• Data Redacted
AAM Delta Project Approval KDP Outline

- Project Organization, Goal and L1 Requirements, Project Document Maturity
- Partnership Strategy, Public Outreach, Cybersecurity, Facilities, Budget and Resources
- Automated Flight and Contingency Management Subproject and Technical Challenge
- High Density Vertiplex Subproject and Technical Challenge
- National Campaign Subproject
- Summary
- Backup
Advanced Air Mobility Project Goal

Relevant Strategic Thrusts - SIP
6 - Assured Autonomy for Aviation Transformation
1 - Safe, Efficient Growth in Global Operations
4 - Safe, Quiet, and Affordable Vertical Lift Air Vehicles
5 - In-Time System-Wide Safety Assurance.

AAM Mission 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.

Project Goal
Develop and implement an environment to accelerate AAM development and operational adoption concepts, including developing and demonstrating key automation functions, and delivering validated system architectures and requirements to the benefit of the AAM ecosystem.
Advanced Air Mobility Project L1 Requirements

Project Goal
Develop and implement an environment to accelerate AAM development and operational adoption concepts, including developing and demonstrating key automation functions, and delivering validated system architectures and requirements to the benefit of the AAM ecosystem.

L1 Requirement - National Campaign
Demonstrate UAM operational safety, industry capabilities and integration of automated flight systems throughout a series of National Campaign flight and airspace simulation events with industry partners progressing toward UML-4 operations in urban environments.

NC Subproject Goal & Objectives

L1 Requirement - AFCM
Develop and validate key vehicle automation functions and candidate certification methods that safely enable simplified piloting and high-density flight operations in low-visibility conditions and obstacle challenged urban environments.

AFCM TC, Subproject Goal & Objectives

L1 Requirement - HDV
Develop a prototype High Density Vertiplex (HDV) to assess scalable and efficient aircraft operations, flight and airspace management procedures, and interoperability of capabilities needed to support the expansion of sUAS Part 135 Operations and contribute to the achievement of UML-4.

HDV TC, Subproject Goal & Objectives
Data Redacted
• Data redacted
AAM Project Partnership Support of the Industry Timeline

- NC Series Operational Demonstrations – Focus on AAM partnerships with NASA as facilitator
- X-Series Simulations – NC / ATM-X lead preparing airspace partners to support NC flight activities
- R&D Flight Tests -- Build-up and research flights with partners bringing key technologies/vehicles
  - Includes AFCM and HDV technologies and partners with IAS research and demonstration flights
AAM Project Partnership Engagement and Announcements

NC Series (NC-2+) Ecosystem-wide

- KARI
- NRC
- FAA

AEWG

NC-2 Information Exchange

AFCM Automation Research

AMIO Community Integration

RVLT Crashworthiness Testing

ATM-X Comm, Nav, Surveillance Testing

NC-1

Vehicle Information Exchange

NC-1 Infrastructure – Companies that provide technologies to help enable NC-1 flight activities. e.g. Comms, Nav, ground infrastructure, vertiports, etc.

NC-1 Airspace – Participate in X4 airspace simulation (2021)

NC-DT

Flight Vehicle Partners

NC-DT

Airspace Simulation Partners

NC-1

NC-1 infrastructure

NC-1 Flight Vehicle

NC-1 Airspace X4 Simulation

AAM Research and Demonstration Partnerships (ACO-3)

- NC-2 Information Exchange – Industry early prep for NC-2 (2024) – Broad partnership including: vehicle, airspace, infrastructure, any others to support NC.
- Automated Flight and Contingency Management (AFCM) – Vehicle and avionics companies for automation technology development/demonstration
- Community Partnerships (AMIO) – Early work with communities to prepare for AAM urban integration.
- Vehicle crashworthiness testing (RVLT) – AAM vehicle companies provide test article for crash safety testing
- CNS Testing (ATM-X) – NASA to flight test AAM CNS industry technologies and hardware

NC-1 Partnerships (ACO-2)

