UAS-NOISECHECK – RESULTS AND RECOMMENDATIONS FOR EASA DRONE NOISE MEASUREMENTS

Martin Blass[1], Stefan Grebien[1], Franz Graf[1], Markus Hofstätter[2], Christoph Sulzbachner[2]

[1] *JOANNEUM RESEARCH Forschungsges.m.b.H., Graz, Austria*
[2] *AIT Austrian Institute of Technology GmbH, Vienna, Austria*

Abstract

The increasing deployment of unmanned aerial systems (UAS) raises important questions regarding environmental noise impact and public acceptance. To support regulatory development, the *European Union Aviation Safety Agency* (EASA) has proposed guidelines for standardized drone noise measurements; however, practical experience with their implementation remains limited. Within the *UAS-NoiseCheck* project, comprehensive measurement campaigns were conducted on eight multicopter drones. The sensor setup combines acoustic, visual, GNSS, and meteorological components to enable multisensory data acquisition. Reference microphones in both ground-based and inverted configurations, together with a hemispherical 32-microphone array, enable the determination of standardized noise metrics as well as spatially resolved acoustic analysis. By assessing array localization performance and steered sound pressure levels, practical aspects of drone noise certification and regulation are investigated. Improved RTK-based GNSS and electro-optical camera systems provide a precise reference for positioning and target detection. The results confirm the general applicability of the EASA methodology while revealing practical challenges related to environmental sensitivity, flight path repeatability, positioning accuracy, and complex directivity patterns. Based on these findings, recommendations are derived to improve measurement procedures, array integration, and data evaluation. The presented work supports the refinement of standardized drone noise assessment and provides experimentally grounded guidance for future regulatory frameworks.

Keywords: *drone, noise, measurement, sound pressure level, sound emission, microphone array*

Corresponding author: *martin.blass@joanneum.at.*

1. Introduction

Unmanned aerial systems (UAS) produce distinctive acoustic signatures that are often characterized by tonal components, blade-passing harmonics and broadband high-frequency noise. Christian and Cabell [1] and Torija and Clark [2] showed that these characteristics, combined with low-altitude flight and hovering close to populated areas, can cause greater perceived annoyance than conventional transportation sources at comparable sound levels. As civil UAS operations continue to increase, reliable assessment of their noise emissions is therefore becoming increasingly important for public acceptance, operational planning and future regulation.

In response to this development, the *European Union Aviation Safety Agency* (EASA) published guidelines in 2022 for measuring the noise of UAS lighter than 600 kg operating in the *specific* category [3]. The guidelines define standardized level-flight and hover procedures for determining the A-weighted sound exposure level (L_{AE}) and the A-weighted equivalent continuous sound pressure level (L_{Aeq}), respectively. They bridge the gap between established aircraft and machinery noise standards, e.g. ISO 3744:2010 and ICAO Annex 16, and the particular operational and acoustic characteristics of modern UAS discussed by Malaval [4]. However, as indicated by the field study of Miguel-Ayala et al. [5], their practical implementation still requires evaluation with regard to repeatability, measurement uncertainty and operational feasibility.

Outdoor measurements are essential because UAS noise is influenced by changing source–receiver geometry, ground reflections, meteorological conditions and flight-control dynamics. Greenwood and Konzel [6] investigated sound pressure level (SPL) variability using ground-plane and elevated microphones, while Ramos-Romero et al. [7] applied multiple measurement positions and propagation corrections. Nash and Kennedy [8] further examined sound pressure, sound power, spectral content and source directivity. Recent reviews by Raza and Stansbury [9] and Rinaldi et al.

[10] emphasize the need for integrated approaches that combine standardized acoustic measurements with information about the aircraft trajectory, operating state and environmental conditions. Such information is also relevant because conventional level-based indicators alone may not fully represent human responses to drone noise. The works of [1], [2], [11] therefore highlight the relevance of psychoacoustic properties such as loudness, sharpness, tonality and roughness.

