미국 방산제도 분석을 통한
국내 체계개발사업 방산원가 개선방안 연구

2022년 5월

방위사업청
김동선

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   (School of Public Affairs, University of Colorado Denver)

3. 훈련 분야 : 행정

4. 훈련 기간 : 2020.8.13 ~ 2022.6.12

훈련기관 개요

○ 기관명 : 콜로라도 대학교 덴버 캠퍼스 행정대학원

(School of Public Affairs, University of Colorado Denver)

○ 주소 : 1201 Larimer St. Denver, CO 80204(콜로라도 대학교 덴버 캠퍼스),

1380 Lawrence St. Ste 500 Denver, CO 80204 (행정대학원)

○ 인터넷 주소 : www.ucdenver.edu(콜로라도 덴버 대학교),
www.ucdenver.edu/academics/colleges/SPA (행정대학원)

○ 대학 조직

- 1912년에 개교한 미국 콜로라도주 덴버시에 위치한 주립대학교로, 콜로라도 대학교는 볼더(Boulder) 캠퍼스를 중심으로 덴버(Denver), 콜로라도 스프링스(Colorado Springs), 안슈츠 의학캠퍼스(Anschutz Medical Campus)를 포함한 4개의 캠퍼스로 구성됨. 연구 중심의 대학으로 행정학, 법학, 경영학, 문화, 역사, 어학, 자연과학, 생물의학, 의학 등 140여 개의 학위 과정 프로그램을 개설 중임.

- 전체 학생은 1만 9천여 명으로 55%는 학부생이고, 나머지는 석/박사 과정이며, 외국학생은 총 4%를 차지함.

○ 소속 학과 (SPA : School of Public Administration)

- 콜로라도 덴버 대학교의 행정대학원은 공공정책에 대한 비전을 가진 차세대 리더를 양성하는 것을 목표로 함. 행정학 교육 과정은 학생들에게 현실 세계의 관점을 제공하고, 다양한 연구를 통해 공공정책을 수립하는 교수로부터 수업과 학습을 제공받을 수 있음.

- NASPAA(Network of Public Policy, Affairs and Administration)의 인증을 취득하고, 환경정책/비영리관리/공공관리 등의 여러 가지 높은 수준의 행정학 프로그램을 제공하고 있음.

- U.S. News & Report에 따르면, 콜로라도 대학교 행정대학원의 행정학 프로그램은 행정학 분야(Public Affairs) 중 25위를 차지하였음. 행정대학원 내 세부영역으로는 환경정책 및 관리 11위, 공공 재정 및 예산 17위, NGO 관리 21위, 공공행정관리 23위를 차지하였음

- 학장을 비롯한 27명의 교수와 16명의 직원이 재직하고 있으며, 제휴를 맺고 있는 주정부 및 주요 공공기관, 정치인, 지역사회 리더, 저명한 사회활동가 등이 참여하는 세미나를 연 100여 차례 개최함

○ 훈련 프로그램 : 인사혁신처 1+1 과정 AMPA (Accelerated Masters in Public Administration)

○ 수강 과목

- 필수 과목

- Introduction to Public Administration & Public Service
- Public Service Leadership and Ethics
- Organizational Management and Behavior

- The Policy Process and Democracy
- Research and Analytic Methods
- Public Budgeting and Finance
- American Public Service Environment
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I . Introduction

1. Current status of Korea's defense research and development

In 2020, as the "Defense Science and Technology Innovation Promotion Act" ("Defense Science and Technology Act") and the "Defense Industry Development and Support Act" ("Defense Industry Act") were enacted, defense Research and Development (R&D) policies became more critical.

The purpose of the "Defense Science and Technology Act" is to promote the robust national defense and contribute to the national economy by innovating defense science and strengthening national competitiveness.[1] The purpose of the "Defense Industry Act" is to strengthen the competitiveness of the defense industry, lay the foundation for independent defense, and contribute to the national economy.[2]

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[1] Article 1 (Purpose) stipulates that, "The purpose of this Act is to create a foundation for defense science and technology innovation, to innovate defense science and technology, and to strengthen national competitiveness to promote solid national defense and further contribute to national economic development."

[2] Article 1 (Purpose) stipulates that, "The purpose of this Act is to stipulate matters necessary for the development and support of the defense industry, to create a foundation for the defense industry, strengthen competitiveness to prepare the foundation for an independent defense, and contribute to the development of the national economy."

In other words, the policy direction is to contribute to strengthening national defense power and the development of the national economy through the development of defense science and technology and the defense industry. According to the Defense Agency for Technology and Quality's analysis of the defense science and technology level of 16 major defense-advanced countries, Korea ranked ninth in 2020 (Defense Agency for Technology and Quality, 2020).

Meanwhile, defense R&D, which had been regulated by the “Defense Acquisition Program Act”, came to be regulated by the “Defense Science and Technology Act” with the enactment of this Act. The “Defense Science and Technology Act” emphasized creating an innovative and challenging defense R&D culture.

According to the DAPA’s press release, the main contents of this Act are as follows. 1) It introduced the agreement method to supplement the rigidity of the existing defense R&D contract. It expanded the sincere performance recognition system which allows companies that have faithfully conducted defense R&D to be exempted from penalties even if R&D fails to support challenging and innovative R&D. 2) It laid the groundwork for future-challenging defense technology R&D, which is to create future demands by securing advanced technologies before determining the requirements for weapons systems. 3) Incentives for excellent private companies to participate in defense R&D were increased by allowing the defense intellectual property rights previously owned exclusively by the government to be jointly owned by companies participating in defense R&D. It is to prepare for the rapidly changing future battlefield in the fourth industrial revolution era and serve as a basis for innovative research and development for independent national defense (DAPA, 2021a)

2. Current status of Korea's defense cost system

In August 2019, DAPA held a final report on defense cost structure improvement policy research service. It announced that it was planning to revise the regulations after consulting with relevant organizations. The improvement plan announced on this day is the result of a defense cost structure improvement task force in which defense companies also participated, five discussion sessions, and three interim presentations. It included the introduction of the principle of sincerity estimation and the conversion of the cost method of compensating for actual costs incurred for 45 years to the method of applying the standard cost concept. It also specifically included simplifying the complex defense cost-profit structure, abolishing the profit recovery and reduction system in case of cost cheating, recognizing domestic export test and evaluation fees, and increasing export profits (DAPA, 2019a).

Accordingly, DAPA will introduce a system for estimating sincerity. In this case, if the cost data submitted by the DAPA's contracting party to DAPA meets specific requirements, DAPA assumes that the cost data is true and omits a separate calculation procedure. In the past, conflicts and disputes were frequent because the objective judgment of the cost manager who was a public official was limited on the cost data presented by defense companies. Accordingly, DAPA has specified the basis for requesting data necessary for cost from companies. For this system to be applied, three requirements are required: 1) the pledge between the Chief Executive Officer (CEO) and the defense cost division executives, 2) the auditor’s audit report submission when submitting a separate accounting report, and 3) the defense cost management system certification (DAPA, 2021b).

The requirements for a company to apply the sincerity estimation system are as follows. Regarding 1), the pledge for faithful submission of cost data includes the fact that the cost data has been verified with due care, that there is no false statement. It includes the contents of taking responsibility under laws and regulations when an unreasonable profit is obtained from the cost data. It also includes the content that an internal control system for defense costs has been prepared in relation to the preparation of cost data as a minimum requirement to prove that due care has been taken. Concerning 2), this system is premised on external audit of accounting reports separated by private and defense industries. About 3), for defense cost management system certification, in order to increase the transparency of cost data, the data submitted by the company must be systematically managed and tracked in the company's system. They also should be entered into the DAPA's defense integrated cost system (Maeng, 2021).

DAPA revealed that the legislative effect could strengthen the autonomy and responsibility of defense companies and build trust between DAPA and companies. In addition, it stated that it is expected that the contract administration period will be shortened, and disputes between DAPA and the companies will be reduced as a separate preliminary review and examination are omitted when the contracting officer determines the expected price (DAPA, 2021b).

3. Purpose of this report

The importance of defense R&D is generally recognized with the development of advanced technology. Its importance has become more critical with the enactment of the “Defense Science and Technology Act” in Korea. In addition, various R&D type systems are being discussed, and an agreement system has been introduced in addition to the existing state contract system. DAPA is examining the direction of improvement of defense costs. System development is a critical stage in R&D as it designs a weapon system and produces prototypes to complete the standards necessary for mass production after exploration development. Therefore, it is necessary to review the defense cost system of the system development program at this point.

The United States is a militarily advanced country with a defense budget of 752.9 billion USD (DoD, n.d.) and the world's largest arms exports. The US government researches and develops various advanced technologies and weapon systems, and operates various R&D program systems that include competitive prototyping. In addition, it has been stably estimating the cost of these various defense R&D programs and signing defense R&D contracts for a long time.

This report intends to study on Korean defense cost improvement of system development program by examining the US defense acquisition systems with experience in developing various weapon systems and stable defense acquisition program systems.

Ⅱ. Defense acquisition system between the United States and Korea

1. Defense acquisition system in the United States

1) Defense acquisition policies in the US

(1) Overview of defense acquisition

a. Defense acquisition organizations

There are “Under Secretary of Defense for Acquisition and Sustainment” (USD(A&S)) and “Under Secretary of Defense for Research and Engineering” (USD(R&E)) in the “Office of the Secretary of Defense” (OSD) under the “United States Department of Defense” (DoD).

The USD(R&E) researches and develops defense technologies and oversees them. USD(R&E) drives the DoD's “National Defense Science and Technology strategy” based on the “2022 National Defense Strategy” (NDS). It will advocate for research, science, technology, and innovation to maintain the technological superiority of the US military (USE(R&E), 2022).

The USD(R&E) has “Department of Defense Research and

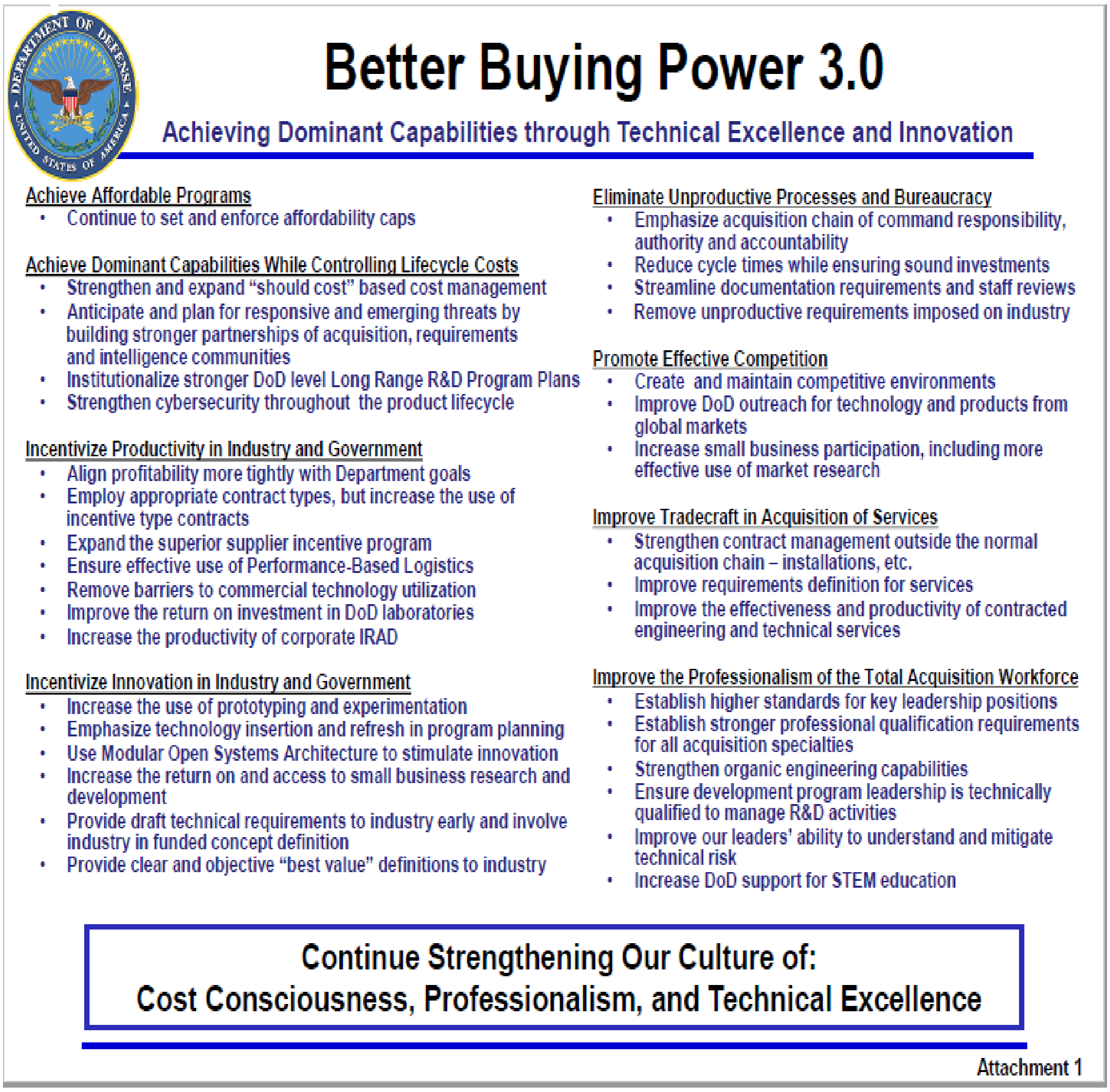
Engineering Enterprise" (DDR&E(R&T)), "Directorate of Defense Research and Engineering for Advanced Capabilities" (DDR&E(AC)), "Defense Advanced Research Projects Agency" (DARPA), "Missile Defense Agency" (MDA), "Defense Innovation Unit" (DIU), "Defense Science Board" (DSB), "Defense Innovation Board" (DOB), "Defense Technical Information Center" (DTIC) (USE(R&E), n.d.).

