Chapter 2 Science, Technology and Innovation Policy Toward Realization of Society 5.0

Section 1 Transformation to a sustainable and resilient society that ensures the safety and security of the people

This chapter is on the government's initiatives to redesign Japanese society and transform it into a society that enables each individual to realize well-being by solving global issues ahead of the world and ensuring the safety and security of the people.

1 Creating New Value through the Fusion of Cyberspace and Physical Space

To realize Society 5.0, the goal of the 6th Basic Plan, our aim to is to create new value by merging cyberspace and physical space. Specifically, the goal is to create a high-quality digital twin using a monnwide variety of data in cyberspace, based on the digital twin, change physical space by actively using AI, and reproduce the result in cyberspace and transform society into a society that creates a dynamic virtuous cycle that is constantly changing.

❶ Strategy and organization for building cyberspace

The "Basic Act on the Formation of a Digital Society" (Act No. 35, May 19, 2021) and other laws related to digital transformation were promulgated on May 19, 2021. The Digital Agency was launched on September 1, 2021, as the control tower for forming a digital society.

The Digital Agency will inspect and review the conformity of regulations and systems to digital principles and bring full-fledged structural transformation in Japanese society; concerning regulations that use analog methods, such as regulations that rely on the human eye, the Agency will first conduct cross-sectional inspection and review of such regulations taking into account the possibility of using digital technology such as high-precision cameras and infrared sensors, create new growth industries resulting from the streamlining of the regulations, and achieve economic growth to enable citizens and business operators to gain the benefits of digitalization and realize growth.

In addition to the inspection and review of the existing laws and regulations, the Digital Agency aims to build processes and systems for autonomous checks of the conformity of drafts of Bills and regulations to digital principles, to realize a digital society.

Also, a "Bill on the Use of Information and Communications Technology to Make Payments That Become Part of the National Revenue" was submitted on February 8, 2022, at the 208th National Diet Session and passed and enacted on April 27 of the same year to enable cashless payments of fees and other charges for administrative procedures.

Furthermore, the government formulated the "National Data Strategy" on June 18, 2021, aimed at clearly defining principles of conduct for each player concerned with data, including administrative agencies and private companies, building cyberspace, and creating new businesses and administrative services utilizing data.

❷ Development of data platforms and provision of highly convenient data utilization services

In May 2021, National Strategy Office of IT, Cabinet Secretariat, designated specific data, such as land and maps, for the base registry that will form the basis of data utilization services. In the future, the base registry will be developed gradually in cooperation with the relevant ministries and agencies.

In addition, the Digital Agency formulated the "Basic Policy for Development and Management of Information Systems" (decided by the Minister for Digital Transformation on December 24, 2021), which is an important policy, particularly from the perspective of information systems, for the national government, local governments, incorporated administrative agencies, and other related parties to work in collaboration effectively. The Digital Agency also conducts reviews throughout the year at each stage of the project, before the budget request, at the time of the request, and at the time of execution and the results of the reviews are appropriately reflected in the budget request and execution, thereby aiming to reduce the system modification expenses included in the operation and maintenance cost of government information systems, by 30% in FY2025, which amounted to a total of 540 billion yen as of FY2020.

Furthermore, to promote digitalization and data linkage in semi-public sectors such as health and medical care, education, and disaster prevention and provide personalized services to users, the Digital Agency is working on conducting research and demonstration in each field under cross-ministerial and cross-agency systems.

To enhance the industrial competitiveness of Japan and realize safe and secure data distribution, the Digital Architecture Design Center established at the Information Technology Promotion Agency, Japan, has been working on the design of architecture, including standards for linking systems and data that have been individually developed among different businesses and sectors.

The Cabinet Office, Government of Japan, is developing "Cross-Sectoral Data Linkage Infrastructure Technology" to realize data linkage across sectors under the SIP Program "Big-data and AI-enabled Cyberspace Technologies." When a connector for this technology is installed in the data infrastructure of each sector, data can be easily provided, searched, and retrieved. Using this technology, the government aims to build a cross-sectoral data linkage mechanism by demonstrating the linkage of the Research Data Infrastructure System and the sector-specific data infrastructures to be built under SIP, etc.

❸ Building a reliable data distribution environment, including data governance rules

The Digital Agency is examining and studying the current situation, issues, and rules for developing an environment to promote data distribution (information banks, data transaction markets, etc.).

In addition, the Digital Agency and the Cabinet Office of the Government of Japan have formulated the "Guidance for Implementing Data-Handling Rules on Platforms, Ver. 1.0" on March 4, 2022, providing perspectives and procedures for review when data handling rules necessary for dispelling concerns and anxiety of stakeholders about data distribution and promoting data distribution, are implemented on the platforms of the semi-public sectors, etc.[1]

At the same time, for personal authentication and assurance of data authenticity that supports data society as a whole, the Digital Agency is investigating the actual situation of disincentives

1 https://cio.go.jp/sites/default/files/uploads/documents/digital/20220304_policies_data_strategy_outline_01.pdf

to digitalization and trust needs pertaining to transactions and procedures and examining the direction of appropriate trust services while also paying attention to international cooperation by organizing the assurance levels considered necessary depending on the types of transactions and procedures.

❹ Next-generation infrastructure for the digital society and development and R&D of data /AI utilization technologies

1. Next-generation infrastructure for the digital society

In order to respond to the rapid increase of network traffic, diversification of service requirements and complication of networks in Society 5.0, MIC conducted R&D aimed at practical use of an optical transmission system exceeding 5 Tbps per operation unit, and R&D for automation of communication network operation taking advantage of artificial intelligence. MIC has also performed verification tests for specific usage scenarios and conducted R&D to achieve lower power consumption and smaller size of 5G base stations, keeping in mind further social implementation of the 5th generation mobile communication system (5G). Furthermore, since 2019 MIC has been conducting R&D for further advancement in reliability, energy efficiency, etc. of 5G. Besides, from FY2020 the ministry is implementing development demonstration of local 5G assuming various actual usage scenes. The aim is to enable various entities including local enterprises to construct their own 5G system according to their individual needs.

In addition, R&D on ultra-high-definition video interface technology, beam control technology, and wireless signal processing technology was conducted to develop applications for the wireless communication infrastructure technology that enables uncompressed transmission of ultra-high-definition video using terahertz waves.

National Institute of Information and Communications Technology (NICT) worked on R&D of device technologies and integration technologies aiming to realize a wireless communication system at the level of 100Gbps using terahertz waves, and fundamental technologies regarding signal source, detectors, etc. In order to respond to rapid increase in communications traffic and power consumption accompanying ICT use, NICT promoted R&D on all-optical network that realizes networks with ultra-high speed and low-power consumption.

Because 5G with further enhanced functions including ultra-low latency and multiple concurrent connection (“Post 5G”) is expected to be used for diverse industrial applications including the smart factory and automated driving, METI is tackling the development of Post 5G-compatible information communication systems and related technologies such as the semiconductors used in the system. In addition, as the IoT and electrification of industries progress and the importance of supporting semiconductor-related technologies increases, the government has initiated research and development for the advancement of new generation power semiconductors and semiconductor manufacturing equipment to realize electronic products with more efficient energy conservation by utilizing Japan's high-level elemental technologies, etc. In March 2021, MIC established research and development funds at NICT to support research and development by companies and universities to realize Beyond 5G, a next-generation information and communications infrastructure that is expected to serve as a foundation of all industrial and social life in the 2030s. By the end of FY2021, a total of 47 research and development topics were selected to conduct research and development related to elemental technologies necessary for the

realization of Beyond 5G having features such as ultra-high speed and ultra-large capacity, ultra-low latency, ultra-multiple simultaneous connections, autonomy, scalability, ultra-safety and reliability, and ultra-low power consumption, using these funds.

2. Development and R&D of AI utilization technologies

The government formulated "AI Strategy 2019" as a comprehensive policy package in June 2019 in the context of the education reform, R&D, social implementation, etc. related to AI, and the initiatives based on the strategy have been carried out integrally based on "AI Strategy 2021" formulated in June 2021 in collaboration among the relevant ministries and agencies. For example, to promote comprehensive and integrated information dissemination and exchange of opinions among AI researchers, the government has established and operating the AI Japan R&D Network based on this strategy with the National Institute of Advanced Industrial Science and Technology (AIST), RIKEN, and NICT as core organizations, which promotes collaboration among universities and research institutions, etc. that proactively engage in AI research and development, and 116 universities and public research institutions in Japan have joined the network as of the end of February 2022. The strategy also will promote fundamental/linking R&D concerning artificial intelligence and develop research infrastructure.

In addition, MIC at NICT has developed a system for objective assessment of human emotions using brain activity analysis technology. Using this system, the ministry developed an efficient information processing process based on the unconscious value judgments appearing in brain activities, etc., and is making efforts toward its social implementation. In addition, intending to realize universal communication where everyone can understand each other, MIC is conducting research, development, and demonstration of multilingual translation, interactive systems, and behavioral support using advanced technologies such as deep learning technology that uses a vast amount of data including voice, text, and sensor data.

At the Center for Advanced Intelligence Project that was established at RIKEN, MEXT has been promoting (1) elucidation of the principle of deep learning and development of basic technologies for generic machine learning, (2) R&D on AI and other basic technologies for further development of the fields where Japan has its strengths and solutions to social challenges, and (3) research of Ethical, Legal and Social Issues arising from the spread of artificial intelligence technologies (ELSI [1]). In FY2020, the ministry promotes R&D on Trusted Quality AI (AI systems capable of explaining the basis for their decisions), R&D using AI technology to address COVID-19 (promotion of behavior change and individual optimization through media and pedestrian traffic flow analysis, etc.) and other R&D based on the AI Strategy 2019, etc. Furthermore, JST has been providing integrated support for unique ideas of young researchers in artificial intelligence and other fields and for challenging research tasks in order to open the way for new innovations (AIP Network Lab[2]).

METI brought together excellent researchers and technologies at the Artificial Intelligence Research Center (AIRC) established at AIST in May 2015. As a hub for research by universities and industry, the center has been working to create an environment that produces an efficient cycle for commercializing the results of goal-oriented basic

1 Ehical, Legal and Social Issues
2 Advanced Integrated Intelligence Platform

research. Specifically, the center has worked on advanced research on artificial intelligence integrating data with knowledge, the development of tools for artificial intelligence frameworks and advanced core modules that enable the early bridging of research results. In addition, the ministry established "AI Bridging Cloud Infrastructure (ABCI)," a large-scale and power-saving computing system with the world's top level AI processing performance, which has been operated by the Department of Information Technology and Human Factors of AIST , and the processing capacity was expanded in FY2020 in response to high demand from the industrial sector and the expanded capacity was made available to the public in May 2021. Furthermore, based on METI's "Development of Next Generation Artificial Intelligence, Sensing and other Core Technologies for Realization of IoT Society", the New Energy and Industrial Technology Development Organization (NEDO) launched the "Development of AI-Based Innovative Remote Technologies" project in FY2021 to form the basis for innovative remote technologies that enable advanced state estimation and information presentation of remote environments using artificial intelligence. In addition, as part of the "Development of Integrated Core Technologies for Next-Generation AI and Robots" project for the advancement of energy demand and supply structure, started in FY2018, METI is working on research and development to accelerate the implementation of AI technologies that contribute to the advancement of energy demand and supply, development of basic technologies to accelerate the introduction of AI dramatically, and development of AI technologies to support the transmission and efficient utilization of "skills and tacit knowledge (experience and intuition) of experienced professionals" accumulated at design and manufacturing sites in the manufacturing sector.

Also, for efficient use of the massive amount of information that has increased with the advent of IoT society, METI has been working on development of a computing technology pertaining to innovative ultra-low power consumption AI chips that operate on the edge side of the network, and a next-generation computing technology that combines high-speed and low power consumption based on a new principle (e.g., brain type computer, quantum computer), and optoelectronics technologies. Under the "Innovation Promotion for Acceleration of AI Chip Development," the ministry has been supporting AI chip development by private companies by building an AI chip design center equipped with design tools and verification devices that were necessary for AI chip development.

❺ Fostering human resources who will play a vital role in the digital society

With rapid progress of innovations and bewildering evolution of technologies in recent years, there is an increased need for commercialization of technological innovations including AI, big data and IoT and at the same time development of human resources who can promote structural reform of industries by using the technologies toward realization of the fourth Industrial Revolution and Society 5.0.

With the aim of achieving the goal of the strategy: "all humanity and science students of universities and colleges of technology (about 0.5 million graduates/year) master introductory-level skills" and "students of universities and colleges of technology (about 250,000 graduates/year) master basic skills for application in their respective fields" MEXT developed and is using a model curriculum (literacy level and advanced literacy level)

systematizing the basic concept of mathematics, data science and AI education, learning objectives/skill set, education methods, etc. The curriculum has been spread to universities, etc. across the country through development of teaching materials, and collection and compilation of actual social challenges and real data, which can be used for education.

Based on the AI Strategy 2019, the government certifies excellent programs on mathematics, data science and AI education provided in universities and colleges of technology. Seventy-eight educational programs were given a certification of literacy level in FY2021, and the certification system for the advanced literacy level is scheduled to be established in FY2022. This certification system aims to foster an environment where not only the government but the entire society including industry actively evaluate initiatives of individual universities, etc. to improve the quality of education.

The "Doctoral program for Data-Related InnoVation Expert" has been implemented since FY2017 with the aim of developing training programs for top-class experts in various fields in order to cultivate abilities to play key roles using data science, etc. in academia and industry. In addition, MEXT has been working on the "Statistics Professors Training Programs" since FY2021, with the aims of fostering personnel with advanced statistics skills and building an ecosystem of human resource development on the subject.

MIC launched the Innou-vation program. (Innou is Japanese for "unusual talent.") The program, which is under the Strategic Information and Communications R&D Promotion Programme (SCOPE), supports R&D on fantastic and ambitious technological themes.

METI through the Information-technology Promotion Agency has been implementing the "The MITOU program" to discover and train excellent individuals (IT creators) who have original ideas and skills to create innovations taking advantage of IT.

❻ Contribution to the international society on the ideal digital society

To establish a global framework for data distribution toward the realization of Data Free Flow with Trust (DFFT), the Digital Agency has been implementing measures for solving issues that need to be addressed in promoting international data distribution, such as data quality, privacy, security, mutual trust in infrastructure, rules, and standards.

The Cabinet Office, Government of Japan is considering how to respond to international discussions on the ideal way of a digital society, etc., in cooperation with relevant ministries and agencies, while taking into account the technological outcomes obtained through the efforts to establish a data collaboration infrastructure.

In view of the Expo 2025 Osaka, Kansai, Japan, MIC are implementing R&D for realization of "simultaneous interpretation" by AI covering also business and international conference discussions by further advancing the multilingual translation technology of NICT under the "Global Communication Plan 2025" (March 2020).

The Ministry of Foreign Affairs (MOFA) and the Japan International Cooperation Agency (JICA) are working to promote cooperation that

contributes to the building of a digital society in developing countries under their official development assistance projects, including the utilization of digital technologies in various fields of development, development of human resources and industries that will be responsible for digitalization as a foundation for such utilization, and strengthening of cybersecurity capabilities, etc.

❼ New policy themes

The Cabinet Office, the Government of Japan, is reviewing measures to promote the use of data across national borders, measures to promote the construction of digital twins in the public and private sectors, measures to attract highly skilled human resources from around the world to Japan, and measures to reflect social acceptance in policies, through various efforts based on AI Strategy and National Data Strategy while taking into account trends in discussions by relevant ministries and agencies, such as support for DFFT.

2 Promoting Social Change and Disruptive Innovation to Overcome Global Issues

The goal is to achieve carbon neutrality by 2050, which will reduce carbon house gas's overall emissions to zero by 2050 and create a society in which a virtuous cycle between the economy and the environment is created by taking actions to realize a circular economy through sound and efficient waste treatment and advanced recycling of resources, which will lead to economic growth through the development of the green industry.

❶ Promotion of R&D and cost reduction of innovative environmental technologies

1. Environment Innovation Strategy and Green Growth Strategy

Based on the "Environment Innovation Strategy" and other such strategies, the government is strengthening its research and development of innovative technologies related to promising areas. In addition, by formulating a "Green Growth Strategy Through Achieving Carbon Neutrality in 2050," the government is promoting research and development and demonstration of innovative technologies and their implementation in society, utilizing Green Innovation Fund projects that provide continuous support for the development of innovative technologies.

2. Promote research and development toward carbon neutrality

To promote the development of carbon recycling technologies in which CO_2 is treated as a resource, separated and captured, and recycled into concrete through mineralization, into chemicals through artificial photosynthesis, and into fuels through methanation [1], etc. to reduce CO_2 emissions into the atmosphere, METI has formulated the "Roadmap for Carbon Recycling Technologies" in June 2019 and revised it in July 2021 in light of the latest trends. In line with this roadmap, METI is developing Sustainable Aviation Fuel (SAF), concrete production technology using CO_2, and bio-production process technology to produce biomass-derived chemicals.

Aiming at the practical use of CO_2 Capture, Utilization and Storage (CCUS), METI is advancing R&D for the demonstration of an integrated system designed to separate, capture and transport CO_2 from large CO_2 emission sources and store it underground at depths of

1 Technology to synthesize methane, the main component of natural gas, by synthesizing carbon dioxide and hydrogen.

more than 1,000 m, and also developed technologies to drastically reduce costs and improve safety. In steel manufacturing, METI carried out (1) Hydrogen reduction process technology development project (COURSE50[1]), and (2) Ferro coke technology development project, with the aim of reducing CO_2 emissions significantly and saving energy in the steelmaking process. For (1), METI developed iron ore reduction technology using hydrogen and CO_2 separation and capture technology using unused waste heat in the ironmaking process. For (2), METI developed technologies to lower the temperature and increase the efficiency of iron ore reduction reactions using coke (ferro coke), which is produced by effectively utilizing low-grade raw materials.

MOE has been compiling (1) costs of separating and recovering most of the CO2 from exhaust gas from coal fired power plants, (2) design and construction of Japan's first full-scale CO_2 separation/recovery equipment toward assessment of degradation in power generation efficiency and environmental impact, and (3) methods for smooth introduction of Carbon Capture and Storage (CCS) suitable for Japan. METI and MOE have jointly conducted geological investigations, including elastic wave explorations, to determine areas suitable for CCS in Japan. Since FY2018 the ministries have been implementing demonstration of CO_2 Capture and Utilization (CCU), artificial photosynthesis and methanation initiative as well as examination and evaluation of the CO_2 reduction effects over their lifecycle.

METI is conducting demonstration of HEFA[2] technologies, including ATJ[3] technology (producing SAF[4] from alcohol using catalyst technology), gasification FT[5] synthesis technology (reacting materials such as wood with water vapor and oxygen to produce hydrogen and carbon monoxide, and producing SAF by reacting the gas and catalyst), and microalgae culture technology utilizing carbon recycling, in order to commercialize sustainable aviation fuels (SAF) that will contribute to decarbonization initiatives in the aviation field.

In addition, through the Green Innovation Fund Project: Development of Technology for Producing Fuel Using CO_2, etc. Projects, METI plans to support technologies that will enable mass production of SAF (ATJ technology).

JST is promoting research and development of innovative biotechnologies to produce chemical products from biomass that will replace petroleum products, under the "Strategic Creative Research Promotion Project: Advanced Low Carbon Technology Research and Development Program (ALCA)" and MIRAI program: "Low Carbon Society" mission area.

RIKEN has been conducting leading studies on the cyclic use of carbon, which has been consumed in petrochemical products, through interdisciplinary studies on plant science, chemical biology, catalytic chemistry and biomass engineering.

Another RIKEN endeavor is R&D on the establishment of innovative bioprocesses towards the discovery of new materials derived from biomass.

1 CO_2 Ultimate Reduction System for Cool Earth 50
2 Hydroprocessed Esters and Fatty Acids
3 Alcohol To Jet
4 Sustainable Aviation Fuel
5 Fischer-Tropsch

COLUMN 2-1

Direct Air Capture, the Last Trump Card Against Global Warming

The problems of climate change and marine pollution caused by plastic waste and other pollutants are major global issues for the future. Goal 4 of the Moonshot R&D Program, "Realization of sustainable resource circulation to recover the global environment by 2050", aims to address the issues of global warming "Cool Earth" and environmental pollution "Clean Earth" through the realization of sustainable circulation, for the global environment. R&D projects of Goal 4 are developing technologies to reduce greenhouse gases and plastics that biodegrade to harmless levels in the marine environment (Reference 1).

Among these, Direct Air Capture, a technology that "directly captures CO_2 from the atmosphere", is expected to be the "trump card" and "savior of decarbonization", and competition to develop this technology is intensifying around the world. The concentration of CO_2 in the air is very low at 0.04%; hence, it is not easy to capture CO_2, and it requires an enormous amount of energy to capture and separate CO_2 in large amounts. Therefore, there is an urgent need to develop technologies to capture CO_2 energy efficiently.

Under the "Development of technologies to recover greenhouse gases and convert them into valuable materials" projects, which are parts of Moonshot Goal 4, innovative technologies are being developed to "capture CO_2 with an ultra-thin membrane", "absorb CO_2 with honeycomb structures", "trap CO_2 in concrete", and "utilize microorganisms capable of absorbing CO_2 and turning it into a resource". Both the technology of a rotor with a "honeycomb structure" that allows air to pass easily and has a large surface area and of a new absorbent amine that can capture CO_2 with energy as low as the waste heat from a factory, are already developed, thus offering a prospect of significantly reducing the energy required for capturing and separating CO_2. The ultra thin membrane of 34 nanometers thickness has also been developed. The aim is to capture CO_2 with high efficiency by sending air to this membrane and utilizing CO_2 by converting it into a "compound that can be used as a resource." Through the combined use of the "conversion unit" and the "ultra-thin membrane", the projects aims to develop a system that can easily capture CO_2 anywhere and convert it into a resource.

<Reference URL>
1 Cabinet Office, Government of Japan Website
https://www8.cao.go.jp/cstp/moonshot/index.html

CO_2 permeable membrane of 34 nanometer
Provided by: Kyushu University

3. Initiatives for Moonshot

The Moonshot R&D Program sets nine goals for science and technology to proactively take on the challenges facing Japan, such as an aging and declining population, extreme natural disasters and global warming, and to open up future growth areas (refer to Chapter 1, Section 2 2 4). The program sets "Realization of sustainable resource circulation to recover the global environment by 2050" as the target in goal #4, aiming to solve the global warming problem (the Cool Earth) and environmental pollution problem (the Clean Earth) through the realization of sustainable resource circulation for the regeneration of the global environment. The program sets "Creation of the industry that enables sustainable global food supply by exploiting unused biological resources by 2050" as the target in goal #5, which aims to satisfy both food production and global environmental conservation.

4. Global Zero Emission Research Center

AIST established the Global Zero Emission Research Center (GZR) on January 29, 2020. GZR conducts basic research on key technologies for the Environment Innovation Strategy, including in the fields of renewable energy, rechargeable batteries, hydrogen, separation and utilization of carbon dioxide, and artificial photosynthesis through international collaboration, and also promotes its activities as an innovation hub such as international conferences of leaders gathering national research institutes from G20 nations on clean energy technologies (RD20) and serves as the secretariat of the Tokyo Zero-emission Innovation Bay (Zero-emission Bay).

5. Initiatives for agriculture, forestry and fisheries

In addition to medium- to long-term R&D, Ministry of Agriculture, Forestry and Fisheries (MAFF) is promoting technology development with a view to field implementation with clear goals in order to overcome challenges in the agriculture field by using science. For example, aiming at stable food supply, productivity improvement of agriculture and other purposes, MAFF is conducting research to develop super-high-yielding crop varieties, crops suitable for harsh environments, and breeds of cow with high lifetime productivity. To help achieve Japan's food self-sufficiency target, MAFF is also working to develop food and feed crops that have novel features in terms of quality and processability and techniques for differentiation and quality improvement of livestock products by using domestic feed.

Smart agriculture demonstration projects were conducted across Japan in 182 districts to develop smart agriculture technologies, such as automatic driving systems for agricultural machinery using satellite positioning information and image data and robotized harvesting of vegetables and fruit trees, and to clarify the economic benefits of introducing these technologies to production sites (as of March 2022). To disseminate the demonstration results, MAFF published a pamphlet introducing the details of the initiatives, a video that summarizes the "real voices" of the farmers and students who participated in the demonstration, and the first-year results of the districts selected in FY2020.

In addition, to realize the "Fukushima Innovation Coast Framework," MAFF will develop advanced technologies in agriculture, forestry and fisheries using ICT and robotics, promote on-site demonstrations, and social implementation initiatives for contributing to addressing the new issues faced by the field.

In order to accelerate social implementation of

smart agriculture in light of the challenges experienced in the fields, the ministry compiled the direction of measures in the Smart Agriculture Promotion Comprehensive Package (formulated in October 2020 and revised in February 2021).

Based on this package, the ministry pursued steady implementation of the demonstration and dissemination of the results, fostering of agriculture support services including farm work contracting and agricultural machinery sharing, and verification of the safety and rulemaking for robotics that requires solution of safety issues before installation in the field.

MAFF, in cooperation with related government ministries and agencies, started to study the standardization of agricultural information and the development of open APIs [1] to link agricultural machinery and other data to promote the use of data in the agricultural field. In February 2021, the "Guidelines for the Development of Open APIs in the Agricultural Sector" was established to provide guidelines for agricultural machinery manufacturers, ICT vendors and other businesses.

ICT services are being developed for farmers using the "Agricultural Data Collaboration Platform (WAGRI)," a data platform that enables the linkage and provision of various data types. In addition, research and development are being conducted for a "smart food chain" that aims to optimize the food chain by connecting agricultural production, distribution, processing, consumption and export with data.

As the global focus on SDGs and environmental issues accelerates, it is necessary to take the initiative in establishing sustainable food supply chain. In May 2021, MAFF launched the "Strategy for Sustainable Food Systems, MeaDRI" that aims for enhancing productivity potential and ensuring sustainability of agriculture, forestry, fisheries and food industries in Japan through innovation, and shared the concept of the strategy among stakeholders including producers, food industries and consumers to achieve it. In addition, MAFF submitted the "Bill Concerning Promotion of Low Environmental Impact Business Activities to Establish a Food System in Harmony with the Environment" and the "MeaDRI Sustainable Food Systems Bill" to the 208th session of the Diet for developing technologies and community actions that contribute to reducing environmental load.

The Public Works Research Institute is implementing research on improvement and maintenance of agricultural production base in snowy cold regions to contribute to enhancement of the food supply, and fisheries base in cold sea to contribute to enhancement of the food supply.

Since FY2020, MAFF has been working on the development of carbon sink technology using materials including biochar, blue carbon and wood biomass as climate change reduction technologies in agriculture, forestry and fisheries. The ministry is also developing implementation-scale climate change reduction technologies that can reduce GHG emissions and improve productivity in rice paddies, dry field crops and horticultural facilities, and has newly started developing a technology to significantly reduce the breeding period for forest species with excellent carbon sequestration capabilities. The ministry is also promoting the development of GHG emissions reduction technologies for agriculture through global cooperation, such as the development of methane emission reduction technology for methane derived from fermentation in the digestive tract of cows, the development and use of BNI[2]-enhanced crops, and the practical application of AWD[3].

1 Application Programming Interface
2 Biological Nitrification Inhibition
3 Alternative Wetting and Drying

Also, MAFF has been working on the development of driftwood disaster prevention and damage reduction technologies, as well as technologies for the management of pests and invasive alien species as part of climate change adaptive technologies.

In order to support development of new cultivars by private companies and other breeders using genetic resources of plants from foreign countries, MAFF has been promoting bilateral joint research with mainly other Asian countries and conducting surveys focusing on collection and evaluation of genetic resources. While in its genebank project concerning genetic resources is for agricultural purpose, NARO collects, preserves, evaluates and provides genetic resources of rice and other crops.

MEXT publishes the Japanese Standard Tables of Food Composition, which lists the composition of the Japanese diet. With the aim of considering how the Japanese Standard Tables of Food Composition should be improved and utilized, MEXT conducted a survey of food composition analysis, etc., based on the demand for the accumulation of high-quality information corresponding to modern dietary habits.

COLUMN 2-2

Discovery of a New Species of Bacteria in the Stomachs of Dairy Cows, which is Expected to Limit Methane Generation
- Potential Contributor to the Reduction of Methane Emissions from Cow Burps -

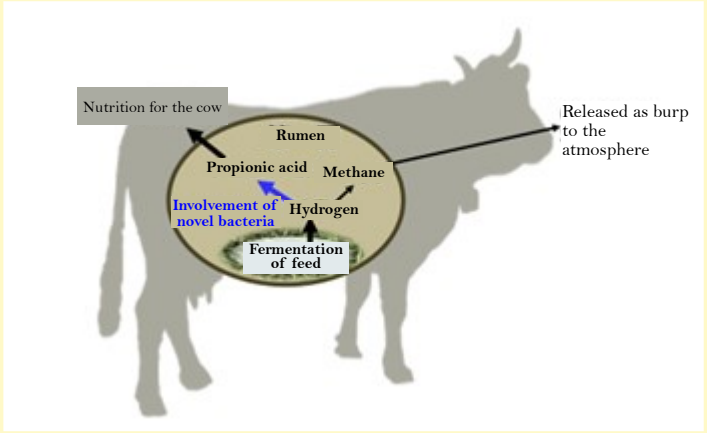
The National Agriculture and Food Research Organization (NARO) has discovered a new species of bacteria in the stomachs of dairy cows, which is expected to limit methane generation.

At the 26th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 26) held in November 2021, the Global Methane Pledge was launched with the aim of reducing global methane emissions by 30% below 2020 levels by 2030. More than 100 countries have announced their participation, as reducing methane emission, a greenhouse gas, has become an important international issue.

In particular, methane is contained in the burps of cattle and other ruminant animals, and 1 cow releases 200 - 600 liters of methane as burps per day. Annually, this is estimated to be about 2 billion tons (CO_2 equivalent) of methane worldwide, which is considered to account for about 4% (CO_2 equivalent) of the world's greenhouse gas emissions.

In this context, a new bacterium was discovered in the rumen of dairy cows. In the rumen, the activity of microorganisms decomposes and ferments fodder, which produces methane and propionic acid. Propionic acid is a substance that cows use as a source of energy, and it is known that when more propionic acid is produced in the rumen, methane is less likely to be produced. Since this new bacterium has the characteristic of producing more source material for propionic acid than previously known bacteria, it is known that limiting methane generation can be expected.

If the progress of research in the future enables cows to produce more propionic acid as a source of energy in the rumen, it is expected to contribute to increased productivity by reducing methane emissions from dairy cows and other ruminant animals and increasing energy efficiency.



Schematic diagram of fermentation in the rumen of cows
Provided by: National Agriculture and Food Research Organization (NARO)

6. Initiatives to improve energy efficiency and zero emissions of social infrastructure facilities

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been supporting the technological development of next-generation ships (zero-emission ships, etc.) in order to consolidate and strengthen cooperation in the maritime industry centered around the top runners in technology. In collaboration with MOE, MLIT conducted a project to promote the introduction of LNG-fueled ships to spread advanced navigation systems that combine LNG fuel systems and the latest CO2-saving equipment.

The National Institute of Maritime, Port and Aviation Technology (MPAT) has been in charge of research on fundamental technologies to significantly reduce GHG emissions from ships,

which contribute to achieving regulatory control aiming at zero emissions with social rationality, resulting in mitigating environmental impact.

MPAT is promoting onsite surveys and experiments in coastal areas for quantitatively measuring the atmosphere/seawater gas exchange rate and the carbon flow between the seawater and benthic ecosystems. The aim is to establish a method for measuring blue carbon, which has potential for both domestic and international applications.

The Public Works Research Institute is conducting research on effective utilization of resource and energy with a focus on sewage facilities.

The National Institute for Land and Infrastructure Management (NILIM) is conducting studies on sewerage disposal technology to reduce greenhouse gas emissions and collect energy and resources; and effects of greening to improve urban environment.

MPAT is conducting R&D pertaining to submarine construction, transportation/communication between ocean base and sea floor, etc. MPAT is also 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.

7. Development of technologies for observation of the earth environment and continued observation

(1) The promotion of Earth observations

To understand current global warming trends, many countries and organizations worldwide have been observing the Earth from the outer space by satellite, as well as by ground-based and maritime observation systems. To enhance the effectiveness of global efforts for tackling climate change problems, a system that facilitates access to observational data and scientific knowledge to countries and institutions through international collaboration is important. The Group on Earth Observations (GEO) was established as an international framework to promote the development of the GEOSS[1]. It had 253 countries and institutions as members as of March 2022. Japan has been playing a leading role on the GEO Executive Committee.

As one of the studies using the Environment Research and Technology Development Fund, MOE has been implementing the "Comprehensive Research on Projection of Climate Change Impacts and Evaluation of Adaptation (S-18)" aimed at creation of the latest scientific information on projection of climate change and adaptation evaluation to support Japan's adaptation to climate change. The ministry is comprehensively promoting the strategic studies and other research on observation/monitoring, projection and assessment of climate change and its impacts as well as countermeasures using the Environment Research and Technology Development Fund.

(2) Satellite-based observation

To promote satellite observations of the earth, Japan Aerospace Exploration Agency (JAXA) has been operating the Global Change Observation Mission - Climate "SHIKISAI" (GCOM-C[2]), the Global Change Observation Mission - Water "SHIZUKU" (GCOM-W[3]) and the Advanced Land Observing Satellite-2 "DAICHI-2" (ALOS-2) and so on, and has been conducting R&D for the Advanced Land Observing Satellite-3 (ALOS-3), Advanced Land Observing Satellite-4 (ALOS-4)

1 Global Earth Observation System of Systems
2 Global Change Observation Mission-Climate
3 Global Change Observation Mission-Water

and for other satellites (See Chapter 2, Section 1 3 ❺).

In order to help clarify climate change and its effects, MOE, with related ministries and agencies as well as relevant organizations at home and abroad, has developed and is operating global CO_2 and methane, etc., observation technologies using the Greenhouse Gases Observing SATellite "IBUKI" (GOSAT) and "IBUKI-2" (GOSAT-2). In addition, the ministry is conducting continuous monitoring by using airplanes and ships, and monitors on the ground. With the aim of further promotion of climate change countermeasures, GOSAT has been used for clarification of the global concentration distributions of CO_2 and methane, as well as estimation of absorptions and emissions by month and region. The project revealed a trend of rising concentration of CO_2 and methane through seasonal changes since 2009 when the observation started. The project also suggested a possibility of identifying the sources and amounts of greenhouse gasses emissions from human activities. The successor "GOSAT-2" improved the accuracy of observation of CO_2 and methane that have been observed by GOSAT and added CO to its observation targets. Carbon dioxide is emitted not only from human activities such as industrial activities and fuel consumption but also from forests and activities of other living things. On the other hand, carbon monoxide is emitted from human activities but not from forests and activities of other living things (excluding natural fires). Its aim is to estimate CO2 emissions of "human origin" through observation and analysis of CO2 emissions in combination with carbon monoxide emissions. GOSAT-2 was launched in October 2018. In addition to succeeding the mission of GOSAT, that is, to observe global greenhouse gas concentration, it aims to contribute to transparency increase of emissions reporting based on the Paris Agreement through new functions to identify sources of emissions of human origin and improve accuracy of emissions estimation. Furthermore, in order to continue the mission of water cycle and GHG observation and further enhance its observation capability, since FY2019 the ministry has been promoting development of the Global Observing SATellite for Greenhouse Gasses and Water Cycle (GOSAT-GW[1]) that mounts the successor sensor of GCOM-W (Advanced Microwave Scanning Radiometer 3: AMSR3) and the successor sensor of GOSAT-2 (Total Anthropogenic and Natural emissions mapping SpectrOmeter-3: TANSO-3).

In addition, to contribute to increased transparency of climate change measures implemented by countries around the world under the Paris Agreement, MOE is promoting verification and overseas deployment of international standardization of emissions estimation technologies, etc., based on observation data of the GOSAT series. MOE, in collaboration with the Government of Mongolia, has been working on advancing these technologies since FY2018 and has succeeded in improving the technologies until the amount of CO_2 emissions estimated from GOSAT observation data roughly matched the volume of emissions calculated by Mongolia from statistical data. The ministry has been promoting the expansion of this business to countries other than Mongolia since FY2021.

(3) Ground and oceanographic observations

The marine environment is rapidly changing in recent years: sea temperature is rising, ocean acidification is progressing worldwide and oceans are polluted by plastic wastes, for example. We need to understand the changes in the marine environment for the preservation of oceans and marine resources and their sustainable use, and elucidation of global environmental changes. To

1 Global Observing SATellite for Greenhouse gases and Water cycle

this end, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been constructing an integrated ocean observation network by combining drifting floats, moored buoys, observation by vessels and other means.

JAMSTEC and Japan Meteorological Agency (JMA) in cooperation with MEXT and other relevant organizations are participating in an ocean observing system (the Argo program [1]) for a detailed understanding of changes in the ocean interior around the world to improve the accuracy of climate change prediction. The Argo program aims at the real-time monitoring and evaluation of oceans around the world based on Argo floats deployed in these oceans.

MEXT is promoting research and observation in various fields related to the Antarctic and the Arctic, where it is possible to accurately measure global environmental changes. Under the Antarctic Research Programs, research and observation in the Antarctica have been conducted based on the 9th Six-Year plan for Antarctic Research Program (FY2016- FY2021).

The Arctic is known as the place where warming is most rapidly progressing due to various mechanisms. On the other hand, the melting of ice in summer presents the possibility of various uses for Japan and other countries. Both for correspondence to global climate change and contribution to sustainable use of the Arctic, it is essential to enhance scientific knowledge that is their basis.

To this purpose, MEXT has been implementing the Arctic Challenge for Sustainability Project II (ArCSII) as the successor to the Arctic Challenge for Sustainability Project (ArCS) since FY2020. In order to realize sustainable society, including Japan, the project evaluates the impact of rapid environmental changes in the Arctic on human society toward social implementation of the research results, while implementing international joint research and other initiatives to provide domestic and foreign stakeholders with scientific knowledge forming the foundation of legal policies for international rule making regarding the Arctic.

Under the ArCS II in FY2021, MEXT conducted observation of the Pacific sector of the Arctic Ocean, which is undergoing particularly dramatic environmental changes, by using the oceanographic research vessel “Mirai.”

In FY2021, the ministry constructed the Arctic research vessels into an international research platform capable of observing the sea ice areas for which data has not been sufficient.

JMA has been observing and analyzing greenhouse gasses in the atmosphere and seawater, aerosols and terrestrial radiation, the ozone layer and ultraviolet radiation, and has also been collecting and analyzing various observation data from ships, Argo floats, satellites, etc. It compiles and disseminates information on the current status and future outlook of oceanic changes related to the global environment as the "Ocean Health Index".

JMA has also been observing greenhouse gasses in the atmosphere at three sites in Japan and at the Showa Station in Antarctica. In addition, JMA is observing greenhouse gasses in seawater and in the atmosphere near seawater by using an ocean weather observation ship and in the atmosphere at high elevations in the northwest Pacific Ocean by using an aircraft. These data and other observed global warming-related data and their analyses are made available to the public. JMA has also been observing the ozone layer and ultraviolet rays in the atmosphere at three sites in Japan and at the Showa Station in Antarctica.

1 The Argo program is an international project in which over 30 countries, including Japan and the United States, and international organizations such as the World Meteorological Organization (WMO) and the UNESCO Intergovernmental Oceanographic Commission (IOC) participate to observe the oceans of the world constantly.

COLUMN 2-3

Rich Data Is the First Step in Creating High Quality Research Results! ～Observations and Results at the Polar Regions～

While several examples of innovation have been introduced in this white paper, the first step in most research that leads to innovation is to obtain data by conducting precise experiments, observations and measurements. The more accurate and abundant the data is, in other words, the "richer" the data is, the higher the quality of papers and mathematical models that can be produced.

Some experiments are conducted in laboratories to obtain such data, while others involve observations and measurements in the so-called field, such as an outdoor location. Below are some observations and their results in both polar regions, which are harsh natural environments that are not easily accessible.

(Case 1: Elucidating the Mechanism of Antarctic Glacial Decline)

The basin of the Totten Glacier, located near 116 degrees east longitude in Antarctica, contains an ice sheet that, if melted, would raise the global sea level by 3 to 4 meters. Reports in recent years indicate that the ice sheet in this region is melting. Previous observations have shown that warm water originating offshore is distributed along the front of the glacier. However, how this warm water is transported from offshore to the Totten Glacier has remained unclear.

The research vessel Kaiyo-Maru, operated by the Fisheries Agency, on its 10th Antarctic research expedition (December 2018 - February 2019) as well as the Antarctic research vessel Shirase on the 61st Japanese Antarctic Research Expedition (November 2019 - March 2020), conducted oceanographic observations in a wide area of the Totten Glacier and acquired vertical profile data such as water temperature, salt content and dissolved oxygen. The data obtained from both expeditions were integrated with satellite observation data and analyzed.

The water temperature distribution along the continental slope showed that particularly warm water was distributed on the east of several giant standing eddies (in the southern lower reaches). This indicates that these standing eddies efficiently transport offshore warm water toward the continent.

This is the first time that the entire picture could be clarified thanks to the acquisition of large-scale data over a wide area by multiple vessels and it is expected to lead to a comprehensive understanding of the glacier melting process by the surrounding ocean.

Totten Glacier terminus in East Antarctica. The blue area on the left is the sea

QR Code 1: Discovery of ozone hole

https://www.mri-jma.go.jp/Research/explanation/ozonhole.html

This is just one example of observations and results of research in the polar regions. The discovery of the well-known ozone hole, for example, resulted from observations in the Antarctic region (QR code 1).

