












RVLT FY22 Town Hall Status Update

*Susan Gorton, Project Manager, Revolutionary Vertical Lift Technology (RVLT)
July-August 2022*



ARMD Six Strategic Thrusts and Community Visions

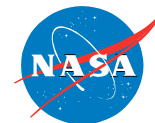
- 
- 
- 
- 
- 
- 
- 
- 
- 
- Safe, Efficient Growth in Global Operations**
 - Achieve safe, scalable, routine, high-tempo airspace access for all users
 - Innovation in Commercial Supersonic Aircraft**
 - Achieve practical, affordable commercial supersonic air transport
 - Ultra-Efficient Subsonic Transports**
 - Realize revolutionary improvements in economics and environmental performance for subsonic transports with opportunities to transition to alternative propulsion and energy
 - Safe, Quiet, and Affordable Vertical Lift Air Vehicles**
 - Realize extensive use of vertical lift vehicles for transportation and services including new missions and markets
 - In-Time System-Wide Safety Assurance**
 - Predict, detect and mitigate emerging safety risks throughout aviation systems and operations
 - Assured Autonomy for Aviation Transformation**
 - Safely implement autonomy in aviation applications

RVLT focus is
on Thrust 4

Strategic Implementation Plan (released 2020) at: <https://www.nasa.gov/aeroresearch/strategy>

National Academies Study (2020) at: <https://www.nap.edu/catalog/25646/advancing-aerial-mobility-a-national-blueprint>

Term “Advanced Air Mobility” used for more than one thing



- NASA Focus on **Advanced Air Mobility (AAM) Missions**
- ARMD has the **Advanced Air Mobility Project**
 - AAM Project has National Campaign subproject, Automated Flight and Contingency Management (AFCM) subproject, and High Density Vertiplex (HDV) subproject
- ARMD stands up **Advanced Air Mobility Mission Integration Office**
 - Provides strategic vision and outreach
 - Coordinates across projects working AAM
 - Ecosystem Working Groups on-going
 - <https://nari.arc.nasa.gov/aamecosystem>



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



- AAM missions characterized by
< 300-500 nm range
- Vehicles require increased automation and are likely electric or hybrid-electric
- Rural and urban operations are included
- Missions can be public transportation, cargo delivery, air taxi, or emergency response
- Urban Air Mobility (UAM) is a subset of AAM and is a segment that is projected to have high economic benefit and be the most difficult to develop
 - UAM requires an airspace system to handle high-density operations
 - UAM requires an advanced urban-capable vehicle
 - UAM vehicle variants can target other missions



RVLT is one of the seven projects that support the AAM Mission

Revolutionary Vertical Lift Technology Project

A blue, futuristic vertical lift aircraft (RVLT) is shown hovering in the air. The aircraft has a sleek, modern design with a large cockpit and multiple vertical lift fans. It features the NASA logo and the text "RVLT" on its side. The aircraft is positioned over a city skyline at sunset, with a helipad visible in the foreground.

Focused on Urban Air Mobility (UAM) vehicle tools and technologies for noise, safety, environment, and efficiency

Develop and validate tools, technologies, and concepts to overcome key barriers for vertical lift vehicles

