Chapter 3 Responses to Critical Issues Facing Japan

Section 1 Advancement of Measures for Solving Key Issues

1 Assuring Safety, Affluence and High Quality of Life

Under the 4th Science and Technology Basic Plan, one goal is for Japan to become "a nation that affords its citizens safety, fulfillment and a high quality of life." To assure safety, fulfillment and a 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 ensuring a stable supply of food and water. Efforts are also needed to help people enrich themselves mentally and cultivate themselves in terms of sensibility.

(1) Enhancement of safety and convenience of life

① Surveys, observations and predictions of earthquakes, volcanoes, tsunamis, high waves and storm surges, wind damage, flooding and landslides, and R&D to improve disaster prevention, mitigation and response capabilities

In FY 2015, Japan was visited by various natural disasters, such as the earthquake off the west coast of the Ogasawara Islands and the volcanic eruption of Kuchinoerabu Island in May, and the Kanto-Tohoku Heavy Rainfall Disaster in September. Overseas, natural disasters caused tremendous damage in many parts of the world, such as the Earthquake along the Central Coast of Chile in September 2015. To mitigate damage caused by natural disasters, it is important to advance R&D on science and technology (S&T) that contributes to the reduction of various types of disasters.

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

Under the Headquarters for Earthquake Research Promotion (Director: the Minister of MEXT), administrative agencies are working in close cooperation on seismological investigations and research.

Because the long-term evaluations of the probability and scales of earthquakes conducted by the Headquarters for Earthquake Research Promotion did not cover massive multi-segment earthquakes such as the 2011 Great East Japan Earthquake, conventional evaluation methods have been reviewed to discuss the renewal of evaluation methods.

MEXT has conducted investigation and research into potential earthquakes which may cause tremendous social and economic damage, including the Special Project for the Mitigation of Great Disasters which the Vulnerability of Cities Causes for earthquakes directly beneath the Tokyo Metropolitan Area and the Research Project for Compound Disaster Mitigation on the Great Earthquakes and Tsunamis around the Nankai Trough Region for Nankai Trough earthquakes. In the Project for Investigations of Earthquakes and Tsunamis in the Sea of Japan, controlled-source surveying and investigations of tsunami deposits were conducted 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. 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, comprehensive earthquake observation networks were densely built in land areas. Although several sea-area observation networks have been built, there are far fewer observation points in these networks than in land-based observation networks. Accordingly, 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 Off Kii channel 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 (See Chapter 2, Section 1, Paragraph 1(3).)

(ii) Enhancement of resilience against disasters (Cabinet Office)

Natural disasters have been expanding in scale, so damage caused by them has been exacerbating and Japanese society has become increasingly vulnerable to these disasters. In light of these situations and the concept of disaster resilience, the Cabinet Office has been promoting R&D on technologies for a disaster-resilient information system under the Strategic Innovation Promotion Program (SIP).

Resilient infrastructure minimizes disaster damage, thereby helping communities to withstand and rapidly recover from shocks and helping affected people to regain control of their lives. The "disaster information system for resilience" is based on advanced technologies for predicting, preventing and responding to disasters as well as for sharing information, and it can be used to improve the disaster prevention and mitigation capabilities of the national government, local governments, businesses and the public.

(iii) Promotion of S&T for disaster prevention (NIED)

The National Research Institute for Earth Science and Disaster Prevention (NIED) has been conducting a research project on seismic engineering utilizing E-defense, studies on accurate predictions of rainfall and damage caused by landslides, windstorms and floods using next-generation high-performance radars and research contributing to the damage reduction caused by natural disasters such as volcanoes and heavy snow. NIED has also advanced the research to develop systems for integrating and utilizing information for various natural disasters. In FY 2015, large-scale rock friction experiments were conducted to simulate semi-natural friction conditions for the purpose of understanding seismogenic faulting. Research based on these experiments led to the discovery of a new rock friction mechanism. Regarding the volcanic activity at Kuchinoerabu Island and Mount Hakone in and after May 2015, NIED analyzed earthquakes and tectonic deformation. Additionally, it collected and analyzed volcanic ash, conducted topographic investigation, and submitted data and materials concerning the prediction of volcanic activities to the Coordinating Committee for the Prediction of Volcanic Eruptions. When the Kanto and Tohoku regions were seriously affected by heavy rainfall in September 2015, NIED analyzed the 3D structure of cumulonimbus clouds and posted the results on its website. At the same time, by utilizing the e-community platform, which is an outcome of R&D efforts for developing systems for integrating and utilizing information of various natural disasters, NIED also posted maps online showing the flood damage in the City of Joso, Ibaraki Prefecture, and supported procedures for issuing the certificates of affliction to flood victims.

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

The JMA processes and analyzes the monitoring data collected at its earthquake monitoring facilities and related institutions and provides analytical results to the same institutions. The JMA collaborates with NIED to conduct R&D and further advance technologies for the earthquake early-warning system.

The Meteorological Research Institute (MRI) of the JMA's researches the following topics: the development of tsunami forecasting technologies to mitigate damage by tsunamis based on 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 an assumed Tokai Earthquake.

(v) 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[1] observation at electronic reference stations[2], through Very-Long-Baseline Interferometry (VLBI[3]) and through SAR[4] Interferometry. 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 FY 2009), NIED (since FY 2010), the National Institute of Advanced Industrial Science and Technology (AIST) (since FY 2012), the Hot Springs Research Institute of Kanagawa Prefecture (since FY 2012) and the Earthquake Research Institute of the University of Tokyo (since FY2015).

Observation from a light aircraft for analysis of the eruption activity at Kuchinoerabu-jima Island

Source: National Institute of Advanced Industrial Science and Technology (AIST)

(vi) Promotion of technologies for monitoring and analyzing crustal movements (the Japan Coast Guard: JCG)

The Japan Coast Guard (JCG) has been advancing observations of crustal movements on the sea floor[5] by means of GPS and echo ranging, as well as advancing surveys of submarine topography and active faults and announcing the observation results from time to time.

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

To collect geological information useful for disaster prevention, AIST conducts deposit surveys of active

1 Global Navigation Satellite System
2 There were 1,300 electronic reference stations across the country as of the end of March 2016.
3 Very Long Baseline Interferometry: an advanced technique that utilizes radio waves from deep space as far as billions of light years away for precisely measuring the distance between two radio telescopes situated thousands of kilometers away from each other within a tolerance of a few millimeters.
4 Synthetic Aperture Radar: a technique for using data collected by using an artificial satellite for obtaining information about the evolution and state of earth's surface.
5 A precise location of a surveying vessel on the sea is determined with GPS, the distance between the vessel and a reference point on the sea-floor is measured by using sound waves, and thus the exact location of the reference point is determined.

faults and tsunami sediment, conducts geological surveys of active volcanoes, and publishes the results of these surveys.

Its geological surveys included 7 major fault zones nationwide, 6 fault zones on land and one fault zone in the nearshore sea to clarify the fault distribution and the history of fault activity. AIST's database on tsunami deposits was released to the public in October 2015. Data collected in the areas along the Pacific Ocean in Aomori and Fukushima prefectures and on the Ishinomaki Plain in Miyagi Prefecture, were added to the database. For short-term predictions of Nankai Trough Great Earthquakes, AIST continued to operate its integrated groundwater observation points to measure groundwater levels (water pressures), groundwater temperatures, crustal strains and seismic waves.

Concerning the volcanoes where eruption activities were observed (i.e., Kuchinoerabu-jima, Mt. Aso, Sakurajima, Mt. Asama, and Mt. Hakone), AIST conducted field investigations and analyzed volcanic ash and gases. The investigation and analysis results were used for material scientific studies that are expected to help understand the ongoing eruption activities and predict changes in these activities.

(viii) 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 Harbors (NOWPHAS) in mutual cooperation with the Port and Airport Research Institute and other research institutions. Data on waves and tidal levels observed across Japan are collected through this network, and details are published on MLIT's website in real time.

The National Institute for Land and Infrastructure Management (NILIM) has been conducting research including the following: 1) measures for extremely severe disasters, such as landslides and urban flooding due to sudden torrential rainfall, 2) the development of strategic flood mitigation methods that are incorporated with urban development and that address the needs posed by climate change, 3) urban inundation countermeasures, using flexible pump operation through ICT, 4) road cleaning[1] and restoration of infrastructure immediately after disasters, using airborne portable SAR, existing camera sensors and other technologies, 5) faster initial response to large earthquakes, including R&D to support TEC-FORCE activities, 6) "the creation of tsunami- and fire-resistant towns," including the development of buildings that can be continuously used immediately after an earthquake and 7) the designing of tsunami-resistant disaster centers and study of "preparations for high tides and tsunamis," to improve tsunami and high-tide observation technologies.

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

The 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.

1 Road cleaning: Securing at least one lane available as a transportation route for emergency vehicles and rescue operations by minimally clearing away rubble and roughly eliminating differences in level on the road.

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

FDMA's National Research Institute of Fire and Disaster has been conducting R&D of fire-fighting robots for deployment in the event of disasters at energy or industrial infrastructure. These robots feature sophisticated autonomy based on geospatial information technology and ICT, as well as cooperation and coordination among the robots. Thus, they will be able to collect information and to discharge fire-fighting water at disaster sites that are accessible only to robots. Based on an understanding of problems with information gathering that were identified after the Great East Japan Earthquake (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 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 (NRIPS) specializes in research that helps to enhance criminal investigations, crime prevention and investigations into the causes of accidents. The following research subjects were dealt with in FY 2015: research on the development of forensic science examination methods that apply advanced methods for analyzing constituent elements; research on quick and advanced DNA analysis methods; individual identification of biological data through haplotype analysis to support criminal investigations; behavioral science techniques for interviewing suspects and crime victims; the practical application of simulation techniques used for fire appraisal that are implemented to identify the causes of fire-related accidents as well as detecting 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 FY 2010 and FY 2012 and it has been a part of integrated implementation of social system reforms and R&D since FY 2013.

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

The PWRI has been engaging in research on risk assessment of, 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 (NMRI) 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 to attain zero emissions.

④ Promoting R&D to enhance safety and increase comfort and convenience

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

The National Police Agency (NPA), Ministry of Public Management, Home Affairs, Posts and Telecommunications (MIC) and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) have been promoting efforts to introduce driving safety support systems that rely on vehicle-to-infrastructure and vehicle-to-vehicle communications.

In FY 2015, NRIPS of NPA promoted study on the accident deterrent effects of traffic enforcement.

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

The NMRI 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 the 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.

The National Traffic Safety and Environment Laboratory is responsible for the following: the promotion of the development and practical application of next-generation heavy vehicles; research on technologies for ensuring the safety of land transportation as well as for preventing accidents involving vulnerable road users; testing and research of technologies for environmental conservation; conformity inspection regarding technological standards of automobiles; and the verification of technological requirements for automobile recalls.

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

The PWRI is developing technologies for the efficient maintenance of deteriorating social infrastructure and for the service life extension of social infrastructure while enhancing the functionality of such infrastructure based on advances in materials technology.

The Port and Airport Research Institute is engaging in the development of technologies for the inspection and monitoring of coastal infrastructure indispensable for Japan's socioeconomic activities. Research is also conducted on enhancing the maintenance efficiency and reducing the life-cycle costs of coastal infrastructure.

MIC is conducting R&D on telecommunications technologies for the collection and dissemination of data with high reliability but ultra-low power consumption. Those data are strain and vibration data gathered by sensors at structures. The aim is the effective and efficient management and maintenance of infrastructure using ICT.

MLIT and the Ministry of Economy, Trade and Industry (METI) have promoted the development and introduction of robots to maintain social infrastructure and implement anti-disaster measures more

effectively and efficiently. METI launched the System Development Project to Solve Social Problems for Infrastructure Maintenance and Renewal to develop robots for priority fields.

In cooperation with other MLIT departments and agencies, NILIM has been developing technologies for the following: road structure maintenance; the prompt, automated, low-cost inspection of sewerage pipelines; the maintenance of river structures, sea ports and airports; and more efficient inspection, repair and renewal of existing social capital stock.

Concerning the research topic of "infrastructure maintenance, renovation and management technologies" under SIP, the Cabinet Office considers it important that the needs for maintenance be matched with the seeds of technological development. By translating new technologies into practical applications and by elevating the level of maintenance and management at low cost through preventive maintenance, the Cabinet Office aims to uphold high standards of maintenance and management for important domestic infrastructure. It is intended that the technologies used for this purpose help create an attractive and sustainable market for infrastructure maintenance and management. The Cabinet Office also promotes the export of infrastructure maintenance and management technologies.

