NASA Urban Air Mobility Noise Working Group Activities
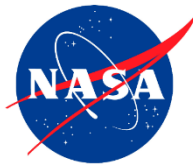
Michael J. Doty
Aeroacoustics Branch Head, NASA Langley

TRB 99th Annual Meeting

Aviation Noise and Vibration

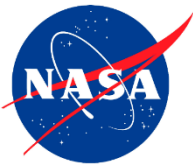January 13, 2020   Washington, D.C.

URBAN AIR MOBILITY (UAM)

- An opportunity to revolutionize mobility around metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system for passengers and cargo

- Community response to noise is recognized as a barrier to the emergence of this market.

UAM NOISE WORKING GROUP (UNWG)

- In early 2018, NASA explored the opportunity to form a UAM Noise Working Group

  – To assemble noise experts from industry, universities, and government agencies

  – To identify, discuss, and address UAM noise issues

- Key topics of interest that emerged included

  – Tools and Technologies

  – Ground and Flight Testing

  – Metrics

  – Regulation and Community Outreach Framework

- Agreed to meet twice a year in conjunction with longstanding NASA Acoustic Technical Working Group Meeting

UAM NOISE WORKING GROUP STRUCTURE
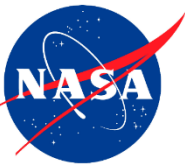
- **Executive Committee**

  Stephen Rizzi (NASA LaRC), Dennis Huff (NASA GRC), and Subgroup Leads

- **Subgroup 1: Tools and Technologies**

  Leads: Doug Boyd (NASA LaRC) and Paul Bent (Boeing)

- **Subgroup 2: Ground and Flight Testing**

  Leads: Brenda Henderson (NASA GRC), Kyle Pascioni (NASA LaRC), and Cal Sargent (Sikorsky)
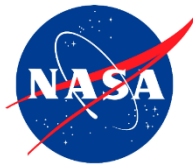
- **Subgroup 3: Metrics**

  Leads: Stephen Rizzi (NASA LaRC) and David Josephson (Josephson Engineering/Uber)

- **Subgroup 4: Regulation and Community Outreach Framework**

  Leads: Mehmet Marsan (FAA), Hua (Bill) He (FAA), and Royce Snider (Bell)
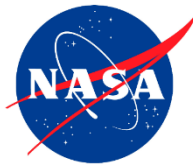
UAM NOISE WORKING GROUP GROWTH

- Exploratory meeting held at NASA Langley in April 2018 (~ 70 attendees)

- 1st meeting held at NASA Glenn in October 2018 (~ 95 attendees)

- 2nd meeting held at NASA Langley in April 2019 (~ 125 attendees)

- 3rd meeting held at NASA Glenn in October 2019 (~ 130 attendees)

Next meeting to be held at NASA Langley on April 9, 2020

FALL MEETING AGENDA

- October 24, 2019:

8:00 AM	Registration
8:15	Welcome and Introduction
8:30	Status of White Paper
8:50	NASA Validation Databases
9:30	Available NASA Noise Prediction Tools and their Usage
10:10	Plans for Acoustic Measurements on eVTOL UAM Vehicle
10:35	Break
10:50	Uber Elevate 2019 Highlights on eVTOL Aircraft
11:50	Sub-Group Activities Going Forward
Noon	Lunch

1:00 PM	Breakout Meetings (Report directly to the breakout rooms)
	Sub-Group 1 - Tools & Technologies
	Sub-Group 2 - Ground and Flight Testing
	Sub-Group 3 - Metrics
	Sub-Group 4 - Regulation & Policy Dial-In
3:00	Report Out & Discussion
4:00	Adjourn

WHITE PAPER
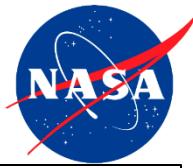
- The white paper is intended to be a consensus document

  - Written with inputs from each of the four subgroups

  - Addressing current practice, gaps, recommendations to meet immediate (<2 yr), near-(5 yr), mid-(10 yr) and far-term (15 yr) goals

  - That is used by members for internal and external advocacy

  - That will be the first work product of the UNWG

NASA/TP–2019-xxxxxx

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
Cal 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

January 2020

EXECUTIVE SUMMARY – TOOLS & TECHNOLOGIES

- Prediction tools need to be able to account for variable speed rotors and other temporal variation effects that impact community noise.

- A reprioritization of noise sources needs to be done since UAM vehicles include multiple rotors/propellers, often in proximity to one another and/or the airframe, 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.

