

UAM Noise: Current Practice, Gaps, and Recommendations (A Summary of the UAM Noise Working Group White Paper) + UAM Operational Fleet Noise Assessment

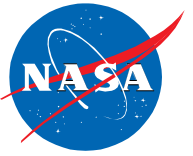


Stephen A. Rizzi
Senior Researcher for Aeroacoustics
NASA Langley Research Center
s.a.rizzi@nasa.gov



NASA Tech Talks
Ames Research Center
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UAM Noise Exploratory Meeting (April '18)



- Positive interest in forming a focused working group to define and address noise goals for UAM vehicles.
- Participants should include stakeholders across industry, government agencies, academia, and community groups.
- Focus efforts on reducing or eliminating the barriers associated with community noise.
- Key topics of interest include:
 - Tools & Technologies
 - Ground & Flight Testing
 - Human Response & Metrics
 - Regulation & Community Outreach

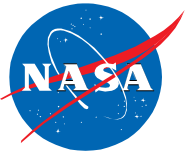


~ 70 attendees at Exploratory Meeting

UNWG Meeting Recap

- Two face-to-face meetings per year held in conjunction with NASA Acoustics Technical Working Group meeting – Spring (LaRC), Fall (GRC)
- 1st Meeting – Focus on organization, defining the scope and setting of goals
 - October 2018 @ NASA Glenn
 - 95 attendees
- 2nd Meeting – Focus on white paper development
 - April 2019 @ NASA Langley, 125 attendees
- 3rd Meeting – Focus on experimental database and model validation
 - October 2019 @ NASA Glenn
 - 131 attendees





UNWG High Level Goals

Immediate (< 2yr)

- Document state-of-the-art and identify knowledge gaps for each of the UNWG subgroups.

Near-Term (5 yr)

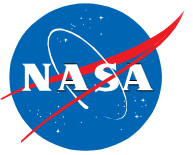
- Assess prediction capabilities for benchmark problems based on open set of reference vehicle designs and validate using available data.
- Assess metrics for audibility and annoyance of single-event vehicle operations using available predicted and measured data.
- Define measurements to support assessment of community noise impact and coordinate with UAM OEMs on development of low noise approach and takeoff procedures for piloted and automated operations.
- Assess the need for development of a public engagement strategy to promote successful UAM integration into communities.

Mid-Term (10 yr)

- Examine fleet noise impacts through prediction and measurement, and characterize effectiveness of supplemental metrics for audibility and annoyance.

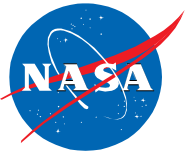
Far-Term (15 yr)

- Promote UAM integration into communities through mitigation of fleet noise impacts, and engagement with the public.



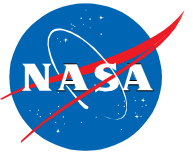
Recommendations – Tools & Technologies

- Prediction tools need to account for variable speed rotors and other temporal variation effects.
- A reprioritization of noise sources needs to be performed.
 - UAM vehicles include multiple rotors/propellers with dynamic transition and new noise sources such as electric motors or hybrid-electric propulsion.
- Scattering and propagation methods need to be developed that include the vehicle components and surfaces near a receiver such as buildings and vertiports.
- Validation databases are needed to quantify prediction uncertainties.
- Prediction tools used to evaluate community noise need source models appropriate for a wide range of UAM vehicles.
- Existing noise reduction technologies need to be evaluated, and new noise reduction technologies should be developed in anticipation of future noise requirements.



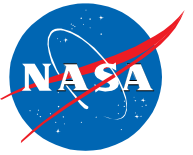
Recommendations – Ground & Flight Testing

- Measurement techniques for source identification, separation, and quantification need to address traditional and nontraditional aircraft noise sources.
- Measurements are needed for developing and validating multipath propagation tools.
 - Introduction of vertiports in populated areas with “urban canyons.”
- Measurement procedures need to be developed to capture the relevant range of operational noise.
 - Unsteady sources due to maneuvers, variety of takeoff and approach trajectories, development of noise abatement procedures.
- Consideration needs to be given for both piloted and autonomous operations.



