

Section 2

Reinforcing Technology Base

1 Necessity of Reinforcing Technology Base

As the security environment surrounding Japan becomes increasingly severe, it is necessary to ensure technological superiority by effectively utilizing Japan's advanced technological strength in order to protect the lives and property of Japanese people in any situation. Particularly in recent years, with the rapid advances in technological innovation, it is forecast that we will see the operationalization of so-called game-changing technology that will completely transform combat aspects in the future, and the United States and other countries are proceeding hastily with research and development.

**Q See** Part I, Chapter 3, Section 1 (Trends Concerning Military Science and Technology)

Thus, as a nation, strategically working on ways to ensure technological superiority and ensuring advanced technology base are important from the perspective of creating superior

defense equipment and ensuring Japan's security. Also, the improvement of the technology base is a pressing issue. The state-of-the-art military technologies in each country are sensitive technologies that must not be easily shared with other countries. From the perspective of Japan, for the areas, which should strategically maintain their domestic technology base, it is necessary to promote research and development domestically. In the cases of defense equipment and technology cooperation, such as equipment procurement and international joint development, it is important to maintain the leading role by owning important cutting-edge technology (key technology). This requires not only research and development by the MOD, but also the promotion of research and development by both the public and private sectors together.

**Q See** Fig. IV-2-2-1 (Current Status of Research & Development Expenditure)

2 Defense Technology Strategy and Related Documents

For the purpose of ensuring Japan's technological superiority, inventing as well as delivering advanced equipment in an effective and efficient manner, and dealing with various policy issues pertaining to defense and civilian technologies, taking account of the National Security Strategy and the 2013 NDPG<sup>1</sup>, the MOD formulated the Defense Technology Strategy in 2016, which presented the specific direction for

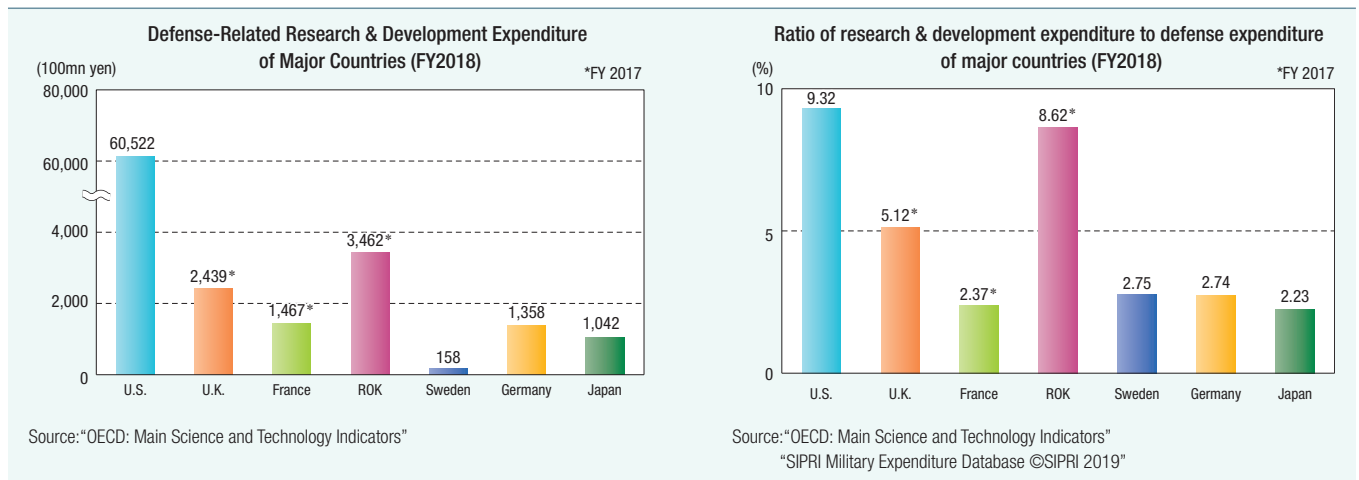
various measures that should be addressed strategically. Based on this strategy, the MOD promotes various measures.