Microphone arrays offer a promising extension to conventional single-microphone measurements. Snellen et al. [12] noted that direction-of-arrival estimation (DOAE) and beamforming (BF) can be used to localize and track an aircraft, spatially separate its acoustic contribution from competing sources and potentially improve the signal-to-noise ratio (SNR). In previous work, Blass et al. [13] presented the *JR-IcoDome32*, a hemispherical 32-microphone array developed for acoustic UAS tracking, and evaluated its performance in stationary and mobile configurations.

In this paper we present the final evaluation results of *UAS-NoiseCheck*, a research project and equally named measurement system developed to implement the EASA procedures and investigate the added value of microphone-array-based analysis. The system combines conventional sound-level measurements and a microphone array with optical tracking, global navigation satellite system (GNSS) reference data and meteorological sensing. Based on several field campaigns, EASA-compliant reference levels obtained with an inverted ground-plate microphone are compared with levels measured by a flush-mounted ground microphone, the central array reference microphone and delay-and-sum beamforming (DSB) signals extracted along acoustically estimated UAS trajectories obtained from a DOAE and sound source tracking algorithm. The objective is to assess the consistency and limitations of these measurement approaches, evaluate the potential of combining standardized noise measurements with automatic acoustic UAS tracking, and provide practical feedback and recommendations for the further refinement and application of the EASA measurement guidelines.

2. Measurement Method

The measurements followed the EASA guidelines for unmanned aircraft systems (UAS) lighter than 600 kg operating in the specific category [3]. The guidelines define separate procedures for level-flight and hover conditions:

1. For level flights, the primary noise metric is the A-weighted sound exposure level, L_{AE}, determined over the acoustic event using a 10 dB-down interval relative to the maximum slow-time-weighted A-weighted SPL, $L_{AS,max}$.

2. For hover measurements, the A-weighted equivalent continuous SPL, L_{Aeq}, is evaluated over a stabilized period of 30 s.

During level-flight tests, the UAS passes the measurement point at its reference ground speed and at an altitude between 17 and 150 m, while remaining within a lateral deviation of ±10° from the vertical above the receiver. For hover measurements, the UAS maintains a stabilized position for 30 s at an altitude between 12 and 50 m within an 8° cone. At least six valid runs are required for each procedure. Flight position, speed and meteorological conditions are recorded to verify compliance with the EASA validity criteria and to calculate the required corrections. Further details on the test procedures, validity limits and level adjustments are provided in [14].

The reference receiver consists of an *NTi Audio XL2* Class 1 sound level meter (SLM) and a 1/2″ microphone of type *Z-TECH 333-507* installed approximately 7 mm above a reflecting ground plate in the inverted configuration (INV). An additional flush-mounted ground microphone (GND), a *GRAS 47AX*, was used to compare both receiver arrangements. All microphones and the SLM were calibrated with a 1 kHz signal at 94 dB before the measurements. Background noise and meteorological parameters, including temperature, relative humidity, wind speed and wind direction, were monitored throughout each campaign.

The *UAS-NoiseCheck* system combines SPL receivers with a hemispherical *JR-IcoDome32* microphone array (ARR), optical cameras, GNSS and meteorological sensors. The array comprises 32 microphones and is connected through *MOTU AVB* audio interfaces. Two *FLIR Blackfly* cameras, a *Holybro H-RTK F9P* GNSS receiver mounted on the UAS and a *DAVIS Vantage Pro 2* weather station provide complementary position and environmental data. All sensor streams are synchronized via an NTP server and transferred to a central processing unit (CORE). Audio signals are recorded at 48 kHz and 24-bit resolution, while the SLM logs L_{AF} and L_{AS} at 5 Hz.

Figure 1: Measurement setup: INV and GND microphones for SPL calculation (top left), CAM for visual detection in case (top right), full sensor setup with ARR, SPL, CAM and METEO (bottom left), and level-flight of *DJI FlyCart 30* with payload for MTOM (bottom right).

