National Aeronautics and Space Administration

ATM-X UAM Subproject

Principal Engineer, Dr. Ian Levitt

Dec 17, 2020

Purpose

Provide a high level overview of ATM-X UAM Subproject, and NASA's Advanced Aerial Mobility (AAM) mission.

NASA Critical Commitment

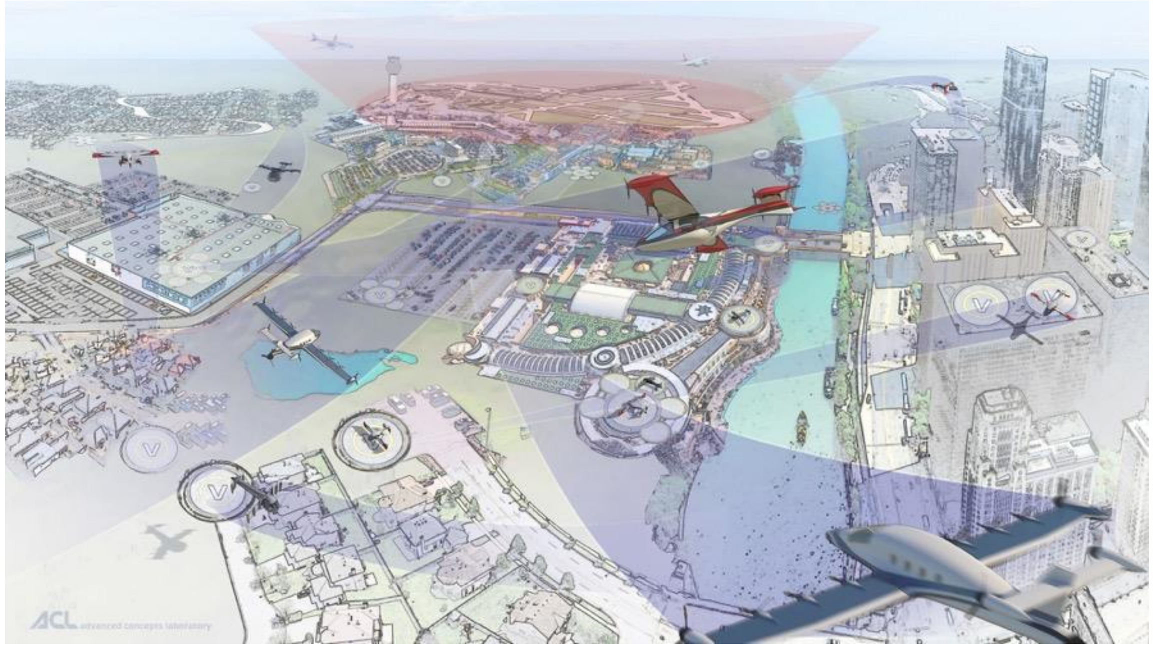
AAM MISSION

Advanced Air Mobility (AAM)

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

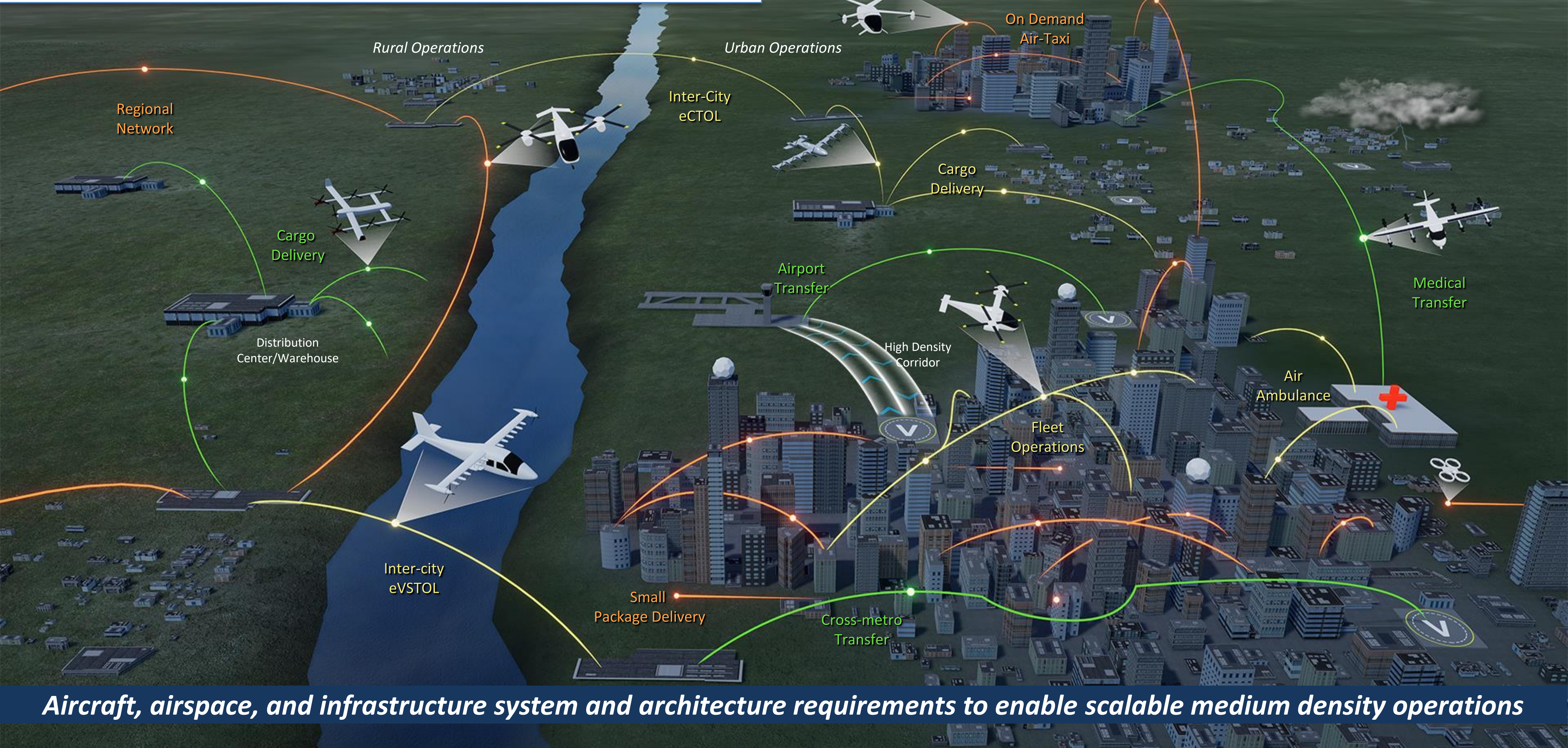
Local mission < ~75nmi, and intraregional mission < ~300nmi

