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Noise Impact Range Assessment Using UAM Noise Hemisphere

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ABSTRACT

The present study aims to investigate the noise impact range in urban areas around vertiport using a noise hemisphere model to simulate UAM noise propagation. In order to this three noise hemisphere methods were compared including Integrated, Interpolated, and Background noise compensation. SoundPLAN software was used for noise modeling in a specific area of a vertiport in Seoul. Both horizontal and vertical noise maps were drawn to evaluate the UAM noise effect on the buildings around vertiport. As a result, it was found that the noise impact range varied depending on the noise hemisphere model. In addition, the horizontal propagation range of noise was confirmed to be at least 200 m to 700 m. The vertical propagation range varied significantly depending on the building height, with higher noise levels observed around taller buildings. Based on the results, it is possible to predict the 3D noise impact range by combining horizontal and vertical noise maps when operating UAM in actual urban areas.

Keywords: *UAM(urban air mobility), noise impact range, noise assessment evaluation, noise hemisphere, noise map*

1. INTRODUCTION

UAM noise reduction research is being conducted in various fields, including motors and aircraft. Research on noise propagation, which is the focus of this study, is also being conducted in various directions. Several studies have analyzed UAM using the Federal Aviation Administration's (FAA) Aviation Environmental Design Tool (AEDT), which is efficiently used for aircraft noise analysis. One study conducted noise analysis for areas of value for UAM operation by setting fixed-point flight conditions.[1] In addition, a NASA time-marking simulation tool was used to generate noise exposure data for efficient operations to help differentiate differences associated with the integrated noise model implemented in AEDT. Possible changes to assess UAM community noise impact offered more consistently with simulation-based modeling.[2]

However, due to the lack of data, FAA's AEDT and other software do not yet support the operation and analysis of UAM aircraft performance models. Therefore, research on developing an appropriate tool for UAM analysis is also being conducted. For the real-time noise prediction of RPM-controlled multi-rotor configurations, a comprehensive multi-rotor noise assessment (CONA) framework based on a six-degrees-of-freedom flight simulation was developed.[3] Based on this, a study on noise evaluation during multi-rotor landing has been conducted. In addition, a psychoacoustical-based prediction was performed on the noise of the multi-rotor in gusty wind conditions.[4] In addition to references, there is a published study in terms of aircraft development that predicts that the noise characteristics generated by UAM-specific aircraft will be less noisy due to the low propeller load under experimental flight conditions.[5] As such, since UAM's noise analysis method is not standardized, research is continuing to determine the level of noise generated by UAM and the propagation of noise through each noise analysis method.

2. RESEARCH METHODS

Noise data were collected through the flight test of the Optionally Piloted Personal Air Vehicle (OPPAV), an eVTOL UAM aircraft being developed by the Korea Aerospace Research Institute (KARI). The flight test was conducted at the Goheung National Aviation Test Center (NATC) in Goheung, South Korea. Acoustic signals were measured hourly using 80 microphones on the ground runway. The test was conducted at an altitude of 60 m to construct a noise hemisphere. The noise data measured by the OPPAV aircraft using 80 microphones are shown in Fig.

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1. Averaging the noise measurements from the 80 microphones yielded an equivalent noise level of 64.0 dB and a maximum noise level of 70.9 dB. The measured noise data were used to generate a noise hemisphere using the SPHPERE-N noise hemisphere generation program.[6] The noise hemisphere with a null value was designated as the 'Integrated noise hemisphere,' and two additional noise hemispheres with corrected null values were added to compare a total of three types of noise hemispheres. Consequently, a 'Compensated noise hemisphere' was created by correcting the null values using background noise data, and an 'Interpolated noise hemisphere' was generated by applying the interpolation method to the null values. [7]

The simulation target areas are two areas in Phase 2-1, corresponding to the K-UAM Grand Challenge. [8] Based on the information presented in the Aeronautical Information Management (AIM), the location of the vertiport in the region and the UAM flight path were set. [9] The simulation was performed using two methods: a single noise source method and a multi-noise source method. The single noise source method aims to investigate the noise level affected by a single noise hemisphere in the region, and the multi-noise source method aims to determine the noise level propagating in the region according to the actual flight path. Both methods were calculated according to ISO 9613-2, and the radius of the noise source was set to 5 m. The color scale of the noise map was set to 5 dB.[10] Fig. 2 shows the location of flight lines and noise sources in the area.