It is essential to prepare observational equipment that can withstand observations at the polar regions and to transport researchers, equipment, and other supplies to the site for obtaining high-quality observation data, made possible through the cooperation and ingenuity of many people involved. In addition, the cooperation of locals is essential for activities in the Arctic region, which is also home to human communities.

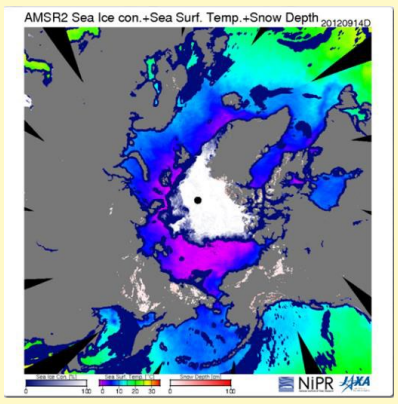
In recent years, so-called data-driven research utilizing big data has been actively conducted in the field of earth sciences. In conducting such research, it is also imperative to organize and publish the acquired data so it can be utilized efficiently.

(Case 2: Multifarious Support Using Arctic Sea Ice Data)

The summer sea ice extent in the Arctic Ocean has decreased by half over the past 45 years. In September 2012, the sea ice extent was recorded to be the lowest ever, making the Arctic Ocean the region where the effects of global warming have been most pronounced. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) published in 2013, it is predicted that summer sea ice will almost entirely disappear as early as 2050.

The National Institute of Polar Research (NIPR) has been accumulating data obtained from satellites of the Japan Aerospace Exploration Agency (JAXA) since 1978 and has published this data as the "quasi-real-time polar environment observation monitor (VISHOP[1])" since 2014 (QR code 2). VISHOP is a visualization service to view satellite data of polar regions on a web browser in quasi-real-time. It has been developed to deliver the current polar environment status quickly. Based on satellite data, VISHOP automatically visualizes information referenced in many fields, such as sea ice concentration, sea surface temperature, snow depth, or cloud movement. It can also show the dynamic movement through animations on the website, which researchers widely use, weather-related business people, university and high school classes, etc.

Arctic sea ice extent has also been an important indicator of global warming in recent years. Since the IPCC Fourth Assessment Report published in 2009 revealed that the Arctic Sea ice extent has decreased beyond the predictions of the global prediction model, the NIPR has been working on improving the global prediction model to improve the accuracy of sea ice extent prediction. NIPR contributes to accurately understanding how sea ice changes due to global warming, assessing the impact of global warming on the entire planet and considering measures against it.



Arctic sea ice at record low sea ice extent
(September 14, 2012)

QR Code 2: VISHOP

https://ads.nipr.ac.jp/vishop/#/monitor
Quasi-real-time polar environment observation monitor
- VISHOP

(4) Advancement of climate change projection/prediction technologies using super computers, etc.

In the Integrated Research Program for Advancing Climate Models (TOUGOU), MEXT has been promoting R&D towards the creation of basic information that will be necessary to address climate change by further advancing climate change models and increasing the sophistication of climate change projection, utilizing the supercomputers such as Earth Simulator. These results have also made international contributions, such as being cited several times in the Working Group I Report of the Sixth Assessment Report of the IPCC, published in August 2021.

In the "MEXT-Program for Data Integration and Analysis System Program (DIAS)," which accumulates and integrates global environmental data for analysis, is being used for the promotion of R&D that contributes to solving global-scale issues such as climate change and disaster prevention through the utilization of global environmental big data.

The Meteorological Research Institute (MRI) under JMA has developed the MRI Earth System

1 VIsualization Service of Horizontal scale Observations at Polar region

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 for regional climate warming prediction.

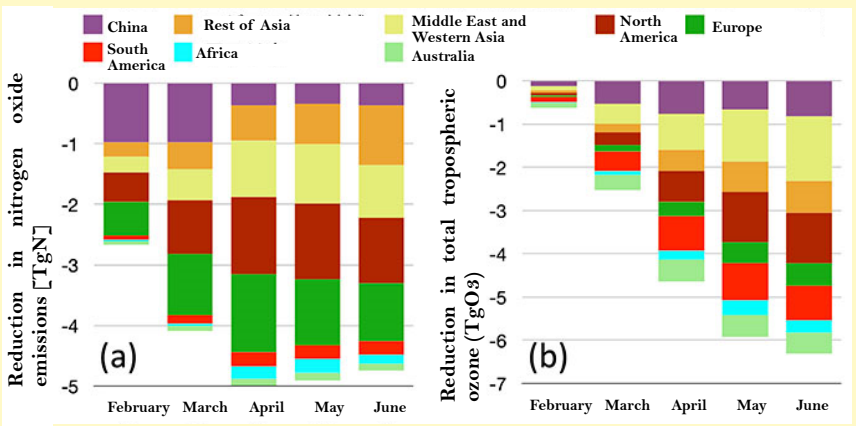
JAMSTEC has been making full use of its supercomputer systems to develop the most advanced predictive models and simulation techniques. These are used to elucidate the possible impacts of global environmental changes on Japan and to help solve climate change problems from the viewpoint of marine science.

COLUMN 2-4 Understanding the Impact of the COVID-19 Pandemic on the Global Environment

In 2020, lockdowns and other measures were implemented in countries around the world to control the spread of the COVID-19 Pandemic. As a result, global socioeconomic activity declined on a scale exceeding that of the Lehman Shock, while emissions of greenhouse gases and air pollutants also decreased. Focusing on this phenomenon, evaluating the relationship between "changes in emissions" and "response of atmospheric concentrations" of each of these substances and the changes in "climate and health effects" will be extremely useful for future policy consideration toward carbon neutrality and air quality improvement. In Japan, researchers at JAMSTEC, MRI and the National Institute for Environmental Studies are conducting intensive analyses.

While carbon dioxide emissions driving global warming were estimated to have decreased by 7% from the previous year based on changes in fossil fuel consumption, global atmospheric concentrations continued to rise. On average, during the 60 years before the COVID-19 pandemic, about 56% of annual carbon dioxide emissions were absorbed by vegetation and oceans, while the remaining 44% were accumulated in the atmosphere(the IPCC Sixth Assessment Report).Given this, even a 7% decrease in carbon dioxide emissions from the previous year was not enough to significantly reduce new accumulations in the atmosphere. This has again highlighted how significant social changes are needed to achieve carbon neutrality by 2050.

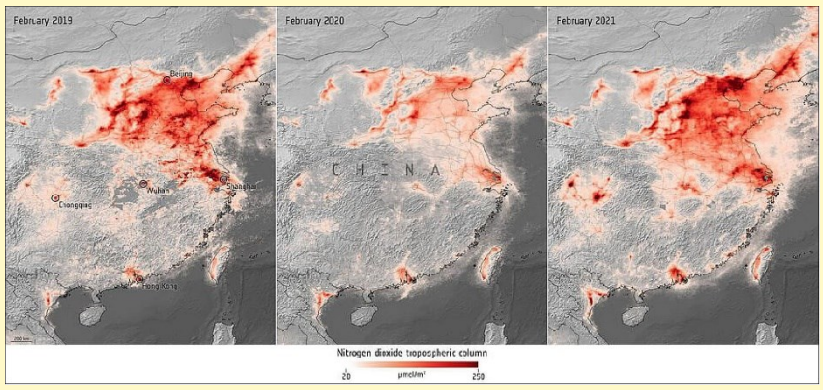
It was reported that in India and China, air pollution caused by aerosol particles (such as PM2.5) subsided, and blue skies returned. This is believed to have reduced the number of premature deaths worldwide (about 4 million/year) due to outdoor air pollution. From the viewpoint of climate impact, though, it has been identified that the "parasol effect" of sulfate aerosol, the main component of aerosol particles which bounces sunlight back, has diminished. Conversely, the temperature tends to increase. While it is necessary to promote air pollution control measures from the perspective of protecting health, global warming is an unfortunate adverse effect. Hence, along with air pollution control measures, there is a need to reduce substances that contribute to global warming sufficiently in order to offset their contribution.



Reduction in (a) nitrogen oxide emissions and (b) global tropospheric ozone due to lockdown
Provided by: JAMSTEC/NASA Jet Propulsion Laboratory

Among other air pollutants, ozone and soot (black carbon, BC) particles, if successfully reduced, can mitigate both impacts on health and global warming, thereby "killing two birds with one stone." By mid-February 2020, total anthropogenic emissions of nitrogen oxides, the raw material for ozone, were estimated to have decreased by up to 36% in China and by more than 15% worldwide from April to May 2020, with ozone also decreasing by 2% worldwide. The latest satellites have made it possible to observe daily and city-wise changes in the global distribution of nitrogen dioxide, the main component of nitrogen oxides. These satellite observations served as the basis for estimating the reduction in emissions mentioned above, and the press covered the images comparing concentrations before and after the lockdown. A study comparing the concentration of BC particles borne by seasonal winds from China to western Japan before and after the COVID-19 pandemic revealed that the reduction in emissions in 2020 compared to ordinary times was relatively small, with an 18% reduction even at the peak. Since emission levels were maintained during the lockdown, it has been interpreted that China's primary emitting sector was households, not industries and transportation. This has allowed us to narrow down the targets for effectively reducing emissions.

As described above, based on an observation system that quickly identifies actual changes in concentrations, a mechanism is being developed to accurately assess the link between the range of change in emissions for each substance and its impact on climate and health, and the results of the COVID period assessment should be utilized as scientific evidence for social policy.



Nitrogen dioxide tropospheric column concentration over China as measured by the Sentinel-5p satellite. Measurements for February 2020 (center) due to the impact of lockdown, compared to February 2019 (left) and February 2021 (right)
Provided by: European Space Agency (CC BY-SA 3.0 IGO)

❷ Promotion of R&D and demonstration for utilization of various energy sources

The Japan government approved the Basic Energy Plan based on a cabinet decision in October 2021. It specifies the importance of technological development and innovation, stating that in order to achieve carbon neutrality by 2050, it is necessary to attempt and realize various innovations common to all economic activities in the industrial, business, household, transportation and electric power sectors, and promote the implementation of new decarbonization technologies in society. Even as we aim to achieve carbon neutrality by 2050, it is important to ensure a stable and affordable energy supply on the basic premise of ensuring safety, and to this end, pursue all alternatives, including renewable energy, nuclear power, hydrogen and CCUS.

1. Generation technologies pertaining to solar power generation system

METI is conducting R&D on component technologies toward the commercial application of innovative technologies such as Perovskite solar cells[1] that are thin and lightweight to overcome restrictions on installation, the development of

1 Solar cell created in Japan using materials with a crystal structure called Perovskite. Because it can be used in simple processes including coating and printing, significant reduction in production costs is expected.

advanced peripherals, the maintenance technology toward improving the efficiency of the solar power generation system and developing low-cost recycling technology.

Under the "Advanced Low Carbon Technology Research and Development Program (ALCA)" and MIRAI program: "Low Carbon Society" mission area, JST is promoting R&D on technologies pertaining to innovative sunlight utilization within a competitive environment. The targeted technologies are aimed at developments that have a high potential for greenhouse gas reduction and that are not merely extensions of conventional technologies.

2. Generation technologies pertaining to floating offshore wind power plant

METI carried out a demonstration project using multiple windmills off the coast of Fukushima Prefecture to verify the safety, reliability and economic efficiency of floating offshore wind power generation systems to expand their introduction. In addition, METI is also promoting a demonstration project using new technologies off the coast of Kitakyushu City, aimed at establishing floating offshore wind power generation system technologies.

MOE conducted a development and demonstration of Japan's first 2MW floating offshore wind power plant and established related technologies. Based on the technology development and demonstration, the commercial operation of offshore wind power started first in the country in 2016. Its secondary effects include new fishing places around the windmills. The ministry also implemented initiatives aimed at establishment of new methods for low-carbon and high-efficiency construction toward full-scale dissemination of floating offshore wind power generation. In FY2021, MOE continued its initiatives from the previous year to promote decarbonization businesses by newly organizing information to contribute to the early dissemination of floating offshore wind power generation, conducting various surveys necessary to aim for local production for local consumption of energy from floating offshore wind power generation, and examining the business feasibility and carbon dioxide reduction effects in relevant regions.

Toward cost reduction of floating offshore wind power plants, since FY2018, MLIT has been studying design and safety evaluation methods, etc. aimed at simplification of the floatation structure and installation methods while ensuring safety. In FY2021, the ministry conducted a fact-finding survey and feasibility study on remote inspection and monitoring.

3. Technology development pertaining to geothermal power generation

In order to solve problems of geothermal power generation, which include high risk and cost of resource exploration, operation efficiency and output stability at the power generation stage, METI has been developing technologies to improve exploration accuracy and drilling speed, streamline development and operation and stabilize output. The ministry is also conducting detailed prior examination of the next generation geothermal power generation (supercritical geothermal system) with high generating capacity, which is a highly anticipated development.

4. Technology development for high-efficiency coal-fired thermal power generation and efficient capture and utilization of CO_2

METI has been developing technologies such as Integrated Gasification Fuel-Cell (IGFC) Combined Cycle, a next-generation high-efficiency coal-fired thermal power generation technology, with an eye on decarbonization. The ministry is

also developing technologies for efficient capture and utilization of CO_2 (Carbon dioxide Capture and Utilization (CCU)/Carbon Recycling) emitted from thermal power generation.

5. Other technology development

METI has been developing an innovative oil refining technology toward greening of domestic refineries. The technology clarifies the composition of heavy oil at a molecular level and uses an oil refining technology that combines reaction simulation models, etc. to assess the components and reactivity of heavy oil in advance with the aim of reducing inefficient operation of refinery apparatuses through correct combination of operations of secondary devices, thereby contributing to the reduction of CO_2 emissions.

6. R&D related to nuclear power

(1) Technologies to improve safety and nuclear security pertaining to nuclear power utilization

METI has been developing technologies and infrastructure under the Technological Development Program Contributing to Improvement of Nuclear Safety to enhance safety measures including sophistication of comprehensive risk assessment of nuclear power plants. This is based on what has been learned since the accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc. (TEPCO). Japan has been working with the International Atomic Energy Agency (IAEA), the U.S. and other countries 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. Japan Atomic Energy Agency (JAEA) established the Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN). This center has provided training courses in nuclear nonproliferation and nuclear security. ISCN has been contributing to development training materials and exchanging lecturers and information regarding human resources development based on practical arrangement with the IAEA regarding the development of human resources for nuclear security. Efforts have also been made to develop technology for the following: 1) non-destructive assay of nuclear materials using the active neutron technique, and 2) nuclear forensics to identify the origin and history of nuclear and other radioactive materials out of regulatory control. ISCN has also been contributing to strengthening detection capability for nuclear tests through the observation at Horonobe town and Mutsu city based on the noble gas joint measurement project with the CTBTO [1].

(2) Basic and fundamental R&D for nuclear science

In the Nuclear R&D, Infrastructure and human resource Working Group, MEXT comprehensively studied the following subjects: (1) development of new technologies that drastically improve safety, reliability and efficiency of use of nuclear energy, and (2) R&D and infrastructure/human resource development toward strengthening of human resources, technologies and industrial infrastructure beyond the boundaries of industry, academia and government. Based on the study result, with the aim of acquiring new knowledge to create nuclear innovations and find solutions regarding challenges, under the "Nuclear System R&D Project," in cooperation with the METI, MEXT has been promoting strategic basic/fundamental

1 Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization

research that will support the nation's nuclear technology by setting strategic themes to be tackled toward future social implementation.

JAEA is conducting basic and fundamental research in such fields as nuclear engineering, reactor engineering, fuel and material engineering, nuclear chemistry, environment and radiation science, partitioning and transmutation, computational science and advanced nuclear science. In addition, R&D on high-temperature gas-cooled reactors which have the possibility of a wide-range of industrial application including power generation and hydrogen production and inherent safety has been promoted in terms of the contribution to the enhancement of safety and to the diversification of nuclear use.

(3) Development of revolutionary nuclear technologies

Because nuclear energy is a practical option for carbon-free society, it is important to promote innovation of nuclear technologies that meets diverse demands of society in addition to safety improvement. Under the "program to support innovative nuclear technology development that responds to demand of society" In FY2019 METI started to support development of nuclear technologies with excellent safety, economy and mobility possessed by private companies and others.

In addition, the JAEA made preparations for the resumption of operation of the experimental fast reactor Joyo and strived to maintain and develop the R&D infrastructure required to develop advanced nuclear technologies.

(4) Securing and developing human resources in the nuclear field

There is the need to foster and secure a wide range of skilled human resources, in order to support the nuclear technology, ensure greater safety, and secure the safety of nuclear facilities and the smooth decommissioning of reactors in older nuclear power plants.

MEXT is supporting development of human resources in an effective, efficient and strategic manner, in collaboration with the relevant sectors of industry, academia and government, based on the Global Nuclear-HRD Initiative (GN-HRD). The Advanced Nuclear Education Consortium for the Future Society (ANEC) was established in FY2021 as an integrated system for human resource development in collaboration with multiple institutions, such as universities and research institutions, whereas in the past, each institution was supported individually. Under the Center of World Intelligence Project for Nuclear S&T and Human Resource Development ("the World Intelligence Project"), MEXT has been promoting human resource development based on the needs in the field of the decommissioning of Fukushima Daiichi Nuclear Power Station with the leadership of the Collaborative Laboratories for Advanced Decommissioning Science (CLADS) of JAEA. When the meeting of relevant cabinet ministers on nuclear power held in December 2016 decided the government's policy to decommission the fast-reactor-breeder Monju, it was also decided to install a new research and test reactor on the site of Monju in the future. In FY2017 the government entrusted research on the reactor type to be installed. After studies at a deliberation council, etc., the government selected a research and test reactor for which the principal purpose is to use

neutron beam, and started examination of its conceptual design and appropriate method of operation.

METI also has been supporting human resource development using funds provided by the Expenses for Commissioning Human Resource Development toward Improving Nuclear Safety, in order to educate field engineers involved in nuclear facility maintenance and in the nuclear safety industry. This undertaking is expected to contribute to the decommissioning of the TEPCO Fukushima Daiichi Nuclear Power Station and to the safety control of other existing nuclear power stations.

(5) Research and development of technologies, etc. for decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company, Inc.

Toward the decommissioning of the Fukushima Daiichi Nuclear Power Station, METI, MEXT and other relevant ministries and agencies have been taking measures in coordination and cooperation based on the Medium-to-Long-Term Roadmap for the Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc. (revised on December 27, 2019). In these measures, these ministries have been supporting R&D conducted by business operators on technologies that are technically difficult and that need the government to spearhead work on them. Such R&D includes a technology for extracting fuel debris and a technology for examining the inside of reactor containment vessels.

Based on the Acceleration Plan of Reactor Decommissioning R&D for the TEPCO Fukushima Daiichi Nuclear Power Station (published in June 2014), MEXT has been promoting basic/fundamental R&D and human resource development in order to consolidate knowledge in Japan and overseas for safe, steady decommissioning. Specifically, CLADS is conducting basic/fundamental research including handling of fuel debris, treatment and disposal of radioactive wastes and clarification of accident development scenarios at the International Collaborative Research Building (Tomioka town, Futaba-gun, Fukushima). Furthermore, through integrating and linking excellent knowledge and experiences in various fields beyond the nuclear field around CLADS and across organizations of universities, research institutions and private companies, the Nuclear Energy Science & Technology and Human Resource Development Project (Mission H) is promoting R&D and human resource development in response to the medium- to long-term needs at actual decommissioning sites.

Development of facilities to establish the technical basis for decommissioning is also advancing. JAEA started full-scale operation of the Naraha Remote Technology Development Center (Naraha town, Futaba-gun, Fukushima), a facility for development and demonstration of remote operation equipment/devices (mock-up facility), in April 2016. In addition, with the aim of developing analysis methods, proper understanding and treatment/disposal of fuel debris and radioactive wastes, Okuma Analysis and Research Center (Okuma town, Futaba gun, Fukushima) started operation of some facilities in March 2018. Furthermore, the 1st building and the 2nd building are under development toward establishment of an analysis implementation system using the center.

(6) Nuclear fuel cycle technology

The Strategic Energy Plan (Cabinet Decision on October 2021) states "In order to resolve the issues related to reprocessing and disposal of spent fuels and mitigate the risks for and the burden on future generations, the government will make efforts towards a nuclear fuel cycle that contributes to the reduction of the volume and harmfulness of high-level radioactive waste and effective utilization of resources while adequately taking the past history into consideration and continuing to gain the understanding of relevant municipalities and the international community, and will promote reprocessing and plutonium use in LWRs[1]." Also "the government will promote R&D of fast reactors. through international cooperation with the United States and France."

(7) Technology development toward radioactive waste disposal

The government is advancing basic/fundamental research of nuclear transmutation and group separation technologies using fast reactors or accelerators, which can contribute to the significant reduction of volume and hazardousness of high-level radioactive wastes.

For disposal of low-level radioactive wastes from research facilities and medical institutions, JAEA has been advancing necessary initiatives according to the "Plan on implementation of burial disposal" (approved in November 2009; changes to the plan were approved in November 2019)" that was formulated by JAEA based on the "Basic policy for implementation of burial disposal" (decision by the Ministers of MEXT and METI in December 2008) presented by MEXT and METI.

(8) Decommissioning of facilities owned by JAEA

JAEA has an important role as a comprehensive nuclear R&D organization. In order to fulfill this role, it is important for JAEA to steadily proceed with decommissioning of the facilities that will no longer be used for research while at the same time ensuring public understanding and giving the highest priority to safety. JAEA published the "Backend Roadmap" that is a long-term policy for decommissioning of the entire facilities of JAEA in December 2018. MEXT supports JAEA's efforts and encourages safe and steady decommissioning of the nuclear facilities owned by JAEA.

For example, regarding the prototype fast-breeder reactor Monju, the meeting of relevant cabinet ministers on nuclear power held in December 2016 decided not to resume its operation but move to decommissioning.

Based on the first stage of the decommissioning plan (approved by the Nuclear Regulation Authority in March 2018), JAEA has been working on the unloading of the fuel assemblies from the reactor core to the fuel pool, which will be completed by the end of 2022, giving the highest priority to safety. Future decommissioning of Monju will be safely, steadily and systematically carried out while listening to opinions from the local area.

Concerning the prototype advanced thermal reactor Fugen, dismantling and removal of peripheral equipment of the reactor is underway based on the decommissioning plan, and necessary measures are being systematically implemented to complete the removal of spent fuel by the summer of 2026.

The top priority for the Tokai Reprocessing Plant is early risk reduction for the highly radioactive waste held in the plant based on the

1 Plutonium separated from spent fuel by reprocessing is mixed with uranium, processed into mixed-oxide fuel and used

decommissioning plan. Efforts are being taken for the vitrification of the highly radioactive waste and securing the safety of the waste storage site, while measures for the aging facility and improvement of safety are steadily progressing.

(9) Efforts for understanding and co-existence with the public

MEXT has been supporting projects to deepen the understanding of the facilities among people nationwide and in regions where those facilities are located, towards the sustainable development of the region and education on nuclear power and other energy sources.

(10) International nuclear energy cooperation

MOFA has been supporting the promotion of the peaceful use of nuclear science and technologies by IAEA and member states' efforts to achieve Sustainable Development Goals (SDGs). Through technical cooperation based on the Regional Cooperative Agreement for Research, Development and Training Related to *Nuclear Science* and Technology (RCA)" in the Asia-Pacific region, financial support to IAEA with contribution to the Peaceful Uses Initiative (PUI) and strengthening of cooperation between IAEA and Japanese universities, research institutions and companies with expert knowledge and technologies, the Ministry has been promoting capacity building in developing countries and supporting international deployment of Japan's excellent human resources and technologies. IAEA in cooperation with Japan, designated an IAEA Response and Assistance Network Capacity Building Centre (IAEA-RANET-CBC) in Fukushima Prefecture in 2013, and has been providing training for persons involved in Japan and abroad to enhance their ability to prepare for and respond to emergencies. Its activities for international strengthening of nuclear security include an international symposium on transport security of nuclear and other radioactive materials held in collaboration with ISCN of JAEA in Tokyo in November 2019.

MEXT has been leading the way in peaceful use of nuclear energy and nuclear non-proliferation by contributing to projects implemented by the IAEA and the Nuclear Energy Agency under the Organization for Economic Co-operation and Development (OECD/NEA). Also, as part of MEXT's contributions to the Forum for Nuclear Cooperation in Asia (FNCA), which is led by the Cabinet Office, MEXT has been supporting FNCA member countries: Asian countries in particular, in their R&D and infrastructure development for the use of radiation and nuclear research reactors, for example.

METI also has advanced R&D for the establishment of verification technology for fast reactors by means of Japan-French cooperation, Japan-US cooperation and other international cooperation frameworks. Fast reactors are expected to contribute to reductions in toxicity and in the volume of radioactive waste.

Japan is also involved in wide-ranging cooperation in nuclear system R&D, etc. with the United States, France and other countries advanced in nuclear science through activities of the Generation IV International Forum (GIF).

(11) Efforts pertaining to the peaceful use of nuclear energy

Japan concluded 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 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 (Act No. 166 of 1957) (Nuclear Reactor Regulation Law), Japan has been implementing a system of accounting for and controlling nuclear material, providing reports to IAEA, and accepting IAEA inspections.

On May 19, 2021 the government reported the result of safeguard implementation activities in Japan during 2020 to the Nuclear Regulation Authority. The result is provided to IAEA as information for its evaluation of our safeguards implementation activities. IAEA: in its safeguard's implementation report, concluded that all nuclear materials in Japan remained in peaceful activities in 2020 as well. Broader Conclusion has been reached since the implementation result in 2003.

7. Research and development of fusion energy technologies

Some key features of fusion energy include ample fuel resources, no greenhouse gas emissions during the power generation process, and the capability of large-scale power generation from a small amount of fuel. Therefore, it is expected to be an important source of clean energy in the future that will fundamentally solve energy and environmental issues and also contribute to ensuring energy security. Coupled with the technological advancements of the ITER Project[1] (discussed below), policy interest in this area has been growing in other countries in recent years.

Japan is promoting the ITER Project to demonstrate the scientific and technological feasibility of fusion energy through the construction and operation of an experimental reactor, taking place with the international cooperation of 35 countries in 7 regions around the world. Construction of the ITER experimental fusion reactor is in full swing in France, and superconducting coils and other important equipment that Japan is responsible for manufacturing are arriving there one after another. Design activities for the blanket, a device that is indispensable for fusion power generation and is used to extract energy as heat from the fusion reactor, are currently underway for carrying out tests in ITER. A ceremony was held in July 2021 to commemorate the opening of the National Institutes for Quantum Science and Technology Blanket Engineering Test Building (Rokkasho Village, Aomori Prefecture). In addition, Japan is promoting Broader Approach (BA) activities, which are advanced R&D activities to establish the technological infrastructure required for the DEMO reactor, complementing and supporting the ITER Project through Japan-Europe cooperation. R&D of the BA activities which include the move of JT-60SA[2] to the adjustment phase toward experimental operation, are also progressing smoothly in FY2021.

Construction of ITER (International Thermonuclear Experimental *Reactor*) in October 2021
(Cadarache in Saint-Paul-Lès-Durance, France)
Source: ITER Organization

For the realization of fusion energy, Japan has

1 An international joint project to demonstrate the scientific and technological feasibility of fusion energy through the construction and operation of an experimental fusion reactor, based on an international agreement between 35 nations in 7 regions including Japan, Europe and the United States

2 The critical plasma testing apparatus JT-60 was shut down in August 2008, dismantled for repair, and reassembled in March 2020. Currently undergoing adjustments to commence operation

been promoting the ITER Project and BA activities based on the Roadmap toward Fusion DEMO Reactor (first report), etc. formulated in July 2018 by the Science and Technology Committee on Fusion Energy of the Council for Science and Technology, as well as various academic research including helical devices (The National Institute for Fusion Science) and lasers (Institute of Laser Engineering, Osaka University), which have achieved world-leading results. In January 2022, the Committee compiled the Report of the First Intermediate Check and Review on Fusion DEMO Reactor R&D, confirming that the goals to date have been achieved and identifying future issues.

＜Reference URL＞

Website on fusion energy study: Fusion Energy -Connect to the Future

https://www.mext.go.jp/a_menu/shinkou/fusion/

The way to fusion energy - ITER

https://www.youtube.com/watch?v=QEohCE1famE (Source: iter japan – QST)

8. Development of other long-term energy technologies

METI has been developing a panel that integrates electric power production and supply, which is necessary for space photovoltaic power generation, while at the same time conducting technology development for its weight reduction and efficiency improvement of the power transmitting unit in order to contribute to efficiency improvement of wireless power transmission using microwaves.

JAXA has been conducting R&D of elemental technologies toward practical use of space-based solar power.

❸ Promoting economic and social redesign

1. Initiatives for transitioning to a "decarbonized society"

MOE is supporting the improvement of energy-saving performance, such as the renovation of residences and buildings with higher thermal insulation, as well as the construction of net-zero energy structures (ZEH/[1]ZEB[2]) and is promoting energy management of solarpower generation and demand-side equipment such as home appliances through the introduction of HEMS[3] and BEMS[4], combined with the use of EVs and [5] PHEVs[6] through the introduction of charging and discharging equipment. In addition, the ministry is promoting "zero-carbon drives" by supporting local authorities and businesses that simultaneously introduce renewable energy equipment and EVs/PHEVs and offer them as a car-sharing service.

MOE formulated the Climate Change Adaptation Plan in November 2018 and published the Assessment Report on Climate Change

1 net Zero Energy House
2 net Zero Energy Building
3 Home Energy Management Service
4 Building and Energy Management System
5 Electric Vehicle
6 Plug-in Hybrid Electric Vehicle

Impacts in Japan in December 2020, based on the provisions of the Climate Change Adaptation Act that came into effect in December 2018. The Climate Change Adaptation Plan was revised in October 2021 based on the latest scientific knowledge presented in the Assessment Report on Climate Change Impacts. Adaptation initiatives were expanded in various fields, such as agriculture and natural disasters. Based on the act and the plan, the Center for Climate Change Adaptation at the NIES has been providing the latest information on adaptation in cooperation with relevant ministries and agencies as well as research institutions through the Climate Change Adaptation Information Platform (A-PLAT) and supporting studies on the impact of and adaptation to climate change and adaptation efforts by local governments and other bodies in scientific aspects. To allow stakeholders in various regions to cooperate in promoting adaptation measures, the Regional Council on Climate Change Adaptation based on the Climate Change Adaptation Act was set up in seven regional blocks across the country.

MEXT has built a network of universities and other institutions to accelerate the region's decarbonization and deploy this regional model to the world. Through A-PLAT of the Center for Climate Change Adaptation at the NIES, R&D results such as climate change prediction information is being provided to local governments and other bodies based on their needs.

2. Research and development for global warming countermeasures

(1) Stable energy use using energy storage technologies including hydrogen/storage batteries

METI is conducting the technological development and demonstration of batteries and fuel cells. Specifically, the ministry is promoting efforts for implementation of technological development for optimal control and management methods when introducing large batteries for power systems, which will become necessary with the expansion of renewable energy introduction. Technological development was conducted also for the performance enhancement and cost reduction of lithium-ion and post lithium-ion batteries for next-generation vehicles, [1] such as plug-in hybrids or fully electric cars. R&D on fuel cells for domestic use and other fixed uses, and on vehicle fuel cells, has focused on lowering costs while increasing durability and efficiency. Toward further spread of fuel-cell vehicles, the ministry has installed about 157 hydrogen stations as of the end of March 2022 (with 9 more stations being installed), mainly in four major cities.

With a view to a future society that will use a huge amount of renewable energy, MOE has been promoting initiatives under the "Construction of autonomous distributed energy system using hydrogen from renewable energy project," which aims to establish methods to introduce and use an autonomous hydrogen energy supply system by constructing a system that can supply renewable energy as power and heat without depending on a power system, but instead by using storage batteries and hydrogen based on regional conditions. In addition, the ministry is

1 Innovative storage batteries with higher energy density than solid-state and lithium-ion batteries

implementing the "Hydrogen Energy Supply Chain Demonstration Project," which aims to build hydrogen energy systems using local resources and utilize them locally and is moving forward to accommodate regional characteristics and diverse technologies.

MEXT is promoting R&D related to the next-generation storage battery with greatly higher performance compared with conventional ones in a technology area of special focus of the "Strategic Basic Research Programs - Advanced Low Carbon Technology Research and Development (ALCA)" of JST. Furthermore, the ministry is conducting R&D with industry-academia collaboration at the advanced storage battery R&D centers of The Program on "Open Innovation Platform for Industry-Academia Co-Creation (COI-NEXT)". The "JST-MIRAI program – Large-scale Type" is promoting R&D of a high-efficiency, low-cost, compact and long-life innovative hydrogen liquefaction technology that will contribute to expansion of hydrogen utilization, including hydrogen power generation, storage of surplus power and transportation means. Also, the JST MIRAI program: "Low Carbon Society" mission area promotes R&D of water electrolysis technology that enables sustainable hydrogen production from renewable energy.

(2) Improvement of energy utilization efficiency and consumption reduction using new technologies

The Cabinet Office through SIP has been working on the "Energy system of IoE society" since FY2018 toward realization of an IoE [1] society where various energy sources are connected to a network enabling supply and demand management of energy. In this SIP, studies are being conducted to design a conceptual model and platform for an integrated energy management system for transportation and electric power infrastructure through sector coupling, aiming for the mass introduction of renewable energy. Specifically, the project is developing guidelines for local authorities to design regional energy systems and establish an energy supply and demand database by municipality. The project promotes R&D toward social implementation of the universal power module and wireless power transmission systems, which will enable optimum control of diverse input power sources including renewable energy by using gallium semiconductor devices.

METI has been conducting a demonstration of a virtual power plant that remotely integrates and controls consumer-side energy resources spread across the power grid including energy facilities such as renewable energy power facilities and storage batteries, and demand response, to make them function as one power plant and use them for adjustment of supply and demand.

In order to ensure advancement and social implementation of innovative technologies and promote necessary technology innovations toward prevention of global warming, MOE promoted not only the use of renewable energy and rational energy use, but also development, demonstration and dissemination of technologies leading to drastic reduction of energy consumption through use of innovative and highly CO_2 emission reducing members /materials such as gallium nitride (GaN) and cellulose nanofiber (CNF), fuel cells, hydrogen energy, storage battery, CCUS[2], for example.

MOE has been implementing projects to establish an advanced model for implementation of CO2 emissions reduction measures with the overall

1 Internet of Energy
2 Carbon dioxide Capture, Utilization and Storage

highest cost performance in the various regions by introducing decentralized and self-reliant energy systems that use renewable energy, and independent cables in public and other facilities, and by optimizing energy supply and demand to increase the ratio of renewable energy in the regions.

Under the "JST MIRAI Program – Large-scale Project" JST promoted R&D on an innovative thermoelectric conversion technology that enables use of heat sources in the environment (e.g., waste heat, body heat) as independent power source for sensors.

RIKEN has been conducting R&D in the fields of condensed matter physics, supramolecular chemistry and quantum information electronics to pioneer new materials and new principles, creating entirely new materials science that enables innovation in energy utilization technologies, including electric power generation, transmission and storage, and to realize radical lower power consumption and significant improvement of energy conversion efficiency.

The Aviation Science and Technology Committee of MEXT outlined a vision for R&D with the direction and specific issues to be addressed in promoting R&D of technologies to reduce CO_2 emissions from aircraft for the realization of a decarbonized society, including electric hybrid propulsion system technology and engine technology using hydrogen fuel cells that can be applied to hydrogen aircraft.

JAXA has been conducting R&D on reducing fuel consumption and the environmental load of airplanes, such as technologies for reducing NOx from engines and improving their efficiency and technologies for electrification of aircraft propulsion. With an eye on the social implementation of the research results in collaboration with the industry, JAXA is accelerating R&D in this area because it is directly related to improved international competitiveness.

NEDO has been implementing the "Program to Develop and Promote the Commercialization of Energy Conservation Technologies to Realize a Decarbonized Society" through open public invitations for proposals. The program focuses on key technologies listed in the Strategy for Energy Efficiency Technologies 2016 (revised in July 2019), for effective promotion of R&D and the spread of energy-efficient technologies.

The Building Research Agency has been conducting R&D for environmentally-sound and efficient use of resources/ energy in housing, construction and urban planning fields.

(3) Application of innovative materials, devices, etc. to a broad range of areas

With the "MEXT program "Innovative Power Electronics Technologies (INNOPEL)," MEXT is promoting R&D for the creation of ultra-energy-saving and high-efficiency power electronics technologies using gallium nitride (GaN), a material that is considered Japan's forte, to create power devices that realize excellent material properties and power electronics circuit systems that can make the most use of these properties. In addition, the "MEXT Initiative to Establish Next-generation Novel Integrated Circuits Centers (X-nics)" was launched to form an academic center that will serve as the core for R&D from a new perspective and development of human resources to drive the future semiconductor industry toward the creation of innovative semiconductor integrated circuits that the society will require around 2035-2040.

Under the "Strategic Basic Research Programs – Advanced Low Carbon Technology Research and Development Program (ALCA)"and JST MIRAI program: "Low Carbon Society" mission area, JST is promoting R&D on innovative materials development/application and chemical processes.

NIMS has been promoting R&D for stable energy supply and efficient energy use. The R&D includes: high-efficiency batteries and solar cells for construction of network systems that promote use of diverse energy sources; energy conversion/storage materials for effective use of energy; R&D toward the breakthrough of high-output semiconductors for energy efficiency, high-luminance light materials, etc.; high-efficiency/performance transportation equipment materials and energy infrastructure materials contributing to a low environmental burden society.

METI has been developing technologies for: producing plastic materials and other major chemical products from carbon dioxide and water by using solar energy (artificial photosynthesis project); highly efficient production of organosilicon materials without using metallic silicon; replacement of the batch synthesis method of functional chemicals with the flow synthesis method, and accurate and speedy evaluation of performance and characteristics of lithium-ion cell materials. The ministry is also developing basic information necessary for development and safety assessment of compounding/processing technologies for cellulose nanofiber production according to the purpose of use, which promises cost reduction in the production process, optimization of the manufacturing process and a mass production effect.

(4) Basic research and development for accelerating regional decarbonization

MEXT has been promoting cross-sector R&D for tools to further advance regional carbon neutrality through collaboration between universities and local communities, utilizing a wide range of knowledge from the humanities and social sciences to the natural sciences with "MEXT-Program for Research and Development for Accelerating Local Climate Actions in Partnership of Universities" to achieve carbon neutrality. In addition, the "University Coalition for Carbon Neutrality" was established in July 2021 to facilitate information sharing and project creation among universities and other research institutions.

3. Initiatives for transitioning to a “circular economy”

In April 2022, the "Act on Promotion of Resource Circulation for Plastics" was enacted to accelerate plastic resource circulation for transitioning to a circular economy.

As a measure to promote plastic resource circulation, METI has been promoting R&D on the practical application of technologies to increase the resource efficiency and resource value of plastics and is also promoting R&D to develop new technologies and materials to meet future applications and demand and to propose international standardization of ocean-degradable plastics through its "Advanced Plastics Utilization Project" for the development, introduction and spread of marine biodegradable plastics.

MOE is carrying out technological demonstrations on material substitution from fossil-based plastics to renewable resources such as biomass and recycling of composite plastics that are difficult to recycle.

The ministry has also released "Guidelines for the Introduction of Bioplastic Garbage Bags in Local Governments" to promote the conversion of plastics, such as designated collection bags for combustible garbage, which must be incinerated due to their primary use, to biomass.

Toward the realization of the Osaka Blue Ocean Vision proposed by Japan at the G20 Osaka Summit, MOE has been actively working on measures against marine plastic litter in Japan and

abroad by participating in the discussions on an international legally binding instrument, providing assistance to developing countries mainly in Southeast Asia, intensifying the accumulation of scientific knowledge that forms the basis of marine plastic litter countermeasures, and considering measures to reduce the leakage of plastics into the environment.

4. Biodiversity that constitutes a "decentralized society"

Concerning biodiversity that constitutes a "decentralized society," MOE is promoting R&D of technologies related to the protection of endangered species and the control of invasive alien species, technologies for monitoring, maintaining and restoring ecosystems including secondary nature, technologies for evaluating the economic and social value of ecosystem services and natural capital including genetic resources, as well as the sustainable management and use of them. The ministry is also taking initiatives to realize "harmonious coexistence with nature."

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has been producing assessment reports with the aim of strengthening the coordination of science and policies regarding biodiversity and ecosystem services. In February 2019, a technical support unit for the invasive alien species assessment was set up under IGES. In order to ensure effective reflection of Japan's knowledge in the assessment reports in the process of creation, domestic liaison conferences were held in July 2021 and April 2022 gathering experts involved in IPBES in Japan and relevant ministries and agencies. Furthermore, MOE held a symposium titled "Biodiversity and Lifestyle – What We Can Do to Preserve Nature's Bounty of Food for Future Generations" based on the IPBES Global Assessment Report in December 2021.

Japan has a part in and supports activities of the Global Biodiversity Information Facility (GBIF) that aims to collect data on biodiversity so that the data can be made available worldwide. Japan also provided GBIF with biodiversity data in cooperation with National Science Museum and National Institute of Genetics which are both GBIF nodes (data providing centers). Data accumulated by GBIF are expected to serve as fundamental for evaluation at IPBES.

The National Institute of Technology and Evaluation (NITE) has collected, preserved and distributed biological resources and has also organized information on these resources in terms of their genes and genetic lineages so as to make the information accessible to the public, including researchers and industry. NITE has also joined the network composed of 28 organizations from 15 countries and regions, which aims for the preservation and the sustainable use of microbial resources and has actively supported Asian countries in their efforts to use biological resources by constructing cooperative relationships with them according to the Convention on Biological Diversity (CBD). Furthermore, NITE has constructed and launched the Data and Biological Resource Platform (DBRP) as a comprehensive database of information related to microorganisms, providing one-stop access to bioresources and related information.

