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A Study on the Urban Air Mobility(UAM) Operation Pilot Qualification System

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Abstract

As around the world, ground and underground transportation capacity is reaching its limit, centering on urban areas. As urban traffic becomes congested, time and cost are astronomical, and environmental destruction caused by urban pollution is becoming increasingly serious.

As a way to solve this problem, the means of flying over the air are in the spotlight as the next generation of future transportation, and the concept of urban air mobility (UAM, Urban Air Mobility) is defined as systematic planning.

The development of an electric-powered vertical take-off (eVTOL) aircraft that obtains electric power through a battery using a personal aerial vehicle (PAV) as a means of transportation has accelerated.

As the aircraft development of new technology aircraft in the evtol method is actively carried out, the need to prepare systems such as aircraft certification standards, pilot qualification systems, and qualification management is emerging.

The Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA), which lead international standards, announced new special technical conditions and temporary regulations SC-VTOL-01, respectively.However, the pilot qualification system for operating the uam aircraft has not yet been clearly announced.

Therefore, this paper analyzes the recently announced FAA regulations and EASA regulations to identify differences and directions in perspectives on UAMs and study the existing vertical take-off and landing aircraft (VTOL) pilot qualification system to present directions for qualification classification.

Keywords: *UAM(Urban Air Movility), PAV(Personal Air Vihecle), Pilot qualification system, eVTOL(electric Vertiacal Take-off and Landing)*

1. Introduction

As the concentration of human and material resources intensifies around the world, mainly in urban areas, the existing ground and underground transportation capacity is reaching its limit. In addition, as urban traffic

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becomes congested, time and cost are astronomical, and environmental destruction caused by urban pollution is becoming more serious day by day by day.

As a way to solve this problem, the means of flying over the air are in the spotlight as the next generation of future transportation, and the concept of urban air mobility (UAM) is defined as systematic planning.

The United States, an advanced aviation country, attempted a helicopter-based urban air transportation business due to increased commuting time due to increased ground traffic, but related industries failed to grow due to high operating costs and noise and pollution.

However, with the recent development of science and technology, electric energy storage, capacity, and battery-related technologies have grown, enabling the development of more eco-friendly gases to minimize cost, noise, and pollution. Using these new technology aircraft, the concept of urban aviation mobility (UAM), a future innovative transportation business, has spurred the development of an electric-powered vertical take-off and landing (VTOL) aircraft that obtains electric power through batteries using personal aircraft (PAV) as a means of transportation.

The eVTOL-type UAM aircraft is expected to appear in the market in earnest around 2025, and by 2028, it is expected to mature and be easily accessible in the city center. Uber in the U.S. is preparing to test-run air taxis in Dallas, Los Angeles, and Melbourne in Australia in 2023 through the UBER ELEVATE program, while Airbus in Europe plans to develop an eVTOL Air Taxi and test-run it at the 2024 Paris Olympics.

As the development of new eVTOL-type aircraft is actively taking place, the need to prepare systems such as aircraft certification standards, pilot qualification systems, and qualification management is emerging, and new special technology standards (Special Condition) and EASA (European Union Aviation Safety Agency) respectively.

In Korea, as companies such as Hyundai Motor and Hanwha System announced their entry into the UAM market, the Ministry of Land, Infrastructure and Transport announced the launch of the UAM Team Korea and announced a roadmap for the Korean Urban Air Transport (K-UAM) industry in June 2020.

Systems such as design certification for UAM aircraft, a new technology aircraft, have been clarified and specified, but the pilot qualification system for operating new technology aircraft has not yet been clearly announced.

Therefore, this paper analyzes the recently announced FAA regulations and EASA regulations to identify differences and directions in perspectives on UAMs and study the existing vertical take-off and landing aircraft (VTOL) pilot qualification system to present directions for qualification classification.

2. Theoretical Background

2.1 UAM's Appearnace

The United States consumes about 8.8 billion hours of road traffic every year, and Figure 1 shows that the concentration of urban traffic by year is intensifying based on the large city center.

Accordingly, the trend of increasing commuting time in the United States can be confirmed.(Based on the car)

In addition, predicting based on the table in Figure 1, it is expected that the time spent on roads will gradually increase by more than 14% of 8.8 billion hours by 2023.