- System level prediction tools used to evaluate community noise will need source models appropriate for a wide range of UAM vehicles.

- Existing noise reduction technologies need to be evaluated for applicability to UAM, and new noise reduction technologies should be developed in anticipation of future noise requirements.
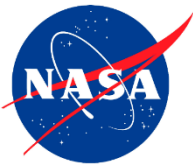
EXECUTIVE SUMMARY – GROUND & FLIGHT TESTING
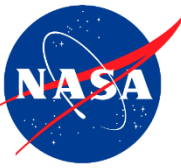
- UAM vehicles introduce new challenges for test procedures such as different source noise directivity, unsteady sources due to maneuvers, and a variety of takeoff and approach trajectories.

- The operating environment for UAM will be more complex than current aircraft with the introduction of vertiports in populated areas with "urban canyons" making reflections an important part of evaluating annoyance.

- It is expected that new test procedures and measurement methods may be necessary.

- Consideration will need to be given for both piloted and autonomous operations.

EXECUTIVE SUMMARY – HUMAN RESPONSE & METRICS

- Human response is expected to be very different for UAM compared to current experience with airport noise.

- Current metrics used to certify rotorcraft and fixed-wing aircraft may not be as useful for evaluating UAM noise.

- New exposures from low-altitude air vehicles are expected to create a lower threshold for annoyance.

- Psychoacoustic testing will be needed to quantify annoyance and develop appropriate metrics.

- It is expected that noise levels will not be as relevant as metrics that account for audibility and the temporal variation of sound.

- Differences between indoor or outdoor exposure will have an impact with dependence on urban and residential flight paths.
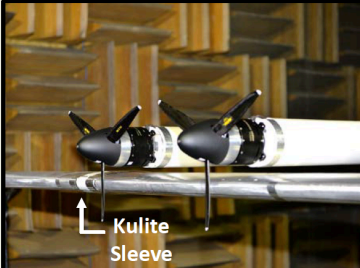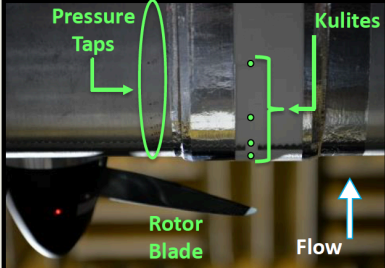
EXECUTIVE SUMMARY – REGULATION & OUTREACH

- Regulators are trying to decide if current policies are sufficient or if new regulations will be needed to address UAM noise.

- There is a lack of data for UAM since prototype vehicles are just starting to emerge. A noise database is needed before regulations can be established.

- There is an uncertainty on how applicable current measurement standards will be for UAM and a strong possibility that new standards will need to be developed.

- 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.
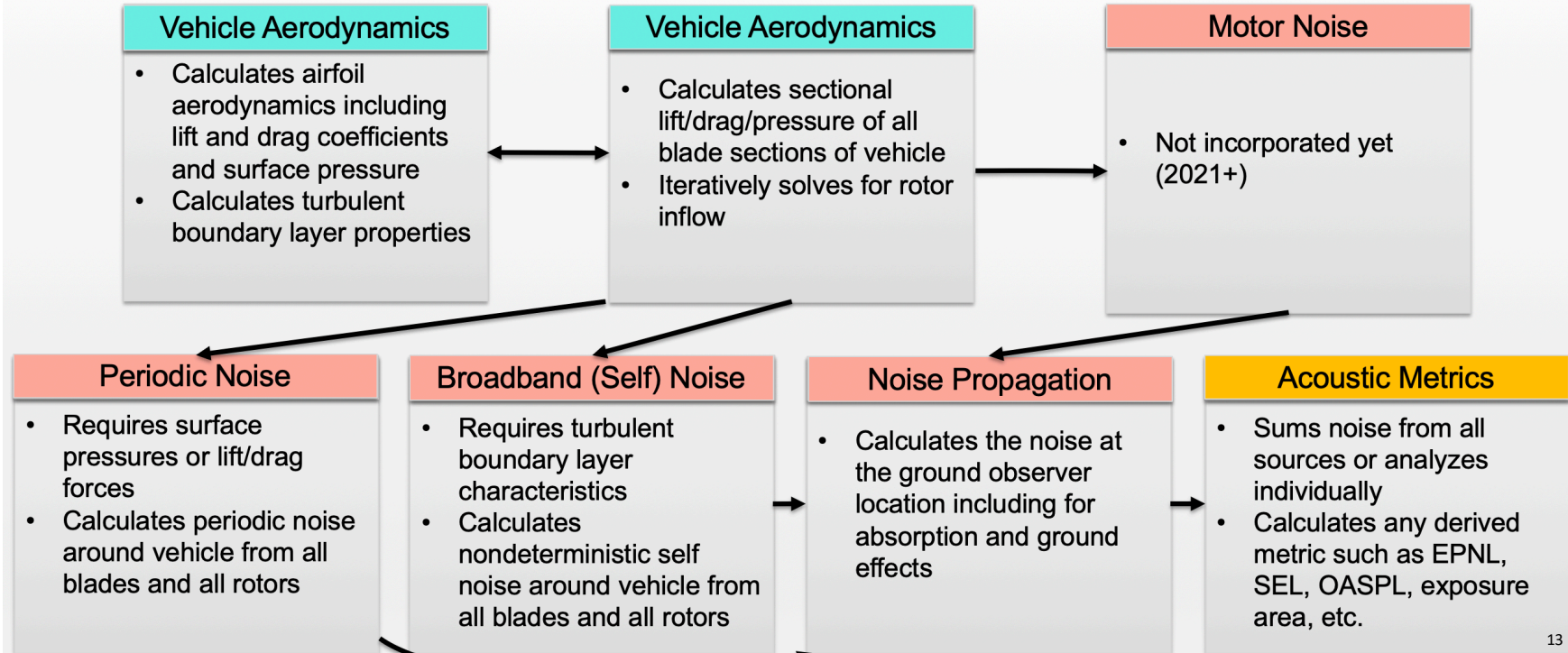
NASA VALIDATION DATABASES