The USD(A&S) covers all matters related to the acquisition, including contracts, logistics, materials, chemical, biological, nuclear weapons, human resources, and defense industry bases (USD(A&S), n.d.).

b. Basic policy direction of defense acquisition

"Better Buying Power 3.0," released in 2015 by DoD, aims to achieve dominance through technological excellence and innovation. It calls for strengthening cost consciousness, technical excellence, and professionalism to achieve these goals. It focuses on economic feasibility, cost control, encouraging productivity and innovation of industry and government, eliminating non-productivity and bureaucracy, promoting effective competition, improving acquisition services, and enhancing the professionalism of defense acquisition personnel to secure superior technology and innovation. Figure 2 shows the details (Under Secretary of Defense, 2015).

Figure 1. Better Buying Power 3.0

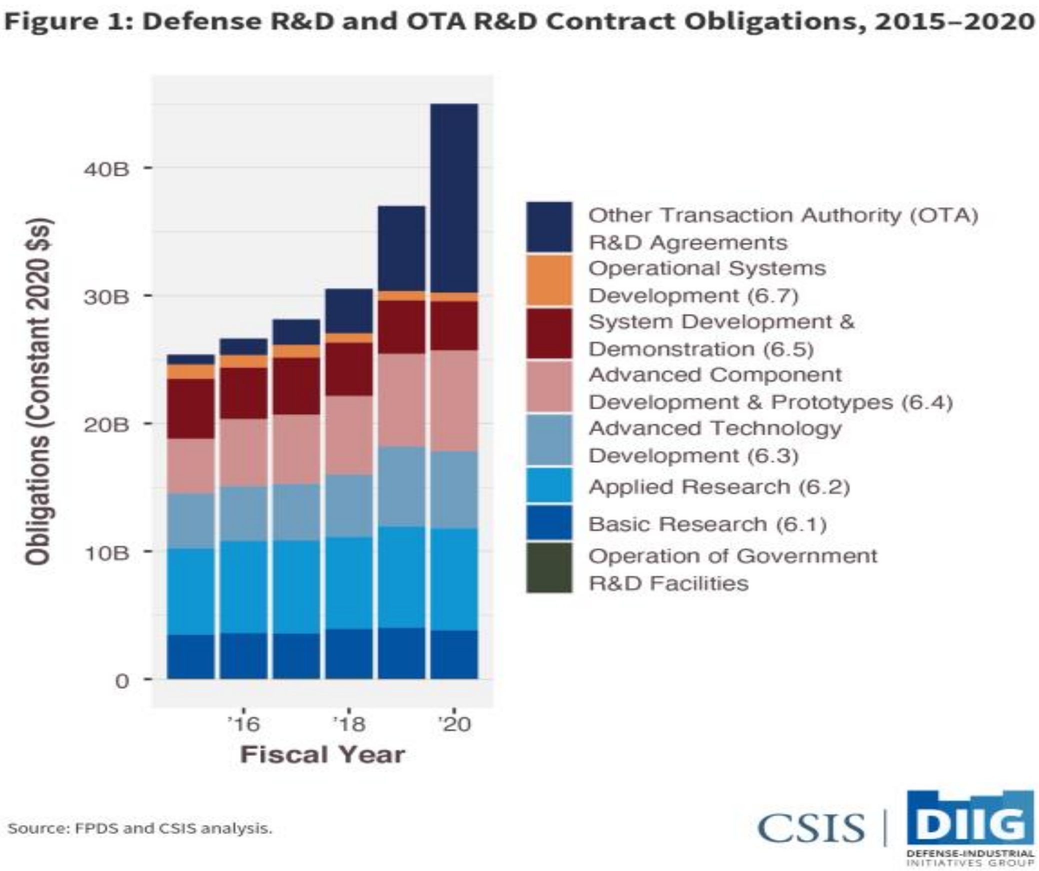


(2) Recent trends in defense acquisition policies

The "Center for Strategic and International Studies" (CSIS) analyzes the trends of defense acquisition in 2021 as follows (Sanders et al., 2021).

First, defense contracts obligations increased to $421 billion in the fiscal year (FY)2020, it is a 41% increase since the trough in (FY)2015. Contractual obligations in (FY)2020 are nearly 58%, the highest percentage for defense "total obligation authority" (TOA) in the past 20 years. It is consistent with a surge in product spending and changes in which "Other Transaction Authority" (OTA) agreements have partially replaced existing contracts as a means of R&D. Figure 3 shows the defense and OTA R&D contract obligations (Sanders et al., 2021).

Figure 2. Defense and OTA R&D obligations



Second, reform of the defense acquisition process includes the establishment of the “Defense Innovation Unit” (DIU) and the use of OTA agreements. It has consistently emphasized innovation, flexibility, and accessibility to commercial technology.

The OTA agreement resulted in a 122% increase in defense OTA R&D spending in (FY)2020, while a decrease in defense R&D contracts by 0.4%. Over the past five years, OTA R&D expenditure has continued to increase. It means that OTAs are rapidly replacing some of the traditional defense R&D. In (FY)2020, the Army accounted for 82% of OTA agreements spending.

On the other hand, the ratio of competed obligations, a key indicator of maintaining a competitive environment, has decreased. About 50% of the obligations were concluded without competition, the highest percentage in the past 20 years.

Finally, about establishing the defense industrial base, the defense acquisition reform requires an expanded industrial base with the participation of more non-traditional suppliers and more commercial suppliers. However, obligations of the Big Five suppliers, including “Lockheed Martin”, “Raytheon”, “Boeing”, “General Dynamics”, and “Northrop Grumman”, increased by 21% in (FY)2020. It has risen to the highest level over the 20 years. The total number of suppliers on a contract basis decreased by 10% from (FY)2019 to (FY)2020.

Meanwhile, the Big Five suppliers play a more minor role in OTA programs. If R&D OTA matures into significant programs with more minor roles for significant non-traditional engagement, this trend of consolidation of traditional contracts could be countered in part.

2) Defense R&D in the US

(1) Overview of defense R&D

Defense R&D in the US is largely classified into “Weapon Systems R&D” and “Tech Based R&D” according to the type of R&D. Also, it is classified according to the type of budget investment. “Weapon Systems R&D” is classified into “funded R&D” (100% investment by the government), “joint investment R&D” (joint investment between the government and companies), and “company-invested R&D” (investment by the company). “Funded R&D” has a competitive prototyping system to induce competition among defense companies from the early stage of development. A competitive prototyping system aims to reduce total life cycle cost in developing finished products, major components, and parts and to develop weapon systems with global competitiveness (Jang et al, 2016).

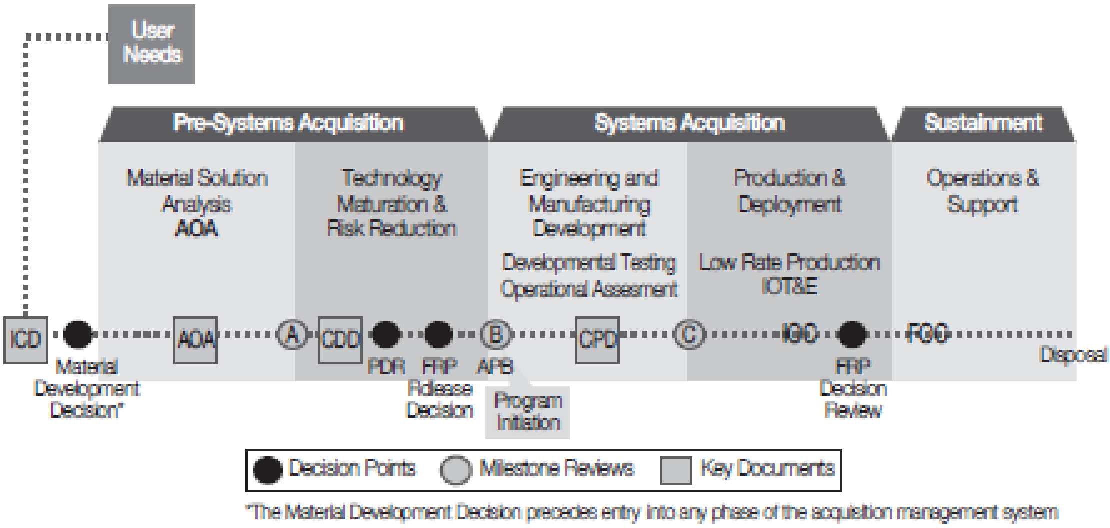
“Tech Based R&D” is classified into “in-house R&D” where the government invests 100%, “independent R&D” and “internal R&D” where companies invest, and “Cooperative R&D Agreement”

(CRADA) where the government and companies (or institutions) jointly invest. “In-house R&D” is conducted by government-affiliated research institutes. “Independent R&D” is carried out voluntarily by a company, and if the US government adopts it in the future, the company can be compensated for a part of the R&D cost (up to 80%). “Internal R&D” is carried out with the company’s budget, and the company bears 100% of the investment, so there is no government compensation. “CRADA” is carried out in the form of joint investment between the government and institutions (Jang et al, 2016).

"Operation of the Defense Acquisition System" (DoD Instruction 5000.02T) stipulates the defense R&D procedures for weapons systems. It is recommended to apply this instruction to “Tech Based R&D” and “Weapon Systems R&D” programs conducted by all agencies under the DoD.

According to this instruction, the weapons system R&D process is classified into the following; 1) “Material Solution Analysis,” 2) “Technology Maturation and Risk Reduction,” 3) “Engineering and Manufacturing Development,” 4) “Production and Deployment,” 5) “Operation and Support.” 1), 2), and 3) can be considered similar to Korea's previous research, exploration development, and system development stages, respectively. Figure 4 shows the process of defense R&D in the US (Jang et al, 2016).

Figure 3. The process of defense R&D in the US



자료 : Congressional Research Service, 2014.5; U.S. DoD 5000.02, 2013.

(2) Organizations for advanced defense R&D

a. Defense Advanced Research Projects Agency (DARPA)

DARPA was established in 1958 and is a technology research institute under the USD(R&E). Not only advanced defense technologies such as precision weapons and stealth technology but also innovative modern civil technology research such as the Internet and automatic voice recognition are considered representative achievements. The budget enacted for (FY)2021 is USD 3.5 billion. The DARPA organization consists of six technical offices and approximately 220 civil servants, including over 100 Program Managers (PMs) who oversee over 250 R&D programs. The PM reports to DARPA's office directors who hire the PM and oversee the PM's program performance. The technical staff performs the PM's work with the support of experts in each field, such as security, law, and contract (DARPA, n.d.).

According to DARPA's "2019 Strategic Framework," DARPA accounts for 25% of science and technology funding for the DoD and 2% of all federal R&D funding. It has signed 2,000 contracts and other agreements. The agreements made are with companies (67% of funding), universities (17% of funding), DoD, and other institutes (DARPA, 2019).

b. Defense Innovation Unit (DIU)

DIU is an organization under the DoD to enhance national security by facilitating the introduction of commercial technology to the military and expanding the innovation base for national security. It focuses on developing technologies in the following fields: 1) Artificial Intelligence, 2) Autonomy, 3) Cyber, 4) Human Systems, and 5) Space (DIU, n.d.).

It was launched as "Defense Innovation Unit Experimental" (DIUx) in 2015 and then renamed DIU in 2017. In particular, through the Commercial Solutions Opening (CSO) process, the time required for a request for contracts was significantly reduced. It aims to be completed in 60-90 days, from identifying problems to awarding a prototype contract. On the other hand, the traditional contracts process often takes 18 months or more. Prototype projects typically take 12-24 months, and Other Transaction (OT) authority applies.

Successful prototypes can be converted into follow-up OT contracts for production or FAR (Federal Acquisition Regulations) -based contracts (DIU, n.d.).