In addition to the EASA noise metrics, the microphone array is used for DOAE, source tracking and beamforming. The algorithm relies on the BF steered response power and adopts a Gaussian Mixture Model (GMM) based approach for the use in 3D with custom frequency and sampling grid settings to enable probabilistic modeling and tracking of an unknown number of sources and signal extraction using masked DSB. This enables the spatially extracted UAS signals to be compared with the reference microphone measurements [14].
The resulting *UAS-NoiseCheck* real-time system provides a consolidated graphical user interface (GUI) for monitoring acoustic, positional, meteorological, and classification data during UAS measurements. Figure 2 shows the GUI during a level-flight with labels for functional blocks. DOAE from the microphone array are visualized in a compass view (1) for three most prominent sound sources, where segment orientation and radius indicate azimuth and elevation, while opacity and width represent source weight and angular uncertainty as standard deviation. In parallel, the system displays the current A-weighted sound pressure level L_{AF} (2), GNSS-based distance, altitude (3), and position reference (4), as well as meteorological parameters such as temperature, relative humidity, wind speed and direction (6). The GUI further combines UAS sound confidence estimates (5) from the beamforming sources and microphone signal into a consolidated dominant-source output, shown by a gray confidence bar and compass needle (4). Additional functions include buttons (orange frames) for activating background noise monitoring and toggling GNSS-based geometric criteria for level and hover flights, such as lateral deviation and cone (1).

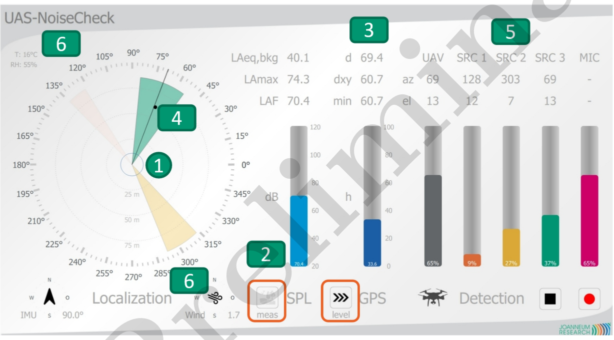

Figure 2: Interactive GUI of the *UAS-NoiseCheck* real-time system combining SPL, GNSS and weather measurements with acoustic detection and localization.

3. Project Results

This section summarizes the results obtained during the *UAS-NoiseCheck* measurement campaigns. The evaluation covers the acquired measurement data, the adjusted SPL metrics according to the EASA measurement procedures, differences between the acoustic sensor signals, and the sound source tracking performance of the microphone array.

3.1. Measurement Data

Throughout the project, eight different UAS were investigated during four measurement campaigns conducted between November 2024 and March 2026. The test objects ranged from compact quadcopters with a maximum take-off mass (MTOM) below 2 kg to large multicopters and an electric vertical take-off and landing (eVTOL) aircraft. In total, approximately 5.5 h of audio data from valid level-flight and hover runs were retained for the final evaluation. Runs were rejected when prescribed flight-paths, meteorological, background-noise, or EASA correction criteria were not fulfilled. Figure 3 and Table 1 show the used UAS models and the respective number of valid/recorded flights within the conducted measurement campaigns.

Figure 3: UAS used in the measurement campaigns:
(a) *DJI Matrice 4T*, (b) *DJI Matrice 300*,
(c) *DJI FlyCart 30*, (d) *APELEON SCALAR*,
(e) *twinFOLD SCI*, (f) *twinFOLD GEO*,
(g) *twinFOLD KAT*, (h) *ViewCopter V6H*.

Table 1: Measurement campaigns and number of valid level and hover runs. The UAS identifiers refer to Figure 3.

