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Analysis of Meteorological Service Requirements for Safe Operation of Low-altitude Aircraft

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Abstract

Meteorological information is essential for the safe operation of aircraft. Many organizations both at home and abroad provide meteorological services for small aircraft flying at a low altitude as a part of open public service and have performed relevant studies. Recently, such a service has been expanded to an online platform in order to deliver information more efficiently. The ultimate goal of this study is to improve the meteorological service for small low-altitude aircraft that mostly travel a short distance for a short time. To achieve this goal, this study considered requirements for developing an effective information delivery system and conducted a survey of user requirements to derive the necessary information that could be used to develop a real service.

Keywords: *Low altitude aircraft, Small aircraft, Weather service, Aircraft operation*

1. Introduction

According to The Korea Development Institute (KDI), the current economy of South Korea shows a moderate rise owing to the growth in exports and consumption. According to Economic Outlook 2018 (Revised) released by the Bank of Korea on April 12, 2018, the economic growth rate is expected to be 3% in 2018 and 2.9% in 2019 on the basis of recent economic conditions at home and abroad [1]. As of March 30, 2017, the South Korean aviation leisure sport industry has implemented the "Aviation Business Act,″ which specifies the registration of aviation leisure sport business and the application with necessary modifications, and the ″Aviation Security Act″ specifying safe aviation activities. Such an aircraft operation includes small aircraft and helicopter operators and service providers, and also leisure aviation providers and relevant clubs of light sports aircraft and ultralight aerial vehicles. The visual flight rule (VFR), which shall be complied with by the majority of small aircraft, specifies the minimum visibility of 5,000 m, the minimum clearance from cloud, etc. Accordingly, such meteorological factors as visibility and cloud are crucial for preventing the collision with nearby aircraft and obstacles and making decisions about operation and safety issues [2]. Especially, small low-altitude aircraft often do not take off owing to low visibility or low clouds. Incidents are frequently caused by risky operation or sudden meteorological phenomena. Among recent accidents, on November 16, 2013, a helicopter of LG Electronics went off course and collided with an apartment building on the Han riverside while flying from Gimpo international airport to the Jamsil helipad. Two pilots were

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killed. On July 17, 2014, a rescue helicopter returning to the headquarter after support work for the Sewol ferry disaster crashed in the central area of Gwangju owing to bad weather conditions related to clouds. Five firefighters were killed. On February 28, 2016, a Cessna 172 of Halla Sky Air took off from Gimpo international airport for training flight but crashed soon owing to bad weather, claiming the lives of one pilot and two students [3]. To prevent such tragic accidents, more accurate and localized meteorological information and weather forecast data are required, which can be used to establish a safe operation plan and to prepare for drastic weather change during flight.

With the intent of supporting the operation of small low-altitude aircraft that mostly travel a short distance for a short time, this study considered requirements for developing an *effective* information delivery system, and surveyed and analyzed operator requirements to derive the necessary information and a development process for further works.

2. Meteorological service requirement analysis

2.1 Current status of low-altitude aircraft

2.1.1 Overseas (USA)

The USA is the world's largest aviation market including flights and aircraft manufacturing. In particular, in addition to small aircraft for educational purposes, personal aircraft form a very large market.

Fig. 1 shows the number of registered small aircraft since 2010. It was observed that the number of registered small aircraft in the USA continued to be at least 200,000. The majority of these registered aircraft are small, experimental, or light aircraft, which are supposed to comply with VFR, as mentioned above [4].

