[Provisional Translation]

Defense Technology Guideline 2023

- To defend our nation at all times with technologies -

June 2023

Japan Ministry of Defense

[Provisional Translation]

Executive Summary

Purpose

This guideline outlines the direction of the reinforcement of the defense technology base to actively promote all Japan Ministry of Defense (JMOD) efforts in accordance with the National Security Strategy, National Defense Strategy, and Defense Buildup Program. JMOD publishes this guideline as a message to our partners, including the relevant ministries, research institutes, industry, academia, and allies and like-minded countries. JMOD will improve the predictability of our partners and share the common understanding to promote technological cooperation with our partners.

Current environment and challenges

Rapid advances in science and technology have added to Japan's own economic and social development. These advances are also having huge effects on the national security environment and are changing warfare. As a result of these changes, if we simply continue incremental updates of equipment, we may fail to defend our nation at all times. To adapt to these changes, we need to maximally utilize Japan's capabilities in science, technology, and innovation (STI) for the purposes of national security and defense. We also need to spin off outcomes of JMOD's R&D to the entire society. In JMOD's R&D activities, to achieve the defense of our nation at all times, we need to take new approaches and implement measures that are drastically different from the past.

Our vision of the future (Ends of this guideline)

JMOD / Japan Self-Defense Forces (JSDF) needs to have sufficient defense capabilities. The objective of reinforcement of the defense technology base is to support Japan's defense capabilities through technology solutions. Therefore, our vision of the future is "To defend our nation at all times with technologies."

Approaches to realize our vision (Methods of this guideline)

This guideline will be anchored by two pillars.

1st Pillar: Accelerating delivery of functions and equipment

We will deliver the functions and equipment in the seven fields of key capabilities as mentioned in National Defense Strategy to warfighters in a timely manner (by 5 years until FY 2027 or within approximately the next 10 years). We will develop these functions and equipment through the reformed R&D process.

2nd Pillar: Ensuring technological superiority and creating advanced capabilities

Over the next 10 years and further ahead, we will put the various technologies into practical and operational use as brand new functions and equipment under nationwide collaborations that gather STI capabilities from the public sector and the private sector of Japan. These efforts will create the new values as functions and equipment to resolutely defend our nation, and these values will transform JMOD / JSDF into the organization that is capable of responding to future warfare. In this guideline, we will call this transformation defense innovation, and we will secure technological superiority in the future and realize the advanced capabilities ahead of other countries through defense innovation.

Means to realize our vision (Means of this guideline)

To achieve the 1st and 2nd pillars, we will create our functions and capabilities that JMOD / JSDF needs, nurture the technologies strategically, and understand the various science and technology factors. We will carry out the various efforts of the three means with the relevant ministries, research institutes, industry, and academia. For this purpose, we will establish the ecosystem that makes continuous growth of JMOD and stakeholders and sustainable cooperation while ensuring technology preservation.

Creating We will speed up R&D processes by implementing every possible measure to

strengthen our defense capabilities rapidly. We will deliver the functions and capabilities to warfighters in a timely manner. To achieve this purpose, we will introduce new R&D methods for early deployment, including trial fielding. In trial fielding, we will produce a prototype that is usable in operational fields and put them into operation as soon as possible. These efforts enable the demonstration of brand-new functions and capabilities and the building of deterrent effects. We will also acquire feedback from operators though the trial use of prototypes and use the feedback for continuous redesign, improvement, and other improvements. We will accelerate the use of R&D resources and ideas outside the ministry as Open Innovation.

Our policy side, operational side, and technology side will work together to create the concept of future warfare and to create the directions of future R&D and acquisition of functions and equipment. We will forecast the future technologies and warfare. And we will create the scheme as to how we utilize new technologies against new threats together with technology specialists outside the ministry.

Technological knowledge, human resources, facilities and test equipment are the essential technology base of R&D. We will share the objectives and goals of our efforts with the technology base, including our ministry's research centers, test centers, and the defense industry, to improve the predictability of industries and gather the capability of the technology base. We will invest in the technology base to maintain and reinforce their capabilities. We will expand communication and collaboration with industries, including start-ups that are not familiar with defense-related programs. We will also establish the framework to promote the participation of various industries in our R&D projects. We will establish the capability in the technology base that can integrate advanced technologies that are developed by start-ups into functions and equipment by the defense sectors. JMOD's competitive research funding program called Innovative Science & Technology Initiative for Security (ISTIS) focuses on developing the technologies in niche areas that cannot gain investments from the private sector and identifying and developing the basic research to expand the boundary of S&T fields. We continue to utilize this program to create the new technology base. To assign the appropriate personnel to the appropriate positions flexibly and quickly, we will reinforce measures for personnel utilization and recruiting, such as the bringing up of personnel and the expanding of mid-career employment to gain talented people.

Nurturing We will explore the technologies to be nurtured, including outside defense and experienced technologies. We will actively take the brand-new approaches that differ from the current R&D style, including a challenging research program with the acceptance of unpredictable technological risks.

Based on the limitation of JMOD's resources and the fact that JMOD's R&D investments are just a small part of S&T investments of the government of Japan, we will utilize the various outcomes of S&T activities outside JMOD for defense purposes. For leveraging these outcomes in an effective way, we will concretely show our needs and the directions of our efforts. We will establish an environment that promotes the participation of the S&T community members into our projects and explore new partners. We will develop a sustainable ecosystem that enables to reward industry's efforts and nurture their businesses. We will fuse the defense sector and the non-defense sector and make the new chemical reactions from that fusion to nurture technological solutions from a different angle that differs from the defense perspective. We will exert the greatest possible efforts to utilize the domestic and international S&T capabilities to nurture technologies.

The outcomes of JMOD's R&D contribute to raising Japan's capabilities in STI. From the perspective of addressing global issues, we will conduct diverse R&D projects

and nurture Japan's capabilities in STI. By conducting ISTIS, we will expand the human resources that conduct use-inspired basic research, foster various researchers, explore new frontier of research areas, establish, and reinforce human networks in emerging research areas to expand the range of STI capabilities.

Understanding We will understand the current STI environment, such as the technological trend in domestic and international private sectors, R&D outcomes from the private sector, including start-ups in Japan, advanced technologies in research institutes and academia, current status, and the results of R&D projects. We will determine what we should do based on the current S&T environment.

Nowadays the various S&Ts are being used on the actual battlefield. Under these circumstances, we need to understand how the various new technologies affect the national security environment and JMOD / JSDF activities in future warfare precisely and quickly. For such S&T changes, we will implement the appropriate measures.

We will actively send the messages outside the JMOD about what we are doing, why we are doing it, and how our efforts in technologies affect the national security environment and defense activities. We will share the future forecasting results and our future R&D plans outside the JMOD to improve the predictability of stakeholders.

Conclusion

We will promote harmony between national security and STI as an organization that can build a bridge between these policies. We will realize the ends of this guideline through achieving the 1st and 2nd pillars with the various efforts of creating, nurturing, and understanding by breaking away from conventional thinking.

Attachment: The important technology areas to defend our nation at all times

In this guideline, we determine the areas that need to gain the superiority for defending our nation at all times and derive the important functions and capabilities for defending our nation at all times. Next, we break down these functions and capabilities to technology areas that are important to realize these functions and capabilities.

We assume the physical area, information area, and cognitive area as the areas to gain superiority. From these three areas we derive the important functions and capabilities to gain the superiority in the physical area, the important functions and capabilities to gain the superiority in the information area, and the important functions and capabilities to gain the superiority in the cognitive area. As the results of this process, we derive 12 areas as the important functions and capabilities to defend our nation at all times as follows. In this attachment, we show examples of the important technology areas to defend our nation at all times by breaking down these as the important functions and capabilities into specific technologies from the technological perspective.

- ○ Automation and Autonomy to prevent damage and the workload of warfighters and civilians
- ○ Utilization of unused platforms
- ○ Utilization of unused energy
- ○ New functional materials and manufacturing method
- ○ Faster and more accurate sensing
- ○ Advanced computing that instantly processes vast amounts of information
- ○ Visualization of invisible things (such as distant objects, electromagnetic waves, and the decision-making process of SDF personnel)
- ○ Capabilities that make virtual / imaginary information as real things
- ○ Forecasting our future to enhance recognition capability beforehand
- ○ Network that enables to connect anywhere, anytime, anyone as we like

- More effective and efficient cyber defense capabilities
- Reinforcement of warfighter's cognitive capability

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1. Purpose

This guideline outlines the direction of the reinforcement of the defense technology base in light of the National Security Strategy of Japan, National Defense Strategy, and Defense Buildup Program (hereinafter referred to as National Security Strategies of Japan), which have been formulated in FY 2022, and replaces the Defense Technology Strategy and Medium- To Long-Term Technology Outlook formulated in FY2016 by the Ministry of Defense and the Acquisition, Technology & Logistics Agency (ATLA) as well as the R&D vision formulated in FY2019 by the Ministry of Defense and ATLA.

This guideline organizes the directions of various efforts necessary for reinforcement of defense technology base as a guideline to actively promote the whole of Japan Ministry of Defense (JMOD) efforts. This guideline also widely disseminates the direction of the reinforcement of the defense technology base in JMOD, improving the predictability of the industries, including defense related industries who are important partners in R&D projects. Furthermore, this guideline fosters the common understanding about reinforcement of defense technology base and aims to establish a base for actively promoting technological cooperation by sharing the direction of JMOD with not only relevant ministries and agencies research institutes such as national research and development agencies, industries, academia, etc. but also allies and like-minded countries. In particular, in light of the direction of creating a whole-of-government mechanism and actively utilizing the results of government-wide research and development in the defense-related field in the National Security Strategy of Japan, this guideline specifies the direction of JMOD for close cooperation with relevant ministries and agencies to ensure the strengthening comprehensive defense architecture while keeping in mind the principles of the Science, Technology, and Innovation Basic Plan and the Integrated Innovation Strategy.

As shown in Figure 1, this guideline describes the current environment and challenges in Chapter 2, our vision of the future (Ends of this guideline) in Chapter 3, approaches to realize our vision (Methods of this guideline) in Chapter 4, and means to realize our vision (Means of this guideline) in Chapter 5, respectively. The important technology areas to defend our nation at all times is organized in an attachment.

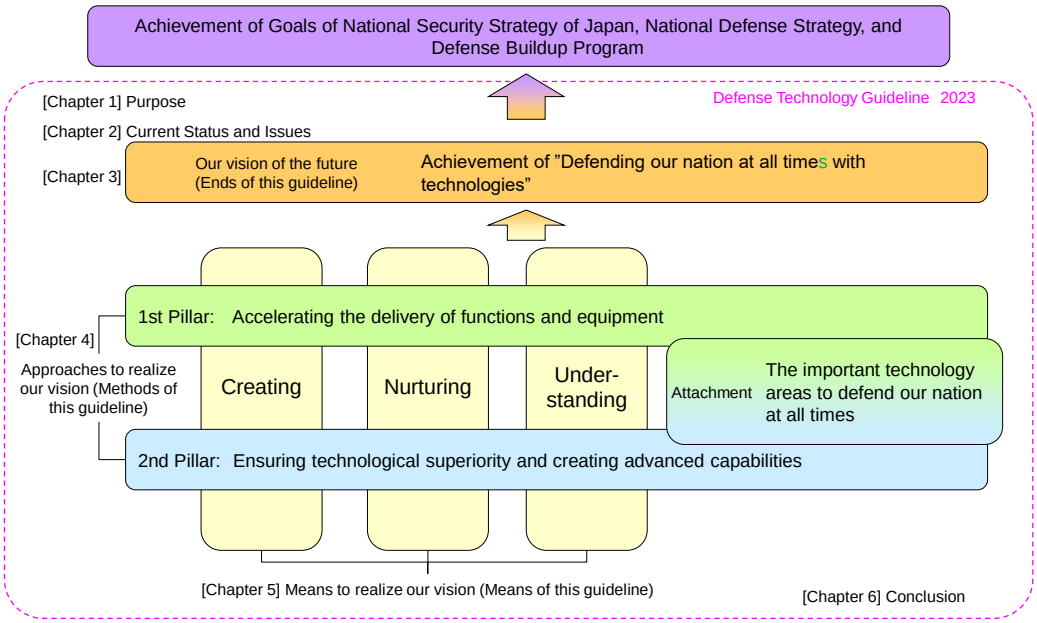

Figure 1: Positioning and Structure of this Guideline

2. Current environment and challenges

Recently, the situation regarding the defense technology base is undergoing major changes. Rapid advances in science and technology have been giving Japan's own economic and social development. These advances are also making huge effects on the national security environment and are expected to change warfare. For example, various products and technologies in the private sector are being utilized in the field where the response to the Russian invasion of Ukraine is underway, and UAVs[1] or other vehicles with rapidly developing unmanned aerial vehicle technologies are having a significant impact on the course of the battle.

