Automated Flight and Contingency Management,

NASA Advanced Air Mobility (AAM) Project

7 August, 2020

Ken Goodrich, AAM Deputy Project Manager for Technology

www.nasa.gov

Goals for Session

- Overview of the goals and approach of NASA's Automated Flight and Contingency Management (AFCM) research for UAM

- Describe NASA's AFCM partnership strategy including current Request for Information

- Answer questions

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 aircraft, airspace, and infrastructure system and architecture requirements to enable sustainable and scalable medium density advanced air mobility operations

Achieving validate "systems and architecture requirements" will require _enabling activities_ such as 1) the AAM National Campaign Series 2) a robust Ecosystem Partnership model and 3) NASA ARMD Portfolio Execution.
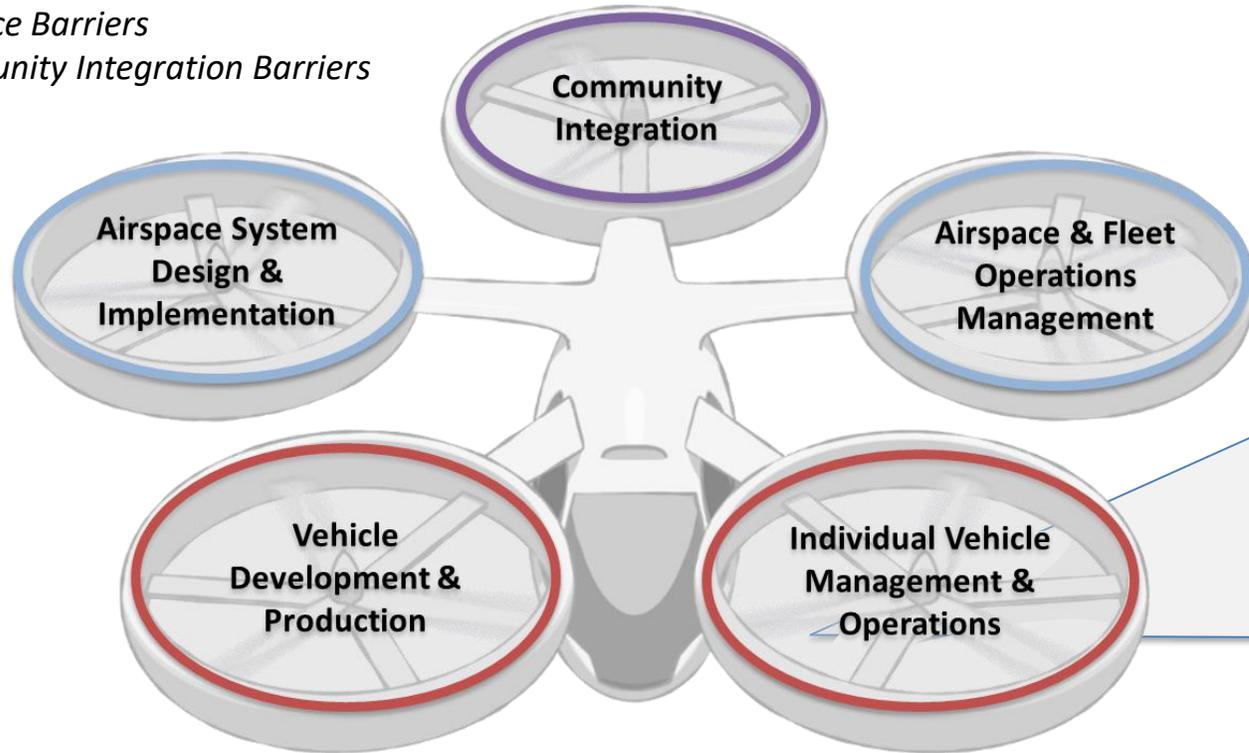
- ## Medium Density
  - 100's of aircraft aloft over metro area
  - 10's of vertiports, some capacity constrained with high traffic densities and rigorous slot management

- ## Medium Complexity
  - Operations into urban cores (e.g. limited physical separation between vertiports, people, property)
  - Visibility independent operations

- ## Collaborative and Responsible Automated Systems
  - FAA certifies automation as responsible for performing specified functions, relieving pilot from learning or performing them in any situation, including degraded system modes not shown to be extremely improbable
    - Human not required to monitor or backup these functions
  - Automation has comprehensive, autonomous situation awareness and collaborates with pilot to identify and manage hazards while safely and appropriately executing flight and contingency operations

AFCM Goals:

Legend:
- 🟥 *Aircraft and Aircrew Barriers*
- 🟦 *Airspace Barriers*
- 🟪 *Community Integration Barriers*

