Technical Review

https://doi.org/10.12985/ksaa.2023.31.2.100
ISSN 1225-9705(print) ISSN 2466-1791(online)

A Study on the Institutionalization of UAM Pilot Training and Education

SungYeob Kim*, JiHun Choi**, JoungMin Choi***, SangYong Park****

ABSTRACT

This study intends to present the UAM pilot qualifications and training and education systems based on the roadmap of technology for K-UAM operation system, which is being promoted for commercialization in 2025. There are currently about 250 eVTOL manufactures around the world, and they are gearing up to produce a variety of UAM aircrafts. In Korea, 35 companies including Hyundai Motor company, Korean Air, Lotte and SKT are accelerating the development of UAM aircrafts. UAM is being developed as a public goods concept centered on public transportation and urban aviation rather than private transportation. Therefore, the UAM pilot qualification and education and training system should be suitable for operations in densely populated areas and complex urban enviroments. In other words, in order to ensure safe UAM operations, the competencies and qualifications of UAM pilots should be clearly established.

Key Words : eVTOL(Electric Vertical Takeoff and Landing, 전기 수직이착륙기), K-UAM(K-Urban Air Mobility, 한국형 도심항공교통), Qualification(자격제도), Training(교육훈련), UAM Pilot (UAM 조종사)

Ⅰ. INTRODUCTION

1.1 Background

Modern society has seen the development of metropolitanization with populations greater than 10 million, due to the concentration of the population in large cities. Consequently, social costs are rising due to a decrease in urban residents' speed of movement and an increase in logistics and transportation costs, both of which are expected to continue to rise in the coming years. As a means to solve the problems associated with traffic jams and noise pollution in the city at the same time, Urban Air Mobility has been proposed as a method to resolve traffic congestion and environmental pollution problems simultaneously.

MLIT[1] has developed the K-UAM technology roadmap (2021.06), which aims to achieve commercialization by 2025. As countries compete with one another for a share of the 700 trillion won market, Korean industries, universities, and research organizations set a roadmap to achieve

Received: 04. Jun. 2023, Revised: 14. Jun. 2023, Accepted: 16. Jun. 2023

* Ph.D. Candidate, Department of Flight Operation, Korea Aerospace University
** Ph.D. Department of Flight Operation, Hanseo University/ Captain, Jinair
*** Ph.D. Candidate, Department of Flight Operation, Hanseo University/ Captain, Jejuair
**** Professor, Department of Flight Operation, Jungwon University
Corresponding Author E-mail : parksy@jwu.ac.kr
Corresponding Author Address : 85, Munmu-ro, Goesan-eup, Goesan-gun, Chungbuk, 28024, Korea

1) MLIT (Ministry of Land, Infrastructure, Transport)

commercialization by 2025.

Nevertheless, since the focus of research and development is on the improvement of aircraft systems and the takeoff and landing sites (Vertiport), the establishment of UAM operators' qualifications and an training and education system tends to be neglected.

The purpose of this study is to suggest the most suitable qualification and training and education system by comparing and analyzing the current aviation pilot qualification system with the overseas UAM pilot qualification system. The multicopter, which is the most basic form of eVTOL aircraft, is similar to a rotorcraft. Due to the similarity between multicopters and rotary wing aircraft, the initial UAM operator training curriculum was modeled after the time-honored training system utilized by the R.O.K aviation school for rotary wing pilot training for over sixty years.

1.2 Purpose of the Study

The advent of a new air transport system, called UAM, has raised many questions about the appropriate flight rules for air transportation, what training and certification is necessary to qualify for a UAM takeoff, flight, and landing permit. Therefore, before proceeding with this study, it is necessary to define UAM.

According to the Federal Aviation Administration (FAA), an advanced country, it is defined as follows. Defining unmanned aircraft as "a device used or extended to fly in the air without a pilot, weapons, or extruding warheads, but including all types of aircraft, pilots, etc.," it is stipulated that this includes airships as well as non-passenger powered flotation aircraft. Unmanned aerial vehicles are classified as RPAS (Manual on Remotely Piloted Aircraft Systems).

