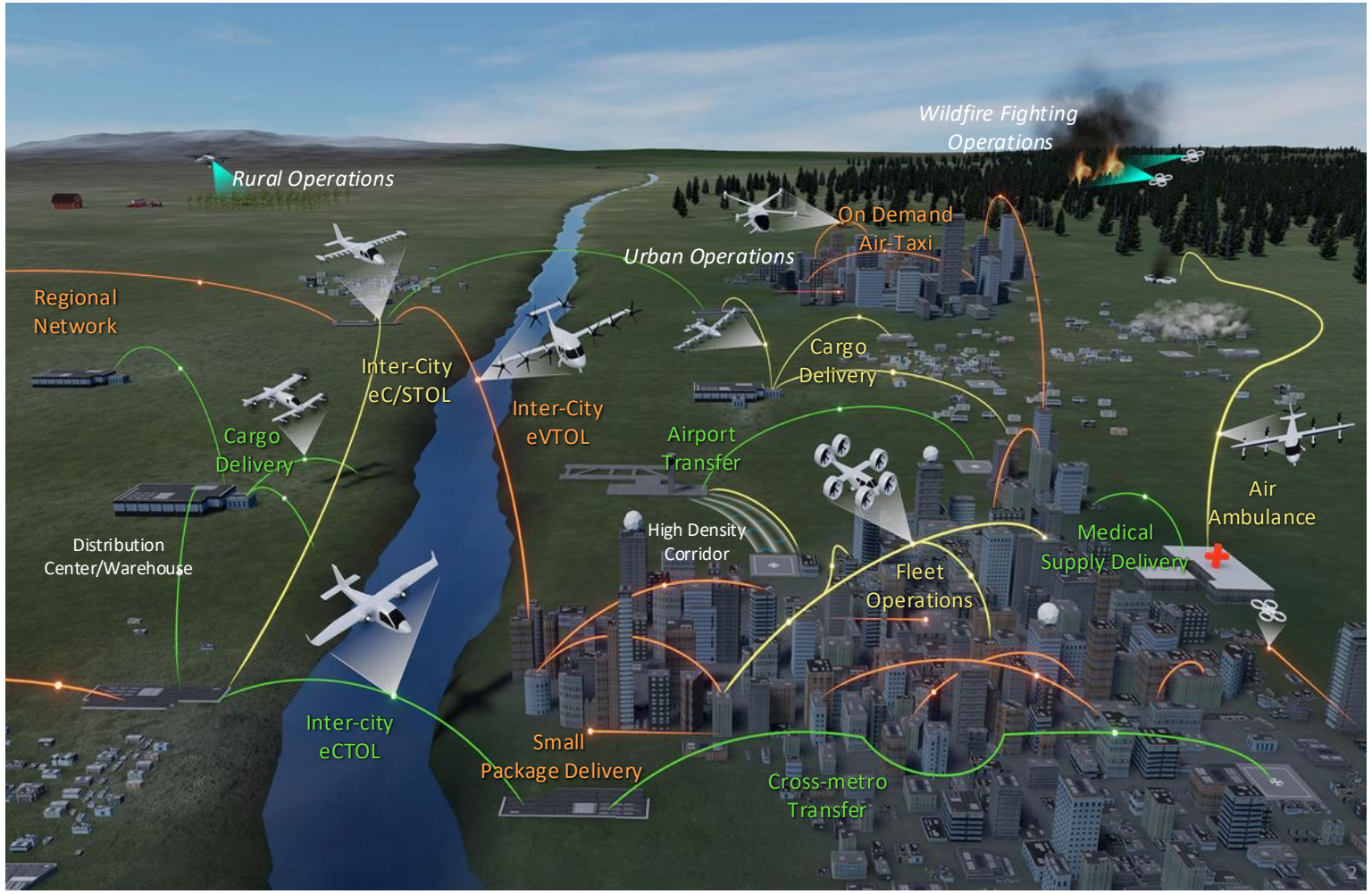
Revolutionary Vertical Lift Technology Project Overview

- Advanced Air Mobility
- Revolutionary Vertical Lift Technology (RVLT) Research Focus
- RVLT Future Work

July 2023

AAM and 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



Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions

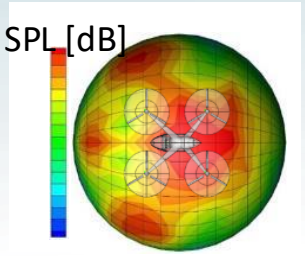
RVLT is one of the eight NASA projects that support the AAM Mission