Drone platforms:
- Community Integration
- Airspace System Design & Implementation
- Airspace & Fleet Operations Management
- Vehicle Development & Production
- Individual Vehicle Management & Operations

Central to Pillar 2:

- **Safe Urban Flight Management**

- **Increasingly Automated Vehicle Operations**

- **Certification & Operational Approval**

- **UAM Maturity Level 4**

Develop validated system architectures & research findings to support standards for vehicle and pilot interface systems enabling "collaborative and responsible" automation and other UML-4 capabilities

Integration is Key for AFCM
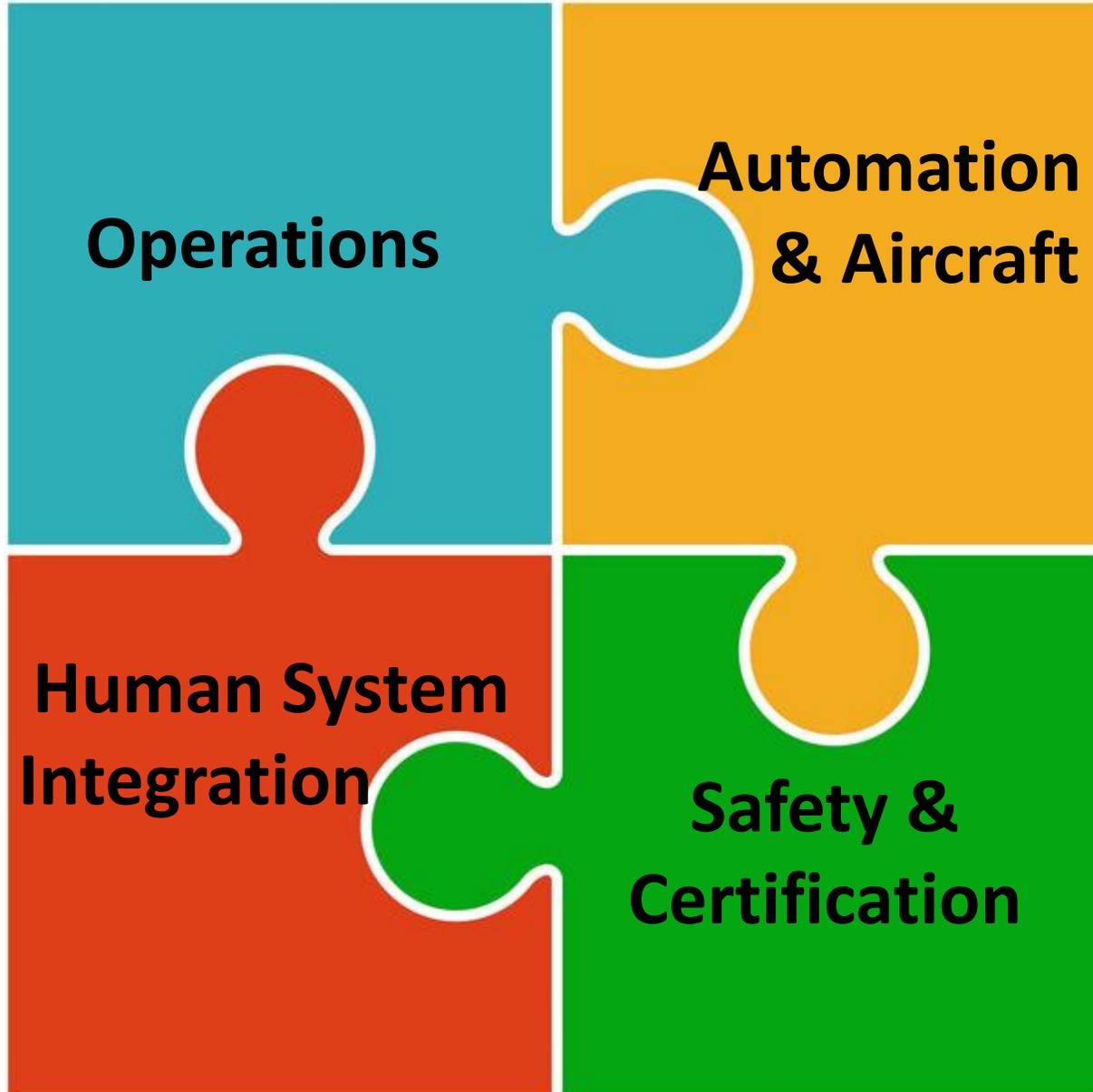
Outcomes-

- Proof of concepts, aircraft automation, pilot interface, and flight operations

- Overall UAM system of requirements: aircraft automation, operations, and external interfaces

