in increases in oil and natural gas production at sea. Offshore and deepwater oil and gas exploration will increase in the future. Against this backdrop, growth is expected in markets for the floating structures that are necessary for offshore oil and gas exploitation. MLIT aims at expanding markets and meeting new demand for ocean resources development by providing support for the development of technologies for Floating Liquefied Natural Gas (FLNG) facilities and platforms for deepwater drilling.

The National Maritime Research Institute is conducting research on the development and improvement of techniques for safety evaluation of offshore structures and for reducing environmental impacts. These techniques are the basis of key technologies for the exploitation of ocean resources and energy.

(2) The establishment of science and technology platforms for the creation of new knowledge

To establish S&T platforms for the creation of new knowledge through the elucidation and more comprehensive understanding of the universe, the earth and the oceans, the government has been advancing theoretical studies, experiments, surveys, observations and analyses on S&T topics.

1) The promotion of oceanographic R&D

Humans know little about the oceans, due to their vastness and inaccessibility. Driven by the intellectual desire to tackle the unknown, humans have conducted diverse investigations and studies of oceans. These efforts have resulted in discoveries of untapped energy and mineral resources and in the elucidation of the oceans' contributions to geoenvironmental, changes including climate change. Elucidation of oceanographic phenomena for building necessary technical platforms is important for solving issues critical to the development of humankind, including issues concerning global environment, responses to massive earthquakes in trenches and ocean resources exploitation. In view of this, in FY2013 the government deliberated on key ocean technologies that the entire nation should address. As the result of the deliberations, ministries and agencies started studies necessary for implementing projects related to key technologies of national importance, such as the project for developing a selected system for exploring next-generation ocean resources.

(i) R&D on deepening our understanding of phenomena at the deep ocean floor

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been conducting research and surveys focusing on the seas around the Japanese archipelago and the entire Pacific Ocean. Specifically, crustal structures are explored by using research vessels, the manned research submersible SHINKAI 6500 and unmanned submersibles, toward deepening our understanding of phenomena at the deep ocean floor, such as tsunamis, volcanic eruptions and huge earthquakes that can cause devastating damage. In FY2013, QUELLE 2013 [1], the round-the-world voyage of the SHINKAI 6500 carried by R/V YOKOSUKA, was implemented. As part of the research on diverse biotic communities living and developing in extreme environmental conditions, SHINKAI 6500 visited the Indian Ocean, the South Atlantic and the South Pacific and collected important samples and data related to ecosystems in specific, extreme ocean habitats, such as hydrothermal vent fields.

- **A 24-cm-long giant amphipod caught in the Tonga Trench (upper left), the first one ever caught**
- **Manned research submersible SHINKAI 6500 (upper right)**
- **Chart showing the route of QUELLE 2013, a round-the-world voyage (bottom)**

Courtesy of JAMSTEC

(ii) R&D on technologies for ocean resources exploration

MEXT has been developing advanced key technologies necessary for ocean resources exploration and is using these technologies for research and exploration. In the Program for Developing Technologies for Promoting the Use of Ocean Resources, MEXT started developing technologies for sensors in FY2008. These sensors are based on scientific findings from academia and are used for efficiently and accurately understanding the abundance of ocean mineral resources in broader areas. In FY2013, technologies that had been verified as practical and effective for deep-sea exploration began to be translated into practical applications with the aim of technological transfer to the private sector.

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) started building a wide-area ocean floor research vessel for the purpose of accelerating research and exploration of untapped submarine resources around Japan. The vessel is capable of investigating submarine topography and structures under the seabed in a broad area, as well as of conducting detailed seabed surveys by operating multiple subsea robots, such as ROVs[2] and AUVs[3]. In FY2013, JAMSTEC succeeded in generating power with fuel cells by utilizing the difference in electrical potential between hydrothermal fluid and seawater at

1 Quest for Limit of Life, 2013
2 Remotely Operated Vehicle
3 Autonomous Underwater Vehicle

an artificial deep-sea hydrothermal vent in the Okinawa Trough. This success opened up the possibility of long-term autonomous power supply at the seabed, which will be important for ocean resources development and exploration, and will contribute to R&D of deep oceans.

(iii) R&D on exploration under the seabed

Aiming at elucidating the microbiosphere under the seabed and the seismogenic mechanisms in ocean trenches, JAMSTEC has been advancing the development of drilling techniques for the deep-sea drilling vessel CHIKYU as well as real-time observation techniques that rely on submarine cable networks. JAMSTEC is using these techniques for research and investigations. In FY2013, in the Integrated Ocean Drilling Program (IODP[1]), which was developed into the International Ocean Discovery Program (IODP) in October 2013, CHIKYU was used for seismological investigation of the 2011 Off the Pacific Coast of Tohoku Earthquake. Long-term temperature data were successfully recovered from the borehole. Data analysis indicated that the friction coefficient of the fault was remarkably small when the earthquake occurred. Analyses of geological specimens collected in the same drilling survey showed that the fault plane was low-strength clay and that friction heating of the fault caused by the earthquake had resulted in the expansion of water in the voids on the fault plane and had induced the fault slip. These findings helped to greatly advance the understanding of the mechanisms of massive earthquakes in ocean trenches, as well as of huge tsunamis. A survey was also conducted off the Kii Peninsula in order to deepen our understanding of the mechanisms of huge earthquakes and tsunamis. Geological specimens were collected from the interior of the accretionary prism in the Nankai Trough seismogenic zone. Drilling reached a depth of 3,058.5 m below the seafloor, a world record for scientific ocean drilling depth.

(iv) R&D on technologies for securing marine biological resources

The adverse effects of global warming, ocean environmental degradation and overexploitation of marine species have become increasingly obvious. Conservation of marine biodiversity and sustainable use of marine biological resources are significant challenges for humans. In the Ocean Resource Use Promotion Technology Development Program, MEXT is implementing R&D for the purpose of realizing innovative production based on an understanding of the physiology of marine species and for the purpose of comprehensively elucidating marine ecosystems. In the Strategic Basic Research Program of JST, R&D has been conducted regarding technologies for observation and monitoring of marine species.

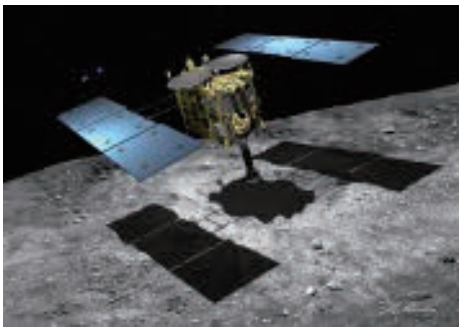
2) The promotion of R&D on space science

The quest for the unknown is a human intellectual activity that motivates people to explore the origin of the universe and the natural laws of the universe. Because of this intellectual activity, innovative technology seeds are developed to expand the possibilities of space exploration, to support technologies for space use and to advance Japan's space exploration programs.

R&D regarding the universe is expected to help utilize space environment for producing specific research results, obtain new scientific findings, and create new industries that use technologies developed on the basis of these research results and findings.

1 Integrated Ocean Drilling Program (until September 2013)/ International Ocean Discovery Program (from October 2013)

(i) Solar system exploration, and astronomical observation in space

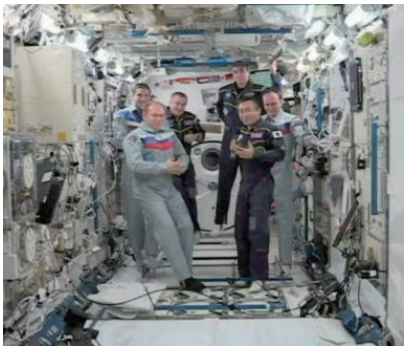


The Hayabusa 2 asteroid explorer
Courtesy of JAXA

Regarding R&D in space science, JAXA has been playing a pivotal role. JAXA has launched scientific satellites and has produced world-leading results. JAXA has been leading the world in X-ray and infrared astronomy, as well as in lunar and planetary exploration. For example, JAXA developed and has been operating the world's first satellite equipped with an X-ray imaging spectrometer and has used the asteroid explorer Hayabusa to recover samples from an asteroid. In June 2010, Hayabusa brought home to the Earth tiny pieces of the near-Earth asteroid Itokawa. An international call for proposals for research on these pieces went out, and excellent proposals were selected for advancing research. The Hayabusa 2 is under development for launch in the winter of 2014. JAXA is also engaging in the development of an orbiter for the BepiColombo mission to Mercury, a cooperative effort with European Space Agency (ESA). Thus, JAXA has been contributing to the enhancement of Japan's international standing in space exploration and to R&D on technologies for space science that helps expand human knowledge.

