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ON-FIELD MEASUREMENTS FOLLOWING THE EASA GUIDELINES ON NOISE MEASUREMENTS OF UNMANNED AIRCRAFT SYSTEMS LIGHTER THAT 600 KG

P. Miguel-Ayala[1*] **L. Estévez-Mauriz**[2] **C. Romero-Romero**[3]
A. J. Torija[3]

[1] Escuela de Ingenierías Industrial, Informática y Aeroespacial, Universidad de León, León, Spain
[2] Grupo de Investigación Ambiente Atmosférico (ATMOSENV), Área de Física Aplicada, Universidad de León, León, Spain
[3] Acoustics Research Centre, University of Salford, Salford, Greater Manchester, UK

ABSTRACT

Unmanned Aircraft Systems (UAS) have gained increasing attention, leading to the development of noise measurement protocols, such as the 2023 guidelines from the European Union Aviation Safety Agency (EASA). These guidelines focus on noise measurement procedures for UAS (lighter that 600 kg), outlining measurements and operational requirements. A key requirement is that the difference between the UAS sound pressure level and the background sound level must be at least 15 dBA. This study presents acoustic analysis results from three UAS (weighing under 600 kg) at three different heights, following EASA's guidelines. The study site was chosen with a background noise level of around 48 dBA. Results showed that only the largest UAS (7,3 kg) met the 15 dBA difference at all heights, while the smallest UAS (0,25 kg) did not meet this threshold at any height. Given that low background noise (below 45 dBA) is crucial to fulfilling the guidelines, the study concludes that it is challenging to apply these standards to small UAS. The study discusses whether the EASA guidelines require amendment for small size UAS.

****Corresponding author***: *pmigua01@estudiantes.unileon.es.*

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1. INTRODUCTION

The use of Unmanned Aircraft Systems (UAS), has grown exponentially in recent years, expanding to a wide range uses such as mapping, surveillance, package delivery, and infrastructure inspection. However, this rapid expansion raises concerns regarding environmental impact and noise pollution, particularly in urban settings. It is worth noting that awareness of urban environmental quality is increasingly pronounced. A clear example of this is the European Green Deal [1] and the Sustainable Development Goals [2], which currently lead the vision for sustainability in the built environment. According to the European Green Deal [1], one of the main concerns is the negative impact of noise, primarily expressed through the annoyance caused by road traffic noise. Europe, along with other parts of the world, is facing a chronic issue in this regard, with estimates indicating that traffic-related noise (including road, rail, and air traffic) in Western Europe leads to the loss of at least one million healthy life years annually, with road traffic being the dominant source [1].

In order to regulate these aspects, the European Union Aviation Safety Agency (EASA) has established guidelines for drone noise measurement [3], including specific background sound level requirements for its acoustic testing [3, p. 12]. However, these regulations impose constraints that can be difficult to meet for small UAS. Specifically, the requirement for low background noise levels (differences above 15 dBA) to obtain valid measurements, may hinder the feasibility of testing in real-world environments, where acoustic conditions are rarely ideal.

This paper, based on an experimental study of UAS sound levels, examines the methodology and the plausible limitations of current EASA criteria, raising awareness about the need to revise certain parameters to better align the regulations with the operational reality of certain UAS. By evaluating different models and measurement conditions, this study aims to provide a technical basis for optimizing regulatory procedures and ensuring a more realistic assessment of the acoustic impact of these aircraft.

2. EXPERIMENTAL STUDY'S DESCRIPTION

The main objective of the study is to carry out measurements on different UAS models according to EASA criteria and compare the sound pressure levels of the three UAS. This aimed to analyze noise differences based on UAS weight, proposing certain adjustments.

The experimental study consisted in the measurement of three different UAS, at three different heights. A location and date had to be selected that met specific requirements regarding pavement characteristics, wind speed, temperature, and humidity for the measurements to be carried out, according to regulations. Additionally, the recommendations specify the type of instrumentation to be used for the measurements, how they should be calibrated, and the setup. Finally, the guideline considers two study cases: level flight and overflight. Each of these must meet specific conditions regarding distances and areas of operation.

Specific information about how the experimental study was conducted are specified in sections 2.1, 2.2, 3 and 4

2.1 Flight

The first thing to select was the type of flight that was going to be measured. Due to its relevance and proximity with real situations, the chosen flight was a hover one.