1 1 Defense Technology Strategy

(1) MOD Technology Policy Objectives

The following two objectives of the MOD technology policy

Fig. IV-2-2-1 Current state of R&D spending



<sup>1</sup> See Part II, Chapter 3, Section 1, Footnote 7

are designed to strengthen the technical capabilities, which serve as the foundation of Japan's defense capabilities, to make the foundation more robust:

- (i) Ensuring technical superiority
- (ii) Delivering superior defense equipment through effective and efficient research and development

## (2) Specific Measures to be Promoted

The following three measures are promoted to achieve the objectives indicated in the previous paragraph.

### (i) Grasping Technological Information

With regard to various scientific technologies that support defense technologies, the MOD grasps the current situation and trends both in and outside of Japan, including **dual-use technology** in the public and private sectors and cutting-edge scientific technology. In addition, the MOD develops and publishes the Medium- to Long-Term Defense Technology Outlook (see Paragraph 2 below) to identify advanced technology fields, which have the potential to become **game changers**.

### (ii) Development of Technologies

The MOD formulates the “Research and Development Vision” (see Paragraph 3 below) that promotes medium- to long-term research and development. At the same time, the MOD also promotes research and development that serve as the foundation of defense force building and initiatives such as “Innovative Science & Technology Initiative for Security,” which puts into perspective the identification and development of advanced technology expected to be used for technology exchange with relevant domestic/overseas agencies and defense purposes.

### (iii) Protection of Technologies

The MOD implements technology control for proper technology transfer to prevent situations in which Japan's technology leaks without the country's intention, undermining the maintenance of the peace and security of the international community or ensuring Japan's technological superiority. The MOD also establishes intellectual property management taking into account the transfer of defense equipment and promotes the utilization of intellectual property.

## 2 Medium- to Long-Term Defense Technology Outlook

The Medium- to Long-Term Defense Technology Outlook presents an outlook of the technologies that can be applied to equipment expected to be established in roughly the next 20 years, and indicates technology fields that need to be developed in order to ensure Japan's technological superiority. It is expected that making this Outlook public

## 3 Initiatives for Research and Development

Technological progress is about to fundamentally change how security should be managed, and major states endeavor to develop weapons that leverage cutting-edge technologies

will facilitate the integration of superior civilian advanced technologies and the development of technologies outside of the ministries aimed at defense equipment applications. Review is now underway for taking a more strategic approach to important technologies, including technologies pertaining to new domains and other potentially game-changing technologies such as AI.

## 3 “Research and Development (R&D) Vision”

The “Research and Development (R&D) Vision” presents principles on R&D, technological challenges, and roadmaps on R&D of the technologies required for our future defense capability for the purpose of conducting advanced R&D systematically from a mid-to-long term viewpoint.

The MOD publishes R&D Vision, and shares them with the defense industry, with the aim of increasing predictability for relevant companies, promoting prior investment, and realizing more effective and efficient research and development by maximally exploiting the investment. So far, the MOD prepared and published the “R&D Vision on the Future Fighter Aircraft” in 2010 and the “R&D Vision on Future Unmanned Equipment: Focusing on Unmanned Aerial Vehicle” in 2016. The MOD is currently conducting various research and study that can serve as a common foundation for unmanned aircraft, etc.

In August 2019, the MOD published the “Research and Development (R&D) Vision—Toward Realization of Multi-Domain Defense Force and Beyond” in order to contribute to the realization of Multi-Domain Defense Force and to achieve technological innovation necessary for further strengthening defense capability. Considering the direction of policy, operational needs, changes in technological trends and others, the MOD will continue to review R&D Vision, as well as establish and publish Visions on new themes.