(ii) The acquisition of space technologies for manned missions through the use of the International Space Station Program

The International Space Station (ISS) Program is an international project collaboratively implemented by five parties: Japan, the U.S., Europe, Canada and Russia. Japan's role in this project is the development and operation of the Japanese Experiment Module KIBO and the KONOTORI (HTV) automated cargo spacecraft. KIBO has been in service since its completion in July 2009, and KONOTORI has been used for resupplying KIBO and the ISS. Japanese astronauts have carried out long-stay missions aboard the International Space Station. In August 2013, H-IIB Launch Vehicle No.4 with KOUNOTORI 4 was launched, and cargo was successfully delivered to the ISS. The Japanese astronaut Koichi Wakata was sent to the ISS on November 2013 on a long-stay mission. During his 6-month stay at the ISS, Wakata conducted various activities, including the capture and docking of a U.S. private-sector transfer vehicle with robotic arms, the orbital deployment of small satellites from KIBO, the filming of Comet ISON and aurora with a 4K high-resolution camera, and the implementation of experiments in life science and astromedicine. In March 2014, Wakata became the first Japanese commander of the International Space Station, aboard which were two American crew members and three Russia crew members. He assumed command of the ISS for the two months until he returned to Earth in May.

Koichi Wakata (left): Change-of-Command Ceremony (right: Wakata is the second right astronaut)
Courtesy of JAXA

For international collaboration in space, the U.S. Department of State hosted the International Space Exploration Forum (ISEF), a ministerial-level meeting, in Washington D.C. in January 2014. MEXT Minister Shimomura attended on behalf of the Japanese government. Representatives of 35 countries/regions and international organizations attended the ISEF in order to exchange views about international collaboration in future space exploration. Minister Shimomura noted that Japan would play an active role in building a framework for international collaborative space exploration and that Japan would actively help realize space exploration by utilizing unique Japanese technologies. Japan's offer to host the next meeting of the ISEF was kindly accepted.

Table 2-3-5 / Key Measures Taken for Maintaining the Foundations of the State (FY2013)

Ministry /Agency	Implemented by	Research Subject
Cabinet Secretariat	Cabinet Information Research Office	Information-Gathering Satellites
MIC	MIC	R&D on the detection and analysis of cyber attacks
		R&D on technologies for predicting and promptly responding to cyber attacks through international cooperation
		Demonstration experiments regarding the framework for detecting and eliminating increasingly sophisticated malware and for preventing malware infections
		Demonstration experiments for practical simulation using a model for analyzing and defending against cyber attacks
	NICT	R&D on key network technologies
MEXT	MEXT	Implementation of the ITER (International Thermonuclear Experimental Reactor) program
		The development of broad-area ocean mineral resource exploration systems
		The advanced use of high-performance computing infrastructure
		R&D for the establishment of high-performance computing infrastructure
		The promotion of use of specific advanced large research facilities (i.e., supercomputers)
		The operation of specific high-speed computer facilities
	Japan Aerospace Exploration Agency	Hayabusa-2
		Advancement of Japan's primary launch vehicles
		The 26th science satellite (ASTRO-H)
		Small science satellite
		International Space Station Program
	Japan Agency for Marine-Earth Science and Technology	Research on the dynamics of the Earth's interior
		Research on the marine biosphere and the extremobiosphere
		The development of key marine technologies
		R&D on technologies for exploring and using ocean resources, including energy resources
		The promotion of the deep-sea drilling program
		Cooperation in scientific research
		The operation of oceanographic research vessels
		The operation of the deep-sea research system and mother vessels
		Subsidies for ship construction
METI	METI	R&D on technologies for downsizing and advancing space systems
		R&D on transportable, integrated small-scale ground systems
		R&D on miniaturization technologies applicable to synthetic aperture radar systems for the acquisition of ultrahigh-resolution radar images
		R&D on technologies for a real-time earth observation network system utilizing small satellites
		R&D on technologies for the remote detection of oil resources
		R&D on a hyper-spectral sensor
		R&D on key technologies for use in next-generation earth observation satellites
		R&D on technologies for solar-powered radio transmission and reception
	Agency for Natural Resources and Energy (ANRE)	Project for promoting the development of methane hydrates
		Subsidies for promoting coal production technologies
		R&D on technologies for mining submarine hydrothermal deposits
		The development of innovative practical nuclear technologies
		Costs for commissioning the development of technologies for fast reactors
		Costs for commissioning research on the standards for radioactive waste disposal
		Costs for commissioning the development of a technology platform for reactor decommissioning as well as for the safety of decommissioned nuclear plants
		Subsidies for the development of a technology platform for reactor decommissioning as well as for the safety of decommissioned nuclear plants

		Subsidies for the development of technologies to improve safety measures for nuclear reactors
		Costs for commissioning the development of a technology platform for improving safety measures for nuclear reactors
	AIST	Geological surveys of the land of Japan and its surrounding waters, and improvement of basic geoscientific maps
MLIT	GSI	Costs for surveying electronic reference stations
MOE	Nuclear Regulation Authority	Costs for commissioning research on technologies for safety measures for nuclear fuel cycle facilities
		Costs for commissioning improvements in nuclear fuel safety
		Costs for commissioning measures for safe criticality control at nuclear facilities
		Costs for commissioning research on the safety of nuclear power staions

5 Improvement and Enhancement of Common Science and Technology Infrastructure

To promote R&D effectively and efficiently toward solving diverse problems that Japan and the rest of the world are facing, it is necessary to promote R&D on science and technology that applies to multiple areas. Furthermore, common and fundamental facilities and equipment that are useful for diverse R&D activities need to be improved and enhanced, and these facilities need to be networked.

Accordingly, the government has been giving priority to R&D on the facilities and equipment mentioned below, in order to respond to critical issues.

(1) The strengthening of cross-disciplinary science and technology

The government is promoting R&D of S&T that are useful across multiple disciplines and in cross-disciplinary fields. This S&T includes mathematical science, nanotechnology and technologies for advanced measurement and analysis, optical science, quantum science and information science.

(i) The development of technologies and instruments for advanced measurement and analysis

Technologies and instruments for advanced measurement and analysis are indispensable for the advancement of S&T, as they form the basis for the world's most advanced, unique R&D results. Many Nobel laureates have won the prize for such R&D results.

According to the MEXT guidelines, Japan Science and Technology Agency (JST) has been implementing Industry-Academia Collaborative R&D Programs (for the Development of Advanced Measurement and Analysis Systems). In collaboration with industries and universities, this agency is promoting the development of the most advanced, unique instruments for measurement and analysis that serve the needs of world-leading researchers and manufacturers (Figure 2-3-6). As of the end of FY2013, 41 prototypes had been developed and put into production. The technologies and instruments for measurement and analysis that were developed in FY2013 contribute to Life Innovation by satisfying the needs of medical care users. Specifically, these technologies and instruments help to improve diagnostic techniques, make medical treatment more patient-friendly and reduce medical costs. Additionally, the development of technologies and instruments for radiation measurement was promoted, and certified reference materials required for checking the validity of radioactivity analysis were developed. These efforts were made by capitalizing on the experience of technology/instrument development for the purpose of supporting reconstruction after the GEJE.

Figure 2-3-6 / Examples of Technologies and Instruments for Advanced Measurement and Analysis



Left: A small, light-weight Compton camera for gamma-ray imaging (used for simultaneous measurement of gamma-ray direction and gamma energy, as well as for imaging of the distributions of radiocesium (137Cs + 134Cs) in a short time) This camera is available at a low price. Thus, it is expected to increase the efficiency of radioactive decontamination.
Middle: A high-resolution scanning probe microscope (suitable for ultrahigh-resolution observation in the atmosphere or liquids, which was difficult in the past) This microscope is expected to be useful for R&D on biotechnology and materials technology.
Right: Certified reference material for radioactivity analysis (It was developed for radioactivity analysis of food items and is used for checking the validity of radioactivity analysis of food as well as for the calibration of instruments. The photo shows a certified reference material for radioactivity analysis of soybeans.)
Courtesy of JST

(ii) R&D of nanotechnology

Nanotechnology and materials technology contribute to the progress of S&T and to solutions to problems in fields such as the life sciences, information and telecommunications, and the environmental sciences. These technologies also serve as important technological keys with which society can realize the growth of industry and which can make people's lives more safe, secure, comfortable and convenient.MEXT has been promoting R&D on key technologies toward breakthroughs in environmental technology. For this purpose, the ministry is implementing the Program for the Development of Environmental Technology Using Nanotechnology and the Elements Strategy Initiative which aims at developing technologies for reducing the use of rare-earth elements and producing substitutes (cf. Chapter 2, Section 2, 1 (1) & (3).)

The National Institute for Materials Science (NIMS) has been developing advanced technologies commonly necessary for materials innovation. The following technologies have been included: the world's most advanced characterization technologies for comprehensive materials analyses; computational simulation techniques for precise prediction and analyses of materials properties; and novel design and processing for the fabrication of functional materials from composition elements such as particles and organic molecules. NIMS has also been creating new substances and materials by taking advantage of physical properties that are unique to nano-sized substances—either organic or inorganic—by manipulating and controlling atoms and molecules on the nano-level (one billionth or 10^{-9} meter). In response to the challenges shared by all humankind in terms of the solutions to environmental/energy/resource problems and the creation of safe, secure infrastructure, the NIMS has been promoting R&D for advancing environmental/energy materials as well as for enhancing the safety and reliability of materials (cf. Chapter 2, Section 2, 1).

The NICT, which is under the control of MIC has been promoting R&D with the aim of overcoming limitations of ICT in terms of technological aspects and performance, and for achieving dramatic advances in ICT. For this purpose, R&D on key technologies has been implemented by using new atomic, molecular or

superconducting materials. These key technologies include advanced quantum control, control of single-photon signals, utilization of unused frequency bands, and control/utilization of atomic/molecular structure.

