Chapter 2
The Impact of Emerging Technologies on the Strategic Environment of the Asia-Pacific Region: Focus on Japan's Perspective

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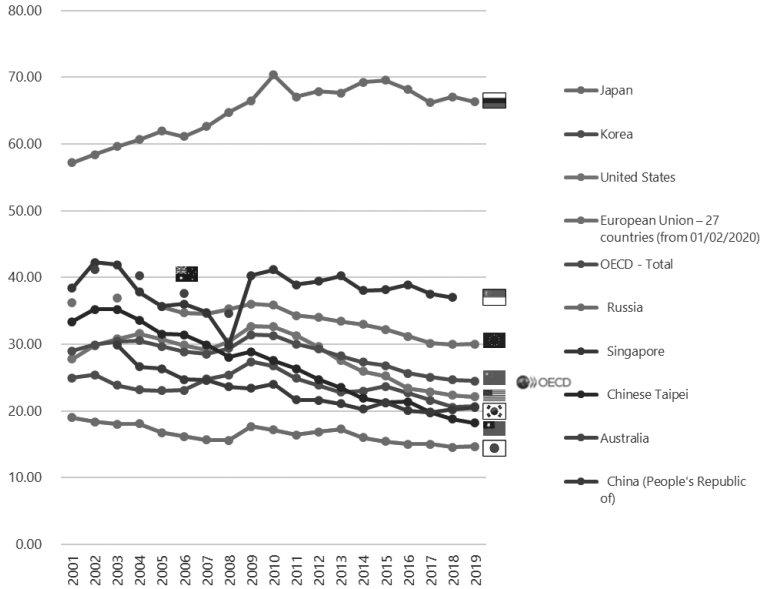
1. Introduction

In recent years, investment in emerging technologies has increased in various countries, including Japan. Investments in emerging technologies are made by investing in research and development (R&D). According to the OECD's definition, "Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge."[1] R&D investment is also defined by the Office of Management and Budget within the Executive Office of the President of the United States as "expenses included in the calculation of net costs to support creative and systematic work undertaken to increase the stock of knowledge and to use such knowledge and practical experience for devising new or improved products and processes, with the expectation of maintaining or increasing national economic productive capacity or yielding other future benefits."[2]

In the private sector, R&D investment is increasing year after year. In 2018, the top 1,000 companies leading global innovation alone invested $782 billion in R&D.[3] Profits are increasing for these companies. This shows that investment in R&D is positioned as a source of future competitive strength.

Figure 1: Percentage of Government expenditure to GERD



GERD: Gross Domestic Expenditure on R&D

On the other hand, the ratio of government R&D expenditure to total domestic R&D expenditure has been gradually declining in many countries, although the average for OECD countries is about 25%.[4] As for Japan, the ratio has been stable at about 15%. Based on this, we can consider governments to still be a major, although not dominant, player in R&D investment.

Beyond military means, there are various means of cross-national competition encompassing politics, economics, and the military. Technology has always played a central role in international politics, both in times of peace and in times of war.[5] Investment in technology leads to the building of military capabilities, but it is not practical to invest equally and fully in all areas of technology. Each country must thus weigh the relative importance of investment in technology. Therefore, investment in technology can be considered a statement of national intent.[6]

In this report, I endeavor to clarify Japan's perspective on the impact of investment in emerging technologies on the strategic environment of the Asia-Pacific region.

2. Definition of Emerging Technologies in this Report

There have been various attempts to define emerging technologies, but there is no clear and consistent definition.[7] Some believe that the term simply refers to technologies in their budding stage,[8] while others focus on their importance from the perspective of export control,[9] others on their economic impact,[10] and others on the process of extending them to new areas of application.[11] For example, Section 232 of the U.S. National Defense Authorization Act for Fiscal Year 2020 defines emerging technologies as "technology determined to be in an emerging phase of development by the Secretary of Defense, including quantum computing, technology for the analysis of large and diverse sets of data (commonly known as 'big data analytics'), artificial intelligence, autonomous technology, robotics, directed energy, hypersonics, biotechnology, and such other technology as may be identified by the Secretary."[12] This report focuses on the impact of technology on the security environment and thus defines emerging technologies as technologies that can have an impact encompassing doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF).[13]

3. The "Strategies-to-Tasks" Framework[14]

In order to consider the impact of emerging technologies on the strategic environment, it is necessary to clarify the perspective. The "strategies-to-tasks" framework developed at the RAND Corporation clarifies the correspondence between a series of objectives, from national security objectives to military task objectives. Specifically, it consists of four steps: national security objectives and national military objectives, national military objectives and campaign objectives, campaign objectives and operational objectives, and operational objectives and operational tasks. Such an approach avoids bias toward specific organizational objectives and tasks and brings consistency between the different objectives.