### KEY WORD

#### Dual-use technology

Technology that can be used for both civilian and defense purposes

### KEY WORD

#### Game changers

Technologies with the potential to drastically change military balance in the future

in strategically important equipment and technology fields through focused investment in technologies in new domains, potentially game-changing cutting-edge technologies such as AI, and other important technologies. Specifically, the MOD has been making efforts to greatly shorten the research and development periods of Hyper Velocity Gliding Projectile intended for the defense of remote islands, UUV, hypersonic weapons, and other equipment through flexible and active use of new methods such as block approach and modularization. At the same time, the MOD/SDF has been working on visualization of the capabilities of future equipment by analyzing alternatives (AOA) in technological demonstration at the initial stage of R&D. The MOD also conducts research regarding a high-energy laser system (HEL) that responds to such threats as a large number of small unmanned aerial vehicles that fly at a low altitude and mortar shells at a low cost and with a short reaction time. Furthermore, the MOD efficiently and effectively conducts research on UUVs, etc. using dual-use technologies based on the “Basic Policy on the Relocation of Governmental Organizations”<sup>2</sup> along with developing a new test and evaluation facility “Iwakuni Test Evaluation Facility (provisional name)” in Iwakuni City. The facility is also available for use by the civilian sector, including local institutions for higher education and research institutes.

In addition, based on the MTDP, the MOD is working to



The next generation warning and control radar units at the time of technical demonstration

actively leverage potentially dual-use advanced commercial technologies through such efforts as technology exchange with relevant domestic and overseas entities, enhanced collaboration with relevant ministries and agencies, and use of the “Innovative Science & Technology Initiative for Security” program. In this regard, the MOD/SDF will strengthen and expand cooperation with countries who are making large-scale investments in game-changing technologies, such as the U.S. and special strategic partner countries, and promote mutually complementary international joint R&D. The MOD/SDF is also conducting studies to reinforce its structure aimed at early discovery of innovative, emerging technologies and fostering thereof by utilizing and creating think tanks that survey and analyze the latest foreign and domestic technological trends.

## 4 Active Utilization of Civilian Technology

### 1 Strengthening Technology Exchange with Relevant Domestic and Overseas Entities and Collaboration with Relevant Ministries and Agencies

The Acquisition, Technology & Logistics Agency (ATLA) and domestic research institutions, such as universities and independent administrative institutions, proactively engage in research collaborations and technological information exchanges in order to ensure that advanced civilian technology is incorporated and efficient research and development is conducted.

At the same time, in order to create excellent defense equipment through the utilization of advanced technologies and effectively and efficiently conduct R&D, the MOD will ensure cross-sectoral and substantial coordination at the Council for Science, Technology and Innovation (CSTI)<sup>3</sup> and other control tower meetings<sup>4</sup> based on the Integrated Innovation Strategy (Cabinet Decision on June 15, 2018). The ministry also actively participates in the

Council for Integrated Innovation Strategy<sup>5</sup> established for its promotion in order to further enhance collaboration with relevant ministries and agencies, national research and development agencies, industry, universities, and other parties. Furthermore, the MOD will further strengthen human exchange with research institutes, etc. in order to understand trends of civilian technologies for complementary and synergistic improvement of technological capabilities.

As international cooperative activities, the MOD will continue Japan-U.S. joint research and engineer exchanges, and continuously consider diverse possibilities through continued opinion exchange with other countries at various opportunities while closely observing their technology strategies, etc.

<sup>2</sup> Decided at the Advisory Council on Vitalizing Towns, People and Jobs on March 22, 2016

<sup>3</sup> One of the important policy meetings aimed at the planning and general coordination of comprehensive and basic science & technology innovation policies under the leadership of the Prime Minister and ministers in charge of Science & Technology policy, at a level higher than individual ministries.

<sup>4</sup> The IT Strategy Headquarters, the Intellectual Property Strategy Headquarters, the Headquarters for Healthcare Policy, the Space Development Strategy Headquarters, the Headquarters for Ocean Policy, and the Geospatial Information Utilization Promotion Committee in addition to the CSTI

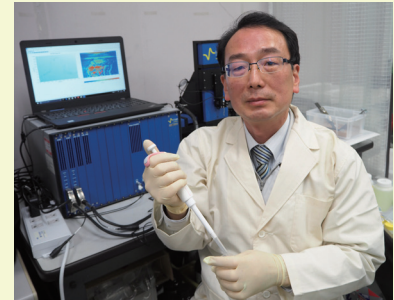
<sup>5</sup> Meeting of all ministers of state under the leadership of the Chief Cabinet Secretary for checking, sorting, and cross-sectoral and substantial coordination, and promotion of items that are included in the Integrated Innovation Strategy (approved by the Cabinet on June 15, 2018) and that require coordination among the control towers related to innovation