According to a US DoD News, as of August 2020, DIU had more than 160 contracts with commercial companies, initiated 72 projects, and completed 33 commercial solutions, converting 20 commercial solutions. Also, it worked with about 120 non-traditional suppliers which are not traditionally involved in defense contracts. Its project performance in 2020 increased by 50% compared to 2019, which is three times of projects undertaken in 2018 (DoD, 2020).

Since DIU was established, the number of projects it undertakes, the number of conversions of prototypes to commercial solutions, the number of proposals from companies per project, and the number of companies it works with have continuously increased. In addition, the contract period is shortening.

The “Rapid Trial Acquisition Project” introduced by the DAPA in 2020, is a system that can shorten the acquisition period by purchasing high-tech products from the private sector and linking it with the military’s pilot operation requirements. It operates for a similar purpose to the DIU.

3) Defense acquisition contract in the US

(1) Organizations

Each army's “Procuring Contracting Officer” (PCO) sets the price and manages the contract. PCO is an individual who has the authority to conclude contracts for supply and service as a representative of the government (DAU, n.d.). The “Defense Contract Management Agency” (DCMA) manages quality and contract performance. The “Defense Contract Audit Agency” (DCAA) audits contracts and prices. It focuses on the “fixed-price contract” method rather than the “approximation contract” method, which carries a high risk to the buyer (Lee & Choi, 2017).

a. Defense Contract Management Agency (DCMA)

DCMA performs contract management services for the DoD, other federal agencies, and international partners. About 12,000 employees (mostly civilians) work in offices and contractor spaces around the world. It manages approximately 250,000 contracts (worth over 3.5 trillion USD) in over 10,000 locations worldwide. It is responsible for contract management from pre-contract to the maintenance stage including contract receipt and review, contract modification, contract closeout, international request for contract services, grants and other transactions. (DCMA, n.d.)

b. Defense Contract Audit Agency (DCAA)

DCAA provides contract auditing and financial advice to the DoD and other federal agencies to manage acquisition and contract. It plays an essential role in getting the best value for the money the

DoD spends on defense contracts. It is under the supervision of the "Under Secretary of Defense" and "Chief Financial Officer." A contract audit is a review of the financial statements made by companies, where DCAA advises in determining whether contract costs are feasible and reasonable. It has about 300 offices in the U.S. and other countries (DCAA, n.d.).

(2) Characteristics of defense acquisition contract in the US

a. Overview of acquisition contracts

Defense acquisition contracts are based on the "Federal Acquisition Regulations" (FAR). Part 16 of FAR stipulates types of contracts, which are differentiated according to the extent and timing of responsibility that the contractor assumes for costs and the incentives for contractors to meet or exceed standards or goals. Contracts are largely classified into "fixed-price contract" (16.2), "cost-reimbursement contract" (16.3), and "incentive contract" (16.4). In "incentive contracts", the performance costs and the incentives are adjusted for uncertainty in the performance of the contract. Contracts negotiated on the basis of Part 15 might be any contract type or combination of contract types that enhance the interest of the government, except as limited in this part (FAR 16).

Factors to consider when choosing a contract type for contracting officers include: 1) price competition, 2) price analysis, 3) cost analysis, 4) requirements (types, complexity, and urgency), 5) combining contract types, 6) concurrent contracts, 7) performance period, 8) contractor's technical capability and financial responsibility, 9) contractor's accounting system, 10) proposed subcontracting, 11) acquisition history. Concerning 1), FAR stipulates that effective price competition generally leads to realistic pricing, and fixed-price contracts are generally in the interest of the government (FAR 16).

b. Types of acquisition contracts based on the FAR

• Fixed-price contracts

The types of fixed-price contracts based on the FAR are as shown in the table 1.

Table 1. Types of fixed-price contracts

Fixed-price contracts
1) Firm-fixed-price contracts
2) Fixed-price contracts with economic price adjustment
3) Fixed-price incentive contracts
4) Fixed-price contracts with prospective price redetermination
5) Fixed-ceiling-price contracts with retroactive price redetermination
6) Firm-fixed-price, level-of-effort term contracts

① Firm-fixed-price contracts

In “firm-fixed-price contracts”, the contractor bears all costs, so the contractor is responsible for risks, resulting profit or losses. Contractors can have the maximum incentives to manage costs effectively, and contract parties take minimum management responsibilities. Its application requirements are as follows. 1) adequate price competition, 2) reasonable price comparisons, 3) realistic estimates of possible performance costs from available cost or price information, or 4) being able to identify performance uncertainties and make reasonable estimates of cost impacts, and accepting a firm-fixed price at which the contractor bears the risk (FAR 16).

② Fixed-price contracts with economic price adjustment

It is a fixed-price contract including adjustments (up or down) of the contract price if there is a specified contingency (FAR 16).

③ Fixed-price incentive contracts

It is to adjust the profit and determine the final contract amount according to the formula based on the final negotiated cost and the total target cost. It is covered in subpart 16.4 (incentive contracts) (FAR 16).

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- Cost-Reimbursement Contracts

It provides the payment of accrued costs that are permissible within limits set by the contract. It establishes an estimate of the total cost to set a boundary that the contractor cannot exceed without the contracting officer's approval and to obligate funds. he application requirements are when a fixed-price contract is not possible because the requirements cannot be sufficiently defined, or when the cost estimate is not accurate enough to use a fixed-price contract because of uncertainties in the performance of the contract (FAR 16).

The types of cost-reimbursement contracts based on the FAR are as shown in the table 2.

Table 2. Types of cost-reimbursement contracts

Cost-Reimbursement Contracts
1) Cost contracts
2) Cost-sharing contracts
3) Cost-plus-incentive-fee contracts
4) Cost-plus-award-fee contracts
5) Cost-plus-fixed-fee contracts

① Cost contracts

Cost contracts are in which the contractor is not charged a fee. They may be suitable for research and development, especially with non-profit organizations (FAR 16).

② Cost-sharing contracts

In cost-sharing contracts, the contractor is reimbursed for the agreed-upon allowable costs without receiving a fee. They can be used where the contractor bears some of the costs and expects substantial compensation (FAR 16).

③ Cost-plus-incentive-fee contracts

It is a contract that provides an initial negotiation fee that will be adjusted later according to the formula based on the total allowable cost and the total target cost. This is covered in incentive contracts (FAR 16).

④ Cost-plus-award-fee contracts

It is a contract to provide a fee based on a base amount at the time of initiation of the contract and an award amount that provides incentives for the performance of the contract as assessed by the government (FAR 16).

⑤ Cost-plus-fixed-fee contracts

It is a contract in which the contractor receives a negotiated fee of a fixed amount determined at the time of contract inception. The fixed fee is not affected by the actual cost but can be adjusted according to changes in the work scope of contract performance (FAR 16).

• Incentive Contracts

Incentive contract is applied when firm-fixed-price contracts are not appropriate. It is applied when supplies or service can be supplied at a lower cost and, in certain cases, when delivery or technical performance is improved through the payment of profits or fees based on contract performance. These are largely classified into "fixed-price incentive contract" and "cost-reimbursement incentive contract." As it is generally advantageous for the government for the contractor to bear cost responsibility and risk, "fixed-price incentive contracts" take precedence when costs and requirements are reasonably certain (FAR 16).

① fixed-price incentive contracts

As described above, it is to adjust the profit and determine the final contract amount according to the formula based on the final negotiated cost and the total target cost (FAR 16).

② Fixed-price contracts with award fees

It is used when the government wants to motivate contractors, but it is difficult to provide incentives because contract performance cannot be objectively measured. The contractor may receive an award-fee in addition to the fixed amount (FAR 16).

③ Cost-reimbursement incentive contracts

It is grouped into “Cost-plus-incentive-fee contracts” and “Cost-plus-award-fee contracts.” Specific details are the same as described above (FAR 16).

4) Defense cost system in the US

Concerning cost management, the PCO of each army performs the price determination, and the DCMA performs the cost analysis. DCAA verifies pricing through an audit of contracts. DCMA only manages contracts worth USD 700,000 or more, and each army manages others. DCMA's cost analysis includes a systematic review and evaluation of each cost element by summing up the judgment factors, profits, and fees that make up the contract cost. (Lee & Choi, 2017).

The rules underlying the defense cost system include; 1) FAR, 2) “Cost Accounting Standards” (CAS), 3) the “Truth in Negotiations Act” (TINA).

In relation to 1), Part 31 (“Contract Cost Principles and Procedures”) of the FAR is applied a) pricing for contracts and subcontracts, b) determining, negotiating, and allowing costs where required contractual clauses. It determines the allowability, reasonableness, and allocability of costs. It regulates "fixed-price contracts", "contracts with commercial or educational organizations", "construction or architect-engineer contracts", "contracts with non-profit organizations", and "advance agreements". It also sets out comprehensively the principle of contract costs, including direct costs, indirect costs, and selected costs (e.g., bad debts, bonding costs, contributions and donations, contingencies, and depreciation). Regarding R&D cost, it regulates the bid and proposal costs of Independent R&D (IR&D). IR&D cost refers to the "cost of effort" that does not include grant and is not required for performing contracts. It also falls under one of "basic research," "applied research," "development," and "systems or other concept formulation studies" (FAR 31)

Concerning 2), Part 30 (“Cost Accounting Standards Administration”) of the FAR governs the application of the “Cost Accounting Standards Board” (CASB)’s Rules and Regulations to negotiated contracts and subcontracts. Part 30 includes the CAS, CAS Program Requirements (contract requirements and disclosure requirements), and CAS Administration (e.g., responsibility, materiality, changes to cost accounting practices, processing noncompliance, resolving cost impacts, subcontract administration).

The CASB is set out in 48 CFR (Chapter 99) and is an independent legislatively established organization. It has the authority to establish and amend the CAS, an accounting standard for measuring, assigning, and allocating costs in contracts with the US government. Executive agencies, contractors, and subcontractors are obligated to use this standard in the estimation, accumulation, and report of costs related to price management (Office of Management and Budget, n.d.).

Concerning 3), according to the TINA, offerors, contractors, and subcontractors should provide cost or pricing data prior to pricing for government contracts. Part 15.403 of the FAR establishes this principle and procedure in requiring cost and pricing data. For example, in prime contracts, the criteria for the application are USD 2 million for a contract awarded on or after July 1, 2018, and USD 750,000 for one before that. Those who are required to provide the cost or pricing data should certify to ensure that the cost or pricing data is accurate, complete, and up-to-date.

2. Defense acquisition system in Korea

1) Defense R&D in Korea

(1) Overview of Korea's defense R&D

Korea's defense R&D was based on the “Defense Program Act” in the past, but it is based on the “Defense Science and Technology Act” as it was enacted in 2020. Defense R&D includes “R&D of weapon systems,” “R&D of core technologies necessary for weapon systems R&D for which requirements are determined or expected to be determined,” “R&D of future-challenging defense technologies, and other R&D such as R&D using new technologies,” and “R&D of force support system in accordance with the Defense Acquisition Program Act” (Article 2 of the “Defense Science and Technology Act”). Concerning the work system, the Minister of National Defense establishes the “Defense Science and Technology Innovation Plan,” and the Minister of DAPA may have the defense R&D programs carried out.

The Minister of National Defense establish the “Defense Science and Technology Innovation Plan” every five years. It should include: 1) mid- to long-term development goals and basic directions for defense science and technology innovation, 2) policy on the promotion of defense science and technology, 3) allocation of resources and expansion of investment for defense science and technology innovation, 4) other essential matters determined by the Presidential Decree (Article 6 of the “Defense Science and Technology Act”).

Concerning the promotion of defense R&D, the Minister of DAPA may have research institutes (company, university, research institute, defense science, and technology-related institutions and organizations, etc.) perform the defense R&D programs. In this case, the Minister of DAPA may make a contract or agreement with R&D agency (a person who supervises and performs defense R&D programs) or R&D participating agency (a person who participates in the relevant national defense R&D programs other than the R&D agency as necessary for effective defense R&D) (Article 8 of the "Defense Science and Technology Act").

In principle, the procedure for defense R&D of weapon systems goes through the stages of exploration development, system development, and mass production. However, to prevent obsolescence of technology, to ensure efficient R&D, and to fulfill timely introduction of weapons, phases may be integrated or omitted if deliberation by the Defense Program Promotion Committee has been passed.

Exploration development is the phase to determine whether it is possible to proceed to the system development phase by developing the technology for the core part of the weapon system (including the production of prototypes for technology verification) and checking the completeness and applicability of the technology. System development is the phase in which weapon systems are designed, prototyped, tested, and evaluated to complete the defense standards required for mass production. Mass production is the phase of mass-producing weapon systems developed through system development (Article 2 of the "Enforcement Decree of the Defense Science and Technology Act").

