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STIMULATING COMMERCIAL DRONES WITH OPEN SPECTRUM PARADIGM

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ABSTRACT

As the number of services that use spectrum such as IoT and commercial drones are increasing rapidly every year, it has become very important to efficiently allocate the spectrum resources. Advanced countries are shifting towards open spectrum system which provides the suitable environment for using radio wave and pursue new technological service innovation. Global companies such as Amazon, DHL, and Google are already investing a lot of resources into the commercial drone technology and made significant contributions. Korea's commercial drone industry, on the other hand, had limited growth because commercial drones are strictly regulated. In this respect, the purpose of this paper is to derive a policy measure for open spectrum to foster the Korean commercial drone industry. The research was conducted as follows: (i) Literature review of open spectrum and commercial drone industry and (ii) Expert interview on key issues. Following implications have been drawn from case studies in other countries and the expert interview: (i) Establishing data-based open spectrum management system, (ii) Designing a plan to develop new service using spectrum in middle and long term, (iii) Selecting spectrum band width exclusive for open spectrum and drone for international compatibility (iv) The need for a unified agency which can manage and regulate drone industry. These results imply that in order to foster the commercial drone industry, it needs a collaboration with the field of spectrum, and an international standard. The contribution of this study is to provide a strategic guideline for the countries that are in the early stage of developing commercial drone industry, and establish policy and legal guidelines to help foster commercial drone industry.

Contribution/ Originality

The paper's primary contribution is to provide strategic guidelines for the countries that are in the early stage of developing commercial drone industry, and establish policy and legal guidelines to help foster commercial drone industry. This study uses an expert interview to investigate key issues.

1. INTRODUCTION

For the past few years, it has become very important to efficiently allocate the spectrum resources since the number of spectrum based services such as Internet of Things (IoT) and commercial drones are increasing rapidly every year. Following this trend, major advanced countries are shifting towards open spectrum system which provides the suitable environment for using radio wave and pursuing new technological service innovation. Global

companies such as Amazon, DHL, and Google are already investing a lot of resources into the commercial drone technology and made significant progress. On the other hand, Korea's commercial drone industry is having a stagnant growth because commercial drones are regulated very strictly. Currently, Korean government poses the regulation on spectrum that commercial drones can use. Also, its weight cannot exceed 150kg but not less than 12kg. In this respect, the purpose of this paper is to derive a policy measure for open spectrum in order to foster the Korean commercial drone industry. The research was conducted as follows: (i) Literature review of open spectrum and commercial drone industry and (ii) Expert interview on key issues. The contribution of this study is to provide a strategic guideline for the countries that are in the early stage of developing commercial drone industry, and establish policy and legal guidelines to help foster commercial drone industry.

2. THEORETICAL BACKGROUND

2.1. Spectrum Sharing

According to Werbach (2002) open spectrum is defined as frequency band available to everyone as long as they abide by the rule. Similarly, spectrum sharing is when different users or different services use same frequency spectrum (Park, 2014). Both concepts aims to solve the spectrum scarcity problem by opening up or sharing network. During the early years, the spectrum management policy was based on the government's command and control system. However, due to the increasing demand of spectrum and technological advance in recent years, there has been a shift in paradigm to open spectrum (Park, 2014). New revolutionary services based on spectrum are being introduced in these days (Park, 2014). For this reason, the shift to the open spectrum policy is critical for new spectrum-based services such as drones.

2.2. Commercial Drone

A drone is an Unmanned Aerial Vehicle that can be controlled remotely without a human pilot abroad (NIA, 2015a). Depending on the switching style, drones can be classified as Fixed Wing, Rotary Wing, and Manned Aerial Vehicle Switch. Drones can be classified by their operating altitude as well. The drones that can fly up to 4.5km is classified as low altitude style, from 4.5km to 12km as mid-altitude style, and from 12km to 20km as high altitude style (Kang, 2015). Moreover, the drones can be classified by their operating purpose. Operating purpose can be either for military or commercial use. Military drones are used for patrol and combat purpose. Commercial drones are used for delivery, agriculture, and shipping (Kim, 2016).

For this paper, we will only focus on commercial drones. The drones require uplink that sends payload control signal for the remote control and the control of camera. In addition, the downlink is required for sending the flying information to the ground such as videos or the location of drones. Each country has different spectrum policy but generally, 900MHz, 1.3GHz, 2.4/5.8GHz frequency spectrum are used for drone communication link (East Chun, 2016). Table 1 explains which type of drones are used for which frequency spectrum.

