



Initial Analysis of Varied Advanced Air Mobility Noise and Geographic Area Response Difference (VANGARD) Test

Siddhartha Krishnamurthy*, Aaron B. Vaughn*, Aric R. Aumann⁺, Brian C. Tuttle[‡], Durand R. Begault[†]

*NASA Langley Research Center

⁺Analytical Services & Materials

[‡]Analytical Mechanics Associates

[†]NASA Ames Research Center

Fall 2025 Acoustics Technical Working Group Meeting

Also presented at: SAE A-21 Fall 2025 Presentations,
December 2025 UNWG Subgroup 3 Meeting



VANGARD was motivated by UNWG recommendations

- Urban Air Mobility (UAM) Noise Working Group (UNWG) white paper recommended human response study to understand community variation in noise perception
- Study Aims:
 - (1) Address insufficient data on human noise response to varied passenger and equivalent-cargo UAM aircraft from geographically distinct communities.
 - (2) Develop remote psychoacoustic testing platform to evaluate human noise response across widespread populations and communities.

NASA/TP-2020-5007433



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

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

Dennis L. Huff, Glenn Research Center, Cleveland, Ohio

D. Douglas Boyd, Jr., Langley Research Center, Hampton, Virginia

Paul Bent, Boeing R&T, St. Louis, Missouri

Brenda S. Henderson, Glenn Research Center, Cleveland, Ohio

Kyle A. Pascioni, Langley Research Center, Hampton, Virginia

D. Caleb Sargent, Sikorsky Aircraft, Stratford, Connecticut

David L. Josephson, Josephson Engineering, Santa Cruz, California

Mehmet Marsan, Federal Aviation Administration, District of Columbia

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

Royce Snider, Bell Flight, Ft. Worth, Texas

October 2020



VANGARD test objectives focused on departure/approach flight phases and responses from geographically distinct areas

- 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 arrival and departure operations?**
 - **Test Objective 4: Different objective parameters (e.g., noise metrics)?**
 - **Test Objective 5: Noise sensitivity (from post-test questionnaire)?**
 - **Test Objective 6: Between controlled conditions (laboratory-based kiosk test) and remote tests that are more under the control of the participant?**

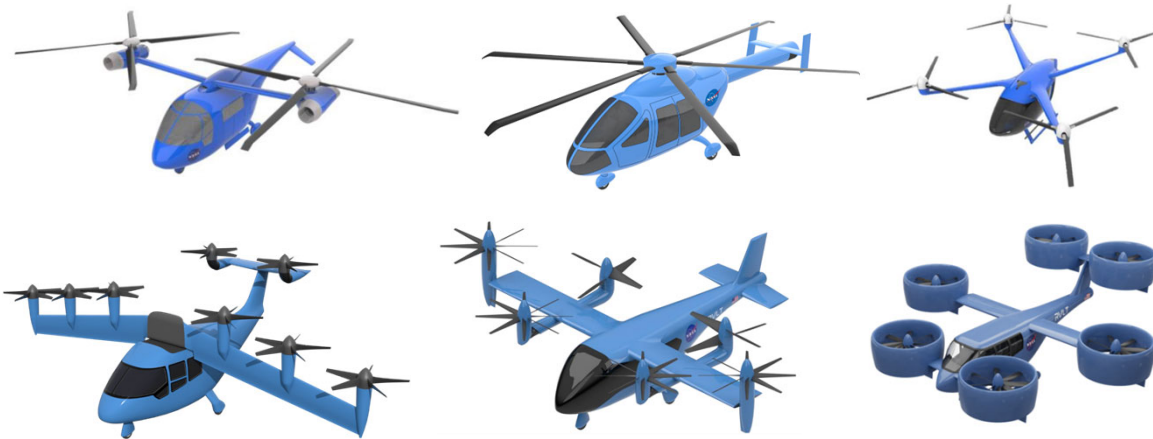


VANGARD test UAM aircraft sound stimuli obtained from multiple Original Equipment Manufacturers (OEMs)

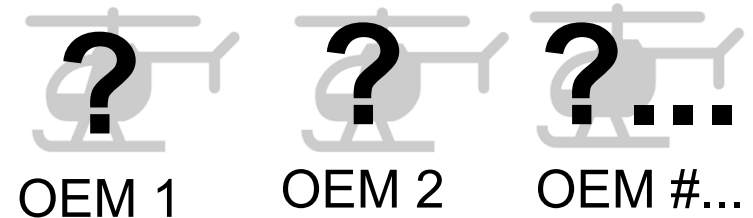
- 6 UAM vehicles
- 28 departure sounds
- 27 approach sounds
- 12 cruise sounds
- Binauralized

- **67** unique sounds
- 3 sounds each repeated 2 more times: **73** total test stimuli

NASA UAM Reference Vehicles (some included)