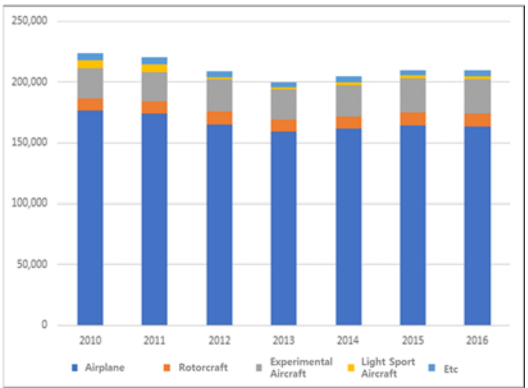

Figure 1. Number of registered small aircraft in the USA

2.1.2 Domestic

In The South Korea, as of March 31, 2018, a total of 5,651 light aircraft and ultralight aerial vehicles were registered. This number is currently on a gradual rise. Moreover, as of the end of March 2018, 1,195 people had been licensed to operate a light aircraft, and 9,598 people had been awarded a license for an ultralight aerial vehicle. Tables 1, 2, and 3 show an increasing interest in the small-aircraft industry [5].

The majority of small aircraft in South Korea are not used for regular passenger transportation but for special passenger or freight transportation, tourism, and educational purposes. Moreover, helicopters operated by public organizations such as the Korea Forest Service are included in these small aircraft. Recently, the percentage of personal light aircraft for leisure aviation has been observed to increase.

Table 1. Number of registered light aircraft

Classification	Powered aerial vehicle		Rotorcraft		Powered parachute	total
	Light airplane	Weight shift aircraft	Light helicopter	Gyroplane		
Number	192	4	7	7	4	214

Source: Aviation Industry Division of the Ministry of Land, Infrastructure and Transport (As of 3/31/2018, unit: airplane)

Table 2. Number of registered ultralight aerial vehicles

Classification	Powered aerial vehicle		Para-gliding	Aerostat	Unmanned aerial vehicle		total
	Light airplane	Weight shift aircraft			Powered UAV	Unmmaned Airship	
Number	3	46	1,086	74	4,228	40	5,437

Source: Aviation Industry Division of the Ministry of Land, Infrastructure and Transport (As of 12/31/2017, unit: airplane)

Table 3. Number of licensees for light aircraft or ultralight aerial vehicles

Period	Ultralight aerial vehicle	Light aircraft
2004-2013	1,852	860
2014	1,241	105
2015	936	65
2016	999	81
2017	2,962	72
2018.03	1,608	12
total	9,598	1,195

Source: Aviation Test Division of the Korea Transportation Safety Authority (As of the end of March 2018, unit: person)

2.2. Research and development process

2.2.1 System engineering process

System engineering (SE) is an engineering approach for developing a complex system that could satisfy the requirements of demanders and adequately operate during a specified life cycle. Generally, the requirements of demanders are analyzed in the initial research and development (R&D) stage before developing and demonstrating a product with suitable functions, performance, and quality through the SE approach. Detailed SE process models have been applied to Defense Acquisition University (DAU), Capability Maturity Model Integration (CMMI), ANSI/EIA 632, ISO15288, etc.

Although there are differences in the details of SE models, the conventional process is implemented in the order of requirement analysis, functional analysis, allocation, design synthesis, system analysis, control, and verification. Requirements investigated in the initial stage of the process are also used as important basic data in the verification stage.

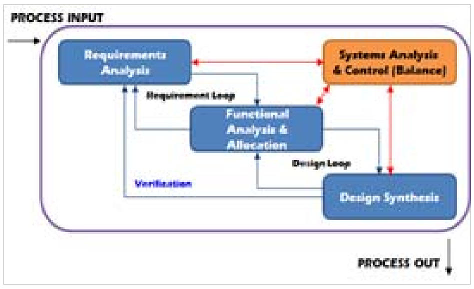

Figure 2. Process of system engineering approach

2.2.2 V verification model on the SE

The output of an R&D project must be continuously checked as to whether it has been adequately processed and completed. This work is essential for achieving the goal of the R&D project. The final result of the project can attain its optimal applicability only when the requirements of the demanders or the society are effectively reflected. In this regard, the SE usually includes a V development/verification process.

The V development/verification process examines the appropriateness of outputs either in each stage or at the end of the project by combining the top-down process for R&D and the bottom-up process for confirmation/verification.