- Reference aircraft automation architectures

- Inform development of framework and standards for human-automation certification and approvals

- Path to increasing scalability

AFCM Functional Scope (Flight Management Function)

Airspace System and Operations

Representative Automation Stack
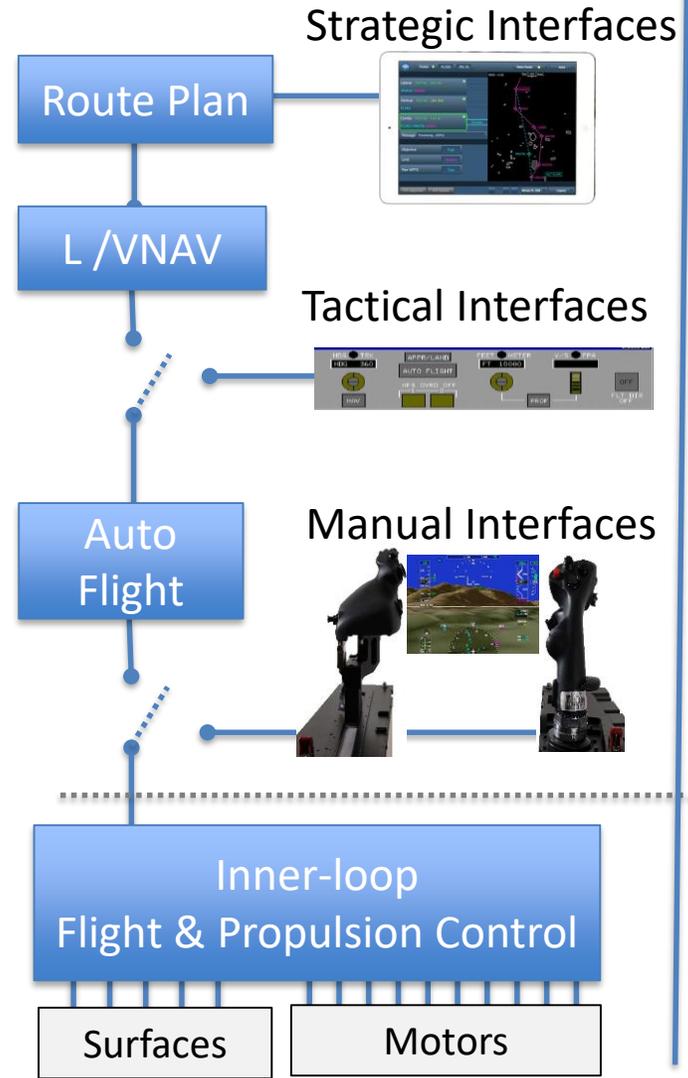
Representative Time Scales

Strategic Interfaces

Flight Planning
Present- end of flight

Route Plan

Flight procedures

Mission Management
- Operations center
- Divert options
- Contingency plans

L /VNAV

Navigation
Minutes

Tactical Interfaces

Strategic flightpath management
- ATM Interaction
- Route optimization

AFCM

Auto Flight

Auto-Flight
~Seconds

Manual Interfaces

Tactical Operations
- Detection / perception
- Situation awareness
- Conflict detection & resolution

"Manual" flight
0.1, ~Seconds

Vehicle control
- Autoflight
- Simplified handling
- Collision avoidance

Base Aircraft

Inner-loop
Flight & Propulsion Control

Inner-loop
<1 sec
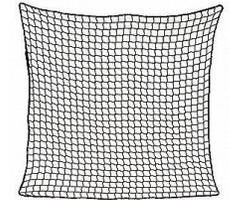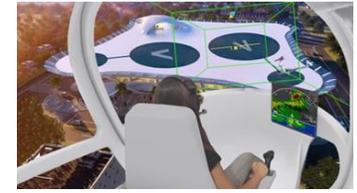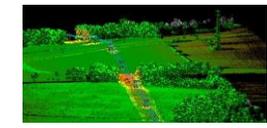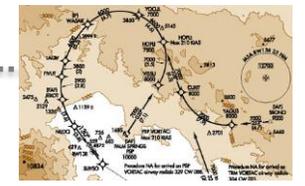
Stability and Control Augmentation, Critical Failure for Performance, Certified Minimum Performance