NASA's RVLT Project Provides Tools and Design Practices for UAM eVTOL Vehicles

Noise Research

Human Response to UAM Noise

UAM Acoustic Impacts



Predictive Tools for UAM Noise

Safety Research

Electric Powertrain Reliability

Handling Qualities

Crashworthiness & Occupant Protection

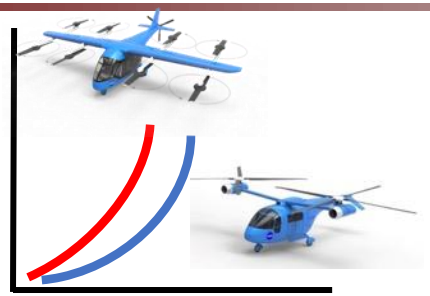
Share technical insights and lessons learned

INDUSTRY — SDOs — ACADEMIA — FEDERAL AVIATION ADMINISTRATION

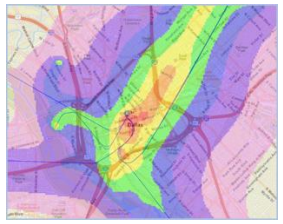
Delivering Tools and Technologies to the eVTOL Community

RVLT Research Focus – Vehicle Noise and Safety

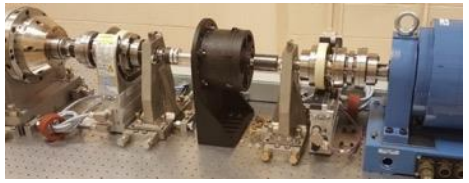
Noise and Performance



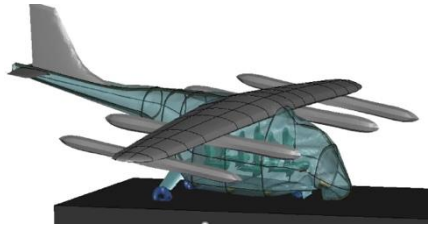
UAM Fleet Noise



Vehicle Propulsion Reliability



Occupant Safety



Handling & Ride Qualities

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 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

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

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

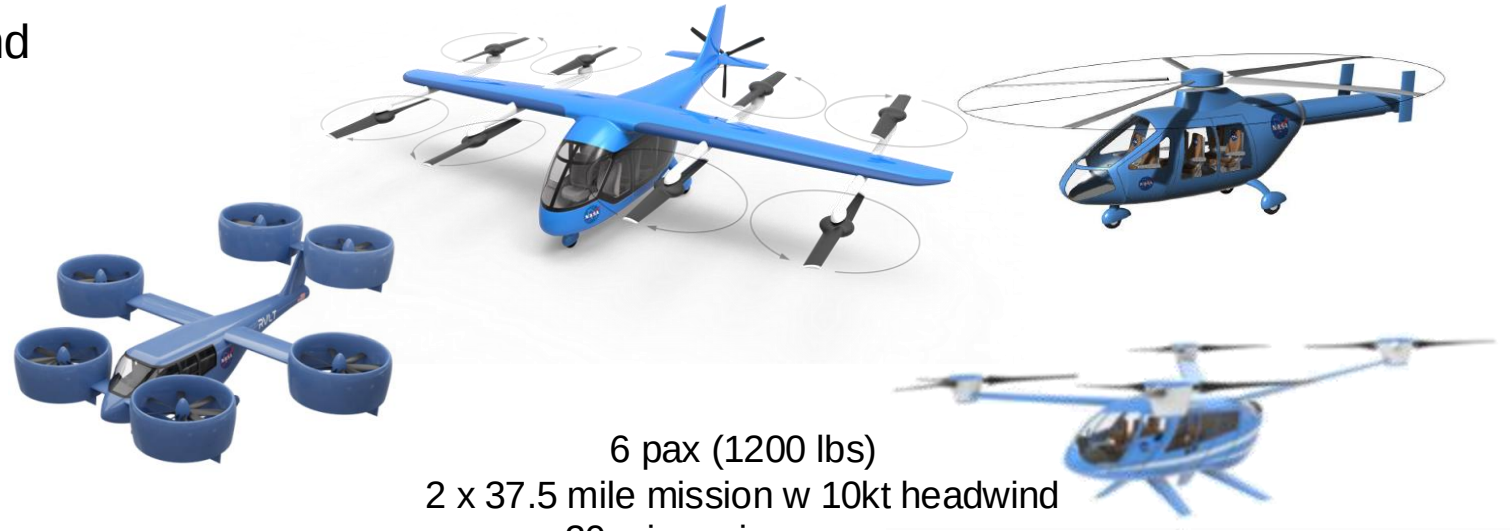
Acceptable Handling and Ride Qualities for UAM

- 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

NASA Concept Vehicles – Generic Configurations that Capture UAM Features

NASA reference vehicles ◆ Widely shared ◆ Fully documented ◆ Realistic performance ◆ Realistic set of compromises ◆ No plans to build or fly these concepts ◆

- Vehicles contain relevant UAM features and technologies
  - Battery, hybrid, diesel propulsion
  - Distributed electric propulsion
  - High efficiency rotors
  - Quieter rotors
  - Wake interactions
- Provide configurations for
  - Communication of NASA's Urban Air Mobility research
  - Design and analysis tool development
  - Technology trade studies and sizing excursions
  - Modeling operational scenarios
  - Common configurations for studies in acoustics, flight dynamics, propulsion reliability, etc.