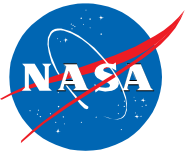
Recommendations – Human Response & Metrics

- Perform psychoacoustic tests to measure human response, e.g., annoyance and audibility, to UAM vehicle noise in representative operational environments.
 - Need for recordings and/or simulations (auralizations)
- Assess the appropriateness of existing metrics and develop annoyance and audibility models for application to research and to inform future rule making.
 - In addition to conventional noise level metrics, considerations such as audibility and temporal variation of sound may be required.
- Provide candidate measures of human response to integrate with perception-influenced design.
- Perform studies to measure the responses of real communities to real UAM operations.
- Assess differences between indoor or outdoor noise exposure.



Recommendations – Regulation & Community Outreach

- Regulators need to decide if current policies are appropriate or if new regulations will be needed to address UAM noise.
- A noise database is needed before regulations can be established.
 - There is a lack of UAM noise data since prototype vehicles are just starting to emerge.
- There is a strong possibility that new standards will need to be developed.
 - There is an uncertainty on how applicable current measurement standards will be for UAM vehicles.
- Premature deployment of UAM could have a devastating impact on the future and could result in local noise ordinances that restrict operations.
- The general public needs to be informed and engaged early in the process.



Next Meeting @ NASA Langley

April 7-8, 2020 – Acoustics Technical Working Group Meeting

- Wednesday afternoon focus – UAM noise
- Presentations include NASA AAM project, recent developments at Joby, multiprop-wing interaction test, psychoacoustic testing at NASA and Uber, noise measurements of Moog SureFly vehicle, electric motor noise

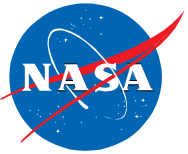
April 9, 2020 – UNWG Meeting (focus on community outreach)

- Preliminary agenda
 - 0830-0845 – Kickoff and status
 - 0845-1115 – Invited talks
 - City of Los Angeles policy making framework of transportation noise, Todd Peterson (Ellis & Associates), Ryan Biziorek (Arup), Peter Falt (DesignWorks)
 - It's not just about noise: an introduction to the Community Air Mobility Initiative (CAMI), Anna Dietrich, Executive Director
 - National Organization to Insure a Sound Controlled Environment (N.O.I.S.E.), Emily Tranter, Executive Director
 - Lessons learned from Google Wing in Australia, Margaret Nagel, Head of Policy and Government Affairs, Wing Aviation
 - 1115-1130 – Breakout session guidance
 - 1130-1230 – Lunch
 - 1230-1500 – Breakout sessions
 - 1500-1600 – Wrap up

