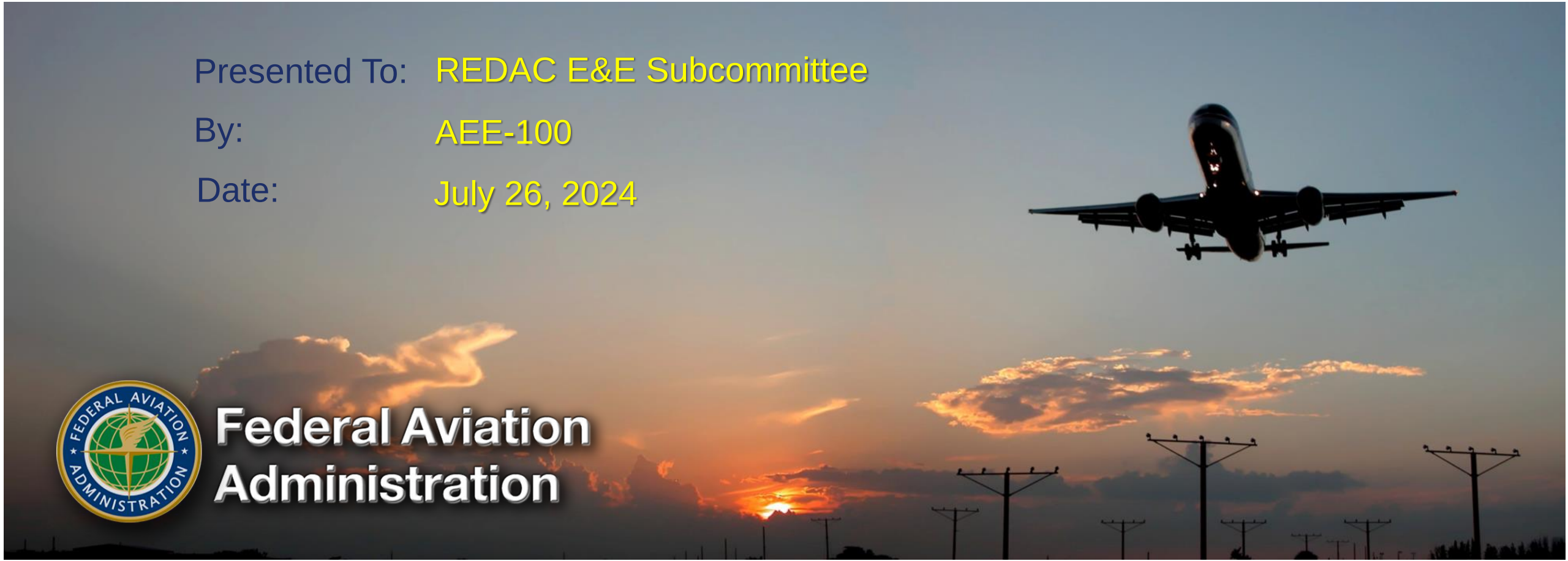
Noise Research on UAS and UAM



Presented To: REDAC E&E Subcommittee

By: AEE-100

Date: July 26, 2024

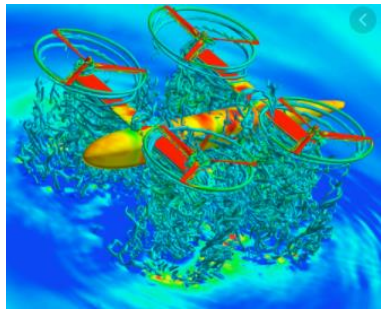
Federal Aviation Administration

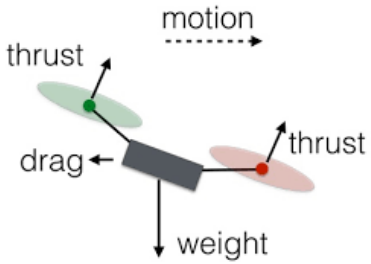
FAA Noise Policy Key Areas – UAS & UAM

- **2024 FAA Reauthorization**
  - **Section§ 909(f) – UAS certification**
- **ICAO CAEP**
  - **New SARPS for ETA, SST, and dual stringency**
- **USC 49 § 44715 (A) (i)**
  - **“Standards to measure aircraft noise and sonic boom”**
  - **UAS noise regulations via Rules of Particular Applicability**

New

UAS and UAM (AAM) research is needed to support noise certification & environmental review





- Which vehicles should require noise certification?
- What procedures should be used? (i.e. operating profiles, altitude and speed, microphone types and placement, etc.)
- What noise metrics and limits are appropriate?
- How should FAA approach the noise analysis for Environmental Review?
- What data are to be collected and what modeling tool(s) need to be updated/developed to support modeling for environmental review?