Campaign	Level	Hover	UAS
UMFC Stocking	51/52	26/26	(e), (f), (g), (h)
LOGG Punitz 1	85/90	32/40	(b), (c), (f), (g), (h)
LOGG Punitz 2	11/48	0/24	(b), (g)
MFC Siegendorf	26/30	12/14	(a), (d)

3.2. Sound Level Metrics

The adjusted acoustic metrics were calculated with the EASA spreadsheets using the measured noise levels together with the flight-path and atmospheric correction data. For level flights, the reported metric is the averaged reference A-weighted sound exposure level $L_{\mathrm{AE,ref,av}}$, whereas for hovering, it is the averaged reference A-weighted equivalent continuous sound pressure level $L_{\mathrm{Aeq,ref,av}}$. The values below are reported as arithmetic mean with standard deviation (STD). Tables 2–5 present the noise metrics for each campaign and Table 6 the combined results over all valid runs.

Table 2: UAS noise metrics measured at UMFC Stocking.

UAS	$L_{\mathrm{AE,ref,av}}$ (dB)	$L_{\mathrm{Aeq,ref,av}}$ (dB)
twinFOLD SCI	66.3 ± 0.39	50.8 ± 1.32
twinFOLD GEO	77.3 ± 0.48	57.6 ± 1.53
twinFOLD KAT	74.4 ± 0.67	66.4 ± 1.09
ViewCopter V6H	77.6 ± 0.81	77.1 ± 1.62

Table 3: UAS noise metrics measured at LOGG Punitz 1.

UAS	$L_{\mathrm{AE,ref,av}}$ (dB)	$L_{\mathrm{Aeq,ref,av}}$ (dB)
DJI Matrice 300	72.4 ± 1.44	63.4 ± 1.65
DJI FlyCart 30	78.2 ± 1.40	67.0 ± 1.90
twinFOLD GEO	74.2 ± 3.15	65.5 ± 1.16
twinFOLD KAT	N/A	N/A
ViewCopter V6H	76.5 ± 2.46	N/A

Table 4: UAS noise metrics measured at LOGG Punitz 2.

UAS	$L_{\mathrm{AE,ref,av}}$ (dB)	$L_{\mathrm{Aeq,ref,av}}$ (dB)
DJI Matrice 300	73.4 ± 2.28	N/A
twinFOLD KAT	N/A	N/A

Table 5: UAS noise metrics measured at MFC Siegendorf.

UAS	$L_{\mathrm{AE,ref,av}}$ (dB)	$L_{\mathrm{Aeq,ref,av}}$ (dB)
DJI Matrice 4T	64.3 ± 2.74	53.9 ± 1.10
APELEON SCALAR	99.4 ± 1.46	84.4 ± 0.79

Table 6: Combined UAS noise metrics from all measurement campaigns as mean ± standard deviation.

UAS	$L_{\mathrm{AE,ref,av}}$ (dB)	$L_{\mathrm{Aeq,ref,av}}$ (dB)
DJI Matrice 4T	64.3 ± 2.74	53.9 ± 1.10
DJI Matrice 300	72.8 ± 1.92	63.4 ± 1.65
DJI FlyCart 30	78.2 ± 1.40	67.0 ± 1.90
twinFOLD SCI	66.3 ± 0.39	50.8 ± 1.32
twinFOLD GEO	76.0 ± 2.69	N/A
twinFOLD KAT	75.6 ± 3.51	66.4 ± 1.09
APELEON SCALAR	99.4 ± 1.46	84.4 ± 0.79
ViewCopter V6H	77.3 ± 0.90	75.3 ± 2.84

3.3. Sound Level Differences

The sound level differences between the individual acoustic signal paths were evaluated with respect to the inverted reference microphone (INV). For each run, equivalent SPL values were calculated for the ground microphone (GND), the center microphone of the array (ARR), and the extracted delay-and-sum beamformer output signal (DSB).

Table 7: Overall SPL differences with respect to INV for level-flight, hover, and total evaluations as mean ± STD. Positive differences indicate a higher SPL than INV.