In addition, the rapid advancement of information-related technologies and information infrastructures, such as IoT[2], AI[3], and social media, has dramatically increased the possibility of hybrid warfare in which military and non-military means are combined and expansion of information warfare through the spread of disinformation or by other means. In particular, advances in AI, social media, or other technologies are not only speeding up the communication of facts but are also rapidly expanding the distribution of information that is different from the facts, leading to various influences on people's perceptions and potentially fundamentally changing the way people think about the utilization of information.

Until now, equipment systems, such as tanks, vessels, and fighter aircrafts, have been steadily developed mainly for high-intensity conflicts between regular military forces. But because of the rapid advancement of technologies, new warfare applied to advanced technologies in a complex manner, such as drones and deepfakes, is being created in neighboring countries. Under these circumstances, if we just continue incremental update of equipment based on the premise of high-intensity conflicts, we may fail to respond to new ways of warfare, and we may no longer be able to defend our nation's peace and independence and continue to maintain our national security.

In light of these changes in the security environment, the National Security Strategy formulated in FY 2022 positions the creation of Science, Technology, and Innovation as the source of our economic and social development and the appropriate utilization of technological capabilities as an important role in improving our security environment while considering technological capabilities to be one of the key elements of the overall national power for our national security. In addition, it clearly states the government's new direction that we will actively utilize the advanced technological capabilities from the public and private sectors, which have been developed over the years, in our defense-related field by making a break away from general understanding. In this manner, the importance of technologies has ever been greater in Japan from the perspective of the national security.

In addition to the emerging new warfare, Japan's capabilities of Science, Technology, and Innovation (STI), including a wide range of technologies in the private sector, need to be maximized for security and defense purposes as what is called Spin-on in order to respond to an imminent security environment in which changing the current situation by force becomes a reality. From the perspective of reinforcement of our national power, it is also important to link the outcomes of JMOD's R&D to raising Japan's capabilities of STI by returning them to society as what is called Spin-off. It is necessary to achieve fundamental reinforcement of the defense capability while contributing to reinforcement of the overall national power by ensuring and enhancing the autonomy, superiority, and indispensability of our technological capabilities through the interactions between these Spin-on and Spin-off activities.

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[1] UAV: Unmanned Aerial Vehicle

[2] IoT: Internet of Things A state where all things are connected to a network and can exchange information etc. with one another.

[3] AI: Artificial Intelligence

As technology progresses at a rapid pace, the organic coordination among the technology side (the implementer of R&D), the operational side (the user), and the policy side (in charge of the defense policy) within JMOD is not always sufficient, and it has become apparent that there are issues in responses in an integrated manner, such as the need to further facilitate communication among organizations. Furthermore, partner companies that are indispensable for R&D have been often limited to defense related industries, making it difficult for companies that have never participated in JMOD's R&D, such as start-ups, and venture companies to participate in new R&D projects. In addition, changes in the industrial structure and business sentiment have led some defense related industries to withdraw from defense-related businesses or to be unable to invest sufficient capital in the defense sector.

There is also an issue that JMOD's R&D has been based on a solid and overly cautious plan in pursuit of stability and certainty and overly focused on steady implementation of the plan, which results in a long period of time before practical applications and a lack of flexibility, being unable to respond adequately to the current situation where the security environment is changing very rapidly. In addition, as the future of warfare itself is about to change with the advent of various sciences and technologies, we must carefully determine the impact of science and technology on security and advanced R&D of functions and equipment that are not limited to extensions of the existing equipment systems. While limited resources to invest in R&D, JMOD needs to take new approaches and measures that are drastically different from the past to achieve defending our nation at all times in light of these environmental changes etc. To effectively create outcomes through new approaches and means, the cooperation of partner companies and others is essential. Also, in order to improve the predictability of industries and others, it is necessary to actively communicate the direction of JMOD's R&D etc. to those outside the ministry.

3. Our vision of the future (Ends of this guideline)

JMOD / Japan Self-Defense Forces (JSDF) needs to have enough defense capability. The objective of reinforcement of defense technology base is to support Japan's defense capabilities by technological solutions, including long-term perspectives. Therefore, our vision of the future for reinforcement of defense technology base is to defend our nation at all times with technologies.

To this end, while conducting R&D promptly at JMOD to deliver necessary functions and equipment to operators at a desired timing, we create new functions and capabilities necessary to defend our nation in the future and promote acquisition of the technologies necessary to realize them.

Furthermore, in order to utilize our various technological capabilities in a comprehensive and integrated manner across the sides within JMOD and the government for reinforcement of the defense capability, we will establish a system to receive cooperation from relevant ministries and agencies, research institutes, and companies including start-ups, and others and, while paying attention to technology security, will make maximum use of the technological capabilities and the R&D outcomes of these organizations.

Within that cooperative framework, we will also link new technologies of research institutes, industries, and others outside JMOD to social implementation of reinforcement of the defense capability as well as actively promoting R&D that directly leads to reinforcement of the defense capability as JMOD, achieving innovation in the defense field. In addition, in light of the viewpoint that technological capabilities bring about economic and social development in Japan, we will link outcomes of JMOD's R&D projects to further reinforcement of Japan's capabilities of STI, and actively catch up the progress of R&D projects conducted by relevant ministries and agencies etc.

4. Approaches to realize our vision (methods of this guideline)

To defend our nation at all times with technologies, we must promptly reinforce our defense capability to deal with imminent threats and ensure our technological superiority in the future to realize advanced capabilities ahead of other countries. Based on the above, this guideline will be anchored by two pillars for our vision. The important technology areas in these approaches are organized in a separately attached sheet entitled "The important technology areas to defend our nation at all times."

4.1. 1st Pillar: Accelerating delivery of functions and equipment

The 1st Pillar is accelerating the delivery of functions and equipment. We will deliver the functions and equipment in the seven fields of key capabilities as mentioned in National Defense Strategy to warfighters in a timely manner (by 5 years until FY 2027 or within approximately the next 10 years). We will develop these functions and equipment through the reformed R&D process.

The National Defense Strategy lists seven functions and capabilities necessary for our national defense: Stand-Off Defense Capabilities, Integrated Air and Missile Defense Capabilities, Unmanned Defense Capabilities, Cross-Domain Operation Capabilities, Command and Control/Intelligence-related Functions, Mobile Deployment Capabilities, and Sustainability and Resiliency. For this list, we will conduct R&D to deliver necessary functions and equipment to operators at a desired timing for reinforcement of the defense capability.

4.2. 2nd Pillar: Ensuring technological superiority and creating advanced capabilities

The 2nd Pillar is ensuring technological superiority and creating advanced capabilities. Over the next 10 years and further ahead, we will put various technologies into practical / operational use as functions and equipment under nationwide collaborations that gather STI capabilities of the public sector and the private sector in Japan. These efforts will create the values as capabilities to resolutely defend our nation in the future, providing defense innovation that will transform our defense. This ensures our technological superiority in the future to realize advanced capabilities ahead of other countries, and we aim to improve the security environment by continuously creating technological surprises and possessing technological capabilities as deterrents.

For the 2nd Pillar, we will conduct R&D for breakthrough functions and equipment as well as advanced capabilities by actively introducing technologies from outside the ministry in such a way as to actively identify new technologies that have been distant from utilization for the defense purpose in addition to technology bases required to improve the capabilities of conventional equipment systems.

The 2nd Pillar also includes basic research. We will make investments from a medium- to long-term perspective to explore basic research that could lead to the creation of innovative functions and equipment, develop them to achieve defending our nation at all times, and achieve delivery of nonconventional new functions and equipment.

5. Means to realize our vision (Means of this guideline)

To achieve the 1st and 2nd Pillars, we must create functions and capabilities required by JMOD/JSDF and also strategically nurture and understand the sciences and technologies necessary to provide the functions and equipment.

Based on the above, we will make efforts using creating, nurturing, and understanding means. These efforts need to be promoted not only within JMOD but also with stakeholders outside JMOD, such as relevant ministries and agencies, research institutes, industries, and academia. For this reason, we will establish an environment and structure in which JMOD,

and stakeholders can recognize their mutual benefits and, while creating synergies, continue to grow together by working together in a reasonable, sustainable, and autonomous manner. On this occasion, we will promote efforts while keeping in mind technology security to ensure our technological superiority and indispensability etc.

5.1. Creating

The primary effort of creating is to deliver new functions and equipment through R&D. Conventionally, R&D has basically been conducted at the request of operators. However, in an environment where new warfare is created with advances in science and technology etc., we must more actively provide technological solutions to issues that may arise in the future battlefields and create the concept of future warfare from now on to create capabilities to defend our nation at all times. Additionally, we will also create the technology base to create functions and equipment.

5.1.1. Creating new functions and equipment

5.1.1.1. Accelerating delivery

For functions and equipment, we will speed up R&D processes by taking every possible measure to reinforce our defense capability rapidly.

In the conventional security environment, uncertainty has been relatively lower and relatively easier to predict future threats, allowing R&D with the aim of improving the capabilities of conventional equipment systems based on such predictions. Under these circumstances, the functions and capabilities required for the equipment have been determined at the start of R&D projects in many cases, and we have conducted what is called waterfall R&D in which the processes of the project are carried out step by step, carefully checking the design, manufacturing, testing, and other operations to achieve the goals to avoid reworking as much as possible.

On the other hand, in today's increasingly uncertain security environment, it is becoming difficult to make predictions regarding future threats. Under these circumstances, it is necessary to flexibly and quickly create technological solutions that can deal with any situation without being restricted by existing equipment systems in order to reliably deal with the various threats that will arise in the future. To provide this kind of response, we will actively conduct not only steady or time-consuming waterfall R&D but also R&D for early deployment in which the minimum required functions and capabilities are quickly implemented and demonstrated with users in the operational field, and the results and lessons learned are quickly and flexibly reflected in design, manufacturing, and testing for continuous improvements. In other words, we will take measures that allows us to deal with various threats quickly and flexibly by quickly repeating the cycle, in which necessary functions and equipment are created first in a short period of time even if their capabilities are limited and then used for further improvement in order to accelerate R&D for putting them into practical use early and by allowing for continuous capability improvements and expansion of scale as needed.

In particular, as software-based delivery of functions with rapidly advancing information-related technologies allows us to make improvements quickly and flexibly compared to hardware-based equipment, and we actively apply means of agile developments used in software developments in the private sector. These functions are likely to lead to effective responses to information warfare including in cognitive domains. In light of environmental changes that include diversified information warfare, we will actively promote delivery of software-focused functions and capabilities in addition to conventional hardware- and

physical platform-based equipment to introduce not only steady but overly cautious means but also quick and flexible means, shifting the idea so that solutions should be quickly provided while responding flexibly to changing circumstances.