- NC-1 Vehicle – Vehicle companies to fly in NC-1 (2022)
- NC-1 Infrastructure – Companies that provide technologies to help enable NC-1 flight activities. e.g. Comms, Nav, ground infrastructure, vertiports, etc.
- NC-1 Airspace – Participate in X4 airspace simulation (2021)
AAM Outreach and Communications

- Plans are coordinated with AMIO to ensure a clear and consistent message
- Key milestones, events, and communications opportunities are rolled up and track by AMIO Communications Calendar

AAM Mission Integration Office

- AAM Public Outreach Plan includes descriptions of stakeholders and tools/tactics to facilitate the building of strong relationships
- Goal is provide timely and accurate information to key stakeholders

Partners Industry OGAs

- Public Outreach Plan details how Project will follow Office of Strategic Communications (OCOMM) guidelines
- Key milestones, events, and communications opportunities are rolled up and tracked by OCOMM Calendar

Office of Strategic Comms
AAM Project Cybersecurity Approach

AAM Cybersecurity is a comprehensive approach to address cybersecurity needs and requirements across the AAM portfolio.

The elements are:

1. Project Protection
   - This is the overall approach to addressing NASA IT and OT security requirements.
   - The project and subprojects are in different phases of addressing requirements with NC being well advanced and having a dedicated team.
   - The AAM team will integrate with the NC Team and work with the other subprojects to establish appropriate subproject level capabilities.
   - The AAM team is also documenting the entire digital boundary of the AAM project and subprojects and is working with the Agency OCIO to develop a new risk model for all data security. This will ensure a common risk posture for data security.
   - Using tailored NIST 800-160 system security engineering processes, the AAM Cyber team will develop Protection Needs (PN)s and derive security requirements for the AAM concepts and architectures.

2. Model Based Systems Engineering (MBSE) supporting the Critical Commitment
   - The AAM team is responsible for the security components of the overall AAM Mission level MBSE effort. They will be working directly with the overall MBSE effort and providing security models for the subprojects as needed.

3. Research and Development supporting the Critical Commitment
   - The AAM team will be evaluating concepts and architectures for Cybersecurity R&D needs. A critical component of this is integration with the rapid developments in the FAA and ICAO to establish cybersecurity standards and services for worldwide aviation operations.
Other possible facilities include wind tunnels, aircraft, ranges, cockpit sims, supercomputers,
• Data redacted
Project Resource Management

• Data redacted
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AFCM Technical Challenge and Goals Flow Down

Project Goal
Develop and implement an environment to accelerate AAM development and operational adoption concepts, including developing and demonstrating key automation functions, and delivering validated system architectures and requirements to the benefit of the AAM ecosystem.

L1 Requirement - AFCM
Develop and validate key vehicle automation functions and candidate certification methods that safely enable simplified piloting and high-density flight operations in low-visibility conditions and obstacle challenged urban environments.

AFCM Technical Challenge FY 2021 - 2025:
Develop and evaluate an initial, integrated set of key vehicle functions for automation enabled piloting in urban operations, and propose recommendations to support requirements for certification and approvals for the selected concepts.
AFCM Portfolio: Motivation and Prioritization

- **Mission Management**
- **Flight (re)planning**
- **Pre-flight procedures**
- **Aviate**
- **Navigate**

**Stakeholder Engagement**
- AFCM RFI
- FAA-NASA UAM Working Group charter documents
- Space Act Agreement Annex (draft) shared with potential industry partners
- Standards organizations’ activities and priorities

**UCAT Findings**
- Barriers and gaps to certification for eVTOL vehicles and UAM operations
- Industry engagement and expectations
- Timeline for expected maturity levels

**Functional Breakdown for Safe, Efficient UML-4 Ops**
- Communication
- Manage vehicle systems
- Maintain safe separation
- Maintain consistent flow of traffic
- Fleet Management
- Cross-cutting information

**AFCM Portfolio Priorities and Contribution Goals**
- Communication
- Manage vehicle systems
- Maintain safe separation
- Maintain consistent flow of traffic
- Fleet Management
- Cross-cutting information
AFCM portfolio focus is **Methods and Means of Compliance (MOC)** and **Operational Performance Requirements** (e.g., MOPS) for eVTOL aircraft and aircraft systems in UAM operations.

