



Urban Air Mobility Vehicle Noise Cooperative Psychoacoustic Test Planning

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**Environment Issues in Aviation Committee
Transportation Research Board
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- **NASA Advanced Air Mobility includes Urban Air Mobility (UAM) vehicles.**

Laboratory psychoacoustic testing can help NASA:

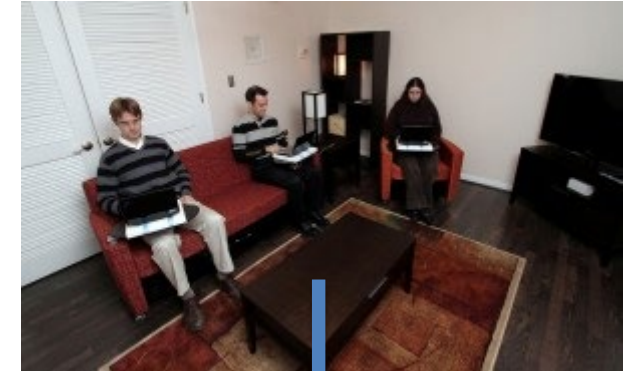
- Answer subset of questions on human response to UAM vehicle noise:
 - What metric(s) best describe short-term human annoyance to UAM vehicles?
 - What characteristics of UAM vehicle noise are objectionable?
 - How does the perception of UAM vehicle noise vary between communities?
- Develop annoyance and audibility models for UAM and vehicle noise human response.

Psychoacoustic Testing at NASA



- NASA has facilities to conduct psychoacoustic testing which have been used to gather annoyance response to aviation noise.

At NASA Langley Research Center:



Exterior Effects Room



Small Anechoic Chamber



Interior Effects Room

Urban Air Mobility Noise Working Group (UNWG) White Paper



- Among the many White Paper comments and recommendations were:
 - “At this time, there have been no published reports of psychoacoustic tests conducted to understand human response to UAM vehicle noise.”
 - “Until early entrants are fielded, ... [it is recommended that] laboratory studies be performed to help inform how different the annoyance... of UAM vehicle noise is from that of existing aircraft noise sources.”
 - “Explore differences in perception of UAM vehicle noise between communities.”

White Paper Reference: S. A. Rizzi, D. L. Huff, D. D. Boyd, Jr., P. Bent, B. S. Henderson, K. A. Pascioni, D. C. Sargent, D. L. Josephson, M. Marsan, H. He and R. Snider, "Urban Air Mobility Noise: Current Practice, Gaps, and Recommendations," NASA/TP–2020-5007433, October 2020.

White Paper Link: <https://ntrs.nasa.gov/citations/20205007433>.

NASA/TP–2020-5007433




Urban Air Mobility Noise: Current Practice, Gaps, and Recommendations

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- **Proposed by UNWG Human Response and Metrics Subgroup: Conduct large psychoacoustic test on UAM vehicle noise using testing facilities around the world**
- **Goals:**
 1. Assemble a wide range of recorded and auralized UAM vehicle sounds through cooperation between multiple agencies and organizations for use in human response studies
 2. Provide insights into human response to UAM vehicle noise that would be challenging for any single agency or organization to acquire
 3. Create a rich database of human response to UAM vehicle noise that can be used for subsequent novel analyses
- **Need to develop remote psychoacoustic testing platform because of novel coronavirus pandemic.**
- **Now a NASA led effort with UNWG input.**

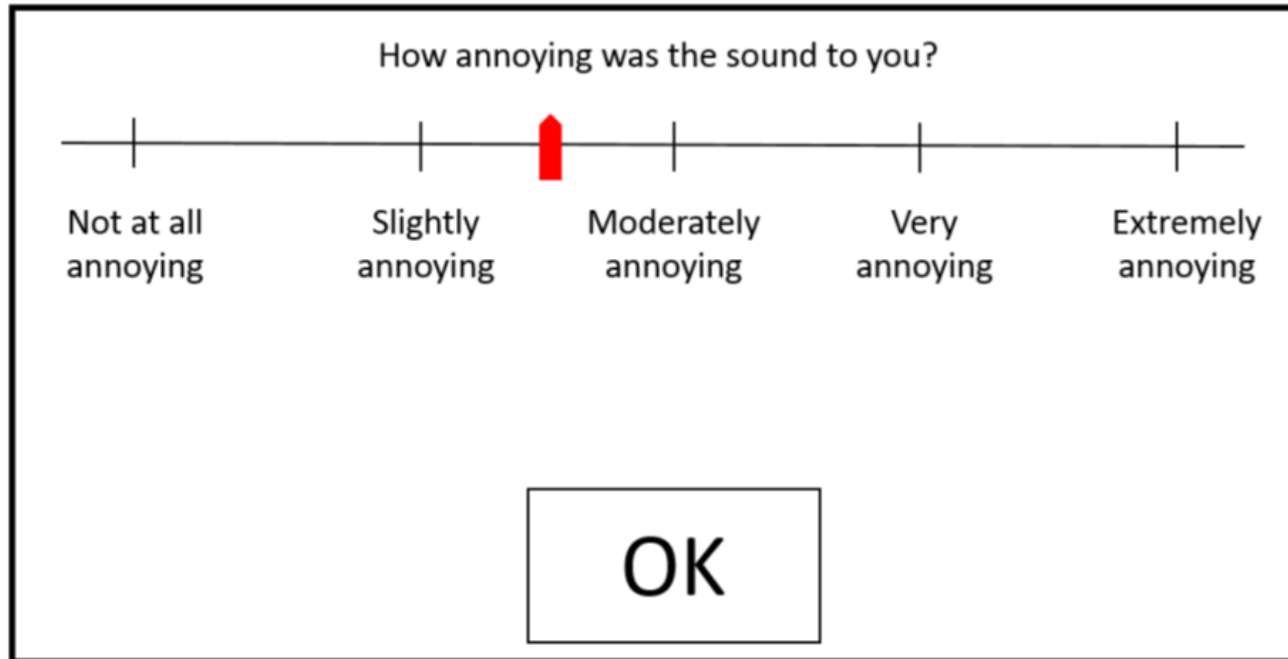
- **Phase 1: Feasibility Study**  **Current Focus**
 - Human response to single-event noise exposure of different air vehicles