For a long time, R&D has been viewed as something to create the means to efficiently accomplish military tasks. Until the Cold War, national security goals were clear, and it was relatively easy for defense scientists and engineers to pursue R&D according to documented and clearly defined requirements specifications.[15,16] However, with the current accelerating changes in the security environment, there is always uncertainty in predicting future ways of war.[17,18] Thus, realizing requirements specifications for new equipment is not as easy as it used to be, and scientists and engineers now need to conduct R&D while being aware of the multiple hierarchies of the strategies-to-tasks

framework.

In this report, I use the strategies-to-tasks framework as a reference and analyze the impact of emerging technologies on the strategic environment from a broad perspective.

4. Basic Equipment Policy and Technology Policy of the Ministry of Defense (MOD)

Defense acquisition involves a long period of time, from the research phase to the procurement, maintenance, and operation of equipment. Foresight is essential for planned personnel allocation and capital investment, which requires a long period of time from investment to returns. Therefore, the MOD announced the Strategy on Defense Production and Technological Bases[19] in June 2014 in order to clarify the basic direction of its equipment policy and technology policy, and the Defense Technology Strategy[20] in August 2016 in order to clarify the basic direction of technological capabilities strengthening.

In this report, I explain Japan's basic perspective with particular focus on references to emerging technology initiatives among these strategy documents.

(a) Strategy on Defense Production and Technological Bases[19]

The Strategy on Defense Production and Technological Bases was formulated to newly indicate the direction for the maintenance and strengthening of defense production and technological bases, succeeding the basic guideline for production and development of defense equipment[21] (the so-called *kokusanka-hoshin* [guideline for indigenous development/production]) formulated in 1970. The goals and significance of the Strategy are encompassed in three points:

1. Ensure sovereignty of security
2. Contribute to latently enhance deterrence and maintain and enhance bargaining power; and
3. Contribute to advance domestic industry driven by highly sophisticated technology.

One of the characteristics of this Strategy is that, from the perspective of effectively and efficiently maintaining and strengthening defense production and technological bases, the policy is to select the most appropriate method for acquiring equipment according to the characteristics of the defense equipment, with the following basic

options: (1) domestic development, (2) international joint development and production, (3) licensed production, (4) utilizing civilian goods, and (5) imports. Among the various measures for this, the specific measures for R&D are: (1) formulating an R&D vision; (2) developing the ability to survey technological information, including advanced civilian technologies; (3) strengthening cooperation with universities and research institutes; (4) cooperating with and utilizing R&D programs, including those that cover dual-use technology; (5) funding advanced research with promising output for defense, and (6) strengthening cooperation with overseas organizations. The Strategy can be interpreted as indicating a policy of focusing on the engineering process from basic technology to equipment systems, noting the need for a medium- to long-term perspective in the R&D of defense equipment, and then showing interest in advanced civilian technologies and the transfer of those technologies to the defense sector.

(b) Defense Technology Strategy[20]

The Defense Technology Strategy was formulated with the objective of practically and effectively strengthening the technological capabilities that are the basis of Japan's defense capabilities. The National Security Strategy also states from the viewpoint of national security, Japan's high technological capabilities are the foundation of its economic and defensive powers, and that Japan needs to take measures to strengthen them by further promoting and nurturing technologies including dual-use technologies.

Unlike the Strategy on Defense Production and Technological Bases, which indicates the basic direction from the perspective of developing defense industry bases, the Defense Technology Strategy is characterized by its emphasis on strengthening technological capabilities which are the foundation supporting defense equipment, rather than on the defense equipment itself.

Thus, the Strategy defines the following two MOD technology policy objectives:

1. Ensuring technological superiority; and
2. Delivering superior defense equipment through effective and efficient R&D.

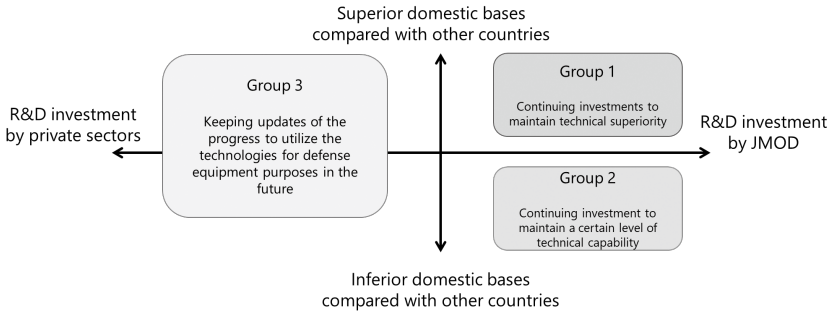
The objectives are considered to be complementary and synergistic, with no order of priority between them. By promoting them, the MOD intends to strengthen Japan's technological capabilities.