Effectors & Propulsors
<0.01sec

Surfaces

Motors
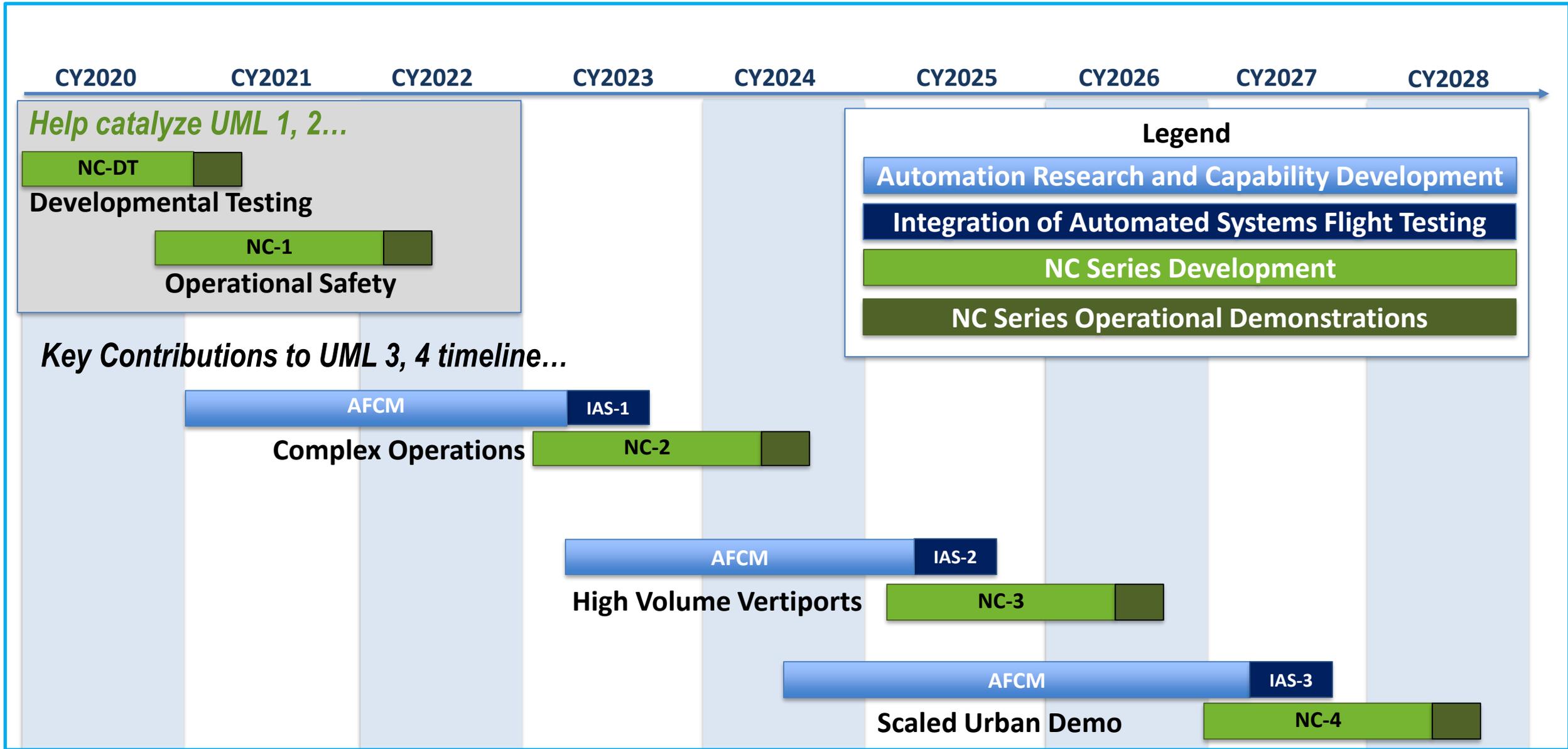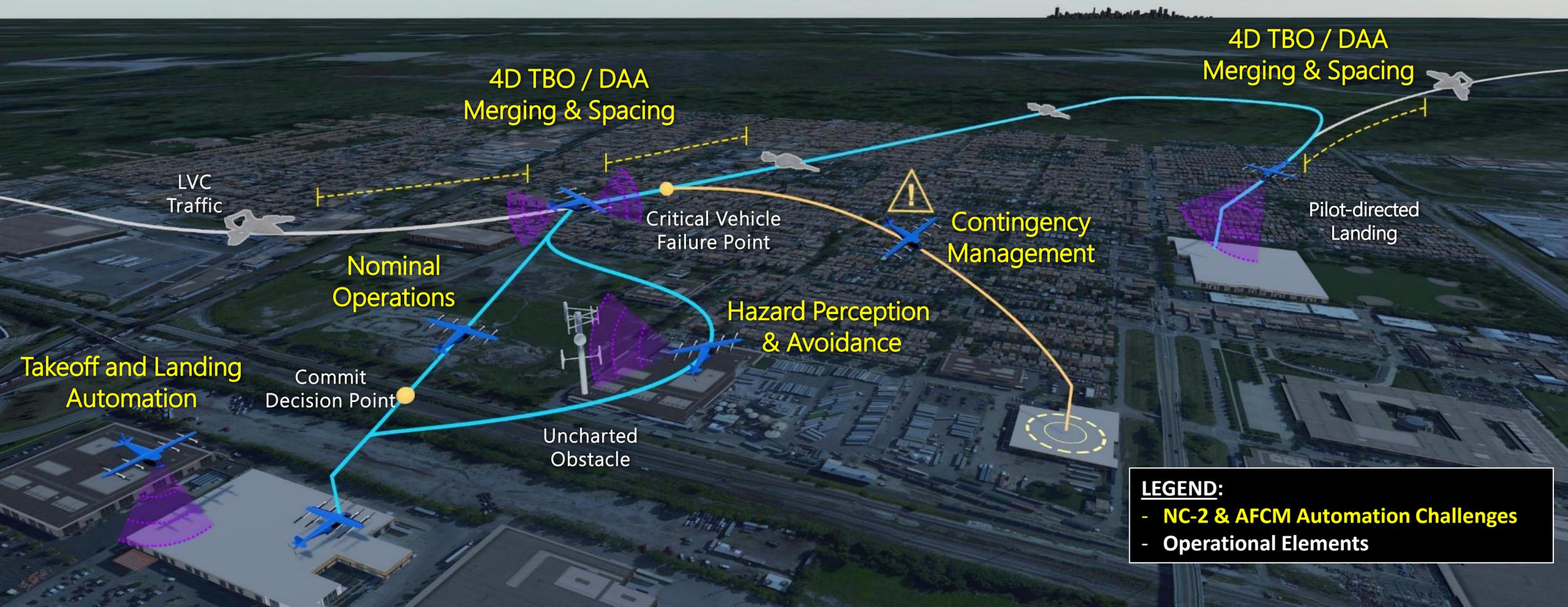
AFCM Strategy and Timeline Synchronized with National Campaign Series