- Presentation by Nik Zawodny (nikolas.s.zawodny@nasa.gov) outlining 13 aeroacoustic databases potentially available for validation
  - Isolated Rotor
  - Rotor-Airframe Interactions
  - Multirotor Interactions
  - Multirotor-Wing Interactions
  - Vehicle Ground Tests
  - Flight Tests

- One recent example from NASA Langley Low Speed Aeroacoustic Wind Tunnel (LSAWT)

9 — **LSAWT (Axial Flight)**

Measurements	Rotor thrust, torque; wing pressures (steady & unsteady); acoustics (sideline survey, near-field)
Test Params.	Rotor disk loading, rotor-wing proximity (ΔX, ΔZ), relative rotor phasing
Rotor Types	Carbon fiber, fixed-pitch propeller (COTS)
Geometry Status	Blade-element and wing profile data available
References	TBA

NASA NOISE PREDICTION TOOLS

- Presentation by Doug Boyd (d.d.boyd@nasa.gov) and Len Lopes (leonard.v.lopes@nasa.gov) outlining NASA tool chain options for various scenarios – example below utilizes NASA's second-generation Aircraft Noise Prediction Program (ANOPP2)

Vehicle Aerodynamics

- Calculates airfoil aerodynamics including lift and drag coefficients and surface pressure
- Calculates turbulent boundary layer properties

Vehicle Aerodynamics

- Calculates sectional lift/drag/pressure of all blade sections of vehicle
- Iteratively solves for rotor inflow

Motor Noise

- Not incorporated yet (2021+)

Periodic Noise

- Requires surface pressures or lift/drag forces
- Calculates periodic noise around vehicle from all blades and all rotors

Broadband (Self) Noise

- Requires turbulent boundary layer characteristics
- Calculates nondeterministic self noise around vehicle from all blades and all rotors

Noise Propagation

- Calculates the noise at the ground observer location including for absorption and ground effects

Acoustic Metrics

- Sums noise from all sources or analyzes individually
- Calculates any derived metric such as EPNL, SEL, OASPL, exposure area, etc.

SUMMARY

- In 2018, NASA formed a UAM Noise Working Group to assemble noise experts from industry, universities, and government agencies in order to identify, discuss, and address UAM noise issues.

- A white paper in the form of a NASA Technical report on current practice, gaps, recommendations for UAM noise will soon be completed.

- The most recent fall meeting also included discussions on other topics such as NASA validation databases and prediction tools.

- The next meeting will be held on April 9, 2020 at NASA Langley, and all are welcome!

ACKNOWLEDGMENTS
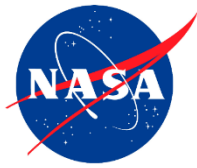
- This presentation represents work from several researchers:
  - Dr. Steve Rizzi
  - Dr. Nik Zawodny
  - Dr. Doug Boyd
  - Dr. Len Lopes

  as well as other members of the UAM Noise Working Group Executive Committee