NASA's RVLТ Project Provides Tools and Design Practices for AAM eVTOL Vehicles

Focus on Barriers of Noise and Safety to Enable New Markets

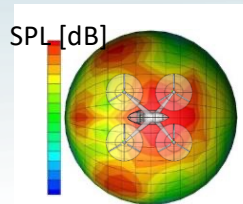
Noise Research



Human Response to AAM Noise



AAM Acoustic Impacts



Predictive Tools for AAM Noise

Share technical insights and lessons learned



INDUSTRY



ACADEMIA

SDOs

Safety Research



Crashworthiness & Occupant Protection



Handling Qualities



Electric Powertrain Reliability

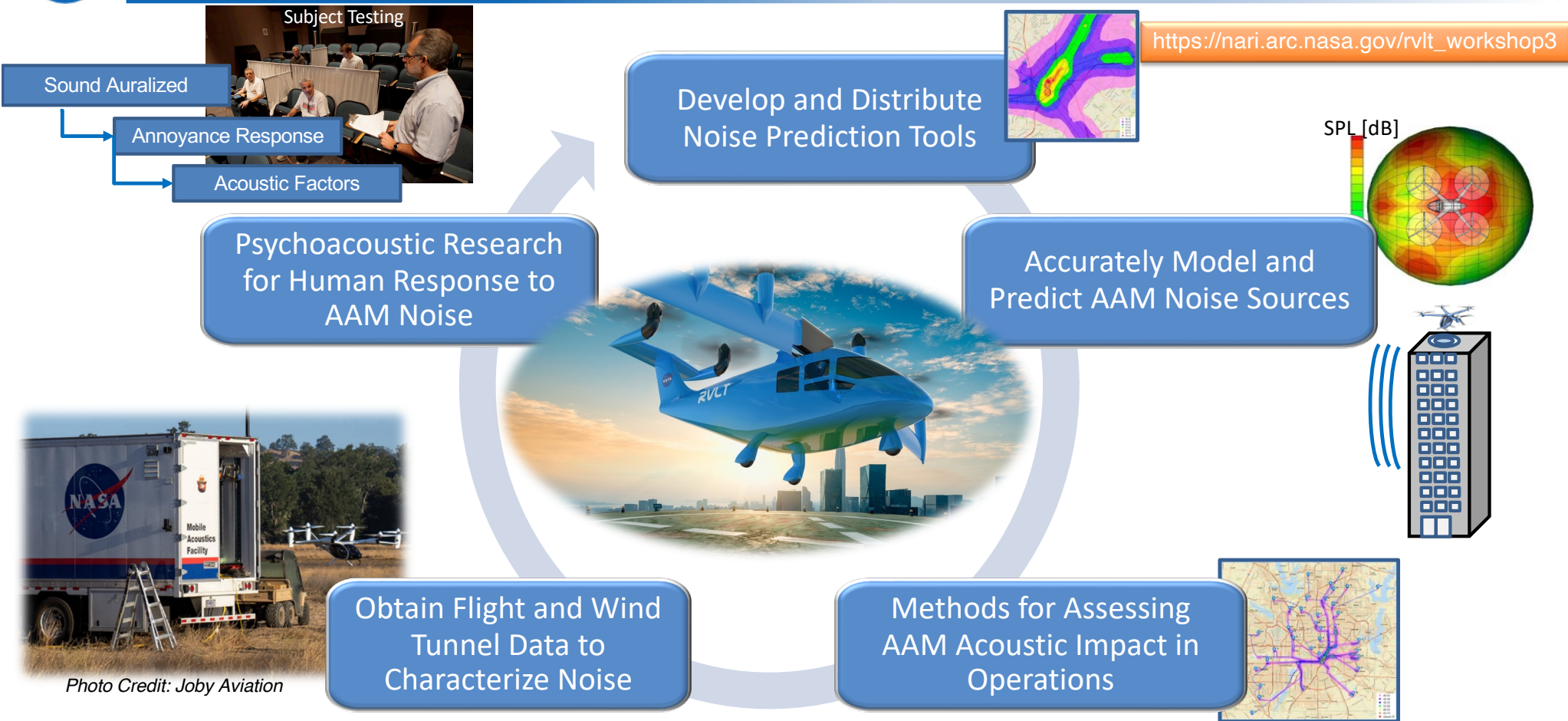
FY22/23 RVLТ Summary

~113/113 Civil Service Workforce

~ \$33M/\$37M per year



