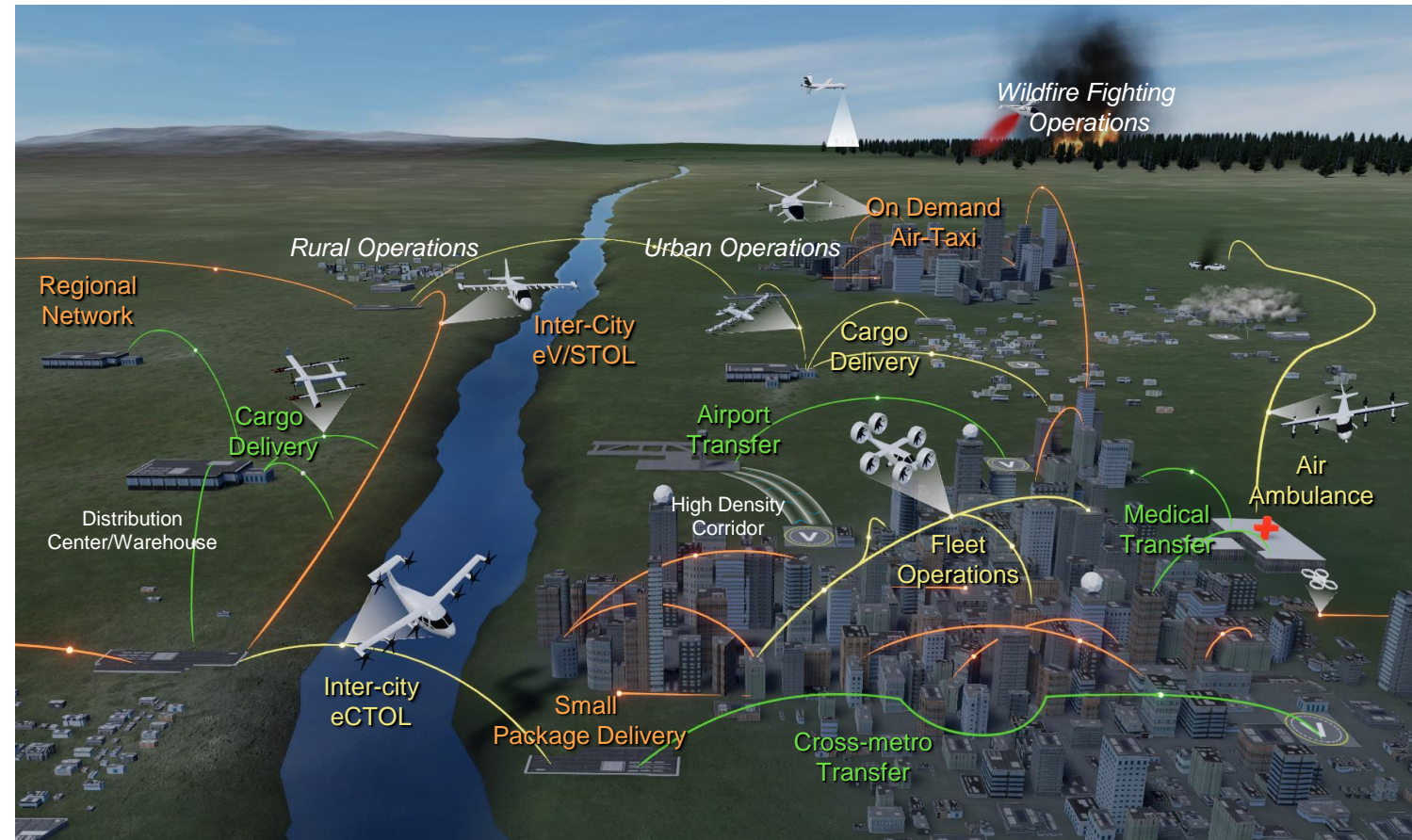# An Overview of NASA Research into Urban Air Mobility Noise

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Aviation Noise & Emissions Symposium 2022
UC Davis Conference Center
May 1-3, 2022

Advanced Air Mobility (AAM) and Urban Air Mobility (UAM)

- AAM is a vision for a safe, accessible, affordable, and sustainable aviation system for transformational local and intraregional missions.

- Missions include public transportation, cargo delivery, air taxi, and emergency response.

- Urban Air Mobility (UAM) is a subset of AAM that is projected to have high economic benefit, but also may be the most difficult to develop.