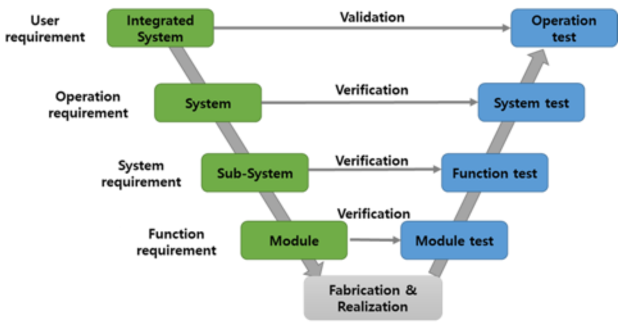

Fig. 3 V model on the system engineeirng

The development stage proceeds in the order of user requirement analysis, system requirement analysis, system design, and realization. The verification stage verifies the requirements of all the levels including subdivisions (modules and subsystems) and the whole system. Here, as for the whole system, it is necessary to verify whether the real requirements of the demanders or operators could be adequately satisfied. Accordingly, requirements must be surveyed and analyzed. Moreover, the requirements for the whole system should be defined to be further divided in terms of subsystems and components.

2.2.3 Requirement analysis

The analysis of system requirements is the early stage for defining the system and also the initial process of the entire R&D project, which provides basic data for architecture design and system integration/verification. When requirements are analyzed, functional and performance requirements are to be so clearly derived/defined that they could be applied as restrictions for interface and design. The requirement analysis must be accompanied by listening to the real opinions of users or demanders, which are typically collected through a survey. In case an unspecified public service is developed, a survey of random people can be conducted. However, if a specialized product or service for a specified group of people is developed, the special conditions of the group must be reflected.

In the case of a requirement analysis using a survey, the importance or satisfaction for an object can be measured on a scale basis. However, if a system is in its initial development stage or special demands of a particular group are to be reflected, the survey often includes questions for a qualitative analysis and also is performed for only a small number of people representing the group.

2.3. Analysis of requirement survey

2.3.1 Subjects of study

This study utilized a survey of Korean pilots. The survey was conducted for 32 days from May 20 to June 22, 2018. Among 300 copies of the questionnaire, 229 copies were effectively returned. Among the respondents of the survey, 178 pilots were in their thirties or younger, and 51 pilots were in their fifties or older. The respondents included 220 male pilots and nine female pilots; 120 respondents were helicopter pilots and the remaining 109 respondents were aircraft pilots. The experience of the respondents in years showed a somewhat regular distribution varying from 2 years or less to 10 years or more.

With respect to flight missions, the respondents were classified into army pilots (37.6%), student pilots (23.1%), instructor pilots (17.5%), general aviation pilots (15.3%), and transport pilots (6.5%). Most of their missions were supposed to be performed within the territory of South Korea. Among risky situations experienced by respondents (accident, semi-accident, hazardous element, etc.), bad weather conditions accounted for the highest percentage (63.3%), followed by aircraft defects (38.4%), clumsy collaboration of crew members (24.9%), and communication failures (12.7%).

2.3.2 Questionnaire

To survey and analyze the requirements of operators for an efficient information delivery system that can support the flights of small aircraft, the questionnaire in this study consisted of 13 questions, which were divided into the following three categories: meteorological information before flight or during the flight planning stage (five questions), meteorological information during flight (five questions), and others (three questions).

2.4. Result of the requirement survey

2.4.1 Preference of meteorological information service

Before flight or during the flight planning stage, the website of the Meteorological Service Office and data of the flight (operation) information center were most actively used (70.3%). During flight, the data of the flight (operation) information center and air traffic service offices were most preferred (65.1%). As mobile phones can be used in a flying low-altitude aircraft, many pilots also utilized smartphone applications (32.3%). Other suggestions included the improvements in the reliability of application service, the access of information,