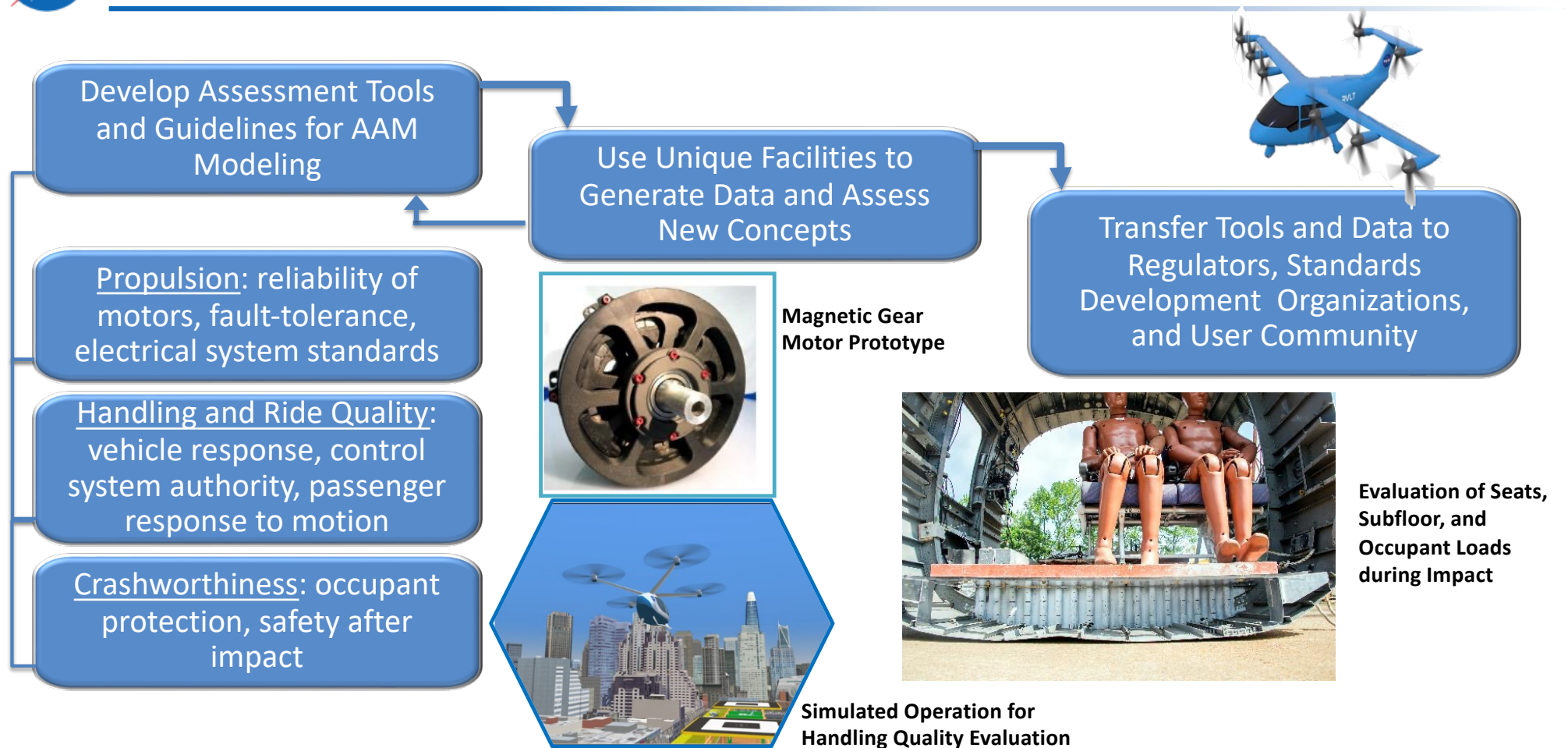
NASA AAM Noise Research Approach



Provide Design Tools and Guidelines for Low Noise Design and Operations



NASA AAM Safety Research Approach



Provide Design Tools and Guidelines for Safe, Reliable Operations and Standards

RVLT Research Focus – Vehicle Noise and Safety



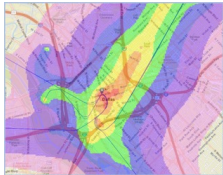
Noise and Performance



Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

- Plan and conduct validation experiments
- Improve efficiency & accuracy of conceptual design tools
- Improve community transition & training for analysis tools