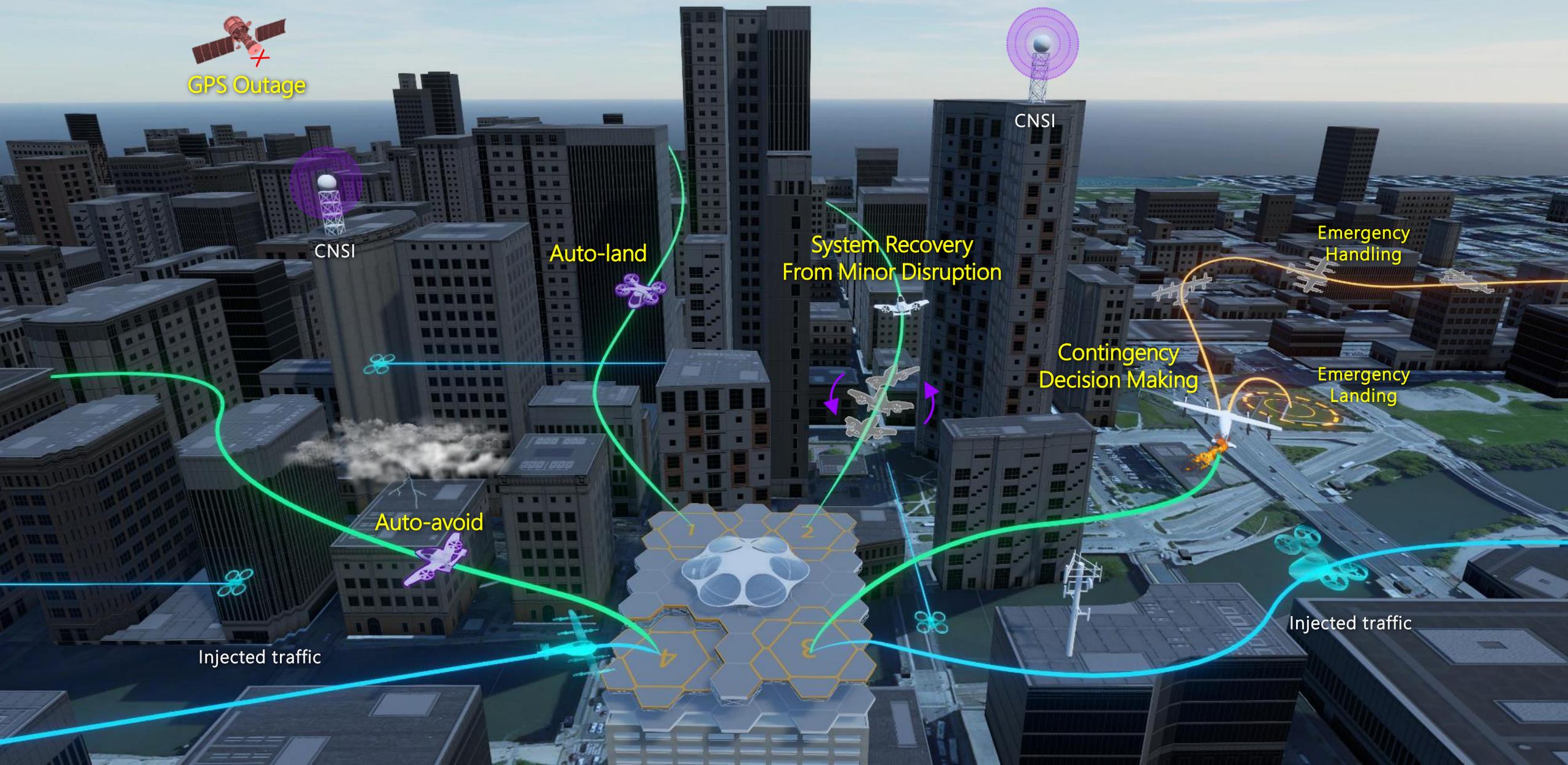# AFCM Strategy and Timeline Synchronized with National Campaign Series