Data collection
Measurement procedures
Modeling methods & tools
Quiet design & operations
Standards and policies

Prior

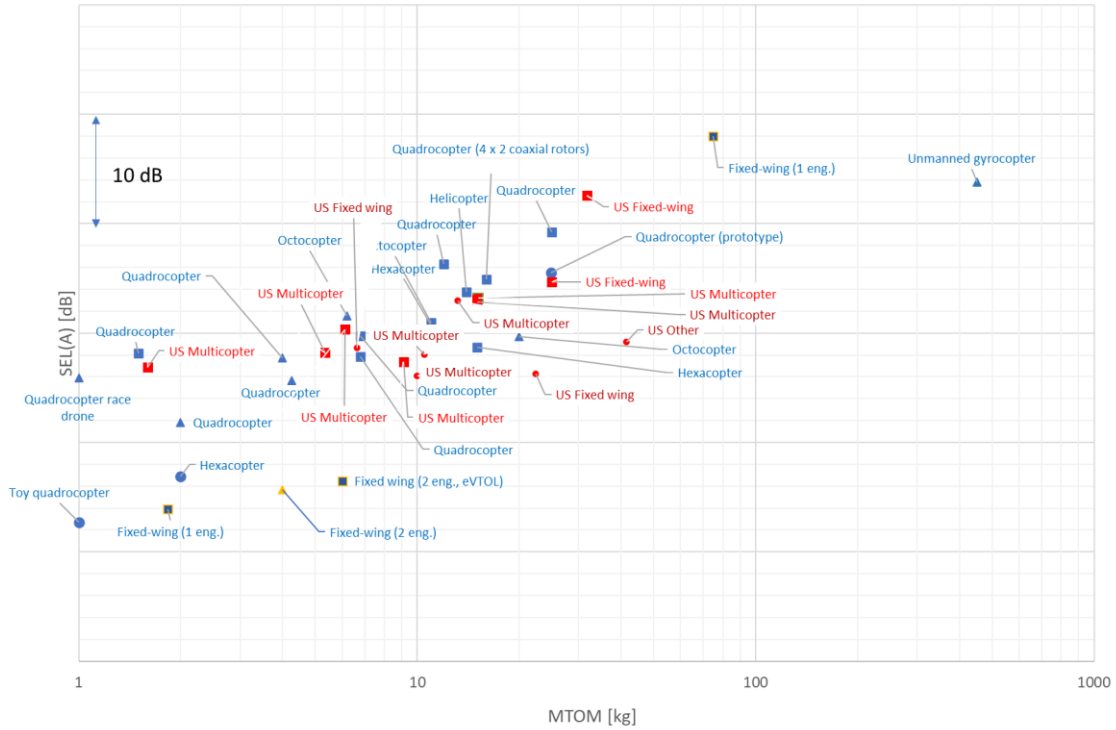
FAA UAS & AAM Noise Research Program

- **Status**
  - UAS RPAs
  - Certification process for UAM
- **Goals**
  - Support 2024 reauthorization §909(f)
  - Support potential future ICAO CAEP ETA SARP(s)
- **Gaps**
  - Coordination of 909(f) and CAEP goals

New

Measurement & Analysis of UAS Noise

- Compiled and analyzed noise data collected in the US from both noise certification projects and noise measurement studies.
- Compared the U.S. noise data with EASA data – see chart of - noise exposure level vs. UAS weight
- Studied adjustments of noise data with reference conditions and measurement methods
- Study ongoing on effects of atmospheric absorption in this adjustment and effects of speed on noise strength.



Level overflight noise data from EASA (blue) and US (red)

Next steps:

- Recommend adjustment factors to allow comparison of data, and to develop future noise testing procedures.

