



Urban Air Mobility Noise Remote Test Response by Geographic Area and Comparison to In-Person Test

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Quiet Drones 2026

Consensus formed that community variation in Urban Air Mobility (UAM) vehicle noise perception needed to be understood



- Urban Air Mobility (UAM) Noise Working Group (UNWG) white paper recommended human response study to understand community variation in noise perception
- Two phases in study to address this recommendation:
 - Phase 1, Feasibility Test: investigated efficacy of online test application (completed in 2022)
 - Phase 2, Varied Advanced Air Mobility Noise and Geographic Area Response Difference (VANGARD) Test: investigated responses to passenger and equivalent cargo-carrying UAM vehicle noise from participants in distinct geographic regions

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

Stephen A. Rizzi, Langley Research Center, Hampton, Virginia

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Hua (Bill) He, Federal Aviation Administration, District of Columbia

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VANGARD Test had six objectives, but only two will be discussed in this presentation



- How do annoyance responses differ/change as a function of:

- **Test Objective 1: Low versus high noise environments?**

- Test Objective 2: Phase of flight?

- Test Objective 3: Distance from flight operations?

- Test Objective 4: Different objective parameters (e.g., noise metrics)?

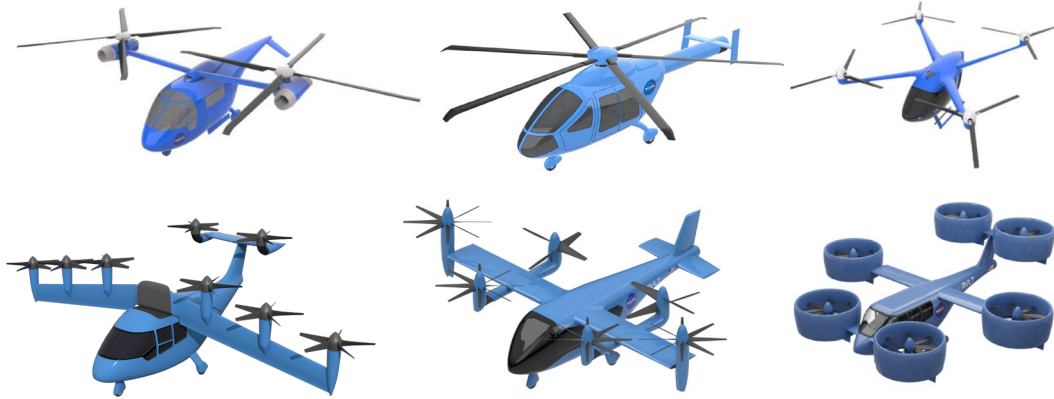
- **Test Objective 5: Noise sensitivity** (from post-test survey)?

- Test Objective 6: **Between controlled conditions** (laboratory-based kiosk test) and **remote tests** that are more under the control of the participant?

VANGARD Test's UAM aircraft sound stimuli obtained from multiple Original Equipment Manufacturers (OEMs)

- 6 UAM vehicles
- 28 departure sounds
- 27 approach sounds
- 12 cruise (En route) sounds
- Binauralized

