

Noise Certification for Emerging VTOL Aircraft

GAMA EPIC eVTOL Committee Interim Equivalent Procedure, Version 1

30 October 2019



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NOISE CERTIFICATION FOR EMERGING VTOL AIRCRAFT

Aircraft being developed for Urban Air Mobility (UAM) applications can take off and land vertically and may transition to wing-borne forward flight. GAMA conducted a workshop on UAM noise on October 4, 2018 and a task group was convened to address noise certification of early UAM VTOL designs under Part 36 of FAA Rules. This document is a product of that task group and represents consensus of those participating.

Electric vertical takeoff and landing aircraft (eVTOLs) are intended to operate not only from existing airports but also in close proximity to communities during approach and departure, so noise during in-community flight operations must also be considered. Community acceptance will depend on quiet vertiport operations as well as low enroute noise, so we are recommending helicopter noise certification requirements as a baseline. We believe that the existing certification metrics using EPNdB are an appropriate interim tool until there is more experience with actual eVTOL aircraft, and when coupled with the Variable Noise Reduction System procedures described in FAA AC 36-4D and ICAO Environmental Technical Manual Doc 9501.

While we are not recommending any change in Part 36 rotorcraft noise certification rules at this time, we are suggesting formulation of detailed FAA recommendations to provide standardized acoustic data for operational planning. Development of noise-operating condition-distance or noise-power-distance (NPD) curves for FAA planning tools such as AEDT is now handled administratively between the applicants and FAA. Existing guidance (SAE AIR 1845A) applies to fixed-wing aircraft. There is no guidance for helicopters. FAA and Volpe are now developing new guidance for helicopter NPD generation. We recommend that this procedure be documented to ensure that vehicles from new applicants can be integrated more effectively.

This document is intended as an interim position while more detailed recommendations are being developed. Members of the GAMA noise task group also participate in the NASA UAM noise working group (UNWG) and other efforts in the US and elsewhere together with government researchers and regulators. We anticipate that detailed guidance beyond this interim procedure will be forthcoming from joint industry-government efforts. It is the intent of the GAMA task group to monitor and participate in these efforts and issue recommendations only when a separate industry position is considered necessary.



SCOPE

The scope of this effort is to identify existing Part 36 certification procedures to be used in noise testing of known eVTOL topologies. This document identifies

- equivalencies for testing to current Part 36 limits
- recommendations for flight test procedures
- additional requirements to inform land use and vertiport planning

EQUIVALENCIES BETWEEN eVTOL AND HELICOPTERS

Most of the requirements in Appendix H for helicopters are applicable to known eVTOL configurations, with one exception: maintaining constant rotor RPM is not possible in eVTOL designs that employ rotor speed rather than collective pitch for attitude control.

Helicopters under 7000 pounds may use Appendix J noise certification, which is a simplified overflight-only procedure intended to reduce certification complexity. It is also defined to be approximately 2 dB more stringent than Appendix H. We recommend that this provision not be extended to eVTOLs, so that each applicant uses the same procedure and the results are comparable.

FLIGHT PROFILE DIFFERENCES

For takeoff, helicopters and eVTOLs can be tested in the same conditions, i.e. maximum power, best rate of climb. Transition from vertical takeoff to climbing flight will typically have been achieved before passing the flight track noise measuring station. For approach, most eVTOLs will be in fixed-wing glide or will have just started to apply vertical thrust to arrest descent as the station is passed descending through 394 feet AGL, and should be tested in the intended approach configuration, however the approach angle may not be the standard 6° approach mandated for helicopter noise certification.

Since these aircraft are designed and operated to operate with low acoustic impact, we suggest that they be tested with that in mind. Unlike helicopters, rotor speed is not constant and there is no expectation that any given approach angle will be the noisiest, given the differences in design. ICAO has implemented a Variable Noise Reduction System (VNRS) procedure in the current edition of the Environmental Technical Manual (Doc 9501 AN/929 SGAR 2015) and it is also described in FAA AC 36-4D. We recommend that rather than the helicopter standard fixed rotor rpm and 6° approach, aircraft should be tested with the applicant's intended flight profile defined as a VNRS. eVTOL takeoffs and landings will be largely automated, with deviations from the intended flight profile only in an emergency. Where aircraft operational documents identify an



optimum flight profile, or where approach angle is controlled by an automatic flight control system, the angle actually used in operations should be used for noise certification.