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

The Ministry of Agriculture, Forestry and Fisheries (MAFF) is conducting research to develop 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, 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 MAFF has been addressing include the following: the 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, such as arsenic and mycotoxins, during the production, distribution and processing of farm products. In addition, MAFF has been addressing the following: techniques for finding scientific evidence of disease-prevention benefits in functional ingredients in farm/forestry/marine products and other food items, in order to support 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 in order to enhance technologies for ocean mineral exploration, such as the deep sea mining of submarine hydrothermal deposits and of cobalt-rich crust, and technologies for the sustainable harvesting of marine biological resources (See Chapter 3, Section 1, Paragraph 4(2).) Towards the realization of a low-carbon society, MEXT is also promoting R&D on innovative technologies for renewable energy (See, Chapter 2, Section 2, Paragraph 1 (1) and (2).)

The NMRI 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.

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. To enhance the recycling of spent lithium-ion batteries that are used in next-generation automobiles, grants were provided for the development and demonstration of technologies for reducing the cost of cobalt extraction and recovery.

(3) Increase of the affluence of peoples' lives

① Efforts to improve quality of life and for increasing affluence

With the aim of promoting the use of information and communications technologies (ICT) in school education, MIC has been collaborating with MEXT in implementing the Future School Promotion Project, an empirical study for establishing low-cost educational ICT systems (the Education Cloud Platform) to provide seamless cloud-based learning at home and school via various terminals and OSs. The project is currently conducted at 12 schools in three areas: Shinchimachi Town in Fukushima Prefecture, Arakawa Ward in Tokyo, and Saga Prefecture. Regarding R&D that benefits welfare, grants have been provided to R&D projects to defray the costs of R&D on technologies necessary for delivering more convenient communications and broadcasting services to elderly and/or disabled citizens. For the benefit of medical and nursing care users, research has been conducted on enhancing the quality of health, medical and nursing services by utilizing ICT to help these users manage and make use of medical and nursing care information, and information on their health. Experimental studies have been implemented on the use of mobile devices to realize telemedicine services and linkage between medical care and nursing care in a secure manner at low cost. 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.

■ Table2-3-1 / Major projects for realizing safe and high-quality lives (FY2015)

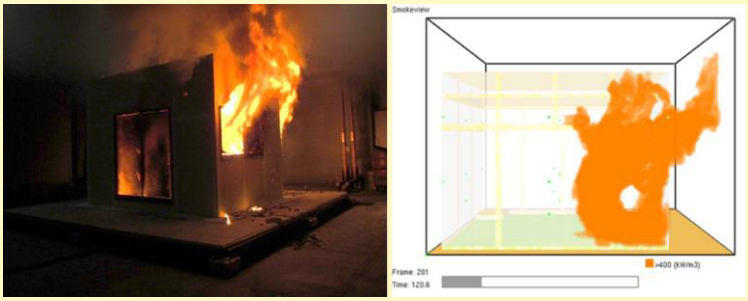
Ministry	Implemented by	Project
MIC	MIC	Expenses required for R&D on technology using radio waves for radio use financial source
		Testing of technologies for addressing the shortage of available frequencies
		Promotion of the Global Communications Plan: R&D on a multilingual speech translation system, including a social experiment
MAFF	MAFF	Promotion of research on S&T for the agriculture, forestry, fisheries and food industries
MLIT	MLIT	Study on the development of plans and designs for harbor improvements
		Comprehensive R&D on construction technology (technical management) (flood control expenses)
		Comprehensive R&D on construction technology (technical management) (road improvement expenses)
		R&D on flood control projects
		Research on road technologies (ITS, etc.)
	Japan Meteorological Agency (JMA)	Advancement of Earthquake Early Warning and tsunami observation information
	Geospatial Information Authority (GSI)	Expenses for improving basic map information
Ministry of the Environment (MOE)	MOE	Expenses for comprehensive measures against particulate matter (PM 2.5), etc.

Column 2-1 Use of fire simulations in fire cause investigations

In police investigations into fire causes, the analysis of fire damage is critical for an understanding of how flames and smoke spread. Fire damage tends to be continuously distributed, but in some cases it is burnt down at several points due to flame growth and consequently is scattered about the fire scene. In these cases, the locations of fire damage need to be connected linearly. For this purpose, full-scale model structures are used for combustion experiments and numerical simulations.

Based on the recent rapid increases in computer capabilities and the maturation of computational fluid dynamics (CFD techniques), the National Institute of Standards and Technology (NIST) of the United States Department of Commerce developed the Fire Dynamics Simulator (FDS), a CFD model of fire-driven fluid flow. The NIST also developed Smokeview (SMV), a visualization program that is used to display the output of the FDS. This program is used for visualizing the spread of flames and smoke in three dimensions. The FDS is used for predicting time-series variations in heat, smoke and CO levels, as well as the combustion-inhibiting effect of water droplets from sprinklers. Currently, the FDS is used in many countries as a tool for assessing a building's fire safety, simulating fires for the purpose of fire cause investigations and training fire fighters.

In Japan, the NPA's NRIPS has been promoting the use of FDS as a way of supporting investigations and analyses of fires, in order to determine the sources of these fires and the associated CO poisoning. This is done addition to conventional combustion experiments that utilize real-size model structures. At present, the results of combustion experiments conducted using full-scale model structures are compared with FDS simulation results, with the aim of verifying FDS's usefulness and applicability. Experiments are also conducted in which the thermal properties of combustible solids are measured. These measurements are used to create an FDS database.



Combustion experiment with a model structure (left), and a fire simulation (right)

Source: NRIPS

The FDS is expected to be used as a tool that supports fire cause investigations in an appropriate and efficient manner.

2 Strengthening of Japan's Industrial Competitiveness

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

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, 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 (See Chapter 3, Section 1, Paragraph 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 Development of key technologies for manufacturing processes

The demand for carbon fiber 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 carbon dioxide emissions and other environmental impacts have been reduced. Research was also conducted for translating these key technologies into basic manufacturing technologies.

② Development of semiconductor technologies

METI has conducted R&D on 10-nm semiconductor micro-fabrication and manufacturing technologies to improve servers, computers and next-generation automobiles that have low energy consumption, and has conducted R&D of technologies for integrating next-generation semiconductor devices (See Chapter 2,

Section 2, Paragraph 1(2).)

③ Support the use-reduction and substitution of rare-earth metals

METI has conducted R&D on alternative materials and reductions in the use of rare-earth metals, which are vital to the manufacture of high-performance motors for hybrid and electric vehicles and other value-added products, but which have a supply risk due to the increasing nationalism of the source countries.

④ Promotion of R&D at small to mid-sized enterprises

METI included the Project for the Strategic Promotion of Advanced Basic Technologies in the budget for FY 2014 to support R&D by SMEs in collaboration with universities and public R&D institutes, pursuant to the Act on the Enhancement of Small and Mid-sized Enterprises' Core Manufacturing Technologies (Act No. 33, 2006) (The SME Technological Advancement Law).

To help solve the policy issues stated in the Comprehensive Strategy on Science, Technology and Innovation 2014 in relation to important technological developments for Japan, METI supported collaborative R&D conducted by SMEs and universities or public R&D institutes that engage in translational research.

⑤ Promotion of open innovation

METI established the Japan Open Innovation Council (JOIC), whose secretariat is the New Energy and Industrial Technology Development Organization (NEDO). The JOIC has been supporting the promotion of private-sector activities for open innovation, including seminars, workshops and programs for matching major companies with entrepreneurial ventures.

⑥ Research support system for transferring technologies to SMEs

Through NEDO, MIC supports joint research projects by SMEs and venture companies using the bridging capability of institutions to commercialize innovative technological seeds.

⑦ Enhanced support for SMEs and venture companies specializing in R&D

To build a venture ecosystem in Japan, METI has implemented a number of policies that promote the invitation of foreign and domestic venture capital investment, in order to resolve the problem of numerical and quality insufficiencies among R&D-oriented SMEs and venture companies. It has done this by combining policies to support R&D-oriented venture companies.

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

In response to the diversification of network services and the expansion of wide-area cloud computing services, MIC has been promoting R&D on key technologies for realizing the flexible control of telecom networks and capacity increases in these networks. MIC has also promoted R&D and demonstration tests of new-generation network technologies and new applications using the Japan Gigabit Network-eXtreme (JGN-X), a new-generation network testbed developed and operated by the National Institute of Information and Communications Technology (NICT), in order to develop ICT human resources, revitalize industry, improve Japan's international competitiveness and accelerate international collaboration.

METI has been promoting the demonstration of technologies that create smart communities (See Chapter 2, Section 2, Paragraph 1(1).) METI has also implemented development projects to create new added value and new industries that use environmental and ecological information. By using IT and data for effective crop cultivation, METI has conducted research projects.

■ Table 2-3-2 / Major projects to strengthen Japan's industrial competitiveness (FY 2015)

Ministry	Implemented by	Project
MAFF	MAFF	MAFF MAFF Innovative technology creation promotion
		R&D for constructing value chains connected by technology
METI	METI	3D printer technology-based manufacturing innovation program (part directly assigned to METI)
		Advanced JIS development project, etc.
		Research project to develop technology for clean diesel
		Survey project for supporting the creation of venture companies

3 Contributing Solutions to Global Issues

(1) Promoting solutions to global issues

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, 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 to promote the development of GEOSS. It had 194 countries and institutions as members as of February 2016. Japan has been playing a leading role on the GEO Executive Committee.

a) Satellite-based observation

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 the collection of observation data on global GHG concentration distributions and changes. The data are needed to improve 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 carbon dioxide and methane are estimated by month and by subcontinent, and three-dimensional carbon dioxide distribution data are

estimated. These estimation results are made available to the public. In FY2015, GOSAT observation data were used for calculating carbon dioxide concentrations in the entire atmosphere. The calculation results suggested that atmospheric carbon dioxide would exceed 400 ppm by the end of 2016. Analysis results regarding observation data on methane have helped to identify regions with high levels of anthropogenic methane. These results also suggest that satellite observation can be effectively used as a tool for monitoring and verifying emissions inventories. In FY 2012, the development of GOSAT-2, the successor to GOSAT, started, with the aim of further improving the observation accuracy. It is scheduled for launch in FY 2017. Multi-point observation data collected by the GOSAT and GOSAT-2 satellites will contribute to the science of climate change, global environmental monitoring and the formulation of measures against climate change. These satellites will also be used to collect data on carbon dioxide emissions from large cities and other large-scale emission sources.

The Japan Aerospace Exploration Agency (JAXA) has undertaken the development of the two GOSATs and the operation of the first GOSAT, and has continued to collect satellite observation data.

The MOE has promoted the observation of global carbon circulation in collaboration with related ministries and agencies to help clarify climate change and its effects. The ministry has also developed global carbon dioxide and methane observation technologies using GOSAT and has continuously monitored greenhouse gases using airplanes and ships, and using monitors in forests.

The National Institute for Environmental Studies has been continuously analyzing GOSAT data and distributing the results.

In May 2012, Global Change Observation Mission - Water SHIZUKU (GCOM-W) was launched for the purpose of elucidating the global mechanisms of climate change and the 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 to improve the accuracy of precipitation estimates.

Not only are the data used for research on climate change, but they are also used 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.

Water cycle observation satellite SHIZUKU (GCOM-W)

Source: JAXA

JAXA has performed observations with the Advanced Land Observing Satellite DAICHI (ALOS[1]) for research on the reduction of greenhouse gas emissions, which are increasing due to deforestation and forest degradation in developing countries (i.e., REDD+[2]). (The operation of this satellite ended in May 2011.) In May 2014, the

1 Advanced Land Observing Satellite
2 Reducing Emissions from Deforestation and forest Degradation in Developing Countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries

Advanced Land Observing Satellite-2 DAICHI-2 (ALOS-2) was launched. It has been expected to help in disaster prevention and management, and in solutions to global issues such as global warming through the wide and detailed coverage of disaster-stricken areas and the observation of forests. Satellite-based Earth observation has been continued to further contribute to increases in the accuracy of climate change prediction and to contribute to an understanding of the mechanisms behind water cycle fluctuations. Such observation has been done in cooperation with NASA under the international Global Precipitation Measurement (GPM) project, which uses a core satellite launched in February 2014. The Global Change Observation Mission-Climate (GCOM-C) satellite, which is scheduled for launch in FY 2016, will be developed under this project. The aim is to promote global satellite observation.

b) Observation by electromagnetic wave sensing

MIC and the NICT have been promoting R&D on an airborne polarimetric and interferometric synthetic aperture radar system (Pi-SAR2) that can observe the ground surface in disaster-stricken areas as needed, regardless of weather conditions. NICT is also analyzing data from the Superconducting Submillimeter-wave Limb-Emission Sounder (SMILES[1]) that the NICT developed in cooperation with JAXA, and is providing stratospheric observation data. MIC has implemented R&D on the electromagnetic environment and on 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[2] 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 linked to environmental changes, such as global warming. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been comprehensively observing global environmental changes, which are significantly influenced by the oceans. For this purpose, JAMSTEC is capitalizing on its advanced observation technologies that rely on research vessels and observation buoys. Additionally, JAMSTEC has been making full use of its supercomputer systems to develop the most advanced predictive models and simulation techniques. These are used to elucidate the possible impacts of global environmental changes on Japan and to help solve climate change problems from the viewpoint of marine science.