For a hover flight the guidelines has some particular requirements [3, pp. 11-16]. In order to meet them, the three UAS were flown at three heights that were 12, 17 and 25 meters over the measurement point. Selecting these altitudes responds to the fact that 12 m is the minimum height allowed for measurements; 25 m is the reference height required by the regulations; and 17 m, was chosen as a relevant height to study scenarios where UAS fly at relatively low altitudes near people to assess their impact. The rest of the requirements such as the instrumentation and mounting, the operability limits and the measurements' number and duration were also followed precisely.

2.2 Place and date

To meet these requirements, the chosen location was a tennis court in the village of Ruiforco de Torío, in the province of León, Spain. This place was chosen for several reasons, including the fact that it was out of the airspace of Leon's airport. The surface of the tennis court was one of the one suggested in the guidelines [3, p. 10]. Finally, this space is located far from roads and urban areas, which minimizes background noise, however, sounds coming from nature were present (rustling leaves, stream). The days in which this study was conducted were the 29 May 2024 and 11 June 2024, both between 11:00 and 13:30. This dates fulfilled the guidelines recommendations of wind speed, temperature and humidity [3, pp. 8-9].

2.3 UAS

For this experimental study, the UAS used were provided by the Cartography Service from Universidad de León. The characteristics of each UAS is presented here, ordered from the smallest to the biggest:

- **DJI Mavic 4:**
  - Mass: 249 g.
  - Maximum autonomy: 34 minutes.
  - Diagonal size with propellers: ± 213 mm.
  - Maximum horizontal speed: 16 m/s
- **DJI Phantom 4 Pro Plus:**
  - Mass: 1375 g.
  - Maximum autonomy: 30 minutes.
  - Diagonal size with propellers: ± 490 mm.
  - Maximum horizontal speed: 20 m/s

- **DJI Matrice 300 RTK (sensor LIDAR Zenmuse L1):**
  - Mass: 7270 g.
  - Maximum autonomy: 55 minutes.
  - Diagonal size with propellers: ± 1150 mm.
  - Maximum horizontal speed: 23 m/s

3. INSTRUMENTATION AND SOFTWARE

The EASA guidelines also specifies the instrumentation needed to carry out the measurements properly [3, pp. 27-28]. The instruments used in the study were:

- *"Microphone CCLD Free-field 1/2 inch" type 4966-H-041"* by *"Brüel & Kjær"*. It was not necessary to calibrate it as it was brand new. The microphone fulfilled the guidelines. According to the EASA's guidelines, the microphone must be placed face down, over a plaque 7 mm above the ground, and it must be protected by a mesh [3, p. 28].
- Acoustic measurement system *"SQuadriga III"* by *"HEAD Acoustics"*. The only requirement from the EASA guidelines is to have a system that can store data.

For data extraction and analysis, the software *"ArtemiS SUITE"* version 15.7 by *"HEAD Acoustics"* was used. This software fulfills the regulatory requirements for data acquisition and analysis (such as slow analysis, the ability to extract "L_{Aeq}" and "L_{Amax}", A-weighted, etc.).

4. RECORDINGS

4.1 UAS noise recordings

As it is stated in subsection 2.1, the UAS had to fly within certain operability limits and during a certain time. Following the EASA's guidelines [3, p. 12], the UAS must remain within a 8° cone from the vertical above the noise measurement point during 30 seconds of noise recording. A minimum of six runs must be performed and the L_{Aeq} must result from the A-weighted sound level averaged over the 30 seconds.

In order to fulfill these recommendations the first step was to mark the ground with adhesive tape to indicate the action cone radius that the UAS should not exceed at each height. For the three chosen heights 12 m, 17 m, and 25 m, the corresponding action radius are 1.7 m, 2.4 m, and 3.5 m, respectively. The UAS were equipped with a camera system to trace the correct radio action. The dimensions of the action cone are shown in Fig. 1.