METI has been working on developing nanocarbon materials, such as high-purity single-wall carbon nanotubes, that enhance the strength and performance of transportation equipment and electronic components while also making them lighter.

METI has also been addressing the establishment of safety evaluation techniques that facilitate the development and application of nanomaterials critical for nanotechnology.

In Tsukuba, where world-class advanced nanotechnology research facilities and human resources are gathered, the Tsukuba Innovation Arena (TIA-nano), a center of industry-academia-government collaboration was created with the support of MEXT and METI. TIA-nano, which has four key research institutions, aims at serving as a global nanotechnology research center (cf. Chapter 2, Section 4, 1 (3)).

(iii) R&D on technologies for optical and quantum sciences

The excellent properties of quantum beams such as neutron or ion beams are used for fine observation, precision processing and the creation of substances. For example, lasers are used for the precision machining of semiconductors, and radiation is used for the analysis of atomic structure.

As a result of remarkable advances in S&T, processing at the atomic/molecular level and detailed investigation of material structure, which were not possible before, are now required. Optical and quantum technologies are the key technologies that support a range of scientific research and industrial applications.

Thus, MEXT has been implementing a program for the development of key technologies toward the creation of an optical and quantum sciences R&D center since FY2008. This program aims at advancing R&D on optical and quantum sciences by using the potential of these sciences for satisfying the needs of various fields through collaboration by diverse researchers from industry, academia and government. The development of future scientists who can further advance these sciences is also promoted. A program for integrated collaborative R&D on optical and quantum sciences was started in FY2013 for enhancing the integrated development of optical and quantum sciences, as well as for producing results from leading research on the application of these sciences.

(iv) R&D on information science and technology

In using science and technology to solve various social issues, information science and technology play a key role. The creation of next-generation IT infrastructure on the basis of information science and technology is essential for sustainable development of the economy, society, science and industry, as well as for the creation of innovations and the realization of a safe, secure society.

In the R&D program for the creation of next-generation IT infrastructure, MEXT has been enhancing the use of "big data" across different fields. For this purpose, MEXT is supporting research and preliminary studies on data linkage, research on systems for academic cloud computing, and the use of "big data" for networking of human resources involved in innovations. MEXT is also implementing R&D on the following topics: solution-oriented integrated IT systems (i.e., advanced integrated systems that aggregate real-world information, derive solutions to problems or directions for necessary measures, and provide society with feedback); and key technologies for spintronic materials and devices, as well as for highly functional and highly available storage, which help enhance IT systems in terms of their resistance

to disasters, their data processing capacity and their reduction of power consumption. MEXT is working on developing innovative High-Performance Computing Infrastructure (HPCI) for the purpose of advancing adequate scientific analysis, elucidation and prediction through use of information science and technology (cf. Chapter 3, Section 1, 4 (1)).

(v) The creation of innovations through the application of math and mathematical sciences

As part of the activities for creating a framework that facilitates the use of knowledge of math and mathematical sciences in solving diverse problems in other scientific disciplines and industries and for creating new value (or mathematical innovation), in FY2012 MEXT started a research promotion program for creating innovations through the collaboration of researchers in mathematics, mathematical sciences, other scientific disciplines, and industry. In this program, issues that are expected to be solved through the application of math are chosen from among important topics, such as "big data" and mathematical optimization/control. Collaboration by researchers in math, mathematical sciences, other scientific disciplines, and industry is enhanced through multiple opportunities that include workshops where these researchers discuss their availability for collaboration. Specific issues of science and industry are chosen, and researchers specializing in these issues form study groups for intensive discussions. Additionally, tutorials on mathematical sciences are given to researchers in other sciences and industries.

(2) The upgrading and networking of common and basic facilities and equipment

As infrastructure for promoting S&T, research facilities and equipment support a range of R&D, from basic research on S&T to the creation of innovations; thus, they need to be further advanced and to be used more efficiently and effectively. *Act on the Enhancement of Research and Development Capacity and Efficient Promotion, etc. of Research and Development, etc. by Advancement of Research and Development System Reform (Act No. 63, 2008; hereinafter the R&D Enhancement Act)* stipulates that the government shall take necessary measures to promote the shared use of research facilities and equipment owned by universities and independent administrative Institutions.

Pursuant to the *R&D Enhancement Act*, the government has been promoting the effective use of key general facilities and equipment by industrial, academic and government research institutions for diverse R&D on science and technology. The government is also working on networking these facilities and equipment such that they will be available more conveniently in a mutually complementary manner, and will be able to respond to emergencies.

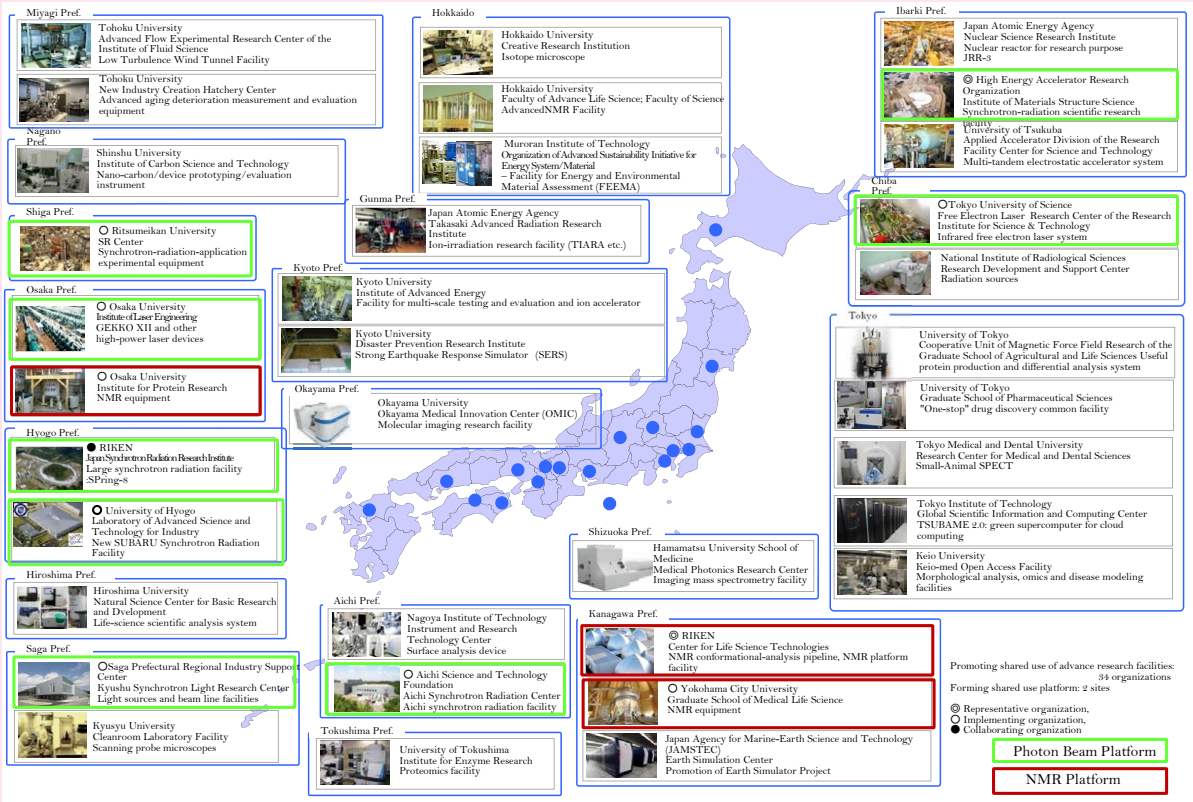
MEXT is also promoting the shared use of research facilities and equipment by researchers at industrial, academic and government research institutions. In this regard, the ministry is financially supporting these researchers for the expenses necessary for developing and sharing large-scale research facilities pursuant to the Act on the Promotion of Shared Use of Specified Large-Scale High-Technology Research Facilities ("Act on the Promotion of Shared Use").

MEXT has been implementing the Program for the Creation of Research Platforms and Sharing of Advanced Research Facilities. This program aims at enhancing the shared use of advanced research facilities and equipment, other than specified large-scale high-technology research facilities, which are owned by universities and independent administrative institutions. Based on this program, networks of facilities and equipment will be built for various technological fields, so that research platforms will be

created to effectively satisfy the diverse needs for these facilities and equipment (Figure 2-3-7). To facilitate shared use and to help produce results from R&D conducted by utilizing facilities/equipment for shared use, the *Kyoyo Navi* website was set up, to provide basic information online regarding locations, use applications, time availability, etc.

MEXT has established a nationwide, shared system that offers opportunities in using cutting-edge equipment and advanced technical support for users from industry, academia and government through the Nanotechnology Platform by collaborating closely with independent institutions. They own cutting-edge research facilities and equipment and have the know-how necessary for using such research facilities and equipment.

Figure 2-3-7 / Universities & Institutions Participating in the Program for the Creation of Research Platforms and Sharing of Advanced Research Facilities



(Specified large-scale high-technology research facilities)

The Act on Promotion of Shared Use of Specified Large-Scale High Technology Research Facilities defines specified large-scale high-technology research facilities as large-scale research facilities of special importance. This act stipulates the need for the systematic development and operation of these facilities, as well as for shared use in a neutral and fair manner, so that investments in R&D are effectively and efficiently made and science, technology and innovation (STI) is enhanced in Japan.