Currently, the first edition of manual (2015), consists of three sections: "Remotely Piloted Aircraft: RPA", "Autonomous Aircraft", and "Model Aircraft". The term remote-controlled aircraft refers to "an unmanned aircraft with a pilot participating in remote control operations", while the term autonomous aircraft refers to "an unmanned aircraft without any interference in flight operations" (Choi, 2022, p.2). "A study to determine the selection of pilots for UAMs and their training".[2)]

However, the K-UAM technology roadmap also notes that autonomous flight without a pilot will take time, and that manned flight will remain inevitable for some time to come. According to the UAM technology roadmap presented by the Ministry of Land, Infrastructure, and Transport, the pilot operation plan will last approximately ten years between the preparation stage for commercialization (2025-2029) and the growth phase (2030-2034).

In order to ensure the safety of pilots during the period of UAM commercialization, it is necessary to prepare for pilot selection and training and education. The objective of this study is to develop pilot training and education measures for the UAM flight environment and technology system that are needed for a safe and effective operation by UAM pilots during the preparation phase for the commercialization of UAMs and final autonomous flight.

1.3 Content of the Study

Currently, foreign countries do not apply for a separate operator qualification system for UAM, as it is in its R&D stage prior to commercialization. The use of current aviation operator qualification holders may be necessary in certain circumstances.

This study aims to analyze UAM pilot qualifications and education training practices do-

2) (Choi, 2022, p.2), “A study on the section of UAM pilot and establishment of training”.

mestically and internationally. It also examines the correlation between existing qualifications, missions and roles, required abilities, and the scope of responsibility. Furthermore, since no specific research has been presented on UAM pilot training and education, we would like to determine the optimal UAM pilot training and education course based on the time-tested education curricula of the R.O.K Army Aviation School, which has trained the largest number of rotor pilots.

II. MAIN SUBJECT

2.1 General

The Ministry of Land, Infrastructure, and Transport has set up a K-UAM technology roadmap with the goal of commercialization by 2025 and is heralding the UAM era through cooperation between related ministries, Urban Air Mobility (UAM).

In order to operate UAM, three resources are required. UAM aircraft, a take-off and landing airport (Vertiport), and a pilot as an operator. In order to enhance operational profitability, UAM aims to provide an ultimate autonomous flight without the need for a pilot. In the following Table 1, we provide an overview of autonomous levels. Nevertheless, the Korean Urban Air Mobility (K-UAM) roadmap states that pilots will have to board in the early stages due to social and technical limitations. The vast majority of UAM's capabilities are focused on developing UAM aircraft and setting up infrastructure for operating Vertieport, as the UAM ecosystem is still in its embryonic stages. Discussions regarding the qualifications and education and training of pilots, controllers, and ground personnel are insufficient.

2.2. Review of Previous Studies

The successful commercialization of UAM requires the establishment of a new system and the rearrangement of the existing system. Despite this, Korean UAM aircraft types have not yet been determined, and many areas remain to be filled in since certification and qualification systems have not been established.

Table 1. Changes in the role of pilots by autonomous level

LEVEL 1 (~2025)	LEVEL 2 (2025~2035)	LEVEL 3 (After 2035)
Determination of flight availability	Determination of flight availability	Determination of flight availability
Carry out flight control and ensure operational safety on board the aircraft	Conduct aircraft control and ensure operational safety on board or in remote control rooms	Conduct aircraft control and ensure operational safety on board or in remote control rooms
		Operational monitoring of a large number of assigned aircraft and intervention in emergency situations

The research on the UAM pilot qualification system remains insufficient. While there has been a lot of interest in this topic, researchers are continuously studying it.

Upon analyzing domestic and overseas pilot qualification standards, Lee (2021) recommended establishing new aircraft types or adding new aircraft types to the existing system in order to set Korean UAM pilot qualification standards.

In addition, SWOT[3] analysis was used to determine the weaknesses of the type and category.

In spite of this, it is regrettable that only the strengths and weaknesses of each expected subject were discussed. There was, however, no conclusion regarding which UAM system would be more effective and safer. Government agencies were left with the additional task of conducting research in this area.

3) SWOT (Strength, Weakness, Opportunity, Threat).