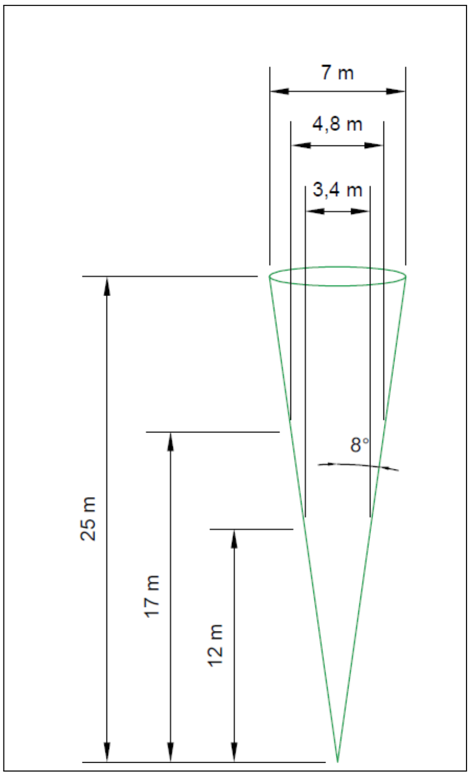

Figure 1. Operability limits for UAS' noise measurement. Adapted from [3, p. 15]

4.2 Background sound levels

To analyze the background noise, measurements were taken in complete silence, without any UAS operating, both before and after recording data for each UAS. The goal is to verify that the background noise remained stable throughout the measurements and, using these values, assess whether the 15 dBA difference between the equivalent background noise level (A-weighted) and the maximum noise level (A-weighetd) produced by the UAS.

The average sound level (L_{Aeq}), the 90th percentile ($L90$) and the maximum sound level (L_{Amax}) are chosen as representative of the background noise level. To compare the UAS' noise values with the background's sound pressure level, the L_{Aeq} of the background noise must be taken by averaging the values before and after the measurement.

5. RESULTS

The measurements were processed using the *"ArtemiS SUITE"* software, version 15.7 by *"Head Acoustics"*, performing an analysis following the recommendations. According to the EASA's guidelines, for a hovering flight, the following data must be reported [3, p. 40]:

- The date on which the measurement was performed.
- The altitude at which the measurement was conducted.
- The equivalent sound pressure level, "L_{Aeq}".
- The maximum sound pressure level, "L_{Amax}".
- The background noise level, "L_{Aeq}".
- The 90th percentile, "L_{90}". That is, the sound pressure level above which the specified percentage of data is found, in this case, 90

The Tab. 1 contains the sound pressure level of the background noise for each UA test. The average values of L_{Aeq}, L_{Amax}, and L_{90} are shown for each test. The maximum sound pressure level recorded was 50.4 dBA whereas the three L_{Aeq} are around 48 dBA.

Table 1. Comparison of the background noise L_{Aeq}, L_{Amax}, and L_{90} for the three UAS.

	$\mathbf{L_{Aeq}}$	$\mathbf{L_{Amax}}$	$\mathbf{L_{90}}$
DJI Mavic 4	48.2	49.6	47.7
DJI Phantom 4 Pro Plus	47.7	49.2	47.3
DJI Matrice 300 RTK	48.0	50.4	47.4

5.1 UAS' sound level

In the same way as for background noise, sound pressure level data was collected for each UAS at the three heights (12, 17, and 25 m). The following figures Fig. 2, Fig. 3 and Fig. 4 show the results for the three UA at 17 meters, as this height best illustrates which UAS seemed more likely to meet the 15 dBA difference requirement with the background noise. Nevertheless, all collected values are included in the Tab. 2.

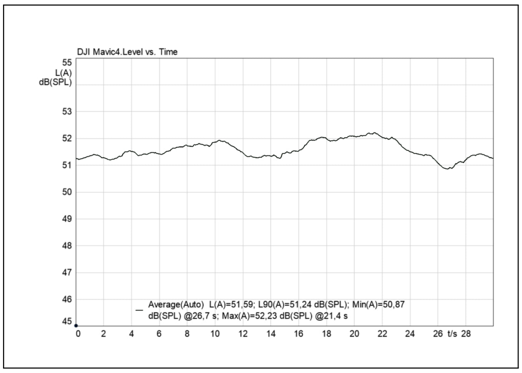

Figure 2. DJI Mavic 4 measurement at 17 m. Level Vs. time.

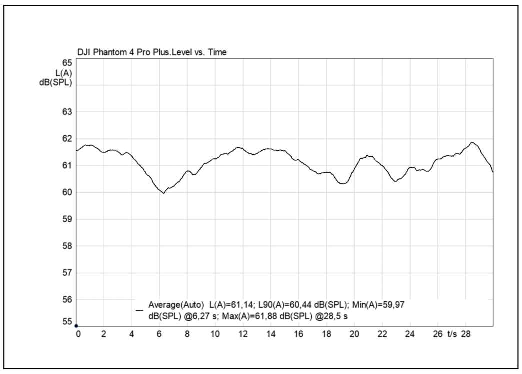

Figure 3. DJI Phantom 4 Pro Plus measurement at 17 m. Level Vs. time.

