National Aeronautics and Space Administration

Multi-Vehicle Control Working Group

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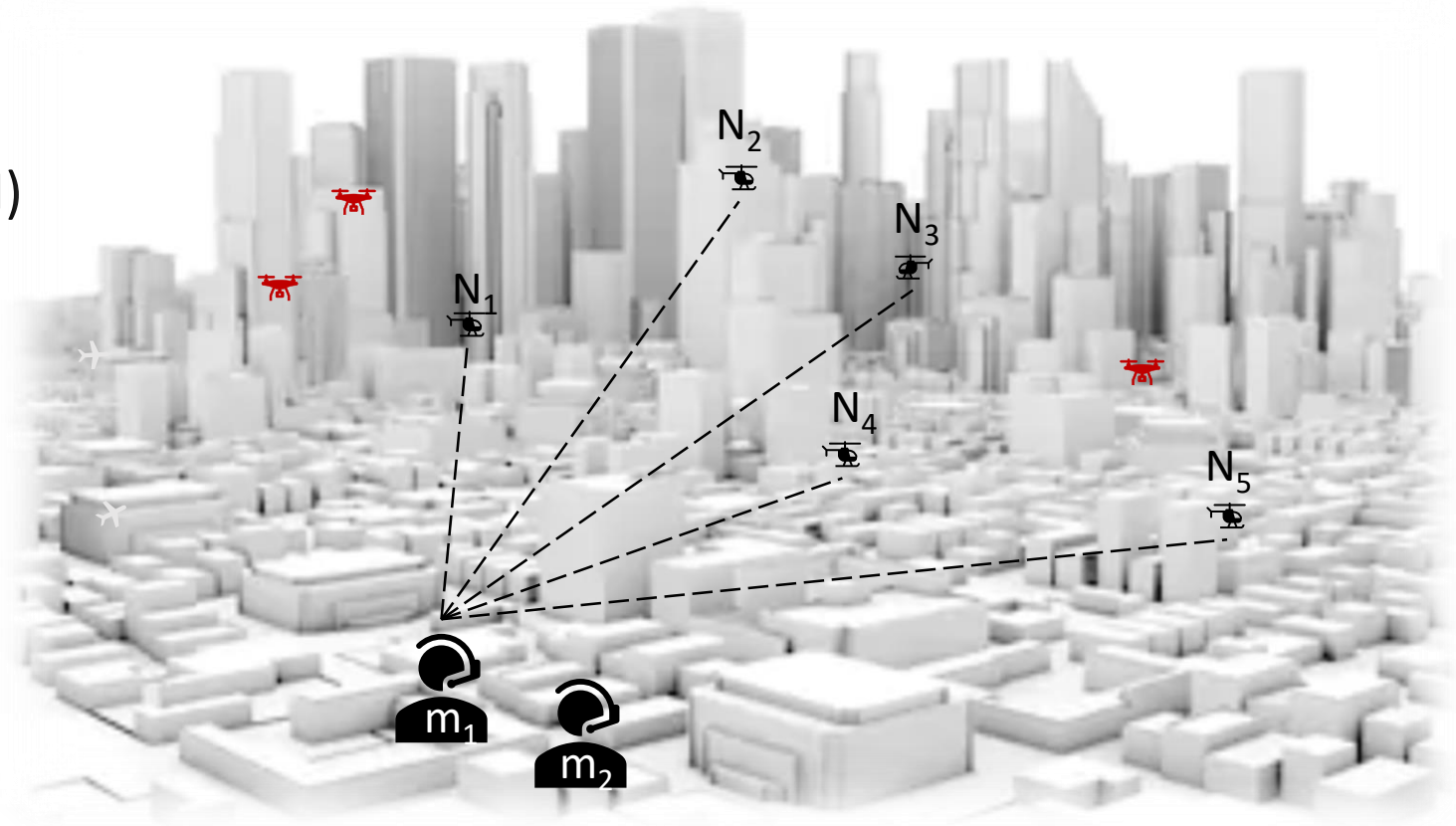
m:N operations

Multi-vehicle control = m:N

- Small group of humans (m) *manages* many highly automated air vehicles (N)
- Not flight vehicle control

Enables desired future state

- Operations scalability
- Increasingly autonomous vehicles

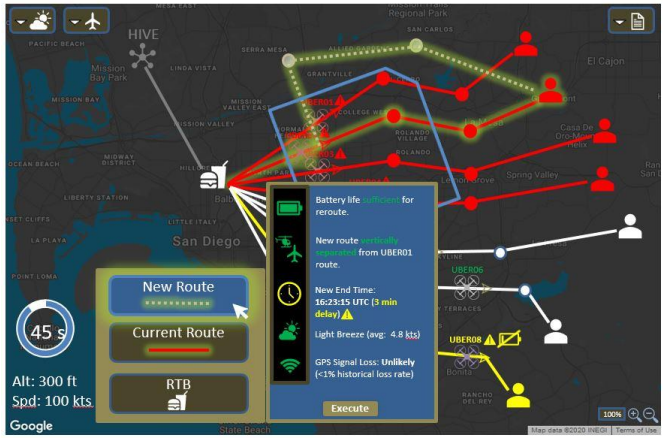


Applicable to range of use cases supporting of advanced air mobility vision

m:N across ARMD

Transformational Tools and Technologies (T^3)