## VOICE

## Thoughts of a Researcher Working on a Research Program Supported by the “Innovative Science &amp; Technology Initiative for Security” Program

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“Visualization” of molecular bonding for adhesives is one of the issues of our research group. Adhesion of carbon fiber reinforced plastics (CFRPs) is widely applied in weight sensitive structures such as aircraft and spacecraft due to the excellence of CFRPs in terms of their high strength-to-weight and stiffness-to-weight ratios. However, full demonstration of the excellence has been difficult due to the adhesion design method of accepting an extra margin for bonding error and the wide distribution of bonding strength. Therefore, our team introduced scanning electrochemical microscopy (SECM), which is a new tool in biotechnology, fuel cell engineering, and so on, to seek the detrimental factors of bonding and succeeded in the visualization of adhesive performance distribution for the first time. Further development of this technology, we believe, will solve the adhesion problems to realize future aerospace structures that utilize CFRPs’ full performance. Our team is on the final term since the start of this three-year-project, under the sincere support by the program officer, not only in the form of technical comments and advice but also in the form of discussion opportunities with other teams in different fields to provide us with hints and new ideas. The excellence of program design also drives forward our team, especially the stable salary system for supporting young scientists, such as doctoral students and postdoctoral fellows, who tend to suffer unstable positions under the present aggressive environment for scientists.



The author (research representative) conducting an experiment

## 2 Innovative Science & Technology Initiative for Security and Its Utilization

In FY2015 the MOD launched a competitive research funding program called “Innovative Science & Technology Initiative for Security” to discover creative research activities conducted in universities, research institutes, companies, etc., which are expected to apply defense equipment in the future and to promote promising research seeds. A total of 53 research projects were awarded<sup>6</sup> by FY2018, this program was expanded in FY2017 in order to enable the awards of larger-scale and longer-term research projects. The program will continue to run on a similar scale in FY2019 (total budget of about 10.1 billion yen).

In the basic research areas, free thinking of researchers leads to innovative and creative results. For this reason, it is necessary to assign maximum value to freedom of research when sponsoring research, so that, for example, researchers will be able to publish all of their research results to have a wide range of academic discussions. Hence, in this program the MOD will neither restrict contractors’ publication of research results, nor designate research results as confidential, never providing any confidential data to researchers. In actuality, some research results have already been published through oral presentations, publications, etc.

Active utilization of advanced civilian technology through such programs is not only essential for securing the lives and peaceful livelihood of the Japanese people into the

future, but is also beneficial for the development of Japan’s science, technology and innovation in non-defense areas as well, similar to how investment in innovative technology by the Defense Advanced Research Projects Agency (DARPA) of the United States facilitated advances in science and technology as a whole including civilian technology, such as the development of the Internet and GPS. From this perspective, the MOD intends to promote relevant measures and strives to raise awareness of this program that contributes to ensuring the freedom of study and its sound development.

In April 2019, an organizational change<sup>7</sup> was carried out for the unified implementation of translational research in order to connect the results of advanced basic research to the research and development of specific equipment. Those research results will be acquired through such efforts as technology exchange with relevant domestic and overseas entities, enhanced collaboration with relevant ministries and agencies, and use of the “Innovative Science & Technology Initiative for Security” program for the R&D of specific equipment.

**Q See** Fig. IV-2-2-2 (FY2018 Awarded Research Projects for the “Innovative Science & Technology Initiative for Security” program)

<sup>6</sup> For the research projects adopted under the Innovative Science & Technology Initiative for Security (a competitive research funding program), see the ATLA website (<https://www.mod.go.jp/atla/funding/kadai.html>)

<sup>7</sup> A part of the affairs concerning the Innovative Science & Technology Initiative for Security handled by Technology Promotion and IP Management Division of the Department of Technology Strategy, the ATLA, was transferred to the Advanced Defense Technology Center (functional change), and three divisions were established.