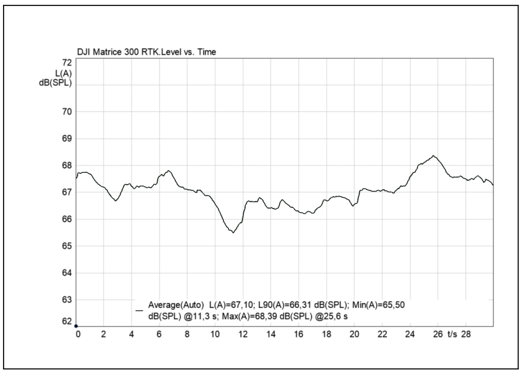

Figure 4. DJI Matrice 300 RTK measurement at 17 m. Level Vs. time.

In order to see the frequency content of the three UAS, the octave band spectrum (A-weighted) measured for the hover procedure at 12 m (top), 17 m (middle) and 25 m (bottom) height is shown in Fig. 5.

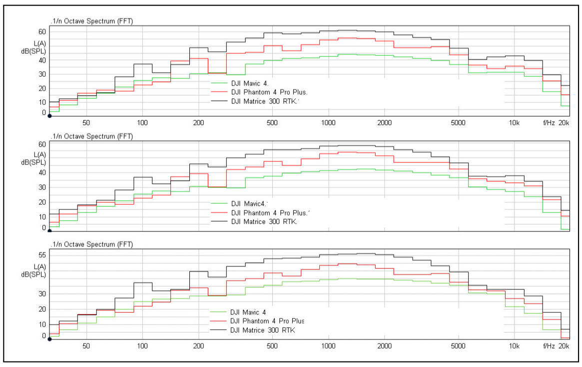

Figure 5. Octave band spectrum (A-weighted) for the three UAS at 12 m (top), 17 m (middle) and 25 m (bottom).

Since the regulations require the L_{Amax}, Tab. 2 shows the L_{Aeq}, L_{Amax} and L_{90} values for each UAS at each of the three different heights, having values between 50.6 and 71.0 dB (L_{Amax}).

Table 2. L_{Aeq}, L_{Amax} y L_{90} values for the three UAS

		12 m	17 m	25 m
DJI Mavic 4	L_{Aeq}	52.5	51.6	49.5
	L_{Amax}	53.7	52.2	50.6
	L_{90}	52.4	51.2	49.0
DJI Phantom 4 Pro Plus	L_{Aeq}	62.9	61.1	56.8
	L_{Amax}	63.8	61.9	57.8
	L_{90}	62.3	60.4	56.3
DJI Matrice 300 RTK	L_{Aeq}	69.9	67.1	64.8
	L_{Amax}	71.0	68.4	65.8
	L_{90}	69.1	66.3	64.1

Comparing Tab. 1 and Tab. 2, it can be observed that the 15 dBA difference with the background noise was not fulfilled in all cases (see Fig. 6). DJI Matrice 300 RTK, the largest of the three UAS, weighing 7270 g, is the only one that meets the 15 dBA difference requirement at all three heights (the differences for each height are: 23 dBA, 20.4 dBA, and 17.8 dBA, respectively). Therefore, this study complies with the recommendations. On the other hand, DJI Phantom 4 Pro Plus, the medium-sized UAS, weighting 1375 g, meets the 15 dBA difference at 12 m, though only marginally (16.1 dBA). At 17 m, it does not meet the requirement, despite being very close (14.2 dBA). However, at 25 m, it falls significantly short of the required difference (10.1 dBA). Finally, for the smallest UAS, the DJI Mavic 4, weighting only 249 g, the 15 dBA difference with the background noise is not met at any of the three heights (5.5 dBA, 4 dBA, and 2.4 dBA, respectively).

In Fig. 6, the difference between maximum noise level from the three UAS and the equivalent background noise for the three heights is shown.