- eVTOL aircraft do not currently have an accepted Means of Compliance (MOC)

- Activities to support MOC and operational performance requirements include:
  - Performance requirements
  - Piloting requirements
  - Hazard mitigation (airborne traffic, weather, obstacles)
  - Methods for evaluation
    - Engineering analysis
    - Part-task sim
    - Flight test
  - Flight path contingency requirements
  - Design-time assurance methods
  - Run-time assurance methods
  - Consensus-Based Industry Standards efforts*

*new as of 2017, only for part 23 airplanes

**Examples of traditional MOC:**
1. statements of similarity
2. design description
3. calculations/analysis
4. evaluations
5. tests

**Acceptable Means of Compliance:**
A means, but not the only means, by which a specification contained in an airworthiness code or a requirement in an implementing rule can be met.
AFCM Schedule Package Contributions

**TC: Automated Flight and Contingency Management**

For Efforts Through FY25

Develop and evaluate an initial, integrated set of key vehicle functions for automation enabled piloting in urban operations, and propose recommendations to support requirements for certification and approvals for the selected concepts.

### AFCM SCHEDULE PACKAGE CONTRIBUTIONS

<table>
<thead>
<tr>
<th>Integrated Automation Suite (cross-schedule packages FPM-HPA-IPR):</th>
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<tbody>
<tr>
<td>Integrated reference framework and evaluation tools for cooperative conflict management and mission management in UAM CONOPS.</td>
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<tr>
<th>Aircraft Handling and Operations (AHO)</th>
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<tr>
<td>Integrated Piloting Requirements (IPR)</td>
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<tr>
<td>Automation Enabled Pilot (AEP) TWP</td>
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<th>Hazard Perception and Avoidance (HPA)</th>
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<tr>
<td>Assured Vehicle Automation (AVA) TWP</td>
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<tr>
<th>Assured Responsible Automation (ARA):</th>
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<tr>
<td>Flight Path Management (FPM):</td>
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</table>

![Diagram of automated flight and contingency management](image-url)
**Goal:**
To accelerate and inform the development of means of compliance for hazard perception and avoidance automation necessary for safe operation of eVTOL aircraft in the UAM environment that pose unique certification and evaluation challenges and have been prioritized by industry and regulatory stakeholders.

**Objective:**
To develop reference models, test methods and performance criteria in order to test and collect data to support the development of hazard perception and avoidance separation standards for means of compliance of UAM DAA, Collision Avoidance, terrain and obstacle avoidance automation, and the integrated functionality required for cooperative conflict management.

**Success Criteria:**

**Min Success through FY25:** Demonstration and assessment of foundational simulation and test method tools that include DAA/CA and terrain and obstacle automation reference architectures and encounter geometries for intruder scenarios using the newly developed tools, methods and criteria to generate recommendations instrumental in the development of standards for UML-4 vehicle automation. Data and analysis report documenting recommendations on data-supported requirements for autonomous collision avoidance (CA) and candidate UAM well clear definitions with technology-agnostic scenario test toolset delivered/presented to the NASA-FAA WGs and RTCA SC-147, RTCA SC-228, and ASTM F38-AC377.

**Full Success through FY25:** Additional inclusion of integrated airspace, DAA/CA/obstacle/terrain and flight path and contingency management automation reference architectures and complex scenarios to min success demonstration, assessment and reporting.

Avoidance maneuvering with eVTOL performance limitations (Coordinated with AHO)

Encounters in UAM environment
# AFCM External Deliverables Summary

<table>
<thead>
<tr>
<th>Schedule Package</th>
<th>Type of Deliverable (and report/presentation content):</th>
<th>External Delivery to:</th>
<th>FAA</th>
<th>Primary Standards Development Organizations (SDOs)</th>
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<tbody>
<tr>
<td></td>
<td>Data and Evaluation Toolsets</td>
<td>Executable Aircraft Automation behavior</td>
<td>Aircraft Automation behavior requirements</td>
<td>Means of Compliance for Design</td>
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<tr>
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<td>HPA</td>
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<tr>
<td>ARA</td>
<td>X</td>
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<tr>
<td>Integrated Automation Suite</td>
<td>X</td>
<td>X</td>
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</tr>
</tbody>
</table>

