

Vertical Flight Society

2020 eVTOL Infrastructure Workshop Series

Workshop #3 / Urban Air Mobility Acoustics & Noise

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Question & Answer Session

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QUESTION

Cliff, in your chopper flight trials, did you encounter sound differences due to weather conditions?

ANSWER

- To be able to acquire the acoustic sound characteristics of the helicopter at a sufficient level for measurement from amongst the background noise, we only did testing in less than 15-20 knots of wind in Visual Meteorological Conditions. The model is valid for conditions greater than that, of course, however, the issue is if we go beyond that on the ambient background noise, the microphones can't discern the difference between the wind and the noise generated by the helicopter. In general, wind speed and atmospheric conditions will have an effect on noise propagation due to the physics involved (i.e. the effect would be strongest for the noise recipients that are directly upwind or downwind of the noise source). – Cliff

QUESTION

On what basis do people think lots of small props will be quieter? I've heard helicopter tail rotors are the noisiest part, so how is putting a bunch of those on an eVTOL made quiet?

ANSWER

- Many small props can be quieter if and only if they have lower tip speed, disk loading, etc. If you design for the props to run at speeds as in conventional tailrotors of course you will get high noise. The leaders in this field are pioneering quiet prop designs that are efficient at low speeds. [DJ]
- This really depends on the design of the rotor, or in this case multirotor, along with the aerodynamics of the vehicle. Helicopters have various main and tail rotor configurations. Although, the tail rotor usually generates the most noise for a particular platform, this is not always the case; as there are many variables involved that dictate the overall acoustics of the rotor system. For eVTOL's this is no different, as the angle of the multi-rotors, composition of the rotor materials, rotation speed, frequency response, and several other characteristics also come into consideration. All of these considerations make a direct comparison between a helicopter tail rotor and an eVTOL multi-rotor challenging. – Cliff

QUESTION

How will the FAA's model that Mr. Johnson is building account for alternate propulsion vehicles likely to be present in UAM/AAM?

ANSWER

- For the platforms tested, the main noise source is not necessarily the propulsion component (i.e. the engine noise), rather the noise of the rotor system (main rotor and tail rotor); although propulsive noise does contribute to the overall noise profile of the vehicle. We are actually planning for the next phase of the testing to examine a different variant of the Sikorsky S76 Helicopter (initial trials tested an S76-D and we plan to test an S76-B). That should provide a good indicator of the relative effect of propulsion units due to the different engines on what amount to essentially the same airframe. For eVTOL platforms, the same logic applies (separate the model effects of the propulsion unit from the rotor system and aerodynamic drag), although they will vary to some extent based on an electric, fuel cell, or combustion propulsion unit. – Cliff

QUESTION

Experiments were done in flat areas. How to insert in the model the city buildings effects for UAM?

ANSWER

- There is a lot of work going on now to model effects of reflections from buildings. [DJ]
- By performing the acoustic noise flight tests in flat areas, we specifically eliminate the orthographic effects of sound propagation due to buildings and urban environments. This is desired, since it gives us a true perspective of the noise characteristics of the test vehicles; save for some interactions with the trees and topography. Once we have a good model of the acoustic noise characteristics of the test rotorcraft, we can expand on that with interaction effects of the environment through tools like AEDT and FRAMES. From a purely physics perspective, we understand how sound travels in urban environments, however, it becomes challenging to measure that from a practical perspective for the same reasons mentioned in an earlier question (background ambient noise and the thresholds for wind from the microphones) which are further compounded in an urban environment. As the need arises to further quantify sound propagation, we can use data from other sources (i.e. anechoic chambers, wind tunnels, flight tests, UAM design noise data, etc.) to fill in the gaps in the models. This is one reason why noise metrics have been proposed that look at background exposure levels since they are easier to measure than the propagation of an individual noise source. – Cliff

QUESTION

Mr. Goyal, what do you see as the most critical flight phase at which the -15dB requirement applies?