JAMSTEC's success helped significantly advance research on the long-term changes of deep waters in the Arctic Sea, as well as on the mechanism behind their warming, which significantly affects the global environment. MEXT and the JMA are participating in an advanced marine monitoring system (the Argo program[3]) for continuous observation of oceans around the world through international cooperation. The Argo program aims at the real-time monitoring and evaluation of oceans around the world based on Argo

1 Superconducting Submillimeter-Wave Limb-Emission Sounder: SMILES performs observations of the atmospheric limb by using an offset Cassegrain antenna. The high-sensitivity, low-noise superconducting receivers of SMILES receives submillimeter waves emitted by atmospheric trace species in order to measure the concentrations of ozone and other molecules. The frequency range from 300 GHz to 3,000. GHz is the submillimeter-wave range. GHz is the submillimeter-wave range. SMILES uses sub-millimeter waves ranging from 624 GHz through 650 GHz.

2 Space environment informatics technology is used for processing large quantities of diverse data collected from observations and simulations of the space environment and for extracting information from the processed data.

3 Argo is an international project for the continuous observation of oceans throughout the world. It is implemented through cooperation among more than 30 countries, including Japan and the U.S.A., as well as international organizations such as the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission of UNESCO (IOC).

floats deployed in these oceans.

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

(ii) Promotion of research that contributes to adaptation to climate change

MEXT has been promoting R&D towards the creation of basic information that will be necessary for the management of diverse risks posed by climate change. The Earth Simulator and other of the world's fastest supercomputers are used for this. By utilizing R&D results, MEXT aims at helping local governments to address adaptation to the adverse effects of climate change according to the geographical characteristics of the localities. In view of this, MEXT has been collaborating with local governments in the development of reliable techniques for predicting near-future effects of climate change, enhancing the definition of prediction data at ultra-high resolution, assessing impacts of climate change and evaluating the effectiveness of adaptation measures (See Chapter 2, Section 2, Paragraph 1(3).)

The MRI under the JMA has developed the MRI Earth System Model for global warming prediction. It can simulate the effects of aerosols on clouds, changes in the ozone layer and the carbon cycle. Using this model, the institute is making near-future climate change predictions (i.e., about 10-year lead time) 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.

MOE has been using the Environment Research and Technology Development Fund[1] and other funds for comprehensively advancing research on the 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 is used for comprehensive studies on ways of formulating global global climate change risk management strategies (FY2012 - FY2016), towards the understanding of risks and uncertainties that arise from global warming in Japan and throughout the world. With respect to science and society, rational climate change risk management strategies and options are proposed for Japan and the global community. The fund is also used for the study of integrated strategies regarding Comprehensive Strategic Research on the Mitigation of and Adaptation to Climate Change (FY2015 - FY2019), under which quantitative data will be developed to address measures for the mitigation of, and adaptation to, climate change.

Toward the steady promotion of Japan's measures against climate change, in July 2013, the Expert Committee on Climate Change Impact Assessment was established under the Global Environmental Subcommittee of the Central Environmental Council towards the development of an adaptation plan as an integrated, government-wide effort. This expert committee has been using existing studies in order to summarize climate change projections and impact assessments, and has been deliberating on the

1 Based on the understanding that environmental issues significantly and seriously affect the humanosphere, the Environment Research and Technology Development Fund, a policy-oriented competitive research fund, was created.

assessment of impacts on, and risks for, Japan. The deliberation results were consolidated into supplementary recommendations in March 2015. Based on those recommendations, the Cabinet decided on the National Plan for Adaptation to the Impacts of Climate Change in November 2015. According to the adaptation plan, climate change observation, monitoring, forecasting and assessment will be continued, and studies and other research on climate change will be enhanced toward the continuous accumulation of scientific knowledge.

To reduce the impacts of global warming on agriculture, forestry and fisheries, MAFF has formulated a MAFF plan for adaptation to climate change. Based on the plan, techniques are being developed for accurately predicting and assessing the future impacts of climate change on each sector of industry and on each production item. Prediction results have been used to promote the development of techniques for stable production as well as for developing breed varieties that are adaptable to climate change. MAFF is also supporting international efforts to help developing countries formulate climate change strategies and promote sustainable food supply.

NILIM of MLIT included disaster prevention and mitigation in its "disaster prevention, mitigation and risk management" issues to cope with a new stage of climatic changes, such as concentrated and regional heavy rainfall on the rise in recent days and is conducting research into anti-disaster measures for landslide and urban flooding caused by regional heavy rain, control of maximum possible river flooding and anti-inundation measures for cities through flexible ICT pump operation.

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 (See Chapter 2, Section 2-1 (1) and (3), and Chapter 3, Section 1 Paragrpah 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 (See Chapter 2, Section 3, Paragraph (1).)

■ Table 2-3-3 / Key projects to help solve global issues (FY2015)

Ministry	Implemented by	Project
METI	Agency for Natural Resources and Energy (ANRE)	Project for promoting the development of methane hydrates

4 Foundations of the State

(1) Enhancement of national security and critical technologies

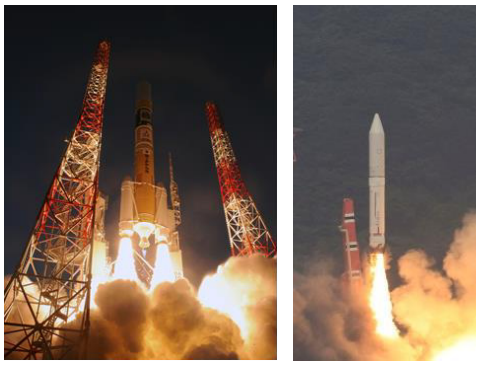
① The development and utilization of space technologies for space transportation and satellites

Space transportation technologies are essential for the utilization of space, because these are an integral

part of technologies for satellite launches. Technologies for sending satellites to their designated altitudes whenever needed are vital for the 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.

(i) Space transportation systems

The development of a new flagship rocket was formally started in FY 2014 to expand Japan's autonomous space activities and ensure international competitiveness. The first new rocket is scheduled for launch in 2030.



Launch of H-IIA F30 (left) and Epsilon-1 (right)

Source: JAXA

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

MIC and MEXT have been collaboratively conducting experiments to develop and demonstrate the following: large-scale satellite bus technology; large-scale deployable antenna and mobile satellite communications technology, using the Engineering Test Satellite VIII KIKU No.8 (ETS-VIII [1]); satellite-based gigabit-class Internet communications technology, using ultra-fast Internet satellite Wideband Inter-Networking engineering tests and the Demonstration Satellite KIZUNA (WINDS[2]). The Japanese government's intention to aim for the launch of an engineering test satellite around FY2021 is explicitlystated in its Basic Plan on Space Policy; thus, the development of the Next Engineering Test Satellite is scheduled to start in FY2016. This satellite will be developed for the purpose of demonstrating technologies of electric propulsion, high-power generation, and flexible payload.

Regarding global positioning satellite systems, MIC, MEXT, METI and MLIT have been collaborating on demonstration experiments that utilize the Quasi-Zenith Satellite-1 MICHIBIKI, which affords high-precision positioning that is unaffected by mountains or tall buildings.

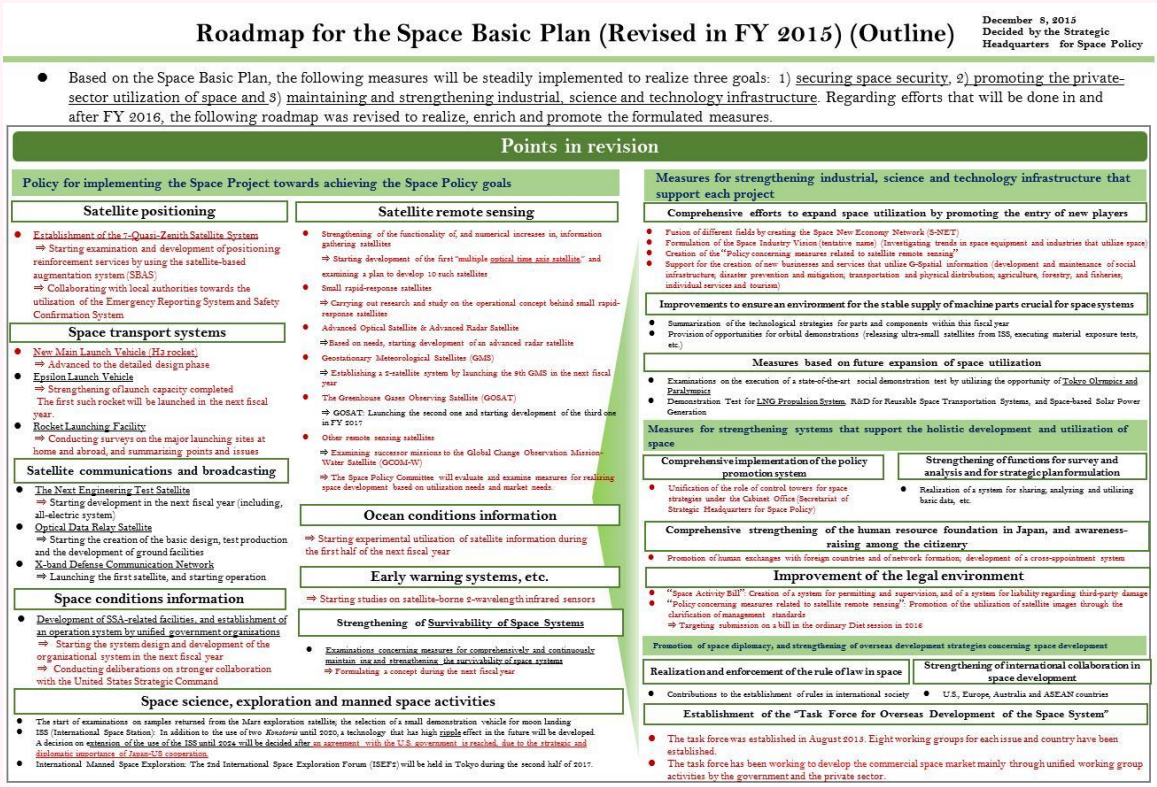
The Cabinet Office launched the development of a practical positioning satellite system in FY2012.

Regarding earth observation systems, the operation of the Advanced Land Observing Satellite DAICHI (ALOS) was completed in May 2011, and the second Advanced Land Observing Satellite ALOS-2, with remarkably improved radar performance was launched in May 2014. Distribution of data collected by ALOS-2 started in November, 2014. (See Chapter 3, Section 3, Paragraph 1.)

To ensure the stable operation of Japan's satellites, MEXT is working with the Cabinet Office and the Ministry of Defense (MOD) on research necessary for the development of a space monitoring system for the ground-based observation of space debris. MEXT is also conducting research on technologies for mounting sensitive infrared sensors on satellites (in cooperation with the MOD), research on advanced optical satellites capable of wide-area, high-resolution imaging, and the development of optical data relay satellites that can achieve intersatellite optical communication.

1 Engineering Test Satellite-VIII
2 Wideband InterNetworking engineering test and Demonstration Satellite

■ Figure 2-3-4 / Implementation schedule of the Basic Plan on Space Policy (summary)



Source: MEXT

(iii) Efforts for enhancing the use of space

Concerning the use of space, MEXT established a system for increasing the utilization of expertise possessed by government, industry and academia. Under this system, the fund for commissioning R&D to promote the use of space is used for the purpose of expanding the base of space users by discovering potential users of satellites and developing new utilization methods. With a view to creating a market for the aerospace industry, this fund is also used for R&D and human resources development that contribute to the enhanced use of aerospace technologies in disaster prevention, environmental conservation and other fields.

For the purpose of strengthening the infrastructure of Japan's space industry, METI has been promoting R&D on small high-performance satellites that compare well with large satellites in performance and are built at low cost in a relatively short period of time. R&D is also advanced regarding space equipment that is internationally competitive. METI is also advancing the development of sensors for the exploration of mineral resources using satellite remote sensing technologies and other satellite-based technologies, including those of data processing and analysis.

Regarding the two topics of "technologies for infrastructure maintenance, renovation and management" and "the enhancement of societal resiliency against natural disasters" in the Cross-ministerial SIP, the Cabinet Office has been supporting the development of monitoring techniques for early and extensive detection of ground displacement and structural deformation, as well as technologies and systems for

understanding/estimating the damage that results from disasters. These techniques, technologies and systems will be based on the use of Synthetic Aperture Radar (SAR) on satellites.