In Article 25 of the "Defense Acquisition Program Management Regulations" (DAPA Ordinance), domestic R&D of weapon systems is classified as follows. 1) Domestic R&D program is classified into “government-invested R&D programs”, “joint-invested R&D programs”, and “company-invested R&D programs” according to the investment entity of the development cost. 2) According to the subject of R&D, it is classified into R&D programs led by a company (company independently, company and government-funded research institute, company and the “Agency for Defense Development” (ADD), etc.) Unless there is a particular reason company-led R&D is considered first. However, if there is no economic feasibility or if it is pursued to maintain confidentiality, it may be promoted as an R&D program sponsored by the ADD.

(2) Defense R&D budget in Korean Government

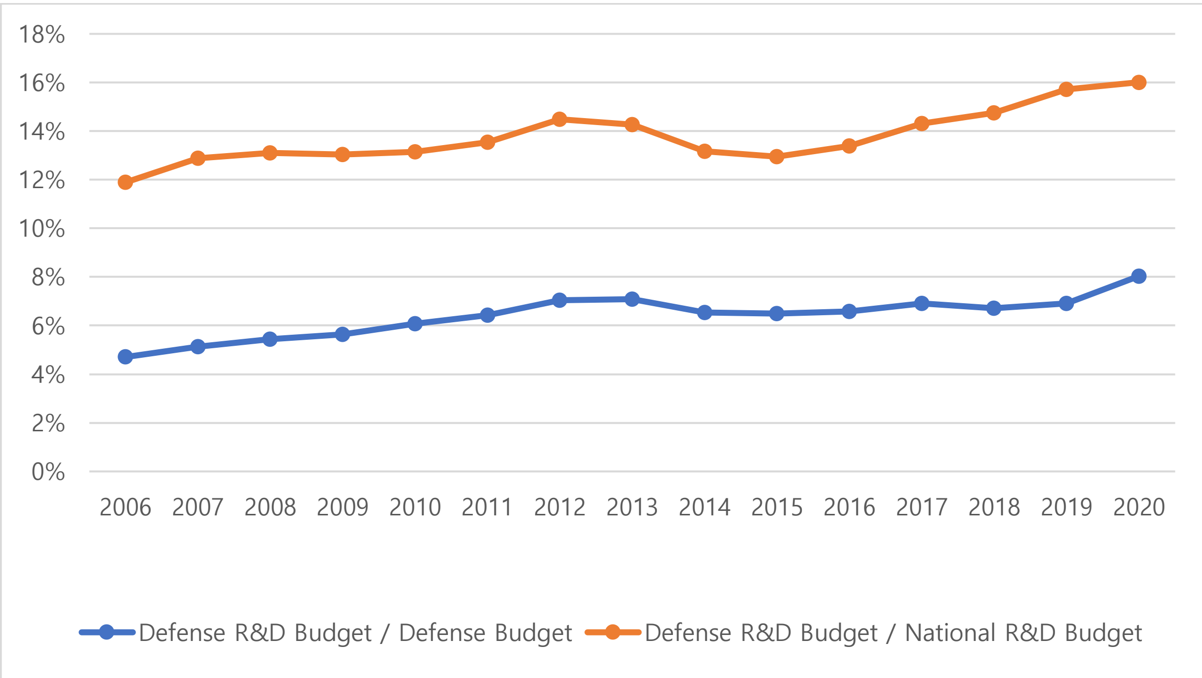
Advances in technology and industry are increasing the importance of R&D worldwide, as is the case in the defense sector.

In 2020, Korea’s defense spending was about 45,000 million USD (Stockholm International Peace Research Institute, n.d.), which is 54,425 billion KRW, the 10th largest in the world. Korea’s total domestic government and private spending on R&D as a percentage of Gross Domestic Product (GDP) in 2019 was 4.6%, the second-highest among Organization for Economic Cooperation and Development countries (Organization for Economic Cooperation and Development, n.d.).

Compared to 2006, when the DAPA was established, Korea’s national R&D budget in 2020 increased by 172%, and the defense

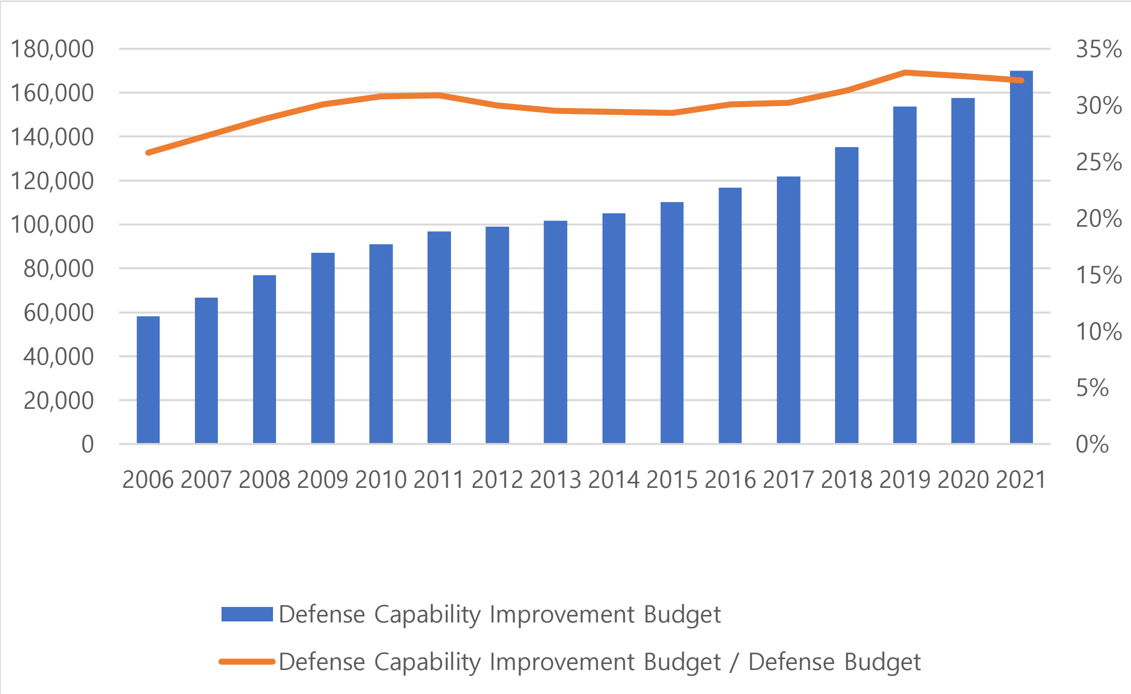
R&D budget increased by 267% during the same period (DAPA, 2010, 2015, 2021c). In particular, the defense R&D budget increased by 20.7% from 2019 to 2020 (DAPA, 2021c). The share of defense R&D in national R&D is 11.9% in 2006 and 16.0% in 2020, and the proportion of defense R&D budget in the national defense budget reached 8.0% in 2020 from 4.7% in 2006 (DAPA, 2010, 2015, 2021c). Graph 1 shows the ratio of defense R&D budget to the defense budget and the ratio of defense R&D to national R&D from 2006 to 2020.

Graph 1. The ratio of defense R&D budget to the defense budget and national R&D budget



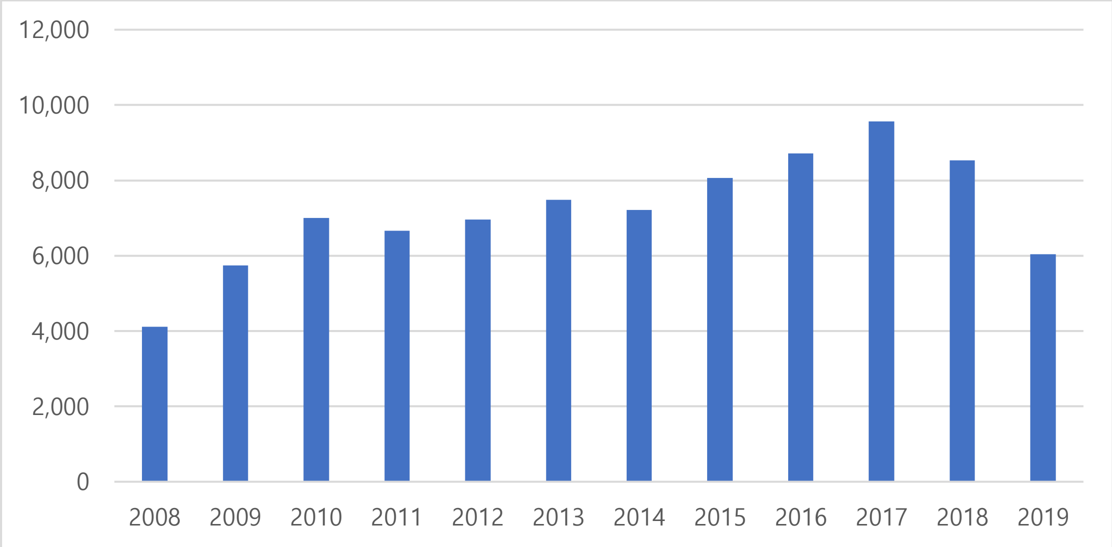
As of 2021, the defense capability improvement budget is 16,996.4 billion KRW, 32.2% of the total defense budget (DAPA, 2021c). Graph 2 shows the defense capability improvement budget from 2006 to 2021 and its proportion in the total defense budget.

Graph 2. Defense capability improvement budget and its proportion in the defense budget



According to the "Korea Defense Industry Association" (KDIA)'s data, the amount of R&D investment in the defense sector of defense companies in 2008 was 410.7 billion KRW, and in 2017 it was 957.1 billion KRW (Korea Defense Industry Association, n.d.). Graph 3 shows the new R&D investment in the defense sector of defense companies by year.

Graph 3. New R&D investment in the defense sector of defense companies by year



(3) The characteristics of Defense R&D in Korea

In a book written by Hartley and Belin (2019), the authors explained that Korea's defense industry is a good example of a mid-tier arms-producing nation advancing the development and manufacturing of weapons systems significantly. They argued that the goals of Korea's defense industry policy include contributing to the national economy through import substitution and technology-intensive industrialization.

A newspaper article reported that Korea ranked ninth in the world in the global defense exporting countries rankings from 2016 to 2020 according to the Stockholm International Peace Research Institute (SIPRI), which is the highest ranking ever (Jang, 2021). According to this article, SIPRI researcher Siemon Wezemann stated that Korea's recent surge in defense exports is due to its superior defense industry's ability to compete with advanced countries.

In the '2018-'2022 Defense Industry Development Plan published by DAPA, the vision of the plan is to make the defense industry a core foundation for independent defense, and the goals of that are to secure the ability to develop advanced weapon systems and strengthen global competitiveness (DAPA, 2018). The policy goals of this plan are 1) securing the ability to develop advanced weapon systems and 2) strengthening global competitiveness.

In relation to 1), strengthen national defense R&D capabilities to realize independent defense and secure domestic development capabilities of high-performance and high-quality weapon systems suitable for the future war environment. In addition, through domestic development of high-tech weapon system, import substitution and the accumulation of cutting-edge technologies will enable domestic defense companies to strengthen their core competencies. Concerning 2), the competitiveness of defense companies will be improved to strengthen global competitiveness, and based on this, the industrial structure will be converted to expand defense exports. Also, through defense exports, it will create quality jobs and realize sustainable growth of the defense industry and economies of scale.

2) Defense R&D contract system in Korea

(1) Overview of defense R&D contracts

Prior to enacting the “Defense Science and Technology Act”, defense R&D programs were carried out in the form of contracts under the “Act on Contracts to which the State is a Party” (“State Contracts Act”) and the “Defense Acquisition Program Act.” However, in some cases, introducing a more flexible agreement other than a state contract can align with the challenging and creative defense R&D policy direction. Accordingly, with the enactment of the “Defense Science and Technology Act,” the agreement system was introduced to defense R&D.

(2) Contracts and agreements of defense R&D

Contracts concluded by the government are, in principle, governed by the “State Contracts Act”, which stipulates essential matters regarding government contracts. However, Article 46 of the “Defense Acquisition Program Act” provides a special case. According to this, the government can establish “short-term contracts,” “long-term contracts,” “firm contracts,” and “approximation contracts” when procuring defense materials and repair parts essential for the operation of weapon systems or conducting defense R&D programs.

Article 61 of the Enforcement Decree of the same Act specifies types of contracts as shown in the table 3.

Table 3. Types of contracts stipulated in the Enforcement Decree of the Defense Acquisition Program Act

Types of contracts used in DAPA
1) General conclusive contract
2) Commodity price-coordinated unit price contract
3) Cost reduction compensation contract
4) Cost reduction incentive contract
5) Ceiling amount contract
6) Midway conclusive contract
7) Indeterminate item contract
8) General approximation contract
9) Performance-based contract
10) Long-term option contract
11) Ceiling performance contract

According to Article 8 of the "Defense Science and Technology Act," the Minister of the DAPA may conclude contracts or agreements on defense R&D programs. However, in principle, the conclusion of an agreement is made in the following cases: 1) R&D that determines or is expected to determine the core technology requirements for weapon systems, 2) R&D for future challenging defense technologies, 3) R&D using new technologies, 4) R&D of forces support system under the "Defense Acquisition Program Act."