Updated

ASCENT# 49 (PSU) Urban Air Mobility Noise Reduction Modeling

Goals:

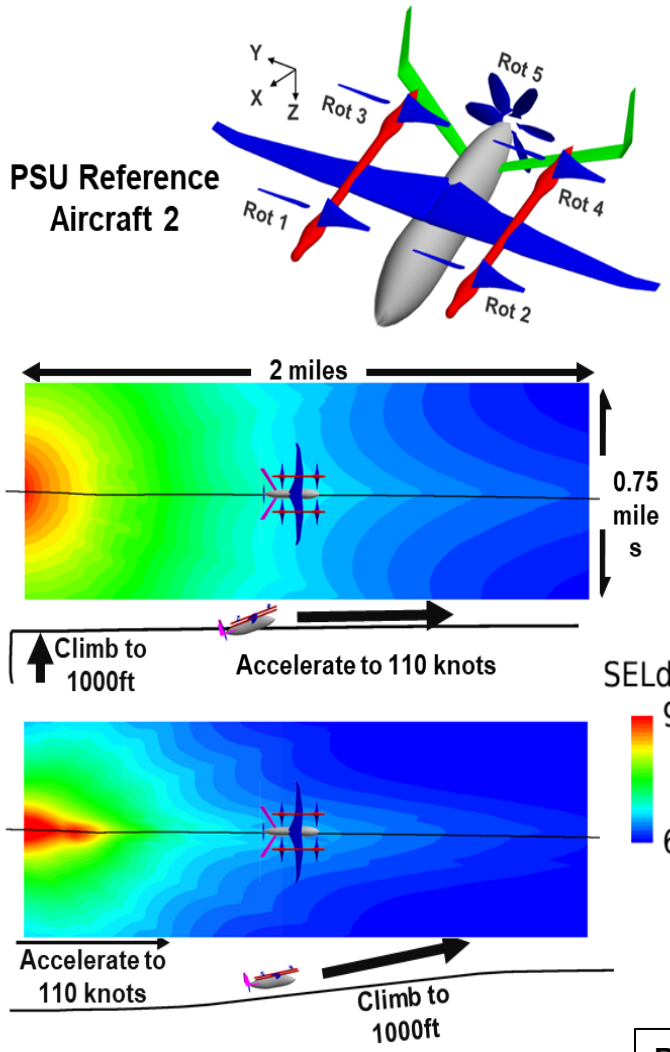
- Develop initial capability to predict UAM acoustics
- Improve understanding of UAM noise characteristics
- Identify noise reduction opportunities

Approach:

- Build on success of helicopter noise prediction system developed under ASCENT Projects 6 & 38
  - Use DEPSim flight simulation tool (tailored to eVTOL vehicles)
  - Investigate trim strategies for low noise
  - New coupling with DEPSIM, CHARM, and PSU-WOPWOP
    - Include variable RPM rotors
    - Generalize broadband noise models (time-dependent broadband noise)

Status:

- DEPSim flight controller has received major upgrades: more robust trimmer, simplified input files
- New PSU Reference aircraft 2: lift+cruise generic model for low-noise flight strategies research
  - Transition (hovering flight to cruise) maneuvers (Sample SEL contours on the right)
    - **MIDDLE: climb then accelerate – more noise and more power required**
    - **BOTTOM: accelerate then climb – better because aircraft "on wing" faster, so less lift-rotor noise and power required**
- Exploring changes in controller to influence aircraft noise in acceleration
- Time varying broadband noise implementation in system made more robust
  - Testing underway prior to external release
- Publications (March 2022 – March 2023)
  - International Journal of Aeroacoustics, "Challenges and opportunities for low noise electric aircraft" (June 2022)
  - Conference papers: VFS Forum 78 (May 2022); 28th AIAA/CEAS Aeroacoustics Conf (June 2022)



Prior

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ASCENT Project #77 (PSU)

Goals:

- Measurements to Support Noise Certification for UAS/UAM Vehicles and Identify Noise Reduction Opportunities

Approach:

- Use extensive lab and field measurement, assisted by numerical modeling, to reliably characterize in-flight UAS/UAM noise sources and noise variation

Status:

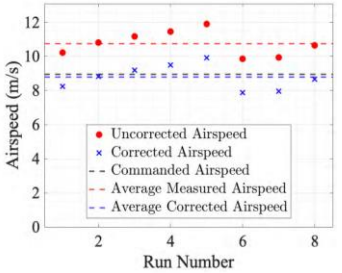
2020 - 2023

- Develop source separation process for "nearly-coherent" noise
- Collect noise data on a variety of UAS and UAM platforms
- Develop reconfigurable multirotor UAS platforms with research instrumentation
- Develop computational models for multirotor UAS, including airframe
- Analyzed acoustic variability for hovering flight conditions
- Develop and demonstrate multirotor synchrophasing for noise reduction

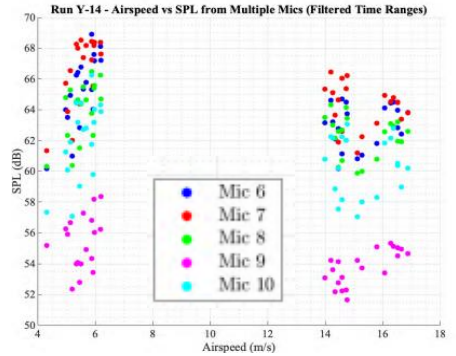
2024

- Assess acoustic impacts of takeoff & landing operations
- Measure the effect of configuration changes on vehicle noise, including payload
- Understand the impact of atmospheric conditions on UAS noise variability
- Implement and demonstrate low noise flight control

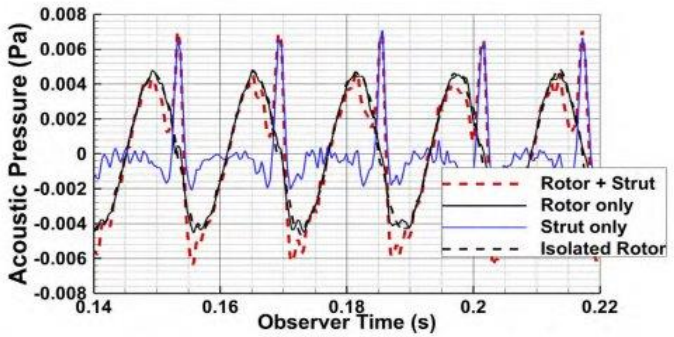
Study airspeed via a sonic anemometer mounted on board of UAS



Wind effect on noise levels (ongoing)



Study of noise contribution

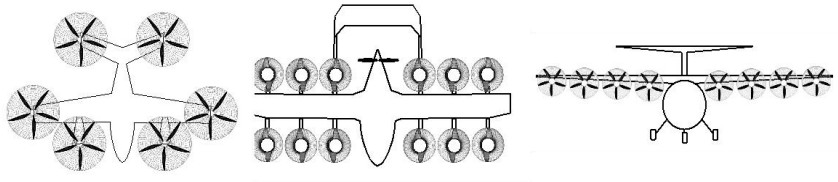


Updated

ASCENT # 84 (MIT/UCI)
Noise Modeling of Advanced Air Mobility Flight Vehicles

Objective:

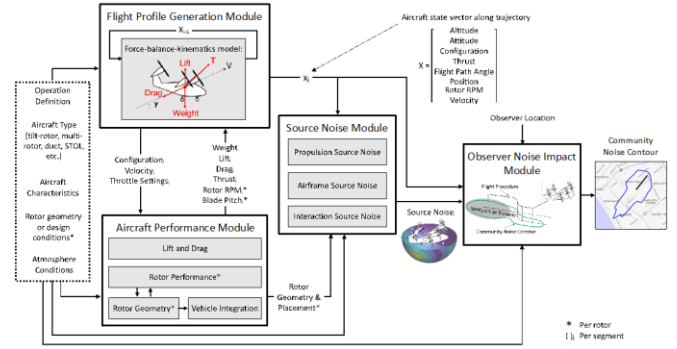
- Develop Aviation Environmental Design Tool (AEDT) compatible noise modeling methods for Advanced Air Mobility (AAM) vehicle configurations to make community noise predictions for AAM aircraft flying arrival and departure trajectories.