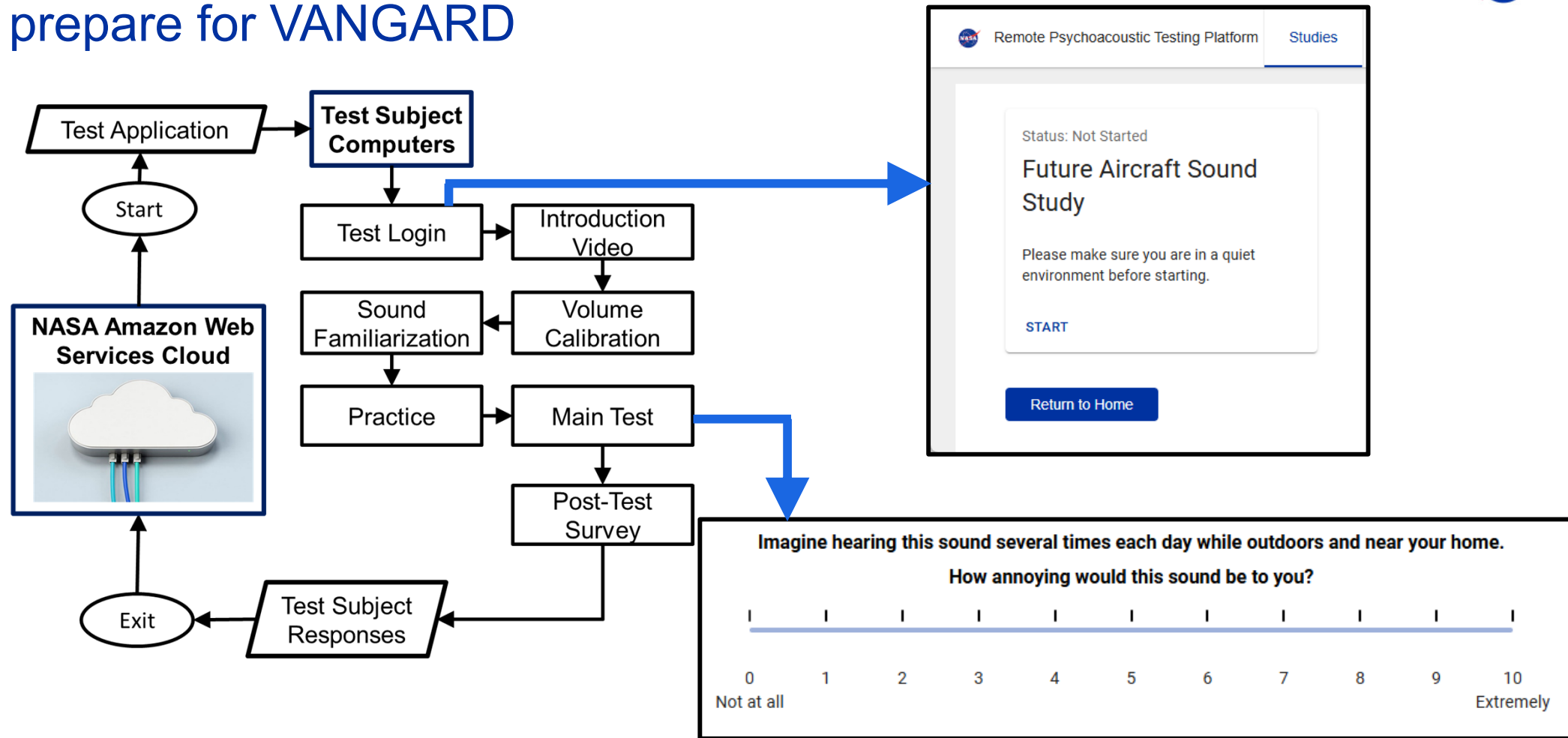


Additional UAM sounds from OEMs





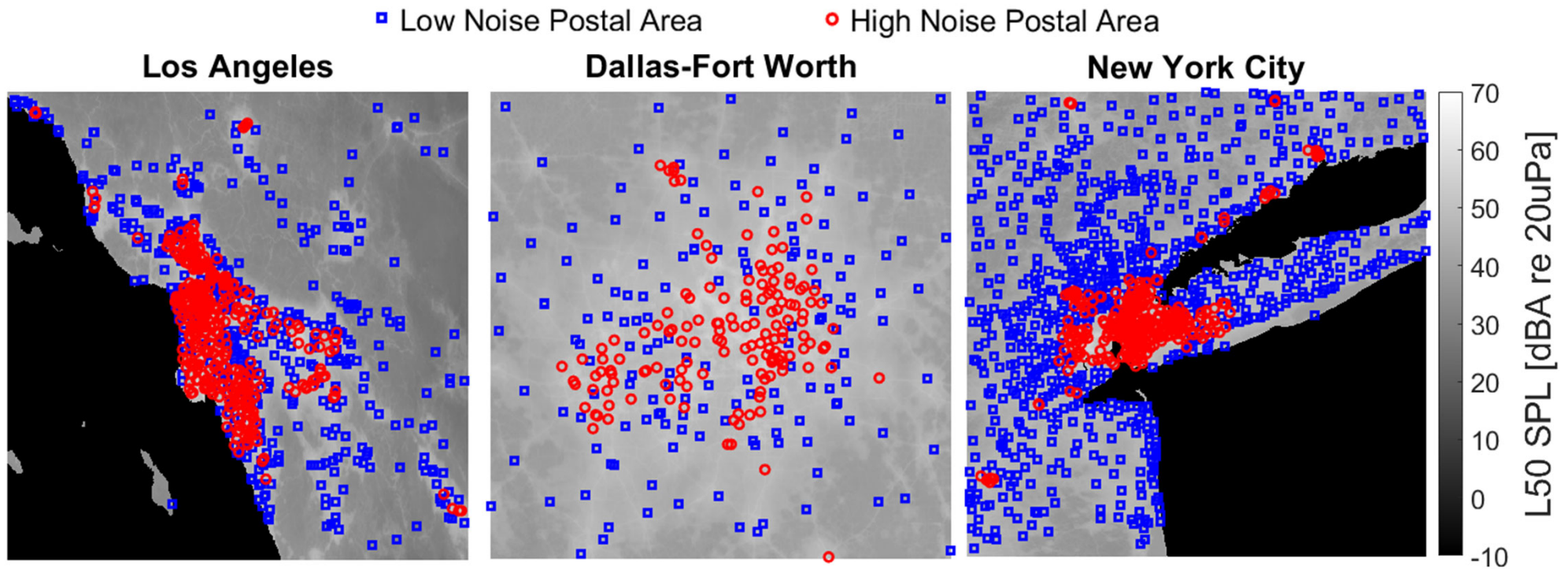
NASA Remote Psychoacoustic Test Platform was developed to prepare for VANGARD