The weapon system R&D programs that can conclude defense R&D agreements are as follows: 1) Projects in the exploration development stage, 2) Projects in which the R&D institution bears all or part of the project cost among the projects in the system development phase, and the R&D cost (total of development costs for system development) is less than KRW 50 billion, 3) A project that the "Defense Acquisition Program Promotion

Committee" deliberated to conclude an agreement for when it is possible to immediately deploy a prototype or it is impossible to go through the procedures of exploration development, system development, and mass production (Article 4 of the Enforcement Decree of the "Defense Science and Technology Act").

(3) Status of defense R&D contracts

The government determines the contract type under the laws and regulations in the implementation of defense R&D. General conclusive contracts under Article 61 of "Enforcement Decree of the Defense Acquisition Program Act" are a type of contract in which the contract amount is fixed at the time of signing the contract, and the fixed contract amount is paid to the contracting party when the agreed contract conditions are fulfilled. Article 61 of this Enforcement Decree stipulates a "general approximation contract." It is a contract concluded when there is no cost data to confirm the contract amount at the time of signing the contract, and the contract amount is to be fixed after the contract is performed.

In addition to the "general conclusive contracts" and "general approximation contracts," the weapons system R&D program was also carried out in the form of an "approximation contract for the upper limit." It means that when the development is completed, the cost is settled, and if the cost is less than the initial contract amount, the contract amount is reduced, and if it is more than that, the excess amount is not recognized. (DAPA, 2019b).

On the other hand, DAPA is improving the system to alleviate the requirements for adjusting the contract amount of the unreasonable upper limit approximation contract to decrease the burden of defense companies. In the case of the current approximation contract, it is possible to modify the contract amount only when the contract amount was increased or decreased by more than a certain amount (5/100 of the initial contract amount). DAPA is promoting system improvement so that if specific requirements are met, such as design changes, a revised contract can be signed even if the contract amount is increased or decreased by less than 5/100 of the initial contract amount (DAPA, 2021d).

3) Defense cost system in Korea

(1) Overview of cost system

Regulations of Korea's defense R&D cost-related include the “State Contracts Act,” the “Rules for the Cost of Defense Cost Objects” (the “Defense Cost Calculation Rule”, Ministry of National Defense Ordinance), and other administrative rules.

Article 8 of the “State Contracts Act” (“Preparation of Expected Price”), in principle, requires that the government should prepare the estimated price in advance according to the relevant specifications and design documents, etc. The standards for preparing the expected price are being specified through the Presidential Decree and the contract rules set by the Minister of Economy and Finance.

The "Defense Cost Calculation Rule" sets standards and methods for cost calculation necessary for contracts for the procurement of defense materials and contracts or agreements for defense R&D programs. In other words, it can be said that it is a special provision for cost calculation in contracts and agreements for defense R&D programs. These regulations include manufacturing cost calculation standards (general standards, cost component items), manufacturing cost calculation items (calculation of manufacturing organization overhead, manufacturing overhead, general administrative expenses, profit), settlement cost calculation of an approximation contract (calculation of estimated cost and settlement cost), service cost calculation, cost information (accounting standards, faithful reporting obligations).

(2) Characteristics of defense R&D cost

In defense R&D, including system development, project management and contract management as well as cost calculation are complicated and highly uncertain. Conclusive contracts are the principle in the defense acquisition programs, and general manufacturing and purchase contracts are based on generally conclusive contracts based on the calculation of the expected price. However, defense R&D programs have difficulties securing accurate cost data, uncertainties in development success at the time of contract signing, and the possibility of changes in project and schedule.

Therefore, the "Defense Cost Calculation Rule" stipulates the "general approximation contract," the "indeterminate item contract," and the "midway conclusive contract" in addition to the "general conclusive contract." Such an approximation contract is to be concluded when it is difficult to determine the contract amount at the time of the conclusion of the contract.

The concept of the "general approximation contract" is as described above. In a "midway conclusive contract", it is difficult to determine the contract amount when the contract is concluded due to the nature of the contract. In the "indeterminate item contract," it is difficult to determine the cost of some items constituting the contract amount at the time of contract conclusion, so only items that can be determined are fixed, and some items that are difficult to determine are confirmed after the contract is executed.

Ⅲ. Analysis and implications related to defense cost system in the system development programs

1. The standard cost system

1) Discussion on introducing a standard cost system in Korea

DAPA is reviewing a plan to introduce standard costs in relation to cost structure improvement. In July 2019, DAPA announced the results of policy research services conducted by an accounting firm on defense cost structure improvement. DAPA stated that with respect to the current actual cost compensation method, the higher the cost, the greater the profit of the companies, so it is impossible to induce voluntary cost reduction efforts of companies. It explained that in the future, it would introduce a “standard cost” system in which the “wage unit price” for each group is applied and the “work procedure” is formally documented in consideration of the company's sales scale and industry type (Lee, 2019).

DAPA has adopted a method of compensating for actual costs concerning defense cost calculation, which adds profits to the costs recognized by the government as actually incurred. Therefore, as DAPA pointed out if the cost is high, the profit of the company will increase accordingly, and if the cost is low, the profit of the company will be small.

On the other hand, the standard cost in accounting is a concept corresponding to the actual cost. It refers to the cost calculated by the quantity standard and price standard based on scientific research on the premise of a certain level of operation. According to the cost calculation standards, the standard cost is the cost calculated as the expected price or arm's length price so that the consumption of a good becomes a measure of efficiency through scientific and statistical investigations (Naver Knowledge Encyclopedia, n.d.).

The standard cost system manages and controls the cost by setting the standard cost of a product or service in advance according to a standard. It has advantages in financial operations by predicting costs in advance and can simplify the costing task. However, it can be not easy to establish criteria for setting standard costs. That is, if the accuracy and objectivity of the standards are not guaranteed, there is a disadvantage that may cause errors in cost estimation.

As such, the standard cost is a fundamental concept in accounting and is used in government contracts other than defense programs. However, since the defense industry has characteristics as a critical industry directly related to national security, the concept of standard cost has not been applied so far, and the method of compensation for actual costs has been applied.

2) The standard cost system in the US

Standard cost refers to the costs calculated using preestablished measures (FAR 31.001). CAS 407 sets the "Cost Accounting Standard". It is stipulated in the Code of Federal Regulations (CFR) Title 48, Chapter 99 (Part 9904). It is to apply standard costs to "direct material" and "direct labor." This criterion is not used for other overhead costs. It is the contractor's choice to use the standard. CAS defines concepts for “labor cost at standard”, “labor-rate standard”, “labor-time standard”, “material cost at standard”, “material-price standard”, "material-quantity standard", "production unit", "standard cost", and "variance". The standard cost refers to the cost calculated through a predetermined measure, and the variance refers to the difference between the preset measure and the actual measure (CAS 407-30).

CAS 407-40 sets the standards for using the "standard cost accounting system." That is, 1) standard costs should be entered into the book basically, and 2) Standard costs and variances should be adequately accounted for at the production unit level (CAS 407-40).

In CAS 407-50, “technicians for applications” are defined. A company that manufactures one product has one labor variance for the entire plant. On the other hand, a company that manufactures multiple products has a variance for each product line and (/or) for multiple common part sub-product lines. 3) Practices of establishing and revising standards, using standard costs, and handling variance should be written and followed. 4) When noncompliances occur, the auditor makes appropriate recommendations under the CAS (CAS 407-50).

The contractor's documentation regarding standards includes the criteria used to establish and amend the standards. A labor-rate standard could also be established to include groups of direct labor workers performing disparate tasks only under one of these following conditions: 1) If a group of workers produces a uniform output in a production unit, the same labor-rate standard applies to workers in the group. 2) When the group of workers forms a team in performing their respective functions, a labor-rate standard is established for each team (CAS 407-50).

Variances in labor-costs are recognized at the point in time when labor costs are introduced into the production unit. The variances between labor-rate and labor-time can be included into the same labor-cost variance account, and a separate labor-cost variance is be cumulated for each production unit (CAS 407-50).

One of the following shall apply to the accumulated variance in production units. 1) The variance is allocated to the cost target at least once a year. Regarding materials, allocation is based on the “material cost at standard”, and in case of the homogeneous outputs, based on the "units of output." In relation to labor, the "labor cost at standard" or "labor hours at standard" are the basis, or in the case of homogeneous output, "units of output" is the basis. 2) Immaterial variances can be included in the appropriate indirect pool for allocation to the cost objectives (CAS 407-50).

CAS 407-60 defines "Illustrations," which provides a number of key examples of standard costing. It can be said to be a way of giving an example of a case that can become an issue and providing an interpretation of the regulations. This form of description of regulations is considered to enhance work efficiency by increasing the understanding of regulations among public practitioners and contracting parties. It seems to be a form of regulatory description that can be used as a reference for regulating government affairs, which have a specific and executive nature, such as cost, contract, and project management in the form of regulations. If these contents are stipulated in the form of administrative rules rather than guidebooks, their binding force would be greater (CAS 407-60). Figure 5 shows the way of description of the illustrations (CAS 407-60).

Figure 4. Descriptive form of "Illustrations" in CAS 407-60

(c) Contractor C allocates variances at the end of each month. During the month of March, a production unit has accumulated the following data with respect to labor:

	Labor hours at standard	Labor dollars at standard	Labor cost variance
Balance, March 1	5,000	$25,000	$2,000
Additions in March	15,000	75,000	5,000
Total	20,000	100,000	7,000
Transfers-out in March	8,000	40,000	
Balance, March 31	12,000	60,000	

Using labor hours at standard as the base, Contractor C establishes a labor-cost variance rate of $.35 per standard labor hour ($7,000 ÷ 20,000), and deducts $2,800 ($.35 × 8,000) from the labor-cost variance account, leaving a balance of $4,200 ($7,000−$2,800). Contractor C's practice complies with provisions of 9904.407-50(d)(1) of this Cost Accounting Standard.

* Source: "National Archives, Code of Federal Regulations"

3) Implications

According to DAPA's announcement in 2019, it is considered that the standard cost system was considering applying a unit cost of labor and documenting the work procedures. This standard cost system can simplify financial operations and cost estimation by allowing the cost to be measured in advance according to the standard. On the other hand, there is a task to secure accuracy and objectivity in establishing standards.

The introduction of a standard cost system to defense costs seems to be a task that requires a detailed review. In introducing standard costs, the government should listen to the opinions of companies and research institutes. As it is the first system to be implemented, the government should accurately and precisely describe the regulations so that there is no confusion among companies and faithfully provide information, including establishing a guidebook that companies can refer to.

In addition, the provisions and practices of CAS 407 determined by CFR Title 48 of the US should be reviewed, and the regulations and cases in the US that can be referred to should be thoroughly reviewed. Also, the regulation in a way that promotes understanding of major cases as stipulated in CAS 407-60 needs to be reviewed.

2. Criteria for R&D contracts and agreements

1) Cost system improvement and contract type

System development usually aims to make a prototype through research in order to proceed to mass production after exploration development. Therefore, it may be difficult for the public contracting manager to confirm the program details and obtain objective and reliable cost data when signing the contract. It can be an obstacle for the public contracting officer to determine the type of contract. In particular, whether the price can be determined at the time of contract is the most fundamental factor in determining the type of contract.

Defense R&D can be carried out in the form of current contracts or agreements, and newly introduced agreements are more flexible than traditional defense contracts. In addition, the public contracting officer might feel more difficult in setting the conditions of the contract or agreements in the case of joint investment or corporate investment than in the case of government investment. Therefore, it is necessary to review the discussion on the contract type decision about improving the cost system.

2) Sharing of development costs between the government and companies

As mentioned above, R&D programs in Korea are grouped into government investment, company investment, and joint investment. In the company investment program, the developer is responsible for managing the program, and it designs the system and produces a prototype. The IPT leader of DAPA can provide Required Operational Capability (ROC) and Operational Requirement Document (ORD). It can also provide opinions and data to the company and cooperate with it. In the joint investment program, the project is managed by the developer, but the IPT leader participates in checking and providing opinions on significant steps related to schedule, cost, and performance (for example, design and configuration management) ("Guidelines for the selection of investment entities for research and development of weapons systems" (DAPA regulations) Article 7).

In this regard, Article 59 of the Defense Program Management Regulations stipulates that for domestic R&D projects, the type of project implementation should be reviewed in consideration of the company's ease of recovery of investment costs, the level of domestic technology, and the technical difficulty of the project. However, government investment will be considered first in the following cases. 1) R&D programs in the exploration development stage, 2) R&D programs in which force integration is completed through system development, 3) Other programs judged to be advantageous for government investment in consideration of the characteristics of defense programs, the timing of force integration, costs.