**AHO:** Aircraft Handling and Operations  
**IPR:** Integrated Piloting Requirements  
**HPA:** Hazard Perception and Avoidance  
**FPM:** Flight Path Management  
**ARA:** Assured Responsible Automation  

### Current Guideline Scope:
- 4 active standards writing activities (leadership or writing)
- 5 general standards committee meeting attendance/presentations of deliverables
AAM AFCM Subproject Milestones through End of TC (2025)

• Data Redacted
AFCM Focus in the NASA IAS-1/NC-2 Complex Operations

Hazard Perception & Avoidance

4D TBO / DAA Merging & Spacing

Contingency Management

LVC Traffic

Nominal Operations

Commit Decision Point

Critical Vehicle Failure Point

Uncharted Obstacle

Airspace/Operation Data Interop

Integrated Piloting Requirements

Pilot-directed Landing

Aircraft Handling and Operations

LEGEND:
Automation Scenarios and Challenges Operational Elements
NC IAS – AFCM Interfacing

Each IAS preparation cycle:
Part Task Simulation ➔ High Fidelity HITL Simulations ➔ IAS Flight

IAS-1 Scenario Execution
(1) DAA – Collision Avoidance (CA)
(2) Flight path and contingency execution

IAS-2 Scenario Execution
(1) Integrated DAA- CA/flight path automation for complex scenarios

Collaborate or coordinate with NC to:

• Define flight platform performance, system, and interface requirements for an effective flight test evaluation UNDERWAY
• Definition prototype approach and landing procedures, including flight path integration for 3D waypoint following autoflight UNDERWAY
• Develop scenarios and IAS flight test matrix for AFCM use cases (HPA and FPM)
• Understand airspace/PSU functionality and CONOPS for IAS UNDERWAY
• Provide automation algorithms, Interface Control Documents (ICD), displays and procedures, and support NC IAS during integration and test

Flight test data value and use:
Test what cannot be well modeled in simulation + show traceability to simulation data

Low Speed Controllability/Performance in UAM
Condensed Terminal Area Procedures

Detect and Avoid – Separation Assurance

Contingency Management

✓ Roles and Responsibilities Documented ✓ Requirements Definition and Support Timeline Documented
General Progress Flow For AFCM

100% OF PROGRESS DIVIDED BY THE FIVE SCHEDULE PACKAGES PLUS INTEGRATED AUTOMATION IN EACH STEP

Definition and Assumptions
- Define barriers to certification
- Document CONOPs requirements and assumptions
- Define detailed test plan to address each barrier
- Define use cases for assurance method application

Develop and Implement
- Reference architecture to assess the technologies in the UAM environment as part of the toolset
- Develop methods of evaluation and preliminary performance parameters as part of the toolset
- Develop test scenarios that exercise the technology and implement the methods of evaluation as part of the toolset

Validation and Sim/Flight Evaluation
- Assessment of reference architectures against assumed requirements
- Collect data in support of preliminary recommendations for requirements, design guidelines, test methods and performance standards as a means of compliance

Means of Compliance Recommendation Document/Delivery
- Document preliminary recommendations for requirements, design guidelines, test methods and performance standards
- Prepare toolset for industry-wide use for vehicle agnostic MOC testing
- Deliver and present to stakeholders
AFCM Project Interfaces and Areas of Collaboration

• Data Redacted
AFCM Partnership Levels for Scoping Within Resources

**OBJECTIVES**

**Coordination Activities:**
- Engagement through AAM Ecosystem WG

**Cooperation Activities:**
- Workshops and tabletops
- Participation in reviews (mutual)

**Collaboration Activities:**
- Development of joint test campaigns
- Collaborative writing/reporting to SDOs

**Current Guideline Scope:**
- (1) Collaboration Partner
- (3) Cooperation Partners
- (1) Integrated Sim Facility for testing