② Technologies for sea floor 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, mainly in potential hypocenters for Nankai Trough earthquakes and hypocenters for earthquakes off the Pacific coast of Tohoku. MEXT is also working to improve technologies for the early detection of earthquakes network systems. (See Chapter 2, Section 1, Paragraph 3, and, Chapter 3 Section 1, Paragraph 1.)

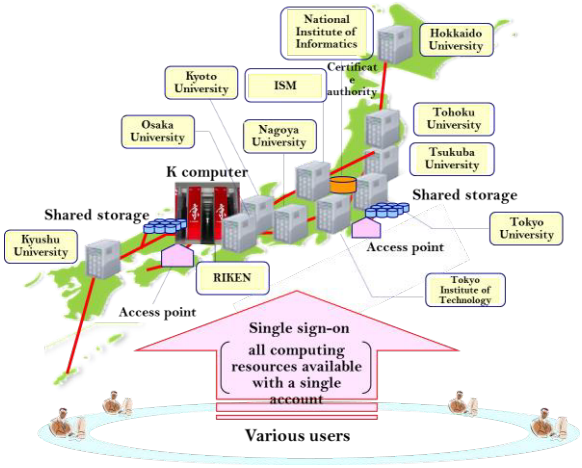
③ The development of Innovative, High Performance Computing Infrastructure (HPCI)

MEXT has been advancing the development of an innovative High Performance Computing Infrastructure (HPCI) that serves the diverse needs of users. The HPCI is based on the K computer, one of the world's most powerful supercomputers, which is connected via high-speed networks with other supercomputers and storage at universities and research institutions in Japan. By making the most of HPCI, MEXT has been supporting R&D in various fields for the purpose of producing innovative results, fostering human resources and developing research and education centers of advanced computer science and technology.

The K computer was officially made available for shared use as of the end of 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 Shared Use Act), 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 a registration organization supporting users of the K computer; and the HPCI Consortium, which consists of organizations that represent user communities. The K computer has been producing breakthrough results in strategic sectors.

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, innovate manufacturing and elucidate the origin of matter and the universe.

In FY 2014, MEXT commenced a project to develop the world's most powerful supercomputer and applications for that computer in a coordinated manner by 2020, toward solving the social and scientific issues that Japan is facing. In the process of system development, the basic design was completed in FY 2015, and the creation of prototypes and the specific design started. R&D on applications has been advanced by focusing on nine priority areas, including healthy longevity, disaster prevention and mitigation, energy and



Conceptual rendering of Innovative, High Performance Computing Infrastructure (HPCI)

Source: MEXT

manufacturing.

Through the coordinated development of the system and of applications for achieving world-leading results that address social needs, it is expected that various issues will be solved and innovations will be created.

④ R&D on nuclear power, including fusion

Nuclear R&D has focused on radiation decontamination and reactor decommissioning in order to promote recovery from the nuclear disaster caused by TEPCO's Fukushima Daiichi Nuclear Power Station. At the same time, MEXT has been engaged in R&D and human resources development to support nuclear infrastructure and safety. Because the need to develop and maintain a high level of nuclear technologies and human resources is stated in the Basic Energy Plan, MEXT started deliberations to address that need by forming a working committee on the development of human resources for nuclear energy under the MEXT Council for Science and Technology. As a result of the interactions between the WG on Voluntary Improvement of Safety, Technology and Human Resources (established under the Nuclear Energy Panel of Electricity and Gas Utilities Subcommittee, Advisory Committee on Energy and Natural Resources) and the Atomic Energy Society of Japan, METI summarized *a roadmap to LWR safety technologies and human resources* on June 16, 2015.

Regarding the Monju nuclear power plant, issues that need to be addressed such as the re-establishment of a system for its use, were discussed according to the Energy Basic Plan. Necessary measures were implemented for R&D on technologies for fusion and for nuclear nonproliferation and nuclear security. (Refer to Chapter 2, Section 2, Paragraph 1(1), for R&D on FBR cycle technologies and fusion, and to Chapter 3, Section 3, Paragraph 2(2) for the development of technologies for nuclear nonproliferation and nuclear security.)

⑤ Promotion of R&D on information security

For the purpose of comprehensively and effectively advancing measures for cybersecurity pursuant to the Basic Act on Cybersecurity, R&D on technologies for information security have been promoted on the basis of the Cyber Security Strategy, which was decided by the Cabinet in September 2015 after deliberations by the cybersecurity strategy headquarters led by the Chief Cabinet Secretary.

According to the Cyber Security Strategy, MIC has been working on R&D and the demonstration of technologies for the following: creating international networks for collecting information on cyberattacks and malware with the help of Internet service providers and universities at home and abroad; detecting signs of cyberattacks in cooperation with other countries; and making prompt responses to cyberattacks. To respond to an increasing number of targeted attacks that aim at stealing confidential information, practical exercises have been implemented to defend against cyberattacks that target government offices and significant infrastructure companies. R&D is also being promoted on technologies for detecting possible cyberattacks on the basis of the attributes of Internet users and the content of communications via intranets.

At the Control System Security Center, which has been operating since April 2013 in Tagajo City of Miyagi Prefecture, METI has established an organization that works improve the security of control systems and to assess, evaluate and certify such systems. Specifically, METI is doing the following: conducting R&D on the above, dispatching personnel to conferences on international standardization,

developing infrastructure for the certification of standards, fostering human resources and conducting public relations activities.

⑥ Development of technologies associated with the exploitation of ocean resources and energy

MLIT aims at market expansion in relation to ocean development. For this purpose, the ministry has been supporting the development of technologies for floating liquefied natural gas (FLNG) operation facilities and deep-water drilling platforms, because the demand for these facilities is expected to grow.

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

(2) Establishment of science and technology platforms for new knowledge frontier development

① The promotion of oceanographic R&D

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

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been conducting research and surveys that focus 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, towards deepening our understanding of phenomena related to the deep ocean floor, such as tsunamis and huge earthquakes that can cause devastating damage. With the aim of studying systems applicable to deep water exploration, MEXT set up Next-generation Deep-water Exploration Systems Committee under the Subdivision on Ocean Resources Development Subcommittee of the Council for Science and Technology.

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

MEXT has been developing advanced key technologies necessary for ocean resource exploration and is using these technologies for research and exploration. Within the framework of the program for developing technologies for promoting the use of marine resources: system development for the wide-area exploration of ocean mineral resources, which started in FY2013, MEXT aims at promoting the transfer of technologies to private companies. For this purpose, cutting-edge sensor technologies developed by universities have been further advanced, efficient wide-area exploration systems have been developed by combining multiple sensors, and new exploitation techniques have been developed and verified for practical application.

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) aims at accelerating research on submarine resources around Japan. For this purpose, JAMSTEC has been conducting wide-area surveys of seafloor topography and subseafloor structure by using autonomous underwater vehicles (AUV) and remotely operated underwater vehicles (ROV). In FY2015, the KAIMEI, a research vessel capable of performing detailed wide-area seafloor research, was built. Operation of this vessel will start in FY2016 after familiarization training.

In FY 2014, MIC started R&D on next-generation satellite communication technologies for marine resource surveys, in order to improve the efficiency of marine resource surveys. MIC has been developing

technologies to make Earth stations more compact and energy-efficient, and has been developing automatic satellite tracking systems.

In FY2014, the Cabinet Office started to work on a new research project of Next-generation Technologies for Marine Resources Survey under the cross-ministerial SIP. This project aims at establishing technologies for efficiently surveying cobalt-rich crusts and submarine hydrothermal deposits containing copper, zinc and rare metals before the rest of the world. These technologies will help create a marine resource survey industry. In FY2015, a system was built for collaboration among research institutions of multiple ministries and agencies, private companies and universities for implementation of the following: 1) scientific research on the genesis of marine resources, 2) the development of marine resource survey technologies and 3) R&D on technologies for the long-term monitoring and actual condition surveys of marine ecosystems.

(iii) R&D on exploration under the sea floor

For the purpose of understanding the subseafloor microbiosphere, the mechanisms of ocean-trench earthquakes and tsunamis, and the genesis as well as the possible existence of marine resources, JAMSTEC has been advancing the development of technologies for drilling by using the deep-sea drilling vessel CHIKYU and technologies for real-time observation by using submarine cable networks. These technologies are also utilized for surveys, research and the development of other technologies.

(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. The conservation of marine biodiversity and the 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 the Japan Science and Technology Agency (JST), R&D has been conducted on technologies for observing and monitoring marine species.

② The promotion of R&D on space science

(i) Solar system exploration and astronomical observation in space

Regarding R&D in space science, JAXA has been playing a pivotal role. JAXA has achieved globally unrivaled results in X-ray and infrared astronomical observation, such as by developing and operating the world's first satellite for simultaneous X-ray photography and X-ray spectrography and by using the Hayabusa probe to collect samples from a celestial body orbiting around the sun. In December 2015, JAXA succeeded in putting its Venus Climate Orbiter AKATSUKI (PLANET-C) into orbit around Venus.

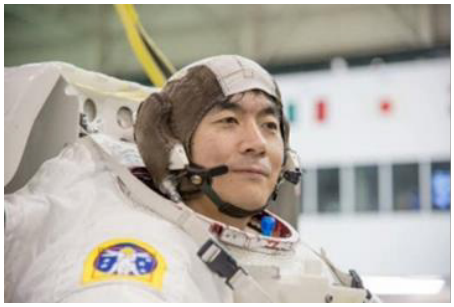
Venus Climate Orbiter Akatsuki

Source: JAXA

It was the first time for a Japanese spacecraft to enter orbit around a planet other than Earth. This space probe has been continuing to make observations, in order to elucidate the mysteries of the Venusian atmosphere. Hayabusa 2, an asteroid explorer launched in December 2014, made its closest approach to Earth in December 2015 when it performed a swing-by to set it on a course toward its target asteroid. It will collect soil samples from the Ryugu asteroid and will return to Earth in 2020. JAXA launched the X-ray Astronomy Satellite ASTRO-H (Hitomi) in February 2016 and developed the Mercury Magnetospheric Orbiter for the BepiColombo international collaborative mission to Mercury, which is being conducted in cooperation with the European Space Agency (ESA). JAXA has been active in establishing a leading position in the world as well as in promoting R&D on space science that helps broaden the frontiers of space for humans.

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

The International Space Station (ISS) Program[1] is an international project collaboratively implemented by five countries: Japan, the U.S.A., Europe, Canada and Russia. In this project, Japan assumes the role of developing and operating the KIBO (JEM) and the KOUNOTORI (HTV) automated cargo spacecraft. KIBO has been in service since its completion in July 2009, and KOUNOTORI has been used to resupply KIBO and the ISS. Japanese astronauts have carried out long-stay missions aboard the International Space Station.The Japanese team has achieved various things, such as establishing manned and unmanned space technologies, establishing an international presence (international standing) for Japan, expanding the space industry, contributing to society based on social benefits accruing from the use of space (e.g. generating high-quality protein crystals leading to drug discovery, acquiring medical knowledge, creating materials useful for next-generation semiconductors and launching ultra-small satellites), and educating young people. From July through December 2015, Kimiya Yui, a Japanese astronaut, stayed at the ISS and successfully guided the HTV to dock with the ISS. He also engaged in the operation of various systems, as well as in scientific experiments. In December 2015, the Japanese government signed an agreement with the U.S. government on a new framework for bilateral cooperation and formally decided to extend Japan's participation in the space station program through 2024, instead of through 2020 as formerly agreed by the countries concerned.




Astronaut Kimiya Yui (left); the HTV-5 and the Nile River (right)

Source: JAXA and NASA

1 The International Space Station is a cooperative program based on the ISS Intergovernmental Agreement between Europe, the U.S.A., Russia, Canada, and Japan for the joint development, operation and utilization of a permanently inhabited Space Station in low Earth orbit (about 400 km above the Earth's surface).

The International Space Exploration Coordination Group (ISECG), which consists of 15 space agencies from countries around the world, has been advancing studies on a sustainable international space exploration plan. Under In this plan, the ISS will be maximally used for staged missions to Mars that start with unmanned exploration and are followed by manned exploration.

Column 2-2

Launch of the Kounotori HTV-5, and the important roles of Astronaut Yui

Kimiya Yui, a Japanese astronaut, is the tenth Japanese to travel into space and the fifth to stay at the International Space Station (ISS) on a long-term mission. As a crew member of the ISS Expedition 44/45 mission, he was tasked with carrying out various experiments and operations at the ISS during a stay lasting the 5 months from July through December 2015.

Mr. Yui said that the highlight of his time at the ISS was the success of the Kounotori H-II Transfer Vehicle (HTV-5) operation in taking equipment and supplies up to the ISS. When Mr. Yui's stay at the ISS started, in the wake of back-to-back failures in resupply missions, countries participating in the ISS program pinned all their hopes on a resupply mission that used the HTV-5.