CY2020 | CY2021 | CY2022 | CY2023 | CY2024 | CY2025 | CY2026 | CY2027 | CY2028

Help catalyze UML 1, 2...

NC-DT
Developmental Testing

NC-1
Operational Safety

Legend
- Automation Research and Capability Development
- Integration of Automated Systems Flight Testing
- NC Series Development
- NC Series Operational Demonstrations

Key Contributions to UML 3, 4 timeline...

AFCM — IAS-1
Complex Operations
NC-2

AFCM — IAS-2
High Volume Vertiports
NC-3

AFCM — IAS-3
Scaled Urban Demo
NC-4

NASA NC-3 High Volume Vertiports OV-1

Automated Flight & Contingency Management, Notional Architecture and Project Interfaces
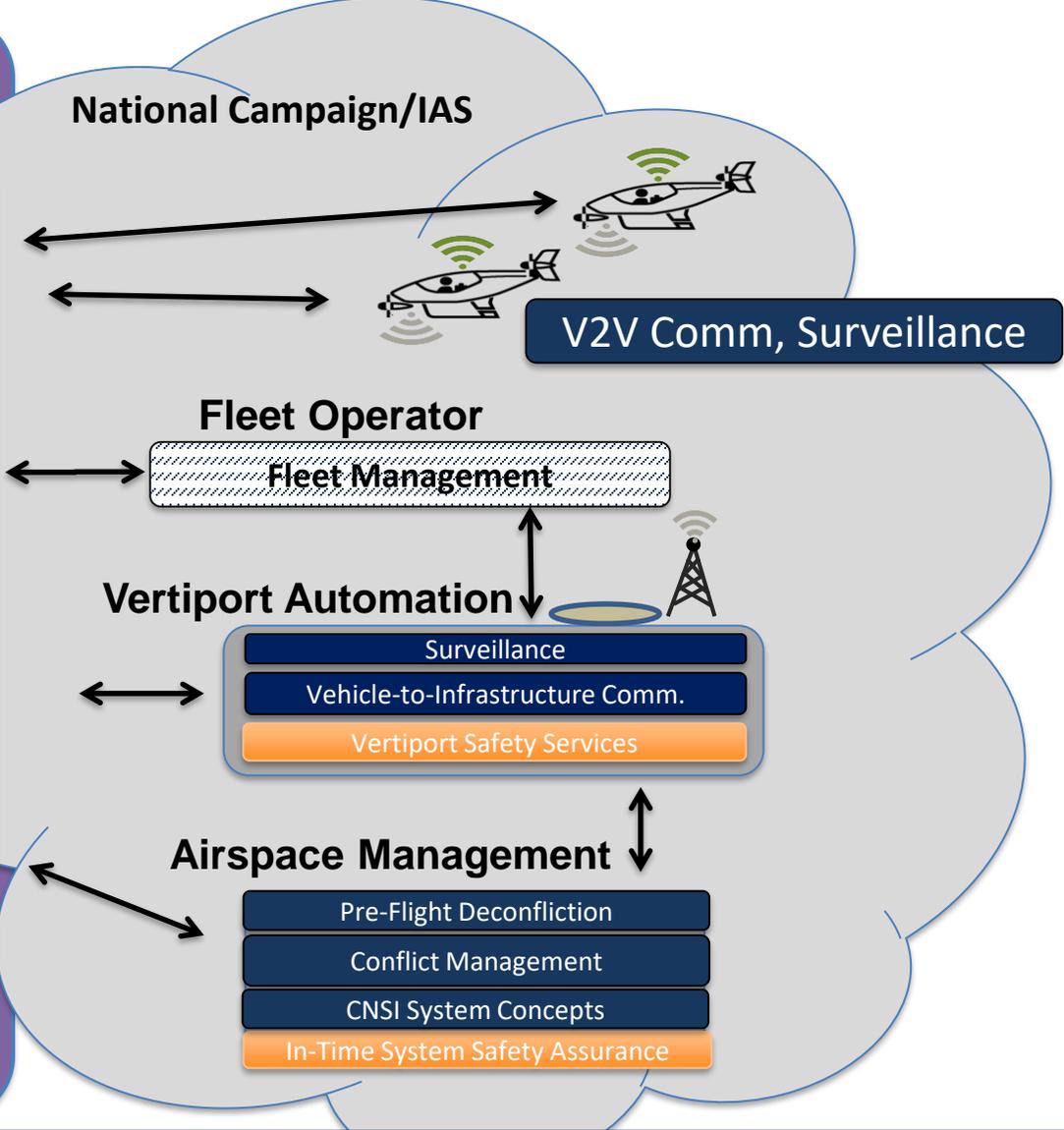