Main test duration: 30 minutes

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

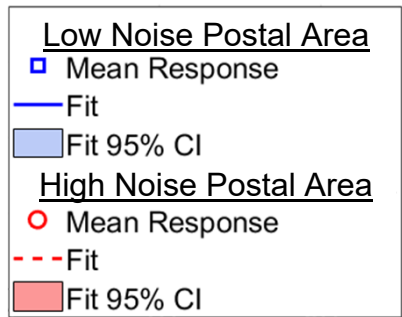


Multiple test reviews were completed in preparation for VANGARD test

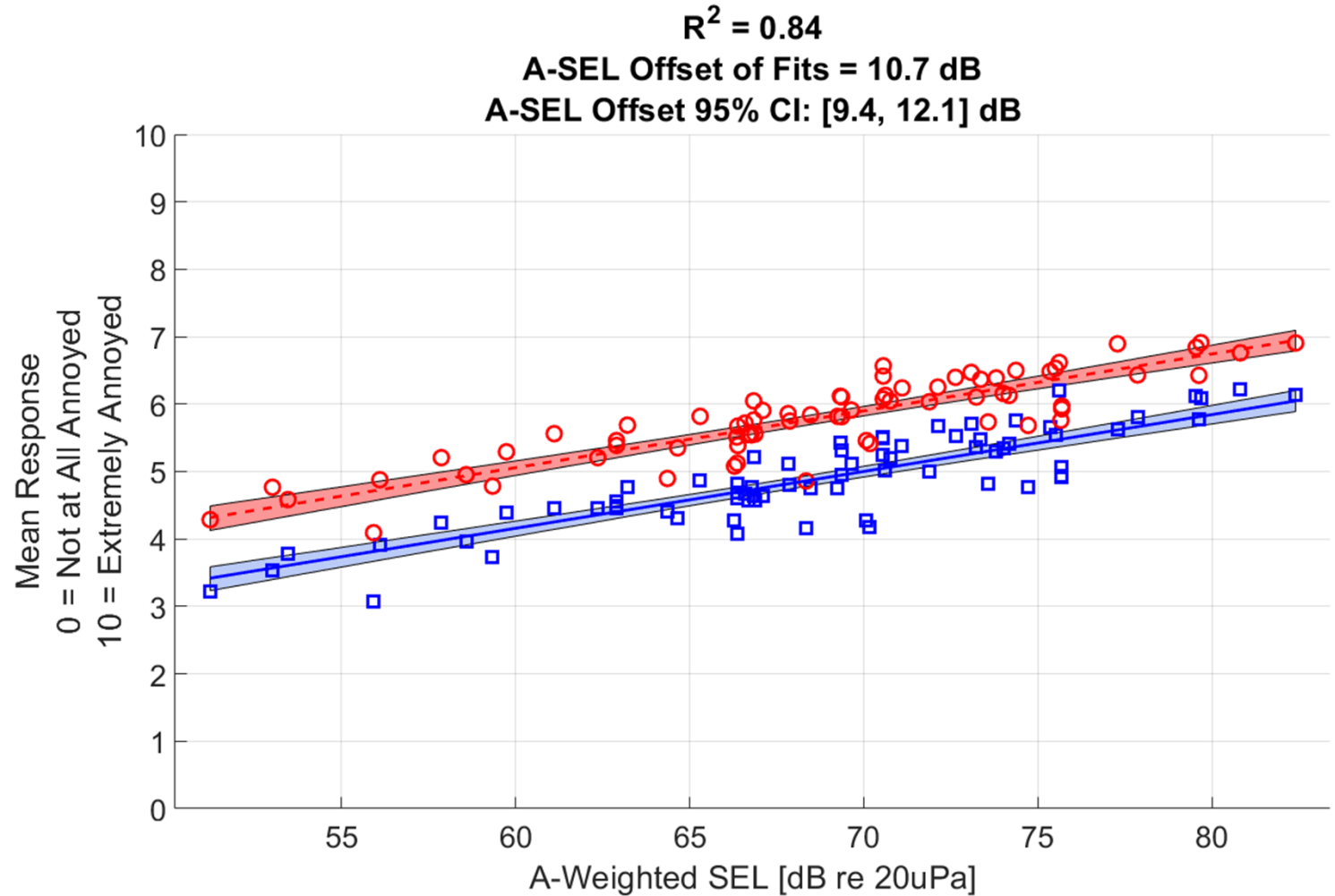
- **NASA Branch Test Review Panel Approval**
 - Assessed test's scientific merit and likelihood of success
- **NASA Institutional Review Board Approval** (eIRB Number STUDY00000862, FWA Number 00019876)
 - Approved that test protects human test subjects
- **Privacy Threshold Analysis (PTA) 3406615 and Privacy Impact Assessment (PIA) 4146570**
 - Approved that test protects Personally Identifiable Information (PII)
- United States Office of Management and Budget (OMB) **Paperwork Reduction Act (PRA)/Information Collection Approval** (OMB Control Number 2700-0196)
 - Approved test's burden on participants, recruitment methods, analyses methods, and test objectives
- NASA Remote Psychoacoustic Testing Platform **Accessibility Conformance Report Update**
 - Documented that Remote Psychoacoustic Testing Platform provides access to people with disabilities (to comply with Section 508 of the United States' Rehabilitation Act of 1973)



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



CI = Confidence Interval



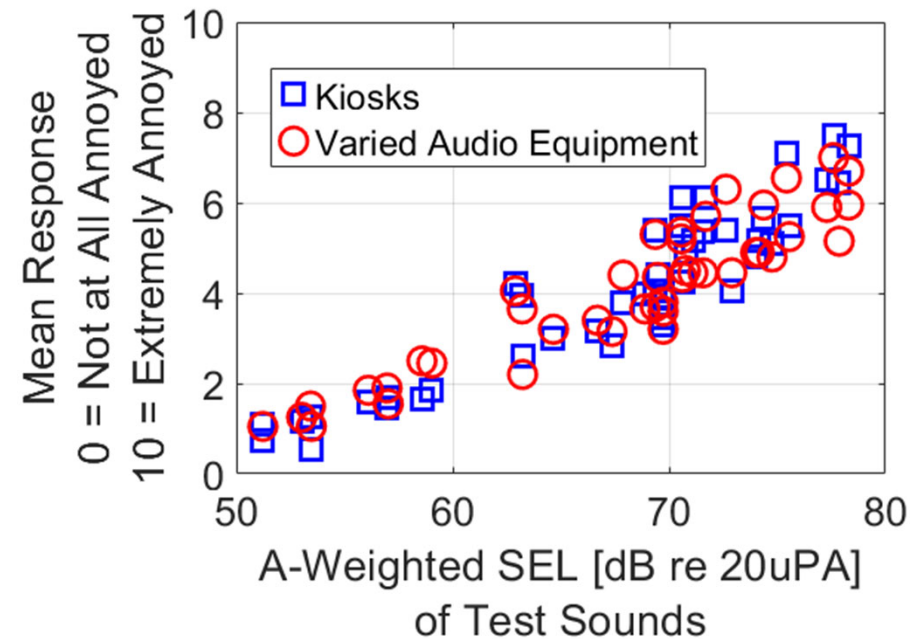
Having varied audio devices and manual calibration does not appear to change overall average responses