- Phase 1 psychoacoustic test execution anticipated in early 2022
- **Phase II: UAM Vehicle Noise Perception**
 - Human response to UAM vehicle noise in different urban soundscapes

Testing for Annoyance in Phase 1

- **Primary objective for Phase 1: rank annoyance responses to the single-event noise exposure from different air vehicles.**
 - Demonstrate ranking to original equipment manufacturers.
- **Subjects will be asked the following single question on annoyance response:**



How annoying was the sound to you?

Not at all annoying Slightly annoying Moderately annoying Very annoying Extremely annoying

OK

The image shows a horizontal line with five tick marks. Below each tick mark is a label: 'Not at all annoying', 'Slightly annoying', 'Moderately annoying', 'Very annoying', and 'Extremely annoying'. A red vertical bar is positioned between 'Slightly annoying' and 'Moderately annoying', indicating a selection. Below the scale is a rectangular button labeled 'OK'.

- **Can potentially compare annoyance responses between different classes of aircraft (sUAS vs jet aircraft vs helicopters).**

- **NASA currently planning different aspects of Phase 1 test.**

Remote Testing Platform

- **General software requirements defined.**
- **Platform will require test subjects to use their own laptops and headphones.**
- **Will include calibration step, sound familiarization and practice sessions.**

Test Stimuli

- **Test stimuli being selected with help from UNWG.**
- **Subset of stimuli will be from NASA Exterior Effects Room test.**



Test Subjects

- **Test subjects will be recruited from UNWG member organizations, but will not be UNWG members themselves.**
- **Post-test survey will be given to test subjects.**

Questions?



Image References

- **Slide 2:**
 - AAM Concept art from: <https://www.nasa.gov/sites/default/files/thumbnails/image/aam-design4-new-image-2-24-2021-3.jpg>
- **Slide 3:**
 - Picture of Exterior Effects Room provided by Steve Rizzi, NASA Langley Research Center.
 - Small Anechoic Chamber picture from <https://stab.larc.nasa.gov/facilities/small-anechoic-room/>.
 - Interior Effects Room pictures from <https://stab.larc.nasa.gov/facilities/interior-effects-room/>.
- **Slide 6:**
 - AS350 Helicopter picture is from: Watts, M.E., Greenwood, E., Sim, B., Stephenson, J.H., and Smith, C.D., "Helicopter acoustic flight test with altitude variation and maneuvers," NASA TM-2016-219354, 2016.
 - DJI Quadcopter picture and sound recording spectrogram from: Christian, A., et al., "Auralization of tonal rotor noise components of a quadcopter flyover." InterNoise 2015, San Francisco, CA, 2015.
 - Fixed wing aircraft picture from: Rizzi, S.A, et al., "A Comparison of Aircraft Flyover Auralizations by the Aircraft Noise Simulation Working Group." 6.2020-2582, AIAA Aviation 2020, Virtual Event, 2020.
 - NASA Quadrotor concept picture provided by Steve Rizzi.
- **Slide 7:**
 - Test question prompt from Christian, Andrew and Cabell, Randolph. "Initial Investigation into the Psychoacoustic Properties of Small Unmanned Aerial System Noise." 23rd AIAA/CEAS Aeroacoustics Conference, AIAA Aviation Forum, Denver, CO, June 5-9 2017, Paper Number 4051, 2017.
- **Slide 8:**
 - sUAS pictures from "Initial Investigation into the Psychoacoustic Properties of Small Unmanned Aerial System Noise." 23rd AIAA/CEAS Aeroacoustics Conference, AIAA Aviation Forum, Denver, CO, June 5-9 2017, Paper Number 4051, 2017.