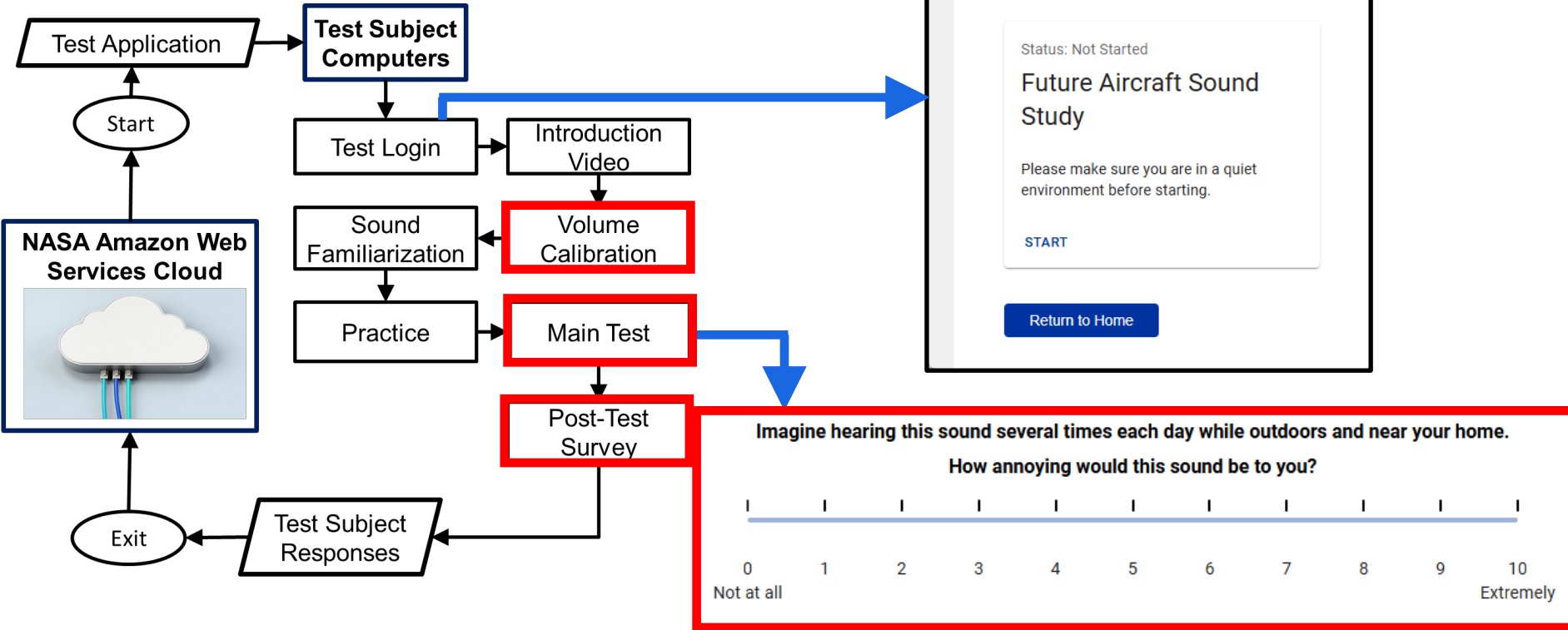
NASA UAM Reference Vehicles (some included)



Additional UAM sounds from OEMs



NASA Remote Psychoacoustic Test Platform was developed to prepare for VANGARD



Post-Test Survey questions were generated to ascertain participant noise sensitivities

Questions unique to VANGARD Test (paraphrased from original questions):

1. Rate personal reaction to outdoor noise of all types: *Least Sensitive* (1) (2) (3) (4) (5) *Most Sensitive*
2. Rate noisiness of background sound outside home: *Quietest* (1) (2) (3) (4) (5) *Noisiest*
3. Rate reaction to aircraft flyovers (but NOT drones): *Least Sensitive* (1) (2) (3) (4) (5) *Most Sensitive*
4. Rate reaction to drone sounds. Enter “0” if you never heard a drone sound.
(0) *Least Sensitive* (1) (2) (3) (4) *Most Sensitive*

