Towards future noise standards for Emerging Technology Aircraft (ETA)

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Introduction

CAEP WG1 adopted the term *emerging technology aircraft* (ETA) to encompass aircraft "not covered by existing categories in current Annex 16 Volume 1 Certification Procedures". Work has begun on harmonized noise certification practices for two types of ETA, small *uncrewed aircraft systems* (UAS) commonly called drones, and larger, potentially passenger-carrying *Advanced Air Mobility* (AAM) aircraft. Unlike conventional aircraft, several different topologies have emerged, with operational and noise characteristics different from existing aeroplanes, helicopters and tilt-rotors. Novel vertical takeoff and landing aircraft that aren't helicopters or tilt-rotors have differing operational characteristics requiring new noise measurement practices due to the limitations of existing chapters of Annex 16.

As with conventional aircraft, noise certification standards are needed to assure common methods in describing and quantifying the sound generated by these aircraft. Information is needed both for airworthiness authorities to establish compliance with certification limits, and for local and regional governments to assess the noise impact of aircraft operations in their jurisdictions. The aircraft may have unique noise characteristics and may operate in close proximity to communities and away from established airports. Noise assessment measures for local consideration such as land use planning may be different from the methods used for certification.

A market in full expansion

Existing civil UAS platforms serve a variety of agricultural, industrial, public safety and security applications. Many of these operations are performed by pilots on the ground within line of sight to the aircraft but uses are beginning to emerge where the aircraft is autonomous or operated remotely, such as the BNSF railway's use for track inspection[1] or police and fire departments' use in public safety. A few authorizations have been granted for delivery of drone operations, where aircraft noise may be experienced by the public without association with an existing activity such as railways.

Larger ETA can share some characteristics with helicopters and aeroplanes, but are often electric, producing no combustion emissions, and are designed for low noise, intended to be inaudible or blend in with community soundscapes. These aircraft are mostly flown by an onboard pilot and may carry passengers. State of the art in electric propulsion today provides a range of 100-200 km on batteries, but hover time is limited to a few minutes between charges. Charging infrastructure is required at vertiports or heliports serving this type of aircraft, which in turn favors a point-to-point route structure, for example routes between city vertiports and conventional airports, rather than the more ad hoc nature of helicopter operation. Hybrid configurations using hydrogen fuel cell power generation have been demonstrated with over 800 km range.

Several different topologies have been developed, with fixed and/or tilting propellers and varying degrees of automation to enhance safety and reduce pilot workload.

1 https://www.bnsf.com/news-media/railtalk/innovation/bnsf-drone.html

The result of these design choices is often that existing noise certification practices, which require fixed power, speed and attitude settings, could be difficult to maintain within the required tolerances because the control laws of the aircraft manage the configuration of engines and control surfaces. Noise certification is performed with the aircraft in its noisiest configuration. While the measurement practices and references share much in common with helicopter noise measurements, work remains to define practices to define the noisiest condition.

Two representative electric VTOL aircraft are shown here, the Joby JAS4-1 (left) and the Eve EVE-1 (right.) The Joby uses a vectored thrust configuration with six tilting propellers, while the Eve is in lift-plus-cruise configuration with eight lift rotors and one cruise propeller.

The need for international regulation

Social acceptance is a challenge to the successful development of new services based on ETA, primarily because it can involve aircraft regularly operating away from airports, representing a new experience for people. It involves many aspects such as visual pollution, privacy, and accessibility of the new services, but the main concerns are safety, environmental issues, security and noise[2]. To handle aircraft noise specifically, ICAO has developed the Balanced Approach to Aircraft Noise Management[3] as overarching policy, based on four pillars: reduction of noise at source, land-use planning and management, noise abatement operational procedures and operating restrictions. The balanced approach applies to ETA, as with any other kind of aircraft. In this context, CAEP has already initiated activities to develop Standards and Recommended Practices (SARPs) that will define measurement procedures and noise limits at aircraft level, for the certification process of ETA types. At a country, region or city scale, this reduction of the noise at source is supplemented by controlling local operational conditions (the three other pillars). Optimisation of the trajectories, flight frequency, time of the day, and choice of complementary noise metrics are just a few of the traditional levers to limit the overall noise exposure of the population. Only a full commitment from the international level at ICAO to local authorities will ensure a correct approach of the social acceptance of ETA.