Fig. IV-2-2-2 FY2018 Awarded Research Projects for the "Innovative Science & Technology Initiative for Security" program

	Research Title	Brief Summary	Representative Institution for the Project
Large-scale research projects (Type S): Seven projects	Research for Long-Range Acoustic MIMO <sup>1</sup> Communications by Time Reversal	Taking advantage of time reversal MIMO communication, a technique for compensating the effect of multipath and spatial multiplexing for improving communication capacity, this research aims to: establish a method for achieving high-rate and long-range underwater acoustic communication; and also conduct demonstration tests in the sea.	Japan Agency for Marine-Earth Science and Technology (national research and development agency)
	Study of predictive adaptive optics control for long-distance high-intensity light beam transmission	This research aims to: predict optical transmission by measuring the backscattered light of search beams; establish a system for dramatically increasing the transmission distance of optical communication by real-time control of a deformable mirror or other means; and conduct indoor demonstration tests.	RIKEN (national research and development agency)
	Fabrication of High Toughness Eutectic Ceramic Composite Materials Excellent in High-Temperature Environmental Resistance	This research aims to: find eutectic ceramic materials excellent in heat resistance and environmental resistance; develop a technology for toughening eutectic ceramic materials and a technology for spinning eutectic ceramic fibers; provide composite materials with high toughness in which these technologies are combined; and demonstrate the performance of these materials.	Japan Ultra-High Temperature Materials Research Center (JUTEM)
	Research for Innovative Wireless Power Supply to Transmit a Large Amount of Electricity to Underwater Vehicles	This research aims to: conduct basic research for properties of seawater in the strong electromagnetic field so as to uncover the mechanism by which electromagnetic waves diminish in the sea; and establish and demonstrate a magnetic-resonance, wireless electricity transmission system capable of efficiently transmitting a large amount of electricity.	Panasonic Corporation
	Research for Innovative Infrared Ray Sensors Making Use of Two-Dimensional, Functional Atomically-Thin Films	This research aims to: highly enhance the efficiency of photothermoelectric effects in graphene, which have been brought about by unique quantum physical properties, by making use of the layer structures; apply the effects to infrared ray sensors; and examine the highly-sensitive and high-speed imaging performance of the sensors at room temperature.	Fujitsu Ltd.
	Basic Research for Ultra-High-Voltage, $\alpha$ -Type Gallium Oxide Power Semiconductor Devices and Pulsed Power Sources	This research aims to: establish a high-quality crystal growth technology and device manufacturing technology for high performance $\alpha$ -type gallium oxide power semiconductor devices; and also manufacture pulsed power sources in which an $\alpha$ -type gallium oxide power semiconductor device is incorporated and confirm the performance of the sources.	FLOSIA Inc.
	Basic Research for Photodetector Elements Making Use of Two-Dimensional, Functional Atomically-Thin Films, E.G., Graphene	This research aims to achieve photodetector elements with high performance using a method in which a voltage change caused by irradiation of light on substrate materials is detected by using the highly-sensitive response of graphene. In advancing the research, the company will manufacture such elements and examine the effectiveness of the proposed method.	Mitsubishi Electric Corporation
Small-scale research projects (Type A/C): 13 projects	Study on detail mechanism of Rotating Detonation Waves	The research aims to: address the fundamental mechanism of detonation waves with quantitative visualization in the cylindrical-ring combustor and with direct numerical simulations; and also identify the condition under which stable rotating detonation waves keep running.	Japan Aerospace Exploration Agency (national research and development agency)
	Innovative Methods for Creating Outstanding Broadband Transparent Nanoceramics	This research aims to: create optical materials that excellently provide not only an infrared transparency property but also mechanical properties by achieving fine-grained microstructures from nano/amorphous ceramic powders; and establish the technologies for manufacturing such materials.	National Institute for Materials Science (national research and development agency)