○ Super Photon ring-8 GeV (SPring-8)

Super Photon ring-8 GeV (SPring-8) is a research facility that delivers the world's best performance in the analysis of atomic or molecular structure/function by using synchrotron radiation, the extremely

bright light produced when electrons accelerated close to the speed of light are forced to travel in a curved path. Since entering service in 1997, this facility has been contributing to *Life Innovation* and *Green Innovation* in Japan and to innovative R&D in multiple fields that help boost Japan's economic growth.

○ X-ray free-electron laser facility (SACLA)

SACLA is the world's most advanced X-ray free-electron laser (XFEL) facility. SACLA's novel light emitted from the XFEL has the characteristics of lasers and synchrotron radiation and is used for analyses that were impossible with conventional techniques. SACLA entered service in March 2012. In FY2012, MEXT started the Program for Priority Strategic Research Using X-ray Free-Electron Lasers. This program aims at creating leading, innovative R&D results that promote the development of pharmaceutical products and fuel cells and that help to elucidate the mechanisms of photosynthesis. For this purpose, instant measurement and analysis are conducted of ultrafast changes/dynamics of chemical reactions and atomic ultrastructures.

Super Photon ring-8 GeV (SPring-8: the circular building on the right) and the XFEL facility (SACLA: the long, low building on the left)

Courtesy of Riken

○ Supercomputer "K computer"

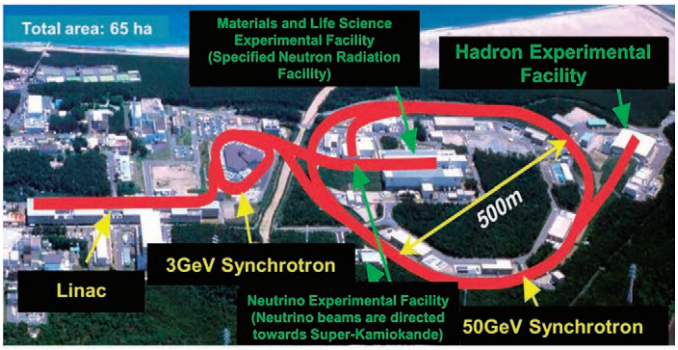
Supercomputer simulations have become the third S&T approach, following theorization and experiments, being vital for the most-advanced S&T and enhancement of industrial competitiveness. The k computer was made available for use by researchers at the end of September 2012. It has been contributing to breakthroughs in diverse fields. These results include advanced development processes for new drugs, the development of next-generation semiconductors that help conserve energy, innovative manufacturing, the mitigation of damage due to earthquakes and tsunamis, and the elucidation of the origin of matter and the universe.

Supercomputer "K computer"

Courtesy of Riken

○ Japan Proton Accelerator Research Complex (J-PARC)

J-PARC is contributing to a wide range of R&D, including basic research and industrial applications, by using secondary particle beams of neutrons and neutrinos[1] that are generated by a proton accelerator with the highest beam intensity in the world. Pursuant to the Act on Promotion of Shared Use of Specified Large-Scale High Technology Research Facilities, the Materials and Life Science Experimental Facility (MLF) at J-PARC is a specified large-scale high-technology research facility. Structural analyses conducted at the MLF have produced results that have lead to the development of innovative materials and new drugs. The Hadron Experimental Facility, where research on atomic nuclei and elementary particles is conducted, and the Neutrino Experimental Facility, which are not specified large-scale high-technology research facilities, are used jointly by researchers from universities.



Japan Proton Accelerator Research Complex (J-PARC)
Courtesy of J-PARC Center

After the radioactive material leak at the Hadron Experimental Facility in May 2013, emergency safety checks were implemented and a new safety control system was established.

Table 2-3-8 / Key Measures Taken for Improving and Enhancing Common S&T Infrastructure(FY2013)

Ministry /Agency	Implemented by	Research Subject
MIC	NICT	R&D on advanced key information and communications technologies
MEXT	MEXT	Program for the creation of research platforms and the sharing of advanced research facilities
		The development of key technologies for creating an optical and quantum sciences research center (Competitive funds)
		Priority strategic research using X-ray free-electron lasers
		Nanotechnology platform
		R&D on key information and communications technologies for future societies (formerly: R&D for next-generation IT infrastructure)
	MEXT RIKEN Japan Synchrotron Radiation Research Institute	The development and sharing of Super Photon ring-8 GeV (SPring-8, SACLA)
	MEXT Japan Atomic Energy Agency (JAEA) High Energy Accelerator Research Organization Comprehensive Research Organization for Science and Society	The development and sharing of the J-PARC
	JST	Industry-academia collaborative R&D programs (for the development of advanced measurement and analysis systems)
METI	METI	The promotion of regional open innovation
		The promotion of information security measures
		The development of economic infrastructure for cybersecurity

1 A neutrino is an elementary particle that is the smallest unit of mass. Neutrinos are difficult to detect because they are electrically neutral and pass through ordinary matter. Many of their properties, including their mass, are unknown.

Section 2 System Reforms toward Solution-oriented R&D

1 System Reforms for Promoting Solution-oriented R&D

To promote solution-oriented R&D in an efficient, effective manner, R&D projects need to be advanced systematically and comprehensively through industry-academia-government collaboration. In this regard, the government has been actively promoting the efforts stated in Chapter 2, Section 4.

2 The Establishment of Systems for Promoting R&D That Should be Led by the Government

R&D on technologies critical for the national security as well as on key facilities and equipment that are shared by multiple institutions across diverse fields are continuously advanced over a long period of time. Thus, under the government initiative, systems for promoting R&D on these technologies/facilities/equipment are created by mobilizing available resources from industrial, academic and government research institutions. Additionally, projects are started for efficiently and effectively promoting the R&D.

One new R&D project started by METI is Pioneering Research for the Future. In the "Pioneering Research for the Future" Project, a governing board is set up for each R&D topic, and R&D projects are managed through industry-academia-government collaboration across ministries and agencies. Each R&D project is consistently implemented, from basic research through practical application. In other words, long-term projects that require 10 years or more for commercialization and, thus, that carry a relatively high risk are implemented under the government initiative. Investments focus on R&D for drastic measures for energy and environmental conservation. Furthermore, teams of excellent researchers from industrial, academic and government institutions are formed to implement internationally competitive R&D projects in terms of technologies and their commercialization. These teams work on the management of intellectual property and international standardization for enhancing the commercialization of technologies. (METI is studying the feasibility of foreign businesses taking part in these teams, on the condition that Japan's national interests are protected.)

R&D topics for the "Pioneering Research for the Future" Project are determined at a review meeting held jointly by MEXT and METI. R&D projects implemented through industry-university-government cooperation are supported, in order to help create world-leading innovations.

Section 3 Strategic Development of Global Activities in an International Context

The promotion of S&T diplomacy through the strategic development of global activities in an international context is important if Japan is to play an active role in the international community and further advance its S&T.

Thus, in accordance with the 4th Basic Plan, the government has been making efforts to strengthen international networks of research and scientists, to help solve global issues and to promote international strategic joint research projects, as well as exchanges of researchers. The government is also enhancing arrangements necessary for increasing global activities that can support the above-mentioned government efforts.

1 Promotion of R&D Toward Solutions to Common Issues in Asia

For Japan to assume a leading role in solving global issues and to maintain a strong position in the world, the nation needs to strategically promote STI policies from the perspective of international cooperation. Japan's strength in S&T is especially useful for other Asian countries in solving many of their problems relating to the environment, energy, food, water, disasters and infectious diseases. By assuming a leading role in addressing problems common to Asian countries, Japan needs to build mutually beneficial relations with them based on mutual trust.

In June 2012, in cooperation with JST, MEXT started the e-ASIA Joint Research Program (e-ASIA JRP) with the aims of enhancing R&D capabilities by accelerating S&T research cooperation in East Asia and of conducting multilateral joint research for solving problems common to Asian countries. In 2013, two projects for joint research by Japan, Vietnam and the Philippines were adopted for support by e-ASIA JRP.

Under the framework of the Asia-Pacific Network for Global Change Research (APN), an intergovernmental network for enhancing research capabilities in the Asia-Pacific region as well as for solving common issues, MOE focused on research regarding adaptation to climate change in FY2013 and established a special program for accepting proposals on research related to adaptation as well as losses and damage due to climate change. The ministry held a workshop concerning biodiversity in Seoul for contributing to IPBES[1]. In July 2013, the second annual meeting of the Low Carbon Asia Research Network (LoCARNet) was held in Japan, in order to help create low carbon societies in the rapidly growing Asian region.

2 New Developments in Science and Technology Diplomacy

(1) The development of international activities that capitalize on Japan's strengths

Japan leads the world in addressing various issues, including environmental and energy problems. The level of Japan's S&T is relatively high among the countries of the world. To achieve sustainable growth, Japan needs to promote the export of prescriptions for solving problems (i.e., export of systems developed on the basis of Japanese S&T) and to create demand for these systems, especially in the rapidly growing Asian region. For this purpose, Japan has been using its strength in S&T to enhance the export of systems that help to bring social changes to emerging countries in Asia.