According to Choi (2022), based on SMS ICAO Annex 19 Safety Management System (SMS) for UAM operating in low altitudes and high density urban environments, safety hazards associated with UAM operation have been discovered and evaluated.

Furthermore, he discussed the qualities that UAM pilots should possess and the curriculum for UAM pilot training and education. His study contains four major components: first, control technology capable of handling UAM skillfully, second, IFR flight ability to fly even in instrument conditions, third, understanding and operation of PBN navigation, and finally, the ability to handle contingencies in unusual circumstances.

Based on the prior studies of the FAA and EASA, Kim (2022) explains that eVTOL-type aircraft have very similar flight characteristics to helicopters. Although the UAM category has been classified as a new item, it is explained that the flight characteristics are not completely independent and can therefore be described as the most similar type of helicopter category. As a result, it is anticipated that eVTOL will be difficult to fully implement with the existing helicopter category.

Accordingly, it is suggested that the best method would be to issue it based on the Type Rating of the PAV[4]. The determination of the level of qualification for future PAV pilots is left for future research in this study.

A limitation of the study is that it does not reflect pilot qualifications for new types of UAM aircraft, such as tiltrotors and lift and cruise aircraft.

Ⅲ. TRENDS IN UAM PILOT QUALIFICATION REQUIREMENTS

3.1 Domestic Trends

The Aviation Safety Act, the Enforcement Decree, and the Enforcement Rules of the same Act stipulate the specific requirements for obligations, delegations, and certifications for each airman qualification in Korea. Moreover, the operating safety regulations stipulate the minimum safety standards that aviation workers must comply with for the safe operation of aircraft (MOLIT, Aviation Safety Act and Implementation Regulations, 2020).

However, as in advanced aviation countries, the pilot qualification system and training and education according to UAM commercialization are not presented.

3.2 Overseas Trend

While in the midst of the establishment and reorganization required for the introduction of UAM, the United States and EU are preparing a certification and qualification system for the successful commercialization of UAM. In this paper, we will examine the current state of representative aviation organizations such as the International Civil Aviation Organization (ICAO), the Federal Aviation Administration (FAA), and the European Aviation Safety Agency (EASA).

3.2.1 International Civil Aviation Organization (ICAO)

Annex 1 of the International Civil Aviation Organization (ICAO) describes the flight qualification requirements for existing aviation workers. However, ICAO has not yet suggested guidelines for a new aircraft concept called UAM.

3.2.2 Federal Aviation Administration (FAA)

In the United States, an aviation license is issued by the Federal Aviation Administration (FAA) to ensure that operators and pilots are familiar with certain levels of technology and safety procedures and are capable of safely flying an aircraft.

4) PAV (Personal Air Vehicle).

In addition, the U.S. Federal Aviation Administration (FAA) has certified UAM as an LSA (Light-sport aircraft) in accordance with PART 23.

It should be noted, however, that due to the wide variety of types and manufacturers of eVTOLs, the UAM certification has been changed to a new category, Powered Lifts.

Within the existing certification system, the FAA is conducting research regarding type certification for VTOL aircraft. In addition, the FAA is understood to be conducting research into the provision of pilot qualifications within the existing system(FAA, UAM Concept of Operations Version 1.0, 2020.).

3.2.3 European Aviation Safety Agency (EASA)

The European Aviation Safety Agency (EASA) has announced the world's first integrated regulatory framework for the operation of UAM (Introduction to the operation of drones, 2022.06).

There are more subject matters covered by the European (EASA) Integrated Rules compared to the American (FAA). EASA also presents a more detailed pilot qualification system than the U.S. (Notice of Proposed Awareness 2022-06 in accordance with Article 6 of MB Decision No. 1-2022).

The purpose of innovative air transportation, such as UAM, is to transport passengers and cargo as quickly and safely as possible, as well as to create an efficient and profitable market for air transportation that is eco-friendly, and fossil-free. Moreover, UAM's sustainability is of primary importance.

UAM pilot licenses will not be issued as separate types during the early stage of commercialization, according to EASA, because "sufficient data or flight experiences are lacking for the training of UAM pilots." Upon accumulation of flight experience in the future, the UAM pilot qualification system and training and education system will be established based on these experiences.