Representative AAM Configurations Modeled

Approach:

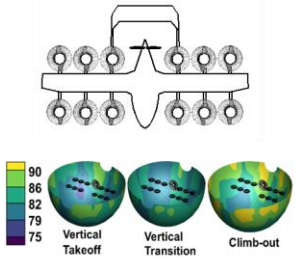
- Develop first principles Source Noise Models and performance models for 3 representative vehicle configurations (Tilt Rotor, Lift & Cruise, Blown Lift)
- Incorporate source noise models into AAM Noise Modeling Framework to simulate potential arrival and departure flight trajectories
- Validate and refine models with available data
- Develop AEDT compatible versions for representative or specific AAM vehicles

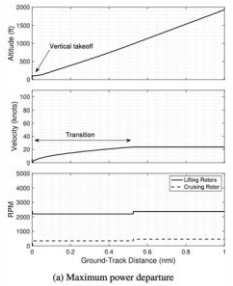


Example Lift & Cruise Takeoff (100 ft acceleration altitude)

Status:

- Noise Modeling Framework defined and implemented
- Preliminary (rotor based) source noise models developed for each representative vehicle
- Performance models developed for each representative vehicle
- Initial results of example arrival and departure procedures
- Evaluating and validating options
- Refining models to include rotor airframe interactions and adding airframe component noise sources





(a) Maximum power departure

(c) 80 dB L_{AE} contour for maximum power departure

Prior

ASCENT # 94 (GT) - GIS Based Probabilistic UAS Trajectory and Noise Estimation Tools and Methodologies for Upcoming Vehicle Concepts

Objective:

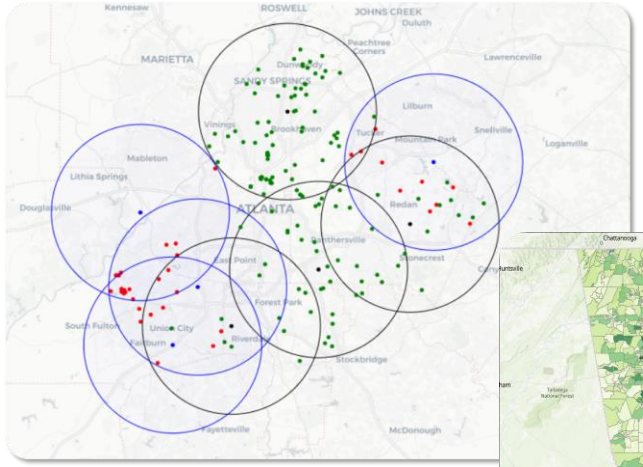
•Develop a novel noise estimation method/tool that supports computation of noise resulting from the stochastic operation of Unmanned Aircraft Systems (UAS) and other upcoming vehicle concepts with irregular locations and operations in large numbers

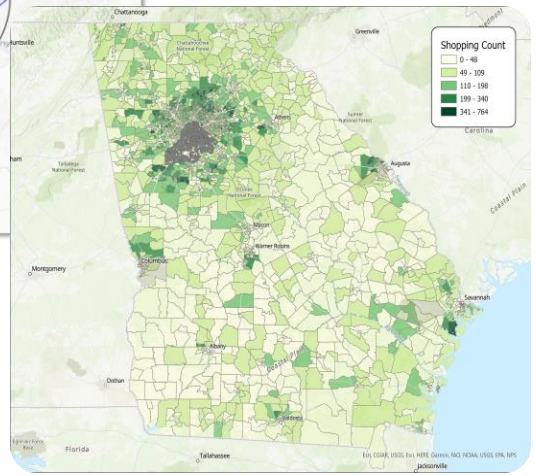
Approach:

•Develop integrated probabilistic noise and trajectory computation methodology
•Visualization of probabilistic trajectories and noise distributions
•Geospatial display of results
•Build on existing prototype noise engine and visualization capabilities developed under ASCENT Project 9 (Develop GIS Noise Estimation Tool)
•Collaboration with Volpe, NASA, and pursuing potential Industry collaborations

Status:

•Developed demand, flight scheduling, noise computation, and integrated path planning modules
•Currently working to integrate separate modules together to carry out probabilistic studies and benchmark noise computation methods against UA noise measurement data collected by FAA and simulated AAM noise data provided by the NASA RVLT program