- 40 test subjects recruited from around Hampton Roads, VA
- 20 subjects in control group with kiosk tablet-headphone pair and fixed volume levels



Associated NASA TM: [Sound Level Calibration of a Kiosk for Psychoacoustic Testing](#)

- 20 subjects in comparison group using personal equipment



*Testing with kiosks used only 40 UAM sound stimuli



VANGARD test conducted with initial findings showing UAM noise response difference between high and low postal area participants

- Other initial test results not presented:
 - **(Test Objective 2)** Responses statistically the same for departure and approach sounds
 - **(Test Objective 3)** Percent Highly Annoyed (≥ 8 annoyance ratings) for departure and approach increases at sideline distances < 1000 ft
 - **(Test Objective 4)** Observed annoyance against different noise metrics in addition to A-SEL
 - **(Test Objective 5)** Observed annoyance vs. noise sensitivity
- Investigation into VANGARD test data continues
- NASA TM on stimuli generation and remote testing platform updates: [VANGARD Test Preparation](#).
- Analysis document to be released in coming months
 - Will provide response data and sound descriptions
 - Aircraft identities will remain anonymous
 - Sound pressure time histories will not be released



Acknowledgments

- The VANGARD test was conducted in support of the NASA Revolutionary Vertical Lift Technology (RVLT) and Subsonic Vehicle Technologies and Tools projects of the Advanced Air Vehicles Program
- UAM Noise Working Group participant feedback and input guided VANGARD test preparation

Questions?

Contact: siddhartha.krishnamurthy@nasa.gov



Acknowledgments, Continued

- The VANGARD test was made possible through the combined efforts of NASA civil servants, contractors, and NASA-external people:
 - Noah Schiller
 - Erin Matthews
 - Lauren Steele
 - Kelly Youngblood
 - Park Service
 - Benny Lunsford
 - Scott Reiff
 - NASA Test Review Panel:
 - Jordan Kreitzman
 - Jonathan Rathsam
 - Ronald Daiker
 - Trevor Carrithers
 - United States Office of Management and Budget
 - Susan Gorton
 - Stefan Letica
 - Angela Williams
 - Carl Russell
 - Len Lopes
 - DeBora Smith
 - Stephen Rizzi
 - Venkat Iyer
 - Shari Trigg
 - Technical Sergeant Elizabeth Valensole (JBLE)
 - Randolph Cabell
 - Doug Boyd
 - Kerry Gumbs
 - And others.....
 - Michael Doty
 - Nathan Cruz
 - Scott Reiff
 - Michael Guerin
 - Douglas Nark
 - Kevin Shepherd
 - Stayce Hoult
 - Whitney Craig
 - Aaron Vaughn
 - Tyler Tracy
 - Laura Midulla
 - Kimberly Taylor
 - Jason Pullias
 - Floor23 Staff:
 - Candace Spears
 - Cyndi Roman
 - Nicole Dedmond
 - Aric Aumann
 - Toya Leftwich
 - Muktar Mohammed
 - Brian Tuttle
 - Chris Sittig
 - Jeffrey Davenport
 - Kristi Willis
 - Durand Begault
 - Robin Edwards
 - Courtney Ritz
 - Andrew Christian
 - Jerlin Hurtado
 - Kenneth Goetzke
 - United States National
 - Ryon Stewart