The HTV-5 captured by the ISS robotic arm (SSRMS)

Source: JAXA and NASA

The HTV-5 was successfully launched with the use of an H-IIB carrier rocket from the Tanegashima Space Center on August 19, 2015. Five days later, on August 24, the HTV-5 successfully docked with the ISS, thanks to Mr. Yui's skillful use of the ISS robotic arm; the help of Mr. Koichi Wakata, who controlled communications between the ISS and NASA's Johnson Space Center; and the work of Team Japan, consisting of ground control group members at JAXA's Tsukuba Space Center. "This success enhanced the credibility of Japan's space technology. "It was a success for Team Japan," said an admiring Prime Minister Abe. The success of the resupply mission strengthened Japan's international presence in space exploration.

The HTV-5, which was launched with the use of an H-IIB F5 carrier rocket

Source: JAXA

During his 142-day stay at the ISS, Mr. Yui conducted many experiments for Japan and other countries and succeeded in deploying two CubeSats developed by the University of Brasilia and the Chiba Institute of Technology, in addition to the resupply mission that used the HTV-5. He also installed payloads on board to enhance the capacities of the Japan Experiment Module KIBO, and he confirmed the functionality of the payloads.

The payloads that Mr. Yui installed include the CALorimetric Electron Telescope (CALET), for observing signatures of dark matter, and the Electrostatic Levitation Furnace

(ELF), for melting levitating materials with very high melting points (e.g., ceramics), in order to take measurements of their properties.

These payloads will be operated on a full scale by Takuya Onishi and Norishige Kanai, the two Japanese astronauts who follow Mr. Yui in staying at the ISS.

Astronaut Yui immediately after returning to Earth

Source: JAXA, NASA, and Andrey Shelepin

After completing many missions, Mr. Yui boarded a Russian Soyuz spacecraft together with his American and Russian colleagues and landed on the plains of Kazakhstan on December 11. The three astronauts helped each other during the space ride. Exiting the spacecraft, Mr. Yui smiled and said, "I'm home."

The HTV-6 is designed to transport lithium-ion batteries developed in Japan to replace existing batteries on which the ISS relies. Since the Kounotori is the only cargo spacecraft in the world that can carry large batteries, countries participating in the ISS program have high hopes for the launch of the HTV-6.

Japan wishes to achieve so much more by using the ISS and to enhance Japan's presence in the international community.

■ Table 2-3-5 / Major projects for maintaining the foundations of the state (FY 2014)

Ministry	Implemented by	Project
Cabinet Secretariat	Cabinet Information Research Office	R&D of the Information-Gathering Satellites
MIC	MIC	M2M Security Demonstration Projects
MEXT	MEXT	Financial contributions to the ITER International Fusion Energy Organization
		The development of wide-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 development of next-generation ultra-fast electronic computing systems
		Promotion of the use of specific advanced large research facilities (i.e., supercomputers)
		The operation of specific high-speed computer facilities
		Expenses necessary for the coordinated promotion of aerospace technologies
	JAXA	Grants for ISS development
METI	METI	Costs for commissioning research on standards for radioactive waste disposal
		R&D on technologies for the remote detection of oil resources
		R&D on hyper-spectral sensors
		Commissioning expenses for research on next-generation reprocessing and verification technology base
		Expenses for research on the advancement of security systems for electric power facilities
		R&D for Downsizing the High-Resolution Synthetic Aperture Radar
	ANRE	R&D on technologies for mining submarine hydrothermal deposits
		Costs for commissioning research on technologies for safety measures for nuclear fuel cycle facilities
		Subsidies for the development of technologies to improve safety measures for nuclear reactors
		Costs for commissioning the development of technologies for fast reactors
		Sea-floor mineral resource survey project
		Expenses for commissioning for surveys on geological disposal technology
MLIT	GSI	Costs for surveying electronic reference stations Promotion of marine research in the EEZ of Japan
MOE	Nuclear Regulation Authority (NRA)	Expenses for commissioning work on improvements to nuclear fuel research safety technologies for nuclear fuel cycle facilities
		Development of Criticality Risk Evaluation Methods
		Expenses for commissioning research on earthquake- and tsunami-resistant safety design evaluation standards for nuclear facilities
		Expenses for commissioning research on regulations for reactor design review Expenses for commissioning research on light water reactor thermal hydraulics at the time of a nuclear accident
MOD	Acquisition, Technology & Logistics Agency (ATLA)	Expenses for commissioning R&D on defense technology

5 Improvement and Enhancement of Common Science and Technology Infrastructure

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

① The development of technologies and instruments for advanced measurement and analysis

In line with the MEXT guidelines, test has been implementing Industry-Academia Collaborative R&D Programs (for the Development of Advanced Measurement and Analysis Systems). In collaboration with businesses 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 FY 2015, 46 prototypes had been developed and put into production.

■ Figure 2-3-6 / Examples of technologies and instruments for advanced measurement and analysis

Upper: The development of a fully automated analysis system that includes the preprocessing of samples using ultra-critical fluid technology and fast, highly accurate isolation and analysis (significant reductions in the use of organic solvents, preprocessing of unstable samples without experience or skill, and highly sensitive, fast, automated processing, isolation and detection)

Lower: Certified reference material for radioactivity analysis (developed for radioactivity analysis of food items and used for checking the validity of radioactivity analyses of food as well as for the calibration of instruments. The photo shows certified reference materials for the radioactivity analysis of *shiitake* mushrooms.)

Source: JST

② R&D on nanotechnology

MEXT has been promoting R&D on key technologies towards breakthroughs in environmental technologies. For this purpose, the ministry launched the Elements Strategy Initiative, in which technologies are developed for the use-reduction of rare earths, rare metals and other scarce elements, including the development of substitutes for these; and the Development of Environmental Technology using Nanotechnology, for the construction of a center for basic R&D on environmental technologies (See Chapter 2, Section 2, Paragraph 1(1).)

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 the precise prediction and analyses of materials properties; and novel designs 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 facing all humankind in terms of finding solutions to environmental/energy/resource problems and creating safe, secure infrastructure, NIMS has been promoting R&D for advancing environmental/energy materials as well as for enhancing the safety and reliability of materials. (See Chapter 2, Section 2, Paragraph 1.) Additionally, NIMS is promoting the MI²I: Materials Research by Information Integration Initiative, under which computer and data sciences are used for the short-term development of materials with innovative function.

The NICT of MIC has been promoting R&D with the aim of overcoming technological and performance limitations of ICT and of achieving dramatic advances in ICT. For this purpose, R&D on key technologies that use new atomic, molecular or superconducting materials has been implemented.

These key technologies include advanced quantum control, the control of single-photon signals, the utilization of unused frequency bands and the control/utilization of the atomic/molecular structure. METI has been working on developing nanocarbon materials, such as high-purity single-wall carbon nanotubes, that increase 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, the Tsukuba Innovation Arena (TIA-nano), which consists of four core institutions including the AIST, was established as a center for industry-academia-government collaboration, with the support of MEXT and the Cabinet Office. TIA-nano aims to serve as a global nanotechnology research center (See Chapter 2, Section 4, Paragraph 1(2).)

③ R&D on technologies for optical and quantum sciences

Because neutron beams, ion beams and other quantum beams have useful properties, these beams are used for fine observation, precision processing and the creation of substances.

Remarkable advances in S&T have raised the need for materials to be processed at the atomic/molecular level and for material structure to be investigated in detail. These were not possible before. Optical and quantum technologies are 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 R&D center for optical and quantum sciences since FY2008. This program aims at advancing R&D on optical and quantum sciences by using the potential of these sciences to address 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.

④ R&D on information science and technology

Because rapid advances in ICT have been accelerating the use of cyberspace and networking, the 5th Science and Technology Basic Plan defines our future society as a super smart society and focuses on the strategic enhancement of basic technologies and Japan's technological competitiveness, towards realizing such a society.

In the R&D Project for ICT Key Technology to Realize Future Society, MEXT has been working on R&D for the following technologies and systems: 1) basic technologies of spintronics materials and devices

for the development of basic technologies that realize super-low power consumption and the enhanced disaster resistance of information infrastructure as well as basic technologies for high-performance, highly available storage, 2) cyber physical systems for optimizing social systems and services, and 3) data integration and analysis technologies for utilizing big data.

For example, as part of the research on 2) cyber physical systems for optimizing social systems and services, Hokkaido University has been conducting a demonstration experiment on smart snow removal. Specifically, the university is using data collected from various sensors to identify locations of frequent traffic congestion in Sapporo and is improving the snow removal system for these locations.

Demonstration experiment of smart snow removal by Hokkaido University

Source: Hokkaido University

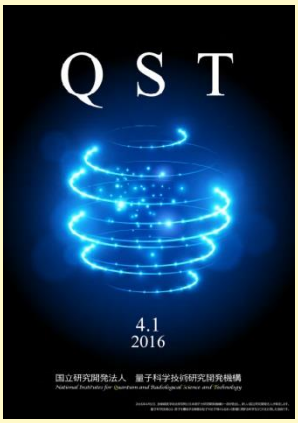
MEXT is working on developing innovative High Performence Computing Infrastructure (HPCI) for the purpose of advancing adequate scientific analysis, elucidation and prediction through the use of information science and technology (See Chapter 3, Section 1, Paragraph 4(1).)

⑤ 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 FY 2012 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, problems that are expected to be solved through the application of math, big data and mathematical optimization/control are chosen from among important problems. Collaborations of researchers from academia and business have been promoted. They are jointly solving these problems at the following venues: 1) workshops in which academic researchers in math, mathematical sciences and other scientific disciplines and researchers at businesses discuss how they can collaborate, 2) study groups in which specific topics of science and industry are chosen for intensive discussion by researchers specializing in these topics, 3) research exchange meetings attended by young researchers in mathematical science from academia and by researchers from businesses and 4) lecture meetings at Science Agora.

Column 2-3 National Institutes for Quantum and Radiological Science and Technology (QST), a new national research and development agency

On April 1, 2016, a new national R&D agency called National Institutes for Quantum and Radiological Science and Technology (QST) was established. Quantum science and technology are increasingly used in various fields including medical care, life sciences and materials; thus, they have been growing in importance recently as basic science and technology for creating innovations. For the comprehensive, integrated promotion of quantum science and technology, QST, which was established under the National Institute of Radiological Sciences (NIRS), assumes certain operations that were previously undertaken by the Japan Atomic Energy Agency (JAEA). The QST will continue to explore innovative research fields without limiting its commitment to conventional research areas. It is expected that the QST will serve as a center where diverse scientists and others work together to create innovations and will play active roles in research at home and abroad to deliver substantial results.



Poster publicizing the establishment of the QST

Source: QST

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

As infrastructure to promote S&T, research facilities and equipment support a range of R&D; thus, they need to be further advanced and used more efficiently and effectively. The 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: 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.

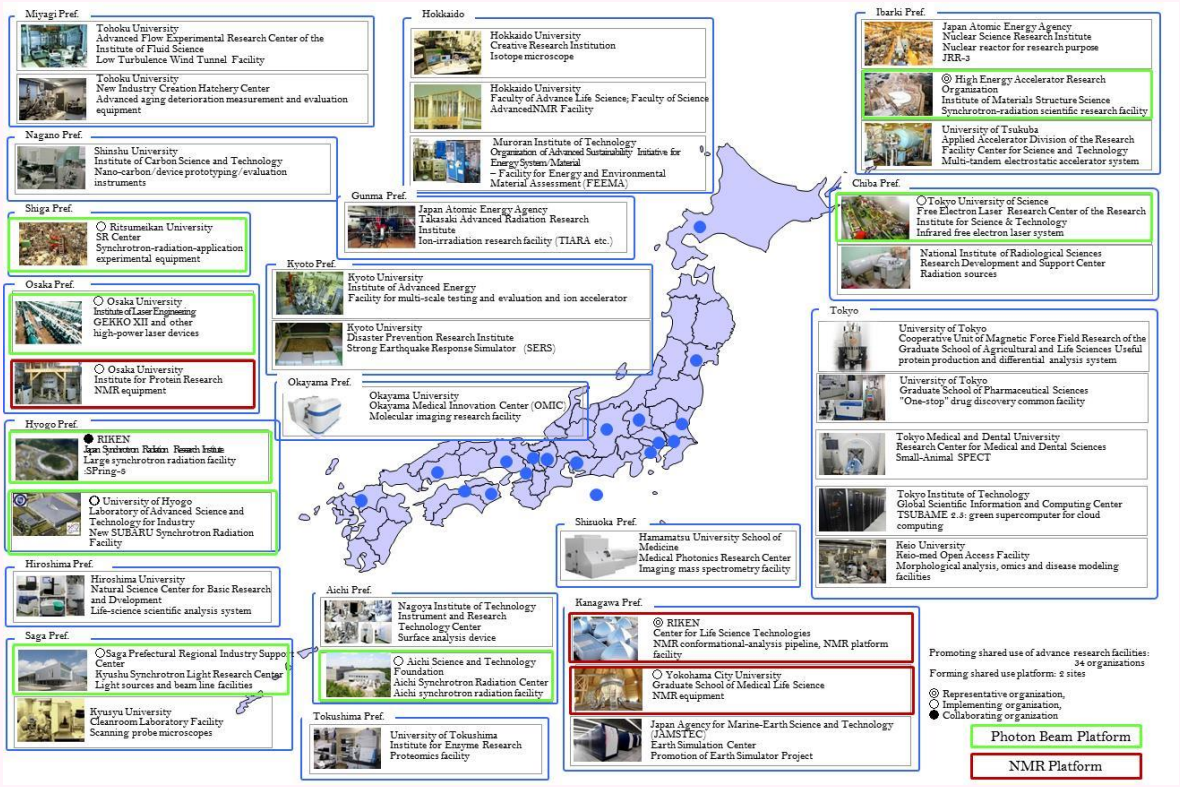
Pursuant to the R&D Enhancement Act, the government has been promoting the effective use of key general facilities and equipment by industrial, academic and government research institutions for diverse R&D on science and technology. The government is also working on networking these facilities and equipment 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 by providing expenses necessary for the development and sharing of large-scale research facilities pursuant to the Shared-Use Act. MEXT has been implementing the Program for the Creation of Research Platforms and Sharing of Advanced Research Facilities (Figure 2-3-7).