- Progressive human-in-the-loop demos for m:N operation with Joby Aviation
- Foundational human-autonomy teaming research

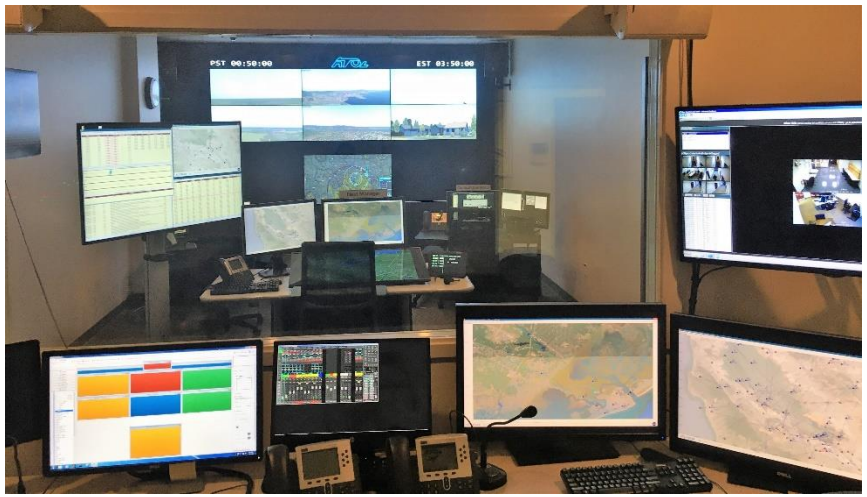


System-Wide Safety (SWS)

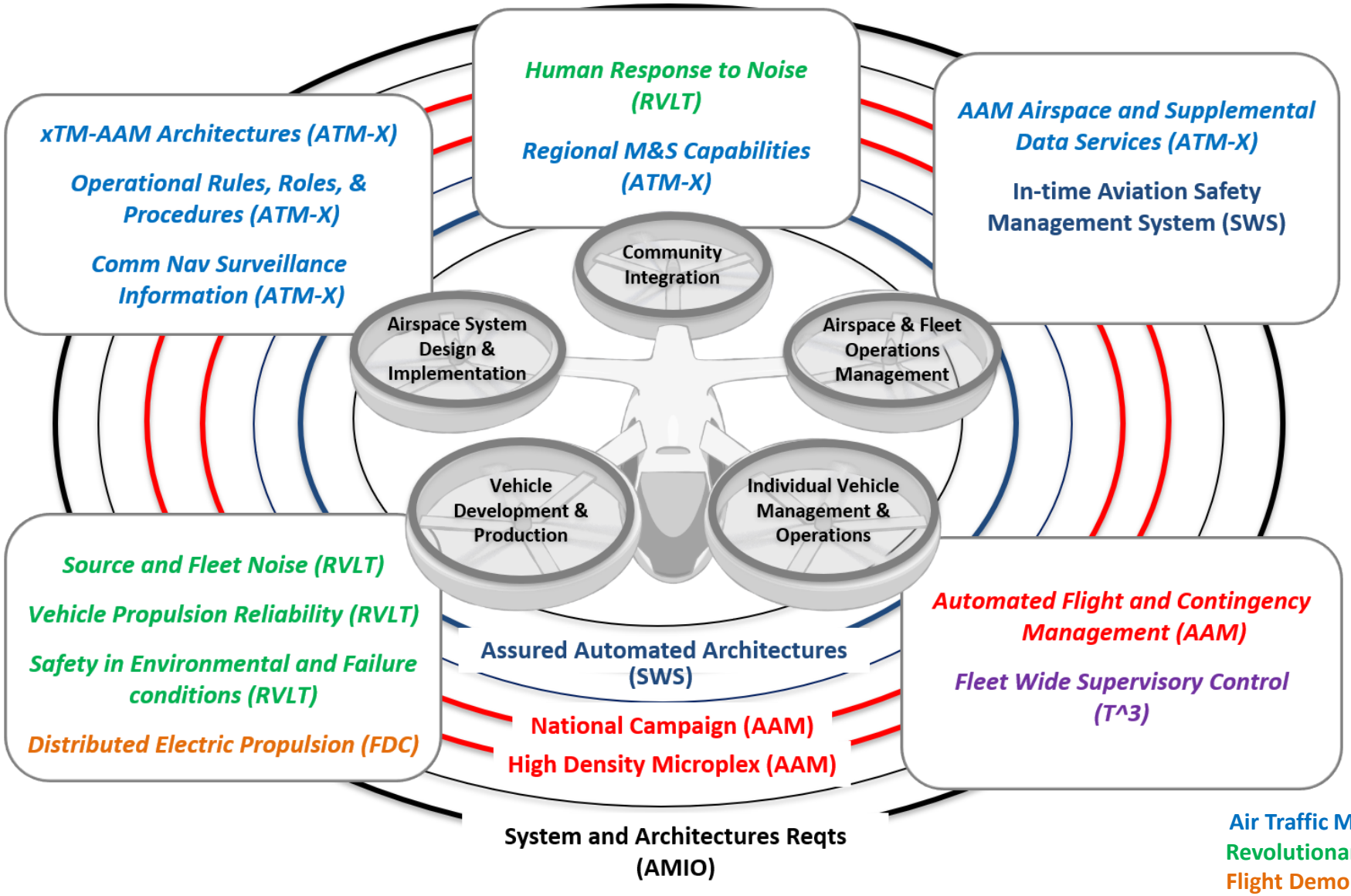
- m:N ConOps development
- Proposed technical challenge includes human-autonomy teaming for wildfire response