Scenario	**GND** (dB)	**ARR** (dB)	**DSB** (dB)
Level	0.59 ± 2.87	-0.37 ± 2.44	-3.29 ± 3.16
Hover	0.25 ± 1.64	-0.34 ± 3.62	-5.55 ± 3.48
Total	0.46 ± 2.48	-0.36 ± 2.95	-4.15 ± 3.46

Across the complete dataset, GND showed the closest agreement with INV, with a mean difference of 0.46 ± 2.48 dB. The result supports the suitability of both the inverted and flush ground-microphone arrangements for measuring UAS noise metrics. ARR also agreed with INV on average, with a difference of -0.36 ± 2.95 dB, although its larger variation reflects the different sensor position and the stronger influence of local propagation and ground-reflection effects.

In contrast, the DSB output showed a systematic level reduction of approx. 4 dB over the total dataset. The reduction was smaller for level flights (3.3 dB), and increased during hover (5.6 dB). For the latter, this difference is explained by the array center being positioned approximately 2–3 m from INV, while INV was located directly below the hover point. Additional differences arise from the array response, spatial filtering of incoherent sound, ground reflections and possible tracking errors. Consequently, DSB provides a useful source-focused signal for detection and analysis, but absolute SPL estimation requires compensation of the array response and robust source tracking.

3.4. Sound Source Tracking

The DOAE performance was evaluated by comparing the array-derived UAS direction with the reference direction obtained from the RTK-GNSS position. For each analysis frame, the source hypothesis closest to the reference direction was selected and the absolute angular error was calculated. The results are summarized in Table 8 using the mean absolute error (MAE) and standard deviation (STD), median absolute deviation (MAD) and interquartile range (IQR).

Table 8: DOAE error statistics for level-flight, hover, and total evaluations as mean ± STD and median with IQR.

Scenario	**MAE ± STD** (°)	**MAD** (°)	**IQR** (°)
Level	6.44 ± 11.20	3.92	[2.27, 6.10]
Hover	4.07 ± 4.36	3.23	[1.97, 4.43]
Total	5.45 ± 9.18	3.49	[2.12, 5.42]

The level-flight results quantify the ability of the array to follow a moving UAS. Larger errors can occur at greater distances, during rapid angular motion near the overhead position, or when competing sources and wind noise affect the estimated track. The hover results represent a less dynamic geometry and therefore show a narrower error distribution. The total values summarize the localization performance over all evaluated measurements.

4. Discussion and Recommendations

Practical Applicability of EASA Procedures

The project confirmed that the EASA procedures can be implemented in practical field campaigns and provide reproducible UAS noise metrics under suitable operational and meteorological conditions. However, usable recordings do not necessarily lead to reportable results, as validity must also be confirmed after calculation of the adjustment terms.

The comparison between campaigns demonstrates the sensitivity of the adjusted reference metrics. For the *twinFOLD GEO*, the level-flight value was 77.3 ± 0.48 dB at UMFC Stocking and 74.2 ± 3.15 dB during the LOGG Punitz 1 campaign. The higher variability at Punitz indicates poorer repeatability caused by differences in wind, ground speed, lateral deviation, altitude, and the resulting corrections. Campaign-specific results should therefore be reported in addition to combined values.

Several datasets were rejected despite initially valid recordings. The *twinFOLD KAT* level flights from the Punitz 1 campaign fulfilled the direct flight and atmospheric criteria, but the calculated adjustment values exceeded the permissible range. No valid adjusted values were obtained for the same UAS during the second Punitz campaign, and individual hover datasets also failed the statistical validity criteria. These cases show that additional reserve runs and preliminary on-site evaluation of the correction terms are essential.

The selected reference ground speed v_{Gref} should be defined before the campaign based on the actual aircraft configuration and operating mode. This is particularly important for aircraft with multiple flight modes. The reported *APELEON SCALAR* values describe only copter-mode operation at 5 m/s and cannot be transferred to its wing-borne cruise condition at 41 m/s. More generally, the measured noise level cannot be inferred from aircraft size alone, as rotor configuration, payload, operating point, flight speed, and control behavior also influence the acoustic emission.