Marine ecosystems, which are closely linked to human society in terms of food production and climate control, have been exposed to environmental stresses such as pollution, global warming and overfishing in recent years, and understanding, conserving, and utilizing marine ecosystems in light of these stresses has become an important subject. For this reason, MEXT has been carrying out R&D to understand complex and diverse marine ecosystems and to develop conservation and utilization technologies for them

by discovering new knowledge from big data based on existing data or data acquisition technologies under "Advancement of Technologies for Utilizing Big Data of Marine Life " of the Ocean Resource Use Promotion Technology Development Program.

❹ Evocation of changes in public behavior

MOE is constructing and demonstrating a behavior change model that encourages voluntary decarbonization actions in various daily life scenarios by combining behavioral insights such as nudges and advanced technologies such as AI/IoT (BI-Tech).

The results are compiled and presented through keynote speeches and panel discussions at domestic and international conferences with nudge units from other countries. The ministry is sharing information and collaborating with a wide range of people, including the general public.

In FY2010, MOE started a large-scale, long-term birth cohort study, the Japan Environment and Children's Study (JECS), by enrolling 100,000 pairs of parents/ children across the country in the study. In this study, biological samples such as cord blood, blood, urine, breast milk and baby teeth have being collected, preserved, and analyzed. Follow-up studies are being conducted using questionnaires.

As of the end of December 2021, 235 papers have been published, with research continuing on the influence of environmental factors, such as exposure to chemicals and the living environment, on abnormalities during pregnancy and delivery, as well as on children's health during their growth after birth. In addition, data from JECS participants is being used for the risk assessment by the Cabinet Office, Food Safety Committee to create weight increase curves for pregnant women, development indices for infants and toddlers, etc.

The research findings to date include dissemination of information to the public and educating people to reduce health risks by holding symposiums and dialogue with stakeholders to promote behavioral changes among people.

<Reference URL>
Japan Environment and Children's Study (JECS)
http://www.env.go.jp/chemi/ceh/

3 Building a Resilient, Safe and Secure Society

The government of Japan aims to build a society that is resilient to natural disasters, which are becoming more frequent and severe. At the same time, the government will ensure the safety and security of people's lives, the economy and society from attacks in new areas such as cyberspace or new biological threats, promote R&D of advanced technologies, and implement appropriate measures against technology leaks.

❶ Responding to increasing frequency and severity of natural disasters

1. Improvement of prevention capabilities

Under Tokyo Metropolitan Resilience Project, MEXT has been building an ultra-high density seismic observation system in public-private collaboration by integrating seismic observation data held by government agencies, local governments, private companies, and others. The ministry is also collecting sensor information concerning the collapse margin of structures including non-structural components (piping, ceiling, etc.) by using the 3D Full-Scale

Earthquake Testing Facility (E-Defense) to collect large amounts of diverse data that will contribute to integrated public-private disaster response, business continuity, disaster prevention actions by individuals, etc. for maintenance of urban functions. The data will be shared and analyzed by industrial, public and academic sectors, which will lead to creation of new value.

MLIT has been developing and operating the Nationwide Ocean Wave Information Network for Ports and Harbors (NOWPHAS) in mutual cooperation with MPAT 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[1].

Public Works Research Institute is working on technology development to reduce damage of flood disasters that have become extreme in recent years and damage of tsunami and sea level rise, prevent and mitigate sediment disasters caused by sudden natural phenomena, and reduce damage of snow/ice disasters caused by extreme weather.

The Building Research Agency is conducting technology development to ensure the structural safety of buildings, thus contributing to prevention of damage/collapse due to natural disasters and ensuring continued use of buildings.

Towards early recovery and reconstruction after a major earthquake, MPAT is conducting research on forecasting earthquake- and tsunami-induced deformation and performance degradation for structures in coastal areas and the areas behind them, for the improvement of safety and reliability for facilities in coastal areas.

In February 2022, MRI, in collaboration with universities and other research institutions, launched a project to elucidate the mechanism of linear precipitation zones to accelerate research into elucidating the occurrence and maintenance mechanisms of linear precipitation zones through conducting intensive observations of water vapor, mainly in western Japan during the 2022 flood season. Furthermore, MRI is addressing the development of real-time observation and monitoring technology for the detection of unusual meteorological phenomena, such as intense localized downpours, by means of dual polarization radar, phased array radar and global positioning system (GPS). MRI is also advancing the development of a numerical prediction model with high enough resolution to display intense localized downpours, in order to improve the accuracy of weather information and thereby to help reduce damage from local meteorological phenomena.

2. Improvement of predictive capability

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

The HERP has been making long-term evaluations of the probabilities and magnitudes of earthquakes. The evaluation methods, as well as their publication methods, have been reviewed and revised, taking into account the 2011 off the Pacific coast of Tohoku Earthquake, which ruptured large

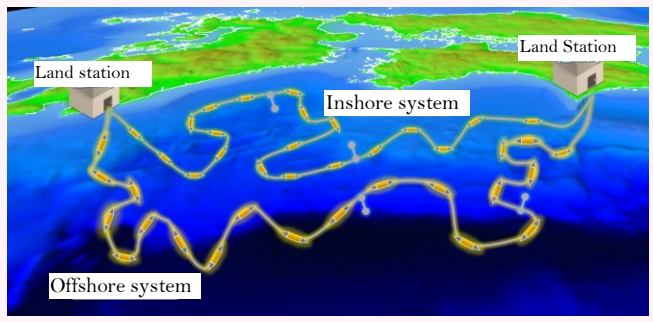
1 http://www.mlit.go.jp/kowan/nowphas/

area beyond the expected regions, and the Kumamoto Earthquake occurred on active faults. Moreover, the HERP is promoting evaluation of tsunamis caused by various earthquakes, considering the serious tsunami damage caused by the 2011 off the Pacific coast of Tohoku Earthquake.

MEXT launched the "Research Project for Disaster Prevention on the great Earthquakes along the Nankai Trough" which includes research and development on scientific evaluation of seismic activities when "Anomalous Phenomena" along the Nankai Trough are observed, and conducting surveys and research on appropriate disaster management for the areas where damage is anticipated.

After the Great Hanshin-Awaji Earthquake, comprehensive earthquake observation networks were 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, National Research Institute for Earth Science and Disaster Resilience (NIED) is operating the Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET) that is a dense submarine network equipped with seismometers and hydraulic gauges for real-time seismic observation in the seismic source region of the anticipated Nankai Earthquake. Furthermore, off the Pacific Coast of Tohoku where large aftershocks and tsunamis are likely to occur, the Seafloor observation network for earthquakes and tsunamis along the Japan Trench (S-net) has been operated to directly detect earthquake and tsunami to contribute to accurate and prompt communication of disaster information. In addition, the construction of the Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis (N-net) was advanced in the sea area extending from off the coast of Kochi Prefecture to Hyuganada, where the observation network is not yet installed in the anticipated seismic source region of the Nankai Trough Earthquake (Figure 2-2-1).

■ Figure 2-2-1／ The Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis (N-net)



Source: MEXT

In the field of volcanology, the Integrated Program for Next Generation Volcano Research and Human Resource Development was launched in FY2016 in response to the eruption of Mt. Ontake in 2014. The program promoted integrated research of "observation, forecasting and countermeasures" in coordination and jointly with other fields in order to contribute to reduction of volcano disasters in addition to existing observation research. The project also fostered volcano researchers who have comprehensive knowledge and advanced technique. In addition, under the "Volcanic Observation Campaign Preliminary Research Project" started in FY2021, preliminary research is being conducted on establishing systems necessary for realizing quick and efficient volcanic observation campaign in the event of emergencies, such as the occurrence of

volcanic eruptions and precursor phenomena.

NILIM has been implementing the "Response to Intensifying Disasters," including developing a calculation method for predicting the extent of sediment reach and sedimentation depth in the event of sediment and flood inundation, with high accuracy.

NIED is observing various tremors ranging from feeble tremors imperceptible to the human body to strong tremors causing big damage by using about 1,900 high-performance and high-precision seismometers covering the entire land area of Japan evenly and densely. It operates about 200 seismometers and tsunami meters in sea area and started full-scale operation of Monitoring of Waves on Land and Seafloor (MOWLAS) in November 2017. MOWLAS is an earthquake, tsunami and volcano observation network covering all land and sea areas of Japan, including the Fundamental Volcano Observation Network (V-net) for 16 volcanoes in Japan. NIED is advancing research and implementation of real-time prediction of earthquakes and tsunamis as well as observation and prediction of volcanic activities by using MOWLAS and has provided observation data to JMA. NIED also promoted use of the observation data by research institutes, local governments and the private sector including railway companies.

In addition, NIED is also conducting research on storm, flood and landslide prediction based on multi-sensing and research contributing to reduction of damage caused by natural disasters including evolving snow/ice disasters and coastal disasters. For example, the creation of new information such as the identification of road conditions such as snow accumulation and flooding using AI, assessment of rainfall-triggered hazard area based on the return period, named as the "rarity" of heavy rainfall, and high-resolution area snowfall information using radar and numerical snowpack models, etc., and expansion of the provision area of snow load alert system; construction of an information website on snowdrifts in Niseko; social application of snow/ice disaster prevention information including provision of snowfall/snow-melting information to local governments by introduction of IoT to the existing snow-melting devices, development of early prediction technique for short-lived local heavy rainfall using cloud radars[1] and; participation in an innovation creation project in cooperation with private companies.

JMA, in cooperation with MEXT, collects, processes, and analyzes data from the fundamental earthquake survey and observation networks, and provides the results to the Earthquake Research Committee of the Headquarters for Earthquake Research Promotion (HERP) in addition to utilizing it in disaster prevention information, etc. Also, JMA has developed and introduced an Automatic Hypocenter Determination Method (PF Method[2]). For the Earthquake Early Warning System, JMA introduced the IPF[3] Method and the PLUM[4] Method for earthquake alerts to cope with simultaneous earthquakes and massive earthquakes, which became an issue during the

1 Weather radar to observe cumulus clouds before developing into precipitation clouds
2 Phase combination Forward search
3 Integrated Particle Filter method. A method to accurately estimate hypocenters even during multiple simultaneous earthquakes. Developed jointly with the Disaster Prevention Research Institute, Kyoto University
4 Propagation of Local Undamped Motion method. A method to appropriately predict the seismic intensity of large earthquakes even over an extremely wide area of strong motion

2011 off the Pacific coast of Tohoku Earthquake. Technological development for further enhancement is underway in cooperation with the NIED. For tsunamis, JMA has introduced a method for accurately predicting the height of coastal tsunamis from offshore tsunami observation waveforms (tFISH[1]).

MRI researches the following topics: the development of real-time scale estimation of tsunami/earthquake to mitigate damage by tsunamis, and tsunami forecasting based on offshore tsunami monitoring data; research on a real-time understanding of the scale, rupture areas and slow slip events of earthquakes occurring in the Nankai Trough, and development of a monitoring method to advance volcanic activity assessment and prediction.

To collect geological information useful for disaster prevention/mitigation, AIST investigates geological surveys of active faults, tsunami deposits, and active volcanoes, and publishes the results of these surveys. Regarding major active faults in Japan, five active faults (Shibetsu, the western margin of the Tsugaru Mountains Nobi, Kikugawa, and Unzen) for which the probability of earthquake occurrence and the latest active period are unknown were surveyed to obtain data necessary for calculating the probability and magnitude of earthquake occurrence. In addition, data updates and system improvements were made to the active fault database. Regarding the tsunami deposits, evidence of tsunami inundation from about 1,000 years ago at Kujukuri Beach, Chiba Prefecture, in the southern Japan Trench, which is not found in historical records, was presented, and a fault model of the wave source was also constructed to explain the evidence. Moreover, a comprehensive groundwater observation site that contributed to the short-term prediction of the Nankai Trough Earthquake was operated and maintained. Groundwater levels (hydraulic pressure), groundwater temperature, crustal strain, and seismic waves were constantly observed.

Regarding volcanos, satellite data analysis, field surveys, and observation and analysis of volcanic ejecta were conducted for Fukutoku-Oka-no-Ba submarine volcano and the Nakadake crater, Aso Volcano, where volcanic eruptions had taken place, to obtain information that would contribute to clarifying the scale and pattern of the current eruptions and predicting future activity trends. The information was provided to relevant ministries, agencies, and local governments and disseminated via the web.

JAMSTEC in cooperation with universities and other relevant organizations, conducts surveys and observations of seafloor earthquakes and volcanoes using research vessels and various types of observation equipment in the sea area assumed to be the epicenter of the expected Nankai Trough mega earthquake , and the oceans surrounding Japan and the West Pacific Ocean. By advancing methods to analyze data from these observations, JAMSTEC predicts transition of seismic and volcanic activities through large-scale and high precision numerical simulations.

GSI is responsible for observation, analysis, and R&D on crustal deformation and plate motions through GNSS[2] CORS[3] network, Very Long Baseline Interferometry (VLBI[4]), and Interferometric Synthetic Aperture Radar

1 Tsunami Forecasting based on Inversion for initial sea-Surface Height
2 Global Navigation Satellite System
3 About 1,300 sites nationwide, as of March 31, 2022
4 Very Long Baseline Interferometry: Technology that measures distances of thousands of kilometers with a margin of error of a few millimeters, using radio waves reaching the earth from billions of light years away

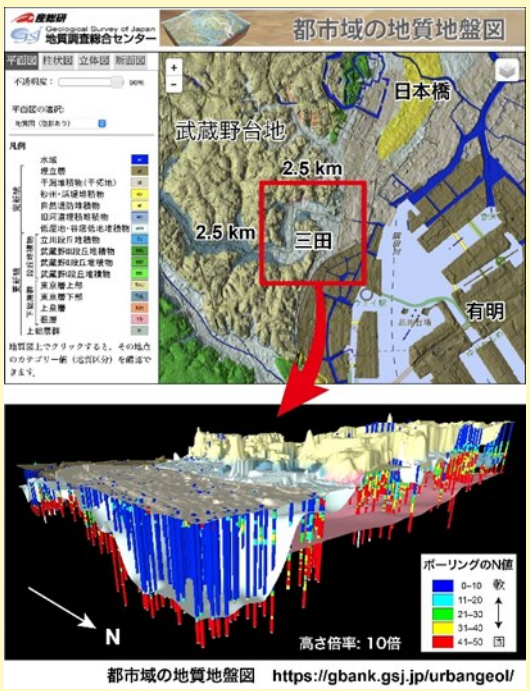
(InSAR [1]). Detailed monitoring of crustal deformation in and around volcanoes has been implemented through integrated analysis of GNSS volcanic observation data, which have been collected by several institutes, such as JMA, NIED, the Hot Springs Research Institute of Kanagawa Prefecture, and the Earthquake Research Institute of the University of Tokyo.

The Japan Coast Guard (JCG) has been operating GNSS-A seafloor geodetic observation and bathymetric survey. The data and results are regularly published.

JMA is strengthening and accelerating efforts to improve the prediction accuracy of stationary linear mesoscale convective systems. In June 2021, JMA began operating the "Information related to localized heavy rainfalls brought by stationary linear mesoscale convective systems" for early updates on the occurrence of linear precipitation zones and began offshore observations in cooperation with the Japan Coast Guard, mainly in the offshore areas from west to southeast of Kyushu.

COLUMN 2-5 A Next-generation Geological Map That Can Express the Subsurface Geological Structure in Three Dimensions (Urban Geological Map)

In Japan, most large cities are located on coastal plains. When a major earthquake occurs, liquefaction occurs in the bay area, and shaking amplifies due to soft ground, causing extensive damage to urban infrastructure. Information on the shallow geological subsurface is essential to assess disaster risks and develop urban infrastructure efficiently. However, it wasn't easy to accurately express subsurface geological structures with conventional planar geological maps. Based on this background, AIST has been developing new geological maps for 3D visualization of the subsurface geology of urban areas, called "Urban Geological Maps," and the Urban Geological Maps of Northern Chiba Prefecture and Central Tokyo were released on the web in 2018 and 2021, respectively.



Data / Urban Geological Map of Central Tokyo
Provided by: AIST

Urban Geological Maps are created by constructing a reference geological data based on facies characteristics, age, and physical properties of geological strata obtained from sediment core samples collected independently by drilling, correlating the geological strata using the borehole data for civil engineering and construction from tens of thousands of sites, provided by local governments, and analyzing the subsurface geological structures in three dimensions. With the development of the Urban Geological Maps, the distribution of soft sediments (alluvium) that fill the valleys formed by the lowering of sea level during the last glacial period (the peak period was about 20,000 years ago) could be drawn with unprecedented accuracy. Furthermore, it became clear that soft mud layers are distributed as if filling a valley, even under the Musashino Upland, which was considered a suitable subsurface. Using Urban Geological Maps, anyone can easily view the three-dimensional extent of the subsurface strata as a 3D drawing on a computer screen. It is also possible to create a geological cross-section of any location and zoom in on your areas of interest to see the details. It is expected that the increased use of Urban Geological Maps will improve the accuracy and efficiency of geological disaster risk assessment and urban infrastructure development and contribute to groundwater flow and geological pollution surveys and real estate transactions, etc., in the coming days.

1 Interferometric Synthetic Aperture Radar: Technology to monitor changes in the earth's surface from space using satellites

3. Improvement of response capabilities

In the First Period of the SIP Program, "Enhancement of Societal Resiliency against Natural Disasters (FY2014-2018)", the Cabinet Office developed the "Shared Information Platform for Disaster Management (SIP4D)," which is a system to gather disaster information on digital maps and enable information sharing among relevant organizations. In the First Period of the SIP Program, "Enhancement of Societal Resiliency against Natural Disasters (FY2014-2018)", the Cabinet Office developed the "Shared Information Platform for Disaster Management (SIP4D)," which is a system to gather disaster information on digital maps and enable information sharing among relevant organizations. During the heavy rains that began on July 1, 2021, and in August 2021, the Information Support Team (ISUT), operated by the Cabinet Office, Government of Japan (disaster management), used the platform to provide information support to relevant government ministries and agencies, local governments, and designated public agencies for their response to the disaster. In the second period of the SIP Program "Strengthening of National Resilience (disaster prevention/mitigation)" that started in FY2018, the Cabinet Office is promoting R&D and social implementation to construct an information system that makes the best of the latest science and technologies including satellites, IoT and big data to support decision making by the central and municipal governments in the event of a natural disaster. The office is also promoting R&D into Disaster Chatbot, a system of automatic talk with AI on SNS at the time of disaster, through demonstration experiments with local governments and other participants.

Quasi-Zenith Satellite MICHIBIKI started service on November 1, 2018. The service consists of disaster crisis management reporting to provide disaster prevention weather information through Michibiki and collection of safety information of evacuees in shelters, etc.

MIC has been conducting R&D on ICT for improving the disaster-resistance of information and communications facilities, and for collecting data on damage at times of disaster. In addition, MIC has vigorously applied its research results, such as a communication system that can be carried in disaster-stricken areas for emergency restoration of communications (a movable and deployable ICT resource unit) in communities in Japan and worldwide.

NIED conducts research on the development of systems to share and utilize information of various natural disasters and has been conducting necessary demonstrations and providing information for public disaster response based on its role as a designated public institution. During the heavy rains on July 1, 2021, and in August 2021, the information collected in "SIP4D" and the information collected in the disaster-affected areas were consolidated in a centralized manner and along with the past information and analysis results related to each disaster disseminated to disaster response agencies via a website that displays maps called "Disaster Prevention Crossview" (bosaiXview; open to the public) and ISUT-SITE (open only to disaster response agencies), assisting the unification of situational awareness, etc.

The National Research Institute of Fire and Disaster of the Fire and Disaster Management Agency has established a new 5-year research plan that started in FY2021 and is currently conducting research and development on (1) Improving firefighting capabilities during landslide disasters using drones, etc., (2) Research and development to control damage caused by fires in urban areas when an earthquake occurs and (3) Mitigating

earthquake disasters at hazardous material facilities as a response to natural disasters.

NICT has been increasing the sophistication of an airborne Polarimetric and Interferometric Synthetic Aperture Radar system (Pi-SAR[1]) that can observe the ground surface in disaster-stricken areas as needed. In addition, a system developed by NICT allows portable communication devices with built-in server functions to physically move around in areas where public communication networks have been disrupted and synchronize and share information through high-speed wireless communication when the devices are close to each other has been introduced to the local authorities. In addition, regarding the development of information analysis technology that analyzes SNS postings in real time and extracts disaster-related information, a user interface with improved usability has been developed. It is being tested in disaster drills in cooperation with the local authorities.

NILIM is conducting the following activities: (1) development of rapid testing of the soundness of key buildings (e.g., government offices) of local governments which were damaged by an earthquake, and; (2) research on design objectives of independent energy systems for continued daily living after a disaster.

Public Works Research Institute is developing technologies to support risk management of water disasters in Japan and abroad, and technologies for minimizing damage of a major earthquake to structures and their early restoration.

JAXA has been contributing to various disasters monitoring and grasping of the state of disaster using the Advanced Land Observing Satellite-2 "DAICHI-2" (ALOS-2) and other satellites.

In response to the global outbreak of COVID-19, METI will advance introduction of EdTech to schools and development of online contents that promote home schooling. The ministry will also enhance support for non-face-to-face/remote business activities. The support includes promotion of use of cross-border e-commerce[2], construction of digital business talk platforms and promotion of smart industrial safety.

4. Development of information platform integrating observation and projection/prediction data

Under the Program to Promote Development of Global Environmental Data Platform, MEXT has developed DIAS. It is an information platform that accumulates, integrates and analyzes big data of the global environment (observation information, projection/prediction information, etc.) to contribute to solving climate change and other global issues. The DIAS has supported R&D in Japan and abroad and produced results including a system that predicts floods caused by a typhoon, etc. MEXT is working to establish a management structure to ensure its long-term stable use by a large number of users including researchers and enterprises in Japan and abroad, and is also promoting development of common fundamental technologies contributing to solution of social challenges in various fields including, energy, weather, disaster prevention and agriculture.

By analyzing the data from the Superconducting Submillimeter-wave Limb-Emission Sounder (SMILES[3]) that NICT developed in cooperation with JAXA, NICT issues warning on global

1 Polarimetric and Interferometric Airborne Synthetic Aperture Radar
2 Electronic Commerce
3 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.

environmental changes based on the new knowledge and has been releasing observation data for free use since FY2020. NICT is also promoting unique mathematical algorism analysis of the global environment observation data from GOSAT, etc. The institute is also distributing monitoring/forecast and alarms regarding solar activities and the electromagnetic environment around the earth, which influences how radio waves are transmitted, while conducting integrated collection, management, analysis and release of space environment observation data. In addition, NICT is advancing the development of space environment measurement/prediction technologies to further advance these observation technologies and prediction technologies using logical models and AI.

Furthermore, JMA observes tropical cyclones and sea surface temperature, etc. by using Himawari-8 and Himawari-9, to contribute to prevention of natural disasters and monitoring of climate change, not only in Japan but also in the entire Asia Pacific region.

❷ Efficient infrastructure management through digitalization, etc.

Under PRISM [1] "innovative construction and infrastructure maintenance and innovative disaster prevention/mitigation technologies field" the Cabinet Office promotes "change through innovation" by allocating additional budget to and accelerating promotion of i-Construction and other measures of relevant ministries and agencies. In order to realize steady and efficient infrastructure maintenance while accelerating open innovation brought about by effective use of data, the ministry in cooperation with MLIT is promoting construction of an infrastructure data platform that coordinates data of the national and local governments and the private sector. The Cabinet Office, Government of Japan, has been promoting the construction of a "Collaborative Infrastructure Data Platform" based on this initiative and conducted a trial data linkage in a model project in FY2021.

MLIT have promoted the development and introduction of robots to maintain social infrastructure and implement anti-disaster measures more effectively and efficiently.

MLIT is promoting i-Construction where ICT is used in all construction production processes from investigation/survey to design, installation, inspection, maintenance and renewal. The aim is 20% improvement of productivity in construction sites by FY2025. Taking the opportunity of the measures against the novel coronavirus infection, "DX (Digital Transformation) is being promoted in the infrastructure field" to transform the "Common sense" of the past by utilizing digital technology to make the surroundings of infrastructure smarter, including the way managers work and the services and procedures provided to users. For example, engaged in providing realistic and recognizable risk information using 3D hazard maps, conducting supervisory inspections by remote attendance and trial rebar inspections using digital data, which will enable site management without the need to be on-site, and conducting unmanned and automated construction. At the end of FY2021, an action plan was formulated showing specific future steps and "things that can be achieved" for each measure. In

1 Public/Private R&D Investment Strategic Expansion PrograM

2022, initiatives will be further accelerated based on the specific steps of the action plan as a "Year of Challenge" to tackle reforms through DX boldly.

In order to promote i-Construction and accelerate DX in the infrastructure field, the Geospatial Information Authority of Japan (GSI) is developing "National Geodetic Datum," which is a common rule for positional information used in individual processes of: investigation, survey, design, construction, inspection, maintenance and renewal. GSI is implementing technology development on novel survey techniques contributing to improvement of the accuracy, efficiency and reliability of 3D surveys.

NILIM is conducting "Research on Fundamental Labor Productivity Improvement through DX in Each Phase of Construction Projects," which examines systems for utilizing digital data such as BIM/CIM [1] models. It develops technologies linked to improved labor productivity and safety by improving the work of construction engineers based on the use of new technologies and analysis of construction site data. In cooperation with other MLIT departments and agencies, NILIM has been developing technologies for more efficient maintenance of sewerage facilities; utilization of existing buildings in order to ensure continued safe use of existing housing and social capital stock through more efficient and advanced inspection, repair and renewal, and techniques and technologies for utilization of existing buildings and building lots.

Public Works Research Institute has been working on the development of: methods contributing to an effective (efficient, advanced) maintenance cycle of existing structures (bridges, pavements and management facilities); methods for renewal/construction of structures, which enables maintenance and long service life in accordance with the management level for bridges, civil engineering structures and tunnels, and; cross-cutting (roads, rivers, harbors, fishing ports and agriculture) technologies and systematization for maintenance and renewal of infrastructure susceptible to frost damage, complex deterioration and other damages.

MPAT conducts research to develop technologies for the inspection and monitoring of coastal infrastructure that supports Japan's economic and social activities and to contribute to improving the efficiency of maintenance and management and reducing life cycle costs.

NIMS has comprehensively conducted R&D in the material field, in which Japan excels, for technologies to inspect, diagnose, repair and upgrade infrastructure and evaluate reliability of materials as well as for development of new structural materials with the aim of extending the service life and enhancing the earthquake resistance of the social infrastructure.

❸ Ensuring security in cyberspace, where attacks are becoming increasingly diverse and sophisticated

For the purpose of comprehensively and effectively advancing measures for Cybersecurity pursuant to the Basic Act on Cybersecurity (Act No. 104, 2014), the Cybersecurity Strategy was decided by the Cabinet on September 28, 2021 after deliberations by the Cybersecurity strategy headquarters led by the government. The government has been promoting R&D on technologies related to cybersecurity based on the strategy.

Since FY2018 the Cabinet Office has been working on the SIP "Cyber Physical Security for IoT Society." Toward realization of a secure Society 5.0, the program is promoting

1 Building Information Modeling/Construction Information Modeling/Management

development and demonstration of Cyber Physical Security Infrastructure that can be used for protection of an entire large supply chain including IoT system services and SMEs, and its social implementation in diverse social infrastructure and services as well as industrial fields with a wide supply chain, which include manufacturing, distribution and building management.

Through NICT and other entities, MIC has been promoting R&D in the field of cyberattack observation and cybersecurity. MIC aims to use its technical knowledge obtained through the R&D to train security human resources who have practical ability to handle increasingly sophisticated and complex cyberattacks. To this purpose, MIC has been implementing practical cyber defense exercise (CYDER [1]) for government agencies, local governments, and others, and SecHack365 to train young security personnel at the National Cyber Training Center organized in NICT. In addition, the same organization has established the "Integrated intellectual and human resource development infrastructure of cybersecurity (CYNEX[2])," which will serve as a node between industry and academia in the collection and analysis of cybersecurity information in Japan and the development of cyber security human resources, with the technologies, know-how and information possessed by the organization at its core and is currently conducting the test run of this platform. METI formulated the "Cyber Physical Security Framework (CPSF)" in April 2019, organizing the overall framework of measures required of industries to ensure cyber security of the entire supply chain in "Society 5.0" realized by IoT and AI, and guidelines for each industry sector (factories, electric power, automobiles, etc.) are being developed based on CPSF. In addition, as a concept linked to the CPSF, a framework for handling data in cyberspace and IoT device security is being developed. The "Cyber Physical Security Research Center," established by AIST in November 2008, promotes and conducts research and development of technologies to analyze increasingly sophisticated and complex threats and strengthen security against threats as cyber space and physical space converge. In addition, to strengthen protection against cyber-attacks in industries that support critical infrastructure and the foundation of Japan's economy and society, the Industrial Cyber Security Center of Excellence (ICSCoE) established in the Information-technology Promotion Agency, Japan, is promoting joint initiatives by the public and private sectors to develop human resources to play a central role in cyber security measures.

METI will support construction of cyber security validation technology as the basis of non-face-to-face and remote activities as well as SME's measures in this area. The ministry also intends to encourage capital investment to promote digitization by SME.

❹ Response to new biological threats

Concerning research and development for novel coronavirus infection, the government supports research and development related to treatment methods, diagnostic methods, vaccines, etc.

Regarding treatment methods, since the first case of novel coronavirus infection in Japan was confirmed, from the perspective of promptly creating a therapeutic drug, the government has been supporting research and development through the Japan Agency for Medical Research (AMED) and Development, focusing initially on drug repositioning, in which the efficacy and safety of existing therapeutic drugs are examined. In

1 CYber Defense Exercise with Recurrence
2 Cybersecurity Nexus

addition, from the perspective of new drug discovery, the agency has provided support for basic and clinical research, which has resulted in the discovery of several new compounds that exhibit SARS-CoV-2 proliferation inhibitory activity.

Regarding diagnostic methods, through AMED, basic research on rapid diagnostic kits for gene amplification tests, rapid antigen diagnostic kits, test reagents, etc., was supported and put into practical use. Performance evaluation results of antibody test kits were reflected in the medical treatment guideline for the new coronavirus infectious disease (COVID-19) prepared by the research project funded by the MHLW subsidy for administrative promotion research project. The project for the development and demonstration of technologies for measures against viruses and other infectious diseases supports research and development that leads to solutions to infectious disease issues and the development and demonstration of equipment and systems to meet the needs of the field for measures for the novel coronavirus disease (COVID-19 pandemic).

In response to the demand to accelerate the development of vaccines and strengthen the supply system in Japan, the implementation of basic, non-clinical, and clinical research by domestic companies and universities is being supported through AMED, and some vaccines are in the final stages of clinical trials.

The pandemic has provided an opportunity to identify the factors that have stalled vaccine development in Japan, and the government has worked together to rebuild the necessary systems to solve the problems. The "Strategy for Strengthening Vaccine Development and Production System" (Cabinet decision on June 1, 2021) was formulated as a national strategy for long-term, continuous efforts. Based on this strategy, the Strategic Center of Biomedical Advanced Vaccine Research and Development for Preparedness and Response (SCARDA) was established at the AMED to strengthen the R&D and production system during normal times in preparation for future infectious disease emergencies. Under the leadership of personnel with expertise in various specialized fields such as medicine and immunology, as well as in the research, development, commercialization, and management of biopharmaceuticals, a system has been established to collect and analyze information on infectious diseases and vaccines in Japan and overseas, and to provide R&D support from an overall perspective of vaccine research, development, and commercialization. Under the new structure, SCARDA will engage in projects such as intensive support for practical application research by industry-academia-government collaboration using new drug discovery methods, the establishment of world-class R&D centers, and fostering drug discovery ventures. In addition to the initiatives by AMED, other necessary initiatives are being taken to establish a system that will enable the rapid development and supply of vaccines, such as the establishment of dual-use vaccine production sites.

The novel coronavirus pandemic has once again shown that a global response system is needed, and the ("Research Program on Emerging/ Re-Emerging Infectious Diseases" (under the jurisdiction of MEXT)) supports strengthening the research infrastructure for infectious diseases in Japan and overseas and promotes basic research through AMED, and the ("Research Program on Development and Promotion of Innovative Drugs for Emerging and Re-emerging Infectious Diseases" (under the jurisdiction of MHLW)) is consistently promoting development and research for practical application of infectious disease crisis-response drugs, etc., as part of a fundamental enhancement of infectious disease contingency

planning. In addition, (the "Project to Create a Clinical Research and Trial Network in the Asian Region" (under the jurisdiction of the MHLW)) is in the process of establishing a foundation to promote clinical research and clinical trials in the Asian region led by Japan.

In addition, monitoring tests were conducted to detect the spread of novel coronavirus infection, including PCR tests focusing on asymptomatic persons, solicited research themes from academia and companies to conduct research and development related to new technologies that contribute to the prevention of the spread of infection, including droplet simulation using the supercomputer "Fugaku," and conducted simulations of the infection situation, such as the number of new positive cases and the number of severely ill cases.

❺ Responding to threats to the safety and security of space, marine, and other fields

1. Promotion of R&D in space science

Today, space systems including positioning, communication and observation are supporting the security and economic/social activities of the nation and are also increasing their importance as infrastructure for realization of Society 5.0. In this context, space activities embark on an age of public-private co-creation and there are efforts to vitalize industries through space use in a wide range of fields. As the progress of space exploration expanded human activities beyond terrestrial orbit to the moon and deeper space, the success of HAYABUSA2 in conducting sample collection from an asteroid demonstrated the high level of the nation's S&T and raised the expectations of the public. Space is further increasing its importance as a S&T frontier and driving force of economic growth. It can be a big driving force in innovation creation in Japan.

Launch of H-IIA F43
Source: JAXA

With this understanding, the government based on the Basic Plan on Space Policy (Cabinet Decision on June 30, 2020) is promoting the nation's space development and use comprehensively, systematically and powerfully as a national strategy.

(1) Space transportation systems

Space transportation systems that have a role to launch satellites are a key pillar for the development and utilization of space. Technologies for sending satellites to their designated altitudes whenever needed are vital for the autonomy of Japan's space activities. The development of a new flagship rocket, H3, started in FY2014 and various combustion tests have been conducted to expand Japan's autonomous space activities and ensure its international competitiveness. The first new test rocket is scheduled for launch in FY2021. With the aim of increasing international competitiveness by achieving both further launch cost reduction and high reliability of key rockets as well as improvement of the satellite operability, Japan has been promoting the development of the Epsilon S rocket.

(2) Global positioning satellite systems

The Cabinet Office started a high-precision positioning service based on a *4-satellite constellation* of Quasi-Zenith Satellites MICHIBIKI on November 2018. Toward the 7-

satellite constellation to be established in FY2023 and its function and performance improvement, the office is promoting the development of MICHIBIKI-5, 6 and 7. Toward further utilization of MICHIBIKI, relevant ministries and agencies are working together on various demonstration experiments including automated driving of automobiles and farm machines, physical distribution and disaster prevention.

(3) Satellite communication and broadcasting systems

In order to realize internationally competitive next generation geostationary communication satellites, MIC and MEXT have been jointly developing the Engineering Test Satellite 9 since FY2016. This satellite will be developed for the purpose of demonstrating technologies of electric propulsion, high-power generation, and flexible payload toward launch in FY2023.

(4) Earth observing system

Through GOSAT launched in FY 2008 and GOSAT-2 launched in FY2018, MOE has demonstrated that global CO_2 and methane concentrations have been rising year by year. In order to aggressively expand this mission and grasp the effects of the measures toward the decarbonized society, the ministry is promoting the development of its successor, GOSAT-GW for the launch scheduled in FY2023.

With the aim of elucidating the mechanism of global water cycle and climate change, JAXA has been operating SHIZUKU (GCOM-W) launched in May 2012 and SHIKISAI (GCOM-C) launched in December 2017. Data from SHIZUKU together with the data from the Global Precipitation Measurement (GPM[1]) core satellite launched in February 2014 under the international cooperation project with NASA[2] are used by JMA to improve the accuracy of precipitation estimates and for various other purposes, including weather forecasting and fishing ground detection. SHIKISAI is used also to grasp the situation of overseas large-scale forest fires. In order to continue the mission to observe the water cycle and GHG and further strengthen observation capability, JAXA is developing the *GOSAT-GW*.

In addition, DAICHI-2 (ALOS-2) launched in May 2014 is contributing to disaster prevention and management, and solutions to global issues such as global warming through monitoring of various disasters, grasping of damage situations and the observation of forests and ice of Polar Regions, etc. Currently JAXA is developing ALOS-3 and ALOS-4 capable of wide-area and high-resolution imaging. JAXA launched optical data relay satellites in November 2020 and is working for demonstration of optical communication between these satellites, which will enable instantaneous relaying of satellite data of affected areas to the ground when a natural disaster strikes. This is expected to help speedy disaster countermeasures in the future.

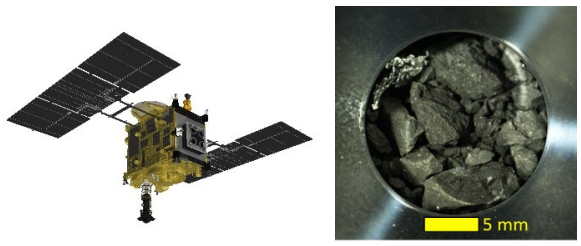
Toward stable operation of Japan's satellites, MEXT and JAXA have established and have been operating the SSA[3] system since FY2002 to observe space debris, etc. from the ground. The entire government including the Ministry of Defense will construct a new SSA system toward FY2023.

1 Global Precipitation Measurement
2 National Aeronautics and Space Administration
3 Space Situational Awareness

(5) Space science and exploration

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 the asteroid Itokawa. Venus Prove AKATSUKI put into Venus orbit in December 2015 produced results leading to the elucidation of the mechanism of "super rotation" in the Venus atmosphere. HAYABUSA2, launched in December 2014, achieved an array of the world's first brilliant feats after arriving at the Ryugu asteroid, including formation of an artificial crater on the surface of the asteroid and twice-repeated touch downs to the same asteroid. HAYABUSA2 returned to the vicinity of the Earth in December 2020 and separated the mounted capsule toward the earth. Later the capsule was collected in a desert in Australia. Samples from Ryugu were confirmed in the capsule, and at present, detailed analysis is being conducted by research institutions in Japan and overseas. The explorer is heading toward exploration of another asteroid (scheduled to arrive in 2031).

In addition, the Mercury Magnetospheric Orbiter MIO of the BepiColombo international collaborative mission to Mercury (launched in October 2018) in cooperation with the European Space Agency (ESA) is now navigating toward Mercury. JAXA is also developing the small moon landing demonstrator (SLIM[1]) in an attempt to conduct Japan's first lunar landing, the satellite XRISM[2] (both SLIM and XRISM are scheduled for launch in FY2022) and the *Martian* Moons eXploration (*MMX*) program for sample return



Asteroid explorer "HAYABUSA2" (left) and collected samples (right)
Source: JAXA

Optical data relay satellite
Source: JAXA

from Mars (scheduled for launch in FY2024). In this way 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 humankind.

In addition, based on Japan's decision to participate in the international space exploration project (Artemis Program) described below, MIC started the research and development of a Lunar Terahertz SUrveyor for KIlometer-scale MappIng (TSUKIMI) on the lunar surface in FY2021 to realize surface exploration of water resources, which are expected to be used as energy resources in lunar activities.

(6) Human space activities

The International Space Station (ISS) Program[3] is an international project collaboratively implemented by fifteen countries: Japan, the U.S.A.,

1 Smart Lander for Investigating Moon
2 X-Ray Imaging and Spectroscopy Mission
3 An international cooperative project to construct, operate and utilize a manned space station in low Earth orbit (about 400 km) based on an intergovernmental agreement between Japan, U.S., Europe, Canada and Russia

Europe, Canada and Russia. In this project, Japan assumes the role of developing and operating the Japanese Experiment Module "KIBO" and the uncrewed cargo transfer spacecraft "KOUNOTORI" (HTV[1]). KOUNOTORI has been used to resupply KIBO and the ISS. Japanese astronauts have carried out longstay missions aboard the ISS. The Japanese team has various achievements, such as establishing crewed and uncrewed space technologies, establishing an international presence for Japan, promoting the space industry, contributing to society through 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 deploying small satellites), and educating young people. All KOUNOTORI from the 1st (2009) to the 9th (2020) successfully completed their missions. With the functions unique to KOUNOTORI, including one of the world's best supply capacities (up to 6 tons) and capacity to mount multiple units of large test equipment, the spacecraft supported the use and operation of ISS. Taking advantage of the experience through KOUNOTORI, Japan is developing its successor, a new space station resupply vehicle (HTV-X) targeting better carrying capacity with reduced development and operation costs.

Two Japanese astronauts, Soichi Noguchi, who is to return in April 2021 from a long-term stay on the ISS for about six months and Akihiko Hoshide, who has just started his stay on the ISS, will stay together at the ISS. Astronaut Hoshide was the second Japanese to serve as ISS commander and returned to earth in November 2021. Furthermore, JAXA conducted a recruitment campaign for new Japanese astronauts from November 2021 to March 2022.

(7) International space exploration

The International Space Exploration "Artemis Program" is a program led by the United States to construct Gateway, a manned space station orbiting the Moon, conduct technology demonstration toward manned exploration on Mars in the future and continued manned activities on the Moon with participation of private enterprises. Japan decided to participate in the Artemis Program in 2019. Europe and Canada also expressed their intention to participate. Based on the decision above, MEXT and NASA signed a joint declaration on moon exploration cooperation in July 2020. Later in December, the Japanese government and NASA signed a memorandum of understanding concerning the cooperation for Gateway. The memorandum provides a legal framework to enable the cooperation confirmed in the joint declaration, which include Japan providing equipment to Gateway, and NASA providing Japanese astronauts multiple opportunities to board Gateway.