1) Active efforts toward international standardization

Based on the Intellectual Property Promotion Plan of 2013 (approved by the Intellectual Property Strategy Headquarters in June 2013), the government has been promoting an international standardization strategy as a joint effort of the public and private sectors, in order to raise Japan's competitiveness in specific strategic S&T fields in which Japan excels.

MIC is actively and strategically promoting international standardization by focusing on the four major areas specified in the *Recommendations on Policies Regarding International Standardization of ICT* in 2012 (in response to *Consultation No.18 of 2011*). With the aim of increasing the options available to users and of enhancing the global competitiveness of Japan's ICT industries, MIC is also collaborating with de jure

1 Intergovernmental Platform on Biodiversity and Ecosystem Services

standardization organizations such as the ITU[1] and de facto standardization organizations in the private sector in efforts to promote the international standardization of ICT that helps to reduce environmental impacts.

The strategic efforts for capturing new markets overseas stated in the Japan Revitalization Strategy include the international standardization of Japan's advanced technologies and expertise and the development of internationally recognized certification systems.

In view of this, METI has been promoting international standardization and the creation of certification systems that will help to ensure a competitive edge for Japanese businesses in global markets.

Specifically, METI makes efforts to obtain support from other countries in voting on international standards decisions, because one vote is allowed to each country concerned. As part of the efforts to strengthen bilateral cooperative relationships in Asia, in FY2013 agreements on cooperation regarding international standardization and certification were signed between Japan and Vietnam, and between Japan and India. These efforts aim at contributing to the proper evaluation and popularization of Japanese products.

To develop domestic certification systems and to provide support for the procurement of test equipment necessary for globally recognized certifications that serve the aims of Japanese manufacturers wishing to capture markets overseas, a feasibility study was conducted under the Project to Develop Global Certification Infrastructure, implemented under the FY2012 supplementary budget. This feasibility study was part of preparations toward the development of infrastructure that certifies the safety and performance of products and systems in strategically important industries concerning smart grids, personal care robots, etc. Additionally, in the Project to Develop Global Certification Infrastructure implemented under the FY2013 supplementary budget, the feasibility study result was used for developing domestic test and evaluation organizations regarding large-scale power conditioners and large-scale batteries that are useful for the introduction of renewable energy and the development of smart grids.

(2) The promotion of international activities regarding advanced science snd technology

To further develop Japan's S&T and to bring about greater synergy between S&T and diplomacy, Japan needs to promote R&D activities concerning advanced S&T and to make active use of these activities in Japan's diplomacy, in cooperation with international organizations and other advanced nations. For this purpose, Japan is required to energetically advance the development of global networks of researchers and international activities regarding advanced S&T, while controlling the outflow of technologies.

1) The development of international networks of researchers

Japan needs to develop networks of researchers across diverse disciplines to connect Japanese R&D with R&D in other countries that have high S&T levels. It is also necessary to promote international cooperation concerning advanced S&T by utilizing excellent research resources overseas.

Currently, universities, research institutions and researchers are individually conducting exchanges with their counterparts abroad. To further advance Japan's S&T and scientific research, it is necessary to attract outstanding researchers from Japan and aboard to research institutions in Japan, and to encourage Japanese

1 International Telecommunication Union

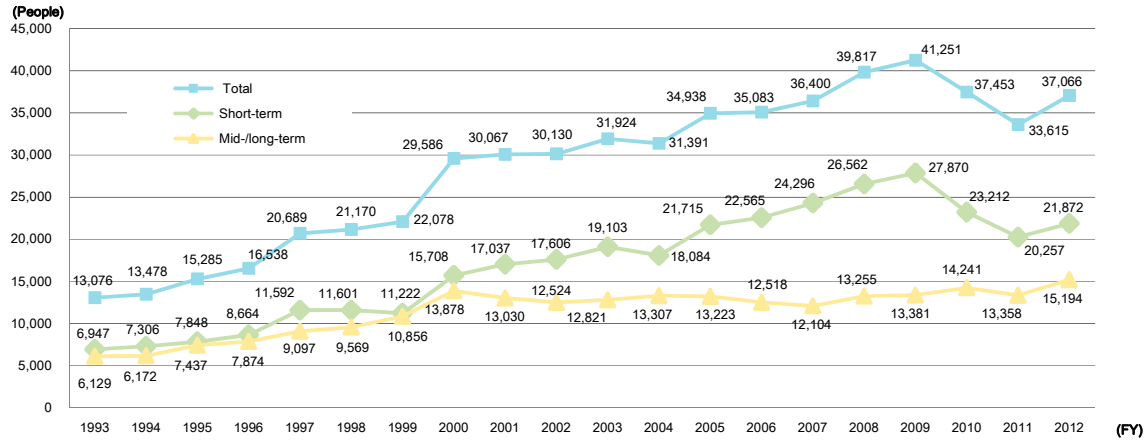
researchers to develop through friendly competition with international researchers.

(i) International mobility of Japanese researchers

The total number of international researchers accepted by universities and independent administrative institutions in Japan for short, medium and long periods rebounded in FY2012, after continued declines since FY2009. Regarding international researchers staying at Japanese universities or research institutions on a short-term basis, their numbers declined from FY2009 until rebounding in FY2012. International researchers staying in Japan on a medium- or long-term basis have numbered between 12,000 and 14,000 for every year since FY2000, and the figure exceeded 15,000 in FY2012 for the first time (Figure 2-3-9).

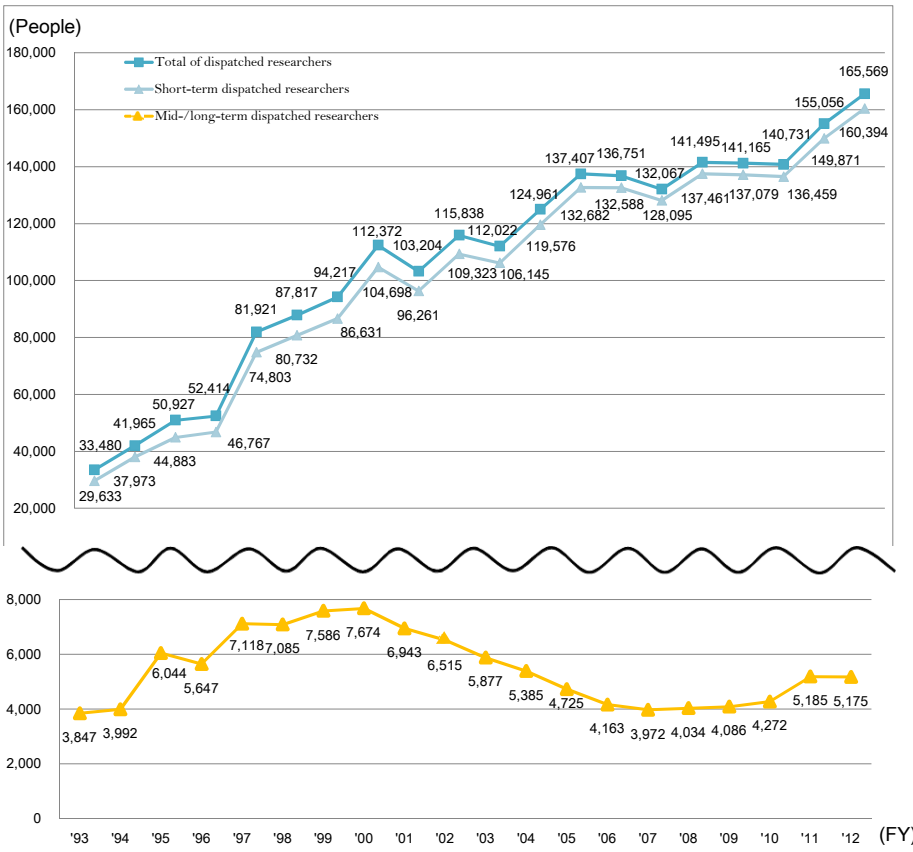
The total number of Japanese researchers sent to overseas universities, research institutions and the like (FY2012) for short, medium or long periods has been increasing since FY2010. The same trend is shown in the number of Japanese researchers sent abroad for a short period, while the number of Japanese researchers sent abroad for a medium or long period was almost the same in FY2011 and FY2012 (Figure 2-3-10).

Figure 2-3-9 / Changes in the Number of International Researchers in Japan (Total / Short-term Stay/ Medium- or Long-term Stay)



Note: 1: "Short-term" means 30 days or less; "medium- or long-term" means more than 30 days.
2: Postdocs and research fellows are included in the figures in and after FY2010.
Source: *Survey on International Research Exchanges*, MEXT, April 2014

Figure 2-3-10 / Changes in the Number of Researchers Working Abroad (Total / Short-term Stay/ Medium- or Long-term Stay)



Note: 1. "Short-term" means 30 days or less; "medium- or long-term" means more than 30 days.
2. Postdocs are included in the figures in and after FY2008, and research fellows are also included in the figures in and after FY2010.

Source: *Survey on International Research Exchanges*, MEXT, April 2014

(ii) Efforts for promoting international exchanges of researchers

In the midst of the globally accelerating brain circulation, Japan is making efforts to ensure that Japanese researchers and research teams can play a central role in networks of international research or researchers.