  →Noise is a major concern for the UAM concept!

https://www.nasa.gov/aam

Advanced Air Mobility (AAM) Mission

Wildfire Fighting Operations

Rural Operations

Urban Operations

On Demand Air-Taxi

Regional Network

Inter-City eV/STOL

Cargo Delivery

Cargo Delivery

Airport Transfer

Air Ambulance

High Density Corridor

Distribution Center/Warehouse

Medical Supply Delivery

Fleet Operations

Inter-city eCTOL

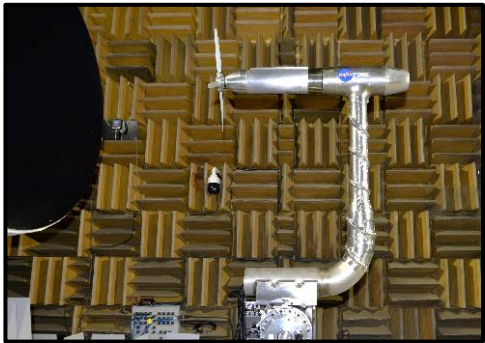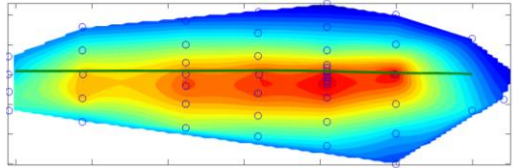Small Package Delivery

Cross-metro Transfer

Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions
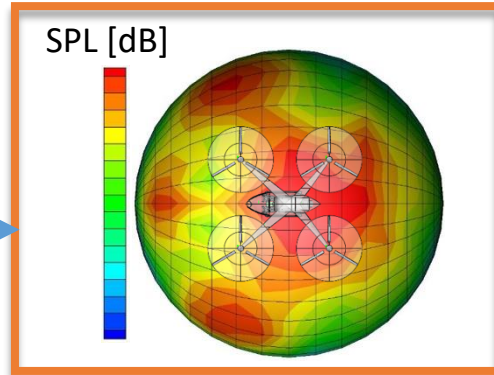
UAM Noise Research @ NASA
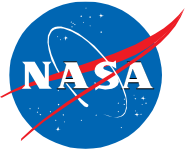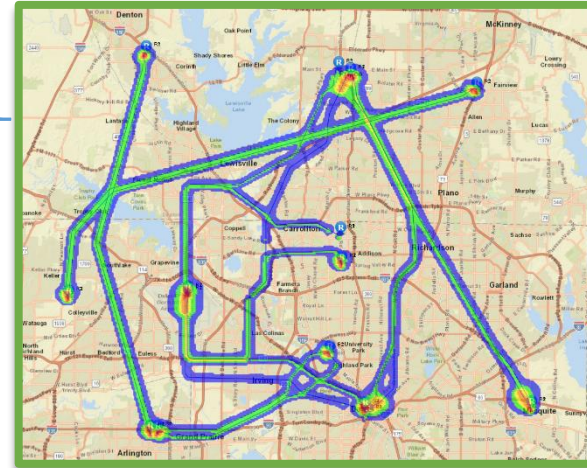
Acoustic Flight Tests

Wind Tunnel Tests

UAM Source Noise Tool Development and Validation
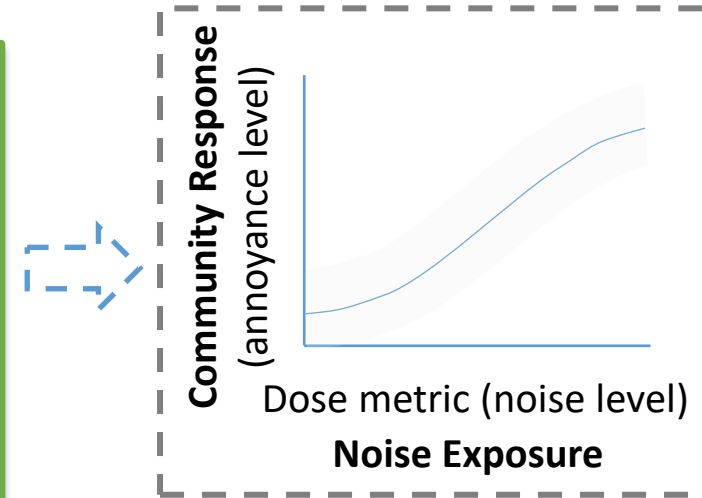

SPL [dB]

Human Response to Noise

NASA seeks to develop audibility and annoyance models and characterize the noise footprint of UAM operations

UAM Fleet Noise Prediction Capability

Community Response to UAM Operations*

Community Response (annoyance level)

Dose metric (noise level)

Noise Exposure

*Possible future effort, not led by NASA

Modelling goals:

- Predictions of audibility and short-term annoyance of UAM vehicles in the presence of an existing soundscape
- Best practices for predicting cumulative noise impact of fleet-wide operations
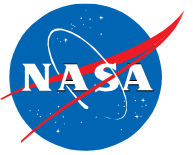
Measurements are taken in order to:

- Validate modeling tools used to generate noise database
- Support human response tests

Laboratory Psychoacoustic Testing

- Figuring out how humans respond to short term noise is something that can be done in a laboratory situation.
- Questions we can answer in a lab tend to be more relative in nature, such as:
  - What are the aspects of sound that cause increased annoyance (e.g., prominent tones)?
  - Is one aircraft model more annoying than another?