(8) 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, entrustment expense fees for the promotion of aerospace science and technology is used for the purpose of expanding the base of space users by discovering potential users of

1 H-II Transfer Vehicle

satellites and developing new utilization methods. Using this system MEXT continues R&D on space utilization technologies with a view to their practical use in human resource development, disaster prevention, the environment and other aerospace fields.

METI is developing the Hyperspectral Imager Suite (HISUI) that enhances remote detection capacity for oil resources. After installing HISUI[1] on the Japanese experiment module "Kibo" of the International Space Station in December 2019, the analysis and use verification of the acquired data were conducted in FY2021. Support for developing low-cost, high-performance space parts and components that utilize technologies from the consumer sector and provide opportunities for in-orbit demonstrations, as well as developing and demonstrating low-cost, high-performance small satellite general-purpose buses for mass production and constellation. In addition, in order to increase the use of space data that has been becoming big data, the ministry provides the government's satellite data for open and free use and is also developing a user-friendly satellite data platform (Tellus).

COLUMN 2-6

Developing a Food Supply System in Space

In recent years, initiatives to expand space development and utilization have been more active in the international community. As one of the key factors to strengthen international competitiveness in space, Japan has been developing a sustainable food supply system that emphasizes Quality of Life (QOL), which is expected to be utilized for sustained manned activities on the Moon and on Mars.

The Ministry of Agriculture, Forestry and Fisheries (MAFF) launched the strategic project "Development of a highly resource-recycling food system that supports long-term stays on the moon, etc." in FY2021 as part of the "Strategic Program for Accelerating Research, Development and Utilization of Space Technology" established by the Cabinet Office, Government of Japan. This project aims to develop a highly efficient food supply system in closed spaces for food production on a lunar base in the future through the (1) Development of a highly efficient food supply system that combines cultivation technologies with environmental control and resource regeneration technology using fermentation systems, etc., for crops such as rice, soybeans and potatoes, and (2) Development of a food-based QOL management system to maintain and improve physical and mental health and good human relationships in closed, isolated environments.

Through these initiatives, the advancement of R&D for the realization of future food supply in space is expected to improve Japan's food production technology, which in turn will have a ripple effect on solving global food problems.

Source: Development of a Resource Circulation Food Supply System

<Reference URL> MAFF website
https://www.maff.go.jp/j/shokusan/sanki/soumu/uchushoku.html

1 Hyperspectral Imager SUIte

2. The promotion of oceanographic R&D

Surrounded by seas on all sides and having one of the world's most extensive sea areas under its jurisdiction, Japan must regard marine science and technology as important for a national strategy and continue to strengthen its efforts in the field from a long-term perspective while taking into account the multifarious nature of science and technology. It is important to accumulate and utilize scientific knowledge related to oceans in order to conserve marine biological resources and ecosystems, secure energy and mineral resources, respond to global issues such as global warming and marine plastic litter, set up countermeasures for threats such as earthquakes, tsunamis and volcanoes, sustainably utilize the Arctic polar region, and strengthen the competitiveness of marine industries.

The Cabinet Office is promoting efforts to solve technology development challenges related to oceans in close cooperation with the Headquarters for Ocean Policy and ensuring consistency with the Third Basic Plan on Ocean Policy (Cabinet Decision on May 15, 2018).

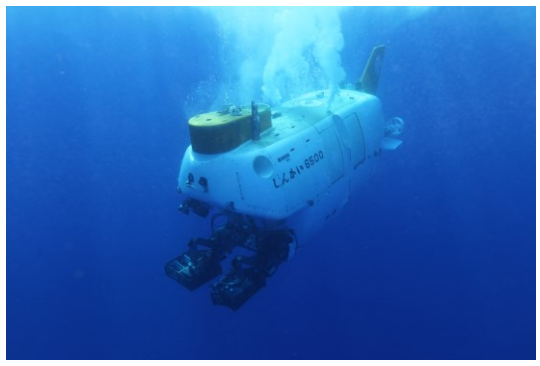
In light of the formulation of the 3rd Basic Plan on Ocean Policy, in January 2019 MEXT revised the R&D plan pertaining to ocean science and technology (formulated at the CST's Subdivision on Ocean Development in 2016) and has been promoting R&D in the marine S&T fields contributing to innovations toward creation of future industries.

Using vessels, probes, observation equipment and other means, JAMSTEC has been conducting surveys and research in the ocean including the deep sea bottom and ice-infested waters that are difficult to access, as well as simulations using obtained data and archiving and dissemination of data. Using these technologies JAMSTEC is promoting basic research to elucidate the actual state of the areas that need further elucidation.

(1) Ocean survey and observation technologies

For the purpose of understanding the subseafloor microbiosphere, the mechanisms of subduction-zone 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 scientific drilling vessel Chikyu and technologies for real-time observations by using DONET. These technologies are also utilized for surveys, research and the development of other technologies. The ministry has also 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

Deep-sea scientific drilling vessel
Chikyu
Source: JAMSTEC



Manned research submersible
SHINKAI 6500
Source: JAMSTEC

understanding of phenomena related to the deep ocean floor, such as tsunamis and huge earthquakes that can cause devastating damages.

(2) Technologies contributing to sustainable ocean development, use, etc.

MEXT has been implementing R&D of observation/measurement technologies for efficient and highly accurate understanding of marine ecosystems, marine environment and other marine information using a wide range of advanced technologies and knowledge held by universities, etc. under the “Technology Development for Understanding of Marine Information” within the framework of the program for developing technologies for promoting the use of marine resources.

In order to contribute to the promotion of industrial use of the ocean in Japan, JAMSTEC is promoting understanding of material cycles and formation of useful resources in the oceans from both biological and non-biological perspectives, and providing related industries with obtained scientific knowledge, data, technologies and samples .

(3) Technologies contributing to the securing of safety and security on the Oceans and preservation of ocean environment

Marine ecosystems, which are closely linked to human society in terms of food production and climate control, have been exposed to environmental stresses such as pollution, global warming and overfishing in recent years, and understanding, conserving, and utilizing marine ecosystems in light of these stresses has become an important subject. For this reason, MEXT has been carrying out R&D to understand these complex and diverse marine ecosystems and to develop conservation and utilization technologies for them by discovering new knowledge from big data based on existing data or data acquisition technologies under " Advancement of Technologies for Utilizing Big Data of Marine Life" of the Technology Development to Promote Utilization of Marine Resources Program.

MPAT 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.

JCG has been gathering information of ship movements for the purpose of ensuring safe marine transportation and improving operational efficiency. JCG is developing a system to predict vessel traffic flow and feedback the information to the vessels based on the analysis of these big data.

COLUMN 2-7

Understanding the Large Amount of Drift Pumice from the Fukutoku-Okanoba Eruption

The Fukutoku-Okanoba submarine volcano, located at the southernmost tip of the Ogasawara Islands, erupted on August 13, 2021, releasing a large amount of pumice stones. The floating pumice formed a large group called a pumice raft, which drifted on the sea, carried by ocean currents and surface winds. Most of the pumice stones drifted in an East-West direction and began washing ashore on the Ryukyu Islands, including Okinawa and Amami, around the beginning of October, affecting local marine traffic, fishing and tourism. Furthermore, it has been confirmed that the pumice stones also drifted to the Izu Islands, carried by the Kuroshio Current and other ocean currents.

This is not the first time that pumice stones from Fukutoku-Okanoba have drifted to the Ryukyu Islands. This

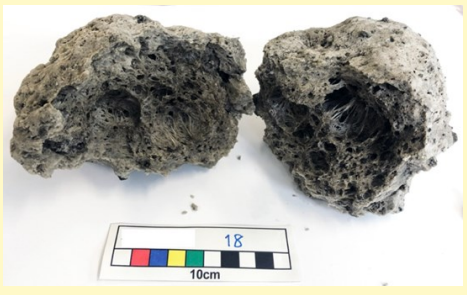
phenomenon was also confirmed during the 1986 eruption of the volcano. However, there has been no record of an entire beach or harbor being filled with pumice stones like this time, and the gray pumice stones that washed up on the white sandy beach stood out and became the focus of much public interest.

Pumice is magma spewed out by an explosive eruption that has been rapidly cooled and solidified. While a large volume of gas is dissolved in magma underground, most of the gas is released from the magma as it erupts . When magma solidifies over time, the gas is released and the magma turns into dense rock. However, in the case of an explosive eruption that forms a high plume of smoke like this one, the magma solidifies as the gas expands, resulting in a rock with many voids (pumice). Due to these voids , the overall density of the rock is lighter than that of water, and it will continue to drift for a long period of time without sinking. Analysis of the chemical composition of the minerals in the pumice stones revealed that the magma from this eruption contained basaltic magma that originates deeper than the Earth's crust. Therefore, it is suggested that basaltic magma originating in the mantle was injected into a magma chamber in the crust, triggering an explosive eruption. Further analysis in the future is expected to elucidate the mechanism of the eruption.

In addition, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) conducted a simulation of how the pumice arrived from Fukutoku-Okanoba after the pumice began to become a problem in the Ryukyu Islands in mid-October and predicted that it might drift to the Kanto region by the end of November. Although the above prediction calculation roughly captured the status of the pumice drift, more percise prediction calculations were needed as it suggested the possibility of the effects of the pumice raft spreading to various locations outside the Ryukyu Islands. Therefore, in collaboration with JAXA, JAMSTEC carried out more realistic prediction calculations by performing drift calculations based on the location of the pumice raft found by JAXA's satellites. In fact, a large number of pumice stones reached the Izu Islands in late November, as predicted, and this was widely covered by the media. JAMSTEC also publishes its prediction results on YouTube, which are then utilized by local governments and fishermen in various regions.

JAMSTEC continuously conducts oceanographic observations during normal times using ships and Argo floats, autonomous drifting buoys, and analyzes the data obtained from these observations using supercomputers such as the Earth Simulator to make oceanographic predictions. These prediction results have been published and used not just in basic research but also in social application research (fisheries, ocean warming, marine plastic, etc.), proving that Japan is capable of handling such simulations.

<Reference URL> http://www.jamstec.go.jp/j/jamstec_news/20211116



Pumice stones collected from the sea. The surface has become rounded due to the eruption and drifting, but the inside of the stones looks like foam and stretched glass fibers, giving the stones a spongy appearance.
Provided by: JAMSTEC

Drifting pumice stones photographed from an aircraft
Provided by: JCG

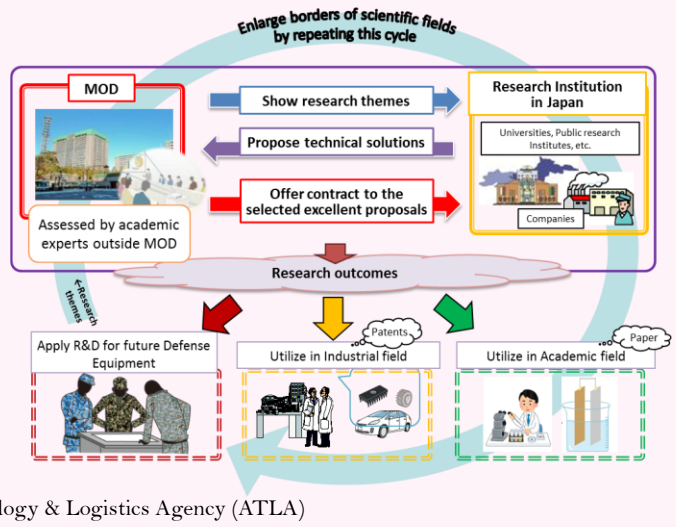
3. Promoting R&D in the field of defense

The National Security Strategy (National Security Council/Cabinet decision on December 17, 2013) states: "The advanced technology of Japan constitutes the foundation of its economic strength and defense forces and is also a valuable

resource that the international community strongly seeks from Japan. Therefore, Japan should encourage the further promotion of technologies, including dual use technologies, thereby strengthening Japan's technological capabilities." Based on the National Security Strategy, it is necessary to promote R&D on technologies necessary to address national security issues in cooperation with relevant ministries and through industry-academia-government collaboration.

Hoping for future contribution to R&D in the field of defense, MOD launched Innovative Science & Technology Initiative for Security to publicly invite and commission basic research on advanced civil technologies (Figure 2-2-2) in FY2015. In FY2021, the ministry established a technology think-tank function to study advanced civil technologies that will be important for Japan's national security in the future and to conduct analyses that will contribute to the consideration of technology development policies for application in the defense field.

■Figure 2-2-2／Innovative Science & Technology Initiative for Security



Source: Acquisition, Technology & Logistics Agency (ATLA)

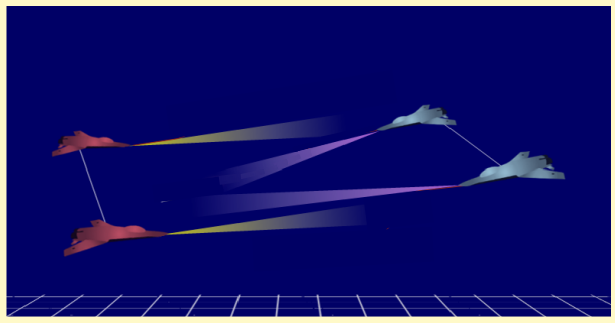
Initiatives are also being implemented since FY2017 to put advanced civil technologies such as AI, which have a quick technological innovation cycle and rapid progress, to practical application in a short period of time of about three years through the combined efforts of engineers and operators in quickly incorporating such technologies. Furthermore, for the early commercialization of defense equipment that could be a game changer, MOD is making efforts to outsource research on relevant important component technologies to private companies, etc., in parallel with its research on the core technologies of such equipment, starting from FY2022.

COLUMN 2-8 R&D Related to AI in the Field of Defense

In recent years, artificial intelligence (AI) technology has been changing our daily lives and is expected to have a major impact in all fields, such as medicine, agriculture and logistics.

This is also true for the defense field, where AI technology is expected to be utilized for quicker and labor-saving information processing, situation assessment and operation planning, and advanced reconnoitering using unmanned vehicles. Many countries, including the U.S. and China, are actively investing in R&D related to AI technology and are steadily applying this technology to equipment.

MOD is also investing in AI technology as a key technology that could become a game changer and has been implementing various initiatives to realize its early application. For example, to efficiently conduct constant and continuous intelligence gathering and warning and surveillance activities, etc., the ministry has begun research on technologies to automate the identification of radar images using AI technology, research on autonomous monitoring technologies for unmanned underwater vehicles, etc. Other new initiatives include a competition for AI models that can be used in air-to-air combat, which was held from January to March 2022. AI technology is making remarkable progress in the private sector, and it is important to discover excellent civil technologies for early application and enhancement in the defense field. Gathering information from the general public through initiatives such as competitions is an effective means of promoting research. The competition received 677 entries, and MOD was able to collect extensive information on AI technology from the private sector. The ministry is analyzing the superiority of the AI models from the top prizewinners and will utilize them in future AI technology research.



AI-based flight model (image)

Further collaboration between MOD, companies, universities and industry-academia-government is essential for the early implementation of AI technology in the defense field, which will continue to advance.

4. Promoting R&D for anti-terrorism measures in the police

The National Research Institute of Police Science has been developing a damage prediction simulator anticipating radiation attack in an urban area. The institute improved its virtual radiation measurement system that uses pseudo radiation sources and smartphones. The improved system is used for first response training simulating nuclear security cases, radiation education in the medical field and other purposes.

The institute also evaluates the power and sensitivity of homemade bombs made of commercially available materials and used for international terrorist attacks, conducts their demonstration tests and implements research that will contribute to measures for sales entities who sell chemical substances that can become materials of explosives.

❻ Initiatives to "Know," "Develop," "Utilize," and "Protect" for ensuring safety and security

The Cabinet Office, Government of Japan, has been carrying out a trial project since the fall of 2021 through to FY2022 for a think-tank function to conduct scientific research on STI from various perspectives such as domestic and international technology trends, socioeconomic trends and national security, with the aim of launching a full-fledged think-tank function in FY2023. And from the perspective of ensuring and strengthening economic security, the “Program for Fostering Key Technologies for Economic Security” aims to

promote R&D of cutting-edge critical technologies in the fields of AI, quantum, space, ocean and others for a wide range of civil and public applications, was budgeted at the FY2021 supplementary budget with funding initiated in March 2022 (public offering has started in FY2022). Furthermore, efforts are being made to autonomously ensure the soundness and fairness of research (research integrity[1]) at universities and other research institutions in response to new risks associated with the internationalization and openness of research activities[2].

In FY2021, METI, in collaboration with MEXT and relevant ministries and agencies, held a briefing session on security trade control for universities and research institutions to promote initiatives to strengthen internal control systems and prevent the outflow of sensitive technologies by explaining and clarifying the control of "deemed exports" under the Foreign Exchange and Foreign Trade Act which was enforced on May 1, 2022, and revising the guidance on sensitive technology control related to security trade.

In addition, the Cabinet Office, Government of Japan and METI collaborated to promote efforts to make security trade control a requirement in contracts for government R&D projects, which requires the establishment of a security trade control system and appealed to funding agencies and relevant ministries and agencies.

Discussions on how to carry out export control of sensitive technologies are underway among the countries concerned, including international export control regimes.

The Cabinet Intelligence and Research Office (CIRO), the National Police Agency, the Public Security Intelligence Agency (PSIA), MOFA, and the ministries and agencies of the intelligence community under the MOD are engaged in intelligence-gathering activities, including in the field of economic security, while maintaining close cooperation. The initial budget for FY2022 included an increase in the number of people engaged in economic intelligence by approximately 130.

4 Formation of an innovation ecosystem that will serve as the foundation for creating new industries for value co-creation

The goal is to create a society in which a new industrial base is built where companies, universities, public research institutions, etc., collaborate with each other to co-create value while ensuring diversity by creating a succession of startups that take on the challenge of solving issues driven by the needs of society.

❶ Support for startup creation and growth based on social needs

1. Support by the Small Business Innovation Research System (SBIR system)

Under the SBIR[3] system, the ground rules were transferred from the Small and Medium-sized Enterprises Business Enhancement Act (Act No. 18 of 1999) to the Act on Vitalizing the Creation of Science, Technology, and Innovation (Act No. 63 of 2008) to strengthen cross-agency efforts as an innovation policy, and the previous specific subsidies, etc., were changed to designated subsidies, etc. and subsidies for specific new technologies, etc. Regarding subsidies for specific new technologies, etc., the target amount of expenditure for FY2021 was set at around 53.7

1 Research integrity refers to the soundness and fairness of research, which must be newly secured against any new risks associated with the internationalization and openness of research.
2 Further details are described in Chapter 2 Part 1 6 ❺ Section 1 (6) Autonomously ensuring the soundness and fairness of research (research integrity) associated with the internationalization and openness of research activities.
3 Small Business Innovation Research

billion yen in order to increase opportunities for spending on R&D startups that conduct innovative research and development. Also, a total of nine subsidies were designated by the eight ministries concerned (MIC, MEXT, MHLW, MAFF, METI, MLIT, MOE, and MOD). In addition to establishing uniform operating rules for public offering and execution by each ministry and agency to promote the commercialization of technology development results, the system informed startup companies on the use of commercialization support measures such as loans at special interest rates provided by Japan Finance Corporation and promoted their use.

MAFF, through the Bio-oriented Technology Research Advancement Institution (BRAIN), launched the "Comprehensive Support for Start-ups" in FY2021 to provide integrated support for the creation of new businesses in the fields of agriculture, forestry, fisheries and food, including the creation of technology seeds and the commercialization of developed technologies.

2. Support for university-launched startups

The number of university-launched startups was on the decrease for a period of time, but has been increasing in recent years, reaching 233 in FY2020.

JST has been implementing the "Program for Creating STart-ups from Advanced Research and Technology (START)," which combines public funding and private-sector commercialization knowhow from the pre-startup stage. The program provides support for initiatives to create university-launched startups with novelty and social impact that will lead to social transformation and solutions for social issues in the post-COVID era and support for initiatives to build ecosystems in cities for startup ecosystems that gather resources from universities, local governments, and industry to create world-class startups. The "SUpport program of Capital Contribution to Early-Stage companies (SUCCESS)" invests in startup companies that attempt to translate the outputs from JST-funded R&Ds into practical applications.

Through the "Intensive Support for Young Promising Researchers" of the NEDO, which was started in FY2020, METI has been providing matching support for young researchers from universities and other research institutions aiming for commercialization with companies, as well as funding joint research with companies.

3. Technology-Based Startup Support Program

METI, in collaboration with NEDO, has been implementing the "Technology-Based Startup Support Program," which provides seamless support for the growth of technology-based startups, including support for entrepreneurs before starting a business, early-stage R&D support after starting a business in collaboration with private venture capitalists, and commercialization support in collaboration with business enterprises, in order to provide integrated support from the discovery to the commercialization of technology seeds possessed by Japan.

In July 2020, nine government-affiliated organizations[1] that provide support to startups concluded the "Agreement on Support for the Formation of a Startup Ecosystem" and set up the platform for unified support for startups (commonly known as Plus). As part of these

1 9 organizations participating in Plus: New Energy and Industrial Technology Development Organization (NEDO), Japan Agency for Medical Research and Development (AMED), Japan International Cooperation Agency (JICA), Japan Science and Technology Agency (JST), National Agriculture and Food Research Organization (NARO), Japan External Trade Organization (JETRO), Information-technology Promotion Agency (IPA), National Institute of Advanced Industrial Science and Technology (AIST), Organization for Small & Medium Enterprises and Regional Innovation, Japan (SME SUPPORT JAPAN)

activities, NEDO launched a one-stop consultation service called "Plus One" on its website to provide information and consultation related to support systems for startups.

❷ Promoting innovation activities in business

METI has been considering measures taking into account the trends of the ISO56000 series and domestic and international trends related to innovation management.

To promote an understanding of the managerial importance of open-source software (OSS), which is essential for the creation of open and agile innovation, and to raise awareness of OSS utilization, the Cabinet Office, Government of Japan held a panel discussion at a workshop organized by the Japan Intellectual Property Association (JIPA), attended by a number of business persons.

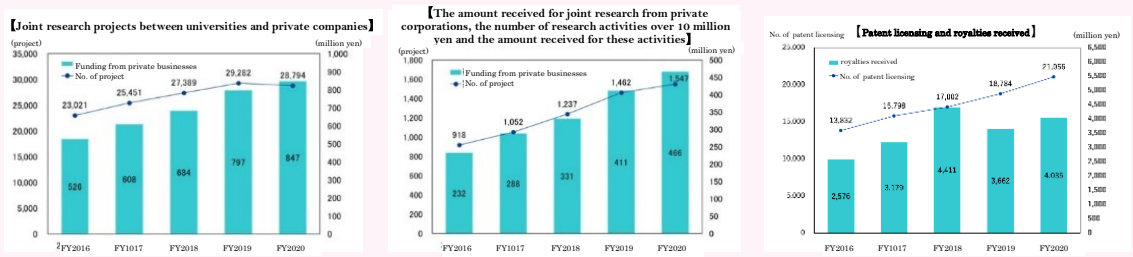
❸ Promoting new value co-creation through industry-academia-government collaboration

1. Current status of domestic and international industry-academia collaborative activities

(1) Status of industry-academia-government collaboration at universities

Since the corporatization of national universities in April 2004, industry-academia-government collaboration activities have been increasing. In FY2020, the research funds received by universities through joint research with private companies were about 84.7 billion yen (up 6.3% from the previous year), of which the research funds received by universities through joint research over 10 million yen per project were about 46.6 billion yen (up 13.2% from the previous year). Also, the number of patents licensed was 21,056, showing a steady increase from the previous year (Figure 2-2-3).

■Figure 2-2-3／Transition in achievements of joint research at universities



Notes: 1. Subjects: national, public and private universities
2. The term "Universities" indicates universities, junior colleges, technical colleges and inter-university research institutes
3. The number of patent licensing denotes the number of patents that have been licensed or transferred (including patents pending)

Source: Implementation Status of Industry-Academia-Government Collaborations at Universities (2020), MEXT (as of February 1, 2022)

(2) Activities of the Technology Licensing Organization (TLO)

As of January 1, 2022, 32 TLOs[1] had been approved by MEXT and METI under the Act on the Promotion of Technology Transfer from Universities to Private Business Operators (Act No. 52 of 1998).

In this regard, also as a response to the 4th industrial revolution in recent years, further promoting a return of research results at universities to society will contribute to the improvement of industrial technology and the

1 Technology Licensing Organization

development of new business fields. For this purpose MEXT launched the "Program to Support Formation of Innovation Management Hub" in FY2019 and has been promoting environmental improvement contributing to effective utilization of intellectual property and formation of joint research at universities through strengthening the networks between universities, industry and TLO.

2. Development of industry-academia-government collaboration systems at universities

With regard to industry-academia-government collaboration systems for joint research by Japanese universities and National R&D Agencies with foreign enterprises, the government commenced studies on guidelines for collaboration with foreign enterprises while considering security trade control.

In November 2016, MEXT and METI formulated the "Guideline for Enhancing Industry-Academia-Government Collaboration Activities," which compiles the issues and solutions for universities and the National Research and Development Agency for strengthening their industry-academia-government collaboration functions from the perspective of industry, based on the government's target of tripling corporate investment in universities and National Research and Development Agency over the next decade. Furthermore, to improve the effectiveness of these guidelines, a supplemental version systematizing the solutions to bottlenecks at universities and other institutions, as well as new issues and solutions for industry/businesses, was compiled in June 2020. In March 2022, the ministries published FAQs [1] that organize specific approaches to be taken and are striving to disseminate them. In FY2018 the ministry started "the development of the Open Innovation System" to encourage private investment by promoting large-scale joint research through the development of a system for centralized management of large-scale research that is deeply involved with corporate business strategies (with focus on competing areas).

<Reference URL>

Development of the Open Innovation System
https://www.mext.go.jp/a_menu/kaga ku/openinnovation/index.htm

Further in July 2019, the ministry jointly with MEXT, Japan Business Federation and METI published the "University Fact Book 2019" to advance "visualization of universities' efforts for industry-academia-government collaboration. In July 2020, "University Fact Book 2020" was compiled with updated contents based on the latest data.

Under the Industry-Academia Collaborative Support Project, MAFF has allocated industry-academia collaboration coordinators (experts in agriculture, forestry and fisheries and in the food industry) around the country to capture needs, collect and provide research seeds, support industry-academia-government matching, introduce and support R&D funding, and support commercialization.

3. Enhancement of R&D through industry-academia-government collaboration

In order to promote the practical application of research results from universities and other research institutions, JST has been implementing the "Adaptable and Seamless Technology Transfer Program through Target-driven R&D (A-STEP)," which provides hands-on support from the discovery of various technology seeds and the business exploration stage for researchers with

1 Frequently Asked Questions

cutting-edge basic research results to the transfer of technologies to companies through establishment of core technologies and promotion of practical development, and the "Newly extended Technology Transfer Program (NexTEP)," which supports the large-scale commercial development of technologies using research results from universities and other research institutions, with development risks implemented by companies and funding from the government of Japan.

Under "the Public-Private Program to Discover and Support Young Researchers" that has been implemented by the NEDO since FY2020, METI supports matching of young university researchers, etc. aspiring to achieve commercialization with suitable enterprises, while subsidizing joint research with enterprises with the aim of tripling the support for young researchers and private investments in universities.

MIC is promoting technological and social demonstrations of IoT and a new generation network in industry-academia-government partnership using the NICT comprehensive test bed that has been developed and managed by NICT.

MAFF has set up and operates the Ministry of Agriculture, Forestry and Fisheries Research Network (MAFFIN) to connect research institutions related to agriculture, forestry and fisheries. As of FY2021, 72 organizations are a part of this network. MAFFIN also has an international line with the Philippines and plays a role in the global distribution of research information.

<Reference URL>

The Program on Open Innovation Platform for Industry-Academia Co-Creation (*COI- NEXT*)
https://www.jst.go.jp/pf/platform/index.h

4. Developing platforms

To promote STI promptly and effectively, it is necessary to develop platforms for industry-academia-government collaboration. Since FY2019 JST has been promoting the projects (1) to (3) below integrally under a framework: "Open Innovation Platform for Industry-Academia Co-creation."

(1) Formation of an innovation ecosystem where knowledge and human resources are collected

JST has been implementing the "Program on Open Innovation Platform for Industry-Academia Co-Creation (COI-NEXT)" since FY2020 to support the formation of open innovation platforms for backcasting R&D in industry-academia-government co-creation toward realization of a desirable future society based on the United Nations Sustainable Development Goals (SDGs), with an eye on the with/post-COVID era, and is promoting R&D at 35 centers as of FY2021.

(2) Forming Open Innovation Platform with Enterprises, Research Institute and Academia

Since FY2013 JST has been implementing the "Center of Innovation (COI) Program". Under the COI Program, R&D is promoted in 18 bases to realize cutting-edge innovations in industry-academia collaboration.

Center of Innovation (COI) Program
https://www.jst.go.jp/coi/

(3) Forming Open Innovation Platform with Enterprises, Research Institute and Academia

JST has been implementing the Program on Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA) since FY2016. Using funds for matching with private companies, the program aims to realize full-scale industry-academia partnership at the organization level toward full-fledged open innovation in Japan. The activities under the program include: integrated promotion of large-scale joint research in noncompetitive fields in consortiums of multiple companies, human resource development of graduate students and reform of industry-academia partnership of universities.

<Reference URL>

Program on Open Innovation Platform with Enterprises Research Institute and Academia (OPERA)https://www.jst.go.jp/opera/index.html

(4) Exploration of technology seeds and promotion of R&D projects by AIST

AIST has been exploring technological seeds and promoting R&D projects while capturing the various technological needs of industry and society. Specifically, AIST plays a role in promoting activities of TIA (see 5.(1)) as an open innovation hub, while participating in its 17 Technology Research Associations as part of the effort to form a place of co-creation (as of March 31, 2022.)

5. Developing open innovation centers

(1) Tsukuba Science City

Tsukuba Science City has been developed as a center of R&D and education of the highest level in Japan, away from the congestion of Tokyo. The city has research institutes and corporations, including 29 national experimental research and education institutes, and has been promoting many governmental plans, such as those for research exchanges and the functional improvement of international research exchanges.

TIA is a center of open innovation founded under the leadership of four public organizations in the city (NIMS, AIST, Tsukuba University and the High Energy Accelerator Research Organization) in 2009 and subsequently joined by the University of Tokyo and Tohoku University. In FY2021, which was the second year of the third term, the TIA Collaborative Research Program "Kakehashi" strengthened its initiatives to enhance research activities through collaboration with companies and carried out initiatives such as SDGs and pre-venture activities. Also, the TIA Graduate School Summer Open Festival, a human resource development project of TIA, was held virtually. Furthermore, "Nanotech CUPAL,[1]" which aims to foster young researchers, held the "Summary Report Meeting for the Human Resource Development Project CUPAL" in the final year of the project.

(2) Kansai Science City

Kansai Science City is promoting the construction of towns that will play a role as bases for developing the world's culture, science and research and the nation's economy. As of the end of FY2021, it had over 150 facilities at which various research activities were under way.

1 Nanotech Career-up Alliance

6. Promoting Open Innovation Platform for industry academia partnership in diverse fields

MAFF has been promoting development of the Field for Knowledge Integration and Innovation (FKII) to promote research in industry-academia-government collaboration that introduces technologies of various fields into agriculture, forestry, fisheries and foods.

In April 2016, the ministry established "The Council of Industry-Academia-Government Collaboration, Field for knowledge Integration and Innovation (FKII)," with 4,235 researchers, producers, and companies from various fields as members. As of February 2022, 172 R&D platforms are active, creating research strategies and business models for specific purposes. Furthermore, research consortiums have been formed within the R&D platforms to develop activities for the commodification and commercialization of R&D and their results.

7. Creating an environment that facilitates matching of technology seeds and needs

In cooperation with the relevant ministries and institutions, MAFF holds the Agribusiness Creation Fair every year. The objective is to exhibit technology seeds from private companies, universities, public experimental research institutions and independent administrative institutions, and to promote collaboration with institutions which are in need of technology. MAFF held a hybrid in-person and virtual event in November 2021 with the participation of 135 institutions from across Japan, as private companies that promote industrial applications of new technologies disseminated information. The number of visitors over the three days of the event reached 33,535, while the dedicated website, which was open to the public for about four months, received a total of 64,723 page views.

MEXT, through its "Program for Building Regional Innovation Ecosystems," supports commercialization projects that can be developed globally by incorporating human resources and technologies from within and outside the region, with the source of the region's competitiveness (core technologies, etc.) at the core and having a high social impact despite high risks. A total of 21 regions have been selected for the program to date.

<Reference URL>

Program for Building Regional Innovation Ecosystems
https://www.mext.go.jp/a_menu/kagaku/chiiki/program/1367366.htm

Under the Strategic Information and Communications Research and Development Promotion Program (SCOPE) and based on the 1st, 2nd and 4th Interim Reports on Desirable New Information Communication Strategy" MIC has been promoting R&D of ICT that will contribute to creation of new value, change of social systems, regional vitalization and problem solution while keeping in mind practical application and social implementation in response to the era of Beyond 5G.

With its "Project for the Creation of Industry-Academia Collaboration Bases" started in FY2020, METI has been providing support for leading initiatives in industry-academia collaboration and the establishment of model bases with the aim of creating shared value through industry-academia collaboration that will deepen and further expand

university-launched open innovation.

With the "Research Program on Development of Innovative Technology" implemented by BRAIN, MAFF contributes to the promotion of regional innovation strategies by supporting open calls for proposals for research and development that focuses on the promotion of R&D that gathers diverse knowledge and technologies from various fields. In addition, MAFF has assigned industry-academia-university collaborative coordinators nationwide who are experts in agriculture, forestry and fishery and on food industries. They promote R&D in these fields through collection/identification of needs and collection/provision of seeds while supporting industry-academia-government matching, introducing and supporting R&D funding and supporting commercialization. MAFF also hosts local matching forums to support local R&D and the diffusion of technology.

AIST is working in close coordination with public experimental research institutions (PERIs) through human exchange to discover needs of local companies and provide them technical support using technology seeds of AIST. Specifically, AIST commissions or employs 143 PERI personnel and former senior officials as AIST Innovation Coordinators who coordinate "bridging" to local companies, and has been strengthening the cooperation system among PERIs as well as their cooperation with AIST through the Industrial Technology Liaison Council and also supporting improvement of technical abilities of personnel and human resource development at PERIs. Furthermore, AIST is actively promoting cooperation with local authorities by signing a comprehensive agreement, and cooperation in the technical field suitable for the characteristics of the regional industry by using the subsidy program of local authorities. This way, by transferring its technical seeds to business activities at the local and national levels to contribute to technical competitive power of local companies, AIST is working on regional revitalization.

❹ Creation of a world-class startup ecosystem

Toward solution of social challenges through creation of a startup ecosystem and innovations, the Cabinet Office, MEXT and METI formulated "Beyond Limits. Unlock Our Potential - Strategies for creation of a startup ecosystem to compete with the world top ecosystems-" in June 2019. In FY2020 four global base cities and four promotion base cities were selected. The Startup City Acceleration Program (SCAP) is being implemented to encourage startups in the hub cities to enter the global market and attract investment from foreign investors, with intensive support being provided by the government, government-related organizations and private supporters to promote the formation of a world-class startup ecosystem.

❺ Developing human resources capable of taking on challenges

To further promote the fostering of entrepreneurship throughout Japan, MEXT has implemented "Exploration and Development of Global Entrepreneurship for NEXT generation (EDGE-NEXT[1])" since FY2017, and to expand its reach, the "National Entrepreneurship Human Resources Development Program" on a trial basis, targeting university students nationwide. Also, JST is supporting the establishment of an entrepreneurship support system, which includes entrepreneurship training at universities and other research institutions in Startup Cities as part START.

MEXT is also implementing the "Building of

1 Exploration and Development of Global Entrepreneurship for NEXT generation

Consortia for the Development of Human Resources in Science and Technology" program, in which consortiums are formed by several universities, etc., in collaboration with companies to increase the mobility of researchers and advance their careers while securing stable employment.

In December 2014, MEXT and METI published the "Basic Framework of the Cross-appointment System and Points to Note," which is based on recognizing the importance of promoting a cross-appointment system that allows researchers to engage in R&D and education according to their roles at each institution and under a certain level of effort management, while being employed at each institution based on an agreement on secondment between multiple institutions, outlining the points to note when implementing the system and providing examples of implementation. A supplemental version of the report was published in June 2020 to promote the introduction of the cross-appointment system.

❻ Continuation and technological succession of R&D for important technologies that are highly necessary to be retained in Japan

AIST has confirmed that, in the event it becomes difficult for companies, etc. to continue research on important technologies that are highly necessary to be retained in Japan, it will, to the extent possible, utilize various acceptance systems and provide support such as temporary employment of the relevant researchers and taking over or continuing the research for a certain period of time, on the assumption that the relevant technologies will be handed over to Japanese companies in the future.

5 Urban and regional development that will serve as infrastructure to pass on to the next generation (development of smart cities)

The government of Japan aims to create a society with sustainable living infrastructure that maximizes human vitality for all stakeholders through the creation of diverse and sustainable cities and regions nationwide that can solve urban and regional issues and continue to create new value while demonstrating regional potential.

❶ Development of infrastructure to facilitate data utilization and development of city OS[1] that enables data linkage

The Cabinet Office, Government of Japan, has been conducting a survey to organize the issues that need revision in "Smart City Reference Architecture," a common design framework for building smart cities (prepared as part of the 2nd Period of the SIP program. Big Data and AI-Enabled Cyberspace Technologies, published in March 2020).

Together with relevant ministries and agencies, the Cabinet Office, Government of Japan has been studying data linkage in super cities/smart cities, and MIC revised the "Smart City Security Guidelines" in June 2021.

❷ Development of smart city creation examples throughout Japan with collaboration centered around super cities

Based on the Act Partially Amending the Act on National Strategic Special Zones (Act No. 34 of 2020), the government is promoting discussions and initiatives to realize the "Super City" concept, which aims to build a "whole future city" that will lead the world toward the realization of a future way of life.

1 Abbreviation for city operating system. A generic term for an IT system that facilitates the introduction of services in various fields to be introduced in smart cities by integrating functions commonly utilized by regions that are wanting to realize smart cities

In April 2022, Tsukuba City in Ibaraki Prefecture and Osaka City in Osaka Prefecture were designated as Super City National Strategic Special Zones, while Kibichūō Town in Okayama Prefecture, Chino City in Nagano Prefecture and Kaga City in Ishikawa Prefecture were designated as Digital Rural Health Special Zones, following deliberations by the Council on National Strategic Special Zones. Super cities are aimed at advancing DX and realizing a future society in a wide range of fields through regional digitalization and regulatory reform. In addition, the Digital Rural Health Special Zones aims to be a pioneering model for solving regional issues by focusing on issues that are particularly problematic in rural areas, such as declining population, falling birthrate and aging population, through the use of digital technology. Through the National Strategic Special Zones, we will continue to work on bedrock regulatory reforms and accelerate the nationwide deployment of the results from special zones that have no exceptional adverse effects.

The Comprehensive Special Zone System consists of an "International Strategic Comprehensive Special Zone," which aims to create a focal point of industries and functions that will serve as the engine for Japan's economic growth, and "Comprehensive Special Zones for Regional Revitalization," which aim to enhance regional competitiveness through regional revitalization efforts that make the most of regional resources. The government provides comprehensive support through special regulatory measures, taxation (only for International Strategic Comprehensive Special Zones), and fiscal and financial support measures.

Related ministries and agencies are promoting local and private-sector-led initiatives to implement advanced services by providing support for matching local governments and private companies through the Smart City Public-Private Partnership Platform and through the horizontal deployment and dissemination of leading examples using the Smart City Guidebook (published in April 2021).

The Cabinet Office, the Government of Japan and related ministries and agencies are working together toward the implementation and spread of smart cities, such as jointly selecting areas for smart city-related projects at the Joint Council on Smart City-Related Projects.

The Cabinet Office, Government of Japan, together with related ministries and agencies, has studied smart city evaluation indicators and reflected the results in a review of KPIs and logic models for national policies and guidelines for setting regional KPIs.

❸ International expansion

Under Japan's concept of "free and open smart cities," the government is utilizing the "Smart City Catalog" to disseminate information at international activities such as the Global Smart City Alliance (GSCA) and various international conferences.

Related ministries and agencies are also promoting initiatives for developing smart cities through the framework of the ASEAN-Japan[1] Smart Cities Network, such as by conducting project formulation surveys and holding the ASEAN-Japan Smart Cities Network High Level Meeting (3rd meeting held in October 2021) with the participation of relevant countries and cities.

Furthermore, related ministries and agencies have been promoting the utilization of international standards related to smart cities, such as reference architecture, etc., in collaboration with domestic and international standards experts. Specifically, the committee studied international standard proposals and the establishment of domestic and international frameworks for the future utilization and overseas deployment of

1 Association of South East Asian Nations

international standards related to smart cities, such as reference architecture, etc., in collaboration with domestic and international standards experts.

❹ Developing next-generation human resources for sustainable activities

In April 2021, related ministries and agencies published the Smart City Guidebook, which includes examples of leading initiatives on issues such as human resource development necessary for the realization of smart cities, and have been considering initiatives to solve such operational issues.

6 Promoting R&D and social implementation to resolve various social issues and utilizing Convergence Knowledge

While utilizing "Convergence Knowledge" based on the fusion of humanities, social sciences, and natural sciences and in collaboration with countries, regions, and international organizations that share values with our country, the government aims to create a society where future industry creation and economic growth are compatible with the resolution of social issues and challenges by working on R&D and social implementation of the results.

