# Section 6 Trends Concerning Military Science and Technology as well as Defense Production and Technological Bases

## 1 Military Science and Technological Trends

Recent developments in science and technology, as represented by the dramatic advancement of information and communications technology (ICT), has impacted a variety of areas, triggering significant and revolutionary changes in many areas such as economy, society, and lifestyle.

The military is no exception. Developed countries, including the United States, consider that transformations driven by advances in ICT can dramatically improve combat and other capabilities, and therefore, continue to pursue a variety of ICT research and policies.

For example, if information on enemy forces collected using information-gathering systems, including reconnaissance satellites and unmanned aircraft, is shared on a network, command and control can be exercised immediately, even from remote headquarters. By extension, offensive power can be directed swiftly, precisely, and flexibly against targets.

Additionally, new ICT technology has developed in recent years. For instance, in August 2016, China launched a satellite called "Mozi" to perform the world's first quantum communications[1] testing. In addition to quantum communications, new technologies such as artificial intelligence (AI) and big data analysis,[2] could potentially be used by countries in military applications in the future.

Furthermore, 3D printing could make revolution in military logistics.[3] For example, the U.S. Army Research Laboratory announced that it carried out a demonstration experiment[4] on a system for manufacturing a small unmanned aerial vehicle (UAV) using a 3D printer based on a request received from the frontlines during a training exercise. In addition, the U.S. Navy succeeded in the test launching of a ballistic missile made with components created by a 3D printer, and a 3D printer has been used to manufacture engine components[5] used for the MV-22 Osprey.

Major countries with sophisticated and modernized military forces, including the United States, place emphasis on improving the destructive capabilities of weapons, precision guidance technology, information-related technology including C4ISR, unmanned technology (e.g., drones[6]), and hypersonic technology[7] to be able to carry out more precise and effective attacks. Recently, reports have been published of successful

Demonstration of UAV produced by 3D printer by U.S. Army Research Institute in December 2016 [photo courtesy of U.S. Army]

1 Quantum communications refers to communications using the characteristics of light particles or photons. In quantum communications, photons cannot be divided or reproduced. For this reason, it is impossible for other parties to intercept or decrypt such communications, making it an ultimate form of communications technology.

2 In the explanation on its "Third Offset Strategy," the United States has given the example of "deep-learning machine" technology using AI, which could analyze big data to detect signs of cyber attack and to issue alerts, among serving other functions.

3 The 3D printer's manufacturing method called additive manufacturing (AM) can form three-dimensional objects from computer drawings using materials such as metal and plastic. Further advancement of 3D printing technologies will make it possible, for instance, to immediately manufacture necessary components without relying on their stock.

4 This training exercise was held in December 2016. A 3D-printed On-Demand Small Unmanned Aircraft System (ODSUAS) was used during the training exercise. Once soldiers inputted the requirements into the software, the system determines the specifications for the optimal UAV and a 3D printer produced it. This system can deliver a UAV in less than 24 hours.

5 Announcement made by the Naval Air Systems Command in July 2016.

6 Drones for military use which have been developed include unmanned aerial vehicle (UAV), unmanned ground vehicle (UGV), and unmanned maritime vehicle (UMV) (UMVs may be classified into unmanned surface vehicle (USV) and unmanned undersea vehicle (UUV)). It is suggested that these drones could shift from human-operated types to fully autonomous types, as known as Lethal Autonomous Weapons Systems (LAWS). Within the framework of the United Nations Convention on Certain Conventional Weapons (CCW), discussions are taking place on the need for international law and regulations for the operation of systems that automatically kill an enemy without human judgment. In January 2016, Gen. Paul Selva, Vice Chairmen of the Joint Chiefs of Staff of the United States, reportedly made the following comment: "that brings us [military] to the cusp of questions about whether we are willing to have unmanned, autonomous systems that can launch on an enemy."

7 For example, in the United States, DARPA and the Air Force are engaged in joint research and development of the Hypersonic Air-breathing Weapon Concept (HAWC), aiming to apply the technology to hypersonic missiles, etc. in the future. HAWC uses the technology of scramjet engine, which enables hypersonic flight by taking in air at hypersonic speed and burning it without reducing the speed to below the speed of sound.

tests of railguns[8] and high energy laser weapons[9] that are expected to provide effective firepower compared to existing weapons, such as artillery, in terms of their cost per firing, range, precision, promptness, and other aspects. Furthermore, there have been reports about the development of high speed strike weapons (HSSW) that can strike even long-range targets with conventional weapons, quickly and with pinpoint accuracy.[10]

Recent research of the Defense Advanced Research Projects Agency (DARPA) of the U.S. Department of Defense (DoD) have included: research to develop a small unmanned aircraft called "Gremlin"[11] capable of airborne launch and recovery, and reuse; and research to develop an unmanned vessel called "Sea Hunter" to detect submarines.[12]

Recent advances in military science and technology are also largely attributed to the advancement of civil technology. In recent years, as the capabilities of existing equipment are improved and new equipment is developed, dual-use technology has been leveraged frequently.