Registration at

<https://evt.grc.nasa.gov/atwg-spr2020/>

UAM Operational Fleet Noise Assessments

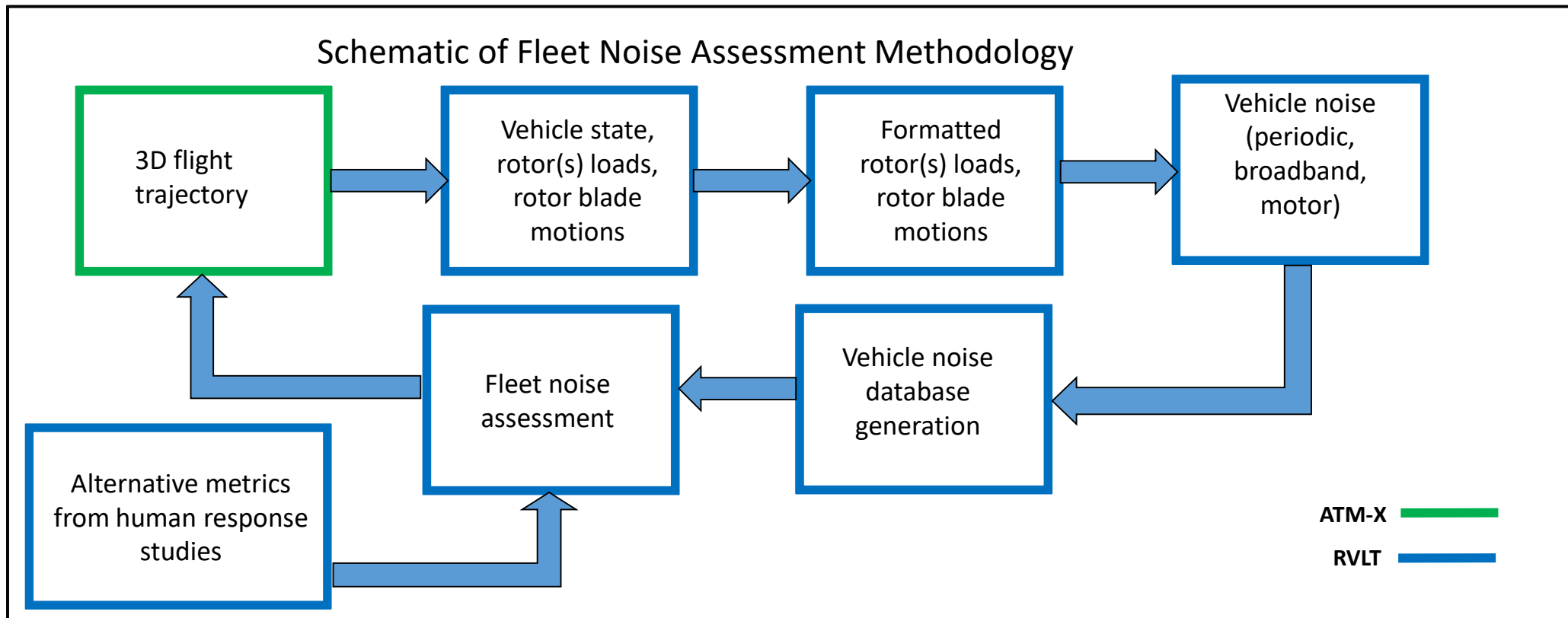


Approach

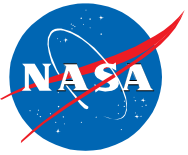
- Three tracks
 - UAM vehicle noise database generation
 - Fleet noise assessments
 - Human response and alternative metrics
- Collaborating with ATM-X for trajectory definition and flight operations optimization

Major Outcomes

- Database for UAM vehicle noise, including broadband and electric motor noise
- Evaluation of AEDT for UAM fleet noise
- Development of models for audibility and annoyance of UAM vehicles
- Noise footprint assessment of UAM operations
- Documented methodology for fleet noise analyses of UAM vehicle concepts