In order to achieve these objectives, the Strategy raises the following three measures to be taken by the MOD:

1. Technology Survey;

2. Technology Development; and
3. Technology Protection.

Figure 2: The three perspectives (or portfolios) in the Defense Technology Strategy



One of the characteristics of this Strategy is that it presents three perspectives (or portfolios) that should be considered as preconditions for promoting specific measures, taking into account the state of Japan's technology bases. In the Strategy, the MOD has laid out the three perspectives to be considered on four-quadrants, with the horizontal axis representing investment orientation (whether the MOD will actively invest) and the vertical axis representing the expected effects of investment (whether it is easy to achieve technological superiority), and has put forward basic investment policy for each group (Figure 2). The characteristics of each group and the basic investment policy are described below.

Group 1) Fields in which Japan already has superiority
Among the technologies referred to as emerging technologies, Group 1 can be considered to include those technologies in which Japan excels in and which have clear applications for defense. Examples include advanced material technologies that have received a certain level of recognition in international joint R&D. The MOD will continue to actively invest resources in these technology fields.

Group 2) Fields of technology in which Japan currently does not have a superior technological footing but which would put Japan at a strategic disadvantage if it does not maintain a certain level of technological capability

As is the case in many countries, the reason for investing in technology is not only to leverage strengths in some emerging technologies. The Strategy states that even for technologies in which Japan does not have a strategic technological footing compared to other countries, it will invest resources to maintain its technological capability because it may be at a strategic disadvantage if it does not maintain a certain level. Group 2 can be considered to include technologies that are not emerging technologies but rather those that are already at a mature stage. Furthermore, continuous investment in Group 2 technologies is considered important from the perspective of maintaining the defense equipment supply chain.

Group 3) Fields of technology where voluntary R&D is underway in the private sector
As shown in the previous figure, R&D investment in the private sector accounts for about 85% of R&D expenditures in Japan. The Strategy states that the MOD will not actively invest in fields of technology for which voluntary R&D is being conducted by the private sector because their applications for defense are not necessarily clear. However, the Strategy states that the MOD will keep track of technological trends in order to efficiently advance their conversion for defense equipment. In particular, Group 3 technologies are becoming increasingly important due to recent advances in digital technology.

Because understanding technological trends is, at the very least, the starting point for technology transfer to the defense sector, continuous and comprehensive research is essential. Going forward, it is expected that it will become increasingly necessary not simply to detect new technologies that are progressing in the civilian sector, but rather to transfer those technologies to the defense sector.[22] In other words, it will become increasingly necessary to review investments and processes aimed at building industry bases and clarifying defense requirements.

These are the basic directions of the current equipment policy and technology policy of the MOD. Various measures are currently being steadily implemented based on these strategies.

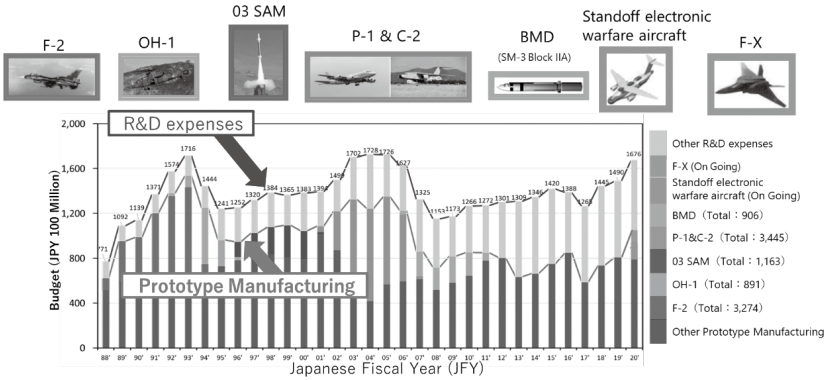
5. Trends in R&D Investment and Investment in Emerging Technologies by the MOD

The amounts and breakdowns of R&D investment are a useful clue for understanding a country's or organization's approach to investment in emerging technologies. Therefore,

this section discusses the trends in R&D investment based on the basic approaches for the equipment policy and technology policy of the MOD.