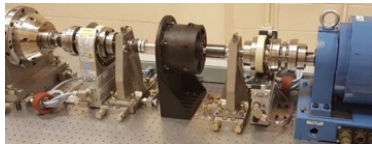
UAM Fleet Noise



UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) database for several UAM ref. configurations & trajectories
- Develop method to assess acoustic impact of UAM fleet operations
- Conduct psychoacoustic testing to assess human response to UAM vehicles

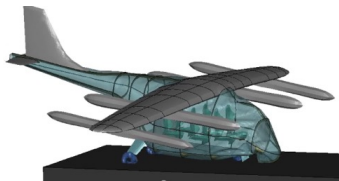
Vehicle Propulsion Reliability



Reliable & Efficient Propulsion Components for UAM

- Reconfigure labs for electric propulsion testing
- Develop tools to assess electric motor reliability & explore new design concepts
- Develop design and test guidelines for eVTOL propulsion & thermal components

Occupant Safety



UAM Crashworthiness and Occupant Protection

- Conduct full-scale and component level tests
- Develop test guidelines, modeling best practices, and vehicle technologies for crash mitigation
- Deliver crash and impact data to consensus standards organizations

Handling & Ride Qualities



Acceptable Handling and Ride Qualities for UAM

- Conduct human subject testing to assess handling and ride qualities
- Establish handling and ride qualities guidelines for UAM vehicles
- Develop flight dynamics and control modeling tools for conceptual design

Tech Challenge: Tools to Explore the Noise and Performance of Multi-Rotor UAM Vehicles



Objective

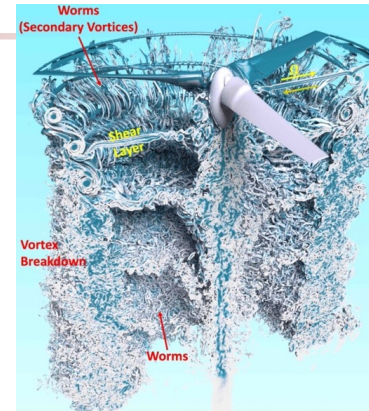
Develop, demonstrate, validate, and document a set of conceptual design tools capable of assessing the tradeoffs between UAM vehicle noise and efficiency.

Approach

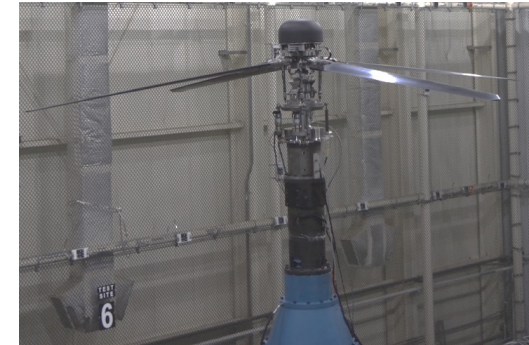
- **Develop** new interfaces between comprehensive analysis-CFD-acoustics tools to create a streamlined tool chain operational on multiple computing platforms
- **Demonstrate** tool chain via workshops with internal and external stakeholders
- **Validate** tool chain with data from wind tunnel tests using new test rigs representative of UAM-like configurations; also leverage flight test opportunities
- **Document** tools, toolchains, and validation datasets; include best practices for:
 1. performing trade studies of UAM multirotor vehicles
 2. acquiring experimental validation data

Status

- Significant FY21-22 progress to develop test stands and acquire specific experimental validation data for eVTOL configurations
- Toolchain Workshop #3 in Aug for external participants
- HVAB test build-up on-going in NFAC
- MTB #2 on-going in 7x10
- Vertical Lift Propeller Test on-going in 14x22