Furthermore, through R&D projects, we will introduce new means for early deployment and early acquisition of capabilities by producing prototypes that can be put into unit operations and deploying them prior to mass production on trial to demonstrate the functions in operational fields as soon as possible, enhancing the deterrent effects.

On the other hand, these means could cause business risks, such as reworking and resulting business delays, or operational risks, such as confusion among users due to the existence of multiple demonstrators of various versions. For this reason, we will assess such risks in cooperation with industries and others that work together on R&D projects and JSDF units as users and agree on how to avoid, mitigate, transfer, and accept them in advance among parties concerned in order to focus on activities to limit the impact of various risks by properly managing the implementation status of projects. We will also take the expected outcomes of projects into account and make a bold decision to promptly discontinue projects that are unlikely to achieve outcomes.

Including these efforts, we will establish a system that efficiently and effectively provides operators with functions and equipment to defend our nation at all times by putting functions and equipment created early into practical use quickly and continuously improving their capabilities.

5.1.1.2. Creating by putting together Japan's capabilities of STI

The new National Security Strategy of Japan indicates the direction of promoting efforts in four areas including R&D under the framework of relevant ministries and agencies for the strengthening comprehensive defense architecture as an inseparable unity with complemented fundamental reinforcement of our defense. In order to promote R&D on science and technology that contribute to the strengthening comprehensive defense architecture, it also indicates the direction of creating a whole-of-government mechanism and promoting the active use of funds for and outcomes of government-wide R&D in the defense-related field. With the aim of further harmonizing the STI policies with the national security policies, we will create an environment that can bring about synergies by which R&D that should be promoted by JMOD itself and R&D that should be promoted under a whole-of-government mechanism play their respective roles for fundamental reinforcement of our defense capability.

R&D that should be promoted by JMOD itself is basically R&D for functions and equipment that ensure the capabilities of JMOD/JSDF. These R&D projects are dedicated to the clear and strong defense purpose of achieving functions and equipment and must be continuously conducted well by JMOD itself. To this end, a new research institute will be established in ATLA to create breakthrough functions and equipment. The ATLA's new research institute will actively explore new technologies that have been distant from utilization in the defense field from outside the ministry, come up with utilization methods that are not an extension of the conventional ones, utilize R&D resources outside the ministry too and, while boldly taking on challenging goals without fear of risks, create breakthrough functions and equipment. It will also consider the introduction of new systems, such as speed-focused processes and simple decision-making

mechanisms to promote bold and challenging research studies that have not been done before for rapid creation of outcomes.

Meanwhile, investments in STI by relevant ministries and agencies for our economic and social developments have been made for various purposes, such as improving the STI creation capabilities and enhancing the technological capabilities of the public and private sectors, achieving outcomes. In such diverse R&D, the outcomes are not easily utilized for the defense purpose due to different R&D purposes in some cases. However, it is becoming extremely difficult to distinguish between civilian and security technologies, and it is necessary to actively utilize such outcomes for the defense purpose by making a breakaway from general understandings.

The relationship between the objectives of various R&D conducted within the government and the technology readiness level is shown in Figure 2. The figure shows the technology readiness level on the vertical axis: the higher the level, the closer to practical application, and the lower the level, the closer to basic research. For R&D dedicated to the defense purpose and R&D in areas where it can contribute to both defense and civilian fields but where investments for civilian purposes are not expected, JMOD needs to continue to conduct every step of R&D from parts close to basic research to practical application. On the other hand, regarding those for the purpose of being applicable in both fields or for the strong civilian purpose, JMOD will catch up the progress of R&D in various technology areas from an early stage to utilize the outcomes for the defense reinforcement while counting on R&D by relevant ministries and agencies to provide technologies.

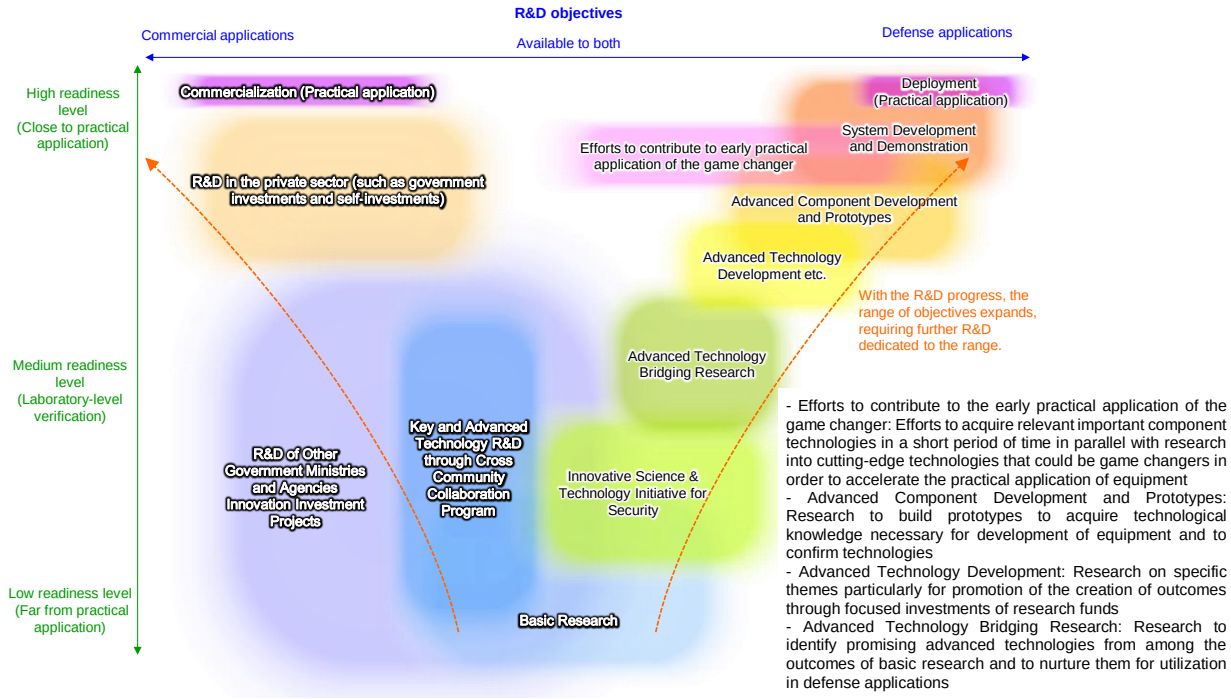

Figure 2 R&D objectives and technology readiness level

5.1.1.3. Creating with the help of support from outside the ministry

Conventionally, equipment used by JMOD/JSDF was generally created through R&D projects conducted by JMOD in light of the peculiarity of the application purpose. However, under the circumstances where sciences and technologies have advanced at an accelerating pace, which makes it extremely

difficult in practice to distinguish between civilian and security technologies, all sciences and technologies are being utilized for security and defense purposes as well. In light of these environmental changes, JMOD's R&D will also efficiently, effectively, and quickly acquire the functions and capabilities necessary for JMOD/JSDF by promoting Open Innovation that actively utilizes resources outside the ministry to achieve innovation, such as R&D resources including technologies, human resources, and facilities outside the ministry as well as ideas and solutions for solving various issues.

To utilize the power of STI communities, including research institutions outside the ministry, industries, academia, and others, it is necessary not only to achieve JMOD's objectives through the implementation of R&D projects but also to make cooperative stakeholders outside the ministry feel benefits and incentives. To this end, JMOD will plan attractive projects for stakeholders outside the ministry in addition to conventional R&D projects and actively communicate the benefits etc. of participating in JMOD's R&D projects to establish a framework to encourage stakeholders outside the ministry to voluntarily participate in JMOD projects.

In addition to these efforts, it is also necessary to create functions and equipment utilizing foreign capabilities through international R&D projects with allies, like-minded countries, and others. In light of common needs etc. with allies, like-minded countries, etc., we will plan strategic and mutually beneficial joint projects that can solve problems on both sides together and acquire the necessary things at a desired timing. In addition, JMOD will take the initiative in establishing projects not only just to achieve the goal of completing the projects but also with an eye toward secondary effects, such as selection of partners who participate in the projects so that those who participate in international R&D projects can establish wider public-private networks, strengthen their supply chains, and further enhance their technological capabilities etc. through the implementation of such projects.

5.1.2. Creating the future concept

5.1.2.1. Creating the concept of future warfare with policy and operational experts

How JMOD/JSDF battle in the future cannot be determined solely from a technological, policy, or operational perspective, and the technology, policy, and operational sides must work together to quickly create the concept of future warfare.

To this end, the technology side, policy side, and operational side in the ministry will work together to create the concept of future warfare, organizes "By when" and "What to do" to achieve the concept, and work together to create the directions of R&D and acquisition of functions and equipment necessary for JMOD/JSDF as ministry-wide efforts.

The technology side will examine the concept of future warfare from a technological perspective and make proposals to the policy and operational sides to stimulate discussion of future warfare. For approaches to be used, a forecast approach, which is used to consider what to do in the future based on the future outlook of technologies, and a backcasting approach, which is used to consider what to do in the future in inverse order from a future vision.

For a concrete future vision that is to be the premise of backcasting approaches, technological solutions to be provided, that is, specific technology applications are devised based on issues in operational fields and R&D to realize

the solutions are planned and implemented. At this time, it is also necessary to create the future concept with a view to introducing technical standards and specifications that could become international standards. If we can create a future concept with international standards in mind, it becomes easy to share R&D goals, specifications, and outcomes with other countries, allowing our technologies, functions, and equipment to be utilized together with more people.

Advances in science and technology also require us to address new ethical, legal, and social issues (ELSI[4]). Under the circumstances where sciences and technologies are serving as various new functions, we will use sciences and technologies as JMOD while determining applications of science and technology well from a policy perspective so that they do not have a negative impact on society and people.

5.1.2.2. Creating the future concept as a defense technology expert

In a forecast approach, the future outlook of technologies is important. Although it is always difficult to accurately forecast and predict what will happen to various technologies in the future, knowledge and experience that have been nurtured to date through R&D of JMOD's technology side can make the future of technology be predicted and the future warfare be forecasted.

In a backcasting approach, although it is of course necessary to focus on the operational side's vision, that is, the future warfare, it is also effective to envision the future utilizing the knowledge and experience of the technology side by thinking outside the box of the operational side. From the perspective specific to the technology side, which is familiar with how technology is used in the operational field of JMOD/JSDF, future technology applications will be envisioned, stimulating discussion.

For technologies necessary for future warfare that are made concrete through these processes, that is, technology needs, government-wide development of the sciences and technologies for these needs will be promoted by providing a clear explanation even for STI communities outside the ministry while taking care not to excessively expose the JMOD/JSDF's cards.

5.1.2.3. Creating the future concept with experts in a wide range of technologies

Although the JMOD's technology side has in-depth knowledge of conventional equipment and related technologies, it is difficult to come up with flexible ideas that depart from extensions of the conventional ones only by considering future warfare based solely on the knowledge. In addition, the JMOD's technology side lacks knowledge of rapidly advancing civilian technologies and their applications, limiting the envisioning of future warfare with advanced technologies.

To solve these issues and achieve the reinforcement of the defense that can respond to new warfare due to advances in science and technology etc. described in the National Security Strategy of Japan, it is necessary to obtain cooperation from experts outside the ministry with extensive knowledge of science and technology in the private sector without being restricted by the organizational framework of JMOD. Also, with the knowledge of technology experts outside the ministry, the ways to utilize technologies against new threats will be considered from the perspective that departs from the JMOD's conventional stereotyped ideas. Including technologies that we could not have noticed their potential for utilization only from the defense perspective, the role of

[4] ELSI: Ethical, Legal and Social Implications/Issues

technologies will be considered together with experts in a wide range of technologies to widely find technologies useful in future warfare. Also to make prior investments in those technologies, activities for future technology forecast will be further developed and strengthened and the concept for the future technology applications will be created working with technology experts outside the ministry to make pictures concrete, such as how and by when this technology is expected to grow and what impact this technology will have on our national security.