	Research for Superconducting Magnetic Sensors Providing both Ultra-High-Sensitivity Performance and Environmental Resistance	Focusing on superconducting quantum interference devices (SQUID) making use of high-temperature oxide superconductors that are workable at the temperature of liquid-nitrogen or higher, this research aims to: find a balance between high magnetic field resistance and magnetic sensitivity; and examine the effectiveness of the sensors that have been manufactured.	Superconducting Sensing Technology Research Association
	Research and Development of 10kV-Class Gallium Oxide Trench MOSFETs <sup>2</sup>	This research aims to develop low-loss and high-current semiconductor devices with ultra-high blocking voltage, which are achieved by increasing the blocking voltage of MOSFETs fabricated by $\beta$ -type gallium oxide with excellent crystal quality.	Novel Crystal Technology, Inc.
	Basic Research for collaboration between a small number of people and a group of AI	This basic research aims to effectively solve complex problems through establishing a method for building consensus between human beings and a group of artificial intelligence.	Mitsubishi Heavy Industries, Ltd.
	Development of Innovative Actuators with MR Fluids <sup>3</sup> for Providing Sensitive Haptics	Focusing on actuators with MR fluids capable of high-speed torque control, this research aims to demonstrate the performance of such actuators that provide haptics in the simulated environment for telesurgery.	Oita University
	Development of a System for Applying Mechanical Stress	This basic research will focus on the mechanism of intracellular signal transduction under the high pressure condition, leading to development of innovative sensing devices in the future.	Okayama University
	Fundamental Research on Shallow Underground Exploration Technology by Acoustic Irradiation Induced Vibration using UAV <sup>4</sup>	The purpose of this fundamental research is to develop a method for exploring buried objects in shallow underground by irradiating sound waves from UAV and measuring ground surface vibration by laser Doppler vibrometer.	Toin University of Yokohama
	Development of Technology for High-Speed Automatic Detection of Low-Bright Moving Objects in Noise Images	Focusing on the observation of space debris and celestial bodies near the earth, this research aims to establish: a technology for image processing by superimposing a large amount of image data; and a technology for highly-speedily detecting moving objects at the noise level or lower levels to which an algorithm for removal of background objects is applied.	Japan Aerospace Exploration Agency (national research and development agency)
	Establishment of Standards for Reliability Assessment for Creating New Titanium Alloy with Properties of High-Temperature Resistance and Oxidation Resistance	This research aims to: establish standards for reliability assessment of new titanium in light of the results of a variety of tests; and create new titanium alloy stably applicable at high temperature by unraveling the mechanism of oxidation of titanium and other efforts.	National Institute for Materials Science (national research and development agency)
	Research for Creating New Materials that Enhance the Sensitivity of Topological Magnetic Sensors	This research aims to seek and create new materials for the purpose of achieving innovative magnetic sensors making use of unique electrical conduction.	National Institute for Materials Science (national research and development agency)
Analysis of Challenges in Devices for Transmission of a Large Amount of Electricity in Water and the Sea Making Use of Electromagnetic Induction, the Devices of which are Capable of Simultaneously Supplying Electricity to Multiple Targets and Providing a Function for Adjusting Distances where Electricity is Supplied; and Method for Solving the Challenges	This research aims to: establish electromagnetically-induced, wireless electricity transmission, which is capable of supplying electricity to targets in water and the sea in a highly efficient manner; and seek a method for analyzing electromagnetic fields in a highly speedy manner.	Science Solutions International Laboratory, Inc.	
Research for High-Speed Charging and Discharging Materials by Controlling of Metal Oxide Nano-Structures.	This research aims to: create metal oxide electrode materials capable of storing ion in their crystal structures; unravel the mechanism of charging and discharging thereof; and improve the properties of the electrode.	Toshiba Materials Co., Ltd.	

\*1: The term "MIMO" is an acronym for "Multiple-Input Multiple-Output," a wireless communication technology that receives and sends data through multiple antennas.

\*2: The term "MOSFET" is an acronym for "Metal-Oxide-Semiconductor Field Effect Transistor."

\*3: The term "MR" is an abbreviation for "magnetorheological."

\*4: The term "UAV" is an acronym for "Unmanned Aerial Vehicle."