Figure 3 shows the changes in the MOD's R&D budget over the past 30 years. The horizontal axis represents the period 1988-2020, and the vertical axis shows the R&D budget and its breakdown. The colors of the bars respectively correspond to expenditures that include applied research[i] and test & evaluation,[ii] and expenditures for prototype manufacturing.[iii] The figure shows that R&D expenditures have fluctuated widely at the MOD in conjunction with specific big projects through now.

Figure 3: Changes in the MOD's R&D expenses



It is true that investment in specific big projects has played a certain role in achieving superior domestically produced equipment. However, Japan must decide whether to continue to prioritize investment in specific platform development in the future given the limited budget and time, or whether to balance medium- and long-term R&D investments and stably invest in acquiring and strengthening capabilities in the new domains of space, cyberspace, and the electromagnetic spectrum (EMS) without being biased toward a specific platform. Japan could also opt to allocate more resources in order to have a balance of both the aforementioned options. Because there has been no

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[i] This can be interpreted as equivalent to 6.1 Basic Research, 6.2 Applied Research, and 6.3 Advanced Technology Development at the U.S. Department of Defense.

[ii] This can be interpreted as equivalent to 6.6 Test & Evaluation at the U.S. Department of Defense.

[iii] This can be interpreted as equivalent to 6.4 Advanced Component Development and Prototypes as well as 6.5 System Development and Demonstration at the U.S. Department of Defense.

noticeable change in the trend so far, it is assumed that Japan is currently in a transitional period. Discussions on this point should continue to be closely monitored.

6. The Impact of Emerging Technologies on the Security Environment in the Asia-Pacific Region

The *Defense of Japan 2021* White Paper[23] characterizes the Asia-Pacific region as follows.

> States in the Indo-Pacific region, including Japan, abound in political, economic, ethnic, and religious diversity. Also, each country has different security views and threats perceptions. Therefore, a regional cooperation framework in the security realm has not been sufficiently institutionalized, and longstanding issues of territorial rights and reunification in this region continue to remain.

These regional characteristics influence the scope, implementation method, and timing of applications of emerging technologies.[24] Therefore, with this in mind, I will discuss the impact on the security environment in the Asia-Pacific region for each of several representative fields of technology.

(a) EMS Technology

The EMS, along with space and cyberspace, is attracting attention as a new domain.[25] Whether the EMS should be treated as an independent domain like other domains is still open to debate.[26, 27] However, its nature of linking and supporting multiple domains is widely recognized.[28]

As suggested by various previous studies, EMS technology has the potential to increase our options in the gray zone and generate initiative to control situations.[29]

As an example, consider one application of EMS technology: directed energy weapons. With respect to effectors that produce some effect on a target, the only conventional means has been the projectile. Thus, although there are various types of projectiles, their use in the gray zone could not be an effective means because of the possibility of unintended escalation. On the other hand, directed energy weapons provide a third option that could not be realized with conventional projectiles: serving as effectors that influence a target through the transmission of energy by electromagnetic waves.

It is difficult for both the user of directed energy weapons and those they are used against to visually confirm the weapons' effects, which are conventionally possible to

confirm. Therefore, it is possible to intentionally use the weapons and then see the reaction of the other party. For this reason, no matter which country uses them, they can be expected to bring advantageous options for the side with the capability.[30]

On the other hand, considering the current situation in the region in which regional cooperation frameworks on security aspects are not sufficiently institutionalized, host-nation coordination (HNC)[31] for the use of radio waves is expected to pose significant difficulties. While this is not a problem that can be solved solely by technology, EMS management[31,32] is considered to become a major challenge in the application of EMS technology.

(b) Wide-Area Surveillance Including Space

In general, the enhancement of wide-area surveillance capabilities is essential for decision-making from the strategic to the tactical level.[33] The increasing use of space has expanded the scope of surveillance, which was previously limited by national borders, and has made it possible to check the surface conditions from above the country or region targeted for surveillance.

Against this background, technological challenges that are expected to be faced in future R&D include the realization of passive distributed detection supported by machine-to-machine communications[34] and advanced arithmetic processing, enhancement of the ability to equip sensors, as well as not only the miniaturization of sensors but also the use of open architectures[35] to ensure flexibility and rapid capability improvement.

Furthermore, in addition to the capabilities of the sensors themselves, sensor signal processing with limited power and sensor fusion algorithms for data from multiple signal sources are expected to be developed in order to efficiently process increasing amounts of data.

The impact on the strategic environment as a result of the development of these technologies is expected to be the need for deception and concealment premised on being the target of space-based surveillance in order to counter increasingly sophisticated surveillance capabilities. Thus, the technologies and methods to do so are expected to be further developed in the future.[36]

(c) Cyber Defense

Today, the stable use of cyberspace is the foundation for a wide range of defense activities. It goes without saying that the equipment system of systems is made up of networks. In order to support the operation of equipment systems, it is necessary to prepare for threats

not only from states but also from various non-state actors, and to ensure the use of cyberspace, which is essential for the operation of equipment.