Tool Development



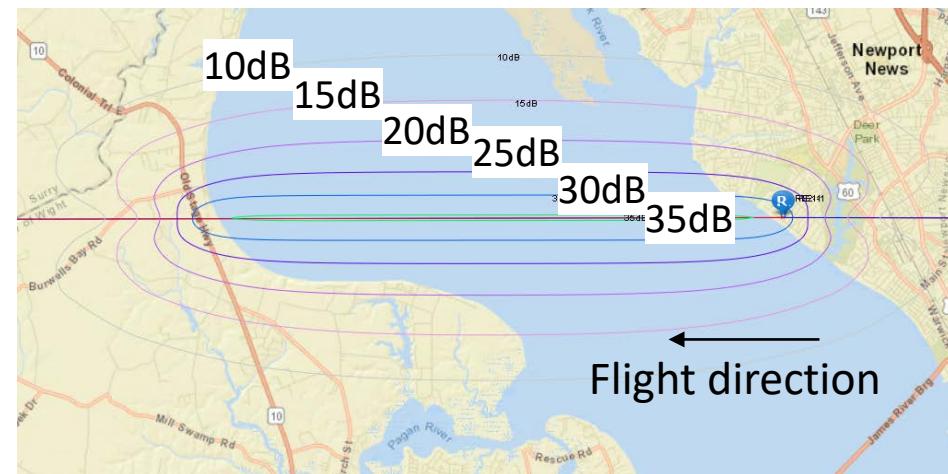
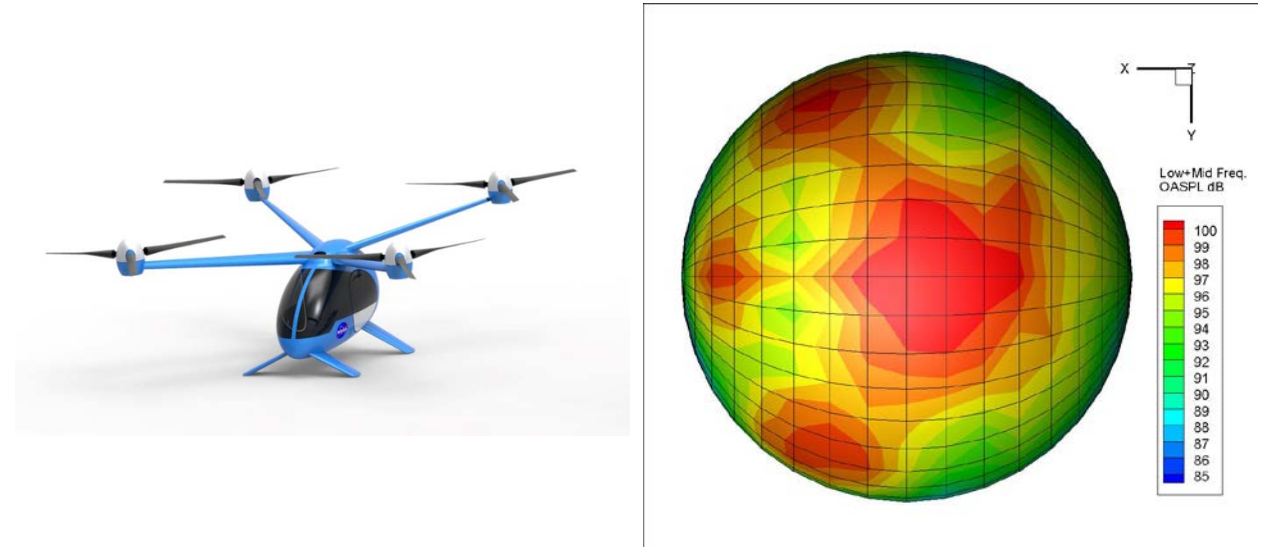
Tools to generate noise data suitable for fleet noise analyses

- Prediction method has been modified to generate initial NPD (Noise-Power-Distance) curves for vehicles
- Source hemisphere predictions with CAMRAD II + ANOPP2/AARON for each vehicle “state” (defined by air speed and climb angle)
- NPD type data generated by “flying” noise hemispheres at AEDT reference speed in level flight over microphone
 - Forward flight segments capture changes in polar directivity
 - Vertical segments use a single point below the vehicle

Tools and procedures for fleet noise analysis

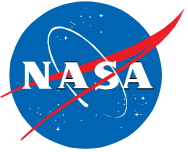
- Predicted NPD curves used as input to AEDT
- Noise footprints using the NPD curves are computed using a fixed point profile method bypassing the need for a UAM performance model
- Familiarization tasks are revealing issues that the team is solving to make AEDT work for UAM vehicle configurations
- Example: Calculation for noise footprint of an R-66 has been performed by generating NPD curves representing unique operational states during flight

Noise hemisphere for RVLT Quad in forward flight



Predicted DNL for one R-66 110 knot cruise at 1000 feet

Gen-1 Noise Assessments



- Fleet mix
 - RVLТ Quad (6 pax electric, with collective control)
 - RVLТ L+C (6 pax turboelectric, with collective control)
- 16 trajectories for each vehicle provided by ATM-X UAM X2 team
- Almost as many unique operational states as trajectory points (too many to generate noise hemispheres for each)
 - Reduced set (less than 100) identified at waypoints selected by user-defined changes in ground track, air speed and climb angle
- In process of developing Gen-1 database (thickness and loading noise)