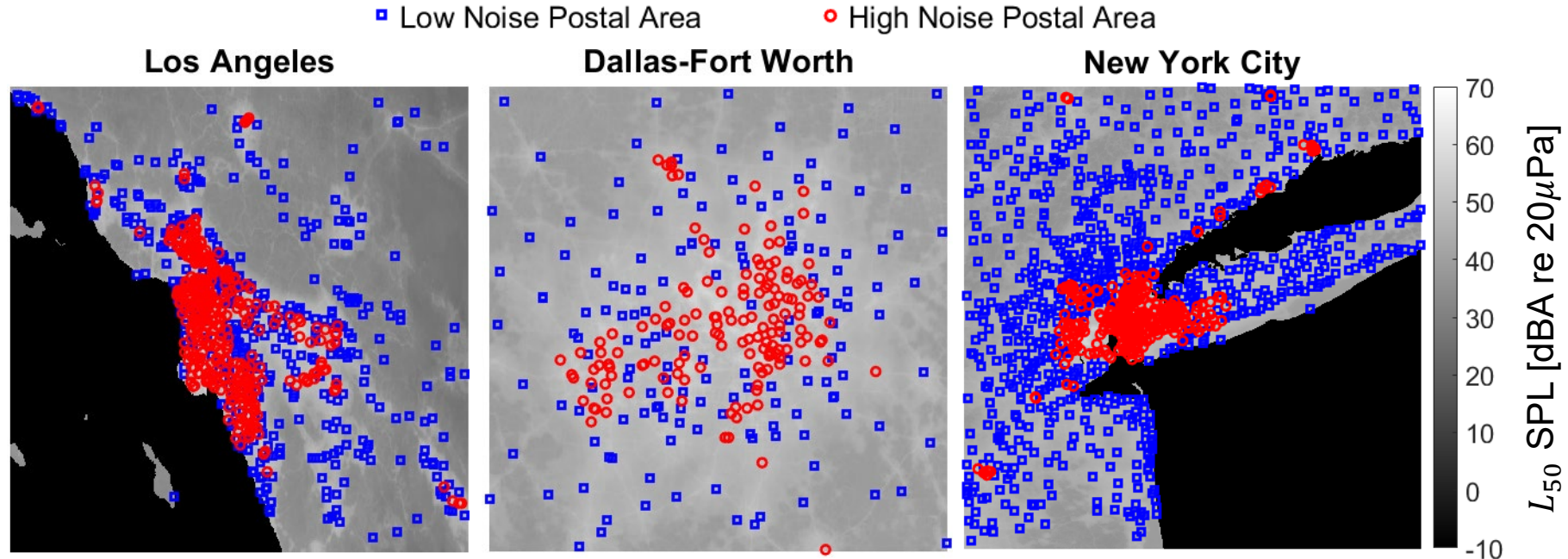
21 Questions/Statements from Weinstein Noise Sensitivity Scale:

1. “I wouldn’t mind living on a noisy street if my home was nice.”
agree strongly (1) (2) (3) (4) (5) *disagree strongly*
2. “I am more aware of noise than I used to be.” *agree strongly* (5) (4) (3) (2) (1) *disagree strongly*
- ⋮
20. “I wouldn’t mind living in an home with thin walls.” *agree strongly* (1) (2) (3) (4) (5) *disagree strongly*
21. “I am sensitive to noise.” *agree strongly* (5) (4) (3) (2) (1) *disagree strongly*

Summing the 21 ratings yields Weinstein Noise Sensitivity Score

Test administered to 300+ participants from three metropolitan regions from August 27 – September 30, 2025