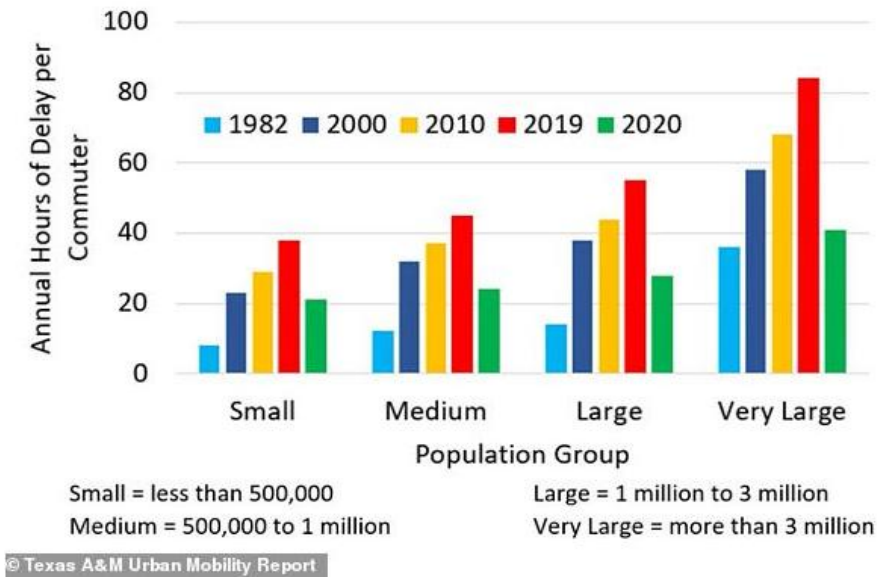

Figure 1. Congestion Growth Trend – Hour of Delay per Auto Commuter

Using eVTOL, which is being developed as a personal air vehicle (PAV) in the U.S. and Europe, the concept of Urban Air Mobility (UAM) is being introduced to resolve traffic congestion in urban areas.
According to Morgan Stanley, "The size of the UAM market using PAV is expected to reach $1.5 trillion by 2040.

In the 2000s, the development and operation of unmanned aerial vehicles including UAVs (UAVs) were actively carried out, and related technology development rapidly developed as the drone market for individual hobbies and shooting was activated. On top of that, as electric motor technology and battery technology have developed due to active investment by large companies, medium and large urban aviation mobility (UAM) for passenger transportation and cargo transportation has been secured.
In addition, along with the 4th Industrial Revolution, technologies related to AI technology and big data have led to the implementation of autonomous flight to the extent that unmanned flight is possible.

2.2 *The Development Status of UAM*

Uber, considered a leader in the UAM industry, announced every 10 seconds that it will start operating air taxis in Dallas and Rose Angeles by 2023 and aim to take off and land up to 1,000 times per hour at vertical landings such as takeoff and landing.

The National Aeronautics and Space Administration (NASA) announced in early 2020 that it will conduct tests to evaluate all factors for UAM operations in weather, transportation and contingencies. Grand Challenge's goal is to study what UAM systems need to operate efficiently in dense urban environments.

The first step, the GC development test, was conducted between July and November 2020, focusing on research on UAM aircraft with both vertical landing and passenger transport capabilities.

According to NASA's timeline, real-time flights and simulations will take place in mid-2022, and the first scenario of the Grand Challenge will be announced.

Hyundai Motor Korea signed a strategic partnership with Uber at CES 2020 in Las Vegas, USA, in January 2020 to present a vision for the S-A1 aircraft and urban aviation mobility ecosystem.

It announced plans and aspirations to realize a human-centered dynamic future city that is free from time and space constraints by utilizing Urban Aviation Mobility (UAM), Purpose-Based Mobility (PBV), and Mobility

Transfer Hub Vertiport.

Uber in the United States established its subsidiary Elevate and aims to commercialize UAM in 2023. China carried out the initial flight of the UAM in January 2016, and demonstrated Ernag's Eh-216 aircraft operation at a pilot event in Seoul for urban air transportation on the Han River in December 2020.

According to data released by the Samjeong Economic Research Institute, "The UAM industry has a potential market size of 1.5 trillion won as of 2040, and countries that operate UAM will benefit greatly from increased work efficiency by reducing travel and transportation time."

2.3 UAM Transportation Service

Inside the UAM Corridors, all aircraft operate according to the specific rules, procedures and performance requirements of the UAM. Airplanes cross the UAM Corridors, and helicopters and UTM aircraft can operate or cross within the Corridors operating range. Even if the airspace rating changes, the operation method does not change within Corridors. Outside of UAM Corridors, ATM(Air Traffic Management) and UTM-related regulations according to altitude, airspace grade, and type of operation are observed.

In ConOps 2.0, UTM will be used inside UAM Corridors and at low altitudes below 400 ft AGL, and ATM will be used in all other airspace.