Currently, in the early stages of commercialization, EASA plans to award UAM qualifications to existing aviation certification holders.

Ⅳ. INITIAL UAM PILOT TRAINING SCHEME

The early type of operations described in the Korean Urban Air Mobility (K-UAM) Operation Concept Book 1.0 (Ministry of Land, Infrastructure and Transport, 2021. 9).

Operating environments include manned VFR and satellite navigation systems. Moreover, according to the FAA and EASA, the UAM aircraft operates within similar operating environments and systems as existing rotorcraft (helicopters). This has resulted in Performance-Based Navigation (PBN).

PBN navigation is one of the most important operating environments for UAM. In addition, existing holders of business and transport pilot licenses have a good understanding of PBN and a great deal of experience with it. As a result, it is recommended that, in order to ensure the stability of the initial UAM operation, education and training should be provided to pilots with flying experience (rotary wing or fixed wing) qualified for business flights.

4.1 Initial UAM Pilot Training

The majority of UAM aircraft are VTOL aircraft which share the same operating environments and systems as rotorcraft. In view of the lack of a UAM pilot training program currently proposed, we would like to analyze the rotorcraft pilot training program for the initial UAM pilot training course in order to determine the subjects that will be covered in the UAM pilot training course.

We studied the flight education subjects and educational measures necessary for the early UAM pilot training based on the time-honored

experience of the R.O.K Army Aviation School, which operates the largest number of rotorcraft and has trained the largest number of pilots in Korea, as well as its proven pilot training program.

4.2 Analysis of Pilot Training of Army Aviation School

In Table 2 you will find a summary of the flight training curriculum of the Army aviation school for the period of 31 weeks, which will entail approximately 1,290 hours of instruction. To begin with, the required abilities for a rotorcraft pilot (excluding military subjects) presented by Army Air can be broadly categorized into three major groups. The first relates to the pilot's ability to perform his/her duties, the second relates to the pilot's ability to cope with severe weather and contingencies, and the third is the pilot's ability to control air traffic. Additionally, Table 2, shows the content of the core subjects and related subjects for each goal as they relate to each objective.

Aside from subjects such as tactical aircraft operation, the study concentrates solely on a training program for people and cargo transport, excluding subjects such as tactical aircraft operation. Below is a table that illustrates the training program derived from empirical data, which can be found in Table 3.

Table 2. Key subjects and related subjects for pilot training of the army aviation

Classify	Core subject	Related subjects
Type / Step Aircraft operational capability mastery	Aircraft handling/ operation act Instrument flight (skilled) Weather (full knowledge) Navigation (full knowledge) Aviation safety (full knowledge) Helicopter structure/ operationa principle	Principles of flight (I, II) Aviation regulations Flight dispatch Radio operation Operation of aviation facilities and related institutions

4.3 Initial UAM Pilot Training Proposal

In accordance with the Korean Urban Air Mobility (K-UAM) Operation Concept Manual 1.0 (Ministry of Land, Infrastructure, and Transport, 2021), pilots are expected to possess the following qualifications, according to the UAM pilot requirements: the ability to operate new aircraft, the ability to operate VFR or IFR in urban routes, as well as the ability to cope with contingencies and right time flying.

The ground school and flight training program that will be introduced to the Army Aviation School as a platform to cultivate the performance of early UAM pilots has been derived from the analysis of early UAM operational environments and the training program of the Army avi-

Table 3. Pilot training course of the army aviation

Classify	Content	Remark (hrs)
Foundation flight training	Boarding flight	1
	Hovering	8
	SFTS (simulator)	3
	Traffic pattern	16
	Evaluation	2
Advanced education	Restricted land operation	2
	Mountain helipad	11
	Procedural training	1
	Instrument flight adaptation training (SFTS)	4
	Evaluation	2
Instrumental flight	Simulator flight	10
	Actual instrument flight (ILS,VOR)	10
Additional education	Night flight	10
	Emergency procedures	1
	Evaluation	2

ation school, as shown in Table 4 below.