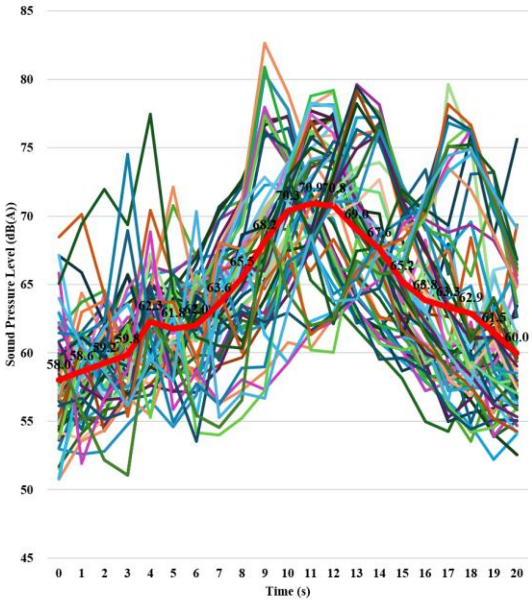


Figure 1. OPPAV noise measurement resluts.

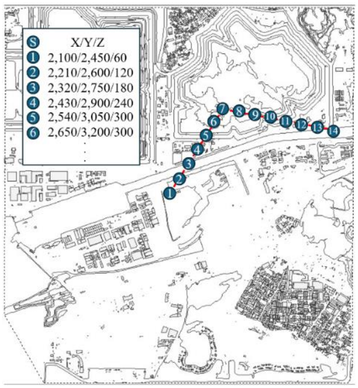
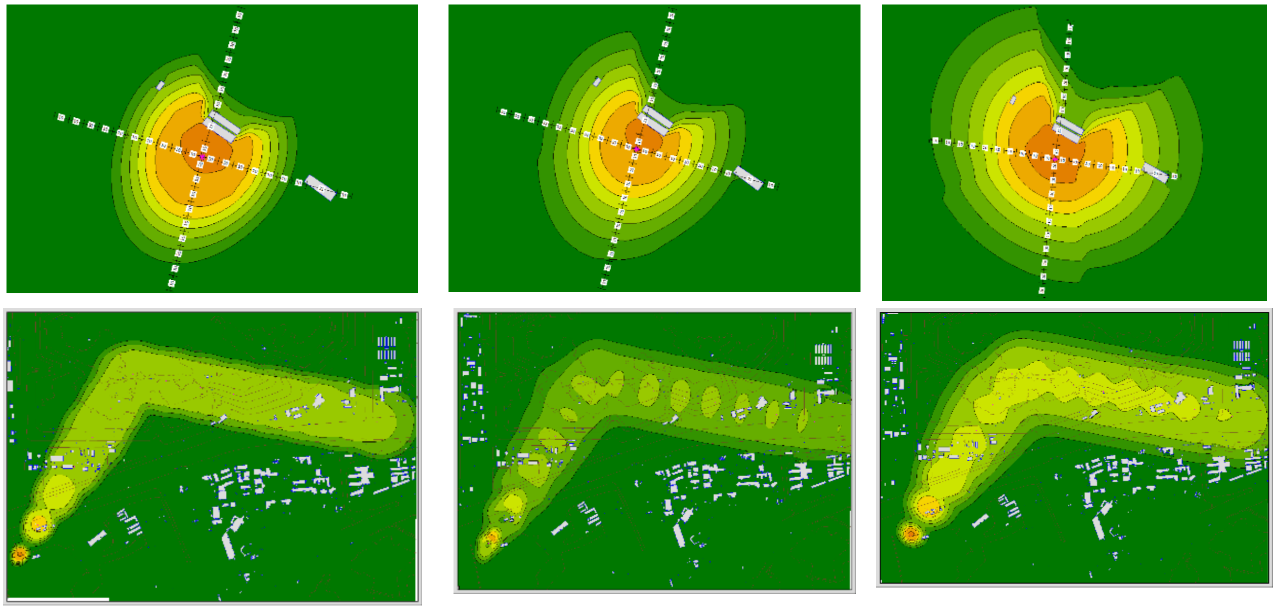


Figure 2. K-UAM Grand Challenge phase 2-1 vertiport and flight path.