Urban Capable Aircraft

UAM Automated Flight & Cont. Man

Automation Enabled Pilots
- Simplified Handling
- Enhanced Displays
- Piloting Requirements

Assured Vehicle Automation
- Autonomous Operations Planner
- Hazard Detection / Perception
- Tactical Planning, Separation
- Navigation, Trajectory Execution
- Collision Avoidance
- On-board In-Time System Safety Nets
- Auto-Flight

National Campaign/IAS

V2V Comm, Surveillance

Fleet Operator
- Fleet Management

Vertiport Automation
- Surveillance
- Vehicle-to-Infrastructure Comm.
- Vertiport Safety Services

Airspace Management
- Pre-Flight Deconfliction
- Conflict Management
- CNSI System Concepts
- In-Time System Safety Assurance

Project Contributing Capability or Expertise
- SWS
- TTT
- ATM-X
- RVLT
- AAM NC/IAS
- AAM HDV
- AAM AFCM

AFCM develops vehicle automation architectures leveraging capabilities across ARMD

AFCM Strategy and Timeline Synchronized with National Campaign Series
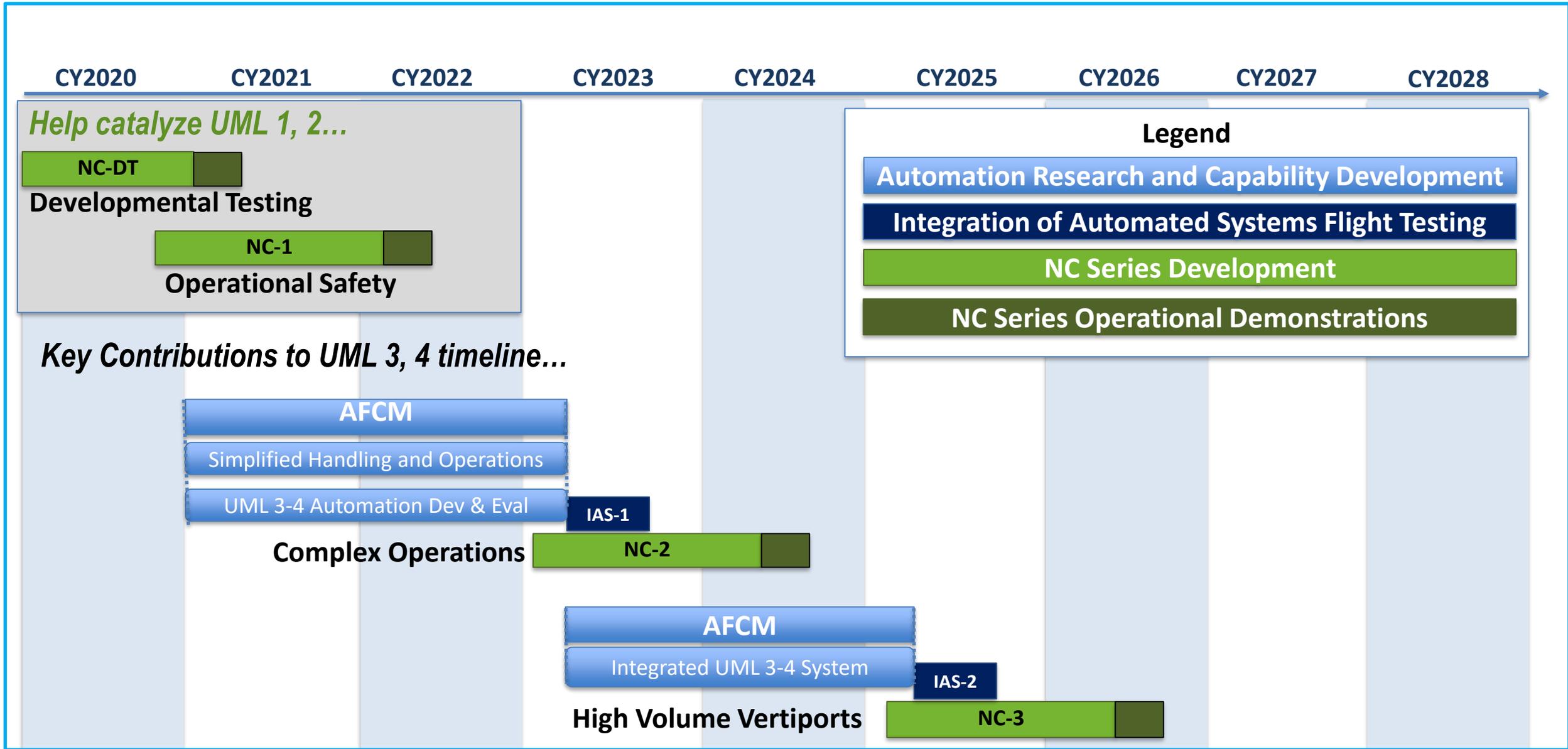
- Open to any organization
  - Particularly interested in responses from organizations developing technologies, integrated systems, integration on vehicles