The IPT leader can conclude an agreement in the case of a company investment program or a joint investment program. If it is a company investment program or a joint investment program, it should be reviewed whether it is reflected as a condition of the following contract (or agreement). 1) In the case of joint investment, the investment cost sharing rate and annual contribution amount as specified, 2) when the contract (or agreement) is canceled due to reasons attributable to the government or the company, the company's R&D investment treatment plan, 3) the R&D prototype use plan, 4) In the case of business investment, a plan to allow the government to own or use the intellectual property rights owned by the company, 5) Other matters necessary for program promotion.

In this regard, Attached Table 5 of the Defense Program Management Regulations sets the "Government and company burden ratio by type of participating company" and is shown in figure 6 below.

Figure 5. Government and company burden ratio by type of participating company

[Attached Table No. 5]

Government and company burden ratio by type of participating company

1. In case of contract-based domestic R&D

Classification of participating companies	Government contribution rate	Company Investment Ratio (Lower and Upper Limits)
When all are large companies	10% or more and less than 50%	50% or more and 90% or less
When all are medium-sized companies	More than 28% and less than 60%	40% or more and 72% or less
When all are small companies	55% or more and less than 75%	25% or more and 45% or less
In the case of medium-sized company and small and medium-sized company, respectively	More than 28% and less than 60%	40% or more and 72% or less
When the ratio of medium-sized company is more than two-thirds	More than 28% and less than 60%	40% or more and 72% or less
When the ratio of small and medium-sized company is two-thirds or more	55% or more and less than 75%	25% or more and 45% or less
Otherwise	10% or more and less than 50%	50% or more and 90% or less

2. In case of domestic R&D in the form of an agreement

Classification of participating companies	Company Investment Ratio
a small business	10% or more
a mid-sized company	12% or more
a large company	20% or more
Other research institutes, etc.	10% or more

3) Contract type of system development

Even in the case of a system development contract, the contract conclusion method is determined among the 11 types of contracts stipulated in Article 61 of the Defense Acquisition Program Act Enforcement Decree. Since the contract type is closely related to the cost estimation method, it is necessary to discuss the contract type to improve system development costs.

Research from Industry Economy Information Institute (2018) discusses conclusive contracts and approximation contracts. It points out the case of unreasonably concluding a firm contract even when it is impossible to properly calculate the cost at the time of conclusion of the contract. It also asserts that losses of government or companies may occur in circumstances where proper cost calculation is not possible. It points out that comparable cost data cannot be obtained from companies that do not produce contract objects because they do not have previous experience in research, development, and prototype production. It also points out that long-term contract items have limitations in costing for firm contracts because it is difficult to predict in advance cost factors (e.g., exchange rate fluctuations, wage increases). Therefore, it recommends stipulating the requirements of the general conclusive contract in order to avoid unreasonable expansion of the general conclusive contract. In addition, it recommends that the "indeterminate item contract" method be utilized to the fullest while avoiding cost management after the contract through special contract conditions after the performance of the contract (Industry Economy Information Institute, 2018).

On the other hand, the US R&D contract system has the contract types of “fixed-price contracts,” “cost-reimbursement contracts,” and “incentive contracts” in the FAR, and it is considered that there is no general estimate contract in Korea (Jang, 2001). That is, FAR 16 (102) stipulates that “cost-plus-a-percentage-of-cost system of contracting” is not permitted. For example, even in the case of various types of cost-reimbursement contracts, there is no form that recognizes the contract amount by calculating the contract amount by combining the costs and profits, as in Korea.

The US does not have a general approximation contract system in the FAR, and it is somewhat similar to Korea's current cost structure improvement policy. The general approximation contract in Korea is a method in which the contract amount is determined by adding the profit calculated according to the regulations to the cost incurred, and the contract amount is settled with the company accordingly. According to this, if the cost incurred increases, the profit of the company increases, and there is a risk of a loss to the national treasury, but it is rather beneficial for the company. On the other hand, in the case of the US, which does not have a general approximation contract, "cost-reimbursement contracts" are being operated in a way that calculates the contract amount by adding various types of fees to the cost.

FAR 35 stipulates “Research and Development Contracting.” In particular, “Contracting methods and contract type” is defined in 35.006, and the main contents are as follows.

35.006 (b) states that it is the contracting officer's responsibility to select the proper contract type. However, it should be selected after receiving a recommendation from the technical workforce due to the technical importance of the R&D contract. Governments generally prefer the "fixed-price arrangement," but that only applies if goals, objectives, and cost estimates allow this. Contracting officers should select the proper contract type for the required work, taking goals, performance objectives into account.

35.006(c) states that it may be more appropriate to enter into a "cost-reimbursement contract" rather than a "fixed-price contract" because the specifications of R&D are not generally precise, and cost estimation is difficult. It provides that a "cost-reimbursement completion arrangement" may be necessary due to the characteristics of the development. It also stipulates that if the use of cost and performance incentives is appropriate and practicable, a "fixed-price incentives and cost-plus-incentives-fee contract" is considered first.

A project with production requirements as follow-ons to R&D is subject to from a “cost-reimbursement contract” to a “fixed-price contract,” depending on the firmness of the design, the degree of risk, and the extent to which production equipment and processes are improved (35.006(e)).“ However, the decision to develop a specific product or test is possible when: 1) When it is judged that development is possible and highly probable according to preliminary exploration and study, 2) When the government determines the minimum requirements and goals for performance and schedule.

4) Implications

As discussed above, the system development program has uncertainties in the design, cost, and schedule of the program and uncertainty in success and commercialization. Also, since there is no experience in development and prototype production, the government may have difficulties in receiving comparable objective cost data from companies. Therefore, the contracting officer of the government might have difficulties in determining the contract type. In accordance with the revision of the "Defense Science and Technology Act" in 2020, the system development program can be promoted in the form of an agreement and the contract form according to the existing "State Contracts Act" and the "Defense Program Act." Agreements are more flexible than existing contracts and are subject to special provisions for challenging and creative R&D. In addition, depending on the type of investment in the system development program, government contract managers may need each objective standard to set the conditions of the contract or agreement.

Therefore, it is necessary to establish more detailed contract conclusion standards so that the contracting officer can refer to them in determining the contract type. In addition, the contract manager of the US government is required to receive recommendations from technical personnel when signing R&D contracts, which is worth referring to. Therefore, it is necessary to carefully review the background and practice of operating these systems in the United States and establish policies in line with the Korean contractual situation.

3. Competitive prototyping system and the defense cost

1) Overview of competitive prototyping

(1) Competitive prototyping in Korea

The basis for competitive prototyping is the "Defense Science and Technology Act" and the "Defense Program Management Regulations." "Defense Program Management Regulations" stipulates the promotion of competitive prototyping (Article 61).

The promotion targets are as follows; 1) Among government-invested projects, where the total project cost (the sum of the development cost and mass production cost) is 100 billion KRW or more, and the development cost is less than 10% of the total program cost, when it is possible to reduce costs beyond the target rate for mass production unit cost reduction[3] through the competition so that the total program cost can be reduced. Exceptionally, if the head of the program division deems it necessary, the amount may be less than 100 billion KRW. 2) When it is necessary to reduce the risk of development failure due to the serious technical difficulty or complexity of the program. 3) In case of strengthening the

[3] Target rate for mass production unit cost reduction (%) ≥ [1 - {(Planned mass production unit price - (single company development cost / mass production quantity)) / planned mass production unit price}] * 100

competitiveness of domestic defense companies. 4) In other cases necessary for defense policy. In principle, competitive prototyping is performed by integrating exploration development and system development, and exploration development can be omitted if necessary. In principle, whether or not to promote competitive prototyping is reviewed in the prior research stage, and two R&D leading organizations or prototype companies are selected through proposal evaluation and negotiation (Article 61 of the "Defense Program Management Regulations").

"Guidelines for the selection of investment entities for research and development of weapons systems" (DAPA Regulation) stipulates that government investment should be prioritized for investment entities in competitive prototyping projects (Article 11).

The Integrated Program Team (IPT) includes the mass production unit price target management plan and the maximum mass production unit price suggested by the companies in the "System Development Action Plan" and manages it until the mass production company is selected. In principle, the "lowest cost when requirements are met" method is applied for the final mass-production target weapon system, component equipment, and components, but the "comprehensive evaluation" method is applied if necessary (Article 61 of the "Defense Program Management Regulations").

On the other hand, the "Guidelines for Defense Technology R&D Programs Process" (DAPA regulation) stipulates as follows concerning the implementation of defense technology programs; For high-risk core technology tasks, multiple leading organizations can be selected for the same task to ensure final success through risk distribution and competition induction.

(2) Competitive prototyping in the US

Competitive prototyping has a legal basis under the 2009 "the Weapon Systems Acquisition Reform Act" (WSARC). According to this law, competitive prototyping is, in principle, compulsory, but exempted in the following cases; 1) When the production cost of competitive prototyping program exceeds the anticipated lifecycle benefit of the prototype, or 2) When crucial national security goals are not met (Government Accountability Office, 2013).

As described above, competitive prototyping is applied in “funded R&D,” which is government-invested R&D. In principle, it is carried out in the "Technology Maturation & Risk Reduction" stage, which is before the program starts decision (Jang et al, 2016).

2) Cost payment and cost calculation

It is known that competitive prototyping has been applied to very few defense R&D programs in Korea for about ten years since the introduction of the system. It is challenging to find regulations related to program cost payment or cost calculation applied only to competitive prototyping. In the past, “Defense Program Management Regulations” (No. 170, Article 171-6, Paragraph 5) stipulated as follows; when R&D was completed, R&D expenses were paid to companies that developed weapon systems that were not selected for mass production among R&D weapon systems that were judged to be suitable for combat, and R&D expenses of companies subject to mass production are included in the mass production cost. However, in June 2012, the above article has been abolished (Jang et al, 2016).

According to the research from Jang et al (2016), the US government pays the entire development cost to partners participating in competitive prototyping, however, the Korean government divided the development cost in half and paid them to companies in the past.

3) Implications

In view of the fact that the US, which develops various weapon systems on its own, makes competitive prototyping mandatory in the exploration development stage, competitive prototyping can be seen as a critical system for acquiring excellent and price-competitive weapon systems through competition. However, the system should be operated appropriately for the reality of Korea.

In this regard, it is necessary to review the policy regarding the payment of development costs and cost estimation of the competitive prototyping program. With the introduction of the "Defense Science and Technology Act", DAPA has introduced various innovative R&D systems and refined details. In addition, it is needed to review whether it is necessary to set clear standards for development cost and cost calculation in the form of regulations to activate competitive prototyping.

4. Defense acquisition cost overrun

1) Background of the cost overrun discussion

In relation to the operation of the defense budget in the US, there has been a long discussion about cost overruns in defense acquisition programs. In particular, it is an essential issue in defense R&D programs and suggests the importance of cost management measures for system development programs. The defense R&D project aims to develop supplies and technologies that do not exist before, so it is difficult to obtain cost data when signing the contract, making it difficult to determine the contract amount. In addition, the contract amount in defense R&D programs is usually large, the success of development and business is uncertain, and the contract period is long. It is difficult to determine the contract amount at the time of signing the contract, and even if the cost is exceeded, there are many cases where the excess cost is not small. Therefore, it is not easy to predetermine the risk burden in the contract terms. Also, since the success of the project is not certain, there may be a discussion about how the government and its contracting parties are appropriate to bear the risk. Therefore, the issues of cost overrun can provide essential implications for the improvement direction of cost management of system development programs.

As described above, FAR basically considers fixed-price contracts to be a way for the government to minimize risk and allow counterparties to control risk and cost reduction. Therefore, in general cases where cost data can be obtained, fixed-price contracts are the primary contract type. In this case, in principle, the companies will bear the risk of cost overrun. However, for example, in the case of cost overruns due to changes in government requirements, problems will arise in the operation of the government's defense budget and the management of government contracts.

"Operation of the Defense Acquisition System" (DoD Instruction 5000.02T, 5 (“Procedures”), b (“Relationship Between Defense Acquisition, Requirements, and Budgeting Processes”) emphasizes the close operation of acquisition programs, requirements, and budgeting. In other words, the requirements are essential for defining the product to be acquired, and the budget process determines the priorities and allocation of resources to provide the necessary funds for the acquisition programs. Therefore, the three procedures should be coordinated to be consistent throughout the life cycle of the product. For example, the requirements may need to be tailored to the technological and financial realities. Acquisition projects may be adjusted according to changes in requirements and availability of funds, and budgets may be adjusted to accommodate changes in program performances and requirements. Therefore, officials in charge of these three processes should work closely to adapt to circumstances and solve issues quickly. This Instruction considers cost an important consideration in the milestones of the acquisition programs (DoD Instruction

5000.02T).