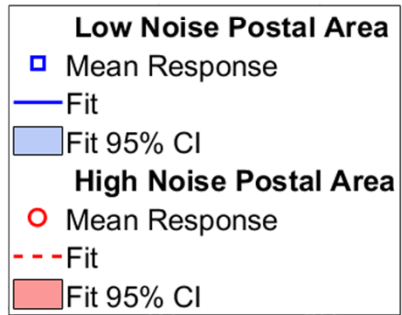
Image Sources

- All images in this presentation were generated internally by NASA

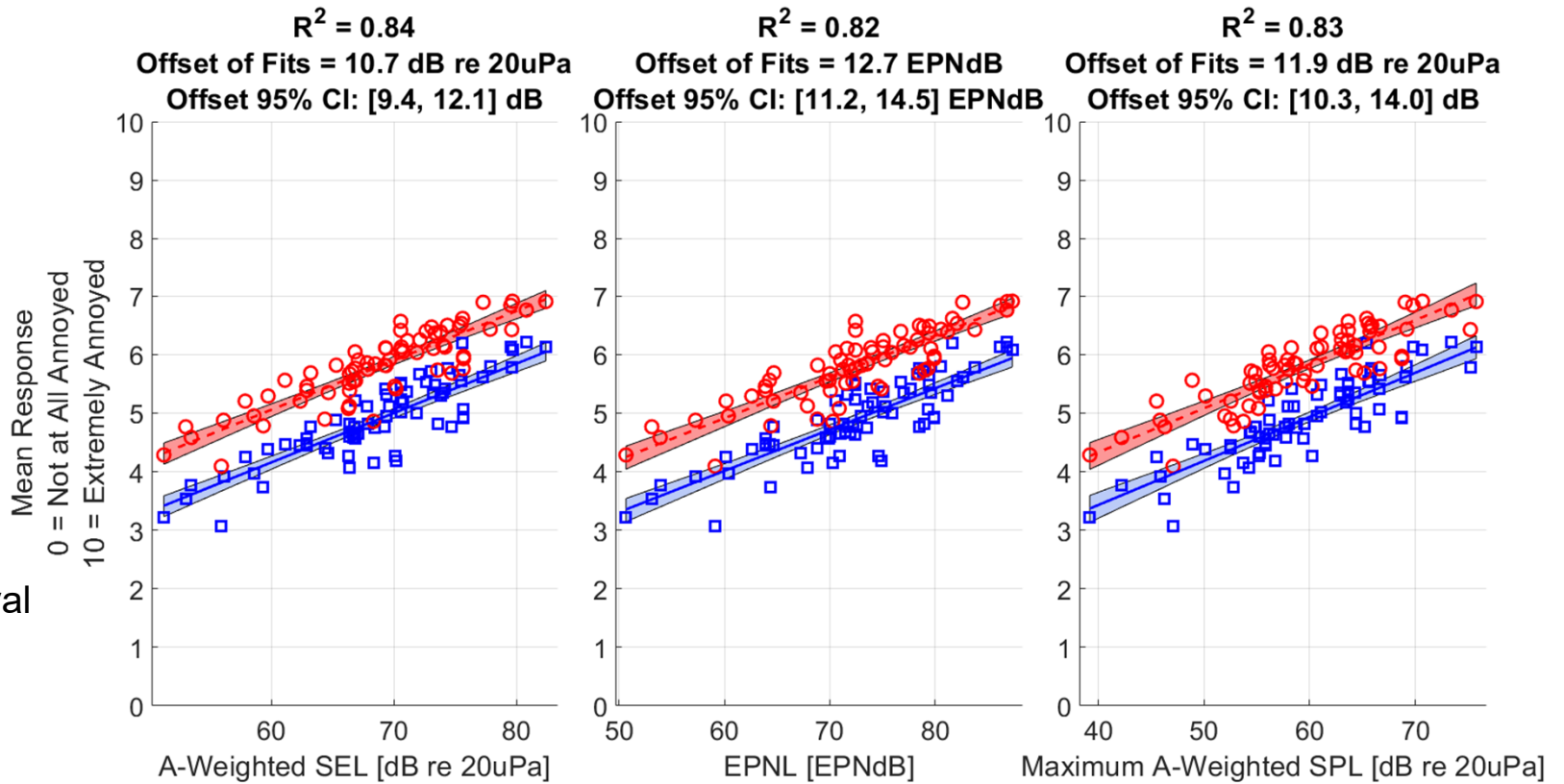
Backup Slides



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

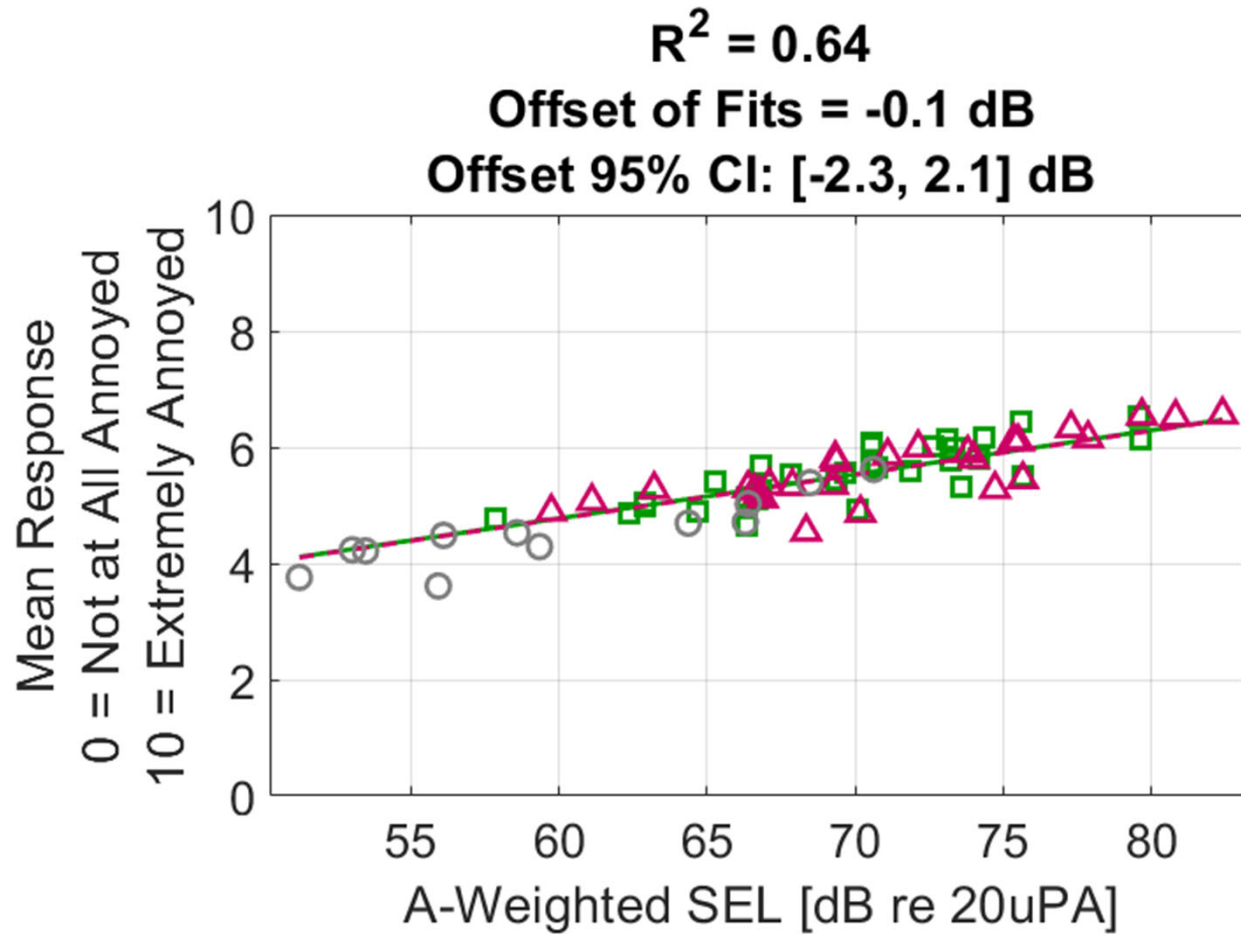
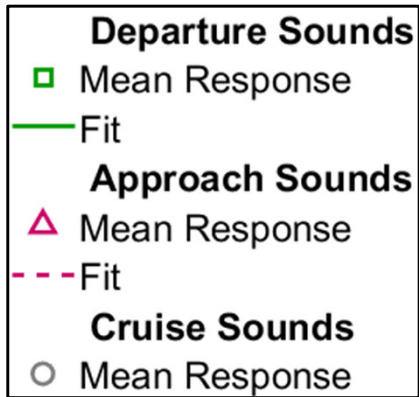


