

The Development Progress of Korean Aviation Industry and its Investment Strategy Based on the Evidence and the 4th Industrial Revolution

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Abstract

This study examines the history of Korean aviation industry and presents the investment strategy based on the evidence and the 4th industrial revolution. Looking at the evolution of the Korean aviation industry and its technological development will be a great help to support industrial and technological innovation in the future. The modern aviation industry is divided into stages of development, focusing on maintenance of equipment introduced in advanced countries, localization through license assembly, production of products based on technology, and international joint development. The development of aeronautics technology has been progressing towards a general improvement of economic efficiency, aircraft safety efficiency through environmental-friendliness, unmanned operation, and downsizing. The Korea Aerospace Research Institute has secured key technologies through development of several aircrafts such as Experimental Aircraft Kachi, EXPO Unmanned Airship, Twin-engine Composite Aircraft, Canard Aircraft, Multi-Purpose Stratosphere unmanned-airship, Medium Aerostats, Smart UAV, Surion, EAV-2H, KC-100, and OPV. The development strategy is discussed at the level of the evidence-based investment strategy that is currently being discussed, and so the investment priorities in aircraft is high. Current drone usage and development direction are not only producing parts using 3D printer, but also autonomous flight, communication (IoT, 5G), information processing (big data, machine learning). Therefore, the aviation industry is expected to lead the fourth industrial revolution.

Key Words : Aviation Industry, Aircraft, History, Evidence-Based Investment Strategy, Fourth Industrial Revolution, Korea, Aeronautics, Technology Innovation Policy, Korea Aerospace Research Institute, World market

1. Introduction

This study examines the history of the domestic aviation industry and presents its investment strategy. Looking at the evolution of the Korean aviation industry and its technological development will be a great help to support industrial and technological innovation in the future. The development strategy is discussed at the level of the evidence-based investment strategy that is currently

being discussed and the fourth industrial revolution.

The term "evidence-based" was begun to be used from the field of medicine. Unlike conventional methods of a medical, the "evidence-based" diagnosis of a patient is the same logic as that of a social problem in view of making it "evidence-based". In addition, the policy based on the evidence, is an extension of the modern rational problem-solving way of that is based on the accurate diagnosis and causal connection. It should be noted in connection with a policy based on the evidence that evidence-based policy has not been achieved simply by saying only "evidence". Policy decisions based on evidence, in addition to the evidence, are

Received: May. 18, 2018 Revised: Aug. 07, 2018 Accepted:
Aug. 18, 2018

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accompanied by a variety of factors such as expertise of policy-makers, evidence of the research, the characteristics of the policy subject.

The need for a policy based on the evidence are ① to provide a justification of policy decision, ②rapid decision-making under policy considered, ③ contribute to the achievement of the goal to be pursued ③policy, because of ④responding to national needs of rational processes in policy decision ⑤overcoming the difficulty of enforcement policy and decision-making process. The policy based on these evidence is contrasted with the policy decisions based on the opinion. In policy based on opinion, you can selectively use the evidence, it depends very heavily on the opinion that is not untested verification of individuals or groups. Due to an increase in difficulty and budget spending of tax revenue earned, not meeting the contemporary policy environment that requires an efficient decision-making than in the past, these opinion-based policy is as time goes by, is transforming to evidence-based policy [1].

Through the science of “aerospace policy”, in order to respond to the strengthening of the optimization of investment in aerospace and social accountability, evidence-based policy is possible. And the policy based on objective evidence is expected to contribute to increase understanding of the rational aerospace policy of officials.

In this study, we tried to examine the medium- and long-term investment strategy based on the evidence in the R&D field of Korean aeronautics. Through the analysis of factors such as the current state of the world and Korean market, current status of investment, marketability, public nature, technical capabilities, productivity of government investment, expert questionnaire of priority investment in the Korean aeronautics, we presented the R&D investment strategy of Korean aeronautics.

The sporadic introduction to the Fourth Industrial Revolution is overflowing, but it is not easy to systematically assess the relevance of the aviation sector. I examined the relevance of the Fourth Industrial Revolution to the aviation development strategy.