- Divided postal areas into “low noise” and “high noise” areas



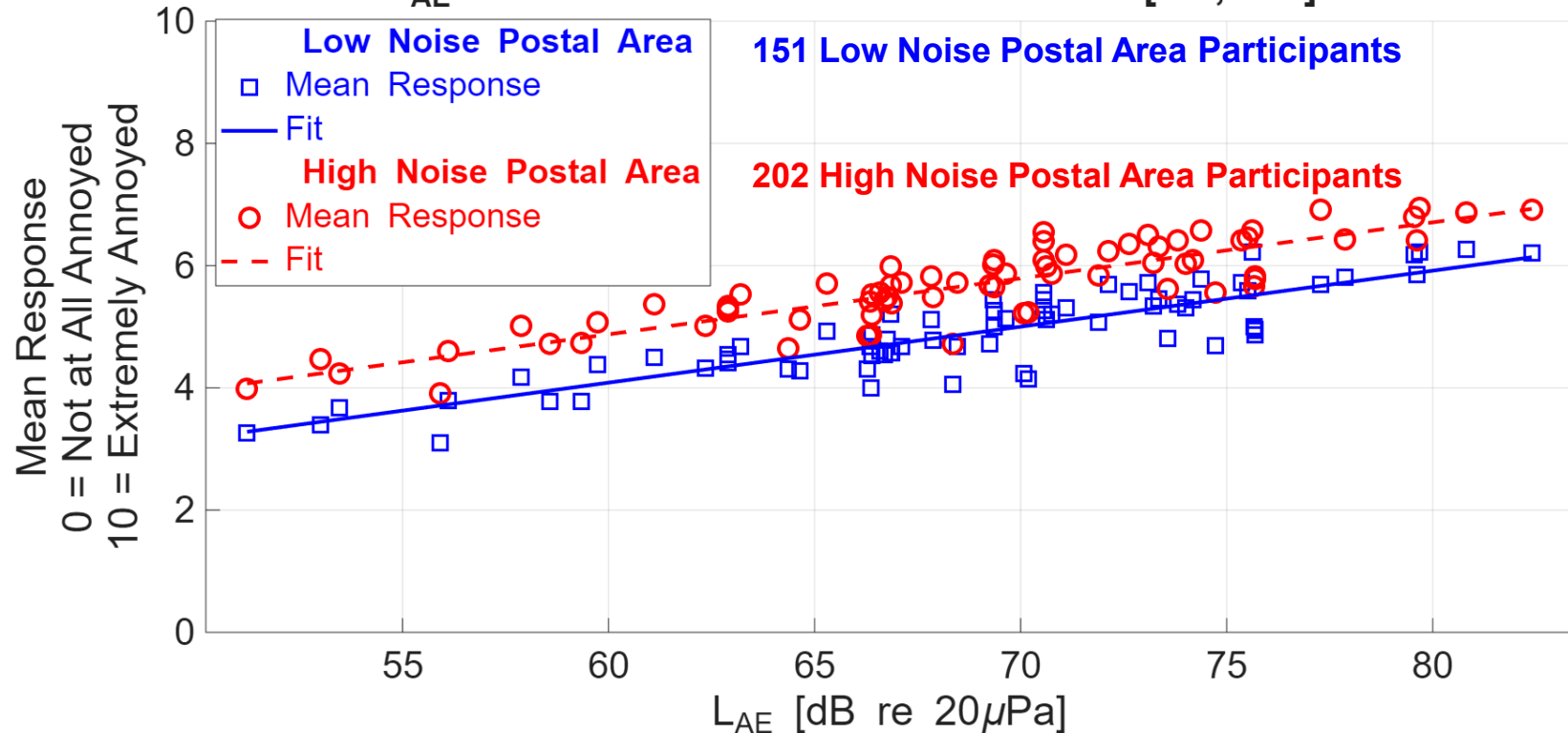
- Recruiter (Floor23) leveraged online networking to recruit test subjects

Response difference found between “low” and “high” noise postal area participants

$$R^2 = 0.82$$

L_{AE} Offset of Fits = 8.6 dB

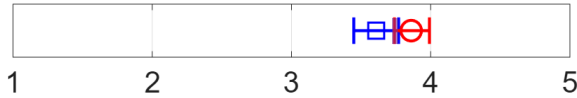
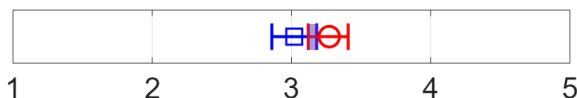
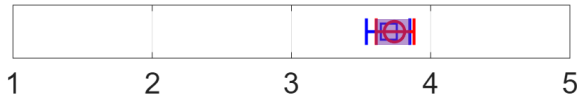
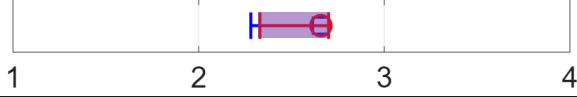
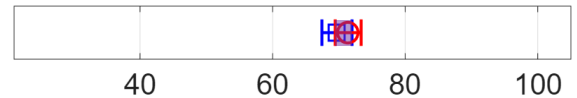
L_{AE} Offset 95% Confidence Interval: [7.7, 9.7] dB



No statistically significant differences found between Low and High Noise Postal Area Participant noise sensitivity ratings