- Includes “rural” and “urban” applications
  - Cargo transport, pax-carrying, aerial work, etc.
  - eVTOL, sUAS, eCTOL, hybrid-electric, etc.
  - Urban Air Mobility (UAM) as a challenging use-case with high benefit
- Enabled by electrification and automation
- Does not include:
  - Supersonic or hypersonic transport
  - Existing hub-and-spoke air service with large transport aircraft



Advanced Air Mobility (AAM) Mission

UAM Maturity Levels (UML)
- UML-4 Medium Density/Complexity, assistive automation
- UML-3 Low Density, Medium Complexity, comprehensive safety assurance automation
- UML-2 Low Density/Complexity, collaborative and responsible automated systems
- UML-1 Conforming prototypes



Aircraft, airspace, and infrastructure system and architecture requirements to enable scalable medium density operations

UAM Maturity Levels (UMLs): Top-Level View

UAM Framework and Barriers

Vehicles | Airspace | Community

INITIAL STATE	UML-1	Mature certification projects
	UML-2	Initial commercial operations
INTERMEDIATE STATE	UML-3	Early adopter markets, initial fleet operations
	UML-4	Scalable, weather-tolerant operations for any city
MATURE STATE	UML-5	Widespread deployment
	UML-6	Ubiquitous on-demand air mobility

ATM-X Project

UAM AIRSPACE SUBPROJECT

ATM-X Project Organization

Air Traffic Management – eXploration

Project Support
Coordinator: Roxana Corzo

Lead Analyst: Warcquel Frieson

Center Analysts: Brenda McKay, Meredith Irwin

Schedulers: Natalie Condon, Donna Gilchrist

Project Office
Project Manager: William Chan

Deputy Proj. Mgr.: Mike Madson

Deputy Proj. Mgr. - Tech: Dr. Bryan Barmore

Chief Engineer: Dr. Joey Rios

ARD Office
ARC APM: Lindsay Stevens
LARC APM: Dr. Taumi Daniels
GRC APM: Rafael Apaza

Vision 2045
Lead: Shawn Engelland

Systems Engineering
Lead: Dr. James Chartres

Risk Mgr: Joshua Moody

Management approach governed by NPR 7120.8A

SUB-PROJECTS

Digital Information Platform – (DIP)
SPM: Mirna Johnson

UAM Airspace Management (UAM)
SPM: Kevin Witzberger
DSPM: Arwa Aweiss
PE: Dr. Ian Levitt

Pathfinding for Airspace with Autonomous Vehicles (PAAV)
SPM: Rob Fong
TL: Kurt Swieringa

Collaborative Traffic Management (CTM)
SPM: Dr. Jaewoo Jung
TL: Dr. Min Xue

Work Package 1: Urban Air Mobility Foundational Research

- **Task 1.1: UAM Demand Analysis**
  - The objective of this task is to identify potential demand for Urban Air Mobility (UAM) in cities/urban areas, in suburban areas/regions, between nearby cities/regions.
    - Jeremy Smith, jeremy.c.smith@nasa.gov

- **Task 1.2: UAM Network**
  - The objective of this task is to develop the necessary knowledge to quantify and qualify the advantages and disadvantages of different designs for a UAM network designs utilizing cost functions, network scheduling algorithms, and UAM demand prediction models.
    - Hanbong Lee, hanbong.lee@nasa.gov

- **Task 1.3: UAM Impacts Analysis**
  - The objective of this task is to develop fast-time simulated system-level impact assessments of weather and localized sub-system failures on potential UAM operations and environmental impacts due to UAM operations in selected urban/rural areas.
    - Hokkwan Ng, hokkwan.ng@nasa.gov

- **Task 1.4: UAM Flight Performance**
  - The objective of this task is to develop a database for typical Urban Air Mobility (UAM) vehicles especially considered as V/STOL configurations will be used for the development and analysis of UAM-concepts dedicated to various urban regions and operational concepts.
    - John Foster, John.v.foster@nasa.gov

UAM Airspace Sub-Project

UAM SPM

Airspace Systems Architecture, Engineering and Management

Principal Engineer: Ian Levitt (ian.m.levitt@nasa.gov)
Lead Systems Engineer: Annie Cheng (annie.w.cheng@nasa.gov)