*adapted from NATO partnership strategy*
• Data Redacted
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• Project Organization, Goal and L1 Requirements, Project Document Maturity
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HDV is developing a vertiport automation architecture that addresses key scalability, safety, and efficiency challenges for UML-4 operations in a vertiport environment.
AAM HDV Sub-Project Milestones through End of TC (2025)

• Data Redacted
## Industry Need for Vertiport Technology

<table>
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<tr>
<th>Heliports</th>
<th>Vertiports</th>
<th>Airports</th>
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<tbody>
<tr>
<td>• Low throughput operations</td>
<td>• Moderate-High throughput operations</td>
<td>• High throughput operations</td>
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<tr>
<td>• No infrastructure</td>
<td>• Infrastructure and Automation Needed</td>
<td>• Infrastructure and automation</td>
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<tr>
<td>• FAA Guidance and State/Local Government Oversight</td>
<td>• FAA Guidance and State/Local Government Oversight</td>
<td>• FAA Regulations and Oversight</td>
</tr>
<tr>
<td>• Operations managed by aircraft Operators (one one certified heliport)</td>
<td>• Operations intended to be managed by vertiport Operators, PSUs, aircraft/fleet operators aided by automation</td>
<td>• Operations managed by airport operator, ATC, procedures, and aided by automation</td>
</tr>
<tr>
<td></td>
<td>• Interoperability with UAM, UTM, and ATM</td>
<td>• Interoperability with ATM</td>
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</table>

HDV is developing technologies and requirements to support industry infrastructure and automation needs and FAA vertiport design guidance development.
HDV Industry Need

Industry and FAA input

• NASA UAM Coordination and Assessment Team (UCAT)
  • Identified UAM Port Design, Supporting Infrastructure, and Autonomy as barriers to UAM

• NASA Contracted New York UAS Test Site Trade Study:
  • This trade study also outlines gaps and potential mitigations based on research conducted by the NYUAST team and interviews with 23 individuals in government and industry.

• Identified Industry Future Needs
  • (1) Assessment of automation needs on vertiports
  • (6) Communication, navigation, surveillance, and information requirements and technologies to enable vertiport operations
  • (7) Scheduling of high throughput operations

• FAA:
  • Based on conversations with aircraft manufacturers, the FAA acknowledges the need for considerations for Vertiport Automation in the upcoming Vertiport Advisory Circular.
**Technical Challenge**

*Develop and evaluate a reference automation architecture that addresses scalable and efficient aircraft operations, flight and airspace management procedures, and vertiport operations in high density vertiplex environments.*

**Schedule Package Goals:**

- **Advanced Onboard Automation (AOA):** Develop reference automation architecture prototypes, integration guidelines, and safety risk assessments that support increasingly autonomous and resilient operations.

- **Scalable Autonomous Operations (SAO):** Develop and evaluate concepts, prototypes, procedures and technologies supporting operations at increased scale from a vertiport.

- **Vertiplex Operations (VO):** Develop and evaluate concepts, procedures and technologies to evaluate system prototypes supporting high density operations in and out of multiple nearby vertiports.

- **Integration of Automated Systems 2 – HDV (IAS-2.HDV):** Develop and evaluate vertiport automation reference architecture for a representative UAM aircraft in a vertiplex environment.
Goal
Develop reference automation architecture prototypes, integration guidelines, and safety risk assessments that support increasingly autonomous and resilient operations.

Objectives
1. Development of an UAS automation architecture to support terminal area operations.
2. Development of a BVLOS sUAS safety case for urban operations in controlled airspace.
3. Demonstration of automated VLOS urban operations in controlled airspace.

Minimum Success Criteria: Develop scenarios that align with partner UAS cargo operations business uses cases.

Full Success Criteria: Demonstration of urban operation scenarios using the UAS automation architecture in flight test with at least 3 UAS equipped with NASA-developed automation technologies.