Today, some ETA manufacturers have already applied for certification of their aircraft, such as Joby Aviation, EVE Air Mobility and Volocopter. As no international standard exists yet, certifying Civil Aviation Authorities (CAAs), such as EASA (European Union Aviation Safety Agency) and FAA (Federal Aviation Administration in the United States), have proposed guidelines based on existing procedures to fulfil the gap. ANAC (National Civil Aviation Agency in Brazil) and JCAB (Japanese Civil Aviation Bureau) have shared with WG1 similar intentions. On the way to proposing an international SARP, CAEP has reviewed existing noise measurement approaches for ETA and evaluated whether they could also be used for developing Standards for ETA, even partially. Through these activities, it was decided to refine the scope of ETA by identifying and distinguishing two general types of aircraft under consideration: smaller ETA (e.g., UAS) and larger ETA (e.g., AAM). This refinement was done to identify and organise the wide range of designs and concepts, which vary in weight, size, design

2 Study on the societal acceptance of Urban Air Mobility in Europe, EASA, May 2021
3 Details at https://www.icao.int/environmental-protection/pages/noise.aspx and ICAO Doc 9829

complexity, and operational environments, that will have to be considered. Such a range of configurations would most likely require different levels of sophistication in noise certification standards.

A first step for smaller ETA

While measurement data for larger ETA are limited, many test results on smaller ETA have been shared within the acoustic community through articles from scientific journals or conferences. However, the measurement process differs from one paper to the other, as the objectives are different. To address this lack of commonality and to develop interim noise standards for smaller ETA, some CAAs organised specific test campaigns to collect data using similar measurement guidelines and testing procedures[4,5]. These experiences have been the basis of a task initiated by WG1 to progress towards the definition of international noise measurement guidelines for smaller ETA.

In this way, WG1 agreed on procedures that test the same phases of flight as those found in several certification authorities' existing noise measurement guidelines: a reference level-flight condition, and a supplemental hover condition for aircraft capable of sustained hover. The use of conventional noise metrics was also agreed, until evidence arises for more appropriate metrics: A-weighted Sound Exposure Level, SEL(A), for level-flight and L_{Aeq}, equivalent continuous A-weighted sound pressure level for hover (over a period of 30 seconds). Despite being similar in their vast majority, these existing procedures still exhibit differences in their implementation, which were analysed in 2024. The result of this work is to be published as an ICAO circular on "Interim noise measurement guidelines for smaller emerging technology aircraft" in 2025.

This document presents the same structure as existing CAEP chapters and appendices: a first section is designed to eventually become a dedicated Chapter of Annex 16, Volume I, containing the main requirements; another section is intended to be developed into an Appendix within Volume I of Annex 16, providing details on the acceptable evaluation methods; a last section corresponds to guidance material that could ultimately become a chapter within Volume I of the ETM (Environmental Technical Manual - Doc 9501).

Future CAEP activities

The boundaries between smaller and larger ETA remain to be defined and no specific definitions or nomenclature have yet been agreed at the ICAO level. Several aspects are being considered to specify this distinction, such as maximum take-off mass, payload capacity and whether the ETA is designed for carrying people. The nature of the operation, the noise exposure and the impact on the community may also be important factors to differentiate the categories. For the time being, a broader definition of the boundaries between smaller and larger ETA has been used, with plans to refine it further in CAEP/14.

Even if it describes in detail the noise measurement procedures for smaller ETA, soon to be published as ICAO circular presents unresolved topics such as noise limits or applicability weight range, which would have required more time to be correctly addressed. Those topics will be discussed during CAEP/14 cycle to agree on a proposal for a noise standard adapted to smaller ETA.

On the larger side of the aircraft range, the discussions during the last cycle on the applicability of methods used to develop Chapter 13 to larger ETA led to recommendations for noise measurement procedures. This preliminary activity will continue during the CAEP/14 cycle to clearly define the noise measurement procedures and progress towards the definition of a dedicated noise standard.

4 EASA guidelines on Noise Measurement of Unmanned Aircraft Systems Lighter than 600 kg Operating in the Specific Category (Low and Medium Risk

5 FAA Noise Certification of UAS/AAM using Rules of Particular Applicability