5.1.3. Creating the technology base

5.1.3.1. Creating the technology base of R&D

In order for JMOD to conduct R&D, technology bases of R&D are essential, including technological knowledge, human resources, facilities, and test equipment. In ATLA, technology bases of R&D include technological knowledge, human resources, facilities, and test equipment that belong to research centers and test sites. Since conventional equipment has often used defense technologies for which there is no need in the private sector, the ATLA's research centers and test sites have played an important role as technology bases of R&D.

And the defense related industries, which have supported R&D projects to date, are also important technology bases of R&D. The new National Security Strategy of Japan clearly states that these bases are, so to speak, positioned as defense capabilities themselves and that strengthening them is essential.

To further strengthen these technology bases of R&D, it is necessary to further strengthen cooperation with the ATLA's research centers and test sites as well as industries that include defense related industries. It is also necessary to implement R&D projects in line with the direction of the research centers and test sites to achieve the JMOD's vision and share the vision with industries and others to improve predictability. For uncertain fields in the future, it cannot be expected that industries and others make steady and active investments and a reliable environment in which to make investments in technology bases of R&D will be created by making when and for what JMOD intends to conduct R&D and acquire, that is, the direction of R&D and acquisition visibly as much as possible and by showing it to industries and others. However, excessive dissemination of information may result in a loss of technical superiority, it is necessary to clarify what information should be shared to effectively improve the predictability of industries and others through careful conversations with them and to communicate necessary information.

As technology bases of R&D cannot be established overnight, whether in terms of technological knowledge, human resources, facilities, or test equipment, such bases need to be maintained and strengthened on an ongoing basis in the future. To ensure fundamental reinforcement of the defense in the face of various limited resources, JMOD, industries and others must also review their respective roles again and pursue the optimal form of cooperation based on their advantages and disadvantages by breaking away from conventional thinking. On this occasion, care must be taken not to lose our superiority in the technology bases of R&D in cooperation also with allies, like-minded countries, etc. by managing the proprietary technologies of JMOD, industries and others as know-how and by choosing close strategies, including exclusive implementation of intellectual properties, or open strategies to share technologies with others.

In addition, collection and utilization of the knowledge obtained in the operational phase that leads to R&D are considered to be effective in fundamental reinforcement of our defense, and therefore quick and effective R&D will be conducted by sharing knowledge mutually between R&D and operational sides and also by accumulating and utilizing the knowledge obtained in the operational phase as technology bases of R&D.

In conducting R&D, it is essential to have not only cutting-edge technologies but also base equipment technologies that have been handed down to date. The functions and equipment necessary for JMOD/JSDF cannot be put into practical use with a single cutting-edge technology only, and the base equipment technologies that make up the surroundings are indispensable. In addition to focusing our investments on the important technology areas to defend our nation at all times as JMOD to actively acquire and utilize cutting-edge technologies, we will also make investments to continuously maintain and strengthen base equipment technologies, including measurement, processing, and testing technologies, which are indispensable for R&D.

5.1.3.2. Creating a new technology base

In the past, ATLA's research centers and test sites as well as the defense related industries that have conventionally participated in R&D and production of equipment have played important roles. In the future, although the importance of these technology bases will not change, new functions and equipment that are not tied to conventional equipment systems must also be created. To this end, it is necessary not only to maintain and strengthen the conventional technology bases of R&D but also to create new technological bases. Therefore, it is necessary to involve industries and others that have had little to do with R&D in the defense field, such as start-ups and venture companies that have created many of such technologies.

However, start-ups and others may have a much different business cycle and culture than general companies. Therefore, businesses, such as JMOD's R&D projects, in which contracts are made for multiple fiscal years and compensation is not paid until the final product is delivered, may not match business styles of start-ups and others. In addition, start-ups and others that seek to market new technologies and expand their businesses are often willing to increase their sales at a breath with extreme technologies to build new markets, rather than maintaining continuous and stable businesses. To expand participation of start-ups and others in R&D projects in addition to defense-related companies in order to utilize their technological capabilities for the functions and equipment necessary for JMOD/JSDF, it is also necessary to change systems and mechanisms so that they think that participating in JMOD's R&D projects is a business opportunity. It is necessary to create new systems and mechanisms that make it easy for companies with advantages in specific technologies etc. to participate in projects while directly listening to the opinions of companies and others, for example, by making short-term contracts focused on specific technologies instead of those for multiple fiscal years or by making contracts with a wide range of features and performance requirements. In the future, the efforts to promote participation in projects are further strengthened by communicating not only with defense-related companies but also with a wide range of industries and others.

To link new technologies to new functions and equipment, it will also be necessary to build a system by integrating technologies of start-ups and others

with other technologies well. From that perspective, technology bases that can integrate new technologies into functions and equipment will be created by attempting to match start-ups and others with new technologies with defense-related companies in charge of system integration so that they can create synergy by leveraging their mutual advantages.

Also, in order to create new functions and equipment that have never existed before, it is necessary to establish new means etc. to assess their capabilities as well as provide test environments and test equipment. In addition, it is also necessary to visualize how new functions and equipment can be effective in operational fields. Since such new means, test environments, etc. for assessments often become special ones that are not needed in the private sector, JMOD will make investments.

In terms of creating new technology bases, it is also important to utilize Innovative Science & Technology Initiative for Security that has been implemented by ATLA since FY 2015.This program focuses on developing the technologies in niche areas which are unlikely to gain investments from relevant ministries and agencies or the private sector but are expected to be effectively utilized and identifying and developing the basic researches which expand the boundary of S&T fields. For example, in R&D of batteries, the private sector tends to focus on the energy density for long-lasting use but little on the power density for producing a large amount of energy at a time. However, under this program, research themes with the aim of improving the power density performance are also set up in the hope that it leads to the creation of new batteries. Because of the era of rapidly advancing technologies, the importance of this program, which is identifying and developing innovative and emerging technologies, is increasing. Using shown research themes in this program as triggers, we will continue to create new technology bases by increasing the number of researchers who take on technology areas with few technology bases and researchers.

5.1.3.3. Creating the human base

What is needed first in JMOD's R&D is personnel of the JMOD's technology side. The JMOD’s technology side is composed of civilian officials, technical officials, JSDF personnel, and so on. Diverse personnel, including approx. 600 technical officials for a career in research who are professionals in technological fields, play a variety of roles with their respective expertise. However, the security environment and the STI trend are now rapidly changing, and it is becoming difficult to create effective outcomes just by continuing the same R&D activities as the conventional ones. Therefore, the way itself of carrying out operations also needs to be reviewed. We need diverse personnel, such as civilian and technical officials who plan technology policies to achieve the goals of this guideline and smoothly and effectively carry out administrative affairs, and JSDF personnel who know JMOD/JSDF’s warfare well, in addition to researchers who look into research studies thoroughly in their field of expertise, engineers who have the ability to come up with ideas to create new functions, equipment, and capabilities in order to defend our nation at all times with flexible ideas, and engineers with project management skills to manage large-scale R&D in a timely and appropriate manner and create maximum outcomes to achieve the concepts. In order to assign personnel in diverse roles in a flexible and timely manner to the sides that needs, the efforts to utilize and recruit human resources will also be actively made, including further strengthening of human

resource development as well as expansion of experienced recruitment and personnel exchanges outside the ministry.

In utilizing R&D resources outside the ministry as described above, it is the human resources that are the core and determine the success or failure of projects. To effectively cooperate with R&D personnel outside the ministry to achieve outcomes, the needs you seek outside the ministry will be clearly indicated, such as the capabilities that JMOD expects from personnel outside the ministry and the roles you want them to play, and an environment to receive cooperation from a wide range of human resources will be built. In addition, R&D personnel necessary for JMOD will be explored while utilizing connections with new industries, research institutes, and universities that are established through the Innovative Science & Technology Initiative for Security.

5.2. Nurturing

To create functions and capabilities necessary to defend our nation at all times, it is necessary to quickly and steadily nurture the technological buds necessary to achieve them and implement the outcomes as functions and capabilities to defend our nation at all times. To this end, it is necessary for JMOD ourselves to nurture technologies, while receiving cooperation from outside of JMOD. In addition, as a member of the government, it is also necessary to take the perspective of nurturing technological capabilities of Japan.

For this reason, the following three means of nurturing will be promoted: Nurturing alone, Nurturing with those outside the ministry, and Nurturing Japan's capabilities of STI. On this occasion, when determining technology areas to nurture, together with whom and what means should be used to nurture them will also be made concrete in consideration of the security situation, the domestic and foreign technological progress, and the STI investment status in the public and private sectors at the time, as well as the characteristics of individual technologies.

5.2.1. Nurturing alone

Conventionally, R&D for the defense purpose is peculiar and JMOD itself has implemented projects to nurture defense technologies with the cooperation of partners outside the ministry, including defense related industries, after planning projects and securing budgets. These projects need to be continued in the future. However, since various sciences and technologies are currently creating new warfare, it is difficult to create functions and capabilities that can respond to such new warfare just by nurturing defense technologies in the same way as in the past. For this reason, we will not only follow the conventional experience in R&D of equipment but also explore new technologies to be nurtured and also actively take new approaches that are different from the conventional R&D means.

One of new approaches is to conduct challenging research. When a difficult-to-achieve challenging goal is set in R&D, great outcomes are obtained if it is successfully achieved. On the other hand, since it is challenging, it is possible that the expected outcomes may not be obtained within a scheduled time frame. With the emphasis on delivering expected outcomes within a scheduled time frame, conventional R&D focused on setting sound goals, making plans, and steadily implementing them. However, we will also recommend challenging research based on free thinking that can break out of stereotypes in the future and then create R&D mechanisms that can accept unanticipated technological risks, such as a failure to achieve expected outcomes.

We will nurture necessary technologies by combining various R&D means, such

as these efforts, the Innovative Science & Technology Initiative for Security, and bridging research between basic research and practical applications, and link resulting outcomes to innovations in the defense field.

5.2.2. Nurturing with those outside the ministry

It is important that JMOD itself nurtures technologies, its resources are limited. In addition, JMOD's R&D investments is just a small part of Japan's government-wide STI investments. Under these circumstances, JMOD must not only conduct R&D on its own but also actively utilize various scientific technologies outside the ministry in the defense field in terms of effective investments. However, R&D outcomes created outside the ministry are intended to achieve the civil purpose set by the respective R&D implementers and do not always match the JMOD's purpose. To effectively utilize outcomes of R&D with such different purposes for the defense purpose, it is necessary to indicate defense needs in the early phase of R&D and then have a thorough discussion with relevant ministries and agencies and R&D implementers, such as research institutes and industries, on what should be the best way to utilize R&D outcomes together. To this end, we will clearly and actively communicate the defense needs, which has not been done adequately in the past due to its self-prescribed R&D approaches. As the conventional equipment market is peculiar in that the shape is determined almost exclusively by JMOD/JSDF's needs, both JMOD and related industries kept a close eye on that peculiar market but did not pay enough attention to technologies outside of the market. In the future, we will create an environment that facilitates participation in JMOD's R&D projects to develop new partners in R&D and promote networking and expansion among researchers by striving to communicate concrete information on the direction of JMOD's efforts in order to nurture technologies with diverse stakeholders, including areas that are not related to equipment.

To effectively utilize R&D resources outside the ministry to nurture technologies, it is also necessary to actively introduce proposals from industries and others. We will figure out the question, "What areas are industries and others currently focusing on for R&D and what technological challenges are they trying to overcome?" as JMOD and, based on our own needs as well, nurture technologies together with those outside the ministry by actively looking for those who can share our goals and objectives and exploring cooperation opportunities. On this occasion, it is also necessary to create incentives to encourage industries and others to participate in activities to nurture technologies on a continuous basis without difficulty. We will also establish the sustainable ecosystem as JMOD that enables to reward industry's efforts and nurture their businesses.