1. *Meteorological information before flight or during the flight planning stage*
    - *a. Preference of the types of meteorological information service*
    - *b. Important items of aviation meteorological information*
    - *c. Important items concerning the accuracy of information*
    - *d. Meteorological information items requiring high accuracy*
    - *e. Meteorological information service type*
2. *Meteorological information during flight*
    - *a. Preference of the types of meteorological information service*
    - *b. Important items of aviation meteorological information*
    - *c. Important items concerning the accuracy of information*
    - *d. Meteorological information items requiring high accuracy*
    - *e. Meteorological information service type*
3. *Others*
    - *a. Units for decrypting aviation meteorological information*
    - *b. Limitation of aviation meteorological information currently used*
    - *c. Suggestions for the aviation meteorological information system currently under development*

and real-time image information system. These suggestions were related to the convenience of operators and the reliability of information service.

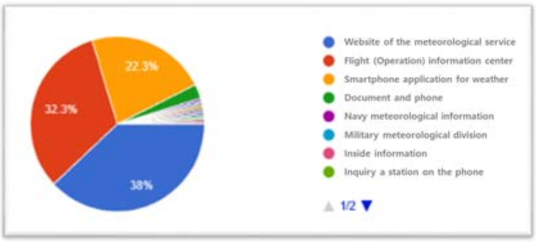

Fig. 4 Preference of the types of meteorological information service (Before flight)

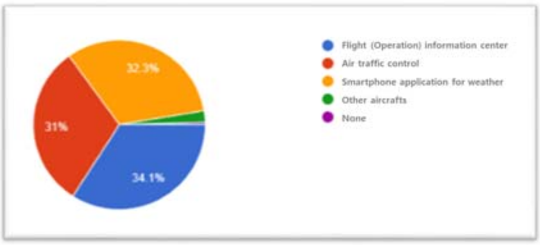

Fig. 5 Preference of the types of meteorological information service (During flight)

2.4.2 Important items of aviation meteorological information

A Cloud amount/height was selected to be the most important information both in the pre-flight planning stage (or before flight) and during flight. Visibility also accounted for high percentages of 87.3% and 81.7% before and during flight, respectively. Every respondent was allowed to select multiple items for each question. It was observed that, among items of meteorological information, cloud amount/height, visibility, and wind direction/speed were considered to be important both before and during flight. In this regard, it was suggested that accurate measuring equipment for visibility and cloud height be installed and local cloud amount and height be measured by using such equipment.

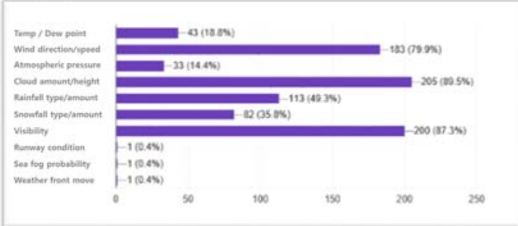

Fig. 6 Important items of aviation meteorological information (Before flight)

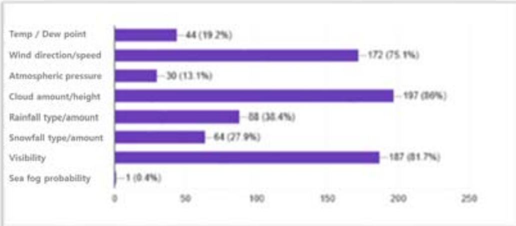

Fig. 7 Important items of aviation meteorological information (During flight)

2.4.3 Important items concerning the accuracy of aviation meteorological information

Both time and location accuracy were equally demanded before flight (or during the pre-flight planning stage) and during flight. Additional suggestions included more detailed meteorological information with respect to location and time, a short-term forecast, and area information regarding low visibility.