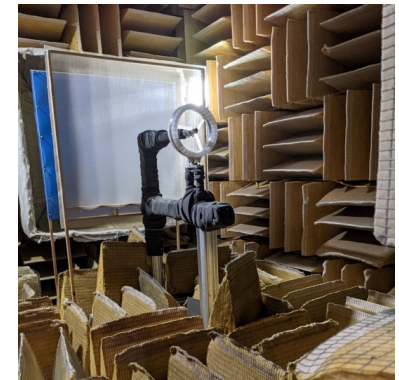
Physics of the Rotor Wake



Initial Checkout of HVAB Blades in Rotor Test Cell



SbS Installed in 7- by 10-ft Wind Tunnel



Ducted Rotor in SHAC

RVLT Concept Vehicles – Connect Research Across Disciplines



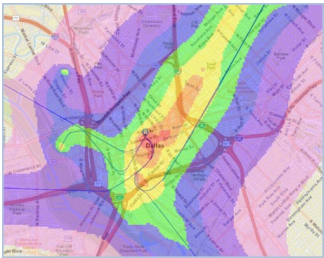
**Electric
Powertrain
Reliability**



Occupant Safety



Fleet & Vehicle Noise



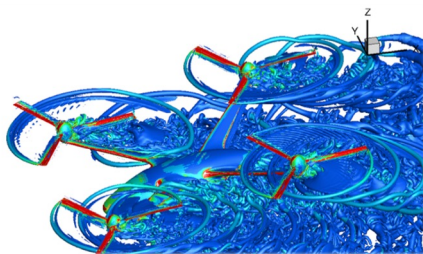
**Handling &
Ride Qualities**



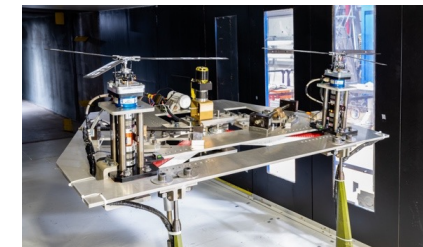
**UAM Concept
Vehicles**



**Vehicle
Modeling Tools**



**Validation
Testing**



Tech Challenge: Urban Air Mobility (UAM) Operational Fleet Noise Assessment



Objective

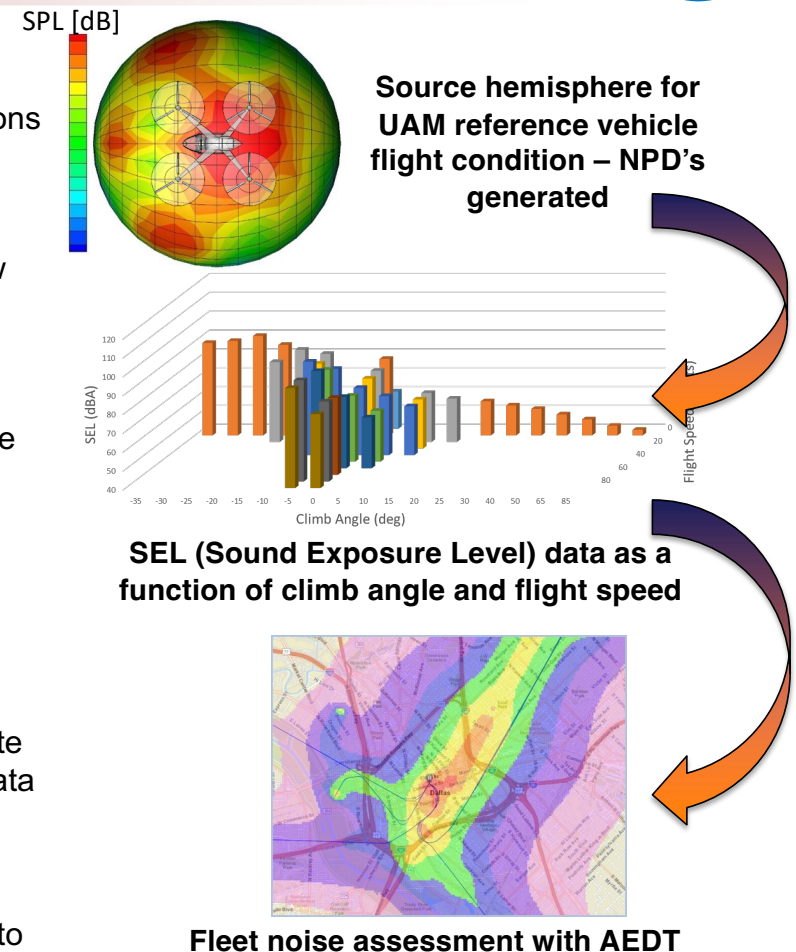
Develop, validate, demonstrate, and document best practices for fleet noise modeling; demonstrate fleet noise assessments of representative UAM operations using the Aviation Environmental Design Tool (AEDT)