To foster young Japanese researchers who can play active roles internationally, the Japan Society for the Promotion of Science (JSPS) has been implementing various programs for sending young researchers overseas or inviting excellent researchers from other countries to Japan.

The Strategic Young Researcher Overseas Visits Program for Accelerating Brain Circulation is a JSPS program for developing excellent young researchers who can play pivotal roles in international research networks. This program supports Japanese universities and research institutions that provide young researchers with opportunities to engage in international joint research on various issues at research organizations overseas, according to the global research strategies of these universities and research institutions. Postdoctoral Fellowships for Research Abroad is another program of the JSPS to send researchers to universities or research institutions abroad for research. The program aims at increasing the opportunities for Japanese researchers to conduct research at preeminent research institutions overseas

and to interact with international researchers.

In JSPS program Postdoctoral Fellowship for Overseas Researchers, excellent international researchers are invited to engage in research at Japanese universities or research institutions based on the positions available or the purposes of research.

To foster young scientists and build networks in the Asia-Pacific and Africa regions, HOPE Meetings have been organized by the JSPS to provide selected graduate students and young researchers from these regions with opportunities to engage in discussions with Nobel laureates and other distinguished researchers.

2) Large-scale international projects

In implementing large-scale international R&D projects or R&D that requires comprehensive databases, cooperation with other countries needs to be enhanced based on input from specific research communities. In this respect, the government takes into account Japan's global position in each S&T research area and provides support to Japanese researchers so that they can play leadership roles in R&D projects in the S&T fields in which Japan has strengths or is greatly interested.

(i) International Thermonuclear Experiment Reactor (ITER)

ITER is an international project aiming at demonstrating the scientific and technological feasibility of fusion energy through the designing, construction and operation of an experimental fusion reactor based on an international agreement. Fusion energy is expected to contribute greatly to solutions to energy and environmental issues, and the ITER has been promoted by the seven parties (Japan, the European Union, the U.S.A., the Russian Federation, China, the Republic of Korea and India) (cf. Chapter 2, Section 2, 1 (1))

(ii) International Space Station (ISS)

The ISS is an international joint project for the construction, operation and utilization of manned space facilities in low Earth orbit (about 400 km) according to intergovernmental agreements signed by Japan, the U.S.A., the European Union, Canada and Russia. Japan is operating the Japanese Experiment Module KIBO and the automated cargo spacecraft KONOTORI (HTV), which is used for resupplying KIBO and the ISS (cf. Chapter 3, Section 1, 4 (2)).

(iii) International Ocean Discovery Program (IODP)

The International Ocean Discovery Program (IODP) was launched in October 2013 to replace the Integrated Ocean Drilling Program (IODP), which had been implemented from 2003 through 2013. The new IODP is an international research collaboration of 27 countries for drilling beneath the ocean floor to elucidate the crustal biosphere, the earth's internal structure, environmental changes and the like. This program is led by Japan and the U.S.A. In the IODP, multiple drilling vessels are used for exploring beneath the sea floor throughout the world. In addition to CHIKYU, a Japanese research vessel capable of drilling up to 7,000 m below the sea floor, and a U.S. drilling vessel that is used as the principal vessel, ECORD's mission-specific platforms are also used. (cf. Chapter 3, Section 1, 4 (2)).

(iv) Large Hadron Collider (LHC)

In the LHC project, a large circular accelerator at the European Organization for Nuclear Research (CERN) is used for recreating the conditions shortly after the Big Bang. LHC experiments are conducted for discovering unknown particles and exploring the fundamental internal structure of matter. The LHC was constructed with the cooperation of the CERN member states, Japan and the U.S.A. It started operation in 2008. The LHC is being shut down for upgrades that will increase the beam energy so that it is among the highest in the world.

About 200 Japanese scientists are engaging in multiple experiments using the LHC. Among them, the ATLAS[1] Experiment resulted in the discovery of a new particle in July 2012, which was later confirmed to be the Higgs boson, the particle that is theorized to explain the origin of mass. This discovery brought the 2013 Nobel Prize in Physics to Peter Higgs and François Englert, British and Belgian theoretical physicists, for their theoretical discovery of a mechanism that is related to the origin of mass in subatomic particles.

(v) International Linear Collider (ILC)

A group of international researchers is planning to operate the ILC in order to investigate the properties of the Higgs Boson, and the *ILC Technical Design Report* was published in June 2013. In May 2013, MEXT commissioned the Science Council of Japan (SCJ) to deliberate on the ILC regarding its scientific significance and practical problems. On September 30, 2013, the SCJ submitted a report on the deliberation results to MEXT. The report recommends that the government budget funds for studies which are necessary to evaluate the viability of the ILC, and that the government spend 2 to 3 years implementing intensive studies and investigations of the ILC together with experts from diverse fields as well as governmental organizations of the countries concerned. MEXT has been examining the issues raised in the SCJ report.

3) The collection and analysis of overseas science and technology information: Use of research centers abroad

For the purpose of referring to overseas information in formulating policies on S&T, a system needs to be created for continuously collecting, accumulating and analyzing overseas information in a structured and organized manner, and for utilizing such information across multiple sectors and disciplines. MEXT and institutions have been working on this.

Specifically, the National Institute of Science and Technology Policy (NISTEP) collects data on current research activities regarding S&T and universities abroad, and analyzes the data for comparison with the situation in Japan. The research and investigation conducted by NISTEP are based on objective and quantitative data, which is useful for enhancing Japan's S&T policies.

The Center for Research & Development Strategy (CRDS), JST is investigating and analyzing overseas trends to benefit the formulation of STI policies.

JSPS has liaison offices abroad. These offices collect information on trends in science and technology, support efforts by Japanese universities to expand their international bases and activities, collaborate with

1 A Toroidal LHC ApparatuS

organizations engaging in promotion of sciences and hold symposiums.

4) Systematic efforts for promoting international activities related to science and technology

(i) Utilization of international frameworks

a) Activities related to summit meetings

The G8 Science Ministers and National Science Academies meeting was held in the U.K. in June 2013. Yuko Harayama, an executive member of the Council for Science and Technology Policy, attended the meeting on behalf of the Minister of State for Science and Technology Policy, and Takashi Onishi, President of SCJ, represented Japan's science academies at the meeting. The meeting participants discussed global challenges, global research infrastructures, open scientific research data and expanding access to scientific research results. They released a joint statement.

Regarding the International Research Network for Low-Carbon Societies (LCS-RNet), which consists of research institutions working on the creation of a low-carbon society in various countries, the fifth annual meeting was held in Japan in July 2013. As of 2013, 17 research institutions from seven countries including Japan were members of the LCS-RNet.

b) Asia-Pacific Economic Cooperation (APEC)

The APEC Industrial Science and Technology Working Group (ISTWG) had been holding meetings for the purpose of improving the levels of industrial S&T in the APEC member economies through joint projects and workshops. In 2012, Russia as the host economy proposed the reorganization of the ISTWG into the APEC Policy Partnership on Science, Technology and Innovation (PPSTI), which has had participation by industries and scientific communities to work on all kinds of innovations. The proposal was accepted at the 20th APEC Economic Leaders' Meeting in September 2012.

The first and second meetings of the PPSTI were held in Indonesia, the host economy for 2013, in April and June for discussions on PPSTI activities.

In conjunction with the second PPSTI meeting, Chief Science Advisers (CSA) and their counterparts from APEC economies gathered to exchange views about science-based policymaking and scientific measures for addressing disaster prevention and other issues common to the Asia-Pacific region. Yuko Harayama, an executive member of the Council for Science and Technology Policy, represented Japan at the CSA meeting.

c) Association of Southeast Asian Nations (ASEAN)

The ASEAN Committee on Science and Technology (COST) is working on S&T cooperation under the framework of COST+3, namely COST plus Japan, China and South Korea. MEXT is taking a leadership role in Japan's contribution to ASEAN COST+3. The seventh meeting of ASEAN COST+3 was held in Kuala Lumpur, Malaysia, in November 2013, for exchanging views on joint projects of ASEAN and the three countries (Japan, China and South Korea). In 2009, the ASEAN-Japan Cooperation Committee on Science and Technology (AJCCST) was started as a framework for cooperation between Japan and the ASEAN-COST. The fourth AJCCST meeting was held in Kuala Lumpur, Malaysia, in November 2013.

d) Other

(Asia-Pacific Regional Space Agency Forum (APRSAF))

Since 1993, Japan has been hosting the annual APRSAF, the largest framework of space cooperation in the Asia-Pacific region. This forum has been used for exchanging information about space activities and utilization in the region as well as for promoting multilateral cooperation. The 20th APRSAF meeting, held in Vietnam in December 2013, was attended by about 420 participants from 28 countries and 8 international organizations, far more than the 60 participants from 15 countries and one international organization that attended the first APRSAF meeting. One major achievement of the initiatives conducted by APRSAF is the Sentinel Asia Project. This project aims at reducing damage caused by natural disasters by sharing disaster-related information online, including earth observation satellite images. As of February 2014, 77 regional institutions and 14 international organizations from 25 countries and regions were cooperating in the project. It has provided observation data 18 times as emergency support to disasters. For example, Japan supplied images sent from the Japanese Experiment Module KIBO on the International Space Station when the Philippines suffered flood damage in August 2013.