The drones are used mostly for military applications, but then their use is expanding in commercial applications such as agriculture and disaster management (Central Officials Training Institute, 2014). Commericial drone industry is growing rapidly in recent years. Teal Group's 2014 market study estimates that UAV spending will nearly double over the next decade from current worldwide UAV expenditures of 6.4 billion dollars annually to 11.5 billion dollars, totaling almost 91 billion dollars in the next 10 years (Teal Group, 2014). Korean commercial drone industry is also expected to grow from 91 million dollars in 2012 to 525 million in 2023, which is an annual growth of 22% (MSIP and MOTIE, 2015).

Table-1. Drone Frequency Spectrum Features

Frequency Spectrum	Type of Drone	Purpose & Features
900MHz	Medium Size Drones	**(Purpose)** - Downlink for Video and telemetry transmitting purpose (East Chun, 2016) **(Characteristics)** - Strictly regulates output intensity to 5~10mW because it Intervenes with mobile spectrum and DECT spectrum for household in Korea and some parts of Europe (East Chun, 2016) - Intervenes with Wifi 11ah wireless LAN spectrum frequency for IoT
1.3GHz	Most of Drones	**(Purpose)** - Downlink for Video and telemetry transmitting purpose (East Chun, 2016) **(Characteristics)** - It affects GPS devices imbedded in drones because it is close to GPS satellite frequency spectrum of 1.2GHz L2, which was launched after 2005 (East Chun, 2016)
2.4GHz (2400~2483.5MHz)	Small Drones	**(Purpose)** - Uplink for most of remote controlled drones and payload control (East Chun, 2016) **(Characteristics)** - Need for securing a visual distance necessary between drones and remote controller on the ground because its transmitting distance is short and can be easily disturbed by obstacles (East Chun, 2016) - Output intensity allowed: Korea (10mW), U.S. (1W) (Park, 2016) - Average Output intensity: Europe (0.1W), U.S. (4W), Korea (1W) (Choi, 2015)
5030~5091MHz	Civilian Drones	**(Purpose)** - Spectrum for Controlling drones from the ground (Oh, 2015) **(Characteristics)** - New frequency spectrum selected in WRC-12 that took place in Geneva, Swiss in 2012 - Until now, it is used only in Korea and drones' output has been extended to 10W in maximum
5.8GHz (5725~5875MHz)	Small Drones	**(Purpose)** - Downlink for new drones' video and telemetry control (East Chun, 2016) **(Characteristics)** - Need for securing a visual distance necessary between drones and remote controller on the ground because its transmitting distance is short and can be easily disturbed by obstacles (East Chun, 2016) - Output intensity allowed: Korea (10mW), U.S. (1W) (Park, 2016) - Average Output intensity: Europe (0.1W), U.S. (4W), Korea (1W) (Choi and Lee, 2015)

Sources: From Variety of Reports and Papers

As the commercial drone industry is growing rapidly every year, the drones are used in many other areas other than recording videos such as agriculture, and deliver service. There is an increasing competition between Amazon and Google for drone deliver services. It is expected that the usage of commercial drones will be divided by personal leisure use and commercial use (IITP, 2015). Also, in commercial drone industry, Korean companies' presence has been very limited compared to China or the USA. However, Korea has technological advantages for military drones such as communication, and battery sector because of its tension with North Korea. Thus, Korea has high potential for the growth of commercial drones. For these reasons, we will conduct expert interview and case studies for other countries in order to provide a strategic guideline, and establish policy and legal guidelines to help foster commercial drone industry.

3. CASE ANALYSIS OF KOREA

3.1. Research Process

For our research purpose, we conducted an expert interview. The expert interview consists of 2 parts, which are open spectrum, and drones. Interview was conducted from Dec 1, 2015 to Dec 16, 2015. Total of 8 experts were interviewed (3 Professors, 3 from research institution, 2 from Industry). Table 2 is the summary of the interview.