- Don't feel limited to suggested content
  - Candor appreciated

- Information identified as proprietary protected

- Consider NASA facilities or capabilities of interest to your organization
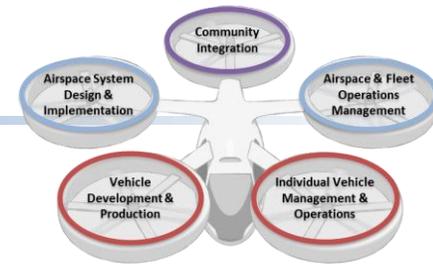
AFCM Partnership Strategy

Example Stakeholders	Example Partners	Engagement Strategy

Example Stakeholders
- FAA
- ASTM
- RTCA
- SAE
- GAMA

Example Partners

Vehicle Developers
- eVTOL
- Surrogate development aircraft

Avionics Companies
- Integrated panel
- Integrated flight systems

Technology Developers
- Subsystems/technologies

Engagement Strategy
- Engage industry on AFCM portfolio via Ecosystem Working Groups, Aircraft subgroup
- Release RFI targeting vehicle, system, and tech developers:
  - Emerging AFCM concepts
  - Vehicle dynamics, performance, and system models and algorithms
  - development of integrated avionics for UAM
  - Integrate AFCM concepts onto prototype, surrogate vehicles
  - Evaluation and application of candidate certification methods
- Release Announcement of Collaborate Opportunities (ACO) in January. Working connections between ACO's for NC-2 Information Exchange, AFCM, IAS, etc.

ACO Release Expected in January

RFI Deadline	AAM Project Formulation Review			ACO Release		ACO Responses Due
◇	◇			◇		◇
Aug	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**

Core NASA Facilities and Capabilities for AFCM

Vertical Motion Simulator

Cockpit Motion Facility

Research Flight Deck

Mobile Operations Facility

Airspace Operations Lab

Cognitive Engineering Lab

Developmental UAM Simulator - Flyer

Testbed Virtual Infrastructure

Air Traffic Operations Lab

Future Flight Central

* 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.

QUESTIONS?

Definitions: Automated Flight and Contingency Management for UAM

- **Automated**
  - Use of technological systems to perform and support operational processes and functions including control, information processing, and management tasks
  - Encompasses autonomous systems (technological) which may (but don't require) AI/ML technologies
  - Includes design and facilitation of appropriate monitoring, interaction, and management by human and external automation agents (e.g. Human-Automation Teaming, Aircraft-Airspace Integration)

- **Flight Management:**
  - Planning, monitoring, and execution of flight operations for an individual aircraft within an operational environment and broader airspace system

- **Contingency Management:**
  - Anticipation, detection, recognition, & mitigation of unexpected and/or off-nominal situation elements effecting flight safety, efficiency, etc.

- **UAM**
  - Emerging aviation system concept enabled by the development, maturation, and integration of dramatically new vehicle, airspace system concepts and technologies
  - UAM system trade space is large, complex & relatively undeveloped for nominal and contingency operations