Approach

- **Develop** new tools for UAM source noise, auralization, and audibility and a new modeling procedure for representing UAM missions in AEDT
- **Validate** new models, approaches, and procedures through verification with comparisons to databases, high fidelity simulations, and alternative simulations
- **Assess** fleet noise scenarios conducted with increasing levels of fidelity over life of TC to improve process and modeling fidelity in a spiral-development-like approach
- **Document** tools, modeling procedures, validations, studies, and assessments; include best practices for: 1) NPD (noise-power-distance) data generation for UAM; and 2) Performing fleet noise analysis for UAM vehicles

Status

- Significant FY21-22 progress to improve fidelity of fleet noise predictions, initiate fundamental work for annoyance models, and collect eVTOL flight acoustics data
- Gen2 fleet noise assessment focused on noise near vertiports, included broadband noise and mix of vehicles
- Gen3 assessment of fixed wing vs helicopter mode completed
- Completed a human response testing with test subjects and developed option to evaluate remote internet-based testing



Fleet noise assessment with AEDT

Tech Challenge: Reliable and Efficient Propulsion Components for UAM



Objective

- Develop design and test guidelines, acquire data, and explore new concepts that improve propulsion system component reliability by several orders of magnitude over state-of-the-art technology for UAM electric and hybrid-electric VTOL vehicles.

Approach

- **Iterative design, model, test, and analyze**
 - Apply vehicle level analysis
 - Develop experimental / analysis capabilities
 - Conduct tests (reliability of components, tool validation)
 - Provide validated models
 - Develop design guidelines & test procedures

Status

- Established operational readiness of low power drivetrain, and completed power upgrade for high power test facility
- Designed two motor concepts – improved reliability (external contract)
- Thermal model of baseline motor
- Learned lessons in integration and operations in low power testbed for application to single-string system integration and testing in AREAL (Advanced Reconfigurable Electrified Aircraft Lab; 150kW power)
- AREAL single string testing underway



Advanced Reconfigurable Electrified Aircraft Lab (AREAL)

Tech Challenge

UAM Crashworthiness and Occupant Protection



Objective

- Deliver: 1) full-scale and component-level data to inform eVTOL standards development; and 2) test guidelines, modeling best practices, and vehicle technologies for crash mitigation.

Approach

- Develop data for occupant protection in unknown vehicle crash environments
- Make advances in modeling techniques to support Certification by Analysis
- Address bird strike impact standards
- Investigate battery pack safety upon and after impact

Status

- Approved at Tech Challenge Tollgate April 21, 2022
- Hosted a series of workshops on eVTOL crashworthiness jointly with FAA
- Conducted crash simulations w/ seat energy absorbers to determine crash survivability envelopes
- Completed design, fabrication and assembly of new drop tower
- Finalized design and fabrication of L+C composite fuselage test article.
- Conducted full-scale drop tests of two Hawker composite fuselage sections
- Completed testing on bird surrogate material



Lift + Cruise Test Article

Tech Challenge: Acceptable Handling and Ride Qualities for Urban Air Mobility (UAM) Vehicles



Objective

- Provide handling and ride qualities (HQ and RQ) guidelines and flight dynamics and control modeling tools for UAM vehicle design, validated with data acquired from human subject testing in TRL 5 environments.