❶ Formulation and promotion of national strategies based on a vision of future society and evidence utilizing the Convergence Knowledge

1. "Convergence Knowledge" that contributes to comprehensive understanding and problem solving of humans and society

The Cabinet Office, the Government of Japan, has studied the basic concept of "Convergence Knowledge" that contributes to a comprehensive understanding of human beings and society and to the solution of problems based on the social background in which "Convergence Knowledge" is required, as well as strategic promotion measures, and compiled them in a mid-term report. A collection of examples of the use of Convergence Knowledge and a list of examples of measures related to the Convergence Knowledge were prepared as reference materials to promote understanding.

2. Sectoral strategies

For areas that should be promoted across ministries and agencies such as AI (see Chapter 2, Section 1 1 ❹), biotechnology (see Chapter 1, Section 3), quantum technology, materials and space (see Chapter 2, Section 1, 3 ❺), marine (see Chapter 2, Section 1, 3 ❺), environment and energy (see Chapter 2, Section 1, 2), health and medical care, food, agriculture, forestry and fisheries (see Chapter 2, Section 1 2 ❶), research and development, etc., are being promoted based on national strategies. Among the sectoral strategies not described elsewhere in this white paper, those for quantum technology and materials are described below.

(1) Optical and quantum technologies

Quantum science and technologies (optical and quantum technologies) are generic technologies that can become the core for the creation of values, which include ultra-high-speed processing of data that have been increasing explosively in recent years. In recent years, worldwide research and development on quantum science and technology has intensified, and overseas, in the US, Europe and China, in particular, governments have formulated R&D strategies and increased R&D investments. Leading IT companies in the world are also making rigorous investments while venture companies have been established and raising funds.

In view of the technology's innovativeness, and its likelihood to become the foundation of all science technologies and international trends, as well as international trends, the government formulated the "Quantum Technology and Innovation Strategy" in January 2020, clearly positioned "quantum technology innovation" and is leveraging Japan's strengths to promote (1) focused research and development, (2) international cooperation, (3) formation of research and development hubs, (4) intellectual property and international standardization strategies, and (5) development and securing of excellent human resources. On the other hand, since the formulation of the Quantum Technology and Innovation Strategy, the role of quantum technology in the rapidly changing social environment has been increasing, such as the progress of DX due to the COVID-19 pandemic, net zero greenhouse gas emissions and the rapid acceleration of quantum computer research. In April 2022, the Vision for a Quantum Future Society was formulated to realize social transformation by utilizing quantum technology to create growth opportunities for Japanese industry and to address social issues such as net zero greenhouse gas emissions. In the future, based on this vision, industry, academia, and the government will work together to promote the development of businesses, research and development in the fields of quantum computers, quantum software, quantum security networks, quantum measurement and sensing, and quantum materials, and to strongly promote fundamental initiatives for the creation of innovation.

Under the 2nd Period of the SIP Program that has been implemented since FY 2018, the Cabinet Office has been promoting R&D and social implementation of (1) laser processing, (2) optical/quantum communication, (3) optical electronical information processing and a network-type production system that will integrate them. In R&D on the Photonic Crystal Surface. Emitting Laser (PCSEL) of (1), in particular, succeeded in developing the most miniature LiDAR system in its class, which is 1/3 the volume of previous systems and is also working on increasing brightness and performance for ultra-compact laser processing systems. Furthermore, the office set up the "Quantum Technology Domain" in the PRISM Program in June 2020 to support R&D contributing to the expansion of public and private R&D investments. Furthermore, in FY2019, under the Moonshot Research and Development Program, the moonshot goal, "Realization of a fault-tolerant universal quantum computer that will revolutionize the economy, industry, and security by 2050", was set to promote challenging research and development.

MIC and NICT have been working on R&D of quantum encryption that is impossible for computers to decode and quantum communication technologies based on quantum signal processing that extracts information from a single photon. In addition, MIC has been promoting R&D of technologies to further extend the distance of terrestrial quantum crypt-communication (long-distance linking and relay technologies). Furthermore, in order to introduce quantum cryptography that has been developed for terrestrial fields to satellite communication, the Institute has been working on R&D for construction of a system that is operable under the restrictive environment of outer space, technology for earth stations to accurately receive light from rapidly moving satellites and technologies mountable on microsatellites. Since FY2021, research and development is being conducted for the Building a Global Quantum Cryptography Communication Network that integrates terrestrial and satellite networks.

MEXT has been implementing the "Quantum

Leap Flagship Program (Q-LEAP)" program since FY2008 targeting (1) Quantum information technology (Quantum simulator, Quantum computer), (2) Quantum metrology & sensing, and (3) Next generation laser and is promoting the Flagship Project, basic fundamental research, and are promoting the Flagship Project, which conducts research and development aimed at demonstrating prototypes, basic research and development of human resource development programs.

The National Institutes of Quantum Science and Technology is engaged in the development of fundamental technologies for quantum life science by applying quantum science technologies such as quantum metrology and sensing to life science, aiming for innovation in life science and the creation of new innovations. In addition, with the aim of building a world-class quantum science and technology research and development platform, research on miniaturization and sophistication of heavy ion radiotherapy equipment, and advanced research using quantum beam facilities such as world-class high-intensity laser (J-KAREN) and ion irradiation research facility (TIARA[1]) is being conducted.

METI through the "Project for Innovative AI Chip and Next-Generation Computing Technology Development", which began in FY2008, has been developing a quantum computer specialized (quantum annealing machine) for "combinatorial optimization problems" that exist extensively in society. Integrated development of quantum annealing machines, from hardware to software to applications, is underway, and in FY2019, the development of interface integrated circuits to connect common software and hardware was started. In addition, to reduce power consumption in data centers, which has become an issue due to the development of cloud computing, etc., initiatives are being taken for the development of optoelectronics technology that combines electronic and optical circuits in the "Development of Technologies for Super Energy-Efficient Optical Electronics Implementation Systems".

1 Takasaki Ion Accelerators for Advanced Radiation

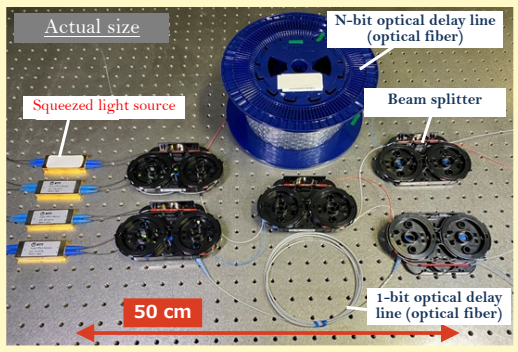
COLUMN 2-9

Realization of modularized quantum light source toward fault-tolerant large-scale universal optical quantum computers ~ Developed a fiber-integrated quantum light source ~

In order to win the fierce national competition with other countries in quantum technology, including quantum computers, the Cabinet Office, Government of Japan is currently revising its "Quantum Technology and Innovation Strategy" to promote research and development on key issues in the quantum field under an all-Japan framework (Reference 1). . Quantum computers are being researched and developed worldwide because they are capable of parallel computational processing using unique phenomena to quantum mechanics such as quantum superposition states and quantum entanglement states. Under Goal 6 of the Moonshot R&D Program, the ambitious goal of "Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050" is being pursued with the research and development of 7 projects (as of Jun. 2022) (Reference 2). One of the projects, "Development of Large-scale Fault-tolerant Universal Optical Quantum Computers", developed an optical fiber-coupled high-performance squeezed light source module, which is the key device to realize a rack-sized large-scale optical quantum computer. By using the developed fiber-coupled quantum light source module and optical communication devices, continuous-wave squeezed light with quantum noise suppressed by more than 75% over a wide bandwidth of more than 6 THz has been successfully generated in an optical-fiber closed system for the first time. This achievement is expected to make it possible to develop an optical quantum computer on a realistic scale in a stable and maintenance-free optical system using optical communication devices and will greatly advance the development of a fault-tolerant large-scale universal optical quantum computer.

< Reference URL>
1. MEXT Website
https://www.mext.go.jp/a_menu/shinkou/ryoushi/mext_01422.html

2 Cabinet Office, Government of Japan Website
https://www8.cao.go.jp/cstp/english/moonshot/top.html



Basic components
Provided by: The Nippon Telegraph and Telephone

(2) Materials

The materials area is highly competitive in Japan's industry and academia, supports a wide range of diverse research areas and applications, and, due to its transversal nature, contributes to solving a wide range of social problems as a key to bringing about discontinuous innovation through the fusion of different fields and technologies, and is a fundamental technology that will be the core for creation of values in future society.

In light of the importance of this field, in April 2021, the government of Japan, with its vision for society and industry for the year 2030, announced the strategy ("Materials Innovation Strategy") at the Council for Integrated Innovation Strategy to enhance the "the potential to create materials innovation" or the "Materials innovation capacity", which will play an important role in realizing Society 5.0, achieving the SDGs, overcoming resource and environmental constraints, and building a strong society and industry. The strategy promotes the (1) Development and swift social implementation of innovative materials; (2) Use materials data and manufacturing technology to promote data-driven research and development; and (3) More sustainable international competitiveness under the common vision of the industry, academia, and government, leveraging

the strengths of Japan, which has a large number of diverse researchers and companies in Japan and a world-class research and development infrastructure.

MEXT strategically promotes basic and pioneering research in this field to technological development from the perspective of practical application and supports the formation of research and development centers. Specifically, the "Nanotechnology Platform" provides industry-academia users with the opportunity to use cutting-edge equipment and advanced technical assistance by building a nationwide sharing system in close collaboration with universities and other institutions that have cutting-edge research facilities and the know-how to utilize, and the "Materials Processing Science project (Materealize)" that aims to establish a system of cooperation between industry, academia, and government at universities, etc., and to build an academic and scientific infrastructure to solve process issues to lead to the social implementation of innovative materials that have innovative functions but require the establishment of process technology.

In light of the stated need to develop a data-based R&D platform and promote the utilization of material data, under the "Materials Innovation Strategy", MEXT established a new hub-and-spoke system consisting of a hub with diverse research facilities and spokes with distinctive technologies and equipment using the advanced equipment sharing system of the "Nanotechnology Platform" as a base from 2021 and launched the "Advanced Research Infrastructure for Materials and Nanotechnology" to establish a nationwide infrastructure for shared use of state-of-the-art facilities capable of generating high-quality data. This project is proceeding with the establishment of a platform for strategically collecting, accumulating, structuring and nationwide utilization of materials data from industry-academia material data through the data core base installed by NIMS. In addition, a feasibility study was conducted in 2021 for the "Data Creation and Utilization-Type Materials Research and Development Project", which aims to develop research methods for innovative materials at ultra-high-speeds by utilizing data and expanding them nationwide. Research and development that covers the creation, integration and utilization of research data for examining the start of full-scale research from FY2022 are being promoted.

NIMS conducts basic research and R&D on materials science and technology, aiming for breakthroughs toward the creation of new substances and materials. In addition to promoting research and development of innovative materials that contribute to the government's priority fields such as quantum and biotechnology, the program also establishes a place for the creation of innovative materials by integrating basic research with the needs of industry and a global center where researchers from around the world can gather, to vigorously promote innovation creation in the materials field, and the "Program for Strengthening Innovative Materials Development - M3 (M-cube)" is being implemented as a project to develop a research infrastructure to maximize these activities. From FY2019, initiatives are being implemented for the smart laboratory of the research environment to accelerate the creation of innovative new materials, and from FY2020, the development of a system as a core data base that enables the use of material data created from cutting-edge shared facilities across Japan, including strategic collection, accumulation and AI analysis.

Based on the results of "Next-generation

Technology for Ocean Resources Exploration" implemented during the 1st Period of the SIP Program, the Cabinet Office, Government of Japan has been promoting "Development of Innovative Technologies for Exploration of Deep-Sea Resources" during the 2nd Period of the SIP Program since FY2018 and proceeding with the development of technologies for efficiently investigating mineral resources such as rare earth mud that exist on the seabed at depths of 2,000 m or more and recovering them offshore. In FY2021, a rough evaluation of rare earth resources in the research area on Minami-tori-shima Island confirmed the presence of rare earth resources of a scale where industrialization can be expected, and steady progress is being made in technological development for future rare-earth production, including the implementation of tests to confirm the pumping performance.

MEXT and METI are working together to overcome restrictions on the procurement of rare elements such as rare earth and rare metals, which are essential raw materials for next-generation vehicles and wind power generation, and to save energy.

MEXT is promoting the "Element Strategy Initiative: To Form Core Research Centers" to create completely new materials that do not use rare elements such as rare earth and rare metals by theoretically clarifying and applying the functions of elements to overcome Japan's resource constraints and to strengthen industrial competitiveness.

METI is developing magnetic materials that are stronger than ever and significantly reduce the use of rare metals through its “Technology Development Project of New Structural Materials that Contribute to the Drastic Weight Reduction of Transportation Equipment”. In addition, to promote the effective utilization of urban mines in Japan, realize the stable supply of resources and resource saving and energy saving with the "Resource Circulation System Advancement Promotion Project ", automatic sorting technology of waste products and waste parts, high-efficiency smelting technology, and arteriovenous information cooperation system are being developed. Furthermore, to strengthen the supply chain of rare earth, which have a high risk of supply disruption, through "technology development and demonstration project that contributes to supply chain resilience", the organization is working to reduce the use of rare earth as much as possible, develop high-performance magnets that do not use rare earth and develop technologies to use low-grade rare earth that are difficult to use due to many impurities.

3. Formulation of evidence-based strategies, planning and promotion of policies that embody the future society

As part of its search and analysis of long-term changes aimed at examining the vision of future society, the National Institute of Science and Technology Policy (NISTEP) of MEXT conducts a science and technology forecast survey every five years (initially conducted in 1971 by the Science and Technology Agency). Since FY2020, a wide range of expert knowledge is being collected and accumulated through annual questionnaires to experts on science and technology that attract their attention as horizon scanning to capture early signs of science and technology and society for the next 12th survey. Since FY2021, the establishment of a system that allows specialists in human and social science fields to participate in the 12th Survey has started.

The Cabinet Office, the Government of Japan, has developed analytical tools that utilize information from academic papers to conduct trial analyses of research trends for contributing to the

exploration and identification of important science and technology areas. A mechanism is being developed for adding the expertise of experts to the bird's-eye view of the science and technology domains, created by the analysis tool, etc., and utilizing them in policy deliberations. In addition, various data necessary for analysis are collected through the Cross-ministerial R&D Management System (e-Rad). These data are utilized in the evidence system (e-CSTI [1]) to analyze research expenses and research outputs, to analyze how many research facilities and equipment are shared, and how much external funds are obtained, and to analyze the human resource development needs of the industry and the status of subjects/courses taken by students.

NISTEP of MEXT established a data and information infrastructure to systematically and continuously develop and accumulate data and other resources for use in formulating policies and surveys, analysis, and research on science, technology and innovation. The results of surveys and research using this platform are provided to and utilized by various policy councils of the Cabinet Office, the Government of Japan and MEXT, including the consideration of the Science, Technology and Innovation Basic Plan.

In addition, the Center for Research and Development Strategy of JST grasps, overviews, and analyzes domestic and international trends in science, technology, innovation, and related societies, examines R&D strategies to maximize R&D results, and makes proposals that contribute to innovation policy planning. As the importance of technological innovation is increasing with the advancement and sophistication of technologies, there is an increasing need for strategic investment of limited resources. From this perspective, the Technology Strategy Center of the NEDO, as an important player in providing evidence and knowledge necessary for formulating industrial technology policies, grasps and analyzes technological, industrial and policy trends from global and diverse perspectives, and works together with policy authorities in the formulation of technological strategies in the fields of industrial technology and energy and environmental technology, and in the conceptualization of important projects based on these strategies.

4. Initiatives to secure technological superiority and a stable supply of semiconductors

Semiconductors are a key technology that supports digitalization, decarbonization, and economic security, and initiatives are necessary as a national policy to secure technological superiority and establish a stable supply system comparable to those of other countries. METI held a semiconductor and digital industry strategy study meeting and launched its semiconductor and digital industry strategy in June 2021. In November 2021, the strategy was further formulated with the "Basic strategies for revitalizing Japanese semiconductor industry". The basic strategy outlines a 3-step approach, Step 1: Establishment of a domestic semiconductor manufacturing base, Step 2: Development of manufacturing technologies for next-generation semiconductors that are expected to be put to practical use in 2025 or later through international collaboration and Step 3: Develop future technologies, such as photoelectric fusion, which could be a game changer for 2030 and beyond.

Based on this strategy, the FY2021 supplementary budget allocated 617 billion yen to develop manufacturing infrastructure for advanced

1 Evidence data platform constructed by Council for Science, Technology and Innovation

semiconductors and 47 billion yen to promote the renewal of production facilities for semiconductors that are highly indispensable in the supply chain to realize Step 1. In addition, to realize Step 2 and Step 3, the supplementary budget allocated 110 billion yen for research and development of future technologies such as (1) Manufacturing technology for ultrafine next-generation semiconductors through collaboration between Japan and the United States and (2) Optoelectronic fusion, which processes large amounts of data at high speed and low power consumption by converting electrical wiring to optical wiring. In addition, specific measures are being promoted through public-private partnerships to develop and secure human resources for the semiconductor industry, which is indispensable to realizing this basic strategy. Necessary measures will be continued based on the strategy.

5. Initiatives for Robot Development, etc.

Based on the "Plan for Promoting Social Change Taking Advantage of Robots" compiled by the Council for the Promotion of Social Transformation through Robots in July 2019, METI has been promoting initiatives for (1) “Creating a Robot-Friendly Environment”, (2) “Establishing a framework for human resource development”, (3) “Building a R&D system that responds to mid- to long-term issues”, and (4) “Open innovation that accelerates social implementation”. Regarding "Creating a Robot-Friendly Environment", R&D is being performed in the fields of facility management, retail, food manufacturing, and logistics warehousing, development of robots from the user's perspective, normalization and standardization related to data linkage, communication and facility design, etc., is being promoted. For example, in June 2021, a unified standard was established for communication between robots and elevators regardless of the manufacturer in the field of facility management. Regarding "Establishing a framework for human resource development", the Council for the Training of Future Robotics Engineers (CHERSI[1]), established in June 2020 with the participation of industries, such as robot manufacturers and system integrators, and educational institutions, provides support for on-site training of teachers and students and to formulate educational curricula. Regarding "Building an R&D system that responds to mid- to long-term issues", basic and applied research is being conducted to realize next-generation industrial robots from a medium- to long-term perspective while incorporating technological seeds from other fields. Regarding "Open innovation that accelerates social implementation", the World Robot Summit 2020 was held in FY2021 as a competition to gather the wisdom of the world's robots (Aichi in September and Fukushima in October).

6. Development of geospatial information

The Office for the Advancement of Utilizing Geospatial Information, Cabinet Secretariat, formulated the Fourth Basic Plan for the Advancement of Utilizing Geospatial Information on March 18, 2022, to realize a "G-spatial Society" where industry, academia, government, and the private sector cooperate in developing an environment in which highly accurate and valuable geospatial information can be used, and make advanced use of this information.

1 The Consortium of Human Education for Future Robot System Integration

❷ Promotion of mission oriented research and development for solving social issues

1. SIP

In addition, concerning the issues to be addressed in the next phase of SIP scheduled to start from FY2023, the government determined candidate issues (target areas) at the end of December 2021 with back-casting based on the 6th Basic Plan for Science, Technology and Innovation (Cabinet decision taken on March 26, 2021), aiming at the realization of a future society (Society 5.0) aspired by Japan. For each candidate issue, a request for information (RFI) was requested in January and February 2022 to solicit a wide range of ideas on R&D themes from universities, research institutes, companies and venture companies. In March 2022, the RFI results were compiled, and the recruitment requirements for program director (PD) nominees were discussed. (refer to Chapter 1, Section 2 (2))

<Reference URL>

Request for Information on R&D Themes for Next SIP Candidate Issues ~ Call for Ideas for the Realization of Society 5.0 ~
https://www8.cao.go.jp/cstp/stmain/20220119sip.html

2. Moonshot R&D Program

The Moonshot R&D Program promotes challenging R&D under which the government sets ambitious goals that fascinate people (Moonshot Goals) to address important social challenges, including super-aging society and global warming. In FY2021, research and development were promoted by utilizing the Convergence Knowledge in the current 7 goals, and applications were solicited for cross-disciplinary support (mathematical sciences, ELSI) of Goals 2, 4, 5, and 6. In addition, two new Moonshot Goals (Goal 8 and Goal 9) were determined based on surveys and research conducted by a diverse group of researchers, especially young researchers, anticipating the economic and social transformation, etc., caused by the COVID-19 pandemic.

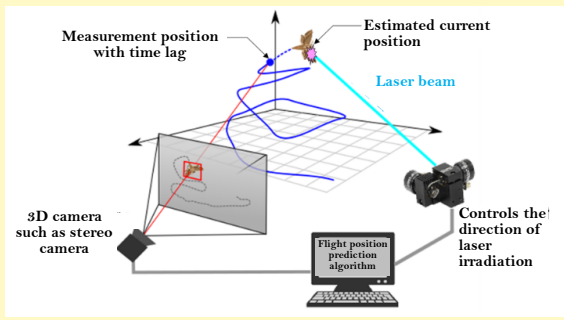
COLUMN 2-10

Prediction of 3D Position of Pests by Modelling Their Flight pattern

The global demand for food is estimated to increase by 2050, along with the increase in population and pest control has become an important issue for stable food production. Goal 5 of the Moonshot R&D Program aims to solve problems related to food production and consumption and has set an ambitious goal of "Creation of the industry that enables sustainable global food supply by exploiting unused biological resources by 2050" with conducting research and development in eight projects (references 1 and 2). One of them is the project "Realization of zero pest damage agriculture by making full use of advanced physical methods and unused biological functions". Efficient extermination of pests flying quickly in the air is not possible with existing pest control technologies. As an epoch-making physical method, technological development to exterminate pests with high-power lasers etc. is in progress. In order to achieve this, it was necessary to spot the exact pest location and eliminate the time lag from detection to extermination. In this project, the flight activity of Spodoptera litura (a type of moth), a typical agricultural pest, was captured with a stereo camera. The three-dimensional position was measured, and their flight pattern was investigated. The flight pattern obtained was modeled, and a new method was developed to predict the position several steps ahead (0.03 seconds ahead) with an accuracy of about 1.4 cm from the real-time image. This project aims for the practical utilization of the technology to exterminate pests by irradiating the predicted position with a laser by the year 2025.It is expected to break away from dependence on pesticides and to realize a new pest control technology with less impact on the environment.

< Reference URL>
1 Cabinet Office, Government of Japan Website
https://www8.cao.go.jp/cstp/english/moonshot/top.html

2 MAFF website
https://www.affrc.maff.go.jp/docs/moonshot/moonshot.html



Schematic diagram of pest control system by laser sniping
Provided by: National Agriculture and Food Research

3. Research Institute of Science and Technology for Society (RISTEX)

The RISTEX of JST conducts research and development through co-creation with a diverse range of stakeholders utilizing knowledge from natural sciences, humanities and social sciences to solve various social problems, including SDGs, such as the declining birthrate and aging population, environment and energy, safety and security, and disaster prevention and mitigation, and to address ethical, legal and social implications/issues (ELSI) that arise in the social implementation of emerging science and technology. A program was launched in FY2021 to prevent social isolation and loneliness, a social issue that has emerged as a result of various changes in social structure, including the impact of the COVID-19 pandemic. This program promotes research and development related to the mechanisms of social isolation and loneliness, visualization and evaluation the methods for the risk, and the development of preventive measures on the issues.

Another program of RISTEX promotes research and development of methods and indicators for understanding and analyzing social issues the current status and potential of science and technology necessary for their solution from multiple perspectives and for forming policies through a rational process based on such evidence (The program is in its third phase since FY2021). In FY2021, seven new projects were adopted in

addition to the 16 projects that had been adopted up to FY2020, promoting research and development and policy implementation of the results.

4. Fukushima Institute for Research, Education and Innovation (F-REI)

In November 2021, the Reconstruction Promotion Council decided on the "Corporate Form of the International Education and Research Center" to establish F-REI, for further development of Fukushima Innovation Coast Initiative and as the core of research and development, industrialization, and human resource development. In February 2022, "Bill to Partially Amend the Act on Special Measures for the Reconstruction and Revitalization of Fukushima" was submitted to the 208th session of the Diet to establish F-REI. In March 2021, the Reconstruction Promotion Council took a decision on the "Basic Concept for F-REI," which stipulates the specifics of the institute's research and development, industrialization, human resource development, and Control Tower functions, etc., and a decision was taken to establish F-REI in April 2023. In this basic concept, F-REI aims to become a world-class "core center for creative reconstruction" that will lead to the enhancement of Japan's scientific and technological capabilities and raise the country's industrial competitiveness to the world's highest level through the creation of innovations.

❸ Social implementation of advanced science and technology for solving social problems

1. Initiatives in the next phase of SIP

In addition, concerning the issues to be addressed in the next phase of SIP scheduled to start from FY2023, the government determined candidate issues (target areas) at the end of December 2021 with back-casting based on the 6th Basic Plan (Cabinet decision on March 26, 2021), aiming at the realization of a future society (Society 5.0) aspired by Japan. For each candidate issue, an RFI was requested in January and February 2022 to solicit a wide range of ideas on R&D themes from universities, research institutions, companies and venture companies. In March 2022, the RFI results were compiled, and the recruitment requirements for PD nominees were discussed. (Refer to Chapter 1, Section 2 2)

2. Public/Private R&D Investment Strategic Expansion PrograM

PRISM is a program established in FY2018 with the aim of directing the policies of various government ministries and agencies to areas[1] that are highly effective in inducing private investment and areas where government spending is expected to be more efficient through the utilization of R&D results. According to the various strategies decided by the Council for Science, Technology and Innovation (CSTI), the funds are being allocated focusing on the fields of AI technologies, innovative technologies for construction/infrastructure maintenance and disaster prevention/mitigation, biotechnologies, and quantum technologies, and additional allocations were made to 32 policies in these four fields in FY2021. Projects of individual ministries and agencies will be accelerated to expand private and public R&D investments based on the various strategies formulated or revised (refer to Chapter 1, Section 2 2) by CSTI.

1 In the first year of FY2021, AI technology, construction/infrastructure maintenance/fire prevention/mitigation technology, and biotechnology were added. Quantum technology was added in 2020.

3. Introduction of advanced technology into government projects

In order to accelerate the social implementation of the results of science, technology and innovation, it is important for the government to take the lead in promoting innovation by introducing advanced technology in government projects. To this end, the Cabinet Office, Government of Japan, in cooperation with related ministries and agencies, promote innovation in a wide range of government projects, including public works projects.

❹ Promoting the resolution of social issues and acquisition of international markets through the international and strategic use of intellectual property and standards

1. Promoting an intellectual property strategy and an international standardization strategy

With the progress of economic globalization, the importance of various intellectual activities that are sources of economic growth has been increasing. To enhance the competitiveness of Japanese industries and improve the lives of the citizens, it has become important for Japan to create advanced technologies and rich culture, and to link these to the creation and expansion of businesses. The Intellectual Property Strategy serves as the foundation for such activities.

In July 2021 the Intellectual Property Strategy Headquarters decided the “Intellectual Property Promotion Plan 2021.” For Japan to win the digital and green competition under the new normal after Corona, the plan summarizes the situation surrounding intellectual property in the "Basic Understanding" section at the beginning of the plan, identifies seven priority policies "Strengthening the functions of capital and financial markets to encourage investment in and use of IP as a source of competitiveness," "Promoting the strategic use of standards aimed at expanding markets where Japan has an advantage," “Environmental improvements aimed at encouraging the use of data, which is the 21st century’s most important form of IP,” "A content strategy suited to the digital age,” “Bolstering the use of IP among startups and SMEs, and in agriculture," "Enhancing institutional, operational, and human resources infrastructure to support the use of IP" and "Restructuring the Cool Japan Strategy," and the IP Strategy is being promoted in line with the plan under the leadership of the Intellectual Property Strategy Headquarters, together with related ministries and agencies.

2. Proactive response to strategic use of international standards

In order to strengthen the international competitiveness of Japanese industry in the global marketplace, promoting the strategic use of international standards by the Japanese public and private sectors is necessary. For this reason, the government as a whole first developed a control tower function and system and is promoting measures that should be prioritized in cooperation with related ministries and agencies under the "Standard Utilization Promotion Task Force" established in the "Integrated Innovation Strategy Promotion Council." Specifically, to further advance important measures by related ministries and agencies, support is provided by allocating additional budget through support projects for accelerating the use of standards utilizing the framework of PRISM. In addition, the strategic use of international standards in important fields such as smart cities, smart agriculture, etc. in terms of solving social issues and acquisition of international markets, is being promoted based on overseas government and corporate trends and the international market environment, and at the same time, a mechanism is being developed to

comprehensively identify, organize and respond to necessary areas.

In addition, through cooperation with government research and development projects, regulations and systems, etc., an environment that promotes changes in corporate behavior related to the strategic use of international standards is being promoted, and a platform system that supports practical activities by private companies is being developed in cooperation with government agencies, etc.

Specifically, to implement standardization activities more appropriately at the research and development stage, the NEDO implemented initiatives with an awareness of the strategic use of standards at each stage, such as when formulating technology strategies and when implementing research and development projects.

In addition, METI has established an international standard for quality and reliability test methods for compound power semiconductors as one of the systems for commissioning projects to acquire and disseminate international standards related to energy conservation (Development of International Standards for Energy Conservation (International Electrotechnical Standards Field)). AIST plays a central role in the promotion, with the participation of several private companies and the cooperation of the Japan Electronics and Information Technology Industries Association (JEITA). In addition, systems are being developed to promote international standardization activities on strategically important research and development themes and cross-industrial themes in collaboration with national research and development agencies and private companies. For human resource development, training courses are provided to develop young human resources who will lead international standardization based on the "three action plans to develop human resources for standardization (made public in FY2016)." METI also supported human resource development through the release of education materials for university teachers, and sending METI personnel for lectures on standardization at universities. Furthermore, the Ministry has established standardization qualification schemes through the Japanese Standard Association (JSA).

METI serves as the secretariat of Japanese Industrial Standards Committee (JISC), Japan's national standardization body (NSB). JISC is undertaking standardization cooperation with foreign countries such as European and Asian countries and conducting technical cooperation aiming for encouraging standardization experts in Asian countries to actively participate in international standardization activities. In FY2021, in order to discuss specific areas for cooperation and further cooperation in international standardization, JISC participated in conferences convened with attendees from NSBs of 24 countries regions in the Asia-Pacific region, a forum attended by standardization experts and NSBs from 3 countries in the Northeast Asia region, i.e. Japan, China, and South Korea, and bilateral meeting with NSBs of Asian countries. In addition, JISC organized human resource development seminars for the Asian region in cooperation with the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). JISC is engaged in strengthening cooperative relationship with counties in the Asian region in international standardization activities by taking the initiative in projects for international standards harmonization, standards development and dissemination of standards under the framework of the Sub-Committee on Standards and Conformance of the Asia-Pacific Economic Cooperation (APEC).

MIC, based on the recommendations of the

Telecommunications Council, has been promoting standardization activities in the International Telecommunication Union (ITU) and other de jure standardization institutions and forum standardization organizations while also conducting research and development, aiming to reflect Japan's ICT in international standards. In FY2021, the "Beyond 5G New Business Strategy Center" (established on December 18, 2020) based on the "Beyond 5G Promotion Strategy" (formulated in June 2020), which brings together key players from industry, academia and government, is working to promote strategic IP acquisition and standardization activities from the early R&D stage.

MLIT and MHLW are promoting strategic international standardization with the aim of creating an international market in which Japanese companies aiming to expand internationally in the fields of water supply and sewerage systems can demonstrate a high degree of competitiveness.

Currently, the ministries are proactive and taking the lead in working on "Drinking water, wastewater and stormwater systems and services" (ISO/TC [1] 224), "Sludge recovery, recycling, treatment and disposal" (ISO/TC275), and "Water reuse" (ISO /TC 282).

3. Promotion of the Global IP Initiative

It is important to improve global IP infrastructure so that Japanese companies can smoothly engage in business internationally. Currently, the Japan Patent Office (JPO) is implementing the "patent prosecution highway (PPH)" with 45 nations (as of January 2022). This will allow patent applicants whose patents have been deemed patentable to apply for early examination in other countries. The JPO and the U.S. Patent and Trademark Office (PTO) have conducted the JP-US Collaborative Search Pilot Program on August 1, 2015. Under this program, the patent examiners in Japan and the U.S.A. conduct independent searches on advanced technology applications and share the search results and opinions before forwarding the examination results to the patent office of each country. For Patent Cooperation Treaty (PCT) international application, the Patent Cooperation Treaty Collaborative Search and Examination (PCT CS&E) was implemented up to June 30, 2020. Under PCT CS&E, five offices in Japan, the U.S., EU, China and South Korea collaborated to produce international search reports.

4. Intellectual property (intellectual property rights and R&D data) management for national R&D projects

(1) Initiatives concerning patent rights and other intellectual property rights

In order to commercialize national R&D results as much as possible, METI ensures appropriate IP management for each R&D project commissioned by the government based on the Guidelines for IP management in commissioned R&D" (May 2015).

In national R&D pertaining to agriculture, forestry and fisheries, MAFF is working on IP management assuming commercialization of research outcomes from the initiation stage of research based on the Intellectual Property Policy for Agriculture, Forestry and Fisheries" (February 2016).

(2) Initiatives concerning R&D data

METI has been publishing the National Project Data Catalog[2], which includes R&D data that can

1 Technical Committee
2 https://www.meti.go.jp/policy/innovation_policy/datamanagement.html

be utilized, since March 2018 based on the "Operational Guidelines for Data Management in Contract R&D" (December 2017) to create new businesses and strengthen competitiveness through the promotion of the utilization of R&D data.

5. Development and provision of patent information

The JPO through Patent Information Platform (J-PlatPat[1]) operated by the National Center for Industrial Property Information and Training (INPIT) and the Foreign Patent Information Service (FOPISER[2]) provides patent information of Japan and patent information of foreign countries, which is highly needed by users in Japan.

Furthermore, the INPIT provides a database service covering information of licensable patents and research tool patents which companies, universities, public experiments and research institutions, etc. intend to license or transfer.

6. Acceleration of the examination

To meet the need among patent applicants for expedited patent rights acquisition, the JPO conducts an accelerated examination that applies under certain conditions.

7. Developing and strengthening patent examination system

The JPO worked to maintain and improve its examination capacity also in FY2021 by re-employing some examiners under limited-time contracts after the termination of their term, for example. Continued efforts were also made for development and strengthening of the patent examination system.

8. Collective examination for IP portfolio supporting business activities

The JPO studied a new examination system to meet the needs of patent applications in response to the Global IP Initiative. The JPO has conducted a new initiative, collective examination for IP portfolio supporting business activities, under which it examines applications and grants rights interdisciplinary according to the timing of the applicant's business development, in order to support applications for comprehensive intellectual property. The new initiative applies to groups of intellectual rights (i.e., patents, design rights and trademarks) that are associated with domestic and overseas projects.

9. Implementation and the publication of a survey on technology trend

In response to the growing demand for coordination between R&D and IP strategies, JPO conducts surveys of patent application trends, etc., focusing on fields expected to create new markets and technological fields that should be promoted as national policy, and publishes the results.

10. Experts' support for IP utilization

JPO implements the "Project for Dispatching IP Strategy Designers to Universities" to help universities identify research results whose IP rights are not yet acquired. Through INPIT the

1 https://www.j-platpat.inpit.go.jp/

2 Foreign Patent Information Service https://www.foreignsearch2.jpo.go.jp/

office also implements the "Project for Dispatching IP Producer" and "Project for Dispatching IP Advisor for Industry-Academia Collaboration." The former supports universities, R&D consortiums, etc. promoting publicly-funded R&D projects. The latter supports universities deploying industry-academia collaboration toward commercialization. In FY2021, 16 IP Strategy Designers were dispatched to 20 universities, 21 IP producers were dispatched to 54 projects and 10 IP Advisors for Industry-Academia Collaboration were sent to 18 universities.

In order to assist in the formulation of research plans that are to be implemented in collaboration among universities, national R&D agencies and public experimental research institutions under national research projects, etc. MAFF deploys approx. 140 coordinators throughout the country who are specialized in the agriculture, forestry, fisheries and food industries. This support includes the introduction of viewpoints of the management of technology (MOT[1]), including the strategic use of intellectual property.

11. Efforts for management of technical information

The revised Act on Strengthening Industrial Competitiveness that was enacted in May 2018 established a "technical information management assessment system" where business operators can receive certification for appropriate management of important information held by them from a certification body authorized by the government (as of the end March 2022, six certification bodies were authorized). In FY2021, in addition to dispatch of experts providing advice, etc. for establishment of appropriate technical information management (90 times), collaboration with industry groups highly interested in the system and development of training materials/pamphlets and PR activities through distribution of e-mail newsletters were conducted, and expert meetings (four study sessions and three WG sessions) were held for dissemination and improvement of the system.

12. Support for acquiring IP rights of research results and promotion of their utilization

JST is making consistent efforts to support the identification of excellent research results and the acquisition of IP rights for them. Specifically, under the "Promotion of the Use of Intellectual Property", JST supports comprehensive utilization of IP rights at universities, etc. by supporting the strategic acquisition of foreign patents for their research results and promoting utilization through collecting and packaging patents scattered across different universities, etc.

❺ Strategic promotion of science and technology diplomacy

1. Strategic promotion of science and technology diplomacy

As R&D activities become increasingly globalized, it is important for Japan to promote science, technology, and innovation and utilize its results to increase Japan's international presence and credibility. Therefore, Japan needs to promote comprehensive S&T diplomacy including promoting science, technology, and innovation internationally and as well as through efforts of the Ministry of Foreign Affairs (via the Science and Technology Advisor to the Minister for Foreign Affairs).

1 Management of Technology

(1) 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 Innovation Policy KISHIDA Fumio, according to a proposal made by Japan, which held the presidency at the time. Subsequent meetings were held in the U.K. in 2013, in Germany in 2015, in Japan (Tsukuba City, Ibaraki) in 2016, in Italy in 2017, in the United States in 2020 and in the U.K. in 2021. Through these meetings, Japan intends to actively facilitate international S&T policy discussions between the Japanese Minister of State for Science and Technology Policy and officials from other countries to cooperatively solve global issues using S&T. In July 2021, the G7 Research Forum was held online under the auspices of the United Kingdom, and based on the "G7 Research Compact," an annex to the Summit Declaration issued in June, the participants confirmed the importance of international research cooperation and a policy of working together to address the challenges faced.

At the meetings of the GSO[1], which was established based on the discussion in the 2008 meeting, the members shared information concerning international research facilities and international collaboration frameworks. The Strategic Research Network for Achieving Climate Neutrality (renamed from the International Research Network for Low Carbon Societies in 2021) held its annual meeting in December 2021 under the theme "Accelerating Actions for Leveraging a Climate-Neutral, Sustainable Society." The 2021 annual meeting featured two keynote speeches and four thematic sessions on industrial decarbonization, employment, international cooperation and finance, with a total of 140 experts and researchers from 23 countries and regions participating in the 2-day event. As of 2022, 17 research institutions from seven countries, including Japan, are part of the network.

B. Asia-Pacific Economic Cooperation (APEC)

Meetings of the APEC Policy Partnership on Science, Technology and Innovation (PPSTI) are held to promote scientific and technological innovation in the APEC region through joint projects and workshops. The 18th meetings were held online in August 2021, and the 19th meetings were held online in February 2022 to discuss PPSTI activity plans and other matters.

C. Association of Southeast Asian Nations (ASEAN)

As the cooperation framework for Japan and the ASEAN Committee on Science, Technology and Innovation (COSTI), the ASEAN-*Japan* Cooperation Committee on Science and Technology (AJCCST) has been held every year. MEXT is taking a leadership role in Japan's contribution to AJCCST. Under the Japan-ASEAN STI for SDGs Bridging Initiative agreed at AJCCST-9 in 2018, the ministry continues the cooperation to strengthen social implementation of ASEAN-Japan joint research results.

D. Other

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

Since 1993, Japan has been hosting the annual APRSAF that has provided a great opportunity to exchange information about space activities and utilization in the region and also to promote multilateral cooperation. The first meeting was attended by 60 participants from 13 countries. It had developed into the largest forum of space cooperation in the Asia-Pacific region in 2021

1 The meeting of the Group of Senior Officials

when the 27th APRSAF meeting was held with attendance by about 843 representatives of 48 countries and regions as well as the representatives of 2 international organizations. The 27th APRSAF was held online in response to the spread of the novel coronavirus infection, but it was attended by almost as many or more participants as the local event, indicating that the APRSAF has a stable appeal in the region. In addition, the reorganized subcommittees and workshops were actively discussed from various perspectives in collaboration with external specialists.

ii) The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

The IPBES is an intergovernmental organization established in April 2012 as an intergovernmental platform to scientifically evaluate trends related to biodiversity and ecosystem services and to enhance the link between science and policy. The IPBES-8 Plenary was held online in June 2021 with the participation of member states.

iii) Group on Earth Observations (GEO)

The GEO is an international framework pursuing the development of the Global Earth Observation System of Systems (GEOSS) in accordance with the "GEO Strategic Plan 2016-2025" approved at the ministerial-level meeting in November 2015. A total of 253 countries, international organizations and entities participate in the GEO as of March 2022.