In order to determine the importance of the training program listed above, the following order could be established: 1) normal takeoffs and landings, 2) rooftop heliports (calculation operations) of vertiports or skyscrapers, 3) performance-based navigation (PBN), and 4) limited area operations.

Table 4. Initial UAM pilot training courses

Classify	Content	Remark
Ground school	UAM handling method/ operation method	
	Understanding and operating the mounted equipment	
	Instrument flight (theory)	
	Aviation regulations	
	Principles of flight Ⅰ,Ⅱ	
	Aiation weather	
	Air navigation PBN (performance based navigation) Precision satellite navigation	RNAV, RNP
	Aeronautical radio communication	CNS ATM
	Aviation safety Just culture SMS (Safety Management System)[5]	ICAO ANNX19
	Evaluation	
Flight school	Boarding flight	
	Hovering	
	Traffic pattern	
	Vertport takeoff and landing	
	Restricted land operation -Building rooftop vertiport take-off and landing -Slope operation	
	Passenger plane/ cargo transportation	
	Night flight	
	Basic instrument flight and departure procedures	
	Navigation procedures	
	Simulated/actual instrument flight	ILS, VOR,
	Evaluation	

The initial pilot training, as well as recurrent training, as described in the above article, have been designed based on the proven training curricula for the R.O.K. Army aviation school. K-UAM operational training and education will also be supplemented by empirical data collected from the initial K-UAM operational training in 2030.

Ⅴ. CONCLUSION

A study by UAM suggests that the UAM project constitutes the center of national industry, with a substantial concentration of national capacity. There will be an era of urban transportation in the near future thanks to the UAM development project. This has become the stage for competition between many countries and companies around the world.

Although we have examined developed countries' UAM status, they have not presented their own UAM pilot qualification system. It is likely that qualifying all types of UAM would pose many difficulties. In addition, according to MILT's road map, a transition to an autonomous UAM is planned when the UAM's stability and social perception change after a period of development (~2034). The current qualification system is based on currentnecessity. It will be discarded or regarded as a nominal method when the pilotless autonomous UAM system is operational in the future.

Therefore, it is believed that granting new type ratings to existing airman qualifications should be the most effective and stable method of UAM operation rather than developing a new system of UAM qualification. Moreover,

5) ICAO Annex 19, "Safety Management System".

since there are no accumulated data regarding training and flight, this study suggests an early UAM pilot education and training system by comparing and analyzing that of the R.O.K. Army aviation flight school, which has similar operational environments and pilot characteristics. Therefore, by giving the pilots a deep understanding of the type of UAM that is encountered in urban air transportation, it is deemed possible to maintain the safety of the urban air transportation system.

Furthermore, since UAM is a new form of transportation, there is no accumulated education and training system and flight data for pilot training at an early stage. Therefore, the initial UAM pilot training and education plan was developed by comparing and analyzing the Army Aviation School's educational data. There is a limitation to the scope of this study in that it addresses only the degree to which a program for army aviation education and training is presented for the UAM pilot training program.

In order to define the specific educational training programs, for example, the detailed curriculum and the length of time that the training will last, it is necessary to wait until future research is completed to determine the exact details.

References

1. UAM Team Korea, "K-UAM Concept of Operations", v1.0, MOLIT, Korea, 2021.
2. Lee, S. K., "A study on rule making for pilot certification for K-UAM", Journal of the Korean Society for Aeronautical and Space Sciences, KSAS 2021 Fall Conference, Nov. 2021, pp.687-688.
3. Choi, J. H., "A study on the selection of UAM pilots and establishment of training", Journal of Korean Aviation Management Association, 30(3), 2022, pp.132-139.
4. Kim. S. R., "A study on the urban air mobility (UAM) operation pilot qualification system", International Journal of Internet, Broadcasting and Communication, 14(1), 2022, pp.201-208.
5. EASA (European Union Aviation Safety Agency), "Notice of Proposed Amendment", 2022, pp.23-40.
6. Uber Elevate, "UBER Operation inside Corridor", OctT, 2020.
7. Bradford, S., "Urban Air Mobility (UAM) Concept of Operations", v1.0, FAA, Washington, D.C., USA, 2020.
8. ICAO, Annex 19, "Safety Management System (SMS)".