Separation Standards

ARC Tech Lead: Seungman Lee
LaRC Tech Lead: Maria Consiglio

Airspace Procedures & Design

ARC Tech Lead: Savvy Verma

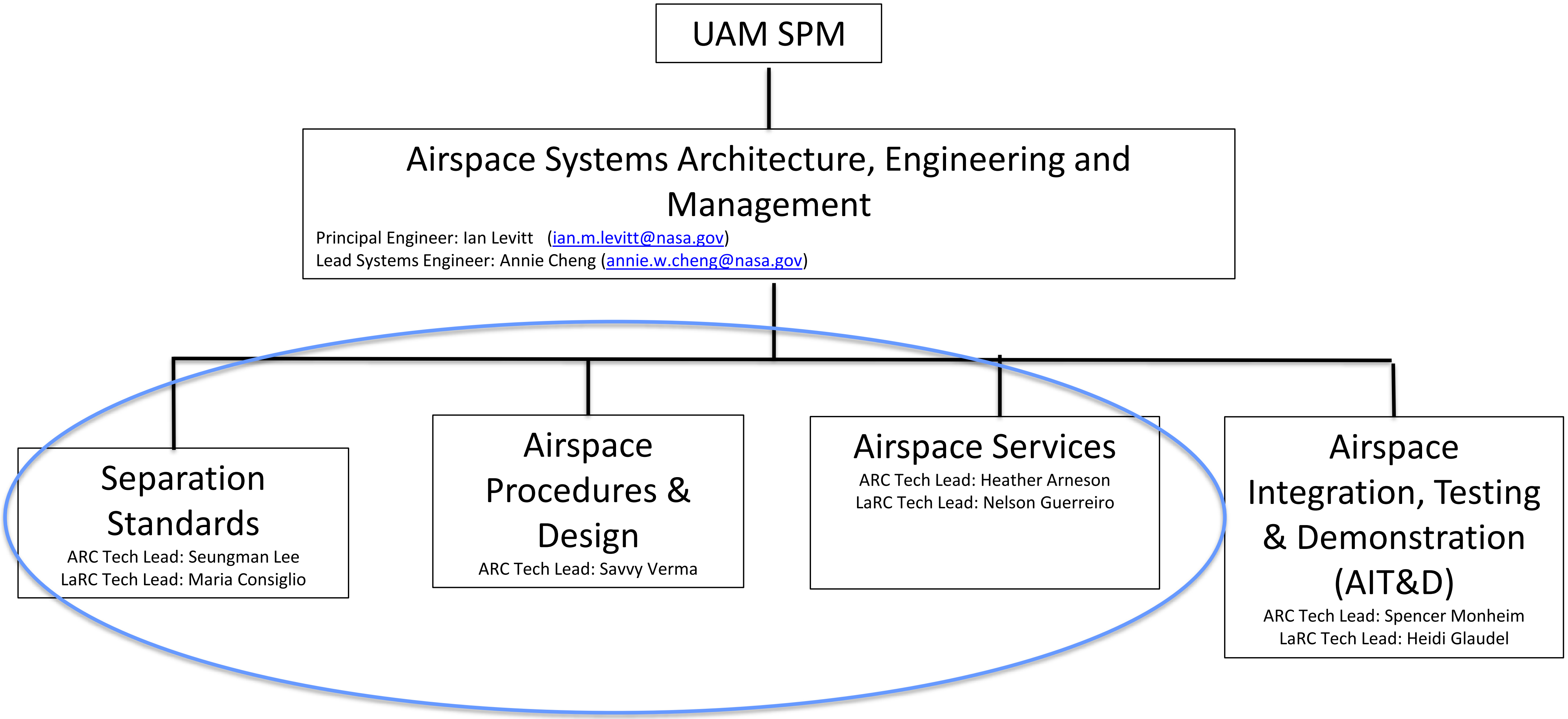
Airspace Services

ARC Tech Lead: Heather Arneson
LaRC Tech Lead: Nelson Guerreiro

Airspace Integration, Testing & Demonstration (AIT&D)

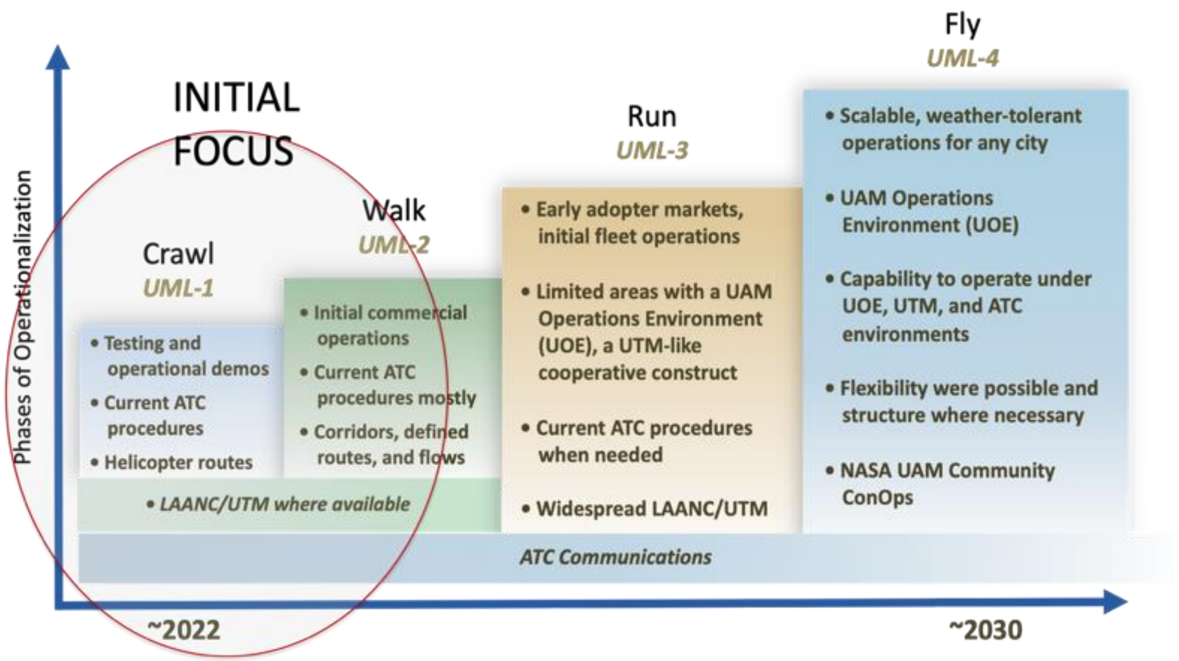
ARC Tech Lead: Spencer Monheim
LaRC Tech Lead: Heidi Glaudel