Also, its enclosure 10 specifies "Cost Estimating and Reporting." It aims to secure that the most effective cost solution to the requirements is applied, the budget is appropriate, and the cost savings potential of multi-year contracts are utilized. "The Director of Cost Assessment and Program Evaluation" (DCAPE) provides instructions for cost estimating and cost analysis of all acquisition programs in accordance with relevant regulations, including setting guidelines for cost estimating and risk analysis. It also provides guidance on collecting standardized cost data and monitoring systems. For multiyear procurement contracts, DCAPE performs a cost analysis and determines whether it supports the finding of the Secretary of Defense (DoD Instruction 5000.02T)

2) Literature review

(1) Research from Smirnoff (2007)

Research from Smirnoff (2007) analyzes the factors that affected the cost overruns in the major DoD acquisition projects over 20 years. The factors are defense budget instability, defense acquisition reform, defense companies' consolidation, cost estimation errors, and war. It argues that cost overruns can be also an issue for the DoD's budget management. It is because the defense budget is basically allotted for the given years. This issue could also affect the extension of the acquisition schedule and the capability and quantity of weapon systems. Also, cost overruns can lead to instability of project costs for programs affected by fund reprogramming, which in turn can exacerbate cost overruns (McNutt, 1998 as cited in Smirnoff, 2007, p.4).

It argues that budget change is a major cause of cost overruns. It finds that the budget change does not affect the cost overrun of the R&D programs, but the decrease in the R&D budget increases the procurement cost overrun. It predicts that a 10% budget reduction in the R&D programs will increase procurement cost overruns by about 4%. It points out that as the cause of this, when the budget is reduced, the budget of existing programs is prioritized and programs with lower priorities are reduced in the budget, which can lead to schedule delays and cost increases.

This study modeled errors due to unexpected inflation with respect to the impact of cost estimating errors on cost overruns. Budgeting and cost estimating involve forecasting inflation. It finds that inflation is underestimated. The DoD, for example, did not predict the high inflation of the early 1980s. It finds that the cost of about $30 billion was exceeded due to unexpected inflation. It recommends that the DoD needs to devote more resources to forecasting inflation.

(2) A Report of the GAO (GAO-21-74)

“The U.S. Government Accountability Office” (GAO) recommended that DoDs establish formal procedures for standardizing the development and documentation for cost savings.

It recommended that economic assumptions, the alternatives considered, and opportunity costs should be included (Government Accountability Office, 2020).

Information on the savings analysis previously reported by the DoD in the budget data was limited, and some savings initiatives did not match the definition of defense reform. Therefore, in order for decision makers to have reliable information on the cost savings of reform in the DoD, there is a need for a process for standardizing the development of savings and documentation of savings and identifying savings consistently.

In response, the DoD agreed with this recommendation. It responded to the GAO with a plan to identify, calculate, and document cost-saving opportunities in the budget review process. The DoD also plans to deploy an “Advanced Analytics (ADVANA)” system to document costs and other critical performance elements for enterprise businesses. DoD estimates these will be performed by 2022.

3) Implications

First, securing an appropriate government R&D budget may be important. Research from Smirnoff (2007) found that a decrease in the R&D budget increases the procurement cost overrun. From this, it can be considered that securing an appropriate R&D budget can be significant in reducing defense acquisition costs. In addition, securing an appropriate budget is a prerequisite for proper management of project, contract, and cost since project details and cost calculations are carried out within the budget range.

Second, budget setting and cost determination systems are essential. Research from Smirnoff (2007) recommends that the DoD needs to devote more resources to forecasting inflation in budgeting and cost estimation. This can be also the case in Korea. It is necessary to prepare a scientific and rational system not only for inflation prediction but also for budget setting and cost estimation overall. It contributes to increasing the objectivity and rationality of cost and cost management tasks.

Third, it is critical to review the cost reduction plan in advance for a specific project. The GAO's Recommendation on DoD highlights the importance of standardizing development and documentation to reduce costs. The US has been performing procedures such as cost estimation, cost analysis, and cost reporting in the defense acquisition programs. However, specifying the content of the analysis data on cost reduction can enrich the cost information of decision makers and contribute to better decision making. Having a formal process to review alternatives, amounts, and opportunity costs of cost reduction in documents in the budget review process of each acquisition program will contribute to the proper decision-making for saving the national budget and acquiring weapons systems. In addition, it can be a way to make management tasks of acquisition programs, contracts, and costs simpler than applying a reduction plan after the contract is concluded by having the cost reduction plan be reviewed before the contract is signed.

4) Need for additional study

The literature reviewed above mainly relates to the aspect of the cost of acquisition projects on the government's budget reduction. In this regard, a study on how the government's defense R&D budget and corporate R&D investment affect the growth of the defense industry is necessary. Countries around the world are promoting their industrial growth as well as improving their national defense capabilities through defense R&D programs. On the other hand, the resources are always limited, and the long-term and uncertain defense R&D project may be subordinated to the government budget and corporate investment, so it will be a meaningful study to review it. In the next chapter, this topic would be reviewed.

5. A study on the R&D investment and the defense industry

1) Purpose of the study

This study is about the impact of defense R&D investment on the defense industry. Currently, the importance of defense R&D is generally acknowledged. However, there are still concerns that the R&D paradox exists because industrial growth through commercialization is inefficient. In other words, it is about whether a national and corporate investment in defense R&D leads to economic performance and has a direct and positive impact on the growth of the defense industry.

Government and corporate resources are limited. Fiscal soundness is also an essential factor to consider when formulating defense R&D budgets, and Korea's national debt has increased recently. Korea's national debt was 30.3% of GDP in 2011, but it was 43.8% of GDP in 2020 (Statistics Korea, n.d.). In addition, it may be challenging for companies to prioritize long-term R&D investments over investments in areas with short-term, tangible economic performance. Therefore, the impact of government and corporate defense R&D investment on economic growth can be an essential factor to consider in defense budget formation, defense R&D, and defense industry policies.

Therefore, this study examines the impact of defense R&D investment by the government and companies in Korea on the defense industry. To this end, this study reviews the literature on defense R&D and the defense industry. In addition, it analyzes the effect of government and corporate R&D investment by year on various indicators of the defense industry through quantitative research. It has not been studied so far despite the need for research. This project presents implications for policies of the defense budget, defense R&D, and defense industry by analyzing the correlation between R&D investment and defense industry growth.

2) Literature review

(1) The relationship between defense R&D and the defense industry

There is a study that explains the characteristics of defense R&D in the defense industry (Mowery, 2012). The author described that the government, which is the main body of defense R&D investment, is generally the sole user of the outcomes in defense R&D. According to this study, because the defense-related product does not go through competition with other products, unlike commercial products, there is no learning process through competition. The author argued that there is a great deal of uncertainty that it must be integrated into a high-performance system at the time of deployment because it takes at least several years to deploy a weapon system after the start of R&D. This study summarized the impact of defense R&D on technological innovation in the private sector in three ways. They are the advancement of private technology and knowledge, the spin-off of technology from the defense sector to the private sector, and R&D expenditure through procurement.

In research from Lee and Park (2019), the authors asserted that the defense industry should lead the defense R&D to strengthen its technology and expertise through long-term planning and investment. According to this study, whether R&D performance is about weapon development is generally considered significant in the budget allocation, but R&D of basic and applied technologies is often not directly related to weapon development. The authors argued that there is a great need for the defense industry to lead defense R&D through long-term investment because latecomer countries tend to have lower R&D performance level than advanced countries. They also claimed that the defense industry tends to lead the weapon system R&D in most advanced countries.

(2) The economic effect of R&D investment

There are many studies on whether R&D investment has a positive effect on the economy, but there is no consensus yet. Zachariadis (2004) studied the case of the US and concluded that R&D intensity has positive effects on economic growth and technological innovation. The author found that R&D intensity affects the patent rate, the patent rate affects technological progress, and technological progress affects the worker's output.

However, other studies show that R&D expenditure is not related to economic growth. For instance, Tuna et al. (2015) analyzed the relationship between R&D investment and economic growth in Turkey, the 17th largest country in the world by GDP. However, they found no causal relationship between the two. There is a study on whether government R&D affects economic growth by Kacprzyk and Świeczewska (2019). They analyzed the impact of government and business R&D stock on the economy in European Union countries. The study found that government R&D stock had no statistically significant effect on economic growth.

In addition to the studies on the economic effects of general R&D, there are several studies on the correlation between defense R&D and the growth of the defense industry. Research from Mowery (2012) premised that it is not easy to calculate the economic value of defense R&D and that much of the improvement in defense R&D performance depends on the size of the program. This study concluded that defense R&D investment affected the performance of huge programs in the US but not on the performance of small programs in the United Kingdom and France.

Research from Fonfria and Duch-Brown (2014) explained that intentional and continuous investment in R&D enhances a company's ability to utilize external knowledge and foreign advanced technology. According to this study, R&D can directly improve productivity through technological innovation and process improvement and prepares to improve future productivity by increasing a company's knowledge and technical capabilities. It found that a company's R&D intensity is related to higher export intensity in the defense-related goods sector. It also found that defense-related material exporter is more capital-intensive and more related to technological fields and ongoing exports, resulting in more excellent learning from overseas projects.

In a study by Su, Wang, Tao, Lobonţ, and Moldovan (2019), the authors investigated whether there is an optimal R&D intensity that can maximize the performance of defense companies. This article concluded that unlimited commitment to R&D does not guarantee a positive return on investment. According to this result, the authors analyzed that it may be possible to assume that defense companies have an optimal level of R&D intensity, and recommended that defense companies should make more specific plans for efficient R&D performance.

Research from García-Estévez and Trujillo-Baute (2014) analyzed the main drivers of private R&D investment of Spanish defense companies. It found that the long-term decisions to participate in R&D and the short-term decisions to invest in R&D

were determined by the intensity of contract participation with the government. It also concluded that companies already doing R&D business need to put more workforce into R&D noting that larger-scale companies and companies with a high proportion of defense exports tend to conduct R&D more.

In research from Lee and Park (2020), the authors described that R&D has a cumulative and support effect, so it takes a certain amount of time for the economic effect of the input of a specific resource to occur. They explained that the time difference may differ depending on the nation, technology, and R&D stage, and the objective criteria for determining the time difference is not clear. They argued that a determined budget allocation and support, cooperation with foreign companies to secure core technologies, R&D investment, workforce, and innovation activities are necessary to improve the effectiveness of weapon systems.

(3) The R&D paradox

There is a Swedish paradox concerning R&D, which is that Sweden's high R&D investment does not contribute much to economic growth and high productivity. Many scholars have studied this paradox, but there is no agreement on whether it applies in general to R&D.

A study by Ejermo, Kander, and Svensson (2011) found that this paradox only occurs in Sweden's fast-growing sector. This study considered the factors of economic growth in Sweden over 26 years, and the general key finding is that R&D can be the basis for success in the medium term. It also stated that Sweden's economic growth would have been lower without the R&D spending and performance of the fast-growing industries. It supported the view that long-term and large-scale R&D is necessary for economic growth.

Research from Yu, Devece, Martinez and Xu (2021) examined whether the Swedish paradox exists as to whether R&D investment promotes economic growth in China. This study found that the impact of total R&D expenditure on economic growth is initially positive and negative when a certain threshold is exceeded. It also found that this paradox occurs before the spending threshold in government R&D and after the spending threshold in corporate R&D. It concluded that a Swedish paradox exists in R&D in China and it depends on the type and the stage of R&D spending.

(4) Summary of literature review

First, defense R&D is a critical element in the defense industry. Defense R&D has the characteristic that it takes a long time to acquire knowledge and expertise. The success of development and commercialization of R&D outcomes are uncertain, so the return on investment is not guaranteed. The defense industry is a field that requires large-scale capital and advanced technology and expertise. Cutting-edge technologies and expertise can be acquired through continuous R&D. Therefore, defense R&D is an essential element in the defense industry. It also applies to Korea, which is recognized for possessing considerable technological competitiveness and defense capabilities.

Second, there is no consensus on the economic effect of R&D investment. Many scholars claim that R&D investment generally promotes economic growth, but others do not. The same is true for the impact of defense R&D investment on economic growth. In other words, several studies find that defense R&D investment affects economic growth under certain circumstances and conditions, but there is no consistent finding on whether defense R&D investment contributes to the growth of the defense industry. In addition, there is no consensus as to whether a R&D paradox expressed as a Swedish paradox exists and under what conditions it exists.

3) Methodology

(1) Research question

This study conducts quantitative research to determine the relationship between defense R&D investment and defense industry growth in Korea. The research question is as follows.

RQ1: How do the government and corporate R&D investment in Korea affect the growth of the defense industry in Korea?

(2) Hypotheses

The hypotheses for this study are as follows.

(H1) Government investment in defense R&D is positively related to the growth of the defense industry.