When UAM is commercialized, a number of aircraft will operate over the city. The reality is that this is difficult to manage with an ATM control system using existing personnel.

Accordingly, it is necessary to introduce an unmanned-based traffic management system, and the development of UTM for low-altitude traffic management is underway. UTM, which provides a number of data-based services at an altitude of less than 500 ft, is a concept that automatically performs flight approval, flight monitoring, and flight ban settings, and UTM is in charge of traffic management in the airspace in connection with ATM.

3. Research on Regulations

3.1 *European Aviation Safety Agency (EASA)'s UAM-related certification system*

The EASA VTOL.2005 Certification of Small-category VTOL aircraft describes the items related to VTOL as follows.

(a) Certification with this small category Special Condition applies to an aircraft with a passenger seating configuration of 9 or less and a maximum certified take-off mass of 3,175 kg(7,000 lbs) or less.

(b) The aircraft must be certified in one or both of the following categories:

(1) Category Enhanced: the aircraft is capable of continued safe flight and landing and meets all applicable requirements. Aircraft intended for operations over congested areas or for Commercial Air Transport operations of passengers must be certified in this Category;

(2) Category Basic: the aircraft is capable of a controlled emergency landing and meets all applicable requirements.

Source: DocNo: SC-VTOL-01(Issue :1. 2019)

Figure 2. Certification of small-category VTOL aircraft

In the case of EASA, a document on small-category VTOL aircraft was prepared as a special condition. It

is expected that the airworthiness certification criteria will be prepared with a new category, and the pilot qualification will be added with certification items related to VTOL.

Considering that most PAV aircraft in UAM are being developed and manufactured as eVTOL, EASA can be considered to be classified as a new category in the early manned operation of UAM.

In addition, aircraft qualifications are classified into two categories: Basic and Enhanced. VTOL aircraft that are not included due to the use and application of new technologies are flexibly allowed through Means of Compliance Special condition Certification(MOC SC-VTOL).

Basic here means that an aircraft is a category that can control emergency landing situations, and Enhance is more limited than Basic and must be able to ensure safe flight and landing in case of an emergency. Commercial means of transportation or aircraft passing over densely populated areas must meet the certification criteria of this category. In other words, it can be seen that the introduction of a new VTOL involves strict regulations on airworthiness certification, just like existing aircraft, in dividing into two categories.

It is believed that the division of categories will require a limited review that requires a limited certification as VTOL's SMALL CATEGORY. The fact that it is limited to this new SC-VTOL category shows that there are no operating procedures for VTOL's development process and VTOL, and that regulations have more restrictions than FAA even though they are outside the authority of EASA.

It can also be an additional problem that UAM's Air Taxi requires the same kind of regulation as airlines regardless of the number of passengers.

In addition, regarding UAM, EASA can see fundamental differences that are institutionally different from FAA.

EASA has come up with regulations on airworthiness certification, type certification, and operation, but there are no regulations on public transportation control such as ATC, UAM corridor, and UTM services proposed by FAA.

It can be seen that the issue of public transportation control is not considered relatively important, unlike FAA, regarding EASA's PAV system.

3.2 *Federal Aviation Administration(FAA)'s UAM-related certification system*

In the case of the United States Federal Aviation Administration(FAA), looking at the 14 CFR § 61.31 - Type rating requirments, Certifications and ratings is under this part regulation, eVTOL is not classified as a separate category, unlike Europe (EASA). Therefore, it is predicted that the pilot will receive certification for each type of eVTOL model that has been certified for airworthiness.

a) Type ratings required. A person who acts as a pilot in command of any of the following aircraft must hold a type rating for that aircraft:
(1) Large aircraft (except lighter-than-air).
(2) Turbojet-powered airplanes.
(3) Other aircraft specified by the Administrator through aircraft type certificate procedures.

(b) Authorization in lieu of a type rating. A person may be authorized to operate without a type rating for up to 60 days an aircraft requiring a type rating, provided—
(1) The Administrator has authorized the flight or series of flights;
(2) The Administrator has determined that an equivalent level of safety can be achieved through the operating limitations on the authorization;
(3) The person shows that compliance with paragraph (a) of this section is impracticable for the flight or series of flights; and
(4) The flight—
(i) Involves only a ferry flight, training flight, test flight, or practical test for a pilot certificate or rating;
(ii) Is within the United States;
(iii) Does not involve operations for compensation or hire unless the compensation or hire involves payment for the use of the aircraft for training or taking a practical test; and
(iv) Involves only the carriage of flight crewmembers considered essential for the flight.
(5) If the flight or series of flights cannot be accomplished within the time limit of the authorization, the Administrator may authorize an additional period of up to 60 days to accomplish the flight or series of flights.