On the other hand, it is expected that countries having difficulty possessing high-tech forces for technological and economic reasons as well as non-state actors including terrorist organizations will carry out research and development on weapons and other equipment that will enable them to gain superiority in fighting against countries with state-of-the-art technology, and illegitimately obtain technology through ICT or other means. In short, these countries and organizations tend to focus on asymmetrical means of attack that can be developed or obtained with relatively low cost, enabling them to attack their opponents' vulnerability without using conventional military capabilities. These asymmetrical means of attack include: WMDs, such as nuclear, chemical, and biological weapons; ballistic missiles; terrorist attacks; and cyber attacks.

As asymmetrical means of attack may spread throughout the world, the research and development of technology[13] that responds to these asymmetrical threats is also recognized as an important challenge.

## 2 Trends Concerning Defense Production and Technological Bases

Recently, Western countries in particular have continued to face difficulties in significantly increasing defense budgets. On the other hand, the sophistication of military science and technology and the greater complexity of equipment have escalated development and production costs and are raising unit prices for equipment procurement. Under these circumstances, many countries are working on a variety of initiatives in order to maintain and enhance their national defense production and technological bases.

Western countries have set a target to increase competitiveness through realignment of their defense industry, based on the aforementioned situation related to national defense budgets. The United States has experienced repeated mergers and integrations among domestic corporations, while Europe has experienced cross-border mergers and integrations of the defense industry, especially in Germany, France, the United Kingdom, and Italy.

In response to escalating development and production costs, Western countries are promoting joint development and production and technological cooperation related to equipment among their allies and partners. This move aims for (1) splitting development and production costs, (2) expanding demands in all countries participating in joint development and production, (3) mutual complementarity of technologies, and (4) raising domestic technology levels by obtaining the latest technology.

For example, the joint development and production of the F-35 fighter jet led by the United States is the

8 A railgun is a weapon that fires bullets by using the magnetic field generated from electric energy instead of gunpowder. The U.S. Forces are developing a railgun with a range of about 370 km, or about ten times that of the existing 5-inch (127 mm) ammunition. A single railgun shot reportedly costs 1/20th to 1/60th the price of a missile.

9 The U.S. Forces are developing laser weapons to strengthen low-altitude air defense capabilities against small ships and drones. From September to November 2014, a laser weapon was test fired onboard the USS Ponce. It is suggested that high energy laser weapons systems would be miniaturized, with a view to placing the weapons also on light mobility vehicles. The cost of a laser shot is reported to be less than US$1. In addition, since July 2015, DARPA and the U.S. Air Force Research Laboratory have been jointly financing and conducting tests integrating the high energy liquid laser area defense system (HELLADS) and a ground-based laser weapons system demonstrator. Their goal is to continue to carry out tests to make operational improvements and to transition to the testing and military use phase.

10 The goal of the HSSW is to considerably shorten the time required for attack with a conventional weapon. The HSSW is deemed to travel at a low trajectory that is clearly different from the trajectory of ballistic missiles. It is suggested that the United States and China are developing HSSWs.

11 The U.S. DoD also develops micro-drones. In October 2016, three F/A-18 combat fighter jets successfully carried out an experiment in which they released 103 small drones and flew in formation together. Micro-drones are about 16 cm long and have a wingspan of 30 cm. They weigh around 300 g and can fly up to about 110 km/hour.

12 As known as the Anti-Submarine Warfare Continuous Trail Unmanned Vessel (ACTUV) ("Sea Hunter"), this pilot vessel christened in April 2016 is a trimaran approximately 40 m long, capable of navigating several thousand kilometers for months without crewmembers on board through constant remote supervision by humans. In August 2016, this vessel allegedly completed its initial sea trials ahead of its deployment by the U.S. Navy slated for sometime before 2018.

13 They include BMD or technologies for countering ballistic missiles, terrorist attacks, cyber attacks, etc. as well as ICT.

largest such project in the world. At present, there is anticipated demand for around 3,100 of these aircraft.[14] This project will have impacts on the defense production and technological base of those countries involved, through the operation and sustainment maintenance stages of the aircraft.