2. The development progress of Korean aeronautics technology

2.1 The development progress and outcome of Korean aeronautics technology

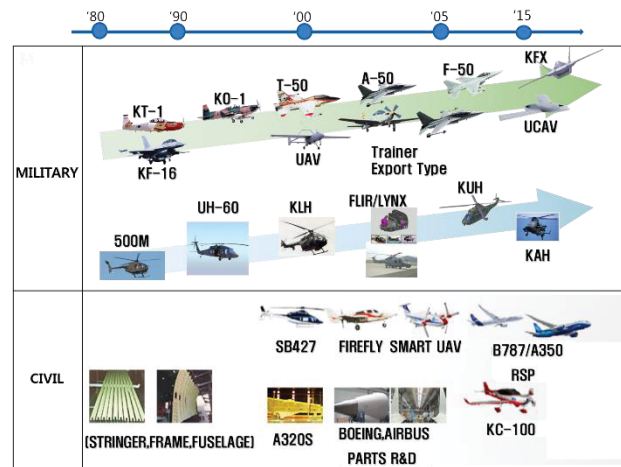


Fig. 1 Major Aeronautics R&D Outcome of Korea[2]

The modern aviation industry is divided into stages of development, focusing on maintenance of equipment introduced in advanced countries, localization through license assembly (license production), production of products based on technology, and international joint development [3]. The emergence of the Korea aviation industry is highlighted by the start of overhaul maintenance of the L-19 reconnaissance aircraft in 1955 and maintenance of the C-130 transport/military aircraft until the early 1970s. However, since the mid 1970s, Korea began production of compact helicopters under license from Hughes Aircraft. In 1978, the government enacted the Aircraft Industry Promotion Act to promote and support the development of the aircraft industry, and established the institutional basis such as systems for providing subsidies to attract investment from foreign aircraft companies [4].

In the 1980s, Korea sought joint production of Northrop's F-5 E/F fighter aircraft and since the mid 1980s produced parts for commercial aircraft manufacturers such as Boeing. Since 1990, Korean Air produced UH-60P (Blackhawk) helicopters under license from Sikorsky Aircraft and supplied them to the Korea military forces. Since 1995, Samsung Aerospace (merged with KAI (Korea Aerospace Industries)) produced KF-16 fighters under license from Lockheed Martin and delivered them to the ROKAF.

Aircraft production in Korea continued to grow until 1988 and then production fell due to the end of Korean Air's 500MD helicopter program in 1989 and delays in the KFP(Korea Fighter Program) and H-X programs. Korea began development of indigenous aircraft with the ADD's development of the KT-1 trainer and acquired jet plane technology through KAI(Korea Aerospace Industries)'s development of the T-50 advanced trainer.

In particular, in 2015, the KF-X and LAH/LCH(Light Armed Helicopter, Light Civil Helicopter) projects and other major programs were started its development. In addition, other important national aviation industry developments such as the T-50A for the purpose of exporting to the U.S. (T-X project), KUH(Surion) based helicopter variant, commercial aircraft parts R&D, and UAV put vital power into Korea aviation industry. Korea's domestic aviation industry is expected to continue to grow. Based on the "Basic Plan for the Development of Aviation Industry," the blueprint which aims to place Korea among the top 7 global position by 2020, existing projects will follow the growth pattern and new projects will be launched smoothly. If these projects are successful, Korea's goal of "producing 20 billion dollars and exporting 10 billion dollars" will soon be reached[5].

2.2 Major R&D Outcome of Korea Aerospace Research Institute



Fig. 2 Major R&D Outcome of Korea Aerospace Research Institute [6]

The Korea Aerospace Research Institute is a developer of Experimental Aircraft Kachi(1993.4),

EXPO Unmanned Airship(1993.9), Twin-engine Composite Aircraft(1997.3), Canard Aircraft(2001.9), Multi-Purpose Stratosphere unmanned-airship(2003.10), Medium Aerostats(2008. 12). The Korea Aerospace Research Institute is a developer of the Smart UAV(2011. 11), a tilt-rotor UAV which can achieve autonomous intelligence flight, collision avoidance and vertical takeoff and landing and, most notably core components of the helicopter 'Surion'(2012. 6) for the Korean Armed Forces. The Korea Aerospace Research Institute has secured key technologies through development of EAV-2H(2013. 10), KC-100, and OPV(2014. 5).