- Low Noise Postal Area Participants
- High Noise Postal Area Participants

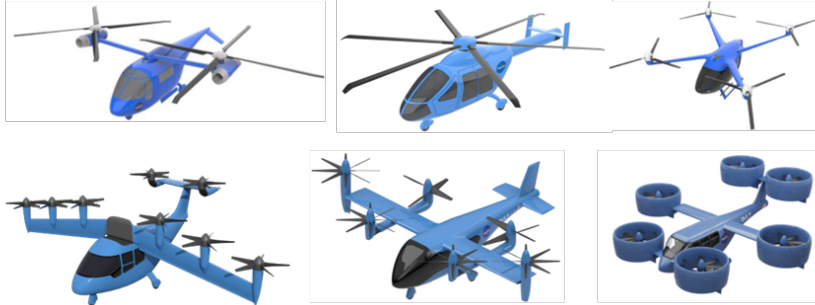
Post-Test Survey Result	Mean Ratings
Question 1: Sensitivity (1 – 5) to outdoor noise	
Question 2: Background Noisiness (1 – 5) outside home	
Question 3: Sensitivity (1 – 5) to aircraft (not drones)	
Question 4: Sensitivity (1 – 4) to drone noise	
Weinstein Noise Sensitivity Score (21 –105)	

NASA also conducted the Helicopter and UAM Laboratory Comparison (HULC) Psychoacoustic Test in July 2025



UAM Vehicles

NASA UAM Reference Vehicles (some included)



Additional UAM sounds from OEMs



Lightweight Helicopters

Airbus AS350 B3



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Bell 206L3



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Bell 407



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Robinson 44

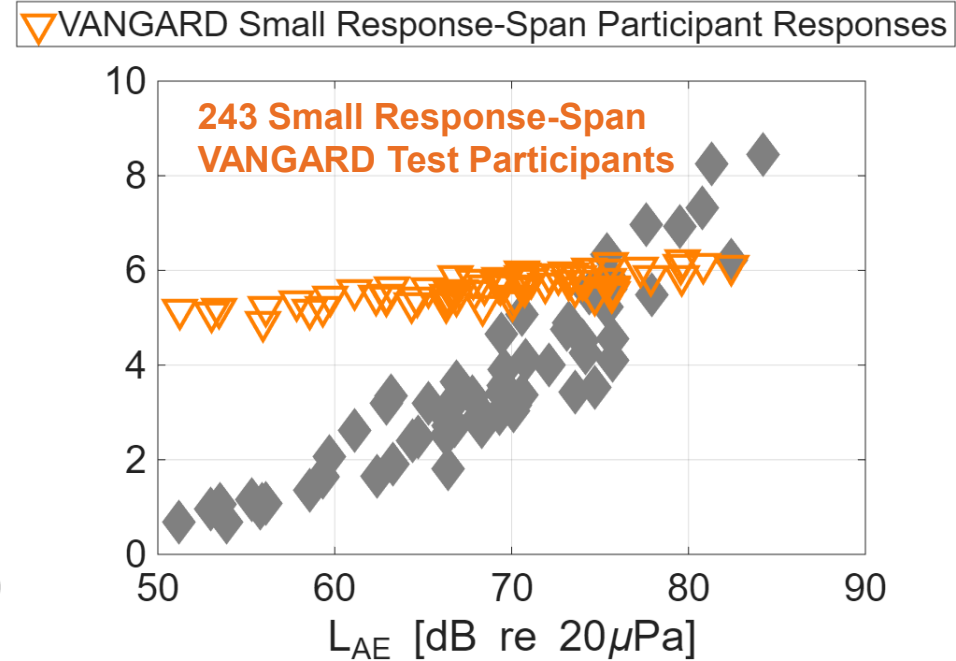
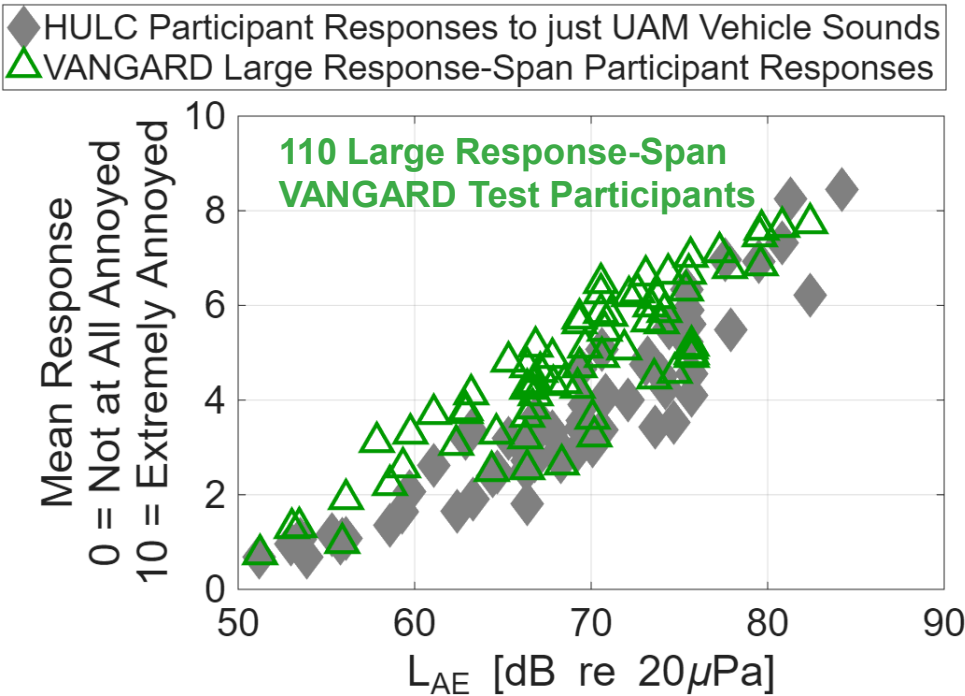