Table-2. The Summary of the Interview

Parts	Main Points
Open Spectrum Policy in General	● New services using Open Spectrum ● Major issues arising from Open Spectrum based services ● Spectrum policy measures for fostering open spectrum based services in future
Drone Industry and Spectrum Policy	● Main issues and characteristics of drone industry ● Influence of Spectrum issue in drone industry's new service introduction ● Special ministry or a team that exclusively deals with drone industry and policy directions for future

Sources: Authors' data

3.2. Analysis of Korean Drone Market

3.2.1. Analysis of Open Spectrum Issue

For promising services based on open spectrum, IoT, Smart Grid, and Mobile have been selected. Among these services, IoT has been mentioned most frequently as the most promising service that is based on open spectrum. This is due to the fact that in order for various devices to communicate through the internet, we need an environment which allows the small amount of information to communicate. This leads to the use of open spectrum because it does not need a license. The drone was mentioned as the second most frequently mentioned service.

Main issues related to open spectrum technology are sharing technology for joint survival and spectrum intervention between devices. Among these issues, the spectrum intervention problem is expected to be the most important issue. Moreover, it needs to find out the frequency spectrum that wireless device users use in order to improve IoT service quality satisfaction. It is hard to gain trust in spectrum joint survival because 70% of land in Korea are covered by mountains. Thus, the new intervention standard and the overall spectrum management based on database need to be established.

The industry related issue mentioned is the change in market environment due to informatization in existing industry. Drone industry is expanding to variety of industries such as deliver services, safety check, and communication tool. Thus, it will be crucial to make connection between existing and new industries in future.

Policy related issues are the widespread of open spectrum considering international standard, and the intervention problem. In Korea, open spectrum band are FACS (60GHz) and Freeband (262~264MHz, 24~27GHz). Unlike other major countries, the use of ISM band (2.4GHz, 5.8GHz) is restricted in Korea. Thus, like other countries, Korea needs to select frequency spectrum if technology meets certain standard. Also, negative regulation has been mentioned as the intervention problem. This means that the use of all types of spectrum should be allowed but considering the interference, the minimum regulations should be imposed.

3.2.2. Analysis of Drone Industry

For the question about the influence of spectrum issue in drone industry, the majority of experts answered that the spectrum issue does have the influence over the drone industry. If the drone industry fosters in future and demands increase, there needs to be a command and control link technology standard and securing of payload link.

In long term, beyond LOS (line-of-sight) command and control satellite spectrum need to be secured. Also, personal injuries or death due to the crash of drones by spectrum intervention or jamming was mentioned as another issue. For this issue, there was a mention of introducing special spectrum just for drones. Moreover, transmitting video data footage for disaster site will be the most advanced drone service in near future. Thus, securing the high volume of data for transmitting drone spectrum other than 5GHz drone spectrum allocated according to international standard is needed. Experts also suggest that the possible frequency spectrum needs to be reviewed.

For the industrial issue, experts mentioned the expansion of commercial use of drones. In case of Amazon, it announced a new drone that can deliver anything in 30 minutes in December, 2015. Amazon also has a plan for testing a drone that can fly in 24km in single batter charge. In Korea, Korean Air is planning to participate in government's plan of commercializing unmanned aircraft industry, and expand unmanned vehicle research. Moreover, Korea Air is planning the testing of drones in areas such as deliver service, forest protection, facility management, and unmanned aircraft using network.

For policy perspective, the absence of control tower has been mentioned. Currently, Korean government's drone regulation and management are carried out by various ministries. These ministries include Ministry of Trade, Industry and Energy, Ministry of ICT, Future Planning, Ministry of Land, Infrastructure, and Transport, and Ministry of Defence. In order to operate drones in Korea, they need to be registered and reported according their purpose in multiple ministries. For this reason, experts suggested that there could be inefficiency due to lack of communication between different ministries. This could lead Korea to fall behind international competition. For instance, issues like collecting and reallocating spectrum resources could slow down the drone related business. Also, if there is an absence of a ministry in charge, it will be almost impossible to reallocate spectrum resources, which will be issues that business that never have predicted.

4. CASE ANALYSIS OF MAJOR COUNTRIES

Currently, major advanced countries like Europe, Japan, and the U.S. are in a process of preparing the plan for fostering commercial drone industry. In Europe, there is "Vision 2020" which was introduced in September 2014 to foster drone industry for commercial and civilian purpose. In the U.S., the FAA is strictly regulating commercial drones by comprehensive regulation and advance registration (Kang, 2015). Table 3 explains the commercial drone industry in other major countries. It is classified by commercial perspective and policy perspective.

5. CONCLUSION

In conclusion, this paper examined the plans for fostering Korean commercial drone industry under rapidly changing open spectrum environment by conducting expert interview and case studies for major advanced countries. From expert interview and case studies for other major countries, we have derived following plans.