UAM Airspace Sub-Project



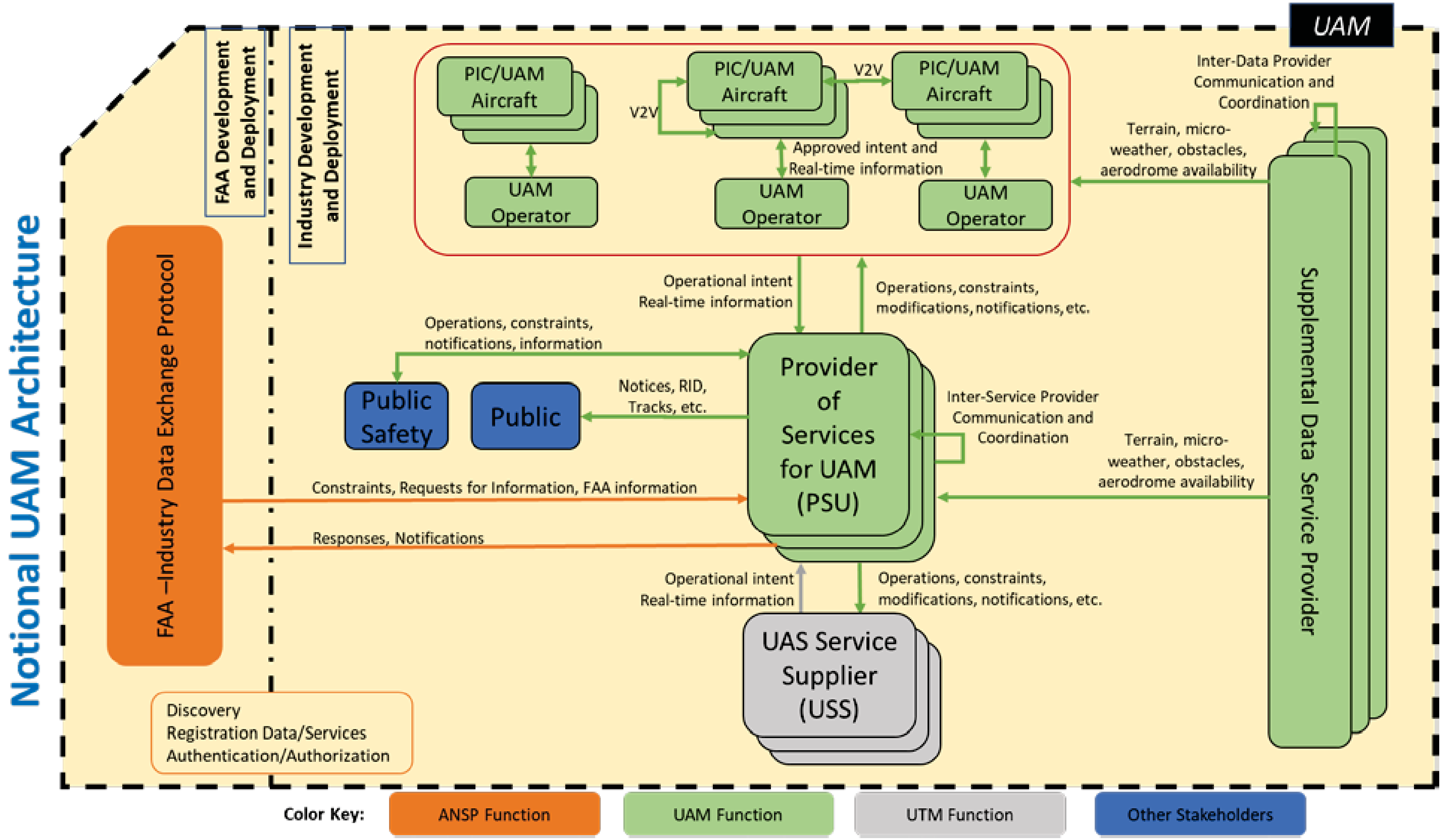
UAM Airspace Evolution

"Airspace is ready when the Vehicle is ready"



- Airspace domain has many components
- Each component *evolves* through the *UML progression*
  - Need to see how to get there from here

Notional UAM Architecture (FAA NextGen Conops v1.0)



BACKUP

Backup Slides

AAM MISSION

AAM Mission Critical Commitment

Vehicle Development and Operations Develop concepts and technologies to define requirements and standards addressing key challenges such as safety, affordability, passenger acceptability, noise, automation, etc.

Airspace Design and Operations Develop UTM-inspired concepts and technologies to define requirements and standards addressing key challenges such as safety, access, scalability, efficiency, predictability, etc.

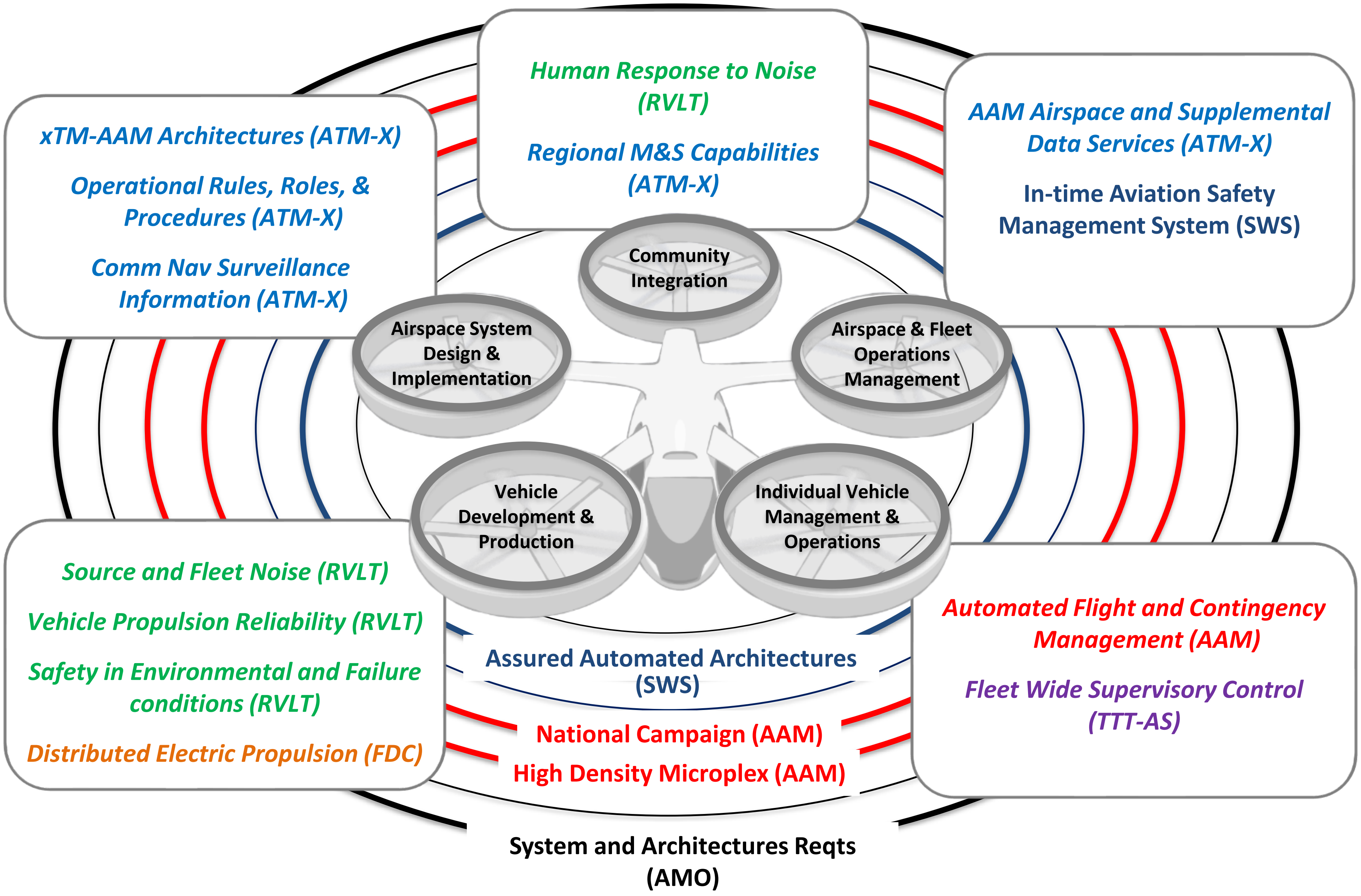
Community Integration Create robust implementation strategies that provide significant public benefits and catalyze public acceptance, local regulation, infrastructure development, insurance and legal frameworks, etc.