(International Space Exploration Forum (ISEF[1]))

In January 2014, the ISEF was hosted by the U.S. Department of State in Washington, D.C. The Minister of Education, Culture, Sports, Science and Technology and others attended the forum from Japan. This was the first ministerial forum held to affirm political support for international cooperation in space exploration. The forum was attended by 35 countries or regions, space agencies and international organizations. Views were exchanged regarding the meaning, significance and future directions of space exploration. At the opening ceremony of the ISEF, the Japanese Minister of Education, Culture, Sports, Science and Technology, representing Japan, stated that Japan was willing to actively contribute to international space exploration. A presidential advisor expressed the will of the U.S. to continue the operation of the ISS at least through 2024. It was the first time for the U.S. to make an official statement about the continuation of the ISS at an international meeting.

(Global Biodiversity Information Facility (GBIF))

The GBIF is an international organization that engages in the development of information infrastructure and data acquisition/analysis tools for the purpose of collecting data on biodiversity so that the data can be made available worldwide. The 20th meeting of the GBIF Governing Board was held in Berlin in October 2013, with the participation of member countries and others, for approving a budget for 2014, electing a Chair and more.

(The Global Earth Observation System of Systems (GEOSS))

GEOSS is a framework for comprehensive earth observation for which diverse observation systems including artificial satellites and ground-based observation systems are linked to address nine areas of critical importance, such as disasters and climate (cf. Chapter 3, Section 1, 3 (1)).

1 International Space Exploration Forum

(ARGO Program)

ARGO is an international real-time ocean-observation program for collecting information on water temperature, salinity and the like by using more than 3,000 drifting floats (Argo floats). The World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) and other international institutions, as well as more than 30 countries including the U.S., Australia and Japan, are participating. The advancement of this program is expected to help elucidate the details of changes taking place in the oceans, leading to the enhancement of the accuracy of climate change prediction. In Japan, MEXT and the JMA are cooperating in deploying Argo floats. As of FY2013, about 200 Argo floats of Japan were in operation.

(ii) Utilization of international organizations

a) The United Nations System (U.N. System)

Japan has been participating and actively cooperating in various S&T projects and activities of the United Nations Educational, Scientific and Cultural Organization (UNESCO), a specialized agency of the U.N.

In UNESCO bodies, such as the IOC, the International Hydrological Programme (IHP), the Man and the Biosphere Programme (MAB) and the International Bioethics Committee (IBC), international rules are formulated and projects are implemented for solving global-scale problems. Japan has established funds-in-trust at UNESCO for cooperating in S&T human resources development in the Asia-Pacific region. Japan also helps to promote UNESCO activities by sending experts to contribute to discussions at committees/commissions. In addition to the promotion of Education for Sustainable Development (ESD), Japan has been promoting Sustainability Science, a new concept of an approach to global-scale problems based on the integration of natural, cultural and social sciences. In April 2013, the Regional Workshop on Sustainability Science was held in Kuala Lumpur, Malaysia, with participants from the Asia-Pacific region. In September 2013, the International Symposium on Sustainability Science was held at the UNESCO Headquarters in Paris for all UNESCO members. At these opportunities, a shared understanding of sustainability science was cultivated. At the 37th Session of the General Conference of UNESCO in November, Japan's proposal to incorporate the concept of sustainability science in the formulation of UNESCO programmes was positively supported by many members and accepted in the UNESCO's Programme and Budget for 2014-2017 (37 C/5).

b) Organization for Economic Co-operation and Development (OECD)

The OECD engages in activities related to S&T through the creation of statistical data and exchanges of views, experience, information and human resources among the member countries at the following OECD bodies: the OECD Ministerial Council; the Committee for Scientific and Technological Policy (CSTP); the Committee for Information, Computer and Communications Policy (ICCP); the Committee on Industry, Innovation and Entrepreneurship (CIIE); the Committee for Agriculture (AGR); the Environmental Policy Committee (EPOC); the Nuclear Energy Agency (NEA); and the International Energy Agency (IEA).

At CSTP of the OECD, members exchange information and views on S&T policies, and study the roles that STI plays in economic growth, development and the enhancement of research systems, the roles of governments and the private sector in R&D, and approaches to international R&D cooperation.

CSTP has six subgroups: the Global Science Forum (GSF); Research Institutions and Human Resources (RIHR); the Working Party on Innovation and Technology Policy (TIP); the Working Party on Biotechnology (WPB); the Working Party on Nanotechnology (WPN); and the Working Party of National Experts on Science and Technology Indicators (NESTI). The main activities in which Japan is playing a leading role by assuming Chair or Vice-Chair are as follows:

(Global Science Forum (GSF))

For enhancing S&T cooperation among member countries, the GSF provides a venue for exchanges of views in an effort to find new opportunities for international cooperation in specific S&T areas, to define international frameworks for vital science policy decisions and to address the scientific dimensions of issues of global concern. The GSF's efforts aim at producing recommendations on future actions based on exchanges of information regarding large-scale scientific R&D projects and research on global-scale problems conducted by the member countries. In 2013, Quality of Scientific Advice for Policymaking: the Role and Responsibility of Scientists, a project led by Japan as the GSF Chair together with the Netherlands and others was implemented. In October 2013, a regular meeting of the GSF was held in Japan for discussions on various projects. It was the first time for the GSF to have its regular meeting outside the European region.

(Working Party on Innovation and Technology Policy (TIP))

The TIP is a venue for discussions on policies related to innovations and technologies that help to increase productivity, promote the creation and utilization of knowledge, encourage sustainable growth and enhance the creation of employment opportunities for highly skilled technicians.

In 2013, the TIP implemented case studies on industry-university cooperation, open science and system innovations, and discussed various projects.

(Working Party of National Experts on Science and Technology Indicators (NESTI))

NESTI supervises, provides advice on and coordinates statistical work, and contributes to the development of indicators and quantitative analysis helpful for the promotion of STI policies. Specifically, with regard to S&T indicators related to R&D spending, S&T human resources and the like, NESTI has been discussing and examining the development of indicators, methods for researching indicators and frameworks for international comparisons of indicators. Japan has delegated experts to the OECD Secretariat, where they are working on developing new indicators. A decision was made at the FY2012 annual meeting to start revising the *Frascati Manual*, the OECD guidelines for measuring R&D, and a working group was organized in April 2013 for implementing the revision.

c) International Science and Technology Center (ISTC)

The ISTC is an international organization established by the four parties of Japan, the U.S.A., the EU, and Russia in March 1994, with the aim of providing Russian and CIS former weapons scientists who had engaged in the development of weapons of mass destruction with opportunities to redirect their talents to R&D conducted for peaceful purposes. As of December 2013, the funds earmarked for approved projects amount to 879 million U.S. dollars, and researchers from Russia and the CIS who have engaged in these

projects exceed 75,000.

(iii) Utilization of research institutions

(Economic Research Institute for ASEAN and East Asia (ERIA))

ERIA is an institution that provides policy analyses and recommendations toward East Asian economic integration. Under the three pillars of deepening economic integration, narrowing development gaps, and achieving sustainable economic development, ERIA implements research, symposiums and human resources development in a wide range of areas, including innovation policies. In FY2013, ERIA conducted research on the production and use of biomass as part of its efforts for the dissemination and promotion of S&T.

(iv) International research grant programs

(Human Frontier Science Program (HFSP))

The HFSP is an international research grant program first advocated by Japan at the summit at Venice in June 1987. This program aims at supporting international joint basic research on the complex mechanisms of living organisms. The HFSP is now operated by 14 parties (Japan, the U.S.A., France, Germany, the E.U., the U.K., Switzerland, Canada, Italy, Australia, South Korea, New Zealand, India and Norway). Japan has been actively supporting the program since its establishment. This program provides grants for research expenses of international joint research teams, supports young researchers by covering the cost of traveling and staying abroad for research activities, and holds HFSP awardees' meetings. The HFSP program has gained worldwide acclaim partly because 23 HFSP awardees had received Nobel Prizes as of FY2013.

(v) Efforts by Japan's scientific institutions

(International activities by SCJ)

SCJ has been contributing to Japan's cooperation with other countries, by representing Japan for taking part in 45 international scientific organizations including the International Council for Science (ICSU) and the global network of science academies (IAP[1]).

Ahead of the G8 Summit every year, the national science academies of G8 countries and other countries develop policy recommendations from the scientific perspective and finalize the recommendations into joint statements. The SCJ has been taking part in this process. Before the G8 Lough Erne Summit was held in the UK in June 2013, the SCJ joined the national science academies of G8 and other countries in finalizing the joint statements on "Driving Sustainable Development: the Role of Science, Technology and Innovation" and "Drug Resistance in Infectious Agents - A Global Threat to Humanity". The SCJ President delivered the joint statements in person to the Prime Minister of Japan.

In May 2013, a conference of the Science Council of Asia (SCA[2]) was held in Thailand for enhancing cooperation among Asian countries in scientific research.

(vi) Efforts for peaceful use of nuclear energy

Japan concluded the *Safeguards Agreement* with the International Atomic Energy Agency (IAEA) in 1977,

1 IAP - the global network of science academies: Founded in 1995 as a forum for global science academies SCJ has been an IAP Executive Committee member from 2004 through 2009 and from 2013 through 2015.

