

UAM Noise Working Group Meeting Subgroup 2: Ground & Flight Testing

14 April 2022

Hybrid UNWG Meeting

Langley Research Center, VA

Group Leads:

Devin Boyle (NASA, GRC), Juliet Page (Blue Ridge Research & Consulting), Kyle Pascioni (NASA, LaRC)

SG2 Activities

- Co-Leadership:

- Devin Boyle (NASA, GRC)
- Juliet Page (Blue Ridge Research & Consulting)
- Kyle Pascioni (NASA, LaRC)

We have an active subgroup!

- Monthly Team meetings:

- Third Thursday of the month, 12-1pm ET
- Appx. 20-30 in attendance at meetings
- Appx. 60 on distribution

- Draft document prepared identifying measurement protocols

- Shared protocols document development via OneDrive hosted by E. Greenwood (PSU)
- Repository for SG2 materials

- Baseline protocol document developed and shared with other Subgroup 1, 3, and 4 leads
- Upcoming Discussions (@Breakout):
 - Eric Greenwood will be discussing variability in noise measurements

Goal: Ground & Flight Testing Subgroup Goal

Develop a research measurement protocol or set of guidelines which can be used to adequately quantify vehicle acoustic emission for the evaluation of community noise impact.

Approach: Define measurements suitable for the creation of acoustic spheres

- Ensure sufficient data is gathered to support quantifying community noise impacts
- Activities envisioned to all the other SGs: Tools/Technologies, Metrics, Regulation & Policy
- **Baseline protocol document has been developed**
 - Created topic groups to develop content for each relevant section of the document
 - Define a prioritized list of measurements that would fully define the acoustic environment for the community
 - Working towards defining minimum requirements for acoustic measurements
 - Include rationale for measurement protocols to inform researchers and practitioners about technical impetus for guidance contained in document
 - Living document

SG2 Measurement Protocol Outline

Introduction

Measurement Protocol

- Environment:
 - Temperature and Humidity
 - Wind
- Background Noise
- Signal to Noise Ratio Assessment
- Microphone Positions and Orientation

- Ground Impedance
- Terrain and Obstructions
- Time Synchronization
- Signal Processing

Open Items and Discussion Topics

- Array Layout
- Variability
- Additional Considerations within Scope of Subgroup 2

Review current research, existing standards, certification procedures and guidelines. Discuss interrelated items and develop SG consensus on testing topics, including confidence level needs.

Ground & Flight Testing - Recommendations

- ✓ Mentioned in Protocol Document
- Not addressed yet

- ✓ Test environment constraints (e.g., ambient levels, benign meteorological conditions), similar to those in ICAO Annex 16 Vol. I and 14 CFR Part 36, be used for all tests conducted to measure UAM vehicle noise.
- ✓ Significant on-aircraft instrumentation and monitoring of the vehicle state be required due to varying levels of autonomy and potential increase in degrees-of-freedom of the flight envelope.
- ✓ Stakeholders (including manufacturers, researchers, and certification authorities) closely collaborate in the development of new measurement approaches.
- ✓ Use of flush mounted or inverted microphones over a rigid ground plane be specified as part of any future noise certification procedures.
- ✓ Signal processing, signal-to-noise ratio, time synchronization and other data acquisition challenges be considered.

Ground & Flight Testing - Recommendations

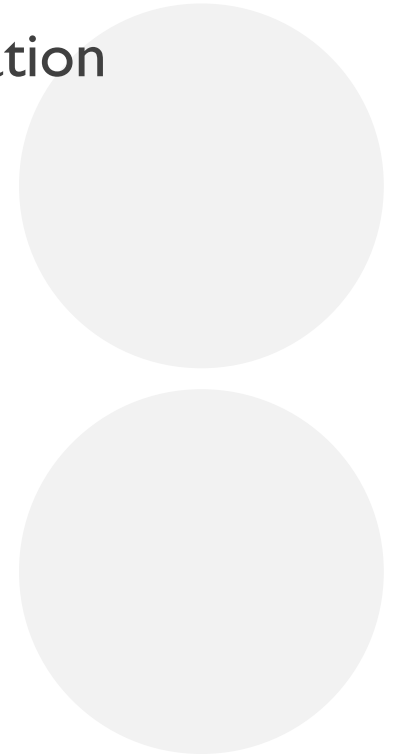
- ✓ Mentioned in Protocol Document
- Not addressed yet

- The “worst” case or the noisiest mode the vehicle will fly (under automatically controlled Variable Noise Reduction System provisions) - define appropriate methods to evaluate acoustic dependence and variability with respect to the vehicle state.
- A full assessment of anticipated UAM aircraft flight performance and operational environments be performed to support the development of any future certification procedures and/or standards.
- Noise measurements above the aircraft be investigated to understand the relative importance of noise directed along the horizon and above the aircraft.

Identified Gaps 1/3

- ✓ Mentioned in Protocol Document
- Not addressed yet

- Altered source prioritization - nontraditional aircraft noise sources
 - Rotor-to-rotor and multirotor-airframe interactions
 - Recirculation in the vertiport environment with surfaces near the vehicle
- Measurement techniques for source identification, separation, and quantification
 - Simultaneous occurrence
 - Priorities that change continuously throughout the flight envelope
- Complex operating environment: need to quantify the noise environment
 - Scattering / shielding
 - Hydrodynamic forcing on nearby structures
 - Urban canyon effects: reflection, reverberation, diffraction, waveguides
- Temporal variation - from independent noise generating components*
 - Measurement procedures to capture relevant range of operational noise



Identified Gaps 2/3

- ✓ Mentioned in Protocol Document
- Not addressed yet

- Variation in Normal Operating Conditions
 - ✓ Wing- vs. rotor-borne flight and transition modes
 - Quasisteadiness of near vertiport operations (e.g., departure, approach, VTOL to/from propeller mode transition)
 - Hover repeatability
- Expanded Directivity Requirements
 - Measurements above the aircraft for upwards radiated noise
- "Steady" flight condition variability
 - Measurement repeatability
 - Lightly loaded rotor sensitivity to perturbations (i.e. wind gusts)
 - Trim state time varying component - result of governing stability and control methods

Identified Gaps 3/3

- ✓ Mentioned in Protocol Document
- Not addressed yet

- "Worst-Case" Operating State
 - Might not be maximum gross weight condition
 - Difficult to define 'worst' condition apriori
 - Varies with vehicle design
- Expanded Flight Envelope Degrees-of-Freedom
 - Measurement procedures should be devised to allow such relationships to be understood
 - Procedures for generating NPDs or characterizing 3D noise emissions for the expanded degrees-of-freedom
- Piloted, Semi- and Fully-Autonomous Operation
 - Might require additional onboard instrumentation so that true state of the AC is known
 - Autonomy might be a simplifying feature

Ground & Flight Testing Subgroup Info

- Please reach out to Leadership to join our Group
 - Devin Boyle devin.k.boyle@nasa.gov
 - Juliet Page juliet.page@blueridgeresearch.com
 - Kyle Pascioni kyle.a.pascioni@nasa.gov
- Monthly SG2 meetings:
 - Third Thursday of the month, 12-1pm ET
- Always looking for people to present topics relevant to the group at monthly meetings
- **Join us for the SG2 breakout session**
 - **Eric Greenwood will be discussing array layout? Variability? in noise measurements**
 - **UAM/AAM scope discussion**