Psychoacoustic Measures for UAM Noise in the Context of Ambient Sound Webinar
Questions and Answers
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Durand R Begault has worked as a research scientist at NASA Ames since 1988 in the areas of human factors, aerospace communication and warning systems, virtual reality, psychoacoustics, and multimodal research. He is a fellow of the Audio Engineering Society and has over 100 publications and 4 patents assigned to NASA. Dr. Begault recently implemented a multi-channel spatial auditory laboratory for psychoacoustic investigations of UAM sound within the Human Systems Integration Division (Code TH) and works collaboratively with psychoacoustic researchers at NASA Langley Research Center.
Question 1

In what way does the "recognizability" of the sound of eVTOL play a role in annoyance of UAM operations? Do you agree that if people don't recognize the sound the annoyance will also be lower or does this need further study?
If attitude towards the source didn't matter, then recognition should not be a significant factor. (I would say that recognition may improve to the degree that a sound would not "blend" with other ambient sound.) I can imagine a situation where, if UAM sound was clearly recognized, a certain proportion of listeners would be more annoyed than if it was confused with a noise source that their attitude deemed to be less annoying, all else being equal.
Question 2

Are there any simulation tools available to predict psycho-acoustics?
• Yes, too many to list and it of course depends on the fidelity of the prediction method and the metrics used to "characterize" human response (if we are speaking of the psychoacoustics of UAM noise)
Question 3

Harley Davidson gets away with producing motorcycles that exceed 80db on average so how will the enforcement be done on urban mobility vs street bikes?
• Existing noise ordinances would prevent a stationary HD from blasting into your domicile if it exceeded a limit. UAMs and HDs though are indeed in motion most of the time! Technically, a noise ordinance would not apply to something in the airspace but the public's sensitivity is probably in part based on their expectations from ground-based noise sources: which can influence, e.g., their influence on whether or not a vertiport
Question 4

There is a safety argument for Harley Davidsons, so that motorists can hear you coming.
• True! Consider also that electric cars are sometimes too quiet for pedestrians to notice. There's a limit to this argument re the HD, in that taken to the limit, you could continually blast a freight truck air horn to improve safety, but who would want that?
Question 5

There is a safety argument for Harley Davidsons, so that motorists can hear you coming.
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Question 6

In your opinion, are existing regulation metrics (EPNL and SEL) sufficient for quantifying UAM perception or do we need a new metric relevant to the spectral characteristics of these new vehicles?
• I do not believe EPNL or other current metrics are sufficient since we are dealing with a sound source that will have several novel tonal characteristics, and will have routing and path characteristics that are far different than turbo jets.
Question 7

Why not ask about being 'highly' annoyed?
• So in my testing I would want to define "annoyance" by a criteria that would be consistent between persons, e.g., "loud enough that you would complain" (without defining to whom- that's another story) but more research is clearly needed. I am planning on screening subjects via factor analysis to find persons of "normal sensitivity", tbd!
Question 8

There are significant cultural and geographical differences in terms of what % of the populace are highly annoyed (given the same DNL). Do you expect to collect subject data that will allow you to characterize such individual differences when looking at blend and annoyance thresholds?
• I hope so! I plan to use questionnaire data and attempt to categorize subjects (via factor analysis); I would want to separately analyze data for persons who appear to be highly sensitive to noise and those persons highly insensitive to noise, relative to persons of "normal sensitivity". This is an educated guess at an approach, and it could be that some other factor is more significant for testing (age; income; etc.)
Question 9

How would we manage the integration of blend from single-person experience to community exposure?
• The threshold for a criteria (e.g., blend) evaluated in an experiment will depend - ideally- on an average of many subjects, evaluated from the standpoint of normality of response, and with the proviso that the particular criterion is significantly different from others being tested for the same person. "blend" or any other threshold may have a dispersion that turns out to not be useful. I hope to find out!
If low-frequency noise is masked by ambient noise, but high-frequency noise is not masked. how does that affect the threshold?
Answer 10

• Uncertain at this point although I will say that ambient sound is more significant at lower frequencies and therefore will more effectively mask (or blend) with a sound source compared to a high frequency, and that high frequency intermittent tones are very difficult to mask
Question 11

Have you correlated field reactions of subjects to reactions to experiences in your auralization lab setup (Dolby Atmos / Open air)?
• I have not done such a calibration. It would be difficult to replicate the literal experiment in the field. Having said that, it would be good to look for correlations between the simulation and real-world experience somehow, tbd.
Question 12

Is there a proposed or emerging standard for such auralization lab setups for aircraft noise assessments or development?
• I believe there are some working groups considering this. I have been in communication with other labs as well (LaRC, ARUP....)
It has been shown that noise that benefits the listener is perceived as less annoying. Can you conduct trials where people are offered the context of the transport benefit to themselves at different (plausible!) prices, to see how that affects annoyance?
Good point in that attitudes toward noise are shaped significantly by their perceived cost or benefit to the individual.
Question 14

Any thoughts on relative harmonics/harmonic composition/dissonance?
• Yes, we have been looking into metrics such as “sharpness” which is a known characteristic of harmonic structure, tones (as I showed in the last slide) can be evaluated or mitigated to evaluate judgments
Question 15

Where are you getting your source profiles from, and are there any vehicle types/architecture (multi-copter, tilt & cruise, etc.), trajectories, or other parameters that you prioritize?
Answer 15

- We are using the NASA concept vehicles under development at NASA
Question 16

How do you map qualitative metrics like blending into soundscapes into quantitative vehicle requirements or government regulations?
• One looks for the quantitative acoustic parameters that best predict the response. In my last slide, I showed two examples: overall level, and level of a spectral component- and how those could be evaluated in terms of response. But those aren't of course the only aspects that one could test, but they're sort of the obvious ones. The relationship between the response to a certain category of question (blend, annoyance) can inform design, routing, density of operations, etc. from the standpoint of physical acoustic measurement or prediction.
Address Additional Questions To

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