Through the Nanotechnology Platform, MEXT is providing a nationwide system for the shared use of advanced equipment and technology. Under that platform, research institutions that have cutting-edge nanotechnological research facilities and knowledge work closely to provide opportunities for researchers from industry, academia and government around the nation to use their facilities.

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



Source: MEXT

① Specified Large-Scale High-Technology Research Facilities

The Shared-Use Act defines large-scale research facilities of special importance as Specified Large-Scale High-Technology Research Facilities. This act stipulates the need for the systematic development and operation of these facilities, as well as for shared use in a fair, even manner.

(i) Super Photon ring-8 GeV (SPring-8)

SPring-8 is a research facility that delivers the top performance in the world in the analysis of atomic or molecular structure/function by using synchrotron radiation, the extremely bright light that is produced when electrons accelerated to near 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 various fields of research that help boost Japan's economic growth.

Super Photon ring-8 GeV (Spring-8) (Right) and An X-ray free-electron laser facility (SACLA) (left)

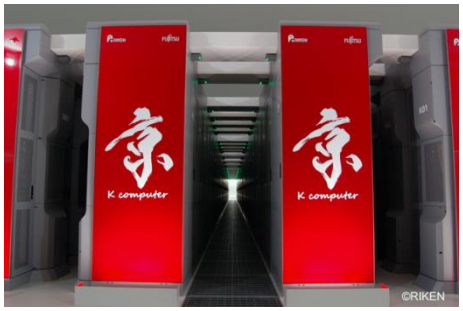
Source: RIKEN

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

SACLA is the most advanced research facility in the world with respect to the generation of light. The unprecedented light generated there has both laser and synchrotron radiation characteristics and allows original analyses that are not possible with conventional methods. The shared use of the facility was started in March 2012. MEXT launched the Priority Strategic Research Issues Using X-ray Free-Electron Lasers program in FY 2012, to generate leading, innovative R&D results that promote the development of pharmaceutical products and fuel cells and that help elucidate photosynthesis mechanisms through the instantaneous measurement and analysis of ultrafine atomic structures and ultra-fast progress or changes in chemical reactions.

(iii) The "K computer" supercomputer

As a third approach to S&T, following the theoretical and experimental approaches, supercomputer simulations have been crucial for cutting-edge S&T and improvements in industrial competitiveness. The shared use of the K supercomputer commenced at the end of September 2012 and has since underpinned breakthroughs in diverse fields, including advanced processes for novel drug development, the development of next-generation energy-saving semiconductors, manufacturing innovations, the mitigation of earthquake and tsunamis damage, and the elucidation of the origin of matter and the universe.



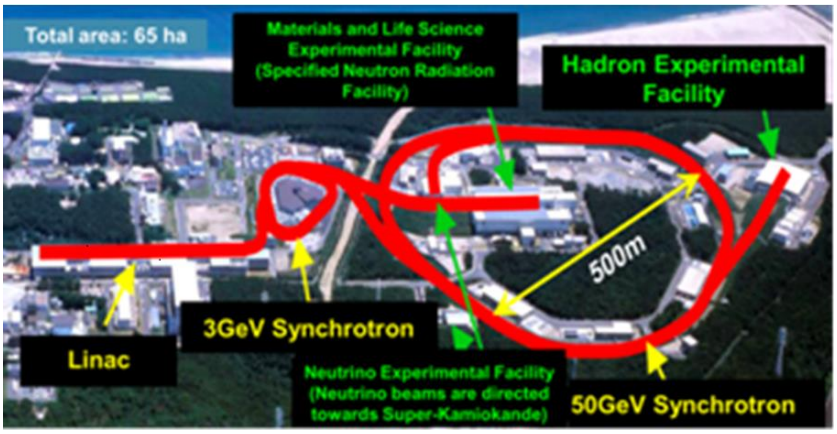
The "K computer" supercomputer

Source: RIKEN

(iv) Japan Proton Accelerator Research Complex (J-PARC)

J-PARC has been 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. The Specified Neutron Facility has been used for structural analyses that may spawn innovative materials and new drugs, and numerous results have been achieved. The Shared-Use Act is not applicable to the Nuclear and Particle Experimental Facility (Hadron Experimental Facility) or the Neutrino Experimental Facility, but these facilities are used jointly by university researchers in Japan and abroad. At the Tokai to Kamioka (T2K) neutrino experimental facility of J-PARC, a multinational physics experiment is under way to investigate neutrino oscillations, with the aim of clarifying the mysterious characteristics of neutrinos. The 2015 Nobel Prize was awarded for the discovery of neutrino oscillations.

1 A neutrino is a neutrally charged, elementary subatomic particle. It is extremely difficult to detect neutrinos because they can penetrate ordinary matter without leaving any trace, and little is known about their characteristics or masses.



Japan Proton Accelerator Research Complex (J-PARC)

Source: J-PARC Center

■ Table 2-3-8 / Key facilities for improving and enhancing shared-use S&T infrastructure (FY 2015)

Ministry	Implemented by	Project
MEXT	MEXT	R&D on key technologies of ICT for future societies (formerly: R&D for next-generation IT infrastructure)
		Nanotechnology Platform Japan
		Program for the creation of research platforms and the sharing of advanced research facilities
		Program for the development of key technologies toward the creation of an R&D center for optical and quantum sciences (competitive funds)
	MEXT, RIKEN Japan Synchrotron Radiation Research Institute (JASRI)	The development and sharing of the Super Photon ring-8 GeV (SPring-8) and the X-ray free-electron laser facility (SACRA)
	MEXT, JAEA High-Energy Accelerator Research Organization	Development and operation of the Japan Proton Accelerator Research Complex (J-PARC)
	JST	The development of advanced measurement and analysis systems
METI	METI	The development of economic infrastructure for cybersecurity

Section 2 System Reforms towards 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 is continuously advanced for technologies that are critical for national security, as well as for key facilities and equipment that are shared by multiple institutions across diverse fields. Thus, under 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 the Pioneering Research for the Future Project, in which 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 carry a relatively high risk, are implemented under government initiative. Investments focus on R&D for drastic measures for energy and environmental conservation. These teams work on the management of intellectual property and international standardization, in order to enhance 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, towards helping to create world-leading innovations.

Section 3 Strategic Development of Global Activities in an International Context

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 the 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 to solve problems common to Asian countries. Within the framework of the e-ASIA JRP, funding agencies from countries in the East Asia Summit (EAS) are promoting collaborative research projects in the following seven fields: health research (infectious diseases and cancer), agriculture (food), alternative energy, disaster risk reduction and management, environment (climate change and marine science), materials (nanotechnology), and advanced interdisciplinary research towards innovation. In the field of health research, the Japan Agency for Medical Research and Development (AMED) has been supporting international collaborative research since April 2015.

In August 2015, the JST decided to fund one research project as part of the Collaboration Hubs for International Research Program (CHIRP) 2015 within the framework of the Strategic International Collaborative Research Program (SICORP). SICORP has been promoted by MEXT and the JST in order to help solve global issues and issues common to ASEAN members, create innovations, enhance scientific and technological capabilities, and strengthen the foundation of collaborative research in the ASEAN

region.

MOE also supported the Asia-Pacific Network for Global Change Research (APN), in order to enhance researchers' capabilities in the Asia-Pacific region, and held its 20th annual inter-government meeting in March 2015 with the cooperation of Nepal's Ministry of Science, Technology and Environment. In October 2015, MOE hosted the 4th annual meeting of the Low Carbon Asia Research Network (LoCARNet), in Malaysia, to realize low-carbon societies in rapidly growing Asian countries.

2 New Developments in Science and Technology Diplomacy

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

① Active efforts toward international standardization

Based on the Intellectual Property Promotion Plan 2015, the government has been promoting an international standardization strategy as a joint effort of the public and private sectors to raise Japan's competitiveness in specific strategic S&T fields in which Japan excels.

METI has been implementing various projects with the aim of preparing and proposing a draft plan of international standards for specific fields so that domestic needs for strategic international standardization are met promptly and adequately. For example, international standardization is strategically accelerated for cutting-edge medical devices, next-generation vehicles, robots and other technologies. These are technological fields in which Japan hopes to dominate world markets. Based on the revised Japan Revitalization Strategy 2015, the Intellectual Property Promotion Plan 2015, and the standardization system for the creation of new markets, METI has been promoting the standardization of excellent technologies and products of small and medium-sized enterprises. Additionally, the partnership system for supporting and capitalizing on standardization was established and was made available in November 2015. Under the partnership system, partner organizations (i.e., local governments, industrial promotion organizations, financial institutions, universities and public research institutes) and the Japanese Standards Association mutually cooperate in providing information and advice to small and medium-sized enterprises regarding the strategic use of standardization in each region.

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 response to Consultation No. 18 of 2011) in 2012. With the aim of increasing the options available to ICT users and enhancing the global competitiveness of Japan's ICT industries, MIC is also collaborating with de jure standardization organizations such as the ITU and de facto standardization organizations in the private sector toward promoting the international standardization of ICT.

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

① The development of international networks of researchers

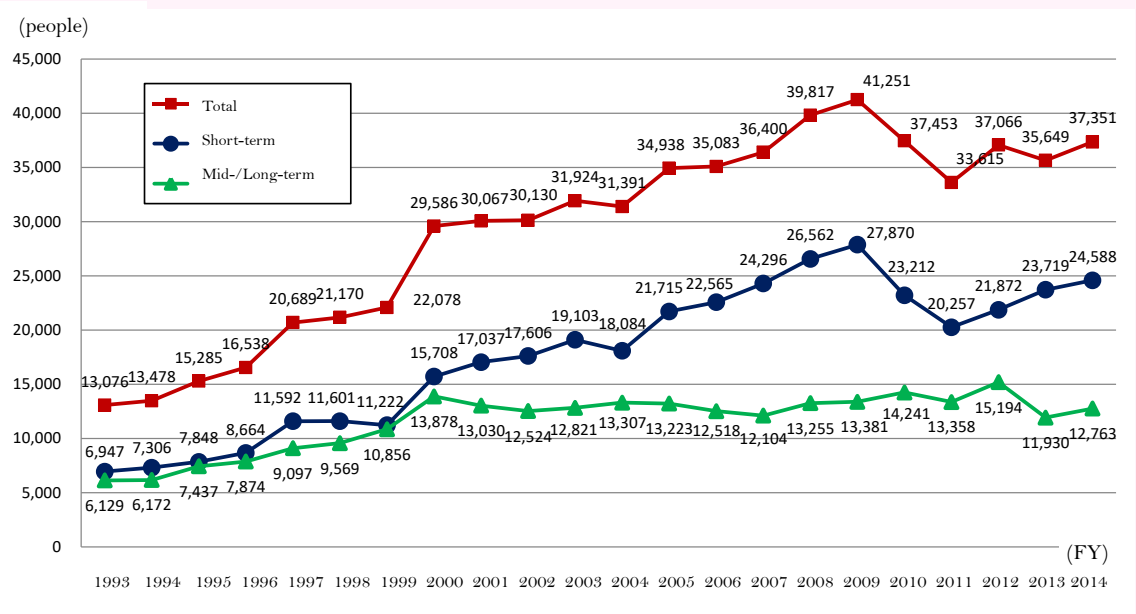
(i) International mobility of Japanese researchers

According to the Survey on International Research Exchanges in FY 2015, the total number of short-stay foreign researchers accepted by universities and independent administrative institutions in Japan showed a tendency to grow until FY 2009, while the number decreased in FY 2011 as a result of the

Great East Japan Earthquake and then rebounded. The number of foreign researchers on mid-length to long stays varied between 12,000 and 15,000 for every year since FY 2000 (Figure 2-3-9).