CI = Confidence Interval





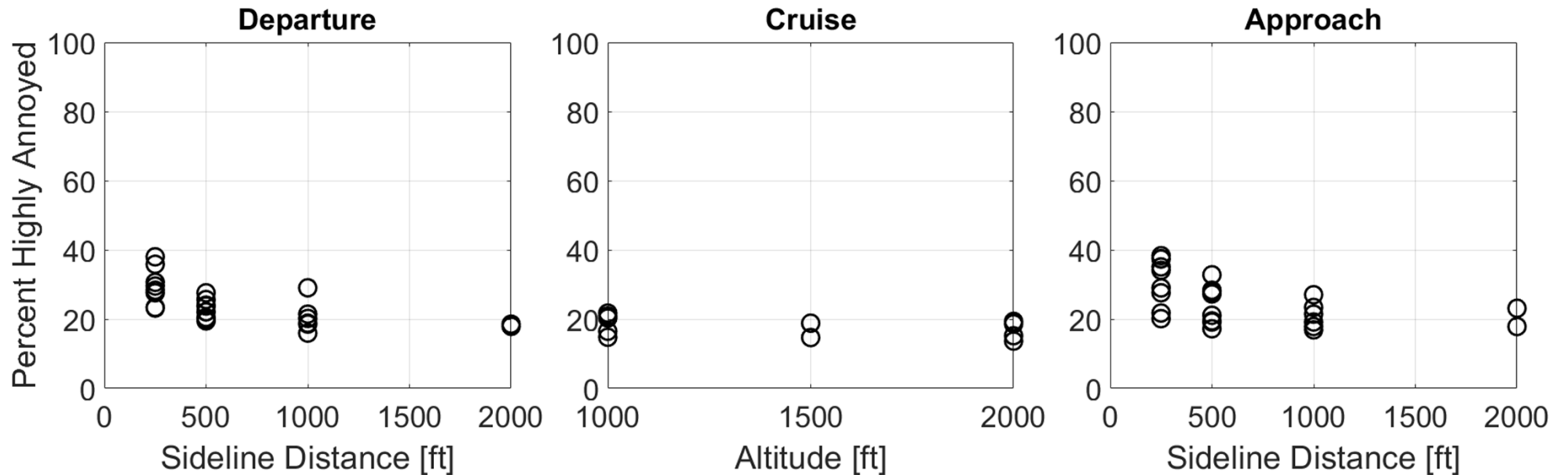
No difference found in mean annoyance responses to approach and departure flight phases





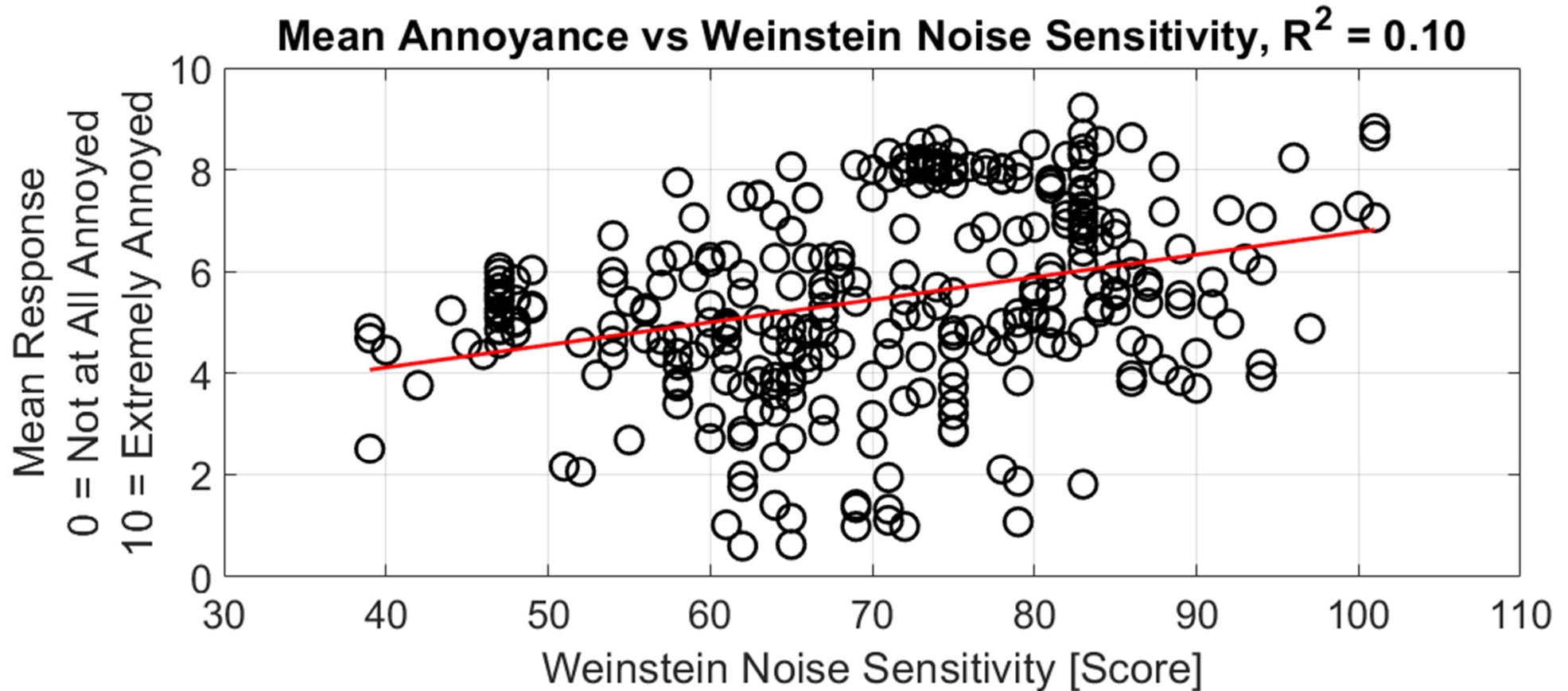
Percentage Highly Annoyed for approaches and departures may be greater than for cruise at sideline distances < 1000 ft