In addition, JMOD itself will actively access R&D resources outside the ministry and create an environment where R&D resources outside the ministry can easily access JMOD. This will fuse the defense sector and the non-defense sector, which makes the new chemical reaction through mutual interaction, nurturing technological solutions based on ideas that are different from the past. To this end, JMOD will first communicate the functions, equipment, and technology needs necessary for JMOD outside the ministry in a clear and understandable manner in order for others to understand JMOD. In addition, we will ask industries, research institutes, etc. to share their technological seeds that could solve the defense needs, determine the areas where chemical reactions should occur together with those outside the ministry, match the needs and seeds, and work together to examine ways to solve issues. In this way, in order for the defense needs to be understood also by stakeholders, we will clarify what to aim, what to do, and what issues need to be solved as JMOD, and

share them with stakeholders, providing open innovation and effectively nurturing technologies with those outside the ministry by working on R&D toward the same goals and purposes, including diverse R&D implementers who have had little to do with the defense field.

In nurturing technologies, it is necessary to maximally utilize Japan's STI capabilities as well as use those of foreign countries. We will analyze the advantages and disadvantages on both sides together with allies, like-minded countries, etc. who can achieve the same goals, complement each other technologically and economically from a strategic perspective, and plan and implement international joint projects that can achieve win-win outcomes.

In planning international joint projects, strategic considerations shall be made in light of needs, trends, etc. that can be obtained by participating in a framework for promoting international innovation. Note that in cooperation with foreign countries, it is also important to attempt to strategically establish human networks and to understand the differences in the systems (preservation, intellectual properties, contracts, budgets) etc. between the partner countries and Japan with regard to R&D.

5.2.3. Nurturing Japan’s capabilities of STI

JMOD's R&D is conducted for the purpose of defending our nation’s peace and independence and continuing to maintain the national security and its outcomes also contribute to raising Japan’s capabilities of STI. From the broad perspective of addressing global issues, it is also important to know that we will conduct various R&D projects and nurture Japan’s capabilities of STI.

In this regard, the Innovative Science & Technology Initiative for Security plays an important role. This program plays the role of expanding the human resources that conduct not only academic research but also use-inspired basic research, and makes investments in the technology areas which are unlikely to be invested from the private sector. By conducting this program, we continue to foster various researchers, explore new frontier of research areas, establish and reinforce human network in emerging research areas to expand the range of STI capabilities.

5.3. Understanding

5.3.1. Understanding cutting-edge technologies, innovative technologies.

Major countries intensify competition in R&D of science and technology, and a variety of science and technology are being created every day in many different places. These sciences and technologies are also changing the very nature of society itself, including the way people work and live as well as the way people connect with one another. To respond appropriately to such rapid advances in science and technology, it is necessary to exactly know the latest status of various sciences and technologies, including where and how they are being created.

Over the years the JMOD's technology side has accumulated knowledge, such as about defense technology trends in other countries and defense technologies necessary to provide equipment. On the other hand, there have been issues, including the fact that a broad understanding of the sciences and technologies created in the private sector has not always been sufficient. In the future, we will exactly understand the latest status of science and technology, such as the technological trend in domestic and international private sectors, the status of industries including start-ups and venture companies in Japan, cutting-edge technologies and innovative technologies in research institutes, academia, etc., and R&D projects and their outcomes to envision how these can be utilized in terms of reinforcement of defense technology bases.

5.3.2. Understanding and notifying the role of technology in terms of security

Various sciences and technologies, particularly those not previously used in the defense-related and defense fields, are being used in actual battlefields. In particular, rapidly advancing information-related technologies have increased the potential for the expansion of information warfare and so on through the spread of disinformation or by other means. In light of these changes, it is necessary for JMOD/JSDF to accurately forecast how various sciences and technologies will affect the defense-related and defense fields, and to consider what JMOD/JSDF should do in the future to defend our nation at all times.

We will determine the facts precisely and quickly, such as how various sciences and technologies are being used in actual battlefields, how new sciences and technologies will be used in the future, how the results change the security environment and our national defense in order to take necessary measures as JMOD. To this end, we will make maximum use of the knowledge of JMOD's engineers, who have technological expertise. Engineers, who belong to JMOD, have diverse areas of expertise. We will foresee the role of technology in terms of security and defense while collecting and summarizing their respective knowledge to cover a wide range of technology areas. In addition, we will foresee not only the future based on our past experience and knowledge in the defense field but also flexibly think how various sciences and technologies can and should be used in future battlefields to exercise our capabilities as a professional group of diverse engineers and other professionals while exchanging opinions with operators and others, and make judgments to determine the impact of technology on security and defense.

The judgment results will be appropriately translated from both defense and STI perspectives and made known to all concerned. We will present what functions and capabilities will be provided by new technologies to defend our nation at all times and what effect the outcomes will have on operational fields in an easy-to-understand manner to policy makers and the operational side within the ministry and promote their understanding. From the STI perspective, we will transform the nature and role of technology into each other, such as what kind of technology the JMOD needs and what technological solutions can be provided to meet JMOD/JSDF's needs by sciences and technologies that exist in the private sector, and present in a way that is easily understood even by STI communities. Through these efforts, we will translate bidirectional needs and seeds for mutual matching for further utilization of science and technology from both defense and STI perspectives, such as how issues in the defense field can be solved by technology and what kind of technology should be nurtured in what way, and stimulate discussion on what should be done in the future as JMOD/JSDF and also as a member of an STI community.

5.3.3. Notifying those outside the ministry of JMOD's efforts

To have the understanding and cooperation of those outside the ministry regarding JMOD's efforts, it is necessary to actively explain what JMOD is doing regarding technology, what the purpose is, what effect they have in terms of defending our nation, etc. to those outside the ministry.

To this end, we will actively send the messages through a variety of media about the implementation status of JMOD's efforts. We will actively send the messages to outside the ministry about what kind of outcomes our R&D projects have achieved, for example, by sending videos of the latest R&D status, including what kind of prototypes are currently made and what kind of tests are conducted with the prototypes.

In addition, we will share our plans and future forecasting results of JMOD's R&D

projects with those outside the ministry as much as possible while taking care not to excessively expose the JMOD/JSDF's cards. Through these efforts, we will improve the predictability of stakeholders regarding concrete projects and technology areas in which to invest, establish an environment that allows for participation in JMOD's projects on a continuous basis without difficulty, and promote involvement in R&D projects in the defense-related and defense fields as well as actively planning and announcing projects etc. that can be business opportunities for industries etc.

6. Conclusion

Since a new national security strategy of Japan or other strategies are formulated, the relationship between the national security and STI in Japan will undergo significant changes. A paradigm shift has occurred, whereby the national security, science and technology, and innovation, which have previously been considered as mutually independent elements in Japan, are now treated as a unity. In response to this, we will promote harmony between national security and STI as the organization which can build a bridge between these policies. We will realize the ends of this guideline through achieving 1st and 2nd pillars with various efforts of creating, nurturing, and understanding by breaking away from conventional thinking.

Note that this guideline shall be reviewed when necessary while keeping in mind the rapidly changing security environment and rapid progress in science and technology surrounding Japan in consideration of policy requirements, operational needs, changes in technological trends, and so on.

Attachment: The important technology areas to defend our nation at all times

The important technology areas to defend our nation at all times (hereinafter referred to as the important technology areas) are determined here. Over the next 10 years and further ahead, the important technology areas include both the technology areas that should be acquired through JMOD's own investments and the technology areas to be acquired under the cooperation between the public and private sector in order to ensure technological superiority in the future to acquire advanced capabilities ahead of other countries. In addition, for the important technology areas that lead to accelerated delivery of functions and equipment, JMOD will introduce them in a timely manner for reinforcement of the defense capability.

In determination of the important technology areas, as shown in Figure 3, we first examined the areas we should gain superiority to defend our nation at all times, determine what functions and capabilities are needed to achieve it, and then make what technology areas are needed concrete by breaking down into the technical areas necessary to achieve it.

By nurturing these important technology areas, we will create new functions and capabilities that contribute to the future activities of JMOD/JSDF and are not an extension of conventional equipment. Note that the important technology areas shall be reviewed when necessary in consideration of the situation, such as advances in science and technology and changes in the security environment.

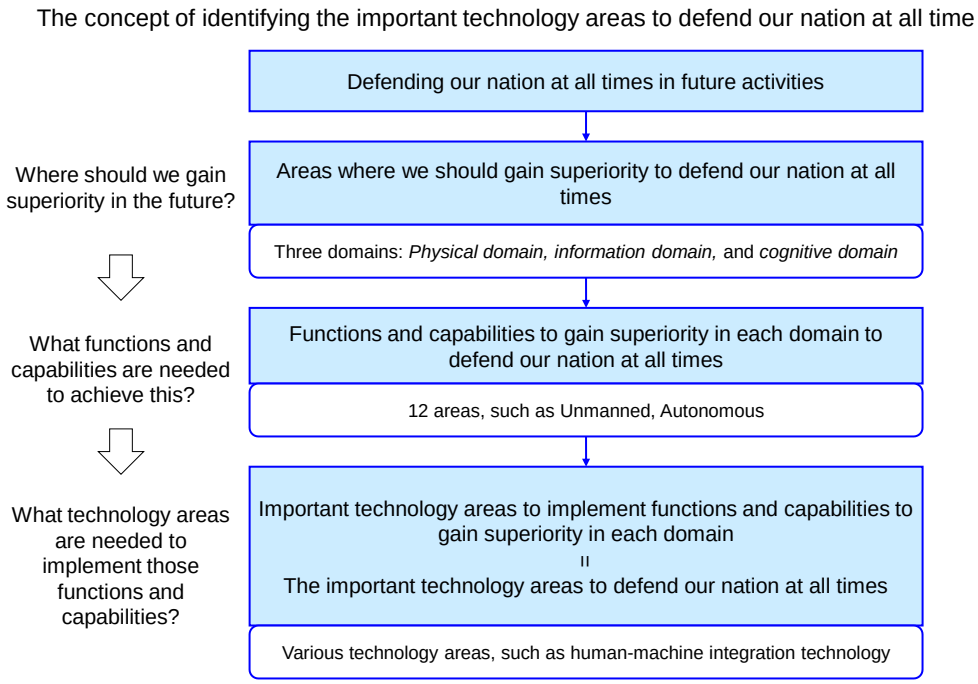

Figure 3: The concept of important technology areas to defend our nation at all times

In order to go beyond ideas that are an extension of conventional ones, it is necessary to break through the common sense and the limitations in the past. To this end, it is also necessary to take approaches of pursuing new functions and capabilities in such a way as not only to have the idea of R&D just to meet requirements but also to deeply see through the meaning in terms of security of various advanced technologies exploring new applications as well as bringing it close to the theoretical value based on physical phenomena as much as possible.

At this point, however, pursuing functions and capabilities that have no technological solutions at all just results in fantasy.[5] Therefore, when breaking down functions and

[5]For example, "a time machine" is just a fantasy at present as the principles and theory themselves to achieve

capabilities into technology areas, the minimum requirement shall be that the technological feasibility has been confirmed (e.g., at least the principles or theory have been discovered and confirmed).

First, we break down the functions and capabilities to defend our nation at all times in future activities into three technology areas that are important to realize these functions and capabilities. We assume Physical domain, Information domain and Cognitive domain as the areas to gain the superiority. Physical domain indicates the domains of land, sea, air, and space. Information domain indicates the domains where the success or failure of activities depend on the superiority or inferiority of information, including cyber and electromagnetic domains. The Cognitive domain indicates a new activity domain that consists primarily of the cognition (such as perception, judgment, imagination, logic, reasoning, decision-making, memory, and language comprehension) of commanders and staff members, and that the success or failure of activities depends on the superiority or inferiority of cognition.