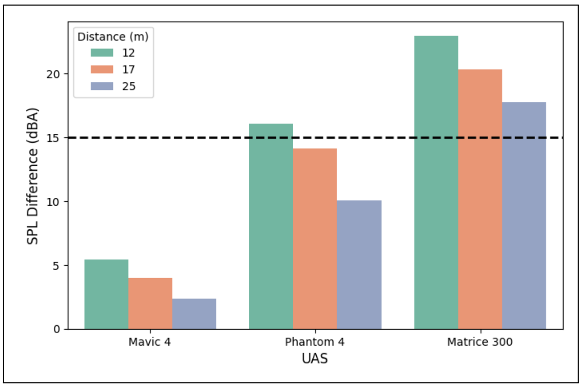

Figure 6. Difference between maximum noise level (L_{Amax}) from UAS and equivalent background noise level (L_{Aeq}). The level difference must be greater than 15 dBA to consider the run as a valid one.

6. DISCUSSION

As it is said in section 5.1 for UAS weighing less than 1.4 kg, it is very difficult to exceed the required 15 dBA difference from the background noise, even when measurements are conducted in a location outside urban areas.

For these reasons, based on this study, it is suggested EASA's recommendations to be revised. The proposed changes include adjusting the difference between maximum level from the UAS and background noise level, for UAS weighting and distance operation. It is suggested EASA's guidelines to study these limitations so it allows UAS below the black line on the Fig. 6 that have not exceed the 15 dBA difference with background noise reduce the threshold. To establish more precise limitations, additional tests should be conducted with UAS of different sizes and across a wider range of altitudes and situations. However, with the collected data, a multiple linear regression can be established with the independent variables mass (X1) and height (X2), and the dependent variables considered as the difference between background noise level and UA maximum noise level (dBA):

$$y = 13,43747 + 0,001958X1 - 0,364728X2 \quad (1)$$

According to this, when mass increases, the difference in noise level is higher; and when height increases the difference in noise level is lower.

In order to fulfill the 15 dBA difference required, according to the regression with the collected data, a certain mass and height must me accomplished, shown in the Tab. 3:

Table 3. Mass and height requirements to fulfill the 15 dBA difference

Mass (g)	Height (m)
≤3100	12
3650	15
4000	17
5500	25

From this regression, mass below 3100 g requires less noise level difference at different heights. In Tab. 4 an example of plausible values with flights at 12 m height are presented. The same can be done for other height values, however, the intention in the present work is to highlight the variances and plausible adaptations.

Table 4. Minimum difference level for certain UA mass flying at 12 m height

Mass (g)	Difference level (dBA)
250	9
250 - 750	10
750 - 1250	11
1250 - 1750	12
1750 - 2300	13
2300 - 2800	14
2800 - 3100	14,5

Fig. 7 shows the limitations for the UAS Mavic 4 and Phantom 4 Pro Plus according to the values from Tab. 4. UAS Matrice 300 RTK is not included as it weights more than 3100 g.

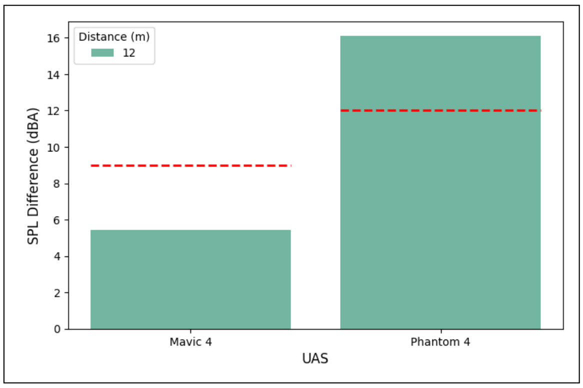

Figure 7. Difference between maximum noise level (L_{Amax}) from UAS and equivalent background noise level (L_{Aeq}) for UAS Mavic 4 and Phantom 4 Pro Plus at 12 m. The red line shows the limitations for each UAS according to Tab. 4

As it is highlighted, to establish more precise limitations, additional tests are needed, however, this work establishes a first relation between UA mass, test height, and required difference level between the background noise level (L_{Aeq}) and the UA maximum noise level (L_{Amax}).

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8. REFERENCES

[1] European Comission, *Communication from The Comission to the European Parliament, the Council, the European Economic and Social Committee and*

the Committee of the Regions. Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil' COM/2021/400 final, 2021.

[2] United Nations, *The Sustainable Developlment Goals Report 2024*, 2024.

[3] European Union Aviation Safety Agency, *Guidelines on Noise Measurement of Unmanned Aircraft Systems Lighter than 600 kg Operating in the Specific Category (Low and Medium Risk)*, 2023.