In November 2021, the 14th AOGEO [1] symposium targeting the Asia-Oceania region was held under the auspices of Japan. Researchers and practitioners exchanged information on their views and achievements. The symposium concluded with the "2021 AOGEO Statement," which reflects the common understanding of the AOGEO's future direction for solving social issues unique to the Asia-Oceania region.

iv) Intergovernmental Panel on Climate Change (IPCC)

The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) with the aim of preparing a report summarizing the latest scientific findings on climate change and providing scientific basis for national policies regarding climate change. The 6th Assessment Report of Working Group I was published in August 2021, and Working Group II in February 2022.

v) Innovation for Cool Earth Forum (ICEF)

ICEF is an international conference that has been held annually since 2014 as a knowledge platform for discussions among industry, academia, and government leaders from around the world to promote "innovation," which is the key to solving the problems of global warming. The main theme at the 8th Annual Meeting held online on October 6th and 7th, 2021, was "Pathways to net zero greenhouse gas emissions by 2050: Accelerating the pace of global decarbonization," focus was on specific and realistic discussions toward net zero greenhouse gas emissions in 2050. There were over 2,000 participants from approximately 87 countries and regions, including government agencies, industry, academia, and international organizations, in the 2-day meeting.

vi) Research and Development 20 for Clean Energy Technologies (RD20)

RD20 is an international conference that brings

1 Asia-Oceania Group on Earth Observations

together leaders from research institutes of G20 nation to create noncontiguous innovation aimed at drastically reducing CO_2 emissions. The third meeting held online in October 2021,presented the results of the discussions toward net zero greenhouse gas emissions in the form of a Leaders' Statement. The meeting also launched taskforce activities aimed at the creation of joint projects.

vii) Arctic Science Ministerial (ASM)

The 3rd ASM, co-hosted by Japan and Iceland, was held in Tokyo, the first in Asia, from May 8th (Saturday) to the 9th (Sunday) in 2021. This was a meeting of cabinet ministers aimed at promoting research observations in the Arctic and responding to major social problems, and the participating countries and organizations held discussions on the theme "Knowledge for a Sustainable Arctic" and compiled a joint statement on promoting international cooperation in the scientific field of the Arctic region, accelerating understanding of the Arctic region, and supporting science as the basis for policy-making in the Arctic region.

viii) Global Research Council (GRC)

The 9th Annual Meeting of the GRC, an international conference of heads of major academic-promotion organizations from around the world, was held from May 24th (Monday) to 28th (Friday), FY2021. It was co-sponsored by The National Research Foundation of South Africa (NRF) and UK Research and Innovation (UKRI) and was an online event with Durban (South Africa) as the host. The meeting was attended by the heads of 70 institutions from 71 countries, and issues concerning research support and the role that academic-promotion organizations should play were discussed.

(2) Cooperation with international organizations

A. United Nations system (UN system)

i) Science, Technology and Innovation for Sustainable Development Goals (STI for SDGs)

As a partner country of the "Global Pilot Programme" launched in 2019 by the United Nations Inter-Agency Task Team (UN-IATT[1]) to promote the formulation of STI for SDGs roadmaps in countries around the world, Japan will provide support to promote the provision of digital financial services (DFS) to Kenyan farmers through contributions to the World Bank from FY2020 and proposed a roadmap for building an ecosystem related to DFS to the Kenyan government in FY2021.

In addition, through contributions to the United Nations Development Program (UNDP), which implements initiatives to understand social problems and needs in developing countries, since 2020, the “Japan SDGs Innovation Challenge for UNDP Accelerator Labs” has been implemented, in which Japanese companies consider commercialization based on local needs. In FY2021, Japanese stakeholders began to study solutions and commercialization for issues in three new countries.

In addition, through a commissioned survey on the construction of the STI for SDGs platform, which has been implemented since FY2019, local stakeholders and participants from Japanese companies, etc., jointly analyzed the issues of four developing countries under the cooperation of the World Food Programme (WFP), developed and demonstrated a program to study solutions and commercialization, and created and published an operation manual as the result.

ii) United Nations Educational, Scientific and Cultural Organization (UNESCO)

Japan has been participating and actively

1 UN Interagenecy Task Team on STI for SDGs

cooperating in various science and technology projects and activities of UNESCO, a specialized agency of the U.N. In UNESCO bodies, such as the Intergovernmental Oceanographic Commission (IOC), the Intergovernmental Hydrological Programme (IHP), the Man and the Biosphere (MAB) Programme, UNESCO Global Geoparks, the International Bioethics Committee (IBC) and the Intergovernmental Bioethics Committee (IGBC), international rules are formulated and projects are implemented towards solving global challenges. Japan is implementing support programs including the science human resource program in the Asia-Pacific region and the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) through contribution to UNESCO/Japanese-Funds-in-Trust, etc. Japan also promotes UNESCO activities by sending experts to contribute to discussions of committees/commissions. In November 2021, Japan made various contributions to the Recommendation on Open Science and the Recommendation on the Ethics of AI, which are adopted at the 41st session of the UNESCO General Conferences, including sending Japanese experts to advisory committees, regional consultations, and intergovernmental committees for the formulation of recommendations.

iii) The United Nations Decade of Ocean Science for Sustainable Development (2021-2030)

The United Nations Decade of Ocean Science for Sustainable Development (2021-2030) is an international framework for concentrated initiatives for the ten years from 2021 to 2030 in order to attain the United Nations Sustainable Development goals including SDG14 through promotion of ocean science. It was started in January 2021.

As societal outcomes to be achieved through the initiatives over the 10 years, the plan presents: (1) A clean ocean, (2) A healthy and resilient ocean, (3) A productive ocean, (4) A predicted ocean, (5) A safe ocean, (6) An accessible ocean, (7) An inspiring and engaging ocean. To this end, 10 challenges will be addressed, which include reduction in marine pollution, preservation of the marine ecosystem, improvement of marine literacy and change in human behavior. Aiming to contribute to these social achievements, Japan is promoting various initiatives at the national, interregional, and international levels by promoting collaboration among industry, government, academia, and the private sector, including relevant ministries, agencies, and organizations through the framework of the national committee established in February 2021.

B. Organisation for Economic Co-operation and Development (OECD)

The OECD engages in activities related to science and technology by developing statistical data and fostering exchanges of views, experiences, 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 on Digital Economy Policy (CDEP), the Committee on Industry, Innovation and Entrepreneurship (CIIE), the Nuclear Energy Agency (NEA), and the International Energy Agency (IEA), etc.

In the CSTP, information and views concerning science and technology policies have been exchanged and the role of STI in economic growth, enhancements of research systems, and the roles of government and the private sector in R&D and international collaborations in R&D have been studied. The CSTP has four subgroups: the OECD Global Science Forum (GSF), the Working Party on Innovation and Technology Policy (TIP), the

Working Party on Bio-, Nano- and Converging Technologies (BNCT[1]), and the National Experts on Science and Technology Indicators (NESTI[2]).

i) Global Science Forum (GSF)

The GSF discusses ways to facilitate international cooperation for solving global issues. In 2021, the following projects have been implemented: "Science Mobilization in Times of Crisis", "Large Research Infrastructures (VLRIs)", "Integrity and Security in the Global Research Ecosystem" and "Future Research Talent".

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

The TIP studies how STI can contribute to economic growth through policies. In 2020, it discussed co-creation in industry-academia-government collaboration with citizen participation, and innovation policy for continued and inclusive growth, for example.

iii) Working Party on Biotechnology, Nanotechnology and Converging Technologies (BNCT)

BNCT makes policy proposals for effective use of biotechnologies to contribute to sustainable economic growth and the prosperity of humankind, and has been advancing projects on the ripple effects of nanotechnology, internationalization of research and research infrastructure, etc.

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

NESTI supervises, directs and coordinates OECD statistical work and contributes to the development of indicators and quantitative analyses, which are helpful for the promotion of STI policies. Specifically, with regard to science, technology and innovation indicators related to R&D expenditures, science and technology human resources and other factors, NESTI has been discussing and examining the development of survey methodologies and indicators as well as frameworks for international comparisons of indicators.

C. International Science and Technology Center (ISTC)

The ISTC is an international organization established 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. Today ISTC supports research activities of scientists in a broad area beyond Russia and the CIS with contribution from Japan, the United States, EU, ROK and Norway.

(3) Utilization of research institutions

A. 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.

1 Working Party on Biotechnology, Nanotechnology and Converging Technologies
2 Working Party of National Experts on Science and Technology Indicators

(4) Promotion of Strategic International Activities Related to Science Technology Innovation

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.

Since FY2008, MEXT has been implementing Science and Technology Research Partnership for Sustainable Development (SATREPS) and promoting international joint research with Asian and developing countries in other regions by combining excellent science/technologies and the Official Development Assistance (ODA) of Japan. The research will contribute to solving global issues in the fields of environment, energy, bioresources, natural disaster prevention and mitigation, and infectious diseases control. Since FY2009, the ministry has been implementing the Strategic International Collaborative Research Program (SICORP) to promote diverse international collaborative research according to the potential of the partner country/region, the field and the cooperation phase in equal partnership based on agreement among ministries and agencies toward the creation of innovations through strategic international cooperation. Furthermore, since 2014, the Japan-Asia Youth Exchange Program in Science (Sakura Science Exchange Program) has been implemented to raise interest in Japan's cutting-edge science and technology among young people in Asian countries and regions, and at the same time, promote youth exchanges in the field of science and technology with foreign countries in order to contribute to the future acquisition of excellent human resources for science, technology and innovation from overseas. In FY2021, the program was renamed to the Sakura Science Exchange Program, expanding the scope of the program to include youth from countries and regions around the world and including exchanges in the human and social science fields in addition to the natural sciences (see Chapter 2 Section 2 1 5).

MOE has been supporting the Asia-Pacific Network for Global Change Research (APN) which was established to improve researchers' capabilities and to solve issues common to the nations in the Asia-Pacific region. In February 2021, the 24th intergovernmental meeting was held, and the 5th Strategic Plan was adopted toward further development of its activities. The ninth annual LoCARNet (Low Carbon Asia Research Network) meeting was held online in March 2021 with the aim of sharing the latest research outcomes and knowledge toward low-carbon growth of Asia.

(5) Cooperation with Other Countries

A. Cooperation with the United States and European countries

Japan has been advancing science and technology cooperation with the United States and European countries in advanced research areas such as life sciences, nanotechnology, materials science, environmental sciences, nuclear energy and space exploration. Specifically, Japan has held joint committees' meetings 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.

Based on the Agreement between the Government of Japan and the Government of the United States of America on Cooperation in Research and Development in Science and Technology signed in June 1988, the Joint High-Level Committee on Science and Technology Cooperation and Japan-U.S. Joint Working-Level Committee on Science and Technology

Cooperation were established with the United States. In June 2021, the 16th Japan-U.S. Joint Working-Level Committee Meeting on Science and Technology Cooperation was held to exchange views on science and technology policy, current collaboration and new areas of collaboration. In addition, at the Japan-US Summit Meeting in April 2021, the Japan-US Competitiveness and Resilience (CoRe) Partnership was launched to promote cooperation in important areas such as AI, quantum technology, space, biotechnology, health and medical care. In accordance with this partnership, MEXT and the U.S. Department of Energy signed a business agreement on quantum technology at the 16th Japan-U.S. Joint Working-Level Committee on Science and Technology Cooperation.

Also, since 2021, SICORP has been conducting research related to the novel coronavirus disease (COVID-19) in non-medical fields, as well as research in the field of digital science that contributes to new lifestyles required in the aftermath of COVID-19.

A document on the Japan-EU Green Alliance was published at the 27th Japan-EU Summit held in May 2021. In addition, MIC and the European Commission have been soliciting for R&D projects in the e-Health field as the 5th Japan-EU Joint Call for Proposals since November 2019, with one project adopted in October 2020 and R&D continuing in 2021. Joint Committee Meeting on Cooperation in Science and Technology were held to discuss further promotion of science and technology cooperation between Japan and the United States and Spain respectively in June 2021, the United Kingdom in October 2021, Norway and the EU in November 2021, and Israel and Canada in March 2022.

B. Cooperation with China, South Korea and Russia

Based on a Memorandum of Cooperation signed between MEXT and the Ministry of Science and Technology of the People's Republic of China in August 2018, the SICORP "Collaboration Hubs for International Research Program" (environment and energy) is being implemented with China.

The Japan-China-Korea Trilateral Science and Technology Policy Seminar jointly held by NISTEP under MEXT and Chinese and Korean S&T policy research institutes was held virtually for the second consecutive year within the framework of the three countries.

Based on a Memorandum of Cooperation signed between MEXT and the Ministry of Science and Higher Education of the Russian Federation in September 2017, joint research is being carried out between Japan and Russia, with the priority fields of cooperation being "Rational nature management including Arctic Research", "Energy efficiency" and "Nuclear science".

C. Cooperation with ASEAN countries and India

In Asia, Japan can make use of its science and technology for the solution of problems in many fields including environment, energy, food, water, natural disaster prevention, and infectious diseases. It is necessary to play an active role in solving Asia's common issues and build relationships of mutual trust and benefits in the region.

In June 2012, MEXT in cooperation with JST launched the *e-ASIA Joint Research Program* for multilateral joint research. The program aims to strengthen R&D capabilities and solve common issues facing Asian countries. Institutions of East Asia Summit member countries participate in the program that covers seven fields: materials (nanotechnology), agriculture (food), alternative

energy, health research (infectious diseases and cancer), disaster risk reduction and management, environment (climate change and marine science) and advanced interdisciplinary research towards innovation. The health research field has been supported by AMED since April 2015. In FY2020, urgent public invitation was made for joint research projects on COVID-19 infection.

As for Collaboration Hubs for International Research Program (CHIRP) in the SICORP, support started in ASEAN (environment/energy, bioresources, biodiversity and disaster prevention fields) in September 2015 and in India (ICT field) in October 2016. With an eye to creating innovation, improving Japan's science and technology capabilities, and strengthening the foundation of research cooperation with partner countries and regions, JST has promoted continuous joint research and cooperation programs, aiming to promote Japan's identifiable and sustainable contribution, while also building research networks and fostering young researchers. In November 2020, JST held the 10th Japan-India Joint Committee on Science and Technology Cooperation as a teleconference. The attendants were appreciative that the cooperation in the S&T field has been promoted continuously.

D. Cooperation with other countries

Japan has promoted science and technology cooperation with other countries as well, including information exchange, researcher exchange, and joint research. MEXT convened the "Africa-Japan Ministerial Dialogue Meeting on STI for SDGs" as an official side event of the 7th Tokyo International Conference on African Development (TICAD7) in 2019. Based on the discussions at the meeting, AJ-CORE[1] which is a program of joint research by Japan and more than two African countries with the leadership of Japan and South Africa started research invitation in December 2019 and adopted four projects in February 2021.

To promote science and technology cooperation with developing countries in Asia, Africa and Latin America etc., MEXT, the JST, AMED, MOFA and JICA have been collaboratively implementing the SATREPS program by utilizing Japan's excellent science and technology and ODA. The program promotes international joint research to address global issues and promote future utilization of research outcomes based on the needs of these countries. From FY 2008 through FY 2021, 168 SATREPS projects in 53 countries (including 91projects in Asia, 42 projects in Africa and 25 projects in Latin America) were adopted for implementation.

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 international joint research projects to earn degrees in Japan. Thus, MEXT is cooperating with other countries in developing their human resources.

(6) Autonomously ensuring the soundness and fairness of research (research integrity) associated with the internationalization and openness of research activities

From the perspective of appropriately responding to new risks associated with the internationalization and openness of research activities, it is important that researchers, universities, research institutions, etc.,

1 African-Japan Collaborative Research

autonomously ensure the soundness and fairness of their research (research integrity). Therefore, in April 2021, the Integrated Innovation Strategy Promotion Council decided on the "Government policy for ensuring research integrity in response to new risks associated with the internationalization and openness of research activities". In accordance with this policy, the "Guidelines for Appropriate Execution of Competitive Research Funds" was revised in December 2021 in order to clarify that researchers are required to submit appropriate information to their affiliated research institutions and research funding agencies.

2. Ensuring Research Integrity

Securing of the integrity of research is essential for researchers to build trusting relationships with various stakeholders of society. Researchers and research institutions including universities need to bear firmly in mind that tirelessly addressing research misconduct is the way to respond to society's trust in STI and increase STI's driving force.

For promotion of fair research activities, MEXT works to ensure system development and other efforts by research institutes based on the Guidelines for Responding to Misconduct in Research (decision by the Minister of MEXT on August 26, 2014.) In addition, the ministry has been supporting research ethics education provided by research institutes in cooperation with JSPS, JST and AMED.

In order to prevent inappropriate use of research funds, MEXT urges appropriate management of public research funds at research institutions based on the Guidelines for Management and Audit of Public Research Funds at Research Institutions (Implementation Standards) ("the Guidelines": Decision of the MEXT Minister on February 15, 2007), while at the same time providing guidance and advice to support efforts by research institutions. The guidelines were amended in February 2021 to enhance measures to prevent misuse of research funds. In addition, METI is addressing this issue based on the Guidelines for Responding to Misconduct in Research (revised on January 15, 2015), and the Guidelines for Responding to Misuse of Public Research Funds (revised on January 15, 2015). Other relevant ministries and agencies are also addressing the issue based on their respective guidelines, etc.

In addition, information on persons involved in misconduct is shared among relevant ministries and agencies, and their eligibility to apply for competitive research funds at all relevant ministries and agencies is restricted in accordance with the "Guidelines for Appropriate Execution of Competitive Research Funds" (Revised on December 17, 2021, based on the agreement of the Inter-Ministry Liaison Conference).

Section 2 Expanding the frontier of knowledge and strengthening research capabilities as a source of value creation

Research based on the intrinsic motivation of researchers has pioneered the field of human knowledge, and the accumulation of such knowledge has supported the prosperity of humans. This white paper describes the government's measures to develop human resources, research infrastructure and research environments that foster "knowledge" through the realization of a culture that allows researchers to take on diverse research challenges.

1 Reconstruction of the environment that generates diverse and outstanding research

To produce diverse and excellent research results that open up new frontiers of knowledge, the government aims to realize research environments in which researchers can demonstrate their abilities to the fullest and continue to take on the challenge of solving issues based on the diverse awareness of issues inherent in each of them.

❶ Improving the treatment of doctoral students and expanding their career paths

MEXT launched the "Establishment of University Fellowships towards the Creation of Science Technology Innovation" in FY 2021 to support universities that have the ability and motivation to provide financial support for outstanding and ambitious doctoral students to devote themselves to research and to develop career paths for doctoral human resources to work in a wide range of fields, including industry. MEXT is also working on the new program called "Support for Pioneering Research Initiated by the Next Generation (SPRING)," in which JST is playing the lead role.

To foster top level researchers who will play major roles in future scientific research, the JSPS offers the Research Fellowship for Young Scientists Program under which fellowships are granted to doctoral students (DC[1]).

The Japan Student Services Organization (JASSO) provides scholarship loan programs to financially support motivated students who excel academically but who have difficulty pursuing their studies due to financial constraints. Interest-free scholarship loan recipients who are recognized by JASSO as having achieved particularly outstanding results in their studies may be partially or completely exempt from repaying their loans. Starting from the enrollment in FY2018, JASSO has expanded the system to exempt doctoral students with excellent performance from repaying their loans. The aim is to encourage continued education by reducing financial burden on students of doctoral programs.

It is expected that through such programs, the government's target of providing financial support to approximately 15,000 doctoral students, as indicated in the "Comprehensive Package to Strengthen Research Capacity and Support Young Researchers (Council for Science, Technology and Innovation, January 23, 2020)" will be realized. In the future, the government will aim to provide financial support to 22,500 doctoral students, which is the goal of the 6th Basic Plan.

Furthermore, to improve the treatment of doctoral students, the government is promoting the active participation of doctoral students as research assistants (RA), and payment of appropriate compensation for RA expenditures resulting from such participation under the competitive research funding system established based on the 6th Basic Plan and the "Guidelines for Employment and Training of Post-doctoral Fellows" (December 3, 2020, Human Resources Committee, CST).

MEXT has started a long-term and paid cooperative education through research internships as a preliminary and trial initiative from FY 2021 for doctoral students in graduate schools, where industry and universities will collaborate to provide graduate school education and foster practical skills backed by research capacity in the doctoral course, and has been working on initiatives to realize various career paths.

In addition, the Cabinet Bureau of Personnel Affairs, the National Personnel Authority, the Cabinet Office, and MEXT have been conducting interviews and other such activities to discuss how to improve the treatment of doctoral degree recipients in the national civil service based on their expertise and research experience.

❷ Development of an environment in which young researchers can play an active role at universities, etc.

Based on the Integrated Innovation Strategy

1 Doctoral course

2019 decided by the Cabinet on June 21, 2019, and on the premise of establishment of a system for appropriate implementation by the research institutions, it was decided to allow payment of labor cost to the principal investigator (PI) from the direct cost of the competitive research fund in proportion to his/her efforts for the research activities at the request of the principal investigator. In this way, based on appropriate cost allocation, research institutions can use secured funds to enhance research performance of principal investigators through environmental improvement for focused research and also to strengthen research capacity of the institutions by securing diverse and excellent talents including young researchers. The reform is expected to enhance research capabilities of both researchers and research institutions.

MEXT has prepared a guideline on personnel salary management reform (supplement) for national university corporations, which includes good examples of organization-wide efforts to secure positions for young researchers, provide support for the promotion of their fostering and participation, and build a sustainable research system through initiatives to allocate internal financial resources generated by the use of external funds (competitive research funds, joint research funds, donations, etc.) for employment funding to increase the number of positions for young researchers and to establish the research support system, utilization of annual salary schemes and cross-appointment system, and promotion of the conversion to fixed-term employment for senior researchers with external funds. The guideline was officially announced on December 21, 2021.

Promotion of fostering and participation of research management personnel such as research administrators (URA) is important to develop the research environment for researchers and to strengthen URAs at universities further, etc.; the "Study Committee on Strengthening of Research Administrator's Activities" compiled a summary of issues toward the introduction of an authorization system that will contribute to the improvement of their knowledge/skills and visualization of their executive ability (September 2018). Based on this summary of issues, a survey study was conducted toward introducing an authorization system in FY 2019 and FY 2020. In FY 2021, a quality assurance (authorization) system for URAs was implemented under the project "Implementation of a Quality Assurance System for Management Personnel such as Research Administrators."

With the aim of increasing world-class research universities, the Program for Promoting the Enhancement of Research Universities has been implemented since FY2013. Under this program, the government supports employment of research management personnel including URA, as well as intensive reform of research environments of 22 research institutes including universities selected based on quantitative indices so that the research capacity of Japanese universities will increase.

The "Strategic Development Program for Young Researchers" has been implemented since FY2019 and has been supporting five organizations in FY2021. The program aims to construct a well-organized system to foster researchers beyond the boundary of laboratories, and will include: incorporating knowledge of advanced initiatives in Japan and abroad to improve research productivity in the country; developing programs for fostering of world-class researchers and; a support system for publishing in top journals and acquisition of overseas funds, for example.

In addition, MEXT has been implementing the

Leading Initiative for Excellent Young Researchers (LEADER) program since FY 2016 to support researchers and research institutions so that excellent young researchers can obtain a stable and independent research environment to devote themselves to voluntary and independent research at research institutions of industry, academia or government. By FY2021 at least 441 young researchers (March 31, 2022) found a stable and independent research environment at positions created under the program.

In addition, MEXT has been implementing the "Building of Consortia for the Development of Human Resources in Science and Technology" to secure stable employment for young researchers while increasing their mobility to help their career development and also to support universities, etc. in constructing a mechanism to diversify their career paths. The support was provided to 10 organizations in FY 2021.

JST operates the Japan Research Career Information Network Portal site (JREC-IN Portal[1]) to provide researchers and assistants with information for career development including job information and to support the efficient use of such information.

NISTEP of MEXT conducted a follow-up survey on the employment status and treatment of those who completed their doctoral course in 2018, 1.5 years after the completion (JD-Pro[2]). It published the 4th report in January 2022. In addition, a survey was conducted for prospective master's degree recipients, which is the preliminary stage of the doctoral course, regarding their plans to enter a doctoral course, their financial situation, career awareness, etc., and the report for those who completed the course in FY 2020 was released in June 2021 (JM-Pro[3]). Regarding Japan Graduates Database (JGRAD[4]), which is the information base for understanding the current situation of doctoral human resources, the system was updated in September 2021 to improve user convenience.

COLUMN 2-11

Visualizing the Activities of Laboratories and Research Groups: Labo-Panel Survey

The National Institute of Science and Technology Policy (NISTEP[5]) of MEXT analyzes the current state of Japan's research capacity using data from papers, etc. The results of this analysis were also used in the 2019 White Paper on Science and Technology to show that Japan's research capacity is declining relative to that of other countries. While a common understanding of Japan's current situation is being formed through White Papers and other such reports, NISTEP has recently been asked to provide suggestions on measures and policies to improve Japan's research capacity.

Based on the recognition that for responding to such needs, it is important to understand the research process between inputs such as the number of researchers and R&D expenditures and outputs such as the number of papers, NISTEP has been conducting the "Survey of research activities in Japanese universities using a database for comprehension of research activities (Labo-Panel Survey)" since FY 2020. Through the survey, NISTEP will continue to collect basic information on university faculty members in the natural sciences and their laboratories and research groups, the portfolio of research projects conducted by university faculty members, and the details of specific research projects from FY 2020 to FY 2024.

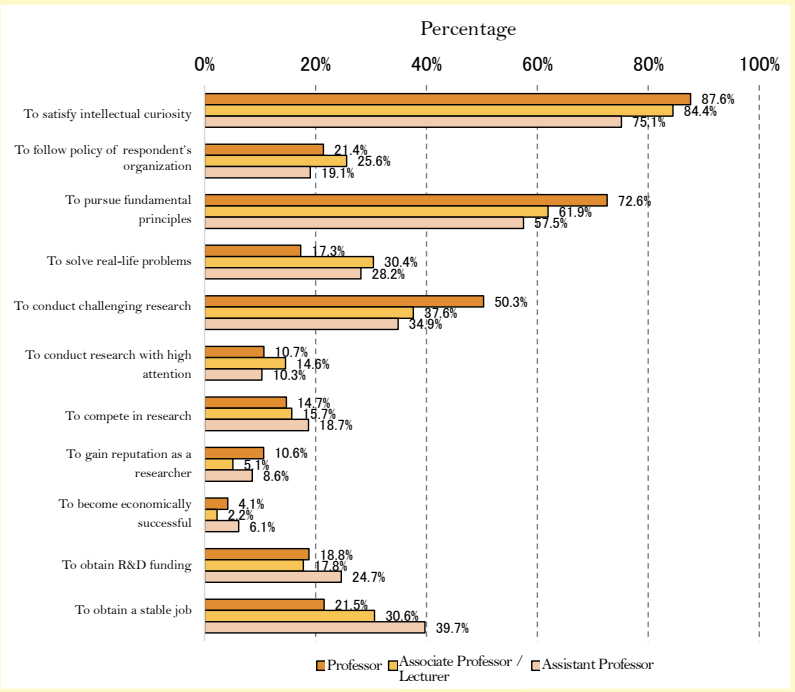
Through the analysis of the results of the first-year survey conducted in FY 2020, suggestions were made regarding (1) Expansion of the scope of management through advancement in positions, (2) Inter-disciplinary differences in the

1 https://jrecin.jst.go.jp

2 Japan DoctoralHuman Resource Profiling (https://www.nistep.go.jp/jdpro/en/)
3 Japan Master's Human Resource Profiling
4 raduates Database
5 l Institute of Science and Technology Policy

structure of laboratories and research groups, (3) Independence of assistant professors and their sense of values, (4) Importance of students in conducting research, and (5) Diversity in objectives and outcomes of research projects. The diagram shows the sense of values concerning research motivation among faculty members at different positions in the field of science. A high percentage of assistant professors emphasized "To obtain a stable job," while the percentage of "To satisfy intellectual curiosity" and "To conduct challenging research" was the highest among professors. Dr. Syukuro Manabe, the winner of the 2021 Nobel Prize in Physics, pointed out the importance of curiosity in research, and in light of this, the data are somewhat problematic. The Labo-Panel Survey also revealed that many assistant professors hold tenured positions and that about half of the funds used by assistant professors for research activities come from external funds obtained by their supervisors. These factors may influence the sense of values among assistant professors.

From FY 2022 onward, NISTEP plans to provide the findings from the Labo-Panel Survey to MEXT and the Council for Science, Technology and Innovation as basic data for drafting science and technology policies, not only by conducting surveys but also by a full-scale analysis of the surveys.



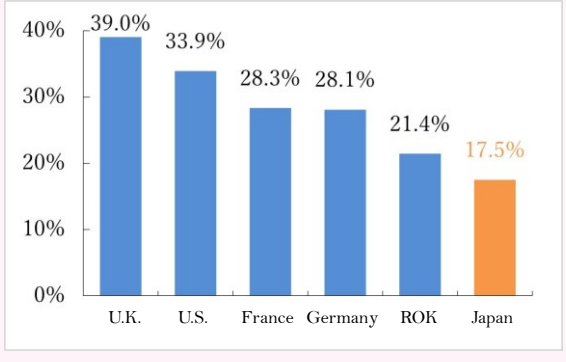
Sense of Values Concerning Motivation of Research (Field of Science, Percentage of those "Placing Emphasis" by Position)

Courtesy: National Institute of Science and Technology Policy, MEXT
Source: "Survey of research activities in Japanese universities using a database for comprehension of research activities (Labo-Panel Survey 2020): Summary of Basic Findings"
National Institute of Science and Technology Policy (NISTEP), MEXT, 2022, Research Material No. 314

❸ Promoting the active participation of female researchers

Creating an environment in which female researchers can demonstrate their abilities and play an active role will contribute to the vitalization of science, technology, and innovation in Japan and the promotion of gender equality. In Japan, by supporting employment and increasing the roles of female researchers, the share of female researchers has been increasing every year. However, woman still accounted for only 17.5% of researchers as of March 31, 2021, which is lower than in other advanced countries (Figure 2-2-4). The 6th Basic Plan set the following goals for the ratio of women among researchers hired by universities by 2025: 20% in the physical sciences, 15% in engineering, 30% in agriculture, 30% in medicine, dentistry and pharmacology combined, 45% in humanities and 30% in social sciences.

■Figure 2-2-4／Percentage of female researchers by country



Note: 1. Data as of 2020 for South Korea, as of 2019 for the U.K., U.S., and Germany, and as of 2017 for France
2. For the U.S. data on scientific professionals (i.e., bachelor's/ master's/ doctoral degree holders in science or engineering who engage in a science-related profession) are used instead of data on researchers. "Science" includes the social sciences.

Source: Adapted by MEXT based on Survey on Research and Development (MIC), Main Science and Technology Indicators (OECD) and Science and Engineering Indicators 2022 (NSF)

The Cabinet Office provides information, such as information on initiatives and events of universities and companies that promote women's participation in the field of science and engineering and messages from women playing active roles in these fields, on the website "Science and Engineering Challenge (Riko Challenge)[1]." In July 2021, an online symposium "How will career choice change my life? - Science will expand my future 2021" was held on the website. Through the symposium, diverse role models in science and engineering fields sent messages to female junior-high/high school students across Japan, their guardians and teachers.

MEXT has implemented the Initiative for Realizing Diversity in the Research Environment, to support initiatives for diversity implemented by universities and other institutions. The initiative includes integrated promotion of leader training through support for researchers to allow them to balance their research with maternity, childcare and other life events and support for female researchers in improving their research capabilities. 124 institutions implemented the initiative in FY2021.

The JSPS has implemented the Restart Postdoctoral Fellowship (RPD)[2] Program to provide research incentives to male/female researchers who have temporarily discontinued their research due to maternity/childcare responsibilities.

JST implements the "project to encourage female students of lower/upper secondary schools to follow scientific career paths." The project provides female junior-high/high school students with opportunities of exchange with female researchers, engineers, university students, and experimental workshops and lectures on demand to arouse the interest of students in science and support their science/engineering career choice.

AIST organized the Diversity Support Office (DSO), a consortium of 20 universities and research institutions nationwide. The DSO contributes information-sharing and exchanges of opinions on diversity promotion among member institutions. The DSO also implements the action plan based on the Act on Promotion of Women's Participation and Advancement in the Workplace in cooperation with universities and companies The DSO promotes diversity in the further

1 https://www.gender.go.jp/c-challenge/

2 postdoctoral researchers restarting research activities

expanded network by supporting work-life balance and career development of the researchers and raising awareness.

❹ Basic research and promotion of academic research

1. National universities

National university corporations as centers of knowledge and human resources have a role to lead knowledge and create innovations in the knowledge-intensive society. In addition, as regional education and research centers based on their strategic distribution across the country, they are a driving force of social changes by developing the potential of regions in order to contribute to regional revitalization.

Japan has many challenges including the paradigm shift to a knowledge intensive society, globalization of high education and formation of a geographically decentralized society. In this context, for national universities to fulfill their roles as the central core of human resource development and innovation creation, they need to develop an environment for solid implementation of university reform with due consideration to continuity and stability of education and research.

In the FY 2021 budget, 1,079 billion yen was allocated as government subsidies for national university corporations, and efforts were made to enhance education/research, such as securing an amount that was substantially higher compared to the previous fiscal year for education/research activities.

Also, regarding the nature of government subsidies for national university corporations during the period of the 4th Medium-term Objectives starting from FY 2022, the government has decided to enhance support for the realization and acceleration of each university's mission and further improve the reform incentives by reviewing the "Performance-Based Allocation with a Focus on Results," based on the deliberation summary of the Expert Panel compiled in June.

2. Reform and strengthening of Grant-in-Aid for Scientific Research

MEXT and the JSPS have been implementing the Grants-in-Aid for Scientific Research (KAKENHI). The Grants-in-Aid for Scientific Research is competitive research funds that cover scientific research in all fields ranging from the humanities and the social sciences to the natural sciences. By supporting creative research activities while ensuring research diversity, the Grants-in-Aid for Scientific Research plays a role in expanding the base of research activities and contributing to the sustainable development of research and forming a massive intellectual pool. In FY2021, around 27,000 research applications were newly selected by peer review screening (assessment of the research proposals by reviewers selected from the research communities) from over 100,000 applications in major research categories. About 84,000 projects, including those continuing for the several fiscal years, were funded. (The KAKENHI budget for FY2021 is 237.7 billion yen).

The KAKENHI system has been reviewed continuously for improvements, and MEXT has carried out radical reforms including the introduction of a Multi-year Fund and a review of its screening system. In FY 2021, the "International Leading Research" program was established to encourage young researchers to take up challenges and to vigorously promote international joint research by excellent research teams led by top-level researchers. The system was also improved, including the decision to relax the restrictions on duplicate applications and those receiving grants for "Grant-in-Aid for Early-Career Scientists (2nd time)" and "Grant-in-Aid for

Challenging Research (Pioneering/Exploratory)" under certain conditions, starting with the 2023 proposal solicitation. To further promote scientific research in the future, the government will continue to review the KAKENHI system and enhance its support.

3. Strategic Basic Research Programs

The Strategic Basic Research Programs (Creating the Seeds for New Technology) operated by the JST and the Advanced Research and Development Programs for Medical Innovation launched by AMED invite applications from researchers at universities and other institutions. These programs are carried under the strategic objectives set by the national government. The research is conducted through a fixed-term consortium that is connected over institutional boundaries. The important results generated by the research are being accelerated and deepened. In order to incite unique and bold ideas of researchers and encourage interdisciplinary research by researchers of diverse fields, the system is reformed by consolidating strategic targets, for example. MEXT set the following eight targets for FY2021.

(1) Strategic Basic Research Programs (Creating the Seeds for New Technology)

- Precision control of bonding and decomposition for resource recycling
- Comprehensive understanding and advanced prediction and control of complex transport phenomena
- System software technology to support safety, security, and trust in the era of Society 5.0
- Toward scientific discoveries through DX in life science research
- Opening up of unexplored exploration space of materials with multi-element, composite, and metastable phases based on elements strategy
- Technology infrastructure for the post-COVID society built by "Convergence Knowledge"
- Integrated understanding of human multi-sensing networks and elucidation of their control mechanisms*

(2) Advanced Research and Development Programs for Medical Innovation

- New approaches in drug and vaccine discovery for infectious diseases
- Integrated understanding of human multi-sensing networks and elucidation of their control mechanisms*

* Common goals of the JST Strategic Basic Research Programs (Creating the Seeds for New Technology) and Advanced Research and Development Programs for Medical Innovation

4. Promotion of emergent research

The "Fusion Oriented REsearch for disruptive Science and Technology" which aims at creating results that could lead to disruptive innovation, is implemented with a fund established by JST. This program provides an environment on a long-term basis in which researchers just before and after independence, especially young researchers, can devote to working on their ambitious ideas. Since FY 2020, 511 research projects have been selected through two rounds of proposal solicitation. Furthermore, additional support has been provided to doctoral students who support the selected research projects as research assistants (RA), and the budget for FY 2021 was used to enhance this support further.

5. Promotion of shared use and joint research at universities and inter-university research institutes

The system for shared use and joint research has made a big contribution to the development of academic research in Japan. Under the system, researchers across the country can use leading edge large equipment and precious materials/data outside the framework of university. The system functions mainly through inter-university research institutes and joint usage/research centers of national, public and private universities certified by the minister of MEXT. [1]

Large-scale scientific research leads the world's scientific research by tackling uncharted research subjects using large-scale state-of-the-art research equipment, forms a global research center by gathering excellent researchers of Japan and other countries, and provides common foundations of research activities for research institutes in Japan and other countries. MEXT supports these projects under the "Large-Scale Scientific Frontier Promotion Projects" program. Representative examples are Super Kamiokande (SK) that produced research results leading to the awarding of the Nobel Prize in Physics to KAJITA Takaaki, Director of the University of Tokyo's Institute for Cosmic Ray Research in FY2015, and Hyper Kamiokande (HK) that is the next-generation of SK. HK has observation capacity that exponentially exceeds the capacity of SK and aims to discover new physical principles and unlock the mystery of elementary particles and space through proton decay search and neutrino research. Construction of HK started in FY2019.

＜Reference URL＞

○ Large-Scale Scientific Frontier Promotion Projects
https://www.mext.go.jp/a_menu/kyoten/20200826-mxt_gakkikan-1383666_001.pdf

1 107 centers of 59 universities (including 7 centers of 5 universities in international joint usage / research centers) have been certified and are active as of April 2021

COLUMN 2-12

The Leiden Manifesto for Research Metrics

Many research evaluations use metrics, such as the number of paper citations. When used appropriately, metrics can be complementary in making expert (peer) evaluation more valid and fair. However, rather than using the data as complementary material, evaluations are often led by the data. Scientometricians have ever often warned against this situation and have discussed the appropriate use of metrics, the crystalization of which is the Leiden Manifesto.

The basis for the Leiden Manifesto was the keynote speech by Dr. Diana Hicks (Georgia Institute of Technology) at the 19th International Conference on Science and Technology Indicators (STI 2014) held at Leiden University in the Netherlands in September 2014. Summarizing the discussions held during the conference, Hicks and four others jointly published "The Leiden Manifesto for Research Metrics" in the Nature journal of 2015[1]. The Leiden Manifesto consists of ten principles, which provide best practices and caveats for using metrics in research evaluation and are considered to be the guidelines for all researchers, administrators, and evaluators. Given below are the headings of the ten principles of the Leiden Manifesto.

Principle 1 Quantitative evaluation should support qualitative, expert assessment.
Principle 2 Measure performance against the research missions of the institution, group, or researcher.
Principle 3 Protect excellence in locally relevant research.
Principle 4 Keep data collection and analytical processes open, transparent, and simple.
Principle 5 Allow those evaluated to verify data and analysis.
Principle 6 Account for variation by field in publication and citation practices.
Principle 7 Base assessment of individual researchers on a qualitative judgment of their portfolio.
Principle 8 Avoid misplaced concreteness and false precision.
Principle 9 Recognize the systemic effects of assessment and indicators.
Principle 10 Scrutinize indicators regularly and update them.

The Leiden Manifesto website[2] provides a link to the article in the Nature journal, as well as to translated articles and videos in various languages. Of the 710 papers citing the article in the Nature journal (surveyed by the Web of Science Core Collection on March 1, 2022), the major ones are that discussing the applicability of the Leiden Manifesto to Altmetrics[3], that examining the practicality of the Leiden Manifesto from the perspective of academic libraries[4], and that asserting that libraries should advocate the use of bibliometrics for research evaluation at universities in line with the Leiden Manifesto[5]. In Japan, paper analysis is being used in many situations to understand research activities; however, when making such use, the caveats pointed out in the Leiden Manifesto should be kept in mind.