The development of aeronautics technology has been progressing towards a general improvement of economic efficiency, aircraft safety efficiency through environmental-friendliness, unmanned operation, and downsizing.

To cope with the increasingly restrictive environmental regulation, numerous environmentally-friendly technologies including electrically-powered propulsion systems are being developed to reduce carbon emissions and noise pollution, aerodynamic design is being enhanced, and efficiency and security are being reinforced with the ongoing improvement of navigation technology.

Notably, research on the utilization and operation of unmanned aerial vehicles (UAV) has been expanded as a key future area of the aviation sector.

2.3 Current status of aviation industry

The theme of the 2016 World Economic Forum held in Davos, Switzerland was the fourth industrial revolution. In retrospect, the first industrial revolution was led by the steam engine. The second industrial revolution occurred with the development of electricity, which later led to mass production. With the advent of computers and the internet, the third industrial revolution was then driven by the automated production system. At the turn of the 21st century, people now live under the influence of the fourth industrial revolution, which is characterized by the ubiquitous mobile internet, cheaper, smaller, yet stronger sensors and "smart" products. As such, the fourth industrial revolution will significantly change consumption, production and employment patterns. Thus, it is time for corporations, governments and individuals to realize such changes and respond more proactively.

Advanced countries around the world are making reliable investments in large-scale public technologies, especially in the fields of aerospace, nuclear fusion and accelerators, regardless of external economic or political influences. In particular, the aerospace industry can greatly increase public interests as its technology can be applied to other industries, evenly distributing the benefits of science and technology development to ordinary people.

The aerospace industry is an integrated industry that combines advanced technologies in various segments, such as machinery, electronics, materials and IT. It is therefore an industry indicative of a nation's level of technological development and industrial capabilities. The industry creates many jobs and completed aerospace goods can create much higher added-value compared to the input of raw materials. It has also far-reaching implications for other industries. According to the National Statistics Agency's 2013 data, the aerospace industry's value-added ratio stood higher at 43 percent than the railway industry's 36.7 percent and the auto industry's 30.1 percent. In the BOK's 2013 list of production inducement coefficients, the aerospace industry showed a higher percentage of 3.83 percent than the auto industry's 3.65 percent and the shipbuilding industry's 3.61 percent. It provides the basis for national strategic industries, such as the defense and space industries, because it enhances defense capability and its component technologies can be utilized for the space industry. Despite a long product development cycle and high market entry barriers, successful entry ensures stable and long-term (more than 20 years) revenue generation.

In the global aerospace market, large global corporations such as Boeing and Airbus are maintaining oligopoly and the verticalization of the aerospace parts industry is becoming more evident. The global supply chain is also going through a change as the Risk Sharing Partnership, in which major component suppliers share costs and profits in developing civilian aircrafts, and global outsourcing is increasing in number. The global aviation market was worth USD 547.8 billion in 2015, and the size of the market is expected to reach USD 739.1 billion by 2024. The civilian aircraft market will continue to grow at an average annual growth rate of 3.5 percent, from USD 254.1 billion in 2015 to USD 346.3 billion.

Although the military aircraft market has little potential to grow, it is diversifying into different sub-markets. In the military aircraft market, high-performance aircrafts, including unmanned aircrafts, are emerging. The component equipment market and the MRO (maintenance, repair and overhaul) market are also seeing stable growth. The sales of the MRO market is expected to increase as the aircraft manufacturing market is expanding and the number of maintenance outsourcing for existing aircrafts is increasing.