EQUIVALENCIES IN TEST CONDITIONS

eVTOLs that employ constant-speed main rotors, such as some compound helicopters, can be tested for noise using Appendix H without modification. H36.103(5), H36.105(c)(2) and H36.107(b)(5) require a stable rotor speed, and this is not possible for EVTOLs using other configurations. The other requirements to operate at consistent airspeed, power, weight, etc. would remain.

STANDARDIZATION OF NPD CURVES

Noise-operating condition-distance curves (called NPD or noise-power-distance curves as with fixed-wing aircraft) for use with AEDT and other land use planning tools are requested for helicopter certification. It's important that standardized information be derived to allow comparison between operation of different aircraft types across the various metrics that can be processed in AEDT. FAA has defined the format for the many sets of NPD data needed to be used in their noise prediction tools, but only basic guidance about how to develop that data from flight tests. No additional flight test procedures are suggested, but we recommend that the calibrated raw data acquired during noise certification flights be provided. The raw data will allow comparisons to be made in future between conventional noise metrics and potentially more accurate metrics for community impact, such as loudness. The same confidentiality provisions would apply as to spectral data now provided to FAA.

It is also important for developers of eVTOLs to be able to replicate FAA's procedures in their design optimization phase. SAE AIR 1845A provides procedures for fixed-wing aircraft but not for helicopters or eVTOLs to generate NPD curves. FAA is in the process of issuing public guidance for development of helicopter NPD curves, which would also be applicable to eVTOL aircraft. While it may be desirable in the future to enhance AEDT's capability beyond the point-source model with limited directivity now in use for rotorcraft, it should be possible to use existing procedures with any measured or simulated eVTOL aircraft being considered.

INSTRUMENTATION

Measurements according to the existing FAR 36 or ICAO Annex 16 requirements are made with grazing-incidence microphones at 4 ft (1.2 m) from the ground. We recommend in the future that FAA accept measurements made with groundplane microphones, rather than the currently mandated grazing-incidence microphones. Measurement uncertainty due to ground reflections is greatly reduced, and it is practical to achieve uniform hemispherical coverage when using groundplane microphones. Either the inverted configuration described in AC 36-4D, G36.107 or



flush-mounted microphones are satisfactory. A -6 dB offset in measured level due to pressure doubling of the groundplane is applied to provide equivalent results to free-field measurements, but there is no such simple offset to provide equivalence to 4-foot measurements, so the groundplane topology would need to be employed together with a different set of limits, just as the limits are different for Appendix J/Chapter 11 limits for light rotorcraft. In future revisions of the requirements with different limit levels, groundplane microphones should be specified.

SUMMARY

For aircraft employing vertical thrust from one rotor, or mechanically synchronized multiple lift rotors, and where rotor speed is intended to be stabilized, use Appendix H. If the aircraft is a tiltrotor, Appendix K would apply.

For aircraft employing speed differences between rotors for attitude control, H36.103(5), H36.105(c)(2) and H36.107(b)(5) are not applicable. The rest of Appendix H would apply. Appendix J (ICAO Chapter 11) would not apply to eVTOL, to assure commonality in measurement results.

For all aircraft using automatically controlled approach and departure, use the settings required in the AFM/POH rather than standard 6° approach and V_y departure, and documented in accordance with VNRS protocol.

For all aircraft, standardize data processing for preparation of NPD database entries for use with AEDT.

NEXT STEPS

A joint task group between the Vertical Flight Society (VFS) and the General Aviation Manufacturers Association (GAMA) called the VFS/GAMA Noise Assessment Working Group (NAWG) has been formed to continue work on noise related issues. The NAWG will develop industry consensus on definition and application of metrics for evaluating the acoustic impact and community acceptability of the new class of aircraft known as eVTOL or UAM. The discussion may extend to conventional aircraft and smaller non-passenger-carrying UAV/UAS, such as the developing noise standards for small drones. The scope is not intended to overlap the work of the NASA-led UAM Noise Working Group (UNWG) and others working to develop methods, but specifically to identify industry consensus on those methods that can be used to predict community acceptance.

GAMA members have been invited to join the NAWG alongside other industry stakeholders. If you have interest to join this group, please contact the appropriate staff listed on the cover.