(H2) Corporate investment in defense R&D is positively related to the growth of the defense industry.

(3) Variables

The independent variables in this study are government R&D budget and corporate R&D investment. The government R&D budget is the total amount of the Korean government's defense R&D budget by year announced by DAPA. Corporate R&D investment is the total amount of new R&D investment of the defense sector of designated defense companies by year announced by KDIA. A designated defense company means a company that meets the facility standards and security requirements stipulated by the Defense Acquisition Program Act enforcement ordinance and is designated by the government to produce defense industry materials.

Dependent variables are sales, operating profit, utilization rate, capital, and localization rate. Sales mean the total sales of the defense sector of designated defense companies by year, and the operating profit means the total operating profit of the defense sector of designated defense companies by year. Utilization rate is the average utilization rate (%) of the defense sector of designated defense companies by year, and the calculation formula is "production performance/capacity * 100." Capital means the total capital of the defense sector of designated defense companies by year. Localization rate is the localization rate (%) of finished products and major components designated as defense materials by year, and the calculation formula is "{(total procurement price - total foreign currency expenditure)/total procurement price} * 100."

As reviewed in the literature review, it takes some time for the economic effect of R&D investment to occur, and the objective criteria for judging the time difference are not clear (Lee & Park, 2020). This study analyzes the economic effects of government and corporate investments after two years, considering that defense R&D is usually a long-term project of more than one year. Therefore, the independent variable, which is the investment amount, uses data from 2008 to 2017, and the dependent variable, which is the economic effect, uses data from 2010 to 2019.

(4) Data collection

The unit of analysis in this study is Korea and the Korean defense industry. The data collection targets annual defense R&D investment of the Korean government and the Korean defense companies and the performances of the Korean defense industry. The data are original. The period covers from 2008 to 2019, when the most recent defense industry statistics exist. Data of government R&D budget, sales, operating profit, utilization rate, and localization rate were collected from annual DAPA Statistical Yearbooks. Data of corporate R&D investment and capital were collected from the management status statistics of the KDIA website.

(5) Data analysis

This study uses the SPSS Statistics program to analyze the data. It also uses the multiple linear regression analysis methods to examine the effect of two independent variables on five dependent variables for hypothesis testing. Regression analysis predicts the value of the dependent variable according to the independent variable, which is a linear model (Frankfort-Nachmias & Leon-Guerrero, 2018). It can analyze the causal relationship between an independent variable as a cause and a dependent variable as a result. Accordingly, this study seeks to analyze whether data analysis is statistically meaningful through examining the p-value.

4) Results

Multiple linear regression analysis of this study was performed with a confidence level of 95% ($p<.05$). Model 1-1 analyzed the effect of government and corporate investment on sales. The government R&D budget is the factor that influence sales of the defense sector of designated defense companies significantly. It is because the p-value (.004) is less than .01. The coefficient of the government R&D budget is a positive value (+7.571), which means that if the government R&D budget increases by 1 billion KRW, defense industry sales increase by 7.571 billion KRW. On the other hand, corporate R&D investment does not have a significant effect on sales because the p-value is greater than .05.

Model 1-2 tested the effect of government and corporate investment on operating profit. In the model validation test, the p-value in the variance table was .327. Since the p-value was greater than .05, this model was not suitable for the multiple linear regression model, and the regression equation was not statistically significant. Therefore, examining the coefficients and p-values in this model is omitted.

Model 1-3 analyzed the effect of government and corporate investment on utilization rate. The government R&D budget is the factor that significantly affects the utilization rate of the defense sector of designated defense companies because the p-value (.013) is less than .05. The coefficient of the government R&D budget is positive (+0.002), which means that if the government R&D budget increases by 100 million KRW, the utilization rate increases by 0.002%. However, corporate R&D investment had no significant effects on the utilization rate, because the p-value was greater than .05.

Model 1-4 analyzed the effect of government and corporate investment on capital. The government R&D budget significantly affects the capital of the defense sector of designated defense companies because the p-value (.019) is less than .05. The coefficient of the government R&D budget is positive (+8.652), which means that if the government R&D budget increases by 1 billion KRW, the defense capital increases by 8.652 billion KRW. On the other hand, the corporate R&D investment did not have a significant effect on the capital, since the p-value is greater than .05.

Model 1-5 tested the effect of government and corporate investment on the localization rate. It was found that neither the government R&D budget nor the company R&D budget had a statistically significant effect on the localization rate of the defense sector of designated defense companies. It is because both p-values were greater than .05.

Accordingly, data analysis supports Hypothesis 1. It finds that government investment is related to the factors of sales, utilization rate, and capital but it is not related to localization rate. On the other hand, it does not support Hypothesis 2 because there is no analysis result that corporate investment is related to defense industry growth factors.

5) Discussion and recommendation

(1) Findings

The findings are summarized in two parts: First, the government's defense R&D budget affects specific areas of the defense industry, but corporate defense R&D investment does not. Most of the defense R&D budget is paid directly to defense companies that research, develop, and produce weapon systems. The government is the only or largest customer of the defense companies. Therefore, it is interpreted that the government budget has a significant relationship with the growth of the defense industry. Regarding the result that corporate investment does not have a significant effect on the defense industry, the significance may be low because the new R&D investment size of the company is relatively small compared to the government R&D budget size. For example, the government R&D budget in 2008 was 1,452.2 billion KRW, and company investment was 410.7 billion KRW. Fundamentally, the defense R&D project requires a large amount of capital. Therefore, it can be interpreted that corporate investment that is relatively small compared to the government budget is unlikely to have a significant impact on the defense industry.

In addition, the meaning of this analysis result can be found in connection with the literature reviewed. The result can support the hypothesis that R&D investment affects economic and industrial growth, similar to the conclusions of studies by Zachariadis (2004), and Fonfria and Duch-Brown (2014). However, it does not support the findings of Kacprzyk and Świeczewska (2019) that government R&D has no significant effect on economic growth. In addition, the result is related to a study by García-Estévez and Trujillo-Baute (2014) which found that decision-making on R&D participation and investment is determined by the degree of contract participation with the government.

Second, the government defense R&D budget significantly affects the sales, utilization rate, and capital of the defense sector of designated defense companies but does not significantly affect the localization rate. Regarding sales, as mentioned above, most defense R&D budget is paid to defense companies, and the most important client of defense companies is the government. Therefore, it can be interpreted that the government's R&D budget has a significant relationship with sales of the defense industry. Regarding the utilization rate, it is able to be interpreted that the higher the defense

R&D budget expenditure, the more the defense companies' activities increase, so the utilization rate increases. As to capital, it is the number of assets minus liabilities, which is net assets. It can be interpreted that as the government's R&D expenditure increases, the profits of defense companies increase, which leads to an increase in corporate capital. Regarding the localization rate, as described above, the localization rate means the localization rate of finished products and major components designated as defense materials, and the formula is "{(total procurement price - total foreign currency expenditure) / total procurement price} * 100." Finished products and major components designated as defense materials can be procured not only from R&D budgets but also from budgets for manufacturing or purchasing programs, depending on the item.

(2) Recommendations

Based on the analysis results and findings, the following policies are recommended.

a. Considering the impact of the government's defense R&D budget on defense industry indicators, the government needs to secure an appropriate defense R&D budget and prepare reasonable budget setting standards in advance. According to the analysis results of this study, the government R&D budget has a statistically significant relationship with the growth of the defense industry, unlike company investment. Therefore, the defense R&D budget can be considered one of the critical factors for the growth of the defense industry. As reviewed in the literature review, defense R&D is an essential element of the defense industry and has the characteristics of long-term business, uncertainty in development success. Therefore, the budget spent by the government, which is the largest consumer of the defense industry and the main body of defense R&D, is essential to the growth of the defense industry. The national budget is limited, and R&D projects expected to have long-term economic effects are likely to take a second place in the budget allocation rankings. Therefore, in a budget constraint, the government's R&D investment should not only contribute to national security but also be used economically efficiently. Thus, the government should secure a defense R&D budget for the sustained growth of the defense industry and set proper standards for efficiently planning and operating it.

b. It is necessary to establish a data system to prepare standards for setting defense R&D budgets. Defense R&D budget setting standards include the current status and scale of R&D acquisition programs, analysis of the impact of current R&D policies and support programs, and system improvement and expected effects, which encompass the work of many divisions. Therefore, there is a need for a data system that contributes to a long-term and comprehensive review of the effects of acquisition programs, defense R&D, and defense industry policies and projects on the defense industry and economic growth.

(3) Limitations

The limitations of this study are as follows. First, among the various factors affecting the growth of the defense industry, only the investment amount of the government and the defense companies was set as independent variables, so the influence of other factors could not be analyzed. Other factors affecting the growth of the defense industry include R&D policies including laws and institutions, and R&D support projects.

Second, there is a limitation in that the detailed expenditure of the government and corporate investment was not analyzed. For this reason, there is a limitation in analyzing why corporate investment is not statistically significant in the analysis results of this study.

Third, data analysis for a more extended period was limited by analyzing data for the last 12 years (from 2008 to 2019) for which publicly available data exist. There is a limitation in that the primary data are those after establishing DAPA.

6) Conclusion of this study

This study is significant for how government and corporate defense R&D investments affect the defense industry. Through quantitative research method, it finds that the government's defense R&D investment has a statistically significant effect on the defense sales, utilization rate, and the capital of defense companies. This study will contribute to determining factors that the government should consider in establishing defense R&D budgets and policies for defense R&D and the defense industry. Based on this study, it is necessary to secure an appropriate defense R&D budget, prepare efficient setting standards for establishing a proper defense R&D

budget, and prepare a data system to manage them.

Although the analysis has limitations because it is difficult to confirm the details of company investment, the conclusion of this study can serve as a basis for the need for improvement of the defense cost system. This study does not conclude that company investment affects the growth of the defense industry. It may mean that the current defense R&D system makes it difficult for companies to induce investment in defense R&D, which can be a basis for supporting the need to increase investment incentives for companies through the improvement of the defense cost system. The Defense Science and Technology Act recently introduced an agreement system, and various methods of defense acquisition programs and contracts are being used. In order to connect this to companies' expansion of R&D capacity and investment, it is necessary to improve the cost system rationally.

Ⅳ. Conclusion

The US has the largest defense R&D budget and weapon system exports globally and has been stably conducting various types of R&D programs and contracts. In response to the fourth industrial revolution, for the development of defense R&D based on advanced technology, Korea has reorganized laws and organizations for creative and challenging R&D, reviewed various types of defense R&D program management systems, and introduced agreement methods to the existing state contract system. In addition, DAPA is working to improve the defense cost system in a way that compensates for the actual cost that has been maintained for decades, which is essential in relation to contract and cost calculation for defense R&D programs. In this regard, this report reviewed ways to improve the cost system of the system development program.

First, it is necessary to closely examine the standard cost introduction method known to be under consideration by DAPA. In this regard, it is necessary to refer to the US CAS regulations. The introduction of the standard cost system in the defense program field aims to reduce the cost of the companies and reduce the national budget by paying the cost determined in advance according to the standard. Also, it should have accuracy, objectivity, and reliability in preparing the standards for setting cost standards. Therefore, lessons learned from standard cost regulations and practices in the US may be helpful. It is also necessary to refer to the regulatory description format, which can give concrete examples to public practitioners and companies, such as the CAS regulation format in the United States.

Second, it is necessary to examine ways to materialize the form of contracts and agreements to implement the system development program. The system development program has the characteristics of difficulty in obtaining objective and reliable cost data, variability of project management (design, specification, cost, and schedule), and uncertainty about development success. Therefore, detailed contract or agreement conclusion standards that the contracting officer can refer to determine the contract type are required. In this case, it would be necessary to review regulations and practices such as the US FAR.

Third, to activate competitive prototyping, it is necessary to review whether it is necessary to prepare a clear basis for related project costs and costs. The United States makes this system to be applied in principle in the early stages of development to research and develop excellent and competitive weapons systems. Therefore, it is necessary to review the policy on the necessity of clarifying the basis for project cost payment or cost calculation to companies participating in competitive prototyping.

Fourth, it is an implication for cost management of the system development program. In this regard, securing an appropriate government budget is important, and an effective system for budget setting and cost determination is required. In addition, it is necessary to review in advance the cost-saving measures in carrying out a specific program. It will contribute to increasing the objectivity and rationality of cost management tasks.

DAPA expects a leap forward by reorganizing laws, organizations, and systems for revitalizing defense R&D and the defense industry. The direction of the cost structure improvement policy that DAPA reviews is also in line with that. For creative and challenging defense R&D to respond to the era of the 4th industrial revolution, not only innovative defense acquisition program systems but also the management of cost and contracts that specifically support program execution are essential. Therefore, in activating defense R&D and improving the cost system, it is essential and valuable to analyze the US defense system and derive implications suitable for the situation in Korea.

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