Measurement Planning and Repeatability

Flight-path repeatability was identified as one of the main practical limitations. Variations in altitude, lateral offset, heading, and ground speed affect both the directly measured level and the subsequent adjustments. Automated flight plans and high-accuracy GNSS should therefore be used wherever possible. Level-flight runs should include sufficient approach distance to stabilize speed and altitude, while hover positions should be defined relative to the acoustic receiver.

Meteorological conditions, especially wind speed and direction, should be monitored continuously. Measurements close to the permissible limits should be avoided because they increase trajectory deviations, correction magnitudes, and run-to-run variability. More than the minimum six valid runs should be recorded to compensate for disturbances, excessive corrections, and invalid statistical results.

A further practical limitation is the required separation between UAS noise and background noise. This can be difficult to achieve for small UAS, which typically produce lower sound levels and may only exceed the ambient noise sufficiently during a short part of the flight. Wind, distant road traffic, aircrafts or agricultural activity can therefore invalidate otherwise suitable runs. Measurement sites should consequently be selected based on preliminary background-noise surveys. For low-noise UAS, reduced measurement distances or altitudes may improve the signal-to-background-noise ratio, provided that all geometrical requirements of the procedure remain fulfilled.

Suitability of Acoustic Sensor Configurations

The inverted microphone setup (INV) and the ground-mounted microphone (GND) showed close agreement and are both suitable for measuring UAS noise metrics when correctly calibrated. The inverted configuration remains the defined EASA reference, whereas GND provides a practical and robust alternative.

The unprocessed array microphone signal (ARR) also agreed reasonably well with INV. Remaining differences are mainly caused by the spatial separation of the sensors, local ground effects and microphone characteristics. Sensor positions should therefore be documented precisely, particularly for hover runs.

The beamforming output (DSB), however, showed a systematic level reduction of 4 dB and more than 5 dB during hover. Besides the 2–3 m offset between ARR and INV, this can be attributed to tracking errors, the direction-dependent array response, suppression of reflections and incomplete capture of the UAS radiation. Beamformed signals should therefore not be used as absolute regulatory SPL measurements without validated frequency- and direction-dependent compensation. Their primary benefit currently lies in source separation, tracking and detection.

Source Tracking and Measurement Automation

The sound source tracking results show that the dominant UAS source can generally be localized with sufficient angular accuracy for real-time tracking and visualization. The low median errors indicate robust performance during most intervals, while larger differences between median and mean errors reveal occasional outliers caused by rapid source motion, low signal-to-noise ratios, or competing sound sources.

Tracking should therefore include continuous validation based on track continuity, angular velocity, source probability, and agreement with GNSS or camera information. Unreliable or physically implausible source hypotheses should be excluded. Combined with GNSS and visual data, the array-based direction-of-arrival estimates can support automatic flyover detection, measurement-cone validation, and association of SPL values with the target UAS.

For measurement automation, the camera-based setup proved comparatively impractical and less reliable because it requires unobstructed visibility, careful calibration, and additional hardware and processing.

A well-integrated and time-synchronized RTK-GNSS connection to the UAS provides more robust and accurate trajectory information and is therefore preferable whenever direct access to the aircraft telemetry is available.

Recommendations for the EASA Guidelines
Based on our results, future EASA guidelines for UAS noise measurement should:

- distinguish between direct run validity, statistical validity, and excessive-correction rejection;
- provide additional guidance for selecting and documenting the UAS reference speed v_{Gref};
- recommend reporting measured and adjusted values, individual corrections, rejected-run reasons, and campaign-specific uncertainties;
- recommend more than the minimum number of runs and the use of high-accuracy positioning;
- discourage measurements close to meteorological validity limits, e.g. due to excessive wind;
- distinguish between multirotor, transition, and wing-borne eVTOL operating conditions;
- recognize microphone arrays as complementary tools for tracking and automated interval selection, while requiring validated spatial-response compensation for absolute SPL estimation.