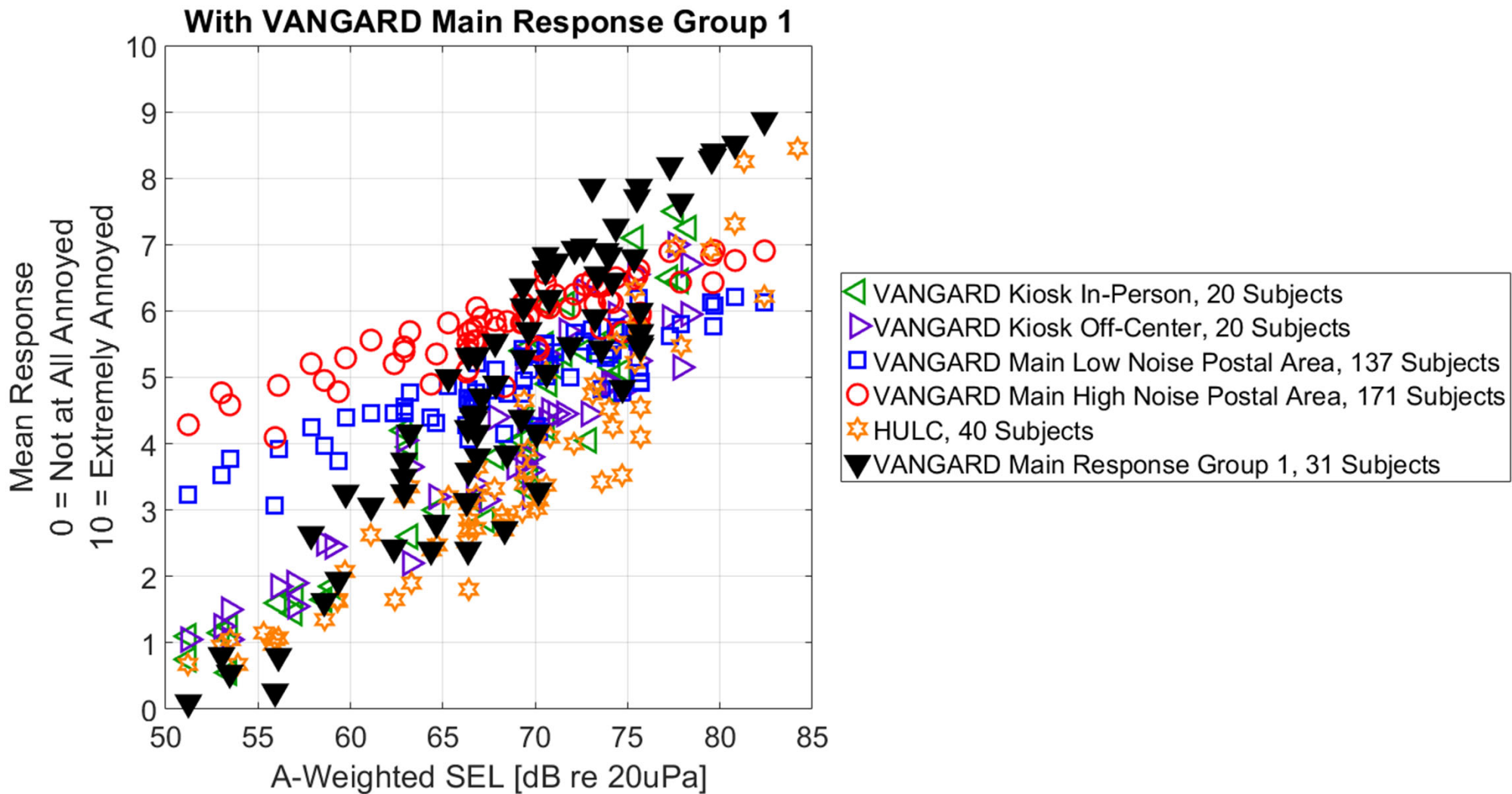
VANGARD Main Test, Percent Highly Annoyed with Distance