ANSWER

- It's important throughout. If we hope that overflight noise is simply not a factor, it may need to be more than a 15 dB reduction. At least one eVTOL maker is promising -20 dB relative to helicopter overflight. Near the vertiport, noise influences how isolated the vertiport site must be from its surroundings, so more reduction will result in more flexibility in site choice. [DJ]

QUESTION

What is the altitude proposed for uber shared rides?

ANSWER

- This will likely be dictated by safety and air-traffic requirements. We are looking at up to 3000 ft typically, including takeoff and landing. [DJ]

QUESTION

Can you expand a little more on target of -15 dB? Is there well accepted metric for UAM noise? Noise magnitude of X dB at certain distance?

ANSWER

- 15 dB was selected as an early target because early eVTOL prototypes achieved this level of reduction compared with a light piston-engine helicopter of similar weight, in hover and overflight conditions.
- There is not yet a well-accepted metric for UAM vehicle noise emissions. We expect that EPNL will be used for certification and SEL for exposure estimation, as with helicopters, but we are pursuing additional metrics that might more accurately predict human response. [DJ]

QUESTION

Question for Rohit: How did you come up with the 15 dB noise level reduction compared to a helicopter? Which helicopter model is the reference and does the reference feature some low-noise technology e.g. low-noise flight guiding concepts (a.k.a. tunnel-in-the-sky)? In which metric do you aim at this reduction, A-weighted or some metric with tonal penalty like EPNL?

ANSWER

- As mentioned in the talk, 15 dB (A) was selected because it was known to be achievable in

hover and overflight. This was a prototype eVTOL compared with a Robinson R22 helicopter (similar weight.) There was no special low-noise technology. Initially we are using ordinary A-weighted sound pressure level but anticipate similar differences when using EPNL or more advanced perceptual metrics. [DJ]

QUESTION

In the research of public acceptance of noise, is there any major difference in public acceptance amongst cities in different parts of the world?

ANSWER

- There is some difference and we are studying it. For example, the difference between annoyance potential of aircraft versus trains varies greatly from country to country. We think part of the difference is due to inconsistencies in the underlying common metrics which don't mirror human perception very well. [DJ]

QUESTION

Question for Rohit: This 15 dB reduction sounds familiar looking at the 65% reduction of perceived noise levels according to ACARE flight path 2050. How do you define your goal here, is the 15 dB reduction required at certain locations only (e.g. some certification locations or at some noise hot-spots) or along the entire flight procedure? This goal might be reachable at certain defined locations (noise dislocation via low-noise flight procedure) but seems very ambitious if not impossible along an entire approach or departure flight trajectories.

ANSWER

- In order for the business case to make sense we need to be able to achieve high numbers of operations. We need to achieve low takeoff and departure noise to get to acceptable levels around vertiports, so the vehicles and flight procedures must be designed with this in mind. Based on measurements of vehicles not yet public we think this is a realistic expectation. [DJ]

QUESTION

Question for David: If you look into DNL contours, each flyover SEL is accounted for and weighted by time and number of flights. SEL is A-weighted, cutting off low-frequency content. What is your opinion: Is this a good metric to deal with a potentially increase in low-frequency noise caused by slow-rotating propeller concepts? Also for the DNL do you think the impact of number of flight events is representative if you consider many, many more flight events of smaller UAM vehicles?

ANSWER

- We think that A-weighted is a very preliminary metric. We don't think there will be the level of low frequency tonal content in eVTOLs as there is in helicopter noise, but there might be low frequency broadband noise from wake-wake and wake-body interactions and we are studying different metrics to consider which might capture human perception the best.
- DNL does seem to scale for hundreds of airport flights. We don't know yet whether the underlying Stevens' power law works for close-proximity operations, so there is ongoing listener-trial testing to investigate this. [DJ]

QUESTION

It was mentioned during the presentation that Volocopter has published some noise measurements. Where can I find them?

ANSWER

- They were publicly presented at a UAM seminar in the US but not published. [DJ]

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