From these three areas we derive the important functions and capabilities to gain the superiority in the physical domain, the important functions and capabilities to gain the superiority in the information domain and the important functions and capabilities to gain the superiority in the cognitive domain. As the results of this process, we derive 12 areas of the important functions and capabilities to defend our nation at all times as shown in Figure 4. In this case, since there are functions and capabilities across the three domains, they are treated as cross-domain functions and capabilities. In this attachment, we show examples of the important technology areas by breaking down these functions and capabilities into necessary technology areas. The concrete technologies shown here are just for reference and not limited to these technologies. For acquisition of future functions, capabilities, and technologies, we will identify various technologies and create new functions and capabilities that are not an extension of conventional ones and contribute to future activities, including technologies that JMOD did not know, with the goal of achieving functions and capabilities necessary to defend our nation at all times without being restricted by the technologies illustrated here. In addition, we will make investments to continuously maintain and strengthen base equipment technologies, including measurement, processing, and testing technologies, which are indispensable in R&D.

time travel have not been discovered or confirmed.

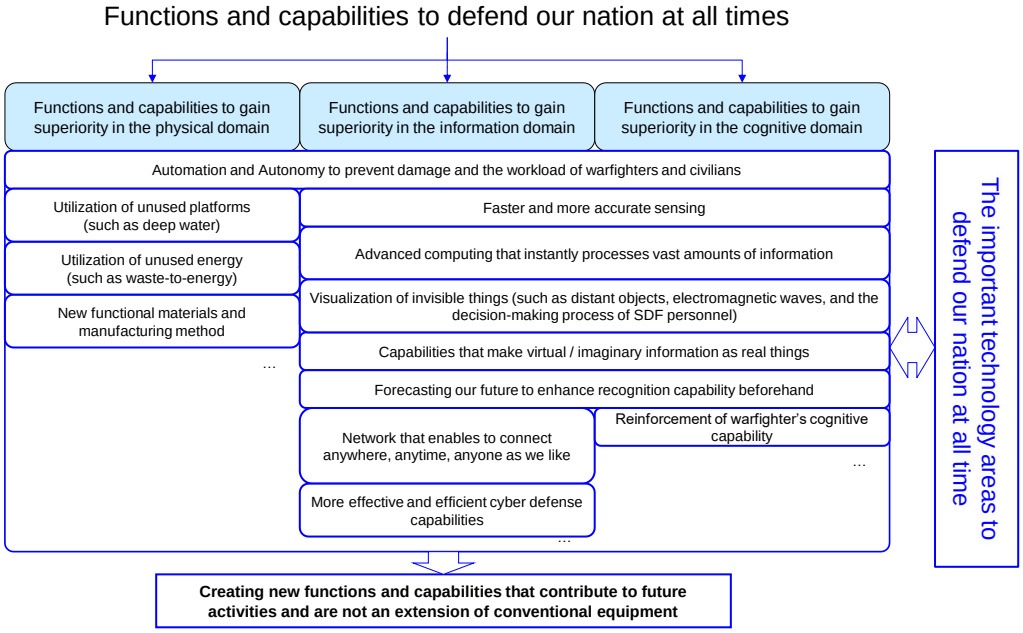

Figure 4: Important functions and capabilities to defend our nation at all times

1. Functions and capabilities to gain superiority in the physical domain and technology areas necessary to achieve them

Activities in the physical domain are the basis for all JMOD/JSDF activities. Therefore, functions and capabilities to gain superiority in the physical domain have been maintained and developed over a long period of time. However, in light of changes in the security environment, it would be becoming increasingly difficult to gain superiority when simply developing these functions and capabilities as an extension of the conventional common knowledge and equipment.

From the perspective of pursuing efficient and effective acquisition of these functions and capabilities, we shall actively explore functions and capabilities necessary for activities that take geographical advantages as the defense side of our homeland and functions and capabilities that can be effectively utilized only for activities on the defense side while keeping in mind that the limitations of our homeland and national conditions can be turned into advantages in our activities.

Among the functions and capabilities necessary for activities that take geographical advantages and the functions and capabilities that can be effectively utilized only for activities on the defense side are, for example, functions and capabilities necessary for activities that take advantage of the long ocean lines and deep surrounding ocean areas as well as functions and capabilities necessary for activities that take into account the difference in available energy between the defense side and the offense side. We, as the defense side, are in operation near large infrastructures, such as an electric power facility, whereas the offense side are approaching from afar to the periphery of our country with limited energy available. To take advantage in our activities, it is also necessary to focus on the asymmetry. In addition, it would be possible that we break through various limitations, such as energy supply, safeguarding, and continuity of activities by fixing equipment that is not designed to be moved, allowing activities that go beyond the limitations in the past.

1.1. Automation and Autonomy to prevent damage and the workload of warfighters and civilians

The most important element to defend our nation at all times is people. Under the

circumstances where the population declines, especially the productive-age population declines, localizing the burden and damage is extremely important to defend our nation at all times. Also, under the circumstances where the boundaries between the defense emergencies and gray zones and the peacetime become blurred, localizing incidental impacts on other than SDF personnel also become important in new activities. These functions and capabilities are important to gain superiority not only in the physical domain but also in the information and cognitive domains.

[Making unmanned and autonomous to reduce the burden on humans]

For a technological trend in the world, research to reduce the burden on humans by making activities previously carried out by humans unmanned and autonomous is being accelerated, just as the automated driving technology for automobiles is developing rapidly. Actively introducing these technologies into our activity sites makes it possible to reallocate human resources that have been spent on activities that can be unmanned or autonomous to activities that can be carried out only by humans. To this end, the degree of human interventions should be set appropriately according to the nature of the activity to be unmanned or autonomous. For example, when conducting activities that affect human safety, critical decisions should always be made by humans, not by machines, it will also be necessary to take measures to ensure that unmanned and autonomous operations will not have adverse effects in such a way as to conduct managements. In this way, in terms of appropriate human interventions in unmanned and autonomous operations, it is also necessary to not only simply make systems unmanned and autonomous but also improve the capabilities of SDF personnel themselves to ensure that SDF personnel involved in and managing unmanned and autonomous systems are able to fulfill their roles appropriately, and that machines are able to understand the intentions of SDF personnel and their priorities in decision-making and that SDF personnel is able to understand the intentions of machines.

[Making unmanned and autonomous to reduce the damage to humans]

Our activities may take place in dangerous places where safety is not ensured. In such case, if SDF personnel do not go directly to such a dangerous site but have machines and other equipment act on their behalf, damage to the SDF personnel can be reduced. In addition, when the quality of activities of machines and other equipment can be improved, it will be possible to have them perform their activities more carefully, safely, and accurately than humans and, as a result, it will also be possible to carry out activities while minimizing the impact on those other than the SDF personnel and even on the surrounding environment.

[Making unmanned and autonomous to expand the scope of activities]

There are limits to the environments where we can act. For example, humans cannot act for long in high-temperature environments and cannot step into high-pressure environments in the first place. If it is possible to utilize unmanned and autonomous machines and to step into special environments that exceed the limits of humans, it will be possible to expand the scope of activities. This is not simply a matter of replacing humans with machines, but of pioneering new functions and capabilities that could not be achieved by humans. To expand the scope of activities with unmanned and autonomous machines, it is necessary to make the machines that can operate beyond the limits of humans autonomous to respond appropriately even in unexpected scenes and to organically link humans to the machines so that they can operate effectively and safely. To establish organic cooperation with humans, it is important to convey human intentions to machines instantly, accurately, and appropriately.

From this perspective, it is necessary to create new technologies, such as for making unmanned and autonomous to reduce the burden on humans, to reduce the damage to humans, and to expand the scope of activities, to provide unmanned and autonomous systems that localize the burden and damage to SDF personnel while also localizing the collateral impact on others.

Among the important technology areas to achieve them are, for example, the Human Machine Interface/Interaction technology, man-machine communication technology, avatar control technology, and the Brain Machine Interface (BMI) technology.

1.2. Utilization of unused platforms

The conventional platforms, such as vehicles, vessels, and aircraft, are expected to continue to play an important role in high-intensity activities. On the other hand, there is a strong possibility that the conventional platforms will not be useful in new activities where the conventional norm may no longer be available due to utilization of various technologies or other reasons. In order to defend our nation at all times even in these new activities, we need to think outside the box of platforms.

[Platforms in areas where we have not been able to work sufficiently so far]

There were also areas within the land, sea, and air domains where they could not operate freely enough in the past. For example, they did not have enough freedom of activity in the water due to various limitations. Underwater, since electromagnetic waves generally propagate less easily than in the air, there are limits to radio communication by radio waves and observation of the surrounding area by radar, cameras, etc. and, due to water pressure, the deeper the water, the severer its effect, making it difficult to conduct activities freely without overcoming these limitations. Also in the space domain, there are still various restrictions even though its utilization continues to expand. Therefore, it is also necessary to create new platforms for free activities in these areas.

[Platforms in areas that we have not focused on so far]

In the past, most of equipment has been designed to be mobile with the goal of having them perform a variety of activities in a variety of locations. However, from the perspective of defending our homeland, there could be fixed equipment that is not moved. Fixation allows for larger size, and infrastructures or other facilities built in Japan allows for sustainable activities by providing a constant supply of resources necessary for activities, e.g., electricity. By allowing for this immovability, we can expect to create new functions that could not been provided before. It is also necessary to think in terms of utilizing existing infrastructures, such as power systems, transportation infrastructures, and telecommunications infrastructures as part of platforms to enable more efficient and effective activities. If fixed equipment and infrastructures can be further utilized, it will be possible to provide platforms with completely different concepts than before. For example, it may be possible to provide new functions and capabilities on a completely different platform than before, such as the formation of barriers to attenuate shock waves, etc., using electric and magnetic fields generated by large electric power, and the utilization of high-energy particles that can only be generated in large facilities.

From this perspective, it is necessary to create new technologies, such as the utilization of platforms in areas where we have not been able to work sufficiently so far and platforms in areas that we have not focused on so far.

Among the important technology areas in achieving them are, for example, the underwater navigation and communication technology to operate freely underwater with various limitations, the long range and long time navigation to operate quickly and freely in the physical domain, the space navigation technology, high mobility propulsion

technology, propulsion supply, responsive satellite launch, automation, autonomy and distribution of satellite operation to operate efficiently and effectively in outer space, fixed equipment technology that takes Japan's geographical advantages, insect-sized microrobot technology, and barrier technology that attenuates shock waves using electromagnetic waves, etc.

1.3. Utilization of unused energy

Various types of energy play an important role in various aspects, such as by being the source of all kinds of activities and having an effect by projecting energy directly at an opponent. In particular, for a source of power for unmanned aerial vehicles and as a means of having new effects, as typified by high-power lasers, it is necessary to consider the utilization of technology in a different way than extensions of conventional ones.

[Energy generation]

If energy can be created from a completely different source of energy from conventional fossil fuels and batteries in such a way as to obtain fuel from the atmosphere, the need for refueling and recharging will be eliminated, allowing us to dramatically expand the scope of activities.

[Energy storage]

Unmanned aerial vehicles are currently powered by fossil fuels, batteries, etc., but their scope of operation and duration of operation are limited by the capacity of the fuel and batteries. If there are more efficient internal combustion engines and batteries than previously available, it is possible to extend the scope and duration of operation.

[Energy projection]

As a new way to utilize energy, energy projection by high energy lasers and high energy microwaves is being realized. They can have an effect on an object (e.g., melting and welding of metal) by concentrating and projecting energy. Currently, energy is projected by electromagnetic waves, such as lasers and microwaves, but if energy can be loaded more efficiently, the effect would be even stronger.