Advanced Air Mobility (AAM)

- m:N for high density vertiport operations including ConOps development and BVLOS safety case



m:N across ARMD



Project Legend

Advanced Air Mobility (AAM)
System-Wide Safety (SWS)
Air Traffic Management Exploration (ATM-X)
Revolutionary Vertical Lift Technology (RVLT)
Flight Demonstrations and Capabilities (FDC)
Transformational Tools and Technologies (T^3)
AAM Mission Integration Office (AMIO)

m:N in T^3

T^3 Revolutionary Aviation Mobility subproject

- Supports ARMD mission programs by providing a pipeline of solutions and knowledge for **foundational challenges in enabling an advanced air mobility market**

- Enables increasingly autonomous transportation in the **UML-4+ timeframe**

OBJECTIVES

Enable scalable operations to achieve the full vision and potential of AAM through development of targeted tools and techniques critical for autonomous m:N fleet management [Draft TC] {AS}

Explore and develop airspace management and operations architectures and tools in expectation of increased heterogeneous air traffic {AS, CNS, MDAO}

Develop modeling, performance, and control tools & techniques for advanced urban capable aircraft {Controls, MDAO}

Explore and demonstrate approaches for scaled vehicle production {M&S}

Multi-disciplinary support

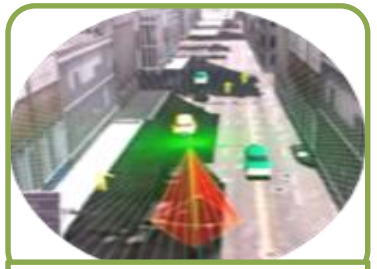
Human Autonomy Teaming

Distribution of roles & responsibilities

Safe, effective teaming strategies

Foundational research tools

Human-in-the-loop simulation



Perception

Vehicle knowledge of surroundings, self, and health through sensing and information processing

Gap analysis and trade studies of capabilities enabling UML 4+

Research-enabling data collection

Intelligent Contingency Management

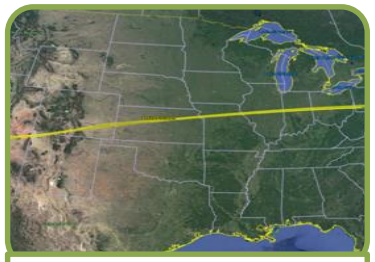
Intelligent machine decisions for unforeseen events with uncertain, incomplete, and unreliable info

Assuring non-deterministic ICM algorithms

Collective Autonomous Mobility

Explore architectures to accommodate heterogeneous autonomous operations in the same airspace

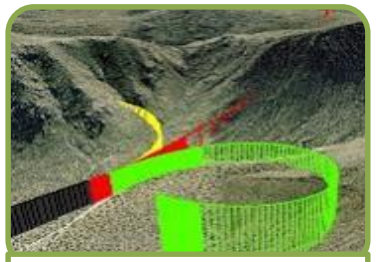
Examine the dynamic relationship among services, operators, and agents



Communication, Navigation, and Surveillance

Autonomous spectrum allocation

Self-optimizing phased array antennas to mitigate interference



Resilient Autonomy

Inform future certification requirements and strategies for highly autonomous aircraft

Project specific certification plans for general aviation and UAS

m:N proposed technical challenge

m:N Fleet Management

For efforts through FY26, $6M/year

Enable scalable operations to achieve the full vision and potential of advanced air mobility through development of targeted tools and techniques critical for m:N operation of autonomous fleets

Supporting capabilities

Human-Autonomy Teaming:
Develop tools and techniques to enable a small number of humans (m) to manage many autonomous vehicles (N) across disparate scenarios and dynamic relationships

Autonomous vehicle technology:
Develop a capability description of a UML 4+ autonomous vehicle through characterization of realistic **Intelligent Contingency Management** and **Perception** functions

Exit criteria

- **Demonstration** of m:N operations with a realistically autonomous fleet in 2+ disparate scenarios
- Complementary **artifacts**:
  - Realistic autonomous vehicle characterization
  - Human-autonomy teaming framework
  - Publicly available research tool

Questions?