Additionally, in an increasing number of cases, governments are providing funding for national defense related research and development conducted by the private sector. In the United States, for example, approximately US$2.87 billion of the FY2016 budget were appropriated to DARPA[15] whose mission is to make pivotal investments in breakthrough technologies for national security for research and development. The defense authorities have long provided substantial funding for the research conducted by companies and universities, among other institutions. The EU, too, has promoted an incremental process for the framework to fund research for defense technology, against the backdrop of the consistent decline in national defense research expenditure by member countries over the past 10 years. In March 2017, the EU is expected to commence Preparatory Action related to research on Common Security and Defence Policy (CSDP) in which it will provide 90 million Euros over three years to more than 12 national defense research programs. The European Defense Agency is the implementing body of this framework.[16]

Countries have been exporting equipment overseas since the Cold War era, and even today, many countries are taking measures to promote exports.

Exports of equipment to the Asia-Pacific region are increasing in recent years. This has been underpinned by economic growth in the region as well as the growing influence of China, the existence of territorial disputes with China, and responses to the enhancement of military buildup in neighboring countries. Countries such as China and the ROK have established the infrastructure required for production of equipment through their past imports of equipment and their improved capabilities in science and technology, enabling them to increase exports of affordable equipment.

Countries that import equipment have adopted offset policies[17] for striking a balance between improving defense abilities through imports and developing defense production and technological bases domestically, requiring domestic companies' involvement in parts manufacturing as a requirement for procurement of equipment and services from outside the country.

See Fig. I-3-6-1 (Top Ranking Countries in Major Conventional Arms Export (2012-2016));
Fig. I-3-6-2 (Trends in Import Value of Major Conventional Arms in the Asia-Pacific Region (2012-2016))

Fig. I-3-6-1 Top Ranking Countries in Major Conventional Arms Export (2012-2016)

| | Country | Global shares in defense equipment export (%), 2012–2016 | Comparison with 2007–2011 export values (%) |
|---|---|---|---|
| 1 | United States | 33% | 21% |
| 2 | Russia | 23% | 5% |
| 3 | China | 6% | 74% |
| 4 | France | 6% | -5% |
| 5 | Germany | 6% | -36% |
| 6 | United Kingdom | 5% | 27% |
| 7 | Spain | 3% | 3% |
| 8 | Italy | 3% | 22% |
| 9 | Ukraine | 3% | 49% |
| 10 | Israel | 2% | 13% |

Note: Created based on "SIPRI Arms Transfers Database." The top 10 countries by export value between 2012–2016 are listed (decimals are rounded).

Fig. I-3-6-2 Trends in Import Value of Major Conventional Arms in the Asia-Pacific Region (2012-2016)

| | Country | Import values ($ billion), 2012–2016 | Comparison with 2007–2011 import values (%) |
|---|---|---|---|
| 1 | India | 182.39 | +43 |
| 2 | China | 63.80 | -11 |
| 3 | Australia | 46.36 | -7 |
| 4 | Pakistan | 44.93 | -28 |
| 5 | Viet Nam | 42.72 | +202 |
| 6 | Republic of Korea | 35.86 | -49 |
| 7 | Indonesia | 29.67 | +70 |
| 8 | Taiwan | 28.24 | +647 |
| 9 | Singapore | 26.16 | -47 |
| 10 | Bangladesh | 21.32 | +681 |

Note: Created based on "SIPRI Arms Transfers Database." The top 10 countries by import value between 2012–2016 are listed.

14 There are nine countries involved in the joint development and production including Australia, Canada, Denmark, Italy, the Netherlands, Norway, Turkey, the United Kingdom, and the United States. Countries acquiring the fighter include Israel, the ROK, and Japan. The defense production and technological base of these countries is involved in production and sustainment.

15 DARPA is the DoD agency. Approximately 100 program managers, who are hired for limited stints, generally three to five years, oversee around 250 research and development programs. It does not have its own research and development facilities.

16 The EU has launched a funding program called Horizon 2020 for research and innovation to which it has committed 80 billion Euros over the seven-year period from 2014 to 2020. However, the provision of funds is limited to research for civilian or dual-use technology. In the United Kingdom, the Defence Science and Technology Laboratory (DSTL) has a budget of £6 million in FY2017 and regularly solicits conceptual demonstration research topics in order to fund research with a novel, high risk and high potential benefit to develop capabilities for U.K. defense and security.

17 The definition of offset in defense trade encompasses a range of industrial and commercial benefits such as co-production, licensed production, subcontracting, technology transfer, purchasing, and credit assistance, according to "Offsets in Defense Trade Version Twenty-First Study" by the U.S. Department of Commerce Bureau of Industry and Security.