Critical Commitment:

Based on validated operational concepts, simulations, analyses, and results from National Campaign demonstrations, the AAM Mission will deliver <u>aircraft, airspace, and infrastructure system and architecture requirements</u> to enable sustainable and scalable medium density advanced air mobility operations

Achieving a "validated system architecture" will require *<u>enabling activities</u>* such as 1) the AAM National Campaign Series 2) a robust Ecosystem Partnership model and 3) NASA ARMD Portfolio Execution.

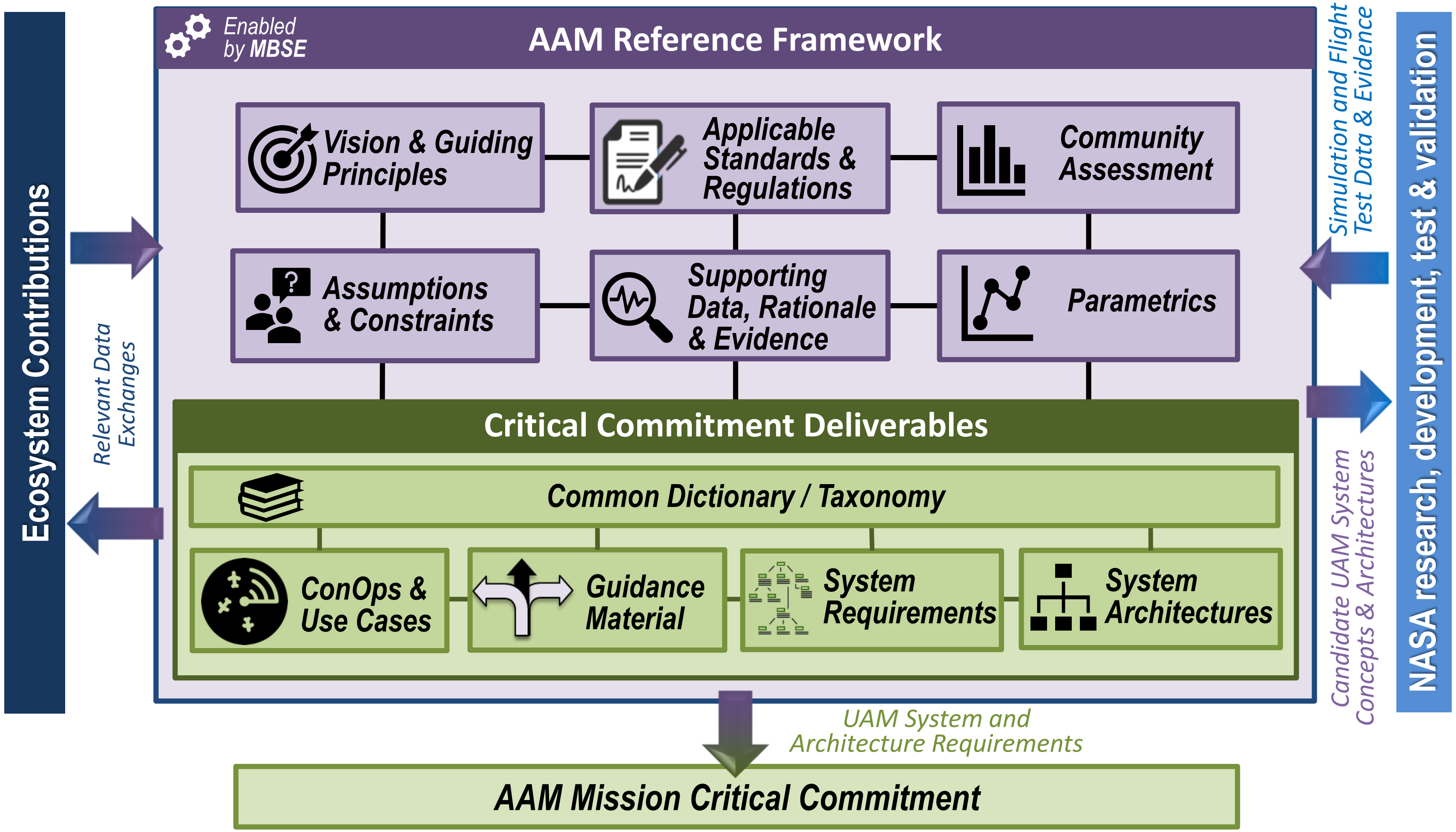
NASA AAM Mission Priorities



Lead Project Legend

AAM
ATM-X
RVLT
SWS
FDC
TTT
AMO

AAM Reference Framework & Deliverables Supporting the Critical Commitment



Collaborating with other federal/state/local governments and industry organizations across the AAM Ecosystem to develop a comprehensive set of AAM system and architecture requirements for medium density operations.

MBSE = Model Based Systems Engineering

AAM Ecosystem Working Groups (AEWG)