- Questions not easily answered in a psychoacoustics lab involve the more socioeconomic aspects of noise, and are more absolute in nature:
  - Do people *fear* the source (e.g., falling on their house)?
  - Do people have an economic relationship to the source?
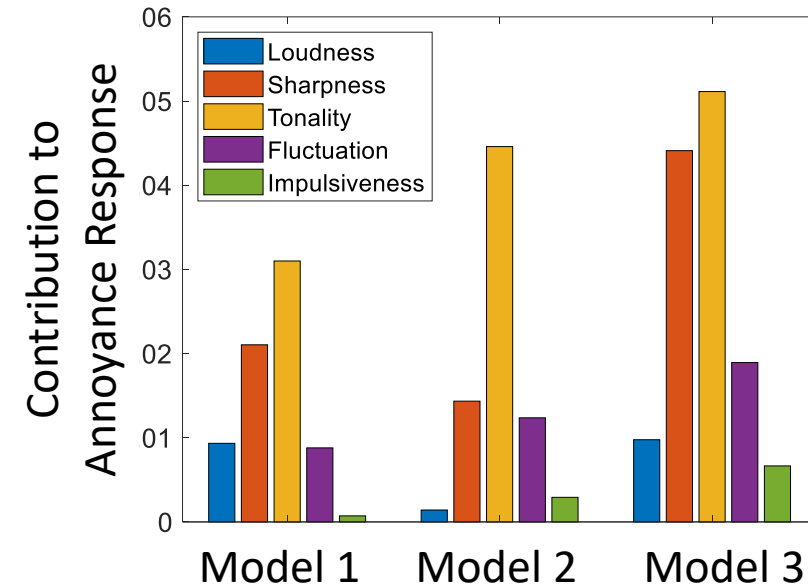
Psychoacoustic Testing for UAM
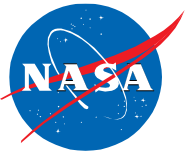
NASA has plans to conduct several lab tests over the next two years for UAM-like sounds.

The questions we are interested in investigating include:

1. What are the qualitative attributes of UAM sound that lead to annoyance? Do things like the presence of tones from motors, impulsiveness of the rotors, or frequency fluctuation in the sound lead to more annoyance?

2. What way should we be integrating annoyance over time? How does annoyance build up over the course of a single event? How does it build up over the course of multiple events?

3. What role does background sound play in the annoyance of UAM? How does a preexisting (e.g., urban) soundscape impact the perception of UAM vehicles?

These tests are meant to produce data that will be used in building models of annoyance that are inclusive of these effects.

Model Building
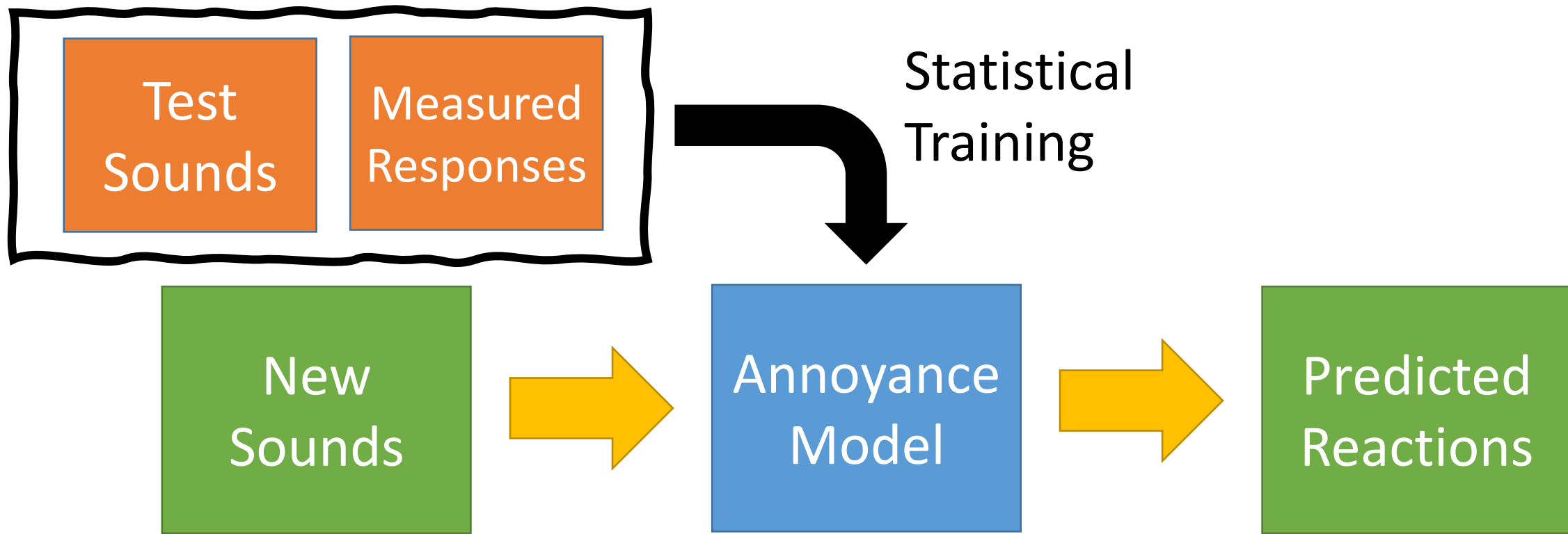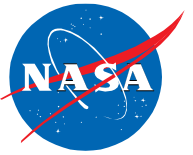
If we do a reasonable job of capturing the human response to UAM-like sounds, then the model that we build from that data should be able to predict the response to novel (not-yet-heard) sounds. We want the model to capture as many of the nuances discovered in the data as possible.
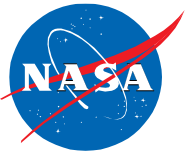
Model Usage(s)