Success Criteria: Advance Onboard Autonomy
HDV implements a spiral development process to mature automation technology and increase complexity of the operations
HDV Research Flow to Key Deliverables

Key Deliverables

**Automated Aircraft**
- Small UAS (x3)
- Small UAS (x5)
- Small UAS (x7)
- AAM eVTOL

**Operations**
- Simulation and Multi-Aircraft VLOS Flight Test
- Simulation and Limited BVLOS
- Simulation and Expanded Operations (BVLOS & m:N aircraft control)
- Operational Environment

**Infrastructure**
- Vertiport Terminal Procedures Design
- Instrumented and Connected Vertiport
- Automated Vertiplex

**UAS Automation Reference Architecture**
- High Density Vertiport CONOPS
- HDV Use Cases
- BVLOS Safety Case
- Vertiport Automation Reference Architecture & Requirements [MBSE]
**TC HDV: Progress Indicator**

**TC End State:** Developed, verified, and (partially) validated to TRL Level 5, a Vertiport Reference Automation Architecture that demonstrates requirements, functions, services, and technologies that support the scale and complexity of UML-4 vertiport operations.

### Development

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<td>(2) Vertiport automation architecture design and requirements</td>
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<td>(4) Initial Vertiport services;</td>
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<td>(5) Advanced Vertiport services</td>
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### Integrations

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<td>(3) Vertiport Services to vehicle automation connectivity; (4) Vertiport Services to PSU</td>
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### Testing

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<td>(3) SAO Flight Test; (4) VO Flight Test;</td>
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<tr>
<td>(5) IAS-2</td>
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### Key Deliverables

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<td>(1) High Density Vertiport CONOPS;</td>
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<tr>
<td>(2) Vertiport automation reference architecture and requirements;</td>
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<tr>
<td>(3) Document results vertiport automation operational performance and recommendations for metrics;</td>
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<tr>
<td>(4) MBSE Model of Vertiport Automation Reference Architecture</td>
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TC HDV: Progress Indicator

**HDV Technical Challenge:** Develop and evaluate a reference automation architecture that addresses scalable and efficient aircraft operations, flight and airspace management procedures, and vertiport operations in high density vertiplex environments.

![Diagram showing TRL and milestones with progress indicators for FY21 to FY25.]

- **TRL:** 2, 3, 4, 5
- **Key milestones:**
  - Vertiport CONOPS
  - Initial Vertiport Automation Architecture
  - AOA Flight Test
  - SAO Flight Test
  - VO Flight Test
  - Final Vertiport Automation Architecture
  - IAS-2 Flight Test

![Graph showing % Complete for FY21 to FY25.]

- **% Complete:** 0%, 20%, 40%, 60%, 80%, 100%

- **Technical Challenge completion status:**
  - Full success = 5
  - Min success = 4

- **Legend:**
  - Development
  - Integration
  - Testing
  - Key Deliverables
  - Milestone
  - Milestone - Complete
  - Technical Challenge

The diagram illustrates the progress and milestones for the HDV Technical Challenge from FY21 to FY25, with key deliverables and success metrics indicated.
Cross-project dependencies are documented in HDV subproject plan and regular coordination meetings are held regularly to track progress, risks, and expectations of deliverables.
Cross Project Dependency Management

Identify
- Capability gaps identified through HDV Project Planning

Agree
- Scope of cross-project deliverables agreed to and documented

Plan
- Deliverable Schedule documented in project IMS

Validate
- Each deliverable mapped to impacted objective

Monitor
- Monthly meetings to track progress, schedule, and risks

AOA Objectives

1. Development of an UAS automation architecture to support terminal area operations.

Minimum Success Criteria: Development of a UAS automation reference architecture that addresses interoperability of different automation systems and procedures for off-nominal conditions.

Full Success Criteria: Collect data to verify the efficacy in terminal area operations of the UAS automation reference architecture through analysis, ground testing and flight testing.

Impact on Objectives

Minimum Success Criteria
- ATM-X UAM Deliverable 1
- STERO Deliverable 1
- TTT Deliverable 2
- SWS Deliverable 1

Full Success Criteria
- ATM-X UAM Deliverable 1
- TTT Deliverables 3 & 4
- SWS Deliverable 1

Success Criteria Impact

High Impact
Moderate Impact
Low