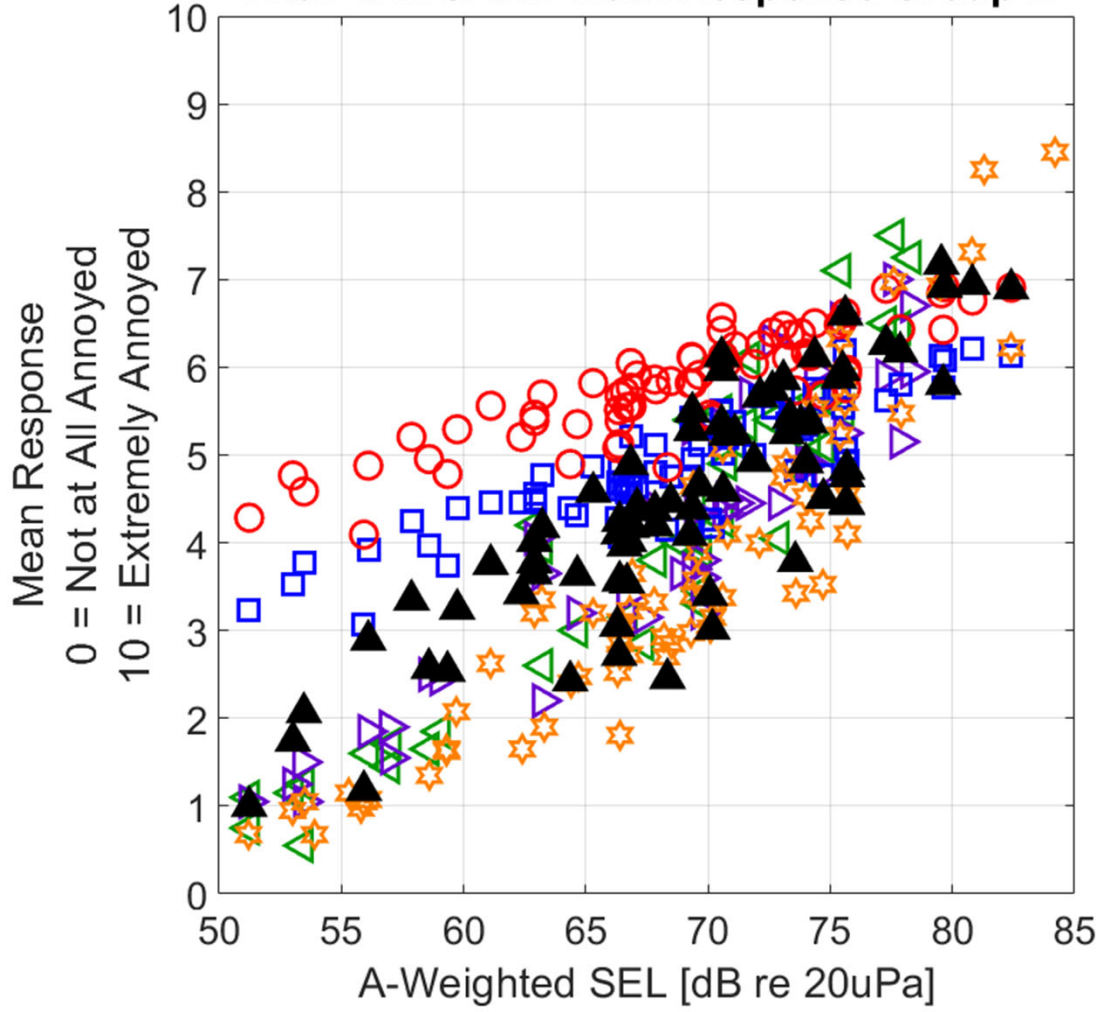


Noise Sensitivity Post-Test Survey results may help determine other objectively measurable factors affecting annoyance



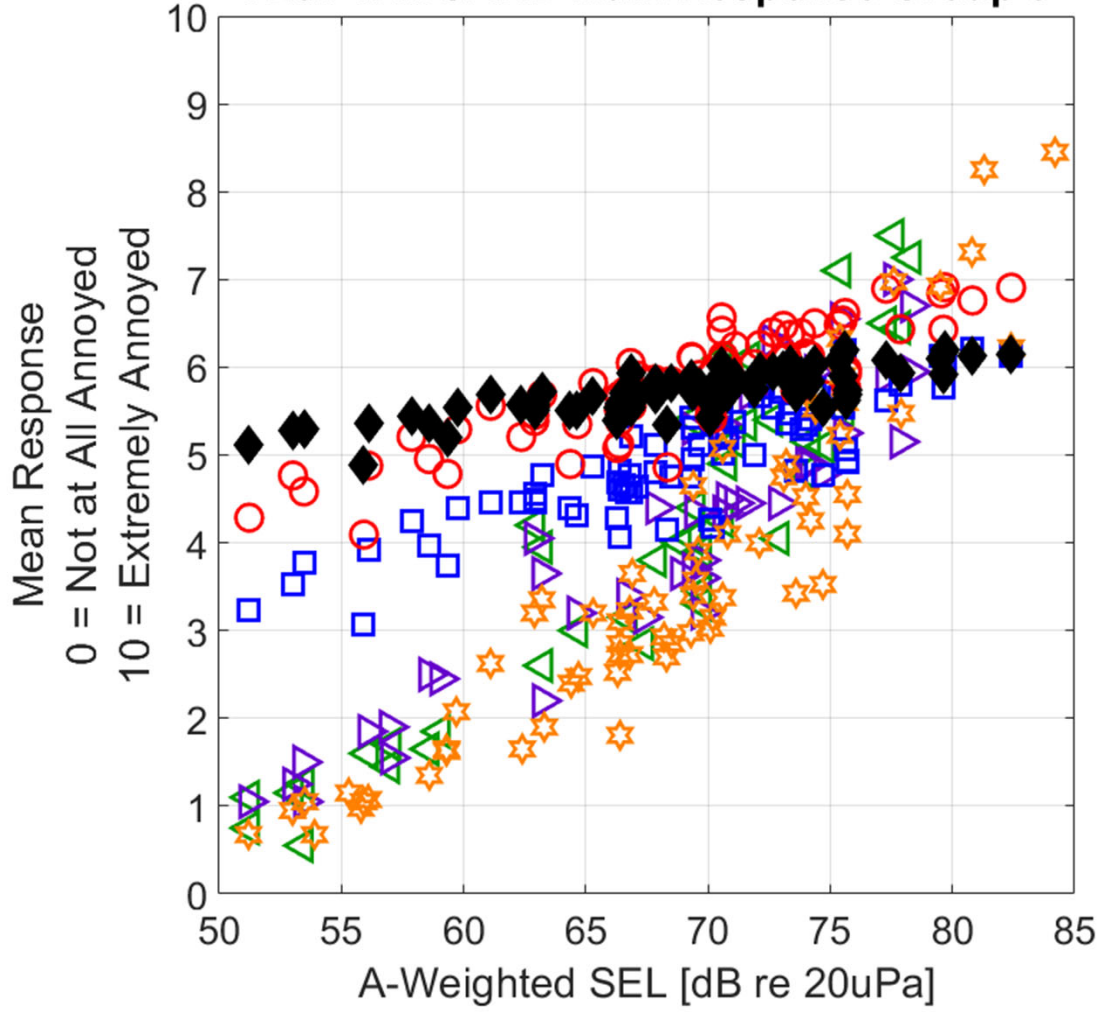


With VANGARD Main Response Group 2



- ▽ VANGARD Kiosk In-Person, 20 Subjects
- ▽ VANGARD Kiosk Off-Center, 20 Subjects
- VANGARD Main Low Noise Postal Area, 137 Subjects
- VANGARD Main High Noise Postal Area, 171 Subjects
- ☆ HULC, 40 Subjects
- ▲ VANGARD Main Response Group 2, 57 Subjects

With VANGARD Main Response Group 3



- ▽ VANGARD Kiosk In-Person, 20 Subjects
- ▽ VANGARD Kiosk Off-Center, 20 Subjects
- VANGARD Main Low Noise Postal Area, 137 Subjects
- VANGARD Main High Noise Postal Area, 171 Subjects
- ☆ HULC, 40 Subjects
- ◆ VANGARD Main Response Group 3, 220 Subjects