Source
Natsuo Onodera and Masatsura Igami (2016). The Leiden Manifesto for Research Metrics.
STI Horizon, 2 (4), 35-39. http://doi.org/10.15108/stih.00050

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2 Leiden manifesto for research Metrics. http://www.leidenmanifesto.org/
3 Bornmann, L. and Haunschild, R. (2016). To what extent does the Leiden manifesto also apply to altmetrics? A discussion of the manifesto against the background of research into altmetrics. Online Inf. Rev., 40 (4), 529-543. https://doi.org/10.1108/OIR-09-2015-0314
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❺ Promotion of international joint research and international brain circulation

1. The development of international networks of researchers

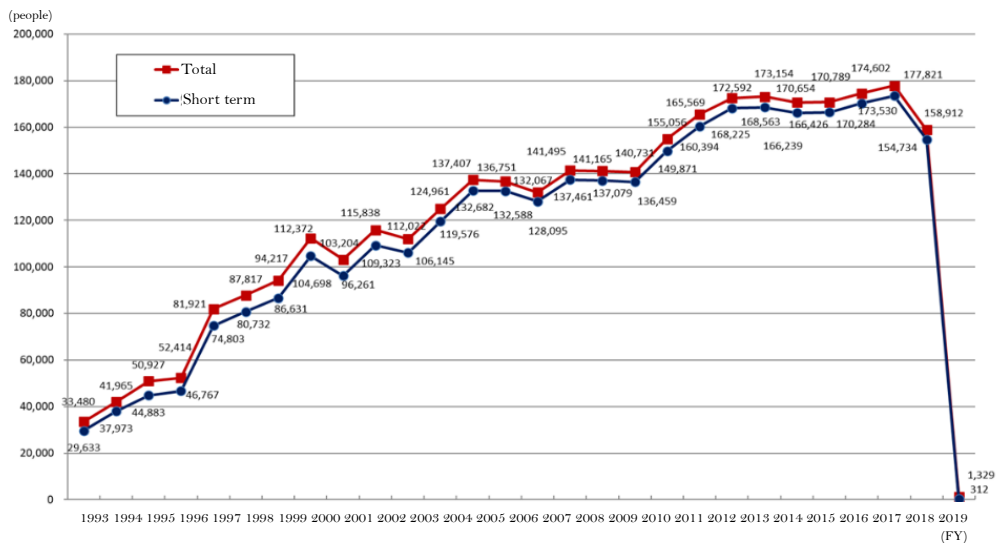
(1) International mobility of Japanese researchers

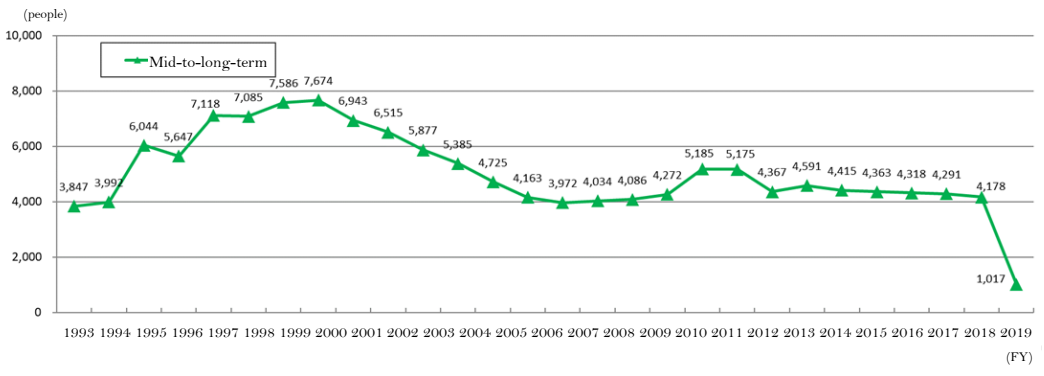
According to the Overview of International Research Exchanges published in FY 2022, the number of short-term researchers dispatched had grown since the start of the survey while significantly decreasing in FY 2020 compared to the previous fiscal year. The number mid-to-long-term researchers dispatched has generally remained between 4,000 and 5,000 since FY 2008, but in FY 2020, there was a significant decrease compared to the previous year (Figure 2-2-5).

The number of short-term foreign researchers accepted by Japanese universities and Incorporated Administrative Agencies had been on the increase until FY2009, then decreased until FY2011 due to the impact of the Great East Japan Earthquake and other factors, and then recovered. In FY 2020, it decreased significantly from the previous fiscal year. The number of mid- to long-term foreign researchers has generally remained between 12,000 and 15,000 since FY 2000 and the number decreased significantly in FY 2020, although to a lesser extent than the number of short-term foreign researchers (Figure 2-2-6).

These significant decreases in FY 2020 were because of the 3 months affected by the COVID-19 pandemic from January to March 2020 in FY 2019, whereas it was the entire year in FY 2020.

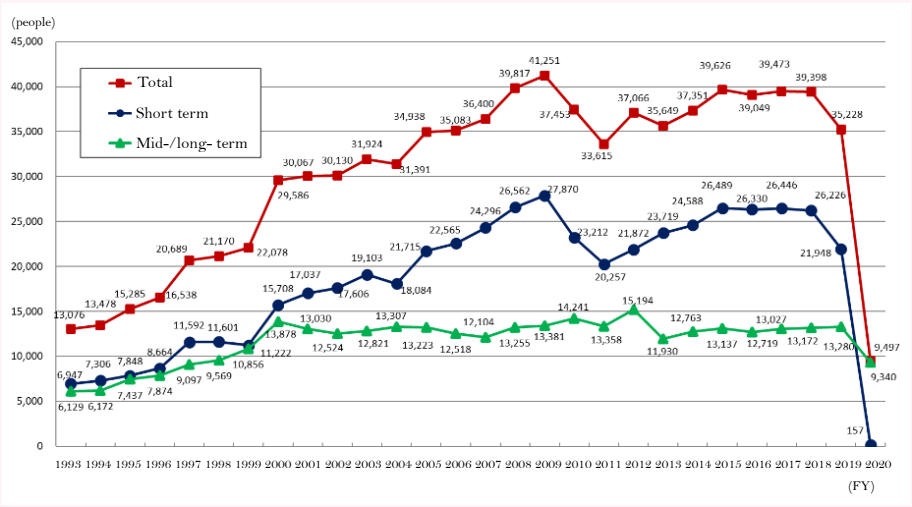
■ Figure 2-2-5／Changes in the number of researchers dispatched abroad (short-term and mid-to-long-term)





Note: 1. "Short-term" refers to a maximum period of dispatch and acceptance of 30 days, and "Mid-to-long-term" refers to a period exceeding 30 days.
2. Postdocs and research fellows are included in the figures in and after FY2010.
Source: Overview of International Research Exchanges, MEXT (2022)

■Figure 2-2-6／Changes in the number of foreign researchers overseas (short-term and mid-to-long-term)



Note: 1. "Short-term" means 30 days or fewer; "Mid-to-long-term" means more than 30 days.
2. Postdocs and research fellows are included in the figures in and after FY2010.
3. The overlap caused by multiple counting of the same foreign researchers accepted at multiple institutions in Japan in the same fiscal year was eliminated from the FY2013 survey.
Source: Overview of International Research Exchanges, MEXT (2022)

(2) 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 JSPS has provided various programs for the purpose of sending young researchers abroad and inviting excellent researchers from other countries to Japan. Under the KAKENHI system, JSPS established the "International Leading Research" program in FY 2021 to promote the development of excellent young researchers who can compete on the global stage by sending young researchers (post-doctoral fellows and graduate students) abroad for long-term exchanges and providing independent support through international joint research, with the requirement that they participate in excellent research teams led by top-level researchers possessing a solid research record and international network.

In addition, JSPS offers the Overseas Research Fellowships, 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 universities or research institutions overseas. The Overseas Challenge Program for Young Researchers offers to support doctoral students traveling abroad.

In addition, the Cross-border Postdoctoral Fellowship (CPD[1]) program has been implemented since FY2019 to provide research grant to excellent young researchers who are working to form a network with famous researchers and others, while tackling ambitious research at a core university/research institution of the international community.

JSPS accepts overseas research fellows under the International Fellowships for Research in Japan to give outstanding foreign researchers opportunities

1 Cross-border Postdoctoral Fellow

to conduct research at universities or research institutions in Japan, which will contribute to internationalization of the research environment of Japanese universities, etc. In addition, Bilateral Programs support forming a sustainable network between Japanese and foreign research teams.

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

JST started the Japan-Asia Youth Exchange Program in Science (Sakura Science Plan) in FY2014 to invite excellent youths from 41 countries and regions predominantly located in Asia for a short-term visit to call in outstanding foreign human resources. In FY2021, the program was renamed, the Sakura Science Exchange Program, expanding the scope of the program to include youth from countries and regions around the world, including exchanges in the human and social science fields and the natural sciences.

2. International research grant programs

The Human Frontier Science Program (HFSP) is an international research grant program first advocated by Japan at the summit in Venice in June 1987. This program aims at supporting international joint basic research on the complex mechanisms of living organisms and providing the research results for the general interest of mankind. Currently the International Human Frontier Science Program Organization (HFSPO; President: NAGATA Shigekazu, Specially Appointed Professor, Osaka University) has 15 members (Japan, Australia, Canada, the EU, France, Germany, India, Israel. Italy, The Republic of Korea, New Zealand, Singapore, Switzerland, the U.K. and the U.S.). Japan has been actively supporting the program since its establishment and playing a key role in its operation.

This program provides grants for research expenses of international joint research teams (Research Grants), supports young researchers by covering the cost of overseas research expenses such as travel and stays (Postdoctoral Fellowships), and holds HFSP awardees' meetings. More than 30 years since the program began in FY1990, HFSPO has given research grants for about 1,200 research projects of over 4,400 researchers worldwide and provided fellowships to about 3,400 young researchers. Among past winners of the research grant, 28 researchers were awarded with the Nobel Prize, including HONJO Tasuku, Distinguished Professor, Kyoto University, who won the Nobel Prize in Physiology or Medicine in 2018. The international cooperation program that supports original, ambitious and inter-disciplinary research is highly regarded throughout the world.

3. Promoting international joint research and creating world-class research centers

For Japan to establish a strong presence and position itself as a significant part of the global research network, it is important to strategically promote international joint research and form nationwide research centers that will serve as the core of international brain circulation.

(1) International joint research with other countries

(a) ITER project, etc.

The ITER project is managed under the international cooperation of 35 countries, seven parties to realize fusion energy. The construction of ITER began in earnest in Cadarache, France, toward the commencement of operations in the

near future. Japan is promoting the production of major equipment of ITER including superconductive coils (See Chapter 2, Section 1, 2 ❷). Japan and Europe are also promoting the Broader Approach (BA) that is an advanced fusion R&D supplementing and supporting the ITER project at Rokkasho Village of Aomori prefecture and Naka city of Ibaraki prefecture.

(b) International Space Station (ISS)

Japan participates in the ISS program by operation of the Japanese Experiment Module "KIBO" and the uncrewed cargo transfer spacecraft "KONOTORI" (HTV[1]) and long-term stay of Japanese astronauts in ISS[2]. (See Chapter 2, Section 1, 3 ❺ .)

(c) International Space Exploration

Japan decided to participate in the international space exploration Artemis Program at the Strategic Headquarters for National Space Policy in October 2019. In December 2020, the Japanese government and NASA signed a memorandum of understanding concerning the cooperation for Gateway, a manned space station orbiting the Moon, which will play the central role in the program. (See Chapter 2, Section 1, 3 ❺)

(d) International Ocean Discovery Program (IODP)

The IODP is a multilateral international cooperation project led by Japan, the United States and Europe with the aim of elucidating global environmental change, the inner structure of the Earth, and subseafloor biosphere, etc. The program has been implemented since October 2013. A Japanese deep drilling vessel, CHIKYU, which features the world's top level drilling capabilities among science drilling vessels, and a U.S. drilling vessel have been the principal vessels of the IODP. Mission-Specific Platforms are also provided by the European consortium. These drilling vessels are used to drill deep sea floors worldwide. In October 2020, 2050 Science Framework (until 2050) was formulated showing scientific goals for the next-term activities.

(e) Large Hadron Collider (LHC)

Currently, in the LHC project[3], the upgrade of LHC to increase its luminosity (HL-LHC[4] project) is underway.

(f) Other

An international researcher community is considering the International Linear Collider (ILC) project to investigate the properties of the Higgs Boson in more detail.

(2) Initiatives for Formulation of world-leading international research centers

MEXT is enhancing and strengthening the centers that serve as "hubs for international brain circulation," through "World Premier International Research Center Initiative (WPI)," boasting highly internationalized research environments and world-class research levels. Specifically, about 700 million yen is provided to each center for 10 years under meticulous progress management by top scientists in Japan and abroad. Fourteen centers were active as of the end of FY2021 (https://www.jsps.go.jp/j-

1 H-II Transfer Vehicle
2 International Space Station
3 Large Hadron Collider: An experimental project that uses the gigantic circular particle accelerator of the European Organization for Nuclear Research (CERN) to reproduce the conditions of the early universe (immediately after the Big Bang) to discover unknown particles and explore the ultimate internal structure of matter. It is being implemented under international cooperation between CERN Member States and others countries such as Japan and the U.S.
4 High Luminosity-Large Hadron Collider

toplevel/04_saitaku.html). In 2020, a new mission, "Values for the Future" was added and upgraded the existing missions. Under this new mission, WPI research centers will be formulated in a planned and continuous manner.

(3) Other initiatives related to research universities

With the aim of increasing world-class universities and also enhancing universities' research capabilities, the government is implementing the Program for Promoting the Enhancement of Research Universities. Under this program it supports and promotes integrated efforts for securing/utilization of research management personnel, university reform and intensive reform of the research environment, so that the research capacity of the entire country will increase.

The Cabinet Office has been supporting the development for expansion of the Okinawa Institute of Science and Technology Graduate University (OIST) in order for OIST to conduct the world's leading education and research.

❻ Securing research hours

1. Utilization of URAs

It is important to develop not only researchers but also diverse human resources and promote their participation. MEXT has been conducting survey and research on support measures for research administrators in order to improve research environments; to encourage more active research, strengthen R&D management at universities and establish diverse career options for scientists/engineers beyond research positions, for example.

With the aim of increasing world-class research universities, the Program for Promoting the Enhancement of Research Universities has been implemented since FY2013. Under this program, the government supports employment of research management personnel including URAs, as well as intensive reform of research environments of 22 research institutes including universities selected based on quantitative indices so that the research capacity of Japanese universities will increase.

In addition, to further enhance URAs at universities, the utilization of a quality assurance (accreditation) system for URAs was started in FY2021 under the "Implementation of a Quality Assurance System for Management Personnel such as Research Administrators" project (see Chapter 2, Section 2 1 ❷).

2. Accreditation of Partnership on Research Assistance Service (A-PRAS)

In October 2019, MEXT established "A-PRAS" to certify research assistance services provided by private enterprises that meet specific requirements as "research assistance service partnerships." Through the accreditation of research assistance services, MEXT aims to improve research environments, including securing research hours of researchers, accelerating the promotion of science and technology and innovation creation in Japan, and supporting the development of various initiatives related to research assistance services. Nine services have been accredited as of FY 2020. A survey was conducted in FY 2021 to promote the utilization of accredited services and their spread.

Accreditation of Partnership on Research Assistance Service
https://www.mext.go.jp/a_menu/kagaku/kihon/1422215_00001.htm

3. Simplification and digitalization of university administrative procedures

MEXT has required universities, technical colleges and inter-university research institutes to adopt flexible measures to simplify and digitalize administrative procedures, such as permitting electronic procedures in accordance with the wishes of teachers, etc., who apply under open recruitment. In June 2021, MEXT began encouraging universities, etc. to consider flexible measures from the perspective of reducing the burden on applicants in preparing documents for job openings, such as permitting applicants the use of documents like resumes and achievements list prepared in formats other than those designated by each institution as applications. Since then, it has repeatedly been disseminating such measures at meetings for academic affairs staff at each research institution.

4. Unification and simplification of rules related to administrative procedures for competitive research funds

In order to secure research hours of researchers by reducing their office work and ensure effective and efficient use of research funds, the entire government is working on system improvement with the aim of improving usability of research funds. Projects that use the existing competitive funds and other projects that use open-type funds will be integrated under "competitive research funds," and the rules on the use of competitive funds that have been unified and simplified will be expanded to cover other research funds in addition to competitive funds. The government will unify application formats that were designated separately by individual programs and enable application using the unified format through the cross-ministerial R&D management system (e-Rad).

❼ Promotion of humanities and social sciences and creation of the Convergence Knowledge

KAKENHI, which are available through MEXT and the JSPS, are the only competitive research funds provided for all academic research in any field, from the humanities and social sciences to the natural sciences. KAKENHI grants have been supporting diverse, creative research, broadening the base of various research activities, continually advancing research, and generating profound knowledge.

In 2020, MEXT launched the "Project for the Co-Creation of Academic Knowledge centered on the Humanities and Social Science", through which initiatives are being implemented to build an environment in which researchers in the human and social science fields play a central role to create research subjects and research teams under the various issues that will be faced by future society ((1) Society and humanity in the face of future demographics, (2) Overcoming Divided Society, and (3) Creation of values that will shape a new human society), pooling their knowledge and expertise with various stakeholders that include industry and civil society in addition to researchers in the natural science fields.

In addition, under the "Topic-Setting Program to Advance Cutting-Edge Humanities and Social Sciences Research," JSPS began promoting research through the "Academic Knowledge Co-Creation Program" in FY2021 to pursue essential and fundamental questions unique to the humanities and social sciences, based on the summary of the deliberations of the Special Committee on Humanities and Social Sciences of the Subdivision on Science, CST.

MEXT has been implementing the Program for Promoting 'Science for Policy' in Science, Technology and Innovation Policy (SciREX Program), with the aim of realizing STI

policymaking through a reasonable process based on objective grounds (evidence). This project provides support to centers (universities) that foster researchers for the scientific advancement of STI policies and human resources to support the making of these policies, and is building a mechanism to link these centers via a network, enabling systematic human resource development throughout Japan. Centered around these centers, MEXT is promoting research projects in which administrative officials and researchers collaborate on policy research and analysis from the topic-setting stage.

The Cabinet Office has considered the basic concept of "Convergence Knowledge" that contributes to a comprehensive understanding of human beings and society and solving of issues, as well as strategic promotion measures, and compiled them in an interim report (see Chapter 2, Section 1 6 ❶).

Since FY2021, the first year of the 6th Basic Plan, MEXT's NISTEP has included questions related to convergence knowledge in the NISTEP REPORT, which is implemented annually in conjunction with the Basic Plan, in order to monitor changes in awareness regarding Convergence Knowledge.

❽ Comprehensive reform of the competitive research funds system

The competitive research fund system is a core research-fund system for the establishment of a competitive research environment and the consistent development of and ongoing commitment to researchers in various creative R&D activities. Efforts have been made to reserve budgets and improve the system (635.3 billion yen for FY2021 initial budget).

To strengthen Japan's research capacities and based on the "Integrated Innovation Strategy 2019" (Cabinet decision of June 21, 2019) and "Integrated Innovation Strategy 2020" (Cabinet decision of July 17, 2020), from FY 2020 onward, the direct expenses of competitive research funds can be used to pay for expenses related to outsourcing of non-research work to secure research hours of researchers. The financial resources secured by paying personnel expenses to research representatives from the direct expenses of competitive research funds can be utilized by research institutions to improve their research capacities.

In addition, the ministry is promoting appropriate payment of research assistant costs involving doctoral students from competitive research funds in order to improve treatment of doctoral students. (See Chapter 2, Section 2, 1 ❶.)

To reduce office work on researchers to secure their time for research, the existing "competitive funds" and funds for open-type projects are integrated as "competitive research funds," and initiatives are being taken to improve, simplify, digitalize and speed up various office administrative procedures under a unified rule (See Chapter 2, Section 2, 1 ❻.). At the same time, the treatment of indirect expenses in competitive research funds, including the ratio to direct expenses, etc., shall be unified, and simplification of use reports and documentary evidence shall be implemented from FY 2022. In order to ensure the fair, transparent and high-quality examination and evaluation of research proposals, the government ensures diversity in the age, gender and affiliation of examiners. It also aims to eliminate stakeholders, to develop an examiner-evaluation system, to specify methods and criteria for examination and adoption and to disclose examination results.

For example, the examination of KAKENHI applications is conducted via a process of peer

review by more than 8,000 examiners. JSPS selects examiners from the examiner candidate database (about 136,000 researchers as of FY2020) by taking into account the balance among research institutions and the aggressive promotion of young and female researchers. Disclosure of examination results to the applicants has been improved in order. In addition to numerical information such as a rough ranking of all unsuccessful research applications and the average score of each evaluation element, detailed items in each evaluation element that examiners have judged as being inadequate are disclosed through the Electronic Application System for KAKENHI to give the applicants a more detailed evaluation of the results.

Concerning measures to prevent the inappropriate use of competitive funds and other public research funds, guidelines have been formulated, which include the Measures to Prevent the Inappropriate Use of Research Funds CSTP), August 31, 2006 and the Guidelines for Management and Audit of Public Research Funds at Research Institutions (Implementation Standards) (Decision of the MEXT on February 15, 2007: "The Guidelines"). While conducting thorough monitoring including investigation of the research institution's system for abuse prevention, MEXT has urged them to establish an adequate system for their management and auditing of public research funds by providing guidance and taking measures for improvement if necessary. In addition, MEXT revised the Guidelines in February 2021 and is working to prevent the abuse of public research funds by reinforcing more effective initiatives toward an organizational culture that prevents abuse based on the strengthening of governance, enlightenment activities and a system to prevent abuse.

＜Reference URL＞
Competitive Research Funds System
https://www8.cao.go.jp/cstp/compefund/

2 Construction of a new research system (promotion of open science and data-driven research, etc.)

These days, data-driven research methods utilizing simulations and AI are expanding as it becomes easier to collect and analyze various data, such as big data. This can be attributed to the digitalization of the whole society and the global trend toward open science, which requires the digital transformation of research itself (Research DX). Furthermore, the progress of Research DX is accelerating worldwide in the wake of the COVID-19 pandemic. In Japan, the government is working to build a research system toward the realization of a new society brought about by Research DX, such as promoting the management and utilization of research data, which is an important keyword, and developing infrastructure to support Research DX.

❶ Developing an environment to promote appropriate management and utilization of reliable research data

Research data generated through various research activities are considered to be important intellectual assets not only for Japan but also for the world. On the other hand, since some data contains important information, securing industrial competitiveness or scientific and technological superiority, it is crucial to implement management and utilization of research data based on open-and-close strategies to consider both

international contributions and national interests. Based on the above, the "Basic Concept on Management and Utilization of Research Data with Public Funds" (decided by the Integrated Innovation Strategy Promotion Council on April 27, 2021) was established as a national policy of Japan, and improvements to the research environment are underway, including the building of a field and institution database and a research data infrastructure for appropriate and efficient data linkage.

The National Institute of Informatics (NII) provides various services to users and appropriately manages and stores academic information necessary for innovation creation. In 2021, NII began operating the NII RDC, a cloud-based system to facilitate the management, sharing, publication and retrieval of research data for shared use by universities and other research institutions to promote the management and utilization of research data. The NII RDC consists of three platforms, contributing to the promotion of effective and efficient research activities: a research data management platform (GakuNin RDM), a cloud-based institutional repository environment provision service (JAIRO Cloud), and a centralized, searchable database of research data and other academic information (CiNii Research).

Based on the policy for handling research results aimed at improving the research environment for promoting open science, JST encourages all research publications resulting from research projects to be made publicly available in principle and the creation of a data management plan that stipulates the appropriate handling of research data. In addition, JST is working to improve the research environment at research sites through the implementation of J-GLOBAL, an easy-to-use public service that systematically creates databases and links basic information on literature, patents, researchers and R&D activities related to science and technology in Japan and overseas, JDream III, a literature information service that supports specialists by providing a comprehensive, searchable database in Japanese of bibliographies, abstracts, keywords, etc., related to science and technology literature in Japan and overseas, with added value that enables analysis and visualization of the search set, and J-STAGE[1], a shared system environment that publishes electronic journals of academic papers by academic societies themselves, and researchmap, which centrally accumulates information on researchers in Japan, manages research achievement information, and builds a database of researchers to support the creation of a comprehensive list of researchers in universities. Furthermore, the National Bioscience Database Center of JST has been contributing to the promotion of open science by implementing the "Life Science Database Integration Coordination Program," expanding a shared portal site that allows centralized access to life science databases held by MEXT, MHLW, MAFF and METI, in collaboration with AMED, etc.

MAFF has been creating and providing databases on information regarding literature on agriculture, forestry and fisheries as well as on the whereabouts of literature, including the bibliographic database (Japanese Agricultural Sciences Index (JASI[2])) on papers published in Japanese science journals related to agriculture, forestry and fisheries. MAFF is also creating and offering databases on digitized full-text information regarding research papers published by independent administrative institutions

1 Japan Science and Technology information Aggregator, Electronic
2 Japanese Agricultural Sciences Index

specializing in R&D, national/public R&D institutions and universities. These cover topics related to agriculture, forestry and fisheries; and topics of ongoing research conducted at R&D institutions.

MOE is collecting, managing and providing information on natural environments and biodiversity throughout Japan by means of the Japan Integrated Biodiversity Information System (J-IBIS[1]).

RIKEN, NIMS and NIED have been working to create new value by accumulating an enormous quantity of high-quality research data in a manner easy to use in the fields of life science, materials and disaster prevention: areas where Japan can use its strength, and by sharing and analyzing the data in industry, academia and governments.

AMED announced a data sharing policy for genomic medicine realization projects toward overcoming diseases and mandated data sharing in research projects in principle.

JSPS presented the direction of efforts pertaining to open access and is promoting open access to papers using KAKENHI etc.

COLUMN 2-13

Science, Technology and Innovation White Paper Search

The National Institute of Science and Technology Policy (NISTEP) of MEXT has built an online search system for all contents of the White Paper on Science, Technology and Innovation (known as "White Paper on Science and Technology" until the 2020 edition) published to date and made them available on its website[1].

This white paper was first published in 1958 and has been published annually since 1964, accumulating major information on trends in science and technology and the government's science and technology policy. To ensure that this valuable source of information is fully utilized, the system not only allows users to search the text of each year's edition of the White Paper but is also provided with a function to specify and search for White Papers from multiple years. In addition, the White Paper includes a section (Part 2 in recent White Papers) that summarizes the government's policies for each fiscal year concerning the promotion of science and technology, and searches can be limited to this section or words or phrases within a chart. Furthermore, in addition to exact matches for a specified keyword, the system also allows for "ambiguous search" using synonyms. This feature reduces search omissions and allows users to search using similar words that come to mind, even if the exact keyword is unknown.

The system is also equipped with several analytical tools. "Word Frequency Analysis" displays the number of times a specified keyword appears in text with a bar graph by year, allowing the user to see how the keyword's use has changed over time.

"Keyword Map" is a function for visualizing and understanding the target text and displays keywords of high importance in a map (word cloud format). For example, if a user specifies "_____ (YYYY) edition," they can see what words and phrases were used frequently in that year's edition of the White Paper. Users can also specify a specific keyword and displays a group of associated keywords as a map. As an example, the maps below compare two editions of the White Paper for the specified keyword "renewable energy." Concerning individual technologies, geothermal power generation and storage batteries are the top associated words in the 2016 edition, while low carbonization and biomass are highlighted in the 2021 edition.

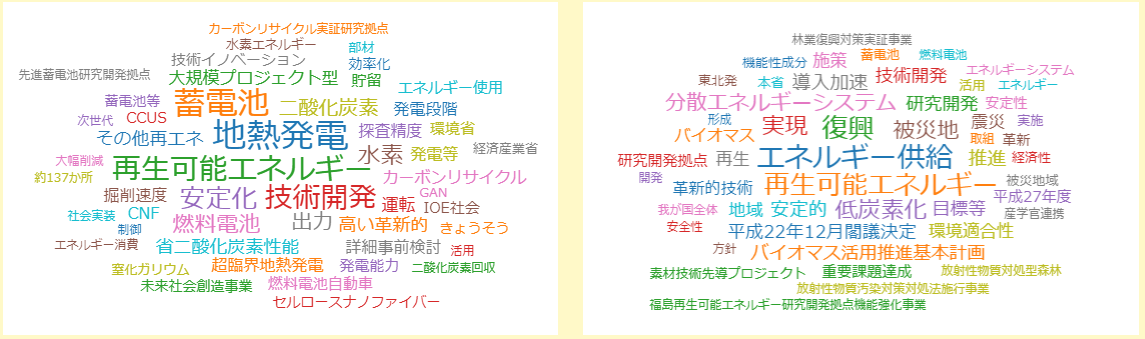
"Related Documents Time Series Analysis" is a tool for analyzing the changes to descriptions of a topic of interest. It automatically extracts items and sections relevant to the user-specified item or section in a White Paper and plots the relationship between these documents in chronological order. This makes it possible, for example, to examine the progress of a specific policy over time and thus can be used as a tool for analyzing policies related to science and technology.

In addition to "Science, Technology and Innovation White Paper Search," NISTEP's Data and Information Infrastructure webpage[2] offers a "Science and Technology Basic Policy Document Search" for basic policy documents related to S&T, with the same search and analysis functions. These are expected to be used in policymaking, policy research and research on the scientific history, as well as in public discussions on science and technology.

1 Japan Integrated Biodiversity Information System

1 https://whitepaper-search.nistep.go.jp/

2 https://www.nistep.go.jp/research/scisip/data-and-information-infrastructure



(Figure) Output results of Keyword Map for the specified keyword “renewable energy”
(Left: 2016 edition, right: 2021 edition)

❷ Developing infrastructure to spur Research DX for research outcome with high impacts

The government has been working on acceleration of Research DX by setting up and maintaining the world’s best research infrastructure: networks, data infrastructure and computation resources. In addition to this, for the research to be carried out beyond the constraints of time and distance, the spread of smart laboratories that enable remote research and automation of experiments. It also promotes the implementation of cutting-edge research that is data-driven and AI-driven and research based on information science and technology to support these new research methods.

1. Development and operation of SINET

NII has developed and operates the Science Information NETwork (SINET) as the primary network to support all academic research and educational activities of universities and research institutions. From FY 2022, the network will begin operating in all prefectures at 400 Gbps [1] (200 Gbps in Okinawa). Also, to facilitate the global exchange of research information required for international advanced research projects, NII has been promoting collaboration with several overseas research networks in the U.S., Europe, etc. and is continuing to take measures to strengthen security in cooperation with national universities and other organizations.

2. Promotion of development/sharing of research facilities/equipment and their networking

As infrastructure to promote S&T, research facilities and equipment support a vast range of R&D; thus, they need to be further advanced and

1 Giga bit per second: Bit per second (bps) is a unit of data transmission speed and indicates how many bits of data can be transmitted per second. 1 Gbps is capable of transmitting 1 billion bits (1 gigabit) of data per second.

used more efficiently and effectively. The Act on Vitalizing the Creation of Science, Technology, and Innovation (Act No. 63, 2008) stipulates that the government shall take necessary measures to promote the shared use of R&D infrastructure facilities and equipment as well as intellectual infrastructure owned by national universities and R&D agencies.

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 of these facilities and equipment so that they will be available more conveniently in a mutually complementary manner and will be able to respond to emergencies.

(1) Specified Large-Scale High-Technology Research Facilities

The Act on the Promotion of Shared Use of Specified Large-Scale High-Technology Research Facilities (Act No. 78, 1994) (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.

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

SPring-8 [1] is a research infrastructure 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. The service commencement in 1997, this facility has been contributing to innovative R&D in various fields of research from life science to environment/energy and new materials development which help boost Japan's economic growth.

Super Photon ring-8 GeV (SPring-8) and
an X-ray free-electron laser facility (SACLA)
Source: RIKEN

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

SACLA [2] is the most advanced research infrastructure facility in the world with respect to the generation of x-ray laser. The unprecedented light generated there has both laser and synchrotron radiation characteristics and allows instantaneous measurement and analysis of ultra-high-speed movements/changes in atomic-level hyperfine structures and chemical reactions. SACLA has been in use since March 2012. In FY2017 simultaneous operation of two hard x-ray free electron laser beam lines by switching the paths of the electric beams[3] started for the first time in the world. Its usage environment has been also steadily improved toward creation of further creation of high-impact results.

(c) Supercomputer "Fugaku"

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

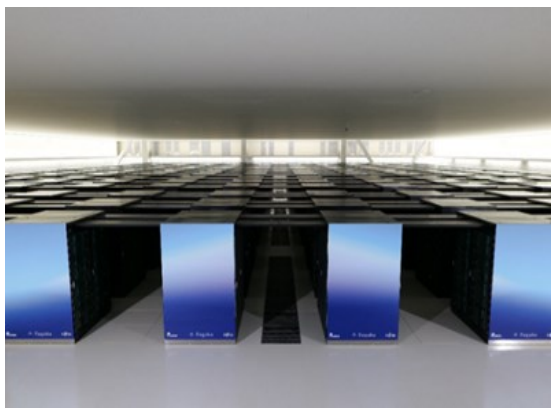
1 Super Photon ring-8 GeV
2 SPring-8 Angstrom Compact free electron LAser
3 Multiple beam lines can be used simultaneously by switching the paths of the electric beam from the linear accelerator pulse-by-pulse.

competitiveness. Development of the supercomputer Fugaku began in FY 2014 as the successor to the K computer (September 2012 - August 2019) to contribute to solving the social and scientific issues facing Japan. The supercomputer was developed with the world's highest level of computational performance and versatility through cooperative development (co-design) of systems and applications, and its shared use began in March 2021. Fugaku ranked first in four supercomputer rankings (TOP500, HPCG, HPL-AI and Graph500) announced in November 2021, topping the world rankings for the fourth consecutive term.

Initiatives have also been taken to expand the user base and develop an environment that facilitates the use of supercomputers so that groundbreaking results can be produced using Fugaku. In addition to fields where supercomputers have been utilized in the past, such as disaster prevention and mitigation, manufacturing, and energy, the use of supercomputers in new fields, such as AI, was also promoted, producing a wide variety of results.

As a shared computation environment infrastructure, the government has connected supercomputers and data storage facilities at universities and research institutions in Japan, including Fugaku, via SINET to build an Innovative High-performance Computing Infrastructure (HPCI) that meets the needs of diverse users while striving for their effective and efficient operation and promoting the use of supercomputers in diverse fields.

In addition, a subcommittee established under the Information Committee of CST has been studying the ideal state of Japan's computational infrastructure for the post-Fugaku era and has summarized the direction for a research study to be implemented from FY 2022 onward.



Supercomputer Fugaku
Source: RIKEN Center for Computational Science

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

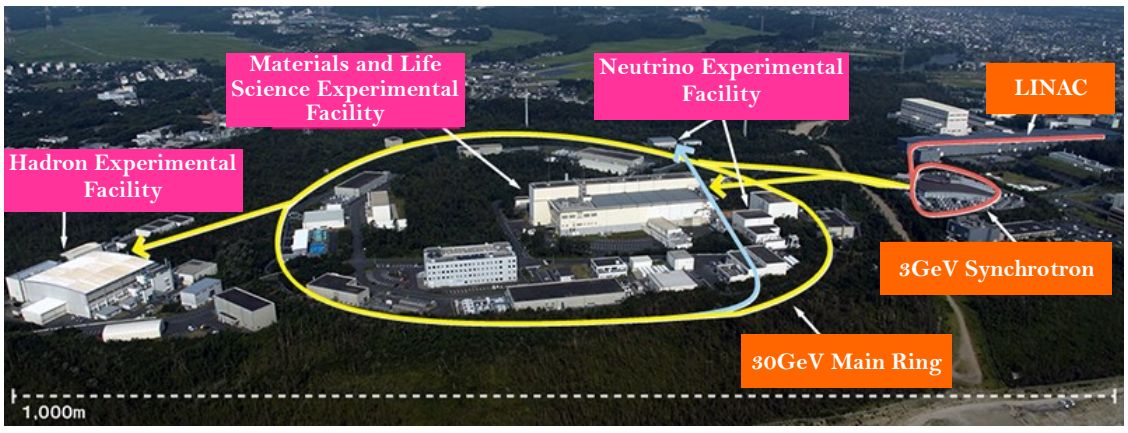
All facilities of J-PARC started operation in FY2009. J-PARC has been contributing to a wide range of R&D including basic research and industrial applications, by using secondary particle beams of neutrons, muons, neutrinos[1] and so on that are generated by its proton accelerator which possesses the highest beam intensity in the world. The Materials and Life Science Experimental Facility (Specific Neutron Beam Facility) has been used for structural analyses which may create 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 Neutrino Experimental Facility, Tokai to Kamioka (T2K) experiments have been conducted with the aim of clarifying the characteristics of neutrino oscillations, following the research of neutrino oscillations that won the 2015 Nobel Prize.

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.

(2) The next-generation synchrotron radiation facility (highly brilliant 3GeV-level radiation light source for soft X-ray)

The next-generation synchrotron radiation facility is a research platform that can visualize not only materials structure in the manner performed by existing facilities but also in the electronic state that influences materials function by using highly brilliant intense soft X-rays that can sensitively observe light elements. Beyond academic research, the facility is expected to be used in a broad range of fields including catalyst chemistry, life science and industrial use of magnetic/spintronics materials and high polymer materials. MEXT will promote the facility in a public-private-regional partnership that designates the National Institutes for Quantum Science and Technology (QST) as the government body responsible for the development and operation of the facility. Furthermore, the ministry selected five private/regional partners: Photon Science Innovation Center (representative,), Miyagi Prefecture, Sendai City, Tohoku University and Tohoku Economic Federation in July 2018. Installation of the particle accelerator and other equipment began in FY 2021, and the construction of the facility is steadily progressing with the aim of starting operation in FY 2023.

Next-generation synchrotron radiation facility (under construction)
Source: Photon Science Innovation Center



Japan Proton Accelerator Research Complex (J-PARC)
Source: J-PARC Center

(3) Constructing a network of research facilities and equipment

(a) Project for promoting public utilization of advanced research infrastructure (Program for advanced research equipment platforms)

With the aim of remote use and automation of the most advanced research facilities and equipment in Japan, MEXT has been advancing initiatives to build a network among research facilities and equipment, which includes their maintenance and operation, to improve convenience through one-stop services and form nationwide platforms with an advanced utilization support system for all researchers.

(4) Strengthening the system for strategically introducing, upgrading and sharing research infrastructure across research institutions

MEXT is promoting initiatives to strengthen the functions of the supervising departments that are responsible for the management of equipment across research institutions. The ministry is also strengthening the system for strategically introducing, upgrading and sharing research facilities and equipment that are being managed by research organizations such as faculties, departments and graduate schools, as research infrastructure for entire research institutions (building core facilities).

In March 2022, the "Guidelines for the Promotion of Shared Use of Research Facilities and Equipment" were established to promote the strategic maintenance and operation of research facilities and equipment at universities and other research institutions.

＜Reference URL＞

○ Project for promoting public utilization of advanced research infrastructure (Program for supporting construction of core facilities)
https://www.jst.go.jp/shincho/program/corefacility.html

3. Promotion of development, sharing and networking of intellectual infrastructure

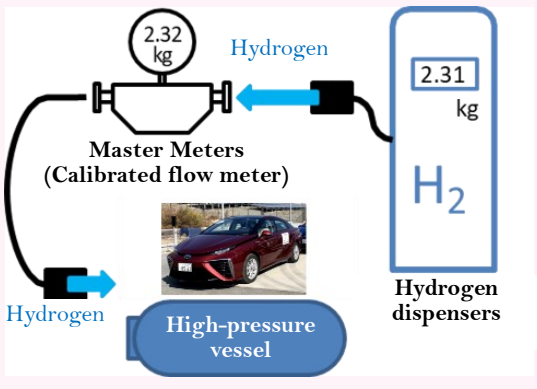
MEXT has established a system for systematically collecting, preserving, and providing bioresources such as animals and plants for research that are important for the strategic development of the national government and the "National Bioresource Project" is being implemented to develop bioresources.

To strengthen Japan's research and development capacity, in May 2021, METI compiled and published the Third Intellectual Infrastructure Development Plan deliberated by the Special Subcommittee on Measurement Standards and Intellectual Infrastructure of the Industrial Structure Council. The progress of each field in the Third Intellectual Infrastructure Development Plan is as follows.

Regarding measurement standards and measurements, the AIST conducted a demonstration test of measurement accuracy inspection equipment using the master meter method for evaluating hydrogen dispensers used in hydrogen stations for contributing to the realization of a green society and contributed to the proposal of the draft revision of JIS B 8576 based on development technology (Figure 2-2-7).

With regard to non-contact thermometry as a measure against SARS-CoV-2 infection, AIST established a manufacturing method for a black body material "dark sheet" having an infrared emissivity of 0.998 or more, and demonstrated that the sheet can be used as a temperature standard with an expansion uncertainty of 0.1 °C. To contribute to safe and effective cancer treatment, the water absorption dose standard was started for high-energy electron beams from medical linear

■ Figure 2-2-7／Measurement accuracy inspection by master meter method



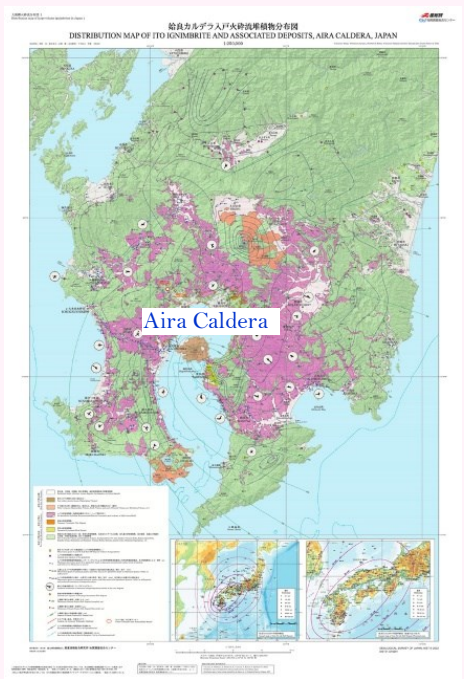
Source: AIST

accelerators and radionuclide actinium 225 radioactivity standard used as radiopharmaceuticals. In addition, for the quick and accurate diagnostics of the integrity of aging infrastructure facilities, AIST developed a dynamic calibration method for small digital output type acceleration sensors used for vibration monitoring of high-rise buildings and succeeded in measuring minute deflection of bridges using aerial drone images. Furthermore, AIST worked on effective and efficient dissemination, enlightenment and human resource development, such as holding online lectures and other events during the COVID-19 pandemic, and enhancing the website contents.

