Automated Flight and Contingency Management, NASA Advanced Air Mobility (AAM) Project

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7 August, 2020
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
**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:

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)

Representative Automation Stack

Strategic Interfaces

Route Plan

L/VNAV

Tactical Interfaces

Auto Flight

Manual Interfaces

Inner-loop Flight & Propulsion Control

Surfaces

Motors

Time Scales

Flight Planning

Present- end of flight

Navigation

Minutes

Auto-Flight

~Seconds

“Manual” flight

0.1, ~Seconds

Inner-loop

<1 sec

Effectors & Propulsors

<0.01sec

Airspace System and Operations

Flight procedures

Mission Management
  – Operations center
  – Divert options
  – Contingency plans

Strategic flightpath management
  – ATM Interaction
  – Route optimization

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

Vehicle control
  – Autoflight
  – Simplified handling
  – Collision avoidance

Base Aircraft

Stability and Control Augmentation,
Critical Failure for Performance,
Certified Minimum Performance
AFCM Strategy and Timeline Synchronized with National Campaign Series

Help catalyze UML 1, 2…
- Developmental Testing
- Operational Safety

Key Contributions to UML 3, 4 timeline…
- Complex Operations
- High Volume Vertiports
- Scaled Urban Demo

Legend
- NC Series Development
- NC Series Operational Demonstrations
AFCM Strategy and Timeline Synchronized with National Campaign Series

Help catalyze UML 1, 2...
- NC-DT
  Developmental Testing
- NC-1
  Operational Safety

Key Contributions to UML 3, 4 timeline...
- AFCM
  Complex Operations
- IAS-1
- NC-2
  High Volume Vertiports
- AFCM
  Scaled Urban Demo
- IAS-2
- NC-3
- IAS-3
- NC-4

Legend
- Automation Research and Capability Development
- Integration of Automated Systems Flight Testing
- NC Series Development
- NC Series Operational Demonstrations
Key automation challenges addressed by AFCM will enable NC-2 vehicle automation
GPS Outage

Contingency Decision Making

System Recovery From Minor Disruption

Auto-land

Auto-avoid

CNSI

Emergency Handling

Emergency Landing

Injected traffic

National Aeronautics and Space Administration

NASA NC-3 High Volume Vertiports OV-1
AFCM develops vehicle automation architectures leveraging capabilities across ARMD
**AFCM Strategy and Timeline Synchronized with National Campaign Series**

**Key Contributions to UML 3, 4 timeline…**

1. **Help catalyze UML 1, 2…**
   - Developmental Testing: NC-DT
   - Operational Safety: NC-1

2. **Complex Operations**
   - AFCM
     - Simplified Handling and Operations
   - UML 3-4 Automation Dev & Eval
     - IAS-1

3. **High Volume Vertiports**
   - AFCM
     - Integrated UML 3-4 System
     - IAS-2

4. **Legend**
   - Automation Research and Capability Development
   - Integration of Automated Systems Flight Testing
   - NC Series Development
   - NC Series Operational Demonstrations
• 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
### 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.

### 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

### ACO Release Expected in January

- **RFI Deadline**
- **AAM Project Formulation Review**
- **ACO Release**
- **ACO Responses Due**

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<tr>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>March</th>
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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