The domestic aerospace industry is also seeing continuous development. In the 1970s to 1980s, Korea manufactured aircrafts by assembling parts and introducing foreign technologies. Since 2006, it has started to independently develop a supersonic speed trainer aircraft and jointly developed civilian aircrafts with other countries.

In domestic production by demand, dependence on military demand was 59 percent and the commercial sector occupied 41 percent. This ratio is still far from that of the global market

Since 2010, Korea's aerospace production and exports increased 15 percent and 21 percent annually. As of 2014, Korea ranked among the top 15 countries in terms of aerospace technology. Despite rapid growth, however, there is a considerable gap between Korea and other advanced countries—Korea's global market share stands at a mere 0.9 percent. Therefore, in order for Korea to become a global player, the country needs to increase its competitiveness in high value-added sectors such as new materials, and lay the groundwork for the development of small and medium-sized enterprises. In Korea, three major companies, such as KAI(Korea Aerospace Industries), Korean Air and Hanwha Techwin, account for 83 percent of total sales in the aerospace industry. In the aerospace component market, airframe structure took up 64 percent of sales, engine components 19 percent, avionics 10 percent, and airframe accessory 7 percent as of 2015.

The domestic aerospace industry is driven by the exports of civilian products as well as SMEs which directly win bids for overseas component supplies. Exports of completed military aircrafts, such as T-50s, are also increasing. The Ministry of Trade, Industry and Energy is providing support for production and exports of the domestic aerospace industry, particularly in terms of R&D, infrastructure,

and marketing support. The ministry is also fostering an optimum environment for aircraft performance examinations. This includes the Sacheon Aerospace Special Industrial Complex, Yeongcheon and Jinju flight test facilities and Goheung National Comprehensive Flight Test Center. The government is also promoting the aerospace industry through global business partnering. For instance, KOTRA's overseas trade centers identify the needs of global corporations, introduce Korean companies to them and help Korean companies improve their technological capability and product/service quality through events like trade fairs.

3. Evidence-based investment strategy of Korean aviation industry

As the field of national security, Aviation industry include the various fusion and complex technologies, and need large investment. It is a state-of-the-art technology.

In addition to research and development investment by the Government, it is in the progress of industrialization

Aircraft market occupies about 5493 billion (2013), and the largest market share (about 49%) of market is the field of aircraft finally assembled of a fixed wing, rotary wing aircraft, UAVs, etc.

2014 domestic market size of the domestic aviation industry is about 6.7 trillion won. It is expected to grow to approximately 9.1 trillion won by 2018.

In 2014, Domestic market share of the supplier is about 36.8%. By increase in domestic production ('15 - '18, the average annual growth rate of is forecasted in about 17.8%), it is expected there to surpass 50% in 2018.

The government investment in the aircraft sector in 2010 is 247.5 billion won. The government investment in the aircraft sector in 2014 is 150.4 billion won. The general trend is declining. The general trend is declining.

In 2013, the government R&D is 180.1 billion won, and private investment is 90.4 billion won. So the private R&D investment is half of government investment.

Aircraft market is in large-scale, and expected to maintain stable growth annual average of 3%. The world market (2014) is approximately 558.4 billion(aircraft) and 197.1 billion (satellite).

Table 1 World market trends and prospects (unit : billion US dollars) [5]

division	2014	2015	2016	2017	2018	Compound Annual Growth Rate (prediction)
Aircraft	558.4	591.3	622.0	651.5	657.8	4.2%

Aircraft technology level compared to developed countries is around 75%. It will take more than seven years to take the technical catch-up[7].

According to survey, satellites, launch vehicles, t publicity is lower than the public good such as marine.

The productivity of government investment (government R&D investment compared to commercialization, and royalties) in aircraft is high.

The royalty income per Government R&D investment(million KRW / hundred million KRW) is 1.18(aircraft) and 0.16(marine and polar). The commercialization number per government R&D(number/hundred million KRW) is 0.012(aircraft) and 0.008(marine and polar)

Aerospace is promoting the strengthening of technical capabilities and industry expertise supplying, whereas the share of the development phase is higher. It is needed to strengthen support for SMEs, and to supply experts through college.