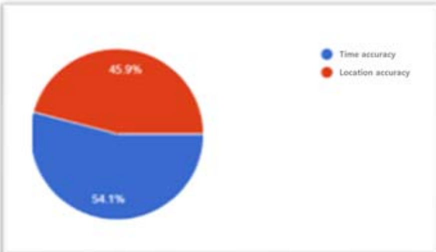

Fig. 8 Important items concerning the accuracy of aviation meteorological information (Before flight)

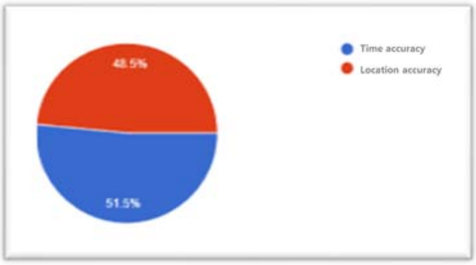

Fig. 9 Important items concerning the accuracy of aviation meteorological information (During flight)

2.4.4 Meteorological information items requiring high accuracy

Visibility was selected as the most important item both before flight (or during the pre-flight planning stage) and during flight. A Cloud amount/height also accounted for high percentages of 29.3% and 25.8% before and during flight, respectively.

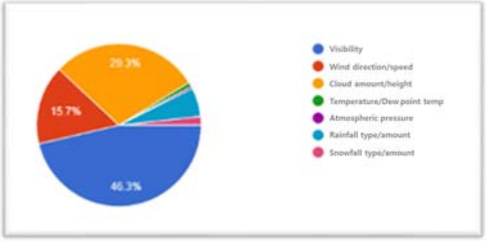

Fig. 10 Accuracy of aviation meteorological information (Before flight)

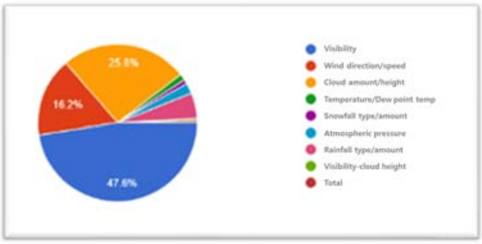

Fig. 11 Accuracy of aviation meteorological information (During flight)

2.4.5 Meteorological information service type

Text and graphic type services were equally preferred both before flight (or during the pre-flight planning stage) and during flight. However, voice information was slightly more preferred than image information during flight. In this regard, a CCTV-based meteorological information system, which is linked to airport meteorological information and many other traffic agencies, must be established, and meteorological data were suggested to be acquired from areas other than airport areas.

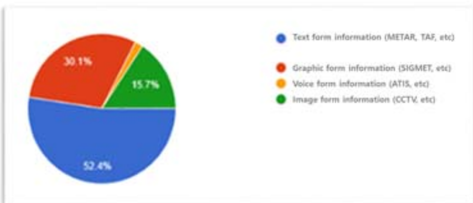

Fig. 12 Meteorological information service type (Before flight)

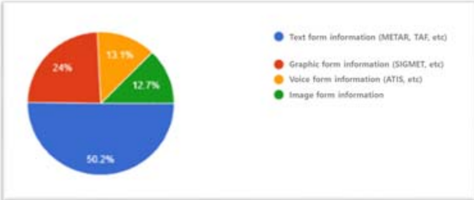

Fig 13 Meteorological information service type (During flight)

3. Conclusion

With the intent of supporting the operation of small low-altitude aircraft that mostly travel a short distance for a short time, this study considered requirements for developing an efficient information delivery system, and surveyed and analyzed operator requirements to derive the necessary information and a development process for further works. As in other countries, air traffic of low-altitude aircraft in South Korea is expected to continuously increase. Accordingly, necessary information must be provided to ensure the safe operation of low-altitude aircraft.

This study conducted a requirement survey for real demanders including low-altitude aircraft pilots. Based on the survey analysis, necessary improvements for future service have been derived and identified.

The approach of this study is utilized as the process of developing products with appropriate functions, performance, and qualities in SE. In the early stage of such an R&D project, the clear requirements of demanders are defined, and the following development process attempts to satisfy the requirements. Requirements thus defined can be used for a verification model, which will confirm the appropriateness of a future system.

The analysis result of this study may not ensure the safe operation of low-altitude aircraft under every condition. However, the most necessary information items have been identified by the survey of low-altitude aircraft pilots, and the direction of future development has been clarified. The findings of this study will be used to develop a service that could contribute to aviation safety.

Acknowledgement

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