The technical challenges for this include preventing damage to cyber systems incorporated in equipment and ensuring the operational continuity of systems necessary for defense.

The use of civilian technologies is indispensable to solve these technological challenges. However, the nature of the systems used for defense purposes makes it impossible to leave everything to the private sector. Therefore, the key will likely be for the defense acquisition community to always grasp threat trends, conduct outreach for the latest civilian technologies, and promptly apply those civilian technologies to individual pieces of equipment. This will require agile acquisition processes for rapidly acquiring capabilities that follow the business practices of the civilian sector, rather than the waterfall R&D processes often seen in traditional equipment R&D.[37]

(d) Unmanned and Autonomous Technology

With advances in autonomous technology, unmanned vehicles are expected to complement or partially replace the functions of traditional manned vehicles. In the Asia-Pacific region, the rate of population growth has slowed in recent years,[38] and some countries and regions are already in a stage of population decline like Japan. These countries and regions in particular are expected to benefit from unmanned vehicles.[30, 39]

To realize autonomous systems, in addition to acquiring technology to recognize the surrounding environment and integrating it into unmanned vehicles, it is necessary to consider command and control systems that include both unmanned and manned vehicles.

Japan, which is surrounded by water on all sides, can be expected to benefit particularly from the utilization of maritime drones.

(e) Hypersonic Technology

Unlike conventional ballistic and cruise missiles, hypersonic vehicles have the following characteristics:

1. Extremely short response times; and
2. Unpredictable flight paths.[40]

They are considered to be extremely difficult to intercept, and are cited as a representative example of a "game changer." Because it is impossible to distinguish the

type of warhead mounted based on the appearance of the projectile, it has been pointed out that hypersonic vehicles have the potential to undermine regional strategic stability.[40]

R&D for hypersonic vehicles is being advanced in Japan. Technological challenges include the establishment of heat-resistant technology to withstand aerodynamic heating at hypersonic speed and supersonic combustion technology. These technologies are considered to be still in the demonstration stage. In order to create equipment using these technologies, it is expected that they will be inexpensive enough to be procured as equipment commensurate with their expected effectiveness.

7. Quantitative Evaluation and Foresight Concerning Impact on the Security Environment Using Digital Technology

The various emerging technologies, including the ones I have explained above, undergo quantitative evaluation of their impacts that goes beyond qualitative discussions, and the key to foresight on their impacts is digital technology. Recent advances in computer hardware performance as well as in modeling and simulation technology have made it possible to perform complex engagement simulations that interweave several different types of units.[41] In the real world, these advances are increasingly enabling electronic warfare simulations using a broad EMS, which are difficult to carry out due to factors such as concerns about signal collection by potential adversaries as well as national and international regulations.[42] Such mission-level modeling and simulation technology can be used not only for training, but also as an opportunity to identify gaps in our own and the other's military capabilities and to consider means of filling them.[43] Digital technology can serve as a "bridge" between the R&D community and users. In the future, mission engineering is expected to bring a broader force-level perspective to the R&D community than the traditional systems engineering perspective. Furthermore, the following are expected to become possible through the use of digital technology:

1. Quantitative prediction of the impact of new technologies;
2. Support for the rationale on investment decisions in technology; and
3. Support for judgments on acquisition decisions.[44]

8. Conclusion

This report outlines the impact of investment in emerging technologies on the strategic environment in the Asia-Pacific region centered on Japan's perspective. In recent years, the private sector has become the main player in technology investment, but state investment in technology also continues to maintain a certain share, and investment in technology is seen as one of the tools of inter-state competition. As for the role of governments, they have been forced to optimize resources for future requirements while optimizing cost effectiveness.

To support the long-term perspective of stakeholders in R&D and procurement, the MOD has released two strategies that show the basic direction for its equipment policy and technology policy.

Because there is always uncertainty involved in predicting future warfare, scientists and engineers involved in defense need to be aware of strategic perspectives.

Given the characteristics of the Asia-Pacific region, the EMS, wide-area surveillance including space, cyber defense, unmanned and autonomous technologies, and hypersonic technologies have the potential to bring about irreversible changes in the regional security environment. Further use of digital technologies is expected for quantitative evaluation and foresight on the impact of these technologies, rather than being limited to qualitative discussions.

(All views expressed in this report are the author's own and do not represent the official position of the Acquisition, Technology & Logistics Agency or the Ministry of Defense.)

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