Regarding microorganism genetic resources, NITE has collected, preserved and distributed microorganism genetic resources and has also organized information on these resources in terms of their genes and genetic lineages so as to make the information accessible to the public, including researchers and industry (As of the end of January 2022, 6,596 strains of biological resources had been distributed.). NITE has also constructed cooperative relationships with Asian countries and regions by joining a network of 28 organizations from 15 countries and regions, which aims for the preservation and sustainable use of microbial resources (the ACM, founded in 2004) and has supported Asian countries in their efforts to use microorganism genetic resources through exchange programs according to the Convention on Biological Diversity (CBD) and the Nagoya Protocol.

Regarding geological information, AIST has published 1:50,000 geological maps for three quadrangles ("Toyota," "Kiryu and Ashikaga," and "Wake") and three marine geological maps ("Geological map of the vicinity of Tanegashima," "Geological map of the vicinity of Kumejima Island" and "Sedimentological map of the vicinity of Kumejima Island"), and is updating the 1:200,000 Seamless Digital Geological Map of Japan. In addition, the institution newly released the "3D Urban Geological Map of central Tokyo" as a geological ground map that expresses the underground geology of urban areas in 3D. "Seamless Geoinformation of Coastal Zone 'Coastal Zone of Sagami Bay'" has been released on the web regarding coastal geology. AIST also published a large-scale pyroclastic flow distribution map corresponding to low-frequency large-scale eruption disasters, "Distribution map of Ito Ignimbrite and associated deposits, Aira Caldera" for volcanic geology (Figure 2-2-8). In addition, for the purpose of data integration, the digitization of geoscientific maps has been promoted, and an API[1] for the linked use of some existing databases has been developed and released on "GeoMapNavi," a comprehensive portal system.

■Figure 2-2-8/Distribution map of Ito Ignimbrite and associated deposits, Aira Caldera (abs.)



Source: AIST

1 Application Programming Interface

The Genome Data Infrastructure Project aims to realize individualized prevention and medical care by promoting the development and utilization of the genome data infrastructure and promoting research and development that contributes to the prevention, diagnosis, and treatment of disease onset and severity with an overview of the life stage. In 2021, further data registration and disclosure were made to the database (MGeND[1]) that accumulates and integrates clinical information and genomic information, etc., in MHLW's support project for the clinical genome information database. The Ministry analyzed whole genomes for approximately 13,000 cases through its innovative research project on practical applications of cancer drugs in the area of cancer and intractable diseases, based on the "Action Plan for Whole Genome Analysis." It promoted the construction of basic information and systems for data utilization. In addition, MEXT and Tohoku Medical Mega-Bank Project are further enhancing the genome database, including launching a general public and private joint genome analysis of 10 million people.

4. Research on mathematical and information science and technology

MEXT aims to create new value (mathematical innovation) in resolving social issues by accelerating initiatives such as joint research between mathematics/mathematical science, various sciences, and industry at research institutions such as universities, etc. Since 2017, the ministry has been implementing the "Advanced Innovation powered by Mathematics Platform (AIMaP)" to build a framework to create new value. In 2021, the final year of the project, MEXT summarized the results of cooperation between mathematics and science and industries through the collaboration with various sciences and industries and a network of base offices with the secretarial bases as a hub and actively engaged in the dissemination of the results to society and promotion of exchanges with different fields and industries by hosting the cross-disciplinary and cross-industrial research exchange meeting 2021 special project "Mathematical Interdisciplinary Innovation in Asia- Pacific" (November 2021) and the public symposium "Can Mathematical Innovation Transform Society - AIMaP Achievements and Future Strategic Development -."

As the world enters the With Corona Post-Corona Era, where AI will further advance, and the promotion of DX is required, the meeting of the "Asia-Pacific Mathematical and Interdisciplinary Research Strategy Committee" was held five times in response to the increasing importance of mathematics and mathematical science as the foundation. Measures were discussed in this meeting to promote international brain circulation with advanced human resources in the Asia and Pacific region, mainly in the field of mathematical sciences, to maintain and improve the research capacities of Japan and establish a base that contributes to innovation utilizing mathematical sciences and solving common problems in the region. A report was compiled in July 2021, and recommendations were made regarding forming an industry-academia-government platform to serve as a hub for international brain circulation in the Asia-Pacific region.

In addition, RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program (iTHEMS) aims to comprehensively elucidate various sciences centered on mathematics, theoretical science, and computational science, discover and solve problems in society and create innovation through collaboration with RIKEN

1 Medical genomics Japan Variant Database

SUURI CORPORATION, which was established through a joint investment with the private sector.

To build a new platform using information science and technology and realize the leading cases of Society 5.0, since FY 2018, universities and other institutions with a high level of knowledge, information, technology and human resources have implemented the "MEXT Society 5.0 Realization Research Support Project" aimed at social implementation in cooperation with industry, local governments and other research institutions while integrating various research results with information science and technology as the core.

5. Analysis of changes in research activities by DX

NISTEP of MEXT, as a part of the development of new analytical methods and indicators using DX related to changes in research activities, conducted a field survey on open science, including the disclosure and sharing of research data and the use of preprint, and conducted a comparison over time, survey on the content of preprint servers by field, and a survey on the public status of various research results based on competitive funding in the U.K.

❸ Creation of a new research community and environment pioneered by research DX

The government will promote research activities such as the creation and fusion of knowledge by co-creating with various entities such as local governments, NPOs and NGOs, small and medium-sized enterprises and start-ups, freelance researchers, and citizen participation. In addition, the government will implement the development of an environment that encourages the participation of various entities as a new science, technology, and innovation policy formulation process as a bottom-up approach by industry, academia, and government, such as the launch of citizen science research projects that expect the participation of many citizens by collecting many samples and conducting scientific experiments that cannot be realized by researchers alone (on a scale of 10,000 people, with the assumption that it will start by FY 2022).

JST has been contributing to promote research activities through the creation and fusion of knowledge and to enhance the literacy of science and technology in society, by building opportunities for dialogue and collaboration (co-creation) through the Science Agora and its related activities in collaboration with local governments and universities and networks of various stakeholders named CHANCE. In the session at Science Agora 2021 "Let's create and think of Citizen Science ideas that involve 10000 people!", a study was conducted toward the realization of citizen science involving various people.

3 Promoting university reform and enhancing functions for strategic management

As nodes of diverse knowledge and the largest and most advanced knowledge base, universities are expected to play a leading role in Society 5.0. To successfully survive in a highly uncertain society by utilizing a rich knowledge base, the goal is to form a diverse group of universities by developing individual strengths and clarifying the missions appropriate for each university.

❶ Transformation of national university corporations into truly corporate management

MEXT will review the modalities of the medium-term goals in preparation for the 4th medium-term target period and set out the basic matters concerning the roles and functions that the government as a whole requires of national university corporations in the "National University

Corporation Medium-Term Goals Overview," and each corporation will formulate a draft of its medium-term goals based on it.

In addition, during the 2021 ordinary Diet session, the National University Corporation Act was amended to abolish the annual evaluation system. As a general rule, it was decided to evaluate the work performance of the university over six years. In addition, each national university corporation publishes a report on compliance status with the "Governance Code for National Universities " to fulfill accountability to relevant parties.

❷ Deregulation to support strategic management

"Act to Partially Amend the Act on National University Corporation " (Act No. 41 of May 21, 2021), which was passed in May 2021, eliminated the president's involvement in the university president selection committee and clarified the check-and-balance function of the university president selection committee. In addition, organizational restructuring procedures at national universities have been simplified, starting with projects scheduled to open in FY 2022.

Furthermore, the government is working to promote donations to national university corporations through successive revisions to the tax system and making it easier to understand from the perspective of various stakeholders, making changes to accounting standards of national university corporations, such as abolishing balanced profit and loss accounting and examining the ideal system related to carry-over, including the special purpose reserve funds and making revisions to enable to set aside funds for the replacement and renewal of facilities and equipment.

The Cabinet Office established the "Leaders' Forum on Promoting the Evolution of Academia for Knowledge Society, PEAKS[1]" in May 2019 for university officials, industry and the government to hold specific discussions on management issues and solutions at universities, promoting lateral development of good practices leading to innovation creation, consideration of deregulation, and fostering university management.

❸ Creation of a 10 trillion yen University Endowment Fund

1. Creation of a 10 trillion yen University Endowment Fund

Japan's research capacity has been relatively declining in recent years compared to other countries. One of the reasons is that top universities in Europe and the U.S. have been making substantial investments in research infrastructure and young researchers by utilizing the investment benefits of the fund, which is in the amount of several trillion yen. For this reason, Japan created a 10-trillion-yen University Endowment Fund using national funds to create world-class research universities and started operating the fund in FY 2021.

Based on the discussions at the specialized research meeting of the expert investigation committee of the CSTI[2], Cabinet Office and the Conference on Reform of System for the Realization of World-class Research Universities held by MEXT, the CSTI determined the "Final Summary of Research Universities that Compete with the rest of the World" for the specific system design of the University Endowment Fund on February 1, 2022 On February 25, 2022, based on this final summary, the "Bill for the Act Concerning the Strengthening of the System to Utilize the Research and Research Results of

1 Leaders' Forum on Promoting the Evolution of Academia for Knowledge Society
2 Council for Science, Technology and Innovation

Universities for International Research Excellence" was approved by a Cabinet decision and was passed and enacted by the plenary session of the House of Councilors on May 18, 2022. The bill establishes a system to intensively subsidize universities that have the potential to become world-class research universities and reform themselves from the University Endowment Fund.

Through these initiatives, under the clear vision of the universities, the Universities will radically strengthen their research infrastructure and provide long-term and stable support to young researchers, thereby leading to a significant strengthening of the research capabilities of research universities in Japan.

2. Comprehensive Promotion Package for Regional Core and Distinctive Research Universities

To raise the research capabilities of Japanese universities, it is also important for universities across the country to develop their individual strengths and form diverse groups of research universities under the mission of each university. For this reason, the "Comprehensive Promotion Package for Regional Core and Distinctive Research Universities" was decided in February 2022 to strongly support initiatives to drive social change by fully demonstrating "distinctive strengths" by regional core universities and universities with strengths in specific fields. Through this package, the government aims to improve the overall research capabilities of Japan by building relationships in which diverse universities that exist throughout the country to serve the various functions of Japan can work together with top-level research universities. In the future, it will revise the Package sequentially and examine the necessary support.

❹ Diversification of public funds and governance to support university foundations

1. Public funds to support university foundations

In the FY 2021 budget, 1,079 billion yen was allocated as government subsidies for national university corporations, and efforts were made to enhance education/research, such as securing a substantially higher amount than the previous fiscal year for education/research activities.

Also, regarding the nature of government subsidies for national university corporations during the period of the 4th Medium-term Objectives starting from FY 2022, the government has decided to enhance support for the realization and acceleration of each university's mission and further improve the reform incentives by reviewing the "Performance-Based Allocation with a Focus on Results," based on the deliberation summary of the Expert Panel compiled in June 2021.

2. Realization of world-class research universities

In addition, to realize world-class research universities, MEXT started holding the "Conference on Reform of System for the Realization of World-class Research Universities" in September and December 2021, and a summary of issues was compiled.

3. Development of facilities for national university corporations

Institutions such as national universities serve as a place for developing human resources responsible for the future. They are also important infrastructures to support educational and research activities, including regional revitalization and innovation creation. On the other hand, while all the large-scale facilities built in the 1960s and 1970s are now simultaneously reaching the point of necessity for improvement against aging, as the

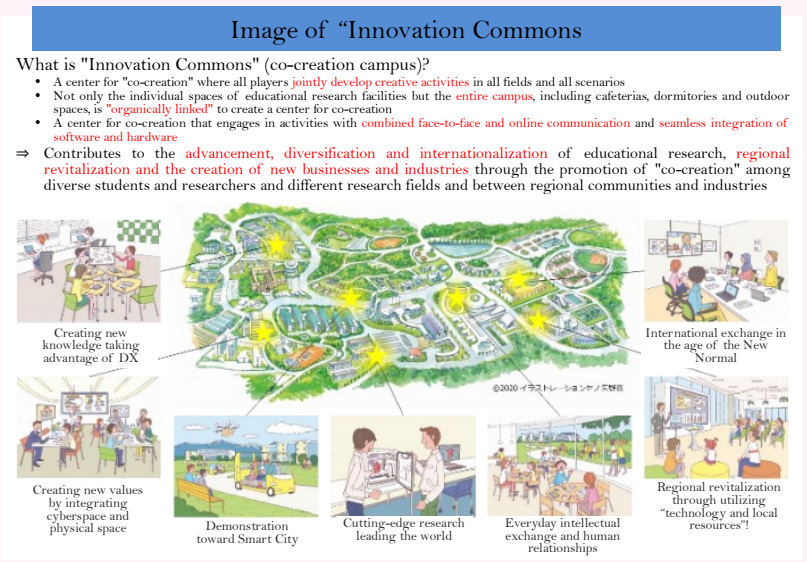
aged facilities have not been sufficiently improved, which is resulting in significant issues in terms of safety and function.

Under these circumstances, MEXT newly announced the " 5th Five-Year Plan for Facilities Development of National University Corporations" from FY 2021 to FY 2025 (March 2021 Decision by the Minister of MEXT on March 31, 2021). Under the plan, while steadily ensuring safety through measures such as the improvement of aging facilities, the entire campus is integrated with software and hardware, aiming at the implementation of "Innovation Commons (Co-creation campus),[1]" where co-creation activities will be carried out by various stakeholders such as the local community and the industrial world (Figure 2-2-9, Figure 2-2-10).

At the "Research Survey Collaborator Meeting on Promotion of Development of Facilities for National University Corporations," which has been held since October 2021 towards the implementation of "Innovation Commons" at each national university, the current situation and issues are sorted based on examples of initiatives for leading co-creation activities and further promotion measures, including government support measures are considered.

In addition, the Plan for Global Warming Countermeasures and Regional Decarbonization Roadmap call for initiatives to take the lead in net zero energy buildings (ZEB) in public facilities to achieve net zero greenhouse gas emissions in 2050. The government has set a goal of ensuring energy efficiency and conservation performance at the level of ZEB standards for newly constructed buildings after FY 2030. For this reason, thorough energy conservation measures are being implemented during new expansion, remodeling and renovation projects at the national university corporations. ZEB is being promoted for facilities that will serve as leading models for other universities and local communities.

■Figure 2-2-9/ Image of "Innovation Commons (co-creation campus)" at National Universities



Source: MEXT

1 Innovation Commons is a campus where students, researchers, industry, local governments, and various other players can gather, interact, hold discussions and create new value through face-to-face and online exchanges in various fields and situations such as education, research, industry-academia collaboration and regional collaboration

■Figure 2-2-10／Image of "Innovation Commons (co-creation campus)" at National Universities

A space for communicating with the community
(Workshop with local residents)

A laboratory that induces interaction between researchers in different fields by visualizing mutual research activities

An active learning space that ensures flexibility with movable partitions and furniture

Source: MEXT

<Related site>
Development of facilities for national university corporations
https://www.mext.go.jp/a_menu/shisetu/kokuritu/index.htm

❺ Strengthening the functions and financial bases of national research and development agencies

The "Act on the General Rules for Incorporated Administrative Agencies" (Act No. 103, 1999) was revised in 2014. This revision led to the promotion of 27 independent administrative agencies to roles as national R&D agencies (as of March 31, 2022), which are expected to facilitate the sound development of the Japanese economy and meet the public interest by making maximum R&D efforts and raising Japan's scientific and technological standards. In addition, the "Act on Special Measures Concerning the Promotion of Research and Development by Designated National Research and Development Agencies" (Act No. 43 of 2016) passed in May 2016. This act promoted three national R&D agencies (NIMS, RIKEN and AIST) to the status of designated national R&D agencies. Their shared mission is to serve as core organizations in promoting the production, popularization and use of world-class R&D accomplishments and to lead R&D innovation in Japan.

In addition, the R&D Capacity Strengthening Act was amended in 2018. The title of the law was changed to the Act on the Promotion of Science, Technology, and Innovation Creation. The amended law expanded the scope of R&D corporations that are allowed to engage in investment and the scope of the businesses subject to their investment, and enabled them to acquire and hold shares of agency-initiated ventures. In June 2020, the act was amended further to expand the scope of R&D corporations that are allowed to invest in businesses using their research outcomes and to specify joint research, etc. and other related things. In addition, in response to this amendment, the Cabinet Office and MEXT amended the "Guidelines for Investment by Research and Development Agencies" (January 17, 2019, decision of the Director General for Science, Technology and Innovation Policy, Cabinet Office, Government of Japan and Director-General, Science and Technology Policy Bureau, MEXT, Japan) in April 2021. These amendments are expected to create an enriched cycle of knowledge, human resources, and funds surrounding National R&D Agencies, and further stimulate science, technology, and innovation creation.

Section 3 Education and Human Resources Fostering to Realize the Well-being of Individuals and the Challenges They Face

The key to realizing Society 5.0 is the human resources responsible for achieving this. For this reason, the 6th Basic Plan emphasizes the importance of abilities and qualities that can be acquired through investigative activities wherein students identify issues and seek solutions themselves with the aim to develop human resources who will pursue diverse happiness and confront challenges by honing and enhancing these abilities and qualities. This white paper describes the measures being taken by the government toward achieving this goal.

❶ Enhancing the development of the ability to inquire by promoting STEAM education

MEXT intends to enhance learning activities to discover problems and solve problems in " Inquiry-Based Study of Science and Mathematics" and " Period for Inquiry-Based Cross-Disciplinary Study" following the new Courses of Study for upper secondary schools, which will be implemented annually from FY2022. Also, as part of its initiatives to enhance science and mathematics education, the ministry continues to assist with the maintenance of facilities such as laboratory equipment for observation and experiments and support for the deployment of scientific observation and experiment assistants based on the Science Education Promotion Act (Act No. 186 of 1953).

MEXT designates high schools that provide advanced science and mathematics education as Super Science High School (SSH). This initiative aims to help students develop scientific abilities and thereby develop human resources for science and technology who can play important roles globally in the future. Specifically, schools designated as SSH are promoting project studies in cooperation with universities, research institutes, etc., developing and using curricula focused on science and mathematics to foster highly creative talents. In FY2021, 218 SSHs throughout the country provided such advanced and specialized education.

Under the Global Science Campus (GSC) program, JST selects and supports universities that develop and implement programs to cultivate high-school students who have desire and talent into international human resources in science and technology. In FY2017, JST started the School to Cultivate Junior Doctors for elementary and junior-high school students with outstanding desire and ability in science and mathematics. In this initiative, universities, etc. provide special education programs to further develop their abilities.

In addition, JST has sponsored preliminary domestic contests for international science and technology contents, such as the International Science Olympiads for mathematics, chemistry, biology, physics, informatics, earth science and geography, and the International Science and Engineering Fair (ISEF), as well as supporting Japanese students' participation in competitions abroad and international competitions held in Japan (Figure 2-2-11).

Figure 2-2-11／Participants in the International Student Contests in Science and Technology (FY2021)

International Mathematical Olympiad (Online/Singapore) Participants

From left

KODAMA Daiki, 1st grade, Nada Senior High School (gold medalist)

SUGAI Ryomei, 3rd grade, Shibuya Education Academy Shibuya Senior High School (gold medalist)

MATSUO Rintaro, 3rd grade, Azabu Senior High School (silver medalist)

WATANABE Yuto, 2nd grade, Shibuya Education Academy Shibuya Senior High School (silver medalist)

Source: International Olympiad in Informatics Japan Committee

International Mathematical Olympiad (Online/Russia) Participants

From back row left

TOKORO Kota, 3rd grade, Senior High School at Komaba, University of Tsukuba (silver medalist)

IMOTO Tasuku, 2nd grade, Azabu Senior High School (bronze medalist)

OKI Yuya, 2nd grade, Nada Senior High School (silver medalist)

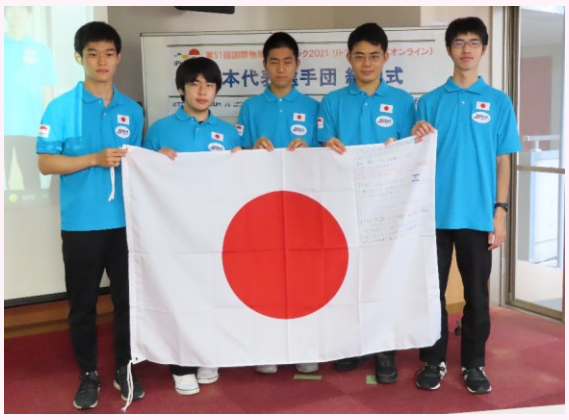
KAMIO Yuhi, 3rd grade, Kaisei High School (gold medalist)

KOBAYASHI Koichiro, 3rd grade, Nada Senior High School (bronze medalist)

YOSHIDA Tomoki, 3rd grade, Todaijigakuen Senior High School (bronze medalist)

Source: The Mathematical Olympiad Foundation of Japan

International Physics Olympiad (Online/ Lithuania) Participants



From left

MURAYAMA Io, 3rd grade, Tokyo Metropolitan Musashi Senior High School (silver medalist)

ITONAGA Taiki, 3rd grade, Kurume University Senior High School (silver medalist)

SATO Souma, 3rd grade, Nada Senior High School (bronze medalist)

AWANO Ryoya, 3rd grade, Senior High School at Komaba, University of Tsukuba (silver medalist)

KUSUMOTO Koki, 3rd grade, Kurume University Senior High School (gold medalist)

Source: The Committee of Japan Physics Olympiad

International Biology Olympiad (Online/Portugal) Participants

From left

YAMAGATA Yusuke, 2nd grade, Tokyo Metropolitan Tama High School of Science and Technology, (bronze medalist)

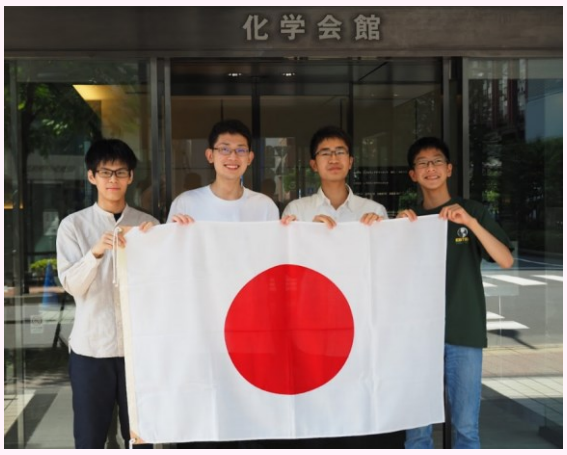
SATO Koki, 3rd grade, Tokyo Metropolitan Musashi Senior High School (bronze medalist)

MURAI Kotaro, 3rd grade, Senior High School at Komaba, University of Tsukuba (silver medalist)

KIRIYAMA Kento, 2nd grade, Tokai High School (bronze medalist)

Source: International Biology Olympiad Japan Committee

International Chemistry Olympiad (Online/Japan) Participants



From left
NISHIURA Kohei, 3 rd grade, Kyoto Prefectural Sonobe High School (silver medalist)
TAKEMOTO Takahiro, 3rd grade, Rakuhoku Senior High School (silver medalist)
KOIKE Yuya, 3rd grade, Nagoya Koyo Senior High School (silver medalist)
ISSE Haruhi, 5th grade, Tokyo Metropolitan Koishikawa High School (bronze medalist)

Source: "Yume-Kagaku 21" Committee, Chemical Society of Japan

International Geography Olympiad (Online/Turkey) Participants

From left
KATAYAMA Taisei, 2nd grade, Senior High School at Komaba, University of Tsukuba (silver medalist)
NAKAMORI Ryo, 3rd grade, Nada Senior High School (gold medalist)
KANAZAWA Masaaki, 3rd grade, Chiben Gakuen Wakayama Senior High School (bronze medalist)
OTOKAWA Bunryu, 3rd grade, Niigata Prefectural Niigata High School (gold medalist)

Source: Japan Committee for International Geography Olympiad

International Earth Science Olympiad (Online)

From left
SON Humitaka, 2nd grade, Senior High School at Komaba, University of Tsukuba (Excellent rating (equivalent to gold medal))
INOUE Shinichi, 2nd grade, Nada Senior High School (Good rating (equivalent to silver medal))
SATO Hiroyasu, 2nd grade, Sakae Higashi Senior High School (Very Good rating (equivalent to silver medal))
IWASAKI Noe, 3rd grade, Kobe College Senior High School (Very Good rating (equivalent to silver medal))

Source: Japan Earth Science Olympiad Committee
(Non-profit organization)

* Note: The schools and grades are as of when the award was won.

In FY 2021, the "9th Japan Junior High School Science Championships" (December 3, 2021) was held at venues in each prefecture and involved teams of junior high school students from across the country competing against each other in comprehensive written and practical skills in science and mathematics. The Tokyo team won the championship (Figure 2-2-12). In addition, the "11th Japan High School Science Championships" for high school students (March 19, 2022) was held in each prefecture, with the Tokyo team from Senior High School at Komaba, University of Tsukuba, winning the championship (Figure 2-2-13).

■Figure 2-2-12／The 9th Japan Junior High School Science Championships

Winning team: Tokyo team

From left
KI Shinobu, 2nd grade, Tokyo Metropolitan Koishikawa Secondary Education School
NAKAJIMA Mizuki, 2nd grade, Tokyo Metropolitan Koishikawa Secondary Education School
KAMEDA Sota, 2nd grade, Tokyo Metropolitan Koishikawa Secondary Education School
SUZUKI Haruto, 2nd grade, Junior High School at Komaba, University of Tsukuba
SUGANO Kosuke, 2nd grade, Junior High School at Komaba, University of Tsukuba
KURAUCHI Minato, 2nd grade, Junior High School at Komaba, University of Tsukuba

Source: Japan Science and Technology Agency
* Note: The grades are as of when the award was won.

■Figure 2-2-13／The 11th Japan High School Science Championships

Winning team: Tokyo team
Senior High School at Komaba, University of Tsukuba

From front row left
NATE Koichiro, 2nd grade, Senior High School at Komaba, University of Tsukuba
SON Humitaka, 2nd grade, Senior High School at Komaba, University of Tsukuba
From middle row left
OYAMA Hiroto, 2nd grade, Senior High School at Komaba, University of Tsukuba
KOHARA Yutaro, 2nd grade, Senior High School at Komaba, University of Tsukuba
From back row left
SUGAE Takanori, 2nd grade, Senior High School at Komaba, University of Tsukuba
ASAI Yuki, 2nd grade, Senior High School at Komaba, University of Tsukuba
KASAI Ryo, 2nd grade, Senior High School at Komaba, University of Tsukuba
SHINGU Kensuke, 2nd grade, Senior High School at Komaba, University of Tsukuba

Source: Japan Science and Technology Agency
* Note: The grades are as of when the award was won.

MEXT hosted the "Science Conference" to improve the research capacities and motivation of university students and for the development of human resources who are highly creative in science and technology. In addition to publishing videos of presentations and posters of independent research on the portal site, an online event consisting of lectures by researchers, research presentations by winners of scientific contests, talk sessions, and opinion exchange sessions was held.

MEXT, JPO, the Japan Patent Attorneys Association, and the National Center for Industrial Property Information and Training (INPIT) jointly host the Patent Contests and Design Patent Contests for students at high schools, colleges of technology and universities. Students participating in these contests are rewarded for inventions and designs and are given support when they apply for a patent or design. MEXT honors the schools of the participating students, which made active efforts for these contests to enhance the Intellectual Property Mind of students or deepen their understanding of the IP system.

The Cabinet Office, Government of Japan, has set up an expert panel in CSTI with the participation of the members of the Central Council for Education to study specific cross-ministerial measures for the enhancement of STEAM[1] education as a source of innovation, and formulated a policy package.

❷ Participation and utilization of external human resources and other resources in learning

MEXT has been implementing the " Project for Reform of High School Education through Regional Collaboration" to promote initiatives by high schools for the realization of inquiry-based learning, such as solving regional issues, in collaboration with local governments, higher education institutions and industry, and held a national summit to disseminate the results of this project.

In May 2021, the "Guidelines for the Examination of Educational Personnel for Special Certificates" were revised to encourage prefectural Boards of Education to utilize special certificates. The Central Council for Education is examining special certificates and the special part-time teacher system since they need to further function as a double-track recruitment route from the perspective of building a group of high-quality teaching staff with diverse expertise for the realization of "Japanese Style School Education in Reiwa."

❸ Promotion of DX in the education field

Development of the ICT[2] environment based on the GIGA[3] School Concept has been generally completed, and new learning has begun under a "one terminal per person" environment.

A leaflet containing examples of such support in the field of education was distributed to promote the placement of "ICT supporters (Information and communication technology support staff)" who provide support for the utilization of ICT by teachers at each school, and the Partial Revision of the Ordinance for Enforcement of the School Education Act was promulgated and enforced on August 23, 2021, to clarify the job titles and descriptions as ICT support staff.

In addition, MEXT published and disseminated a guidebook that provides teaching models and training curriculum for conducting lessons using external human resources to promote the utilization of external human resources in high

1 Science, Technology, Engineering, Art(s) and Mathematics
2 Information and Communication Technology
3 Global and Innovation Gateway for All

school information science courses.

In 2020, MEXT published the "Curriculum Standards Code" and "School Code" as the 1st edition of the "Educational Data Standards" from the perspective of promoting data standardization for the effective use of educational data. In December 2021, the ministry mainly defined "Subject Information," which has been universally utilized in schools based on the previous system and published it as the "Educational Data Standards" (2nd edition).

Since FY2018, regional financial measures have been implemented to introduce an integrated school affair support system that can reduce the workload on teachers in public schools throughout Japan, and the percentage of implementation has steadily increased from 52.5% in March 2018 to 73.5% as of March 2021. Since the establishment of "one terminal per person" under the GIGA School Concept, the utilization of ICT equipment and systems in school affairs have been changing. In December 2021, the "Expert Panel on the Informatization of School Affairs in the GIGA School Program" meeting was held to study the future approach regarding the informatization of school affairs.

❹ Promotion of mobility of human resources and enhancement of learning for career changes and career advancement

In FY2022, MHLW and MEXT are preparing to implement functional collaboration between "job tag," an occupational information providing website (Japanese version of O-NET) (hereinafter referred to as "job tag") and "ManaPass," a website that introduces programs for working adults at universities. In FY2021, links were added to some of the regular courses and certificate programs listed on ManaPass to the occupational information on the "job tag" from "ManaPass" (as of March 2022).

MEXT is promoting efforts for practical education in engineering at universities. Universities are working to achieve qualitative enhancement of education content and method, which include: learning through problem solving using problems at partner companies, and education merging disciplines based on the industrial/social structure. In addition, MEXT has established the "Professional Engineer System" that grants the qualification of "Professional Engineer" to those who perform planning, designing, etc., with a high level of applied skill related to science and technology. The Professional Engineer Examination is divided into the First-Step Examination, which is given to determine whether the examinee has the expertise expected of a university graduate in science or engineering (5,313 successful candidates in FY2021) and the Second-Step Examination, which is given to determine whether the examinee has the high level of applied skill required of a professional engineer (2,659 successful candidates in FY2021). Data on candidates who passed the Second-Step Examination in FY2021 in each technical discipline are shown in Table 2-2-14.

■ Figure 2-2-14／Breakdown of successful candidates of the Second-Step Professional Engineer Examination by Technical Discipline (FY2021)

Technical discipline	No. of candidates (people)	No. of successful candidates (people)	Pass rate (%)
Mechanical Engineering	871	121	13.9
Marine & Ocean	12	3	25.0
Aerospace	35	5	14.3
Electrical & Electronics Engineering	1,077	108	10.0
Chemistry	134	24	17.9
Fiber & Textiles	39	10	25.6
Metals	72	19	26.4
Mining	24	3	12.5
Civil Engineering	13,311	1,384	10.4
Water Supply & Sewerage	1,399	185	13.2
Environmental Engineering	499	51	10.2

Technical discipline	No. of candidates (people)	No. of successful candidates (people)	Pass rate (%)
Agriculture	702	80	11.4
Forest	259	59	22.8
Fisheries	107	11	10.3
Industrial Engineering	210	16	7.6
Information Engineering	373	29	7.8
Applied Science	544	92	16.9
Biotechnology & Bioengineering	27	5	18.5
Environment	411	48	11.7
Nuclear & Radiation	55	8	14.5
Engineering Management	2,742	398	14.5

Source: MEXT

To aid engineers in acquiring a broader range of basic knowledge about science and technology, the JST provides online self-study materials [1] on common science and technology topics and specific science and technology disciplines.

MEXT and the METI have been promoting the introduction of cross-appointment systems to increase the mobility of human resources (see Chapter 2, Section 1 4 ❺). The cross-appointment system is also promoted in the "Guideline for Enhancing Industry-Academia-Government Collaboration Activities," formulated in November 2016, the supplemental version compiled in June 2020, and FAQs published in March 2022.

❺ Fostering an environment and culture in which society and companies promote continuous learning

Due to the lengthening of professional life, the diversification of working styles, and changes in the industrial structure, such as digitalization, there is an increasing need to promote recurrent education to help individuals in career advancement or career change. In this respect, necessary measures such as promoting the development of human resources initiatives in companies and improving recurrent education programs in educational institutions must be taken from a wide range of perspectives. Therefore, the Cabinet Office, Government of Japan, MEXT, MHLW and METI have set up a forum to jointly study and share information on the development of human resources measures with relevant

1 https://jrecin.jst.go.jp/

ministries and agencies.

In addition to the number of working adults enrolled in recurrent education, MEXT has decided to develop indicators to evaluate the educational effects and social impact of recurrent education to increase social momentum for promoting recurrent education, and is promoting their consideration in cooperation with relevant ministries and agencies, based on the initiatives and results of commissioned projects related to the promotion of recurrent education, while considering opinions from the educational and industrial fields.

❻ Provision of diverse curricula and programs at universities and colleges of technology

The "Governance Code for National Universities " requires each national university corporation to disclose information that indicates the educational outcomes that students have enjoyed.

MEXT has been implementing the Program for "Human Resource Development Project for Supporting Knowledge-Based Society" to support the development of human resources possessing both broad education and deep expertise and capable of flexibly responding to new changes and developments in society and academia in the future while establishing university-wide education management, etc. In FY2021, the ministry continued to support the initiatives of universities to construct educational programs to realize a wide range of education across the humanities and sciences, as well as educational programs that bring out the best in students. Three projects aimed at realizing the high quality and density of learning through the refinement of subjects were adopted after inviting applications. In order to cultivate excellent doctoral talents and build first-rate centers for sustainable activities for human resource development/exchange and new joint research, the Doctoral Program for World-leading Innovative & Smart Education (WISE Program) started in FY2018. The program supports development of 5-year integrated doctoral programs by universities based on their strengths, utilizing the results of the reform of their graduate schools in organized coordination with other universities, research institutes, and private companies, etc. at home and abroad. 30 programs of 17 universities were adopted by FY2020.

Furthermore, the "Act to Partially Amend the Act on National University Corporation , enacted in May 2021, enables all national university corporations to invest in businesses that provide consulting, training, and seminars utilizing university research results.

College of technology is characterized by 5-year integrated professional and practical engineering education after graduation from junior high school. MEXT is promoting the development of engineers through initiatives such as strengthening collaboration with other fields, education based on social needs, and improving the ability of engineers to play an active role overseas.

❼ Co-creation of knowledge and strengthening of science and technology communication through the participation of various actors, such as citizen participation

1. Efforts by public organizations

In conjunction with Science & Technology Week (April 12-18, 2021), MEXT distributed the annual S&T poster for everyone "One S&T Poster for Every Household The Ocean: its Diverse Worlds" to elementary, junior and senior high schools, science museums and other museums throughout Japan to deepen interest in science and technology among adults and children alike. A

dedicated website was set up to explain the various events and issues related to oceans introduced in the paper, and initiatives were implemented to enhance learning further. In addition, the annual S&T poster for everyone "One S&T Poster for Every Household- Glass: The Most Universal Modern Material" was published in March 2022.

MAFF conducts outreach activities including: dispatching researchers and other experts for consumers etc. to give lessons on R&D of state-of-the-art technologies, holding study tours of genome editing research facilities for consumers etc. and; disseminating information through websites. The National Research and Development Agencies under MAFF open their facilities to the public and provide lectures, helping to raise awareness by facilitating interactive communication with the public about their research activities and exhibiting research results.

JAXA provides various educational activities in space science, such as the Cosmic College, and lecturers to schools and seminars.

RIKEN publishes booklets and releases animated videos on its website in order to enable a broader range of people to understand the latest science research. Additionally, RIKEN recommends "100 Science Books" for junior and senior high schools and public libraries to get children interested in science.

NIMS is active in introducing its research to the public, particularly to young students who might become scientists in the future. For this purpose, NIMS has a video site titled *Material's Eye* that showcases the mysteries of various materials. NIMS is devoting great effort to help people develop an understanding of, and an interest in, science.

JAMSTEC conducts outreach activities using online content to promote understanding of R&D and the "Marine Discovery Course" for young people, which aims to expand the base of future marine professionals. Efforts were also made to enhance the public's understanding of the marine environment and deep-sea life through deep-sea exploration, etc., in the "GIGA School Special Lecture."

AIST is actively promoting S&T communication programs including operation of permanent exhibition facilities, participation in virtual and other events, open laboratories and lectures on demand. AIST also creates and publishes videos and web contents to explain the latest research outcomes in an easy-to-understand manner in an effort to communicate research outcomes.

<Reference URL> Video sites of individual organizations

○ RIKEN channel
https://www.youtube.com/rikenenglishchannel

○ NIMS Movie Library
https://www.nims.go.jp/publicity/digital/movie/index.html

○ AIST Video Library
https://www.aist.go.jp/aist_e/video/index.html

Universities and public research institutions make efforts to widely disseminate information on research results to the general public.

The Council for Science, Technology and Innovation (CSTI) encourages researchers who receive annual public research funds of 30 million yen or more for individual research projects to actively communicate with the public regarding the contents and the results of their research activities.

The National Diet Library is working to digitize its collection and convert it into full-text data. It also provides an integrated searchable database (NDL Search) of materials and digital content provided by libraries, academic research institutions and other organizations nationwide to improve access and promote the utilization of knowledge and information resources shared by the public.

<Reference URL>

○ NDL Search https://iss.ndl.go.jp

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Bringing You the Latest from the World of Science, Technology and Innovation: Information Website "Science Portal"

As adults, we are sometimes surprised to find how our fundamental scientific knowledge has changed. For example, in school, we learned that "Plants are organisms that perform photosynthesis" and have come to think of it as general knowledge. However, textbooks say that "Plants evolved from algae" and that algae are not considered plants even though they photosynthesize. Also, the age of the universe, which was believed to be 20 billion or 15 billion years, has been firmly determined to be about 13.8 billion years. The former is the result of re-examining the relationship between different species, while the latter results from our ability to use satellites to study the temperature distribution of space in detail.

In our day-to-day lives, we are keenly aware of the innovative power of smartphones and the changes they have brought to our social life. Such convenient technology results from the steady efforts of countless scientists and engineers. As we learn about various scientific and technological developments, our curiosity for "why" and "how" is aroused, even if we are not experts.

On the other hand, the COVID-19 pandemic has been spreading worldwide since 2020 and diverse information about it has been circulating. The authenticity and interpretation of this information have become an issue, and the state of scientific and technical information is being questioned anew.

For human beings to solve problems and build prosperity in an unpredictable future, everyone needs to live vibrant lives and make the best use of their efforts and wisdom while utilizing science and technology. We must keep ourselves up to date with information and think about it.

Sources of information include books, newspaper reports, broadcast programs, and the internet. One such reliable resource is "Science Portal," an information website operated by JST. It opened in 2006. In addition to science and technology reports, reading material and videos, the website also includes event information and links to press releases and covers a wide range of topics not limited to the activities of JST.

New findings and developments in STI are of great interest at the beginning. They also hold the key to the ideal state of humankind. Rather than leaving them to only the experts, looking at these matters from the citizens' perspective will lead to a mature future society.

Science Portal Homepage https://scienceportal.jst.go.jp/

2. Enhancement of activities conducted by science museums

JST has been promoting multilayered science and technology communication activities such as "Science Agora," an open forum for interactive dialogue and collaboration between various people, and provides science and technology information through the website "Science Portal" to enhance the relationship between STI and society. (see Chapter 2, Section 2 2 ❸). In particular, Miraikan - The National Museum of Emerging Science and Innovation is developing activities with visitors to reflect on the relationship between cutting-edge science and technology, and society. The museum promotes multilayered science and technology communication activities through exhibitions and events that utilize emerging technologies such as IoT [1] and AI, as well as collaboration with local science museums and schools across the country.

The National Museum of Nature and Science as the national center of natural history and S&T history has accumulated intellectual, physical and human resources including research results, specimens and materials. Taking advantage of these resources, the museum holds exhibitions that provide opportunities to expand people's interests in nature and science across generations, encouraging them to think together, and provides educational programs following their various needs. In addition, the museum releases videos of researchers explaining their research activities and exhibitions and disseminates information in a timely manner through various social media.

<Reference URL> National Museum of Nature and Science video site
○ [NMNS] Kahaku channel
https://www.youtube.com/user/NMNSTOKYO

3. Efforts of the Science Council of Japan and academic societies

SCJ holds academic forums as part of its activities to feed outcomes of research back to society. In FY2021, a total of 13 forums were held covering a wide range of topics, including "Novel Coronavirus Vaccine and Infection Mechanism," "Academic Forum on Japan's Academic Policies and Research Capabilities," and "Challenges for Academia Toward Realizing Carbon Neutrality."

The academic societies are voluntary associations organized mainly by researchers at universities and other research institutions. They play important roles in research evaluation, information exchanges and communication beyond those of individual research organizations, and they contribute to the development of academic research through academic research meetings, seminars and symposiums that disseminate the latest results from quality research and academic journals.

Through programs such as the Grants-in-Aid for Publication of JSPS for the Promotion of Science subsidizes international conferences held by academic societies and symposiums, and other undertakings to strengthen international information dissemination.

1 Internet of Things