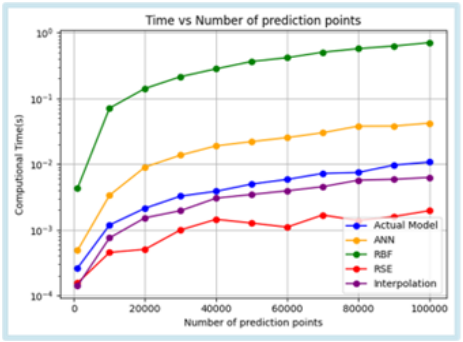


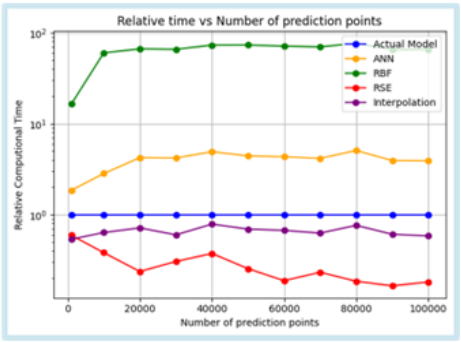


Legend

- ***Blue: warehouses and associated raidi***
- ***Red: homes reachable from warehouse***
- ***Green: homes unreachable from warehouse***
- ***Black: mobile staging locations and associated raidi***

Circles correspond to the 10-mile delivery radius





Updated

Other Programs

NASA UAM Noise Working Group (selected tasks)

- noise measurement procedures
- noise metrics and subjective tests
- noise modeling of fleet noise performance
- noise standard and policy development

NASA AAM National Campaign and Noise Testing

FAA-NASA UAM Community Noise Test Planning

- preliminary data collection planned

FAA UAS-UAM Integration Research Plan

Prior

Industry and international collaborations

FAA projects (certification, operation approval, IPP/Beyond,…)
ASCENT, partnership/cost-sharing
NASA UAM Noise Working Group
SAE-A21 *(noise measurement guidance / noise sphere)*
ISO *(UAS noise measurement standard, not for certification)*
TRB AEP80/AV030 (subcommittee on aviation noise and vibration)
National Academy of Sciences (drone noise workshops)
CAEP WG1 – N.06 ETA (*emerging technology aircraft*)
……..

Prior

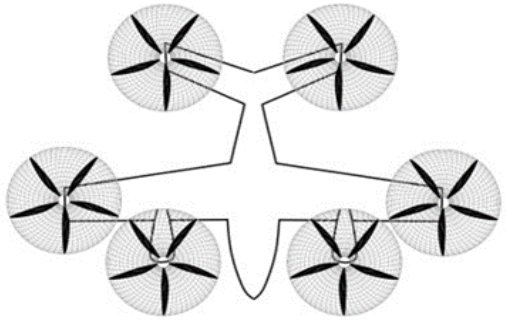
Back-up slides

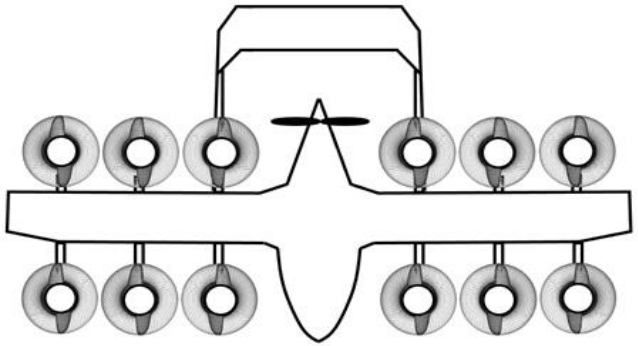
Some definitions

- AAM – Advanced Air Mobility is a transportation system that moves people and property by air between two points in the United States using aircraft with advanced technologies, including electric or eVTOL aircraft, in both controlled and uncontrolled airspace.
- UAS - An unmanned aircraft system is an unmanned aircraft and the equipment necessary for the safe and efficient operation of that aircraft. An unmanned aircraft is a component of a UAS. It is defined by statute as an aircraft that is operated without the possibility of direct human intervention from within or on the aircraft
- UAM – Urban Air Mobility is a subset of AAM. UAM focuses on operations moving people and cargo in metro and urban areas

Prior

Likely UAM Certification methods





STOL	Tilt-rotor	Lift + Cruise
Appendix G	Appendix K (mod)	RPA
Small Propeller-driven	Tilt-Rotor	Helicopter + Prop
Takeoff	Takeoff, Landing, Flyover	Takeoff, Landing, Flyover

Aircraft images from ASCENT 84

Prior