Furthermore, if it becomes possible to project energy into the distance by a medium other than electromagnetic waves, it may be possible to create a completely new effect. Note that some effects described here have an effect on an opponent by direct physical action, whereas some have an effect on the function of electronic circuits etc. by electromagnetic action on them, producing an effect on the function.

[Peripheral elements necessary for utilization of energy]

Utilization of energy requires elements to control it. For example, switching (ON-OFF control) elements and elements for generation of electromagnetic waves (e.g., laser oscillation) are necessary to utilize electric power energy. If these elements can support higher voltages and larger currents, much stronger effects can be utilized.

In addition, cooling functions are also important for utilization of energy. When using a large amount of energy, the heat generated as loss is also large. Therefore, if the heat cannot be cooled efficiently and effectively, the system does not perform as it should, and it may also cause damage to elements and other components. For this reason, it is also necessary to manage heat appropriately by cooling.

From this perspective, it is necessary to create new technologies, such as for "Energy generation," "Energy storage," "Energy projection," and their peripheral elements in order to utilize energy for activities that go beyond conventional common sense.

Among the important technology areas to achieve them are, for example, the energy generation technology that can use conventionally unfit materials as fuel, such as garbage, the high-efficiency, high-power energy generation technology, such as power generation systems with ultra-compact gas turbine engines, high-capacity battery technology, highly-safe battery technology, high energy laser technology, and high-power micro wave technology.

1.4. New functional materials and manufacturing method

When acquiring materials and new manufacturing means that achieve functions and capabilities that go beyond the norm of the past, it is also necessary to fundamentally strengthen equipment and capabilities of JMOD/JSDF.

[Materials with functions and capabilities that have never existed before]

For example, if a material with a theoretically perfect microstructures could be achieved, it could be one to two orders of magnitude stronger than those currently in practical use. In other words, if theoretical perfection could be achieved, we should be able to provide materials with capabilities that are orders of magnitude greater than ever before. It is extremely difficult to achieve this, and hence many researchers are conducting research to pursue theoretical values, overcoming various restrictions. Also, in our R&D, it is necessary not to assume that it is normal that the theoretical values cannot be reached, but to also promote R&D with the aim exceeding the normal.

In general, if a force acting on a material exceeds its strength, the material is destroyed and cannot be restored. However, if we can overturn this common sense and restore the destroyed material to its original form by some means, we can create very significant advantages in terms of sustainability and toughness of our activities. In addition, if materials can be repaired, activities can be maintained without the need to supply new parts or replacements, which drastically reduces the burden of supply and maintenance and fundamentally changes the way of our activities. It is also necessary to create materials that overturn such conventional common sense.

[Manufacturing means for new functions]

The additive manufacturing technology, as typified by 3D printers, has made it possible not only to easily create various objects, but also to create objects that could not be achieved by conventional manufacturing means, such as metal structures with complex micro-piping inside, allowing us to create objects that can create new functions. Although materials applicable to additive manufacturing are still limited, the scope of application continues to expand. If R&D is conducted to expand the range of materials applicable to additive manufacturing and to create completely new manufacturing technologies that are not limited to the additive manufacturing technology, it is expected that new functions that have never existed before can be created.

From this perspective, it is necessary to create new technologies, such as for materials with functions and capabilities that have never existed before and manufacturing means for new functions, in order to provide materials that create new functions and capabilities as well as new manufacturing means.

Among the important technology areas to achieve them are, for example, the self-repairing functional material technology that can repair damage itself with time and the additive manufacturing technology using various materials that can manufacture microstructures and complex structures that could not be achieved with conventional manufacturing means.

2. Functions and capabilities to gain superiority in the information domain and technology areas necessary to achieve them

To know the enemy and know yourself, information is essential. Particularly in JMOD/JSDF operation, it is necessary to improve as much as possible, both in terms of quality and quantity, both in obtaining information about yourself and in obtaining information about the enemy. From a technological perspective, the information-related technologies are dramatically growing areas compared to other technological areas and the use of these technologies is especially important to defend our nation at all times.

Activities, such as taking our advantages and compensating for our disadvantages, as well as changing the situation to be advantageous for us and changing the situation to be disadvantageous for the enemy, are necessary in the information domain as well, and it is important to clarify necessary functions and capabilities, and acquire technologies that can achieve them.

All functions and capabilities to gain superiority in the information domain and technology areas necessary to achieve them except those common to the physical domain are described below.

2.1. Faster and more accurate sensing

Sensing technologies to obtain information are fundamental functions and capabilities to perform various activities. Faster and more accurate sensing leads to more effective and efficient activities. These functions and capabilities are important to gain superiority not only in the information domain but also in the cognitive domain.

[Sensing indispensable in operational fields]

In operational fields, PNT[6] is important. Accurate PNT is the reference for various operations. In particular, accurate timing is a fundamental element that leads to accurate positioning and accurate navigation, and the accurate timing can improve various capabilities in operational fields.

[More accurate sensing than ever before]

Accurate sensing and understanding of all elements (such as humans, things, environments) that appear in an operational field is the first step for effective activities, which leads to a series of processes, such as the assessment of the situation, decision-making, and action. Although many of these sensing methods have already been established, technologies that change the physical size and the size (apparent size) at the time of observation, such as stealth technologies, are also advancing, and sensing is no longer based solely on the existing common sense, such as radars for aircraft.

In light of such environmental changes, it also become possible to sense various elements with high precision by capturing minute environmental changes that have not been captured by conventional sensing technologies, such as respiration of humans, gases emitted from vehicles, hot water discharged from ships, and elementary particles flying around the earth.

[Sensing that have never existed before]

As technological advances continue to expand the scope of activities, it is also necessary to establish sensing technologies in environments where measurements have not been made with conventional technologies. For example, functions, such as for sensing an object outside from a sensor built into a container exposed to high temperatures or for sensing invisible electromagnetic waves over a wide range and wide bandwidth, cannot be achieved only by combining existing technologies but also requires the establishment of new measurement methods or other means.

[6] PNT: Positioning, Navigation, Timing

[Peripheral elements necessary for utilization of sensing information]

To obtain as much information as possible with high accuracy through sensing, it is also necessary to fuse and integrate multiple sensing data of different type, for example, sensing results by light or by radio waves, and perform advanced processing to obtain information that cannot be obtained from a single sensing result.

From this perspective, it is necessary to create new technologies, such as for sensing indispensable in operational fields, more accurate sensing than ever before, sensing that have never existed before, and their peripheral elements.

Among the important technology areas to achieve them are, for example, the quantum sensing technology, the sensing technology that enables measurement in various environments (e.g. at high temperatures and/or high pressures) where measurements have not conventionally been impossible, and the sensing data fusion and integration technology that fuses and integrates multiple sensing data to achieve even more advanced sensing.

2.2. Advanced computing that instantly processes vast amounts of information

The shift to operational fields based on information and IoT has made it is necessary to handle a vast amount of information in the operational fields, which has not previously been unforeseen, but an excessive amount of information can, in some cases, confuse the SDF personnel in the fields. To avoid this, functions and capabilities are also needed to process a vast amount of information instantly and put it into a form that is easily understood by SDF personnel. To this end, it is necessary not only to wait for the gradual improvement in capability of conventional computers, but also to create new information processing and computing technologies or other means. These functions and capabilities are important to gain superiority not only in the information domain but also in the cognitive domain.

[Quantity of data processing]

It is now commonplace to use big data to create new values by accumulating a large amount of information beyond the scope of human processing, which is observed and obtained by various devices or by other means, and by analyzing the information. However, in our activities, a large amount of information that could be called big data has not been sufficiently accumulated. Therefore, it is necessary to first collect and summarize a large amount of information and then utilize the information as something valuable. When we obtain and accumulate highly accurate information in all our activities and further incorporate big data from the private sector, the amount of information will be enormous. However, the communication infrastructures may be minimal, and in such a case, it is also necessary to communicate such a vast amount of information with ingenuity. In light of these characteristics, limitations, or other factors, which are different from those in utilization of big data in the private sector, it is necessary to consider the utilization of information processing technologies.

[Speed of data processing]

In our operational fields, we always need to consider the next activity based on the latest situation and it is very important to produce results of information processing in real time. Until now, humans have made decisions with limited information in real time, but now that it is technologically possible to obtain information beyond the scope of human processing, and it is necessary to accelerate the speed of processing so that a wide variety of information can be processed in real time.

[Quality of data processing]

To process a large amount of information and produce useful results for our operations, it is also necessary to improve the quality of information processing. One way to achieve this is to improve the quality itself of the information to be processed, but another way would be to process multiple pieces of information in an integrated manner to improve the quality of the information. In addition, as the quality and quantity of information that exist individually are limited under the constraint of communication means etc., it is necessary to create new means of producing high-quality processing results from a small amount of information and of integrating information in an efficient and effective manner.

From this perspective, it is necessary to create new technologies, such as for quantity of data processing, speed of data processing, and quality of data processing, in order to achieve computing for instantaneous processing of a vast amount of information.

Among the important technology areas to achieve them are, for example, the edge computing technology that does not send a large amount of data directly to the network but performs advanced data processing in the vicinity of sensors and sends only the minimum necessary data to the network, the quantum computing technology that processes complex operations dramatically faster, and the highly-distributed computing technology that speeds up processing by distributing information processing capacity rather than centralizing it.

2.3. Visualization of invisible things (such as distant objects, electromagnetic waves, and the decision-making process of SDF personnel)

Until now, JMOD/JSDF has visualized the circumstances in and around Japan through various activities and the utilization of various assets, but it has been common knowledge that the scope of such visualization is limited to the area covered by radar and other intelligence-gathering assets or to places that can be directly reached.

If we can go beyond these limits and visualize previously unseen areas, such as objects on the other side of the earth, invisible electromagnetic waves, and even the decision-making process of SDF personnel, we can advance our capability "To know the enemy and know yourself." These functions and capabilities are important to gain superiority not only in the information domain but also in the cognitive domain.

[Visualizing beyond physical limitations]

So far, we have been able to visualize the circumstances only in the areas covered by our assets and where we can go directly. However, it was difficult to visualize areas where signals could not be physically captured, such as distant areas where signals, including radio waves and light, could not reach. If we can visualize what has been physically difficult to visualize due to these distance limitations, we will be able to further advance our operations.

[Visualizing non-physical phenomena]

Unlike quantitative information transmitted from observation equipment, information flowing through social media contains many human thoughts. By analyzing such information, it may be possible to visualize something that is not a physical phenomenon, such as what people are thinking, what people want, and what issues people want to solve. Analyzing various qualities of information may also make it possible to discriminate between accurate factual information and inaccurate fictitious information. If we can visualize such non-physical phenomena, we will be able to make correct decisions based on correct information, which in turn will further improve the quality of our operations.

[Visualizing what cannot be directly observed]

It is conceivable that by performing various processing and analysis procedures on the information that has been obtained so far, new information that has been

invisible may be found indirectly. In particular, now that information-related technologies have evolved dramatically and a large amount of information is distributed in various forms, there is a possibility that what has been invisible will become visible through summarization and analyses of big data, including information that has not conventionally been utilized for the security purpose. For example, technologies for estimating the flow of people by analyzing radio waves from cell phones are already in practical use, and this is considered to be one method of visualizing the flow of people, which is another type of information that has been invisible until now, from radio waves from cell phones.

From this perspective, it is necessary to create new technologies, such as for visualizing beyond physical limitations, visualizing non-physical phenomena, and visualizing what cannot be directly observed.