6 pax (1200 lbs)
2 x 37.5 mile mission w 10kt headwind
20 min cruise reserve

Research Areas for UAM eVTOL Vehicles

PROPULSION EFFICIENCY
light, efficient, high-speed electric motors
power electronics and thermal management
efficient powertrains
light, efficient small turboshaft engine
high power, lightweight battery

PERFORMANCE
aircraft optimization
rotor shape optimization
hub and support drag minimization
airframe drag minimization

ROTOR-ROTOR INTERACTIONS
performance, noise, handling qualities, aircraft arrangement
vibration and load alleviation

SAFETY and AIRWORTHINESS
component reliability and life cycle
crashworthiness / airframe, occupant, battery
bird strike
electric motor reliability assessment
propulsion system failures
FMECA (failure mode, effects, and criticality analysis)
high voltage operational safety
high voltage protection devices

UAM Concept Vehicles

NOISE AND ANNOYANCE
low tip speed
rotor shape optimization
flight operations for low noise
aircraft arrangement/ interactions
cumulative noise impacts from fleet ops
metrics and requirements
human response to noise
active noise control
cabin noise
electric motor noise

STRUCTURE AND AEROELASTICITY
crashworthiness
structurally efficient wing and rotor support
rotor/airframe stability
durability and damage tolerance
high-cycle fatigue

OPERATIONAL EFFECTIVENESS
Ops in moderate to severe weather
passenger acceptance/ ride quality
disturbance rejection (control bandwidth, control design)
cost (purchase, maintenance, DOC)

ROTOR-WING INTERACTIONS
conversion/transition
interactional aerodynamics
flow control

AIRCRAFT DESIGN
conceptual design tools
handling qualities
weight, vibration
active control

Red = primary RVLT research area
Blue = secondary RVLT research area

NASA RVLT Project Research Areas

Ames Research Center

- Aeromechanics
- System Analysis
- Computational Methods
- Experimental Capability
- Flt Dyn & Ctrl
- Acoustics

Armstrong Flight Research Center

- UAM Handling and Ride Qualities
- UAM Electric System and Flight Control Integration

Glenn Research Center

- Hybrid/ Electric Systems
- Electro-Mech Powertrains
- Icing
- System Analysis
- Impact Dynamics
- Acoustics

Langley Research Center

- Acoustics
- Computational Methods
- Aeromechanics
- Experimental Capability
- Impact Dynamics
- System Analysis




FY23 RVLT Resources: ~ 118 Civil Service Workforce
~ $35M per year (includes salary)

Future eVTOL Vehicle Missions

Focus on technologies that improve vehicle capabilities to enable advanced Public Good missions.

- More payload capability
- More range / flight time
- Increased speed
- Lower cost (life cycle, maintenance, mfg)
- Operations in adverse weather

Disaster Relief

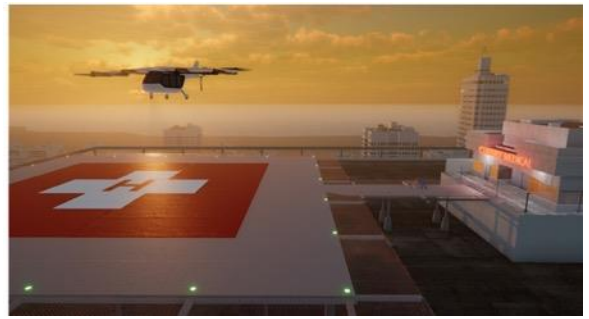
- Assessments
- Evacuations
- Supplies
- Search and Rescue

Aerial Firefighting

- Surveillance
- Responder transport
- Fire retardant delivery

Medical Transport

- Intracity patient transport
- Clinic staff transport
- Organ/supply transport



Environment

- Agriculture
- Conservation/ Environmental surveys
- Wildlife management

UAM Air Taxi

Public Good Missions

Future Research / Technology Areas for eVTOL Vehicles

Noise, Safety, & Performance

Community response to eVTOL noise

Acoustic impacts – new missions

High efficiency, light-weight powertrain / thermal management system

High voltage & EMI protection

Active noise control

Hub & airframe drag minimization

Erosion-resistant, durable, high-fatigue cycle materials & structures

Cabin noise & environment

Safe operations through rain, wind, icing

Rotor interactions: vibration & load alleviation

Disturbance rejection

Damage detection and repair