What could we do with this model once we have it?

- The full model would obviously be useful as a research tool but may require prohibitively pristine data to be used widely.

We can distill the model down when only coarser data are available:
- A model that uses recordings/predictions of a vehicle and some description of a background noise could be used in the design phase of UAM aircraft, in order to address possible noise problems before the vehicle is even built.
- Regulators may be able to compare the performance of the model to that of existing noise metrics. Perhaps it will capture aspects of UAM-noise that will correlate in new ways with (future) community response.

UAM Noise Working Group: Origins

- A good way to engage with NASAs (technical) efforts on UAM noise is through the UAM Noise Working Group (UnWG).
  - NASA-led group including stakeholders across industry, government agencies, academia, and community groups.
  - Twice-yearly meetings for the entire UnWG.
  - Monthly meetings within the 4 subgroups:
    Tools & Technologies
    Ground & Flight Testing
    Human Response & Metrics
    Regulation & Policy

- This group started in Spring 2018 with about 70 members. The most recent UnWG meeting (last month) had ~300 registrants.
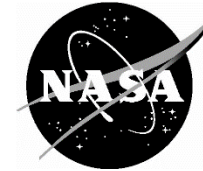
UAM Noise Working Group White Paper
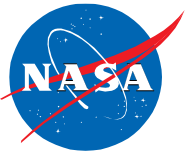
As a first effort, a NASA technical publication was released in 2020: TP-2020-5007433

Available for download via the NASA Technical Report Server (NTRS):

https://ntrs.nasa.gov/search?q=2020
5007433

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
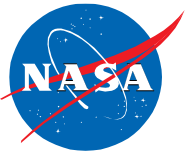Hua (Bill) He, Federal Aviation Administration, District of Columbia
Royce Snider, Bell Flight, Ft. Worth, Texas

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

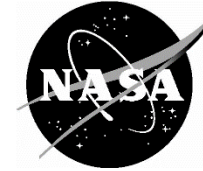October 2020

UAM Noise Working Group White Paper

The overall goal:

- Document noise reduction technologies available for UAM and identify knowledge gaps for each of the four areas of interest (UnWG subgroups).

Among the other high-level goals:

- Assess metrics for audibility and annoyance of single-event vehicle operations using available predicted and measured data.
- Examine fleet noise impacts through prediction and measurement, and characterize effectiveness of supplemental metrics for audibility and annoyance.

NASA/TP–2020-5007433

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

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Mehmet Marsan, Federal Aviation Administration, District of Columbia
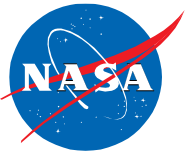Hua (Bill) He, Federal Aviation Administration, District of Columbia
Royce Snider, Bell Flight, Ft. Worth, Texas

UnWG Human Response Study

- Motivated by UnWG white paper recommendations to perform psychoacoustic experiments.
  - Study will utilize a new remote psychoacousitc testing capability.
  - A first phase is expected to run this summer.

- Goals include:
  - Provide insights into human response to UAM vehicle noise that would be challenging for any single agency or organization to acquire.
  - Create a rich human response database to UAM vehicle noise that can be used for model building.

How annoying was the sound to you?

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

Ground Vehicles Offset = -5.64 [dB]