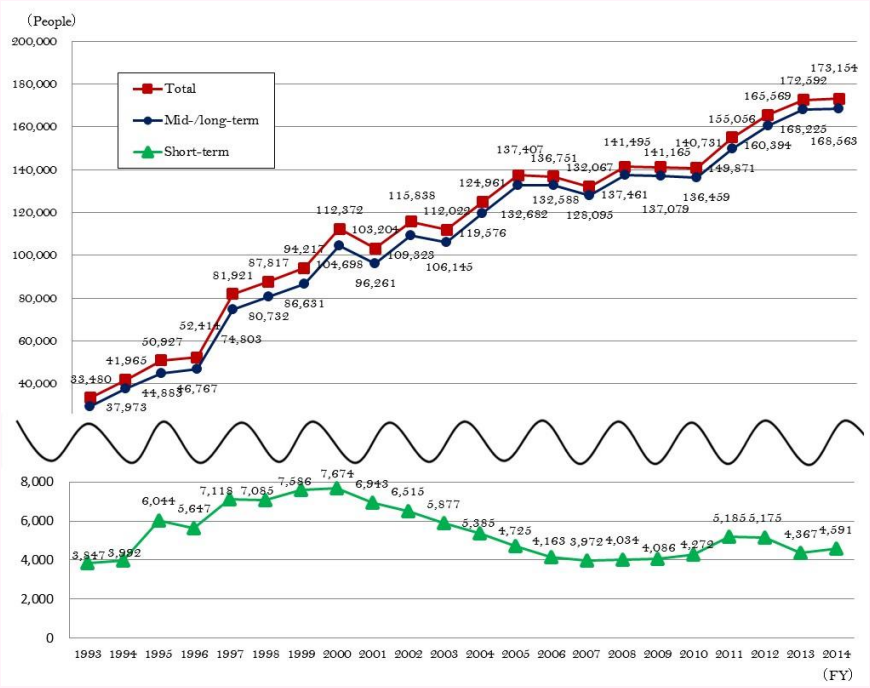
The number of Japanese researchers on short stays overseas has tended to grow since the start of the survey. The number of Japanese researchers on mid-length to long stays overseas varied between 4,000 and 5,000 for every year since FY 2008 (Figure 2-3-10).

■ Figure 2-3-9 / Changes in the number of foreign researchers in Japan (Short or mid-length to long stay)



Note: 1. "Short stay" means 30 days or fewer; "mid-length to long stay" means more than 30 days.
2. Postdocs and research fellows are included in the figures in and after FY2010.
3. The overlap in the number of foreign researchers accepted at multiple institutions was eliminated from FY 2013.
Source: Survey on International Research Exchanges, MEXT, April, 2016

■ Figure 2-3-10 / Changes in the number of Japanese researchers overseas (Short or mid-length to long stay)



Note: 1. "Short stay" means 30 days or fewer; "mid-length to long stay" 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, 2016

(ii) Efforts to promote 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 provided various programs for sending young researchers abroad or inviting excellent researchers from other countries to Japan.

The Strategic Young Researcher Overseas Visits Program for Accelerating Brain Circulation is a JSPS program to support universities and other research institutions that exchange young researchers with leading overseas research institutions and enable domestic research groups with high potential to strategically formulate research networks in their specialties. JSPS also offers the Postdoctoral Fellowship for Research Abroad. Aiming at fostering and securing highly capable researchers who have broad international perspectives and who will forge future academic activities in Japan, this fellowship program provides excellent young Japanese researchers with an opportunity to conduct long-term research at a university or research institution overseas.

Invitation programs such as the Postdoctoral Fellowship for Overseas Researchers are provided to give outstanding foreign researchers opportunities to work at universities in Japan according to their various career stages and purposes. In addition, the Bilateral Exchange Program supports a sustainable network between Japanese and foreign research teams.

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.

The JST started the Japan-Asia Young People Science Exchange Program in FY 2014 to invite young people (high school, undergraduate and graduate students and researchers aged under 40) from 15 Asian countries and regions, for a short period (one to three weeks) in the hope of acquiring outstanding foreign human resources.

② Large-scale international projects

(i) ITER (known as the International Thermonuclear Experimental Reactor)

The ITER project is managed under the international cooperation of seven parties, and Japan is promoting the production of superconductive coils, etc. (See Section 2-1 (1), Chapter 2.)

(ii) International Space Station (ISS)

Japan operates the Japanese Experiment Module KIBO and the automated cargo spacecraft KONOTORI (HTV) in the ISS program. (See Section 1-4 (2), Chapter 3.)

(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 (2003 to 2013).) Drilling vessels work in groups to drill deep sea floors worldwide. These include a Japanese deep drilling vessel, CHIKYU, that features the most advanced drilling capabilities of the science drilling vessels and a U.S. drilling vessel that are acting as the principal vessels of the IODP; and Mission-Specific Platforms provided by European consortium.

(iv) Large Hadron Collider (LHC)

In the Large Hadron Collider (LHC) project[1], the CERN member states, Japan and the U.S. collaborated to complete an accelerator in 2008, and now experiments are being performed.

(v) International Linear Collider (ILC)

A group of international researchers is planning to construct an International Linear Collider (ILC) to investigate the properties of the Higgs Boson particle in more detail, and an ILC Technical Design Report was published in June 2013.

The Science Council of Japan (SCJ) released The SCJ's view on the International Linear Collider (ILC) Project on September 30, 2013, in response to MEXT's request for deliberations on the ILC Project. Based on the SCJ's view, MEXT held a meeting of external experts in May 2014 and summarized deliberation results in June 2015. Deliberations on issues related to the ILC Project have been continued by a working group that was established to discuss measures for training and securing experts who can engage in the construction and operation of an ILC.

1 LHC project: In this experimental project, the large circular collider of CERN is used to reproduce extreme conditions similar to those of shortly after the Big Bang, with the aim of discovering unknown particles and the deep internal structure of matter.

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 science and technology, a system needs to be created for the continuous collection, accumulation and analysis of overseas information in a structured and organized manner, and for the use of such information across multiple sectors and disciplines. MEXT and other organizations have been working on this.

Specifically, the National Institute of Science and Technology Policy (NISTEP) collects data on current research activities regarding science & technology and universities abroad, and analyzes the data for comparison with the situation in Japan. This research and investigation is useful for enhancing Japan's science & technology policies.

The Center for Research & Development Strategy (CRDS) of the JST is investigating and analyzing overseas trends to benefit the formulation of STI policies. The 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 organizations engaging in science promotion and hold symposiums.

④ Systematic efforts to promote international activities related to science and technology

(i) Utilization of international frameworks

a) Activities related to summit meetings

In 2008, the G8 Science and Technology Ministers' Meeting was held under the auspices of the then Minister of State for Science and Technology Policy Fumio Kishida, according to a proposal made by Japan, which held the presidency at the time. Subsequent meetings, held on an irregular basis aimed to solve global issues using science and technology via negotiations on policy adjustments between the Minister of State for Science, Technology and Innovation Policy and other ministers of countries and aimed to proactively contribute to international discussions concerning science and technology policies in collaboration with other countries. The last meeting was held in Germany in 2015, and Yuko Harayama, an executive member of CSTI, attended the meeting.

The Group of Senior Officials (GSO) was founded following discussions at a 2008 meeting. That group discusses international research facilities, and its sixth meeting in Germany in April 2015, included discussions on the sharing of information on international research facilities and international collaboration frameworks.

LCS-RNet, a network of researchers/research organizations that are contributing to individual countries' low-carbon policy-making processes, had its 7th annual meeting in France in June 2015. As of 2015, 17 research organizations from seven countries including Japan were LCS-RNet members.

b) Asia-Pacific Economic Cooperation (APEC)

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 enjoyed participation by businesses and members of academia, for work on all kinds of innovation. The proposal was accepted at the 20th APEC Economic Leaders' Meeting in September 2012. The APEC Industrial Science and Technology Working Group (ISTWG) had been holding meetings for the purpose of improving industrial science and technology in the APEC member economies through joint projects and workshops.

The 5th and 6th meetings of the PPSTI were held in May and August 2015 to discuss the PPSTI activity plan. The Republic of the Philippines was the host economy.

In October 2015, the Third APEC Chief Science Advisor Meeting was held in Malaysia for the exchange of opinions among science advisors to governments, or the equivalent of such advisors, in the APEC region concerning issues and opportunities related to scientific advice to their governments. Yuko Harayama, an executive member of CSTI, also attended the meeting.

c) Association of Southeast Asian Nations (ASEAN)

The ASEAN Committee on Science and Technology (COST) and Japan, China and South Korea (COST+3) are cooperating on science and technology. MEXT is taking a leadership role in Japan's contribution to the ASEAN COST+3. In January 2015, the 8th ASEAN COST+3 Meeting was held in Tokyo for the exchange of opinions on cooperation between ASEAN and the three countries. As a framework for cooperation between Japan and COST, the 6th ASEAN-Japan Cooperation Committee on Science and Technology was held in Tokyo in January 2015 for the exchange of opinions about Japan and overall ASEAN scientific and technological cooperation in the future.

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 22nd APRSAF meeting in Indonesia in December 2015 had more attendees than any other APRSAF meeting held outside Japan. About 480 people from 28 countries and ten international organizations participated. It was the first time that attendees numbered more than 480 for an APRSAF meeting not held in Japan. The number of participants is steadily increasing. One major achievement of the initiatives conducted by the APRSAF is the Sentinel Asia Project. This project aims at reducing damage caused by natural disasters through the sharing of disaster-related information online, including the sharing of Earth observation satellite images. As of January 2016, 84 institutions and 15 international organizations from 25 countries and regions were cooperating in the project. In 2015, a total of 24 emergency observations were provided at times of natural disaster, including an earthquake in Nepal (July-August) and flooding in Myanmar.

(International Space Exploration Forum (ISEF))

The International Space Exploration Forum (ISEF) is a ministerial-level meeting to build support for global cooperation on space exploration. In September 2015, it was announced that Japan would host the second ISEF in the latter half of 2017.

(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 22nd meeting of the GBIF Governing Board was held in Antananarivo, Madagascar in October 2015, with the participation of member countries and others. The purpose was approval of the budget for 2016 and of the GBIF Strategic Plan 2017-2021.

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

GEOSS is a framework for comprehensive Earth observation. It consists of diverse observation systems, including artificial satellites and ground-based observation systems, whose linkage aims for the development of an information base that helps policy-making in eight areas related to social benefits (biodiversity and ecosystem sustainability, disaster resilience, energy and mineral resources management, food security and sustainable agriculture, infrastructure and transportation management, public health surveillance, sustainable urban development, and water resources management) and on global issues related to these eight areas, such as climate change (See Chapter 3, Section 1, Paragraph 3(1).)

(The Intergovernmental Panel on Climate Change (IPCC))

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) for the purpose of comprehensively assessing anthropogenic climate change and its impacts, adaptation to such impacts, and the mitigation of climate change from scientific, technological and socioeconomic viewpoints. The IPCC published the Fifth Assessment Report (AR5) in November 2014 and is implementing its sixth round of assessments, which started in 2015 (See Chapter 2, Section 2, Paragraph 1(3).)

(Innovation for Cool Earth Forum (ICEF))

At the suggestion of Prime Minister Abe, the government decided to hold an annual international meeting called the Innovation for Cool Earth Forum (ICEF), in Tokyo as an international platform for the promotion of discussion and cooperation among international academic institutions, companies and governments towards solving issues of climate change through innovations related to energy and the environment.

(ARGO Program)

MEXT and the JMA joined an advanced ocean monitoring system (the Argo Program) to understand the details of oceans worldwide and to improve the accuracy of climate change prediction (See Chapter 3, Section 1, Paragraph 3(1).)

(The Global Research Council (GRC))

In May 2015, the Fourth Annual Meeting of the GRC was held in Tokyo under the joint auspices of the National Research Foundation (NRF) of South Africa and the JSPS. The GRC is a forum that brings together the heads of major science-promotion organizations from around the world. The heads of 56 science-promotion organizations from 47 countries attended the Fourth Annual Meeting, where they discussed issues related to research support and roles that their organizations should assume. As achievements of the meeting, two resolutions were adopted: Statement of Principles for Funding Scientific Breakthroughs and Statement of Approaches: Building Research and Education Capacity.

(ii) Utilization of international organizations

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

Japan has been participating and actively cooperating in various science and technology 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 towards solving global-scale problems. Japan also helps to promote UNESCO activities by sending experts to contribute to discussions of committees/commissions. Japan has established funds-in-trust at UNESCO as a way of cooperating in science and technology human resources development in the Asia-Pacific region.

b) Organization for Economic Cooperation and Development (OECD)

The OECD engages in activities related to science and technology by developing statistical data and fostering 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).