The step-by-step weight of government R&D('11 - '13) in aerospace is 21.1%(basic), 8.0%(application) and 53.3%(development). The supply of professional staff is in means of rehabilitation industry-university cooperation through Joint research[8].

Table 2 The main indicators by analysis of the level of aircraft [9]

marketability	technical competence	government investment productivity	publicity
high	high	high	middle

According to the first R&D mid to long-term investment strategy('16 ~ '18) of Ministry of Science and ICT, The Investment priorities in aircraft is high [9].

4. 4th Industrial Revolution-based investment strategy of Korean aircraft industry

Currently, GE accounts for 60% of the civilian aircraft engine market share. Sensors attached to engine data transmit information 24 hours a day, and GE Air Operations Center analyzes collected data to propose a way to maximize fuel efficiency. Accordingly, customized services such as engine diagnosis and monitoring are provided. The unexpected failure rate in the aviation industry is about \$ 54 million to \$ 54 billion a day. These systems allow you to predict when maintenance is needed in real time. GE is generating more revenue from these data services.

The 4th Industrial Revolution means revolutionary changes in society as a whole due to the improvement of efficiency through autonomy and informationization and the transformation of production system accordingly. In this process, not only the labor-intensive simple work is replaced by the machine in the existing automation process but also the more complicated work is replaced by the machine. It is expected that the labor demand in the traditional industrial field will be reduced and new jobs will be created. Unmanned aerial vehicles (UAS) have been developed to replace humans in a dull, dangerous, and polluted environment. The beginning of agricultural UAV was also a solution to the decline of the labor force caused by the aging of the rural population in Japan in the 1980s. The proliferation of drones inevitably shows that manpower can be replaced by drones in many areas. In this sense, the development and proliferation of drone can be seen as a factor accelerating the progress of the fourth industrial revolution.

Meanwhile, current drone usage and development direction are not only producing parts using 3D printer, but also autonomous flight, communication (IoT, 5G), information processing (Big Data, Machine Learning). It is influenced by the results of the Fourth Industrial Revolution in all fields ranging from the field of re-analyzing and managing the information obtained by the drone (IoT, Big Data). Therefore, the drones are expected to lead the fourth industrial revolution, while expanding their influence and utilization range by the performance of the fourth industrial revolution [10].

5. Prospects and Challenges

In the field of aviation logistics, the LAH (small civilian helicopter) is pursuing the basic plan such as launching the development by sharing main components with the LCH (small armed helicopter), and the Korean fighter (KFX). It is being carried out according to the project detailed plan including the selection of operators and the 16-year wind tunnel test. Particularly, domestic T-50 (TA-50) participated with Lockheed Martin (to be in the 17th half of the year) in the replacement of the US Air Force Aged Trainer (TX business, 350 units to 10 trillion won). And through the performance improvement process of FA-50, it is necessary to formulate a platformization plan for expansion of exports of military endusers and joint growth of domestic parts industry. And it will have the status and capability as the independent development and production country of the fighter aircraft which has become a true fighter through the development of the Korean type fighter.

In the civilian field, participation in the Risk Share Program has been stagnant due to the completion of the civil joint venture's international joint development project. However, in order to participate in the overseas major civilian aircraft development projects scheduled for the next 2020 or later, we need to support the capacity. In the field of futuristic aircraft such as UAV, we are trying to systematically promote integrated research and development in various fields such as 5-year unmanned vehicle development plan. Activities for real industrialization and securing of national competitiveness in the field of unmanned aerial vehicles are being carried out by establishing laws and systems for problem management and industry upbringing such as safety threats caused by unmanned aerial operations and privacy invasion.

Klaus Schwab, the author of *The Fourth Industrial Revolution*, said, "The gap is widening between those who embrace change and those who resist it." Since the size, speed, and scope of the fourth industrial revolution will be of a formidable change that we have never experienced before, individuals and organizations alike should brace themselves for the change. While the fourth industrial revolution challenges the aerospace industry and technology, it can also provide new opportunities like never before.

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