3. RESULTS

The planar noise impact range of the Integrated Noise Hemisphere was investigated. The ranges to the left and right were 60 m, respectively, for a total influence of 120 m. In addition, the ranges to the front and rear were 50 m and 75 m, respectively, with the range of influence to the rear confirmed to be longer than that to the side. Investigating the planar noise impact range of the Compensated Noise Hemisphere revealed noise propagation up to 70 m from the left and right, respectively, for a total noise impact range of 140 m. In addition, the ranges to the front and rear were 80 m, respectively, for a total noise impact range of 160 m. Investigating the planar noise impact range of the Interpolated Noise Hemisphere revealed a total noise impact range of 200 m, at 100 m from the left and right. In addition, the total range of influence was 180 m, approximately 90 m from the front and rear. The results of the noise impact assessment using a single and multi-noise source can be seen in Figure 3.

In the Integrated Noise Hemisphere, S1 showed a shape, noise level, and range similar to that of a single noise source. The predicted noise level of S2 is 65 dB to 70 dB, a reduction of 10 dB within the same range, and the total impact range increases by 1.5 times to 200 m. The noise level predicted for S3 is 60 dB to 65 dB, a reduction of 5 dB, and the impact range is 300 m. From S4 onward, all noise sources were expected to be the same, with noise levels of 55 dB to 60 dB, and the impact range being 400 m.



(a) Integrated (b) Compensated (c) Interpolated

Figure 3. Noise impact assessment results

In the Compensated Noise Hemisphere, S1 was found to have a shape in which the noise level is concentrated in the front, unlike a single noise source. The noise impact range is approximately 160 m, and the noise level is predicted to be 70 dB to 75 dB. S2 is predicted to have a noise impact range of 200 m, and the noise level is predicted to be 60 dB to 65 dB, a reduction of 5 dB. S3 is predicted to have a noise impact range of 400 m, and the noise level is predicted to be 55 dB to 60 dB. Subsequently, it was confirmed that the noise sources were similar in noise level and influence range, and that the noise level partially exceeded 50 dB to 55 dB at certain points along the flight path.

In the Interpolated Noise Hemisphere, S1 showed noise levels and influence ranges similar to those of a single noise source. The noise level of S2 is 65 dB to 70 dB, and the noise impact range is predicted to be approximately 400 m. The noise level of S3 is 60 dB to 65 dB, and the noise impact range is predicted to be approximately 500 m. From S4 onward, the noise level was mainly predicted to be 55 dB to 60 dB, but it was also predicted to be 65 dB at some positions along the flight path. The noise impact range was predicted to be approximately 600 m.

4. CONCLUSIONS

Examining the three noise hemisphere influence ranges of UAM, noise propagation from a single noise source was expected to occur within a horizontal radius of approximately 60 m to 100 m, and within a vertical radius of approximately 10 m to 50 m. With multiple noise sources, the propagation range varied depending on the flight altitude. At the maximum altitude of 300 m, noise propagation was expected to occur within a horizontal radius of approximately 400 m to 600 m. Through this, the noise impact range can be predicted for an actual UAM flight path.

The noise measured by OPPAV was higher in the high-frequency band than in the low-frequency band. This is an electric signal generated by an electric motor and can have a strong effect at short distances. Therefore, due to the nature of UAM operations in urban areas, the subjective noise level perceived by occupants of nearby buildings may be higher than the expected noise level. Therefore, appropriate noise evaluation factors should be discussed for UAM noise evaluation.

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