(c) Aircraft category, class, and type ratings: Limitations on the carriage of persons, or operating for compensation or hire. Unless a person holds a category, class, and type rating (if a class and type rating is required) that applies to the a is operated for compensation or hire. That person also may not act as pilot in command of that aircraft for compensation or hire.

(d) Aircraft category, class, and type ratings: Limitations on operating an aircraft as the pilot in command. To serve as the pilot in command of an aircraft, a person must—
(1) Hold the appropriate category, class, and type rating if a class or type rating is required) for the aircraft to be flown; or
(2) Have received training required by this part that is appropriate to the pilot certification level, aircraft category, class, and type rating if a class or type rating is required) for the aircraft to be flown, and have received an according to the Part 61.31 Type Rating requirements, additional training, and authorization requirements, details of the pilot's qualification according to the aircraft type are described.

Figure 3. 14 CFR § 61.31 Regulation on Type-Rating

Turbojet-powered aircraft, and Specified by the Administrator, except for aircraft lighter than air. Since eVTOL is driven through an electric motor, it can be applied as items 1 and 3 except 2. (c) The item specifies restrictions on the form of freight or compensation or employment.

It indicates that commercial operation is impossible without receiving limited qualifications for category, class, and type ratings applied to the aircraft, and there is no category classification for VTOL, so it will be necessary to acquire a type limited qualification for the aircraft to operate eVTOL PAV.

4. Conclusion

According to the K-UAM roadmap proposed by the Ministry of Land, Infrastructure and Transport, boarding autonomous UAM aircraft without pilots is expected to be poor until sufficient operational performance is secured compared to the relatively long-term development and proven use of air traffic.

In fact, the Korea Transportation Research Institute surveyed transportation users in Seoul on their intention to board the UAM according to whether they were accompanied by a pilot, and found that the UAM boarding positive rate was 59%, but 27% for unmanned control.

As such, considering general social acceptance, it is expected that the operation of the UAM pilot without boarding method will continue to some extent as stability and reliability have not been secured.

Based on the previous study of advanced aviation countries' regulations on UAMs by FAA and EASA, the International Aviation Organization (ICAO) said helicopters and UAMs have the most similar systems, and the National Aeronautics and Space Administration (NASA) mentioned that they will proceed quite similarly to the initial UAM's operational pattern.

In addition, according to UAM_ConOps_v1.0, it is classified into three categories: initial UAM operations, ConOps_v1.0, and material state operations, and states that "initial UAM operations perform certified UAM aircraft and conventional helicopters in accordance with current rules and limitations."

eVTOL-type aircraft can be seen to have very similar flight characteristics to helicopters, and the number of passengers using the general steering system or landing device is similar to helicopters, and less than 9,000 passengers, less than 13,000 passengers, based on EASA and FAA.

According to the analysis of SC-VTOL-01 of EASA, a new category was classified as a flight certification item for UAM. FAA is expected to determine the limited qualifications of pilots based on the existing certification criteria based on the classification of small and large aircraft without classification of categories.

Considering the similarity between Korea's aviation laws and FAA's regulation, it is possible to set the direction based on the FAA's classification criteria for granting UAM certificates.

It is expected that eVTOL will be difficult to fully apply the category of airplanes or helicopters. However, since the category itself is classified as a new item, flight characteristics are not completely independent, it can be said to be the most similar type of helicopter category. Instead, the DEP scheme used by eVTOL works differently from the aerodynamic features of most single rotor helicopters used by most helicopters, so it will be somewhat difficult to prove the stability of items such as lift imbalance or autorotation. In addition, it should be considered that the flight characteristics in cruise state show the characteristics of the plane.

PAV aircraft will be classified as helicopters or airplanes according to the category received when it receives eVTOL's airworthiness certification, and the pilot will be the most ideal way to issue PAV's Type Rating based on the certificate previously issued with the category.

In future studies, it will remain an important task to determine the level of qualification of PAV pilots in the remote control stage before going to fully autonomous flight. In general, it takes considerable time and resources to acquire pilot qualifications for airliner control, and a high level of expertise is required.

However, since PAV in the UAM ecosystem is used as a low-altitude urban transportation, it seems that relaxed standards should be applied rather than existing pilot qualification requirements. However, it should be premised that the technical safety level and automation level of the UAM aircraft should reach a level close to perfection and the certification criteria for the aircraft should reach a higher level than that of the existing

aircraft.

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