Among the important technology areas to achieve them are, for example, the quantum illumination technology that can lead to the detection of targets that have not been found until now because they have been buried in noise, the elementary particle detection technology that makes use of the ability to pass through even the earth, the Internet information analysis technology that extracts accurate facts or other data from public information circulating on the Internet that is not known to be true, and the big data analysis technology that utilizes artificial intelligence or other technologies.

2.4. Capabilities that make virtual / imaginary information as real things

Even if a vast amount of information is obtained, it cannot be utilized if it is not well communicated to the commander or others. Information can also be useful or a confusing element, depending on how it is communicated. Information is only effective when it is accurately understood by the commander and others who receive it.

From this perspective, it is necessary for us to show all kinds of information, including invisible information, to ourselves in a form that is easy to recognize, and to show various kinds of information, including fictitious information, to the opponents in a form that is convenient for us, in order to mislead their observation activities of the situation and to confuse their behavior, in terms of ensuring our superiority. These functions and capabilities are important to gain superiority not only in the information domain but also in the cognitive domain.

[Showing information in an easy-to-understand manner]

Information is useful only when it is communicated accurately and clearly to those who use it. It is also necessary to organize and communicate complicated information. In our operations, it is especially necessary to select from a wide variety of information that should be communicated to the commander and others, and to present it in a form that can be instantly understood.

[Shows fictitious information]

It is also necessary for us to think in such a way that we can ensure our superiority by showing fictitious information to the opponents so that they misjudge the situation and prevent their intentions from being achieved. Just as we need accurate information, they need accurate information too. Under such circumstances, if we input fictitious information that is not accurate, we can confuse them. Also, depending on the input information, it is possible to move them in the way we intend.

From this perspective, it is necessary to create new technologies, such as for "Showing information in an easy-to-understand manner" and "Showing fictitious information" in order to achieve the ability to make virtual and fictitious information appear as if it were real.

Among the important technology areas to achieve them are, for example, the

metaverse technology that constructs a 3D virtual space from various information, the 3D hologram projection technology that projects images as if they were real, and the geospatial information disturbance technology that intentionally confuses the location information, such as GNSS, which is now commonplace, causing the opponents to lose their own location.

2.5. Forecasting our future to enhance recognition capability beforehand

If we can acquire a large amount of information about now and visualize it to a high degree with a high degree of accuracy, we should be able to utilize advanced information-related technologies and use the information to predict the future with a high degree of accuracy.

If we can predict the future for us and the opponents, we can prepare for future activities by developing our advantages, compensating for our disadvantages, and securing the resources needed to respond, all in advance of future activities. In addition, if the future of the opponents can be predicted, it will be possible to take preemptive action, such as by exploiting the opponents' disadvantages and avoiding the opponents' advantages. These functions and capabilities are important to gain superiority not only in the information domain but also in the cognitive domain.

[Foreseeing your future]

It is difficult to foresee exactly what future will come as a result of what action we take now. However, it may be possible to predict the future with the highest possible accuracy by combining various technologies. If we can create, so to speak, a digital twin that digitally reproduces how we make decisions and act based on what information we have for our activities, we will be able to foresee our future more accurately.

[Foreseeing opponents' future]

It is much more difficult to foresee the behavior of opponents, or others, than it is to foresee one's own future. However, if we can accurately predict the behavior of our opponents and foresee their future movements with a high degree of accuracy through technological means, we will naturally foresee our action to take for ensuring superiority over them. From this perspective, if we can establish a means to predict the behavior of opponents as accurate as possible, it is possible to use it to the great advantage of our operations.

[Foreseeing the future on both sides]

In our operations, the situation always changes relatively to opponents. If we can foresee with a high degree of accuracy how we act and how the opponents respond, we can effectively achieve our intentions with a minimum of burden. To increase the quality of our operations, it is an important factor not only to foresee our future and the opponents' future separately but also to foresee the future in terms of the mutual relationship.

From this perspective, it is necessary to create new technologies, such as for "Foreseeing your future," "Foreseeing opponents' future," and "Foreseeing the future on both sides," in order to obtain the enhanced recognition capability to get ahead of opponents by predicting future situations.

Among the important technology areas to achieve them are, for example, the advanced information processing technologies, including artificial intelligence-related technologies, the future prediction technologies utilizing a large amount of real data or other information, and the real-world digital twin technology that foresees the future and accurately simulates what will happen in operational fields.

2.6. Network that enables to connect anywhere, anytime, anyone as we like

Information obtained in operational fields cannot be used effectively unless it is

shared promptly and accurately not only within a single organization but also throughout JMOD/JSDF.

Although a network connecting required personnel has been established, it is necessary to further expand the network as a surface and create an environment where all personnel can be safely connected to anyone, anytime, anywhere, as needed.

[High-speed, large-capacity, low-latency connection]

The network should be high-speed, large-capacity, and low-latency. A high-speed and high-capacity network enables the communication and sharing of a variety of information. A low-latency network enables both parties in the process of communication to obtain the same information and give instructions without delay, which is important particularly for remote control and automated driving.

[Safe and secure connection]

In our operations, it is a very important to ensure that information communicated through a network is not leaked to third parties. It is also important to ensure that information to communicate is not tampered by third parties. From this perspective, it is necessary to provide a safe and secure network that does not allow third parties to get or touch information.

[Connection with the people you need, anytime, anywhere]

Our operations are typically carried out by a large number of personnel spread out over a variety of locations. A network needs to be established that can connect these personnel with those who need them, without location constraints and without concern for timing. This requires a network that can connect many users at the same time, a network that covers a wide range of areas, and a network for which necessary communication infrastructures can easily be built in places where they are needed.

From this perspective, it is necessary to create new technologies, such as for high-speed, large-capacity, low-latency connection, safe and secure connection, and connection with the people you need, anytime, anywhere, in order to provide a network that enables accurate and instantaneous information sharing anywhere, with anyone, inside and outside the organization.

Among the important technology areas to achieve them are, for example, the Beyond 5G technology for high-speed, low-latency communications, high capacity communication to support a large amount of data due to advances in IoT, the quantum cryptographic communication technology for accurate communications while ensuring confidentiality, the network resiliency for secure communications, the communications relay technology to enable communications anywhere, the wireless power transfer for wide area to wirelessly transmit the power necessary to operate network components, and the optical communication technology to enable high-speed, large-capacity communications by processing light as it is with minimal photoelectric conversion in communications processing.

2.7. More effective and efficient cyber defense capabilities

Attacks in cyberspace can be carried out from any route, by any means, and at any time, requiring a continuous response at all times. On the other hand, if everything needs to be handled manually, it will require an enormous amount of resources and burdens upon personnel.

To avoid this, it is necessary to achieve the capability to defend as efficiently and effectively as possible against cyberattacks carried out from any route, by any means, and anytime.

[Dealing with known attacks]

For cyberattacks by known means, methods of dealing with the attacks are

generally established. However, if it occurs in large numbers, it may not be able to deal with the volume of attacks and, as a result, may allow attacks to occur. To prevent this, R&D will also be required for technologies that can deal with attacks by known means more efficiently and effectively, and achieve a defense means that outperforms attacks. It is also necessary to do so with as few personnel as possible from the perspective of preventing excessive consumption of resources. In this way, it is also necessary to create new technologies to continue to ensure our superiority in the information domain, which may be subject to severe attacks once in case of emergency.

[Dealing with unknown attacks]

Cyberattacks by unknown means require more resources to be allocated more quickly than attacks by known means because of the need to establish a response after the attacks occur. However, continuing to allocate so many resources to deal with attacks by unknown means, which may occur at any time, means exactly that we will continue to be subject to cost imposing. To avoid this, it is necessary to establish technologies that enable earlier detection of attacks by unknown means, and to quickly move on to dealing with them.

[Prevention of damage from attacks]

The immediate action to be taken in the event of a cyberattack is to neutralize the attack as well as minimizing the damage caused by the attack. To minimize damage, it is necessary to deal with the attack while also weakening the power of the enemy's attack. To this end, it is necessary not only to deal with the enemy's attack itself but also to maintain the use of cyberspace by increasing the resiliency by means of disrupting the route of the enemy's attack, effectively disabling individual attack functions, or by other means.

From this perspective, it is necessary to create new technologies, such as for "Dealing with known attacks," "Dealing with unknown attacks," and "Prevention of damage from attacks," in order to achieve the capability to efficiently and effectively defend cyberspace.

Among the important technology areas to achieve them are, for example, the cyberattack defense technologies that efficiently and effectively respond to a large number of attacks by known means with limited manpower and limited time, the unknown attack detection and response technologies that can also respond to unknown means of attacks, and the automatic isolation and reaction of cyber kill chain technologies that disrupt attacks by any route and reduce the power of attacks by increasing our resiliency to effectively defend us.

3. Functions and capabilities to gain superiority in the cognitive domain and technology areas necessary to achieve them

This guideline assumes that the Cognitive domain is a new activity domain that consists primarily of the cognition (such as perception, judgment, imagination, logic, reasoning, decision-making, memory, and language comprehension) of commanders and staff members, and that the success or failure of activities depends on the superiority or inferiority of cognition. Then, from a technological perspective, we will consider functions and capabilities to defend the domain at all times.

In the cognitive domain, it is essential for us to increase the gap between our and the opponent's cognitive capabilities to the great advantage of our operations by increasing our cognitive capability in both quality and speed and conversely decreasing the opponent's cognitive capability in both quality and speed. Therefore, after clarifying the functions and performance required to achieve them, we will incorporate them into the

technology areas.

All functions and capabilities to gain superiority in the cognitive domain and technology areas necessary to achieve them except those common to the physical and information domains are described below.

3.1. Reinforcement of warfighter's cognitive capability

For activities in the cognitive domain, it is necessary to increase our superiority by increasing our cognitive capability and by decreasing the opponent's cognitive capability. To this end, it is necessary to reinforce the cognitive capability of each member, particularly commanders and staff members who act as the center of the cognitive domain.

[Reinforcement of personnel's cognitive capability]

Prior knowledge is necessary for people to recognize information. For example, understanding a language requires knowledge of vocabulary, idioms, grammar and syntax, whereas conversation requires knowledge of pronunciation. Without such prior knowledge, even gaining language and conversation does not lead to understanding. Therefore, it is necessary for personnel to acquire prior knowledge in order to recognize information, and they must be trained to do so to acquire cognitive capability. On the other hand, since there are individual differences in cognitive capability that personnel inherently possess and can acquire through training, it is effective to optimize training for each individual member based on the findings of brain and cognitive science, rather than just repeating training.

[Selection of information that leads to cognition]

Even if a lot of information is given, cognition does not always work appropriately, and the information may be a confusing factor for personnel. In this regard, it is also necessary to select the information to communicate to personnel and to ensure that appropriate cognition takes place. Also, it will be necessary to communicate information in an easy-to-understand manner to personnel so that they can recognize it appropriately. To this end, it is effective to visualize what kind of cognition takes place based on what kind of information, taking into account the findings of brain and cognitive sciences, and then to consider how to respond to selection, communication, etc. of information.

[Scientific elucidation of cognitive capabilities]

Until now, our activities have rarely involved science and technology to improve the quality of our activities by analyzing in detail the cognitive processes of individual members, such as what information they receive, how they interpret it, how they make decisions, and how they act. However, to improve the cognitive capabilities of personnel, it is necessary to utilize the outcomes of brain science research, which scientifically studies the mechanisms of perception and judgment in the human brain, to scientifically clarify how the personnel perceive, and to optimize it in order to improve our cognitive capabilities. This should also be a subject for consideration.

From this perspective, it is necessary to create new technologies, such as for "Reinforcement of personnel's cognitive capability," "Selection of information that leads to cognition," and "Scientific elucidation of cognitive capabilities."

Among the important technology areas to achieve them are, for example, the training technologies for improving cognitive capabilities utilizing the brain science and the cognitive domain visualization technology that visualizes how the cognitive domain works to enable training on how to respond.