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More details on HULC Test: A. B. Vaughn, S. Krishnamurthy, A. R. Aumann, B. C. Tuttle and A. W. Christian, "Helicopter and Urban Air Mobility (UAM) Laboratory Comparison (HULC) Psychoacoustic Test," NASA/TM–20250008984, NASA Langley Research Center, Hampton, VA, 2026.

<https://ntrs.nasa.gov/citations/20250008984>.

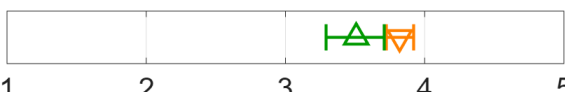
Many VANGARD Test participants gave a span of annoyance responses that were different from HULC Test participants



Contradictory differences observed between Small and Large Response-Span Participant noise sensitivity ratings



 Large Response-Span Participants
 Small Response-Span Participants

Post-Test Survey Result	Mean Ratings
Question 1: Sensitivity (1 – 5) to outdoor noise	
Question 2: Background Noisiness (1 – 5) outside home	
Question 3: Sensitivity (1 – 5) to aircraft (not drones)	
Question 4: Sensitivity (1 – 4) to drone noise	
Weinstein Noise Sensitivity Score (21 –105)	



Post-Test noise sensitivity questions were examined to explain response differences among VANGARD Test participants

- High Noise Postal Area participants more annoyed by UAM vehicle noise than those from Low Noise Postal Areas
- 243 VANGARD Test participants collectively had smaller mean annoyance response span than HULC and 110 other VANGARD test participants
- Noise sensitivity ratings insufficient to explain response differences.
- Future work:
 - Journal paper will discuss other four test objectives
 - VANGARD Test responses to be released in 2026 and may be analyzed by other researchers.
 - Additional thoughts are welcome!



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- Other contributors to test design and stimuli generation: A. Vaughn, B. Tuttle, D. Begault, S. Rizzi, A. Christian, K. Shepherd, and N. Cruz
- There were contributions from many other people.

Questions?

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Image References

- Except where noted with image, all images in this presentation were generated by NASA or by using Microsoft PowerPoint Stock Images