2 Science Council of Asia: Consisting of 27 academic organizations from 16 countries

and signed the *Additional Protocol* in 1998. Pursuant to the agreement and the protocol, Japan has been complynig with IAEA safeguards whereby the IAEA verifies that nuclear materials are used only for peaceful purposes and are not diverted or misused for nuclear weapons assembly. Thus, pursuant to the *Nuclear Reactor Regulation Law*, Japan has been implementing a system of accounting for and controlling nuclear material, providing reports to the IAEA and accepting IAEA inspections. The IAEA evaluation has concluded every year that all the nuclear materials in Japan are used solely for peaceful purposes.

Japan has been working with the IAEA and the U.S in taking the leadership role in advancing international cooperation related to R&D on technologies for nuclear nonproliferation and nuclear security as well as related to human resources development. At the Nuclear Security Summit held in the U.S.A. in 2010, Japan expressed its intention to establish the Integrated Support Center for enhancing nuclear non-proliferation and nuclear security globally with a focus on Asia, and to advance technologies for the measurement and detection of nuclear material as well as for nuclear forensics. After the summit, the Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN) was established within JAEA. This center has provided training courses in nuclear nonproliferation and nuclear security to more than 1,500 officials and personnel from 36 countries, including Japan. In 2013, the ISCN concluded an arrangement with the IAEA regarding the development of human resources for nuclear security. Based on the arrangement, the ISCN and the IAEA have been jointly developing training programs, and exchanging lecturers and information regarding human resources development. At the JAEA since 2011, Japan-U.S. joint efforts have been made in the demonstration of non-destructive assays of plutonium in spent fuel, the development of technology for nondestructive assays of fuel using nuclear resonance fluorescence, and the development of technology for nuclear forensics to identify the origin of illicitly trafficked nuclear materials. Through these efforts, the Japanese government has been promoting international cooperation for the development of technologies and human resources in relation to nuclear non-proliferation and nuclear security, while also securing international trust in Japan's use of nuclear energy for peaceful purposes.

(vii) Other international efforts

In October 2013, the Cabinet Office hosted the Science and Technology Ministers' Roundtable Meeting, which was attended by ministers responsible for science and technology policy, science advisers and others from 27 countries, to discuss Enhancing Knowledge-Sharing through People in the Globalizing World.

(3) The promotion of cooperation with developing countries on issues of global concern

To promote S&T cooperation with developing countries in Asia, Africa and Latin America, MEXT, JST, MOFA and JICA, which have necessary expertise, have been collaboratively implementing the Science and Technology Research Partnership for Sustainable Development (SATREPS) program by utilizing Japan's advanced S&T and ODA. On the basis of the needs in the developing countries concerned, this program is carried out toward helping to solve global-scale problems and toward promoting international joint research aimed at the future application of research results to solutions to problems. From FY2008 through FY2013, 77 SATREPS projects in 39 countries (including 40 projects in Asia and 20 projects in Africa) were adopted for implementation. These projects address issues relating to environment, energy, bioresources, natural disaster prevention and infectious diseases.

MEXT is implementing a program that combines international joint research with government scholarships for international students. Specifically, the government sponsors international students who wish to study at the Japanese universities that are taking part in the SATREPS program. This program makes it possible for young researchers from countries participating in SATREPS joint research projects to earn degrees in Japan. Thus, MEXT is cooperating in many ways with other countries in developing their human resources.

SATREPS "Improving Sustainable Water and Sanitation Systems in the Sahel Region of Africa"
Courtesy of JST

MAFF is also providing support for the development of technologies and human resources in developing countries. MAFF supports agriculture, forestry and fisheries in these countries in order to address global-scale issues such as poverty reduction and climate change. For this purpose, assistance has been provided through international joint research projects to the development of crops resistant to drought and other environmental stress, technologies for reducing greenhouse gases from farmland and technologies for utilizing agricultural waste such as to mitigate global warming. Support is also provided through international agricultural research institutions on the development of techniques for increasing the production of rice, root crops and legumes.

(4) Reinforcement of foundations for advancing international science and and technology activities

To strategically advance bilateral and multilateral cooperation in S&T, Japan needs to further promote inter-governmental dialog with other countries and to continuously collect and use information on overseas S&T trends. For this purpose, Japanese government is making efforts to strengthen the basis for developing international S&T activities.

1) Cooperation with other countries

(i) Cooperation with China, South Korea and other Asian countries

Within the framework of Japan-China-Korea trilateral cooperation, the Minister of Education, Culture, Sports, Science and Technology has attended the Japan-China-Korea Ministerial Meetings on Science and Technology Cooperation.

The third Japan-China-Korea Ministerial Meeting on Science and Technology Cooperation was held in Shanghai, China, in April 2012. At the meeting, the situations of S&T policies in Japan, China and South Korea were reported, and the future direction of trilateral cooperation was discussed.

The Japan-China-Korea Ministerial Meeting on Science and Technology and the Trilateral Director-General's Meeting are held biennially and alternately, and these meetings have resulted in

support for research activities through the Japanese-Chinese-Korean Cooperative Joint Research Collaboration Program (JRCP) and Young Researchers' Workshops.

The first Japan-China-Korea Green Technology Forum was held in Tokyo in March 2012, and the second was held in Beijing, China, in November 2013. The forum aims at sharing research results regarding green technology and at building a research network among the three countries.

In addition to Japan-China-Korea trilateral cooperation, Japan is also promoting bilateral S&T cooperation with China and South Korea. For this purpose, the government has held two-week meetings of a bilateral committee for S&T cooperation, has been exchanging information and researchers, and has been supporting the implementation of bilateral joint research with China and South Korea.

Additionally, JSPS has been using its A3 Foresight Program and other programs for assisting exchanges among research institutions in Asian countries, developing networks of scientific research and fostering young researchers.

(ii) Cooperation with the U.S.A. and European countries

Japan has been actively advancing S&T cooperation with the U.S. and European countries in such advanced research areas as life sciences, nanotechnology, materials science, environmental sciences, nuclear technology and space exploration. Specifically, Japan has held meetings of joint committees on S&T cooperation based on bilateral S&T cooperation agreements, has been exchanging information and researchers with these countries and has been supporting the implementation of joint research.

The 12th U.S.-Japan Joint High-Level Committee Meeting on Science and Technology Cooperation, a ministerial-level meeting, was held in Washington in April 2013 to discuss key issues of S&T in Japan and the U.S. During the meeting, the U.S. Department of Energy and Japan's MEXT signed an "implementing arrangement" on cooperation in research and development in energy and related fields. In conjunction with the meeting, an Open Forum was also held for the first time to extend the U.S.-Japan discussion to include participants from universities and the private sector. Open Forum participants noted the important societal benefits that accrue from cross-sectoral exchanges and emphasized the importance of continuing these kinds of dialogues.

The EU-Japan Science and Technology Agreement entered force in March 2011. Based on this agreement, the second meeting of the EU-Japan Joint Committee on Science and Technology Cooperation was held in June 2013. After consultations with the European Commission, Japan and the EU published the first coordinated call for international joint research projects on ICT topics in October 2012. Joint ICT research started in 2013. In January 2014, the second coordinated call was published. Since January 2011, Japan has been taking part in Connecting and Coordinating European Research and Technology Development with Japan (CONCERT-Japan), an international cooperation initiative funded under the 7th Framework Programme of the European Union (EU) for Research and Technological Development. In this initiative, ministries and funding organizations from Japan and European countries form a project consortium with the aim of networking and of exchanging information on specific S&T policies in each country through symposiums and joint projects.

In 2013, a meeting of the Japan-Canada Joint Committee on Science and Technology Cooperation was held in January. Japan also had a meeting of the Joint Committee on S&T Cooperation with Germany in March, with France in June and with the Czech Republic and Slovenia in July.

The third Japan-U.S.-EU trilateral workshop on critical materials was held in Brussels in May 2013, with attendance by government officials and experts in materials technology from the U.S.A., the E.U. and Japan, which have great need for rare-earth minerals. High-level government officials of the three economies participated in a workshop for cultivating a shared understanding of the global situation related to the supply of rare-earth minerals as well as for discussing strategic efforts required to ensure their stable supply.

(iii) Cooperation with other countries

Japan is also promoting exchanges of information and researchers as well as the implementation of joint research with Australia, Russia, South Africa, Brazil and other countries, according to bilateral Science and Technology Cooperation Agreements. Japan held a meeting of the Joint Committee on S&T Cooperation with New Zealand and Russia in September 2013, and with Ukraine in December 2013.

The Japanese government is exchanging views on the feasibility of cooperation with the countries with which Japan has not signed bilateral Science and Technology Cooperation Agreements.

2) Policy dialogues regarding science and technology initiated by the private sector

Based on the understanding that it is necessary to broaden the range of S&T diplomatic activities and to ensure opportunities for constant dialogues among international stakeholders, in 2013 JST implemented the Program for the Promotion of International Policy Dialogues Contributing to the Development of Science and Technology Diplomacy, a program under the JST initiative for Infrastructure Development for Promoting International S&T Cooperation. This program supports organizers of international meetings that are held to provide a broad range of stakeholders, who are playing a leading role in advancing S&T in industry, academia and government globally, with opportunities to discuss the future direction of S&T.