Approach

- Use two tracks: 1) testing; and 2) tools development.
- Identify coupling between HQ and RQ metrics
- Use a generational approach to incorporate HQ and RQ into conceptual design tool chain.
- Apply vehicle level analysis to assess final result

Status

- Tech Challenge approved February 2022
- VMS Test completed in late FY21
 - HQ disturbance rejection & control response evaluation of a quadrotor
 - Exploration of passenger comfort during quadrotor flights
- Initiated Phase 3 SBIR for high fidelity flight dynamics models for RVLTL UAM vehicles
- Initiated new RQ simulator development at AFRC; hexapod has arrived
- Preparations for next VMS entry in September underway



Quadcopter in VMS Simulation

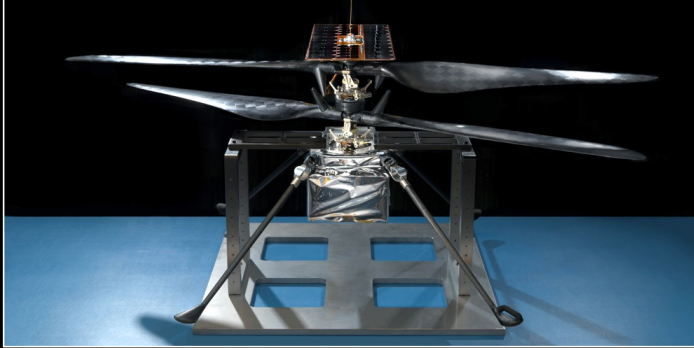
RVLT Congratulates!



*The NASA/JPL
Ingenuity Mars
Helicopter Team
Awarded the 202
Robert J. Collier
Trophy*

Expand Exploration Using Aerial Mobility—Ingenuity

Mars Helicopter Technology Demonstration



First flight on another planet
April 19, 2021

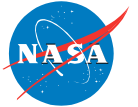
mars.nasa.gov

NASA Aeronautics Contributions to Mars Helicopter (FY15-FY20)

- Sizing and performance calculations. Sizing design code now in use for future planetary aerial vehicles
- Testing methods and options for minimizing recirculation
- Control system design and system identification
- CFD evaluation for airfoil and configuration performance

NASA Aeronautics researchers made significant contributions to the success of the Ingenuity Mars Helicopter.

RVLT Big Picture Priorities for FY22-23



Complete support of National Campaign #1 with acoustic measurements

Technical Challenge execution

- ❖ Reliable and Efficient Propulsion Components for UAM
- ❖ Tools to Explore the Noise and Performance of Multi-Rotor UAM Vehicles
- ❖ Urban Air Mobility (UAM) Operational Fleet Noise Assessment
- ❖ Acceptable Handling and Ride Qualities for UAM Vehicles
- ❖ UAM Crashworthiness and Occupant Protection

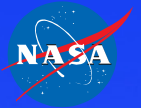
Partnerships, Internal and External

Key Partners

- EcoSystem Working Groups
- FAA Partnerships and Working Groups
- Army Partnerships
- AFRL Partnerships
- ONR Partnerships
- Industry

- AMIO
- AAM/National Campaign
- TTT
- FDC
- AATT Electric Propulsion

Summary



NASA RVLT is focused on

- Vertical lift supporting Urban Air Mobility
- Completing acoustic measurement commitment to NASA National Campaign #1
- Technical Challenges
 - Electric propulsion reliability and performance
 - Tools to compute vehicle source noise and performance
 - Fleet noise
 - Ride quality and passenger acceptance
 - Crash safety and occupant protection



Our vision is to create a future where VTOL configurations operate quietly, safely, efficiently, affordably and routinely as an integral part of everyday life.

NOTE: As Centers return to more normal operations, there may be bottlenecks in services, supply chain, procurement, safety permits, etc. RVLT remains flexible to support our workforce in returning to normal operations.