First, the necessity of establishing databased open spectrum management system. As it was mentioned in the interview, it is important to have joint survival of wireless devices under open spectrum. In order to make this happen, it is necessary to examine information about primary users and information about licence users of nearby spectrum channel. Recently, the U.S., recommended CBRS (Citizen Broadband Radio Service), which is a metropolitan wireless service based on open spectrum. It also suggested SAS and ESC as requirements for spectrum joint survival. This implies that it is necessary to identify spectrum usage of primary users and improve the legal system. Thus, it is crucial to establish database that can manage regional spectrum stably and joint platform based on database.

Table-3. Commercial Drones in Other Countries

Country	Commercial Perspective	Policy Perspective
U.S.	• More participation from corporations in commercial drone market (IITP, 2015) - **(Google)** Using drones in New Generation project called 'Google X' to experiment delivery services. It will be commercialized in 2017 - **(Intel)** Accelerating its advance in commercial drone market by merger and acquisition of drone related companies, and collaborate with AT&T by using LTE Network to test drones	• Regulating policy for Protecting Civilian Privacy issue (NIA, 2015b) - Reviewing regulations for commercial drones in Feb, 2015, and will be finalized in 2016 • Selecting a research and development institutions under the supervision of FAA (KESSIA, 2015) • Classify the level of drones by their altitude and speed. (KESSIA, 2015)
Europe	• More participation from corporations in commercial drone market (IITP, 2015) - **(Parrot)** A major drone company in France that commercialized camera attached drones after 2010, and tried to take lead in market by merging Swiss Startup Senseflower, and Airenove	• In July to Sep 2015, Delegated EU's drone regulations to EASA and receive feedbacks (NIA, 2015b) - Including comprehensive regulations for small drones under 500g to large drones - Classify by 3 categories according its hazard level (Low, Normal, High) • In Britain, 'EUROCAE Working Group 73' established the standard for flying weight. If a drone requests for flying permission, it reviews by each case and gives permission
Japan	• More participation from corporations in commercial drone market (IITP, 2015) - **(Sony)** By cooperating with robot manufacturing company called 'ZMP' in August, 2015, it established Aerosense. Planning to provide drone service that can search and explore places that humans cannot approach	• In Dec 2015, Revised Aviation Law for Preventing crash accidents of drones (NIA, 2015b) • Training Special forces for capturing small drones used for terrorism (YTN Science, 2015) • Hosting the Conference of Robot Revolutionary Realization and announced the strategy for next 5 years in Jan, 2015 (NIA, 2015b) - Designating special zones for future technologies like drones and unmanned vehicle

Sources: From Variety of Reports and Papers

Secondly, the necessity of establishing mid to long-term strategy for introducing new services that use spectrum. In order to foster commercial drone industry, it is necessary to actively use spectrum to create new service model rather than passively managing the demand for spectrum. Also, there needs to be a legal system that allows sharing of spectrum without time and place constraints. In this context, it needs to convert its system to negative regulation so that all types of spectrum are available for use, and everyone can easily use. In addition, as we can see from the cases like Google, Intel, Parrot, Korean companies also need to merge other companies so that they can take the lead in global drone market in advance, and establish mid to long-term service creating strategy.

Third, the necessity of selecting frequency spectrum for open spectrum and commercial drones that considers international standard.

Currently, 2.4GHz and 5.8GHz are used globally for ISM. However, in Korea, these areas are selected as LAN, so it does not match with international standard. It can only transmit spectrum under 10mW. Also, most of drones that use frequency spectrum of 2.4GHz or 5.8GHz are made in China, and the most famous remote controlled drone is made in Japan. Thus, if Korea insists its own standard, then there would be a lot of potential problems regarding interoperability and exports to other countries. Thus, it can be concluded that there needs to be a new open spectrum policy that takes international standard into account.

Fourth, the necessity of creating a special ministry or department that exclusively deals with drone industry. Many experts pointed out that there is a lack of communication between different ministries and departments. In case of the U.S, under the guidance of FAA, it selects an institution to conduct researches and classify different

drone types. Just like the case of the U.S. and other major countries, Korea also needs to select or create a special ministry or team that can exclusively deal with drone industry.

The result of this study implies that in order to foster commercial drone industry, there needs to be a collaboration in the field of researching and developing spectrum and an interoperability with other foreign countries. The main contributions of this study are providing a strategic guideline for the countries that are in the early stage of developing commercial drone industry, and establishing policy and legal guidelines to help foster commercial drone industry.

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