Overall, the EASA procedures provide a suitable basis for standardized UAS noise measurements, but their reliability depends strongly on campaign planning, accurate trajectories, stable meteorological conditions, and transparent treatment of adjustment terms.

5. Conclusion

This study demonstrated the practical applicability of the EASA measurement guidelines across multiple UAS, locations, and operating conditions. Both inverted and ground-mounted microphone configurations provided suitable reference measurements, while the microphone array enabled simultaneous acoustic tracking and directional analysis. The results also revealed practical limitations, including sensitivity to wind, background noise, flight-path deviations, and potentially excessive correction values. Reliable synchronization and accurate GNSS positioning are therefore essential for efficient and reproducible measurements. Overall, the findings support the EASA methodology, while highlighting the need for clearer validity criteria, improved automation, and further guidance for low-noise UAS and challenging field conditions.

6. Acknowledgments

The project *UAS-NoiseCheck* received funding from the research, technology and innovation funding program *Take Off* of the *Republic of Austria, Ministry for Climate Action*. The *Austrian Research Promotion Agency (FFG)* has been authorized for the program management.

References

[1] A. W. Christian and R. Cabell, "Initial investigation into the psychoacoustic properties of small unmanned aerial system noise," in *23rd AIAA/CEAS aeroacoustics conference*, 2017.

[2] A. J. Torija and C. Clark, "A psychoacoustic approach to building knowledge about human response to noise of unmanned aerial vehicles," *International Journal of Environmental Research and Public Health*, vol. 18, no. 2, p. 682, 2021.

[3] EASA, "Guidelines on Noise Measurement of Unmanned Aircraft Systems Lighter than 600 kg Operating in the Specific Category," European Union Aviation Safety Agency, Tech. Rep., 2022.

[4] G. Malaval, "Approach to noise regulation of unmanned aviation in the european union," in *Quiet Drones*, University of Salford, 2024.

[5] P. Miguel-Ayala et al., "On-field measurements following the easa guidelines on noise measurements of unmanned aircraft systems lighter than 600 kg," in *Forum Acusticum*, 2025.

[6] E. Greenwood and N. B. Konzel, "Measurement and characterization of multirotor unmanned aerial system noise," in *INTER-NOISE and NOISE-CON Conference Proceedings*, Institute of Noise Control Engineering, vol. 264, 2022.

[7] C. Ramos-Romero et al., "On-field noise measurements and acoustic characterisation of multi-rotor small unmanned aerial systems," *Aerospace Science & Technology*, vol. 141, 2023.

[8] A. Nash and J. Kennedy, "In Flight Evaluation of UAV Noise Emission Session: Measurement Techniques -Field," in *Quiet Drones*, 2024.

[9] W. Raza and R. S. Stansbury, "Noise prediction and mitigation for uas and evtol aircraft: A survey," *Drones*, vol. 9, no. 8, p. 577, 2025.

[10] M. Rinaldi, S. Maghsoodi, and S. Primatesta, "On the assessment of drone noise for sustainable urban air mobility operations," *Engineering Proceedings*, vol. 133, no. 1, p. 43, 2026.

[11] J. Woodcock et al., "Human response to evtol drone sound: An online listening experiment exploring the effects of operational and contextual factors," *Frontiers in Acoustics*, vol. 3, p. 1 624 669, 2025.

[12] M. Snellen et al., "Research on drone and urban air mobility noise: Measurement, modelling, and human perception," in *Quiet Drones*, 2024.

[13] M. Blass et al., "Experimental Evaluation of Acoustic Drone Tracking using Mobile Microphone Arrays," in *Quiet Drones*, 2024.

[14] M. Blass, S. Grebien, and F. Graf, "UAS-NoiseCheck - Comparing EASA Drone Noise Measurements Using Ground-Based and Microphone Array Approaches," in *Quiet Drones*, 2026.