In the CSTP, information and opinions concerning science and technology policies were exchanged and the role of STI in economic growth, improvements in research organizations, the roles of government and the private sector in R&D and international collaborations in R&D were studied. To discuss science, technology and innovation policies, the CSTP held a ministerial-level meeting in Daejeon, Republic of Korea, in 2015, its first meeting in 11 years. The Daejeon Declaration on Science, Technology, and Innovation Policies for the Global and Digital Age was adopted as an achievement of the meeting. The CSTP has four subgroups: the Global Science Forum (GSF), the Working Party on Innovation and Technology Policy (TIP), the Working Party on Bio-, Nano- and Converging Technologies (BNCT), and NESTI. Typical activities led by Japan as Chair or Vice-Chair are as follows:

(Global Science Forum (GSF))

In 2015, new projects, including those for examining a new framework regarding the sustainability of large-scale research facilities, were launched by the GSF[1].

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

The TIP makes examinations and gives advice on policies related to innovation and technology. These policies are expected to enhance productivity, foster sustainable economic growth, facilitate the creation, diffusion and application of knowledge for both societal and economic goals, and promote the creation of highly skilled human capital.

In the TIP meetings in 2015, government delegates discussed policies for implementing the Knowledge Triangle Project, the System Transformation Project, and other projects.

1 For the purpose of promoting scientific and technological cooperation among OECD member countries, the GSF serves as a venue for consultations among science policy officials of these countries regarding large-scale scientific R&D projects and issues of global concern. To exchange information on efforts in various countries and to produce recommendations for the future, the GSF explores opportunities for new or enhanced international cooperation in selected scientific areas, defines international frameworks for vital national or regional science policy decisions, and addresses the scientific dimensions of issues of global concern.

(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 science and technology indicators related to R&D spending, science and technology 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. In a meeting held in April 2015, NESTI approved revisions to the Frascati Manual, the OECD guidelines on the collection and use of R&D statistics. The Frascati Manual 2015 was officially announced at the CSTP ministerial-level meeting held in October 2015 in the Republic of Korea.

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 former weapons scientists from Russia and the CIS, who had engaged in the development of weapons of mass destruction with opportunities to redirect their talents to R&D conducted for peaceful purposes. With the withdrawal of the Russian Federation from the ISTC in July 2015, the ISTC head office was relocated from Moscow to Astana, Kazakhstan. In December of that year, the Agreement on the Continuation of the ISTC was signed by representatives of Japan, the European Union, the European Atomic Energy Community, the USA, Georgia, Norway, Kyrgyzstan, Armenia, Kazakhstan, the Republic of Korea, and Tajikistan.

(iii) Utilization of research institutions

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

ERIA is an institution that provides policy analyses and recommendations towards promoting 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.

(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 EU, the U.K., Switzerland, Canada, Italy, Australia, the Republic of 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 overseas research travel and stays, and holds HFSP awardees' meetings.

(v) Efforts by Japan's scientific institutions

(International activities by the SCJ)

The SCJ has been contributing to Japan's cooperation with other countries by representing Japan in 45

international scientific organizations, including the International Council for Science (ICSU) and the Global Network of Science Academies (IAP[1]).

In May 2015, the 15th Conference of the Science Council of Asia (SCA[2]) was held in Cambodia to urge Asian countries to collaborate and establish partnerships in scientific fields.

In November 2015, the SCJ produced documents concerning the operation of Future Earth, after meetings of the Committee for Scientific Community and other committees related to governance. Future Earth is a new initiative that aims to solve global issues. The SCJ leads the Japan Consortium for Future Earth, which supports the Japan Global Hub of the Future Earth Global (Permanent) Secretariat.

Ahead of each summit, science councils of the G7, including the SCJ, have been delivering a joint statement to world leaders from a scientific perspective since 2005.

Before the G7 summit at Ise-Shima in Japan in May 2016, the SCJ hosted the G-Science Academies' Meeting in February in Tokyo for discussions on "brain resources," "disaster resilience" and "the nurturing of future scientists."

(vi) Efforts for the peaceful use of nuclear energy

Japan concluded the Safeguards Agreement with the International Atomic Energy Agency (IAEA) in 1977 and signed the Additional Protocol in 1999. Pursuant to the agreement and the protocol, Japan has been complying 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 Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Law No. 166 of 1957) (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 a leadership role towards advancing international cooperation related to R&D on technologies for nuclear nonproliferation and nuclear security, as well as on those 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 nonproliferation 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 the JAEA. This center has provided training courses in nuclear nonproliferation and nuclear security to more than 2,600 officials and personnel from 73 countries, including Japan. In 2013, the ISCN and the IAEA made a rule 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, Japan-U.S. joint efforts have been made in developing technology for the following: 1) the continuous monitoring of the quantity of plutonium in high-level radioactive solutions, 2) the non-destructive detection of nuclear fuel material

1 The IAP is a global network of science academies that was established in 1995. The SCJ was an IAP Executive Committee member in the years 2004-2006, 2007-2009 and 2013-2015.
2 It consists of 31 scientific organizations from 18 countries. The topic of the 15th conference was "Science and Technology for Culture."

by means of nuclear resonance fluorescence, and 3) nuclear forensics that identify the origin of illegal nuclear material. Through these efforts, the Japanese government has been promoting international cooperation for the development of technologies and human resources in relation to nuclear nonproliferation and nuclear security, while also securing international trust in Japan's use of nuclear energy for peaceful purposes.

(vii) Other international efforts

In October 2015, the Cabinet Office held the Science and Technology Ministers' Roundtable Meeting, which was hosted by Shunichi Yamaguchi, Minister of State for Science and Technology Policy and was attended by ministers responsible for science and technology policy, science advisors and others from 25 countries, to discuss Strategies for Inclusive Innovation: The Role of International Cooperation in Science, Technology and Innovation.

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

To promote science and technology cooperation with developing countries in Asia, Africa and Latin America, MEXT, the JST, AMED, MOFA and JICA, which have necessary expertise, have been collaboratively implementing the Science and Technology Research Partnership for Sustainable Development (SATRPS[1]) program by utilizing Japan's advanced science and technology and ODA. These projects address issues relating to the environment, energy, bioresources, natural disaster prevention, and infectious diseases. From FY 2008 through FY 2015, 101 SATREPS projects in 43 countries (including 54 projects in Asia and 26 projects in Africa) were adopted for implementation. In the 4th Annual Global Meeting of the Global Research Council (GRC) held in May 2015 in Tokyo, Prime Minister Abe announced that new international joint research would be started that would focus on neglected tropical diseases (NTDs) in Africa. On the basis of that announcement, AMED established the International Collaborative Research Program for Tackling NTDs in Africa and adopted three R&D projects for implementation under this program.

MEXT launched a program that combines international joint research with government scholarships for international students. Specifically, the government provides scholarships for international students who wish to study at Japanese universities that participate 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.

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 to address global-scale issues such as poverty reduction and climate change. For this purpose, assistance has been provided through international joint research projects for the development of crops resistant to drought and other environmental stresses, 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 in order to develop techniques for increasing the

1 The Science and Technology Research Partnership for Sustainable Development

production of rice, root crops and legumes.

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

① Cooperation with other countries

(i) Cooperation with India and other emerging nations

Japan-India Science Seminar

Source: MEXT

In December 2015, the Japan-India Science Seminar was held in Delhi to promote Japan-India cooperation in advanced science fields. JETRO hosted the Japan-India Innovation Seminar. That seminar introduced the science and technology of Japan and the distinctive features of universities and research institutions in Japan. Taking that opportunity, the JST and the Government of India's Department of Science and Technology (DST) agreed to cooperate on establishing an international collaborative research center with an aim of strengthening research infrastructure, solving common issues, and fostering innovation.

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

For cooperation with China, the 15th Joint Committee on Science and Technology Cooperation was held in Beijing in April 2015. Discussions were held on cooperation to date and in the future.

Within the framework of Japan–China–South Korea trilateral cooperation, the Minister of Education, Culture, Sports, Science and Technology has attended the Japan-China-South Korea Ministerial Meetings on Science and Technology Cooperation. The Japan–China–South 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. In addition to Japan–China–South–Korea trilateral cooperation, Japan is promoting bilateral science and technology cooperation with China and South Korea. For this purpose, the government has been exchanging information and researchers and has been supporting the implementation of bilateral joint research with China and South Korea.

The JSPS supports exchanges between research centers in Asia towards establishing scientific research networks and fostering young researchers by launching the A3 Foresight Program and conducting other activities.

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

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

been supporting the implementation of joint research.

In October 2015, the 13th ministerial-level meeting of the Japan-US Joint High-Level Committee on Science and Technology was held in Tokyo for discussions on significant topics related to science and technology in Japan and the U.S.A. The Third Japan-US Open Forum was held under the joint auspices of MOFA and MEXT in cooperation with the JST and the U.S. Embassy in Japan. At the forum, government officials and scientists representing academic and industrial communities in Japan and the U.S.A. discussed The Future of Japan-U.S.A. Science and Technology Cooperation —How should science be developed for better life in the world? What potential science and applications should Japan and the United States explore?

Following 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, based on an agreement made with the EU. Joint ICT research started in 2013. The Third coordinated call for joint ICT research was made in October 2015. Japan also convened the Joint Committee on Science and Technology Cooperation with the EU in May 2015, Hungary in June 2015, the Netherlands in November 2015, Sweden in February 2016, and Finland in March 2016.

In October 2015, the 5th EU–US–Japan Trilateral Conference on Critical Materials was held in Tokyo with attendance by government officials, materials engineers and other experts from Japan, the U.S.A. and Europe, which account for large shares of global demand 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 the development of rare-earth alternative materials and rare-earth recycling technologies.

(iv) Cooperation with other countries

Japan is also holding joint committee meetings, promoting exchanges of information and researchers, and promoting the implementation of joint research with Australia, Russia, South Africa, Brazil and other countries, based on bilateral Science and Technology Cooperation Agreements.

Human resource development and exchanges, as well as collaborative research, are promoted for the future with emerging countries.

② Policy dialogs regarding science and technology initiated by the private sector

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

Column 2-4

The Fourth Annual Global Meeting of GRC held in Tokyo

In May 2015, the Fourth Annual GRC was held in Tokyo under the joint auspices of the JSPS and NRF of South Africa. Heads of 52 research-funding agencies from 47 countries and representatives of four international organizations attended the meeting in order to address issues related to research support and to actively discuss the roles that these organizations were supposed to play in promoting international research cooperation.

In a video address shown at the beginning of the meeting, Prime Minister Abe spoke about innovation and the positive effects it can have on society. He said that diverse and creative research activities based on free thinking by researchers would lead to innovation.

On the day before the annual meeting, the Global Symposium of Scientific Breakthroughs was held. The symposium consisted of lectures and a panel discussion by experts with a profound knowledge of science and academic research.

In the four years since the establishment of the GRC in 2012, its activities have had a growing influence on academic and scientific development worldwide. The 4th Annual Global Meeting of the GRC, in Tokyo, was a good opportunity for Japan to demonstrate its positive contributions to the international promotion of scientific research.

The topics for discussion at the meeting were ① Research Funding for Scientific Breakthroughs and ② Building Research and Education Capacity. The following resolutions were adopted: Statement of Principles for Funding Scientific Breakthroughs and Statement of Approaches: Building Research and Education Capacity.

Representatives of science-promotion organizations from many countries

Source: JSPS

(Statement of Principles for Funding Scientific Breakthroughs)

Broad, robust scientific research infrastructure provides the wellspring for breakthroughs and innovation. Future breakthroughs are ensured by long-term investments and stable, sustainable, multifaceted financial support for research. Based upon this recognition, the Statement of Principles for Funding Scientific Breakthroughs provides the following five principles: 1. Freedom, flexibility and risk-taking in the pursuit of research; 2. Diversity in research funding support; 3. Effective screening processes and adequate assessment of research; 4. Cooperation and linkage among researchers, government, academia, industry and the public; 5. International collaboration in advancing science that leads to breakthroughs.

(Statement of Approaches: Building Research and Education Capacity)

The development of research and educational capabilities is a matter of vital importance for all people working in a global research framework. To develop such capabilities, system development at the national level is required, in order to identify research needs, commission or implement research, conduct collaborative research, disseminate research results, and ensure that research results are translated into applications or are used for policy formulation. Thus, the Statement of Approaches: Building Research and Education Capacity outlined the following four approaches to the development of research and education capabilities: 1. Creating collaborations, partnerships and networks; 2. Sharing good practices in research management; 3. Providing support to ensure sustainable research and education capabilities over the course of the recipients' careers; and 4. Taking specific actions for capability-building.