Align on a common vision for AAM

Learn about NASA's research and planned transition paths

Adopt a strategy for engaging the public on AAM

Collectively identify and investigate key hurdles and associated needs

Develop AAM system and architecture requirements

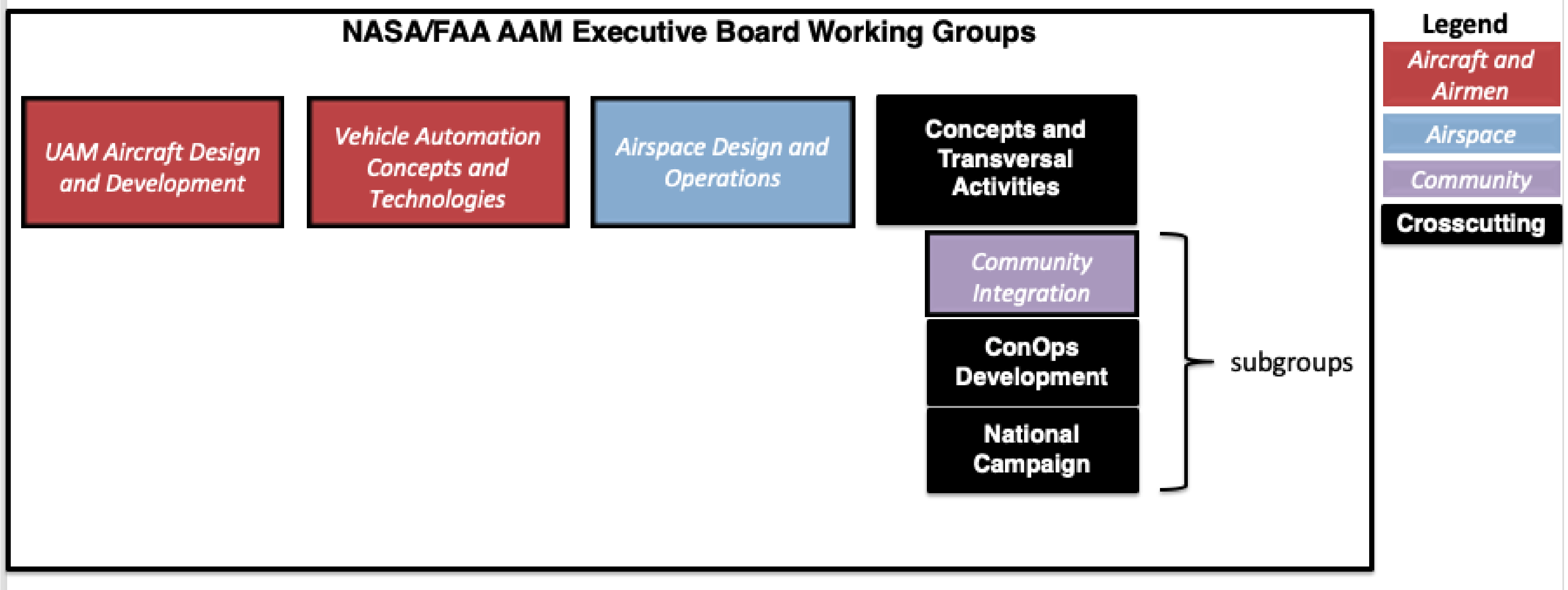
Support regulatory and standards development

Form a connected stakeholder community

Accelerate the development of safe and scalable AAM flight operations by bringing together the broad and diverse community involved in developing this new capability

NASA/FAA AAM WG Structure

- Executive leadership has jointly agreed to a WG structure to continue formalizing AAM planning and execution strategies
- Multiple working groups are extensions of previous collaborations
- All working groups have been through an iteration of a cross-agency planning cycle



Backup Slides

NATIONAL CAMPAIGN

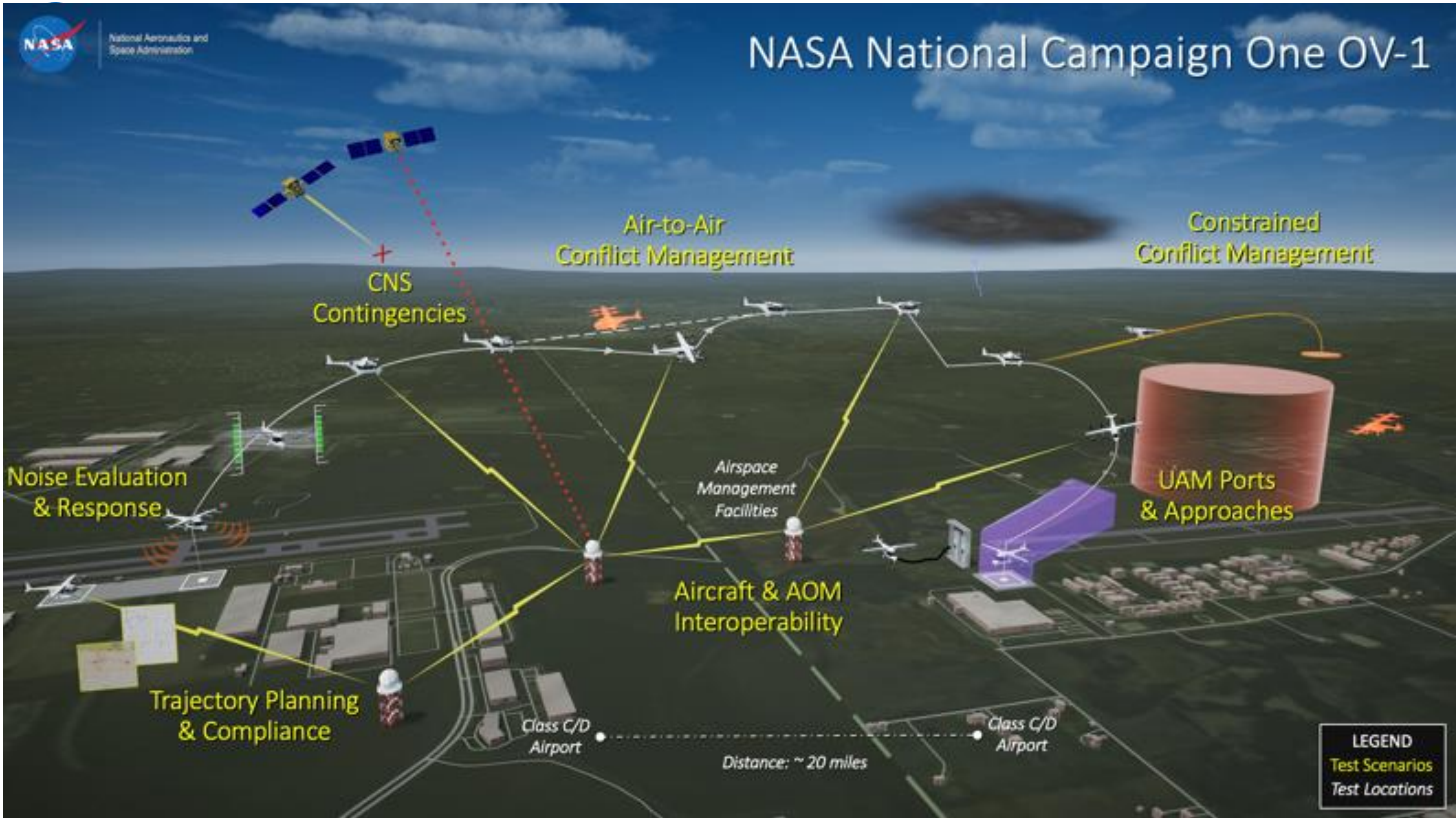
AAM National Campaign (NC) Series

Goal

Assure AAM safety and accelerate scalability through integrated demonstrations of candidate operational concepts and scenarios.

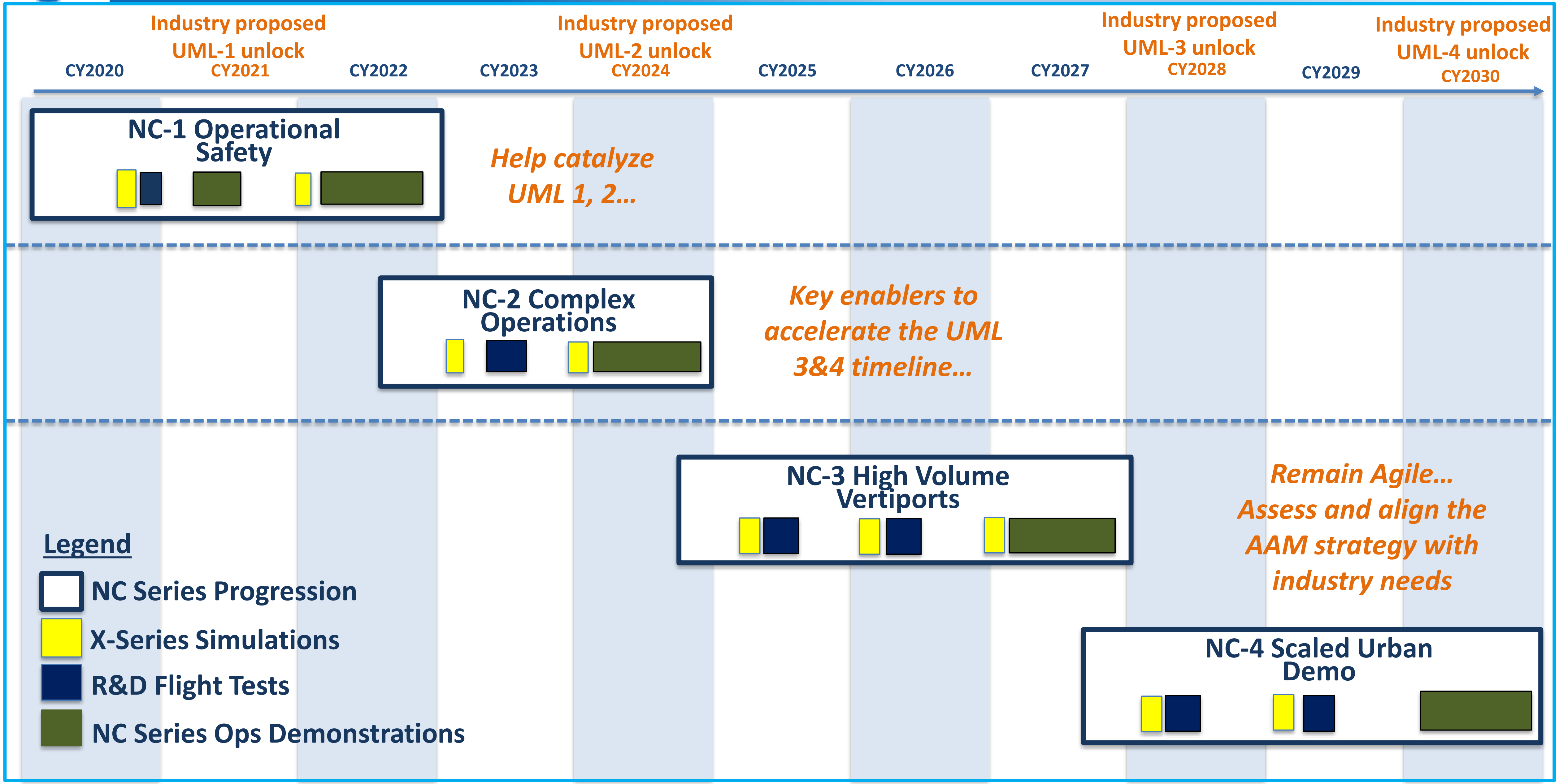
Objectives

1. Accelerate Certification and Approval
2. Develop Flight Procedure Guidelines
3. Evaluate the CNS Trade-Space
4. Demonstrate an Airspace Operations Management (AOM) Architecture
5. Characterize Community Concerns



National Aeronautics and Space Administration
NASA National Campaign One OV-1
Air-to-Air Conflict Management
Constrained Conflict Management
CNS Contingencies
Noise Evaluation & Response
Airspace Management Facilities
UAM Ports & Approaches
Aircraft & AOM Interoperability
Trajectory Planning & Compliance
Class C/D Airport
Class C/D Airport
Distance: ~ 20 miles
LEGEND
Test Scenarios
Test Locations

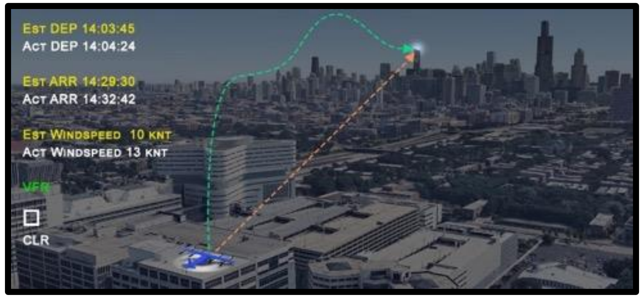
National Campaign Series support of the Industry Timeline



UML "unlocks" based on a range of publicly available industry projections and conversations with partners; not a consensus view

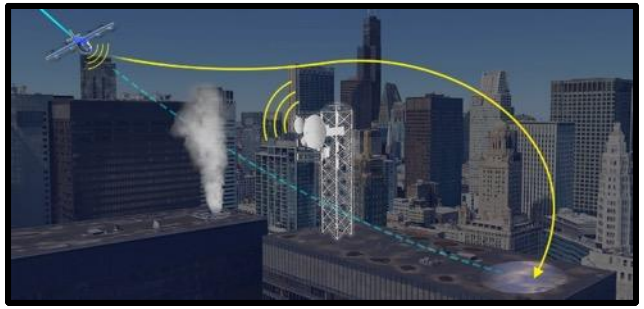
NC DT – Scenarios 1-3

- Scenario 1: Nominal Integrated Flight Operations
  - Nominal flight planning for a flight with no activated contingencies
    - Flight planning, route negotiation and acceptance, route and time conformance
    - Simulated background traffic to study impacts on timing



- Scenario 2: Integrated Flight Operations with an Activated Contingency
  - Nominal point-to-point route, then a temporary flight restriction (TFR) requires the vehicle to re-route while en route
  - Leveraging airspace test infrastructure based on a UTM construct for initial flight plan submission and test re-route from the airspace perspective

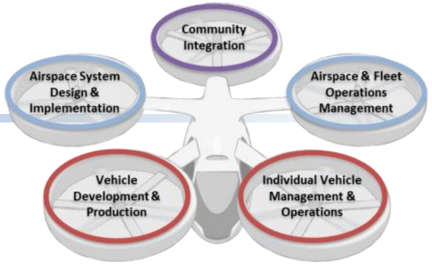
- Scenario 3: Terminal Operations and Approach/Landing Contingencies
  - 3a: Airspace initiates the contingency; go-around, loiter, and land at original site
  - 3b: Vehicle initiates the contingency; balked landing and divert to an alternate site
  - 3c: Vehicle initiates the contingency; vehicle executes a go-around, requests immediate landing, and ATC works vehicle into simulated traffic to land on an active runway

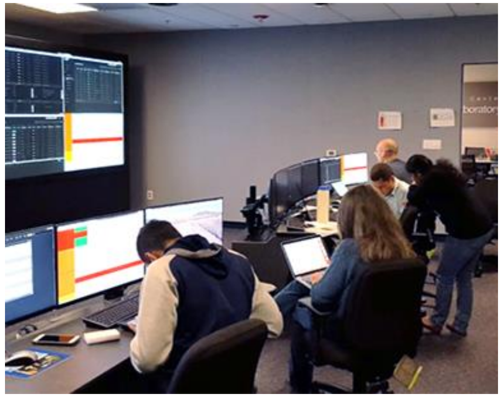


Backup Slides

RESEARCH, DEVELOPMENT, TEST & EVALUATION CAPABILITIES

NASA AAM Facilities and Capabilities





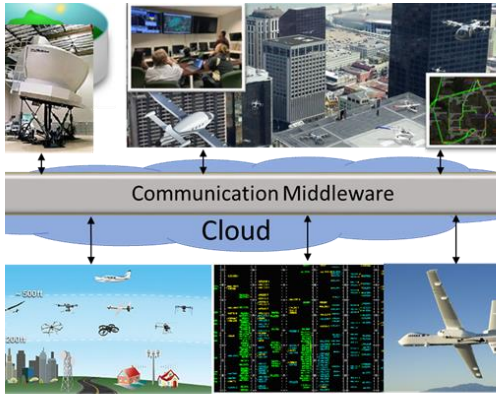
Airspace Operations Lab

Cockpit Motion Facility

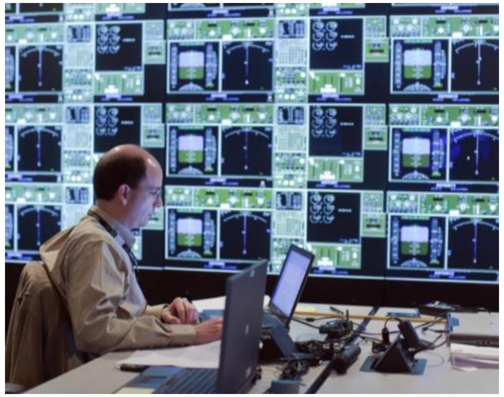
Developmental UAM Simulator - Flyer

Vertical Motion Simulator

Mobile Operations Facility



Testbed Virtual Infrastructure



Air Traffic Operations Lab

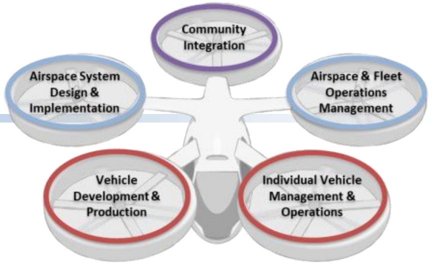
Future Flight Central

Cognitive Engineering Lab

Research Flight Deck

* This list of capabilities is a notional first cut and we are still in formulation, we have not yet assessed all the requirements or made commitments for each capability.

NASA AAM Facilities and Capabilities Cont.



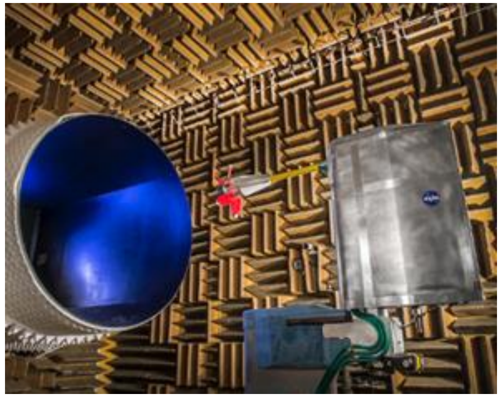

Ames UAM Lab

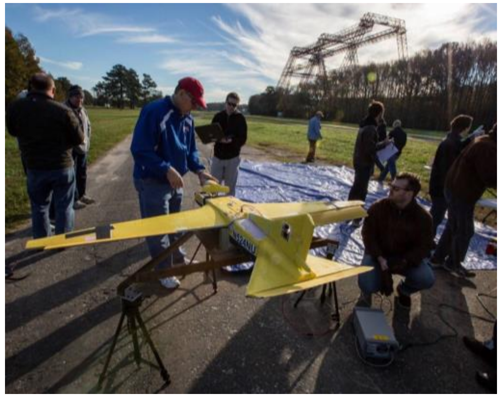
Mobile Acoustics Facility


Icing Research


X-57 Maxwell

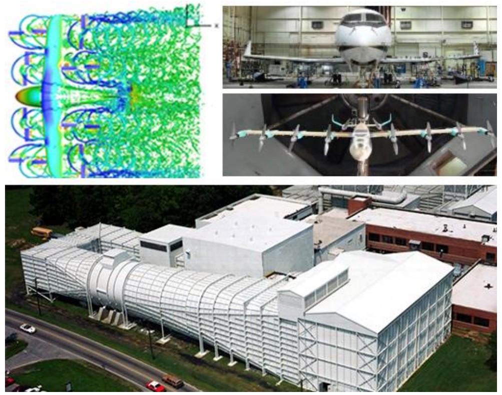

Exterior Effects Room


Low Speed Aeroacoustic Wind Tunnel


CERTAIN Range


Landing and Impact Research Facility


Dryden Aeronautical Test Range


Many others including wind tunnels, aircraft, ranges, cockpit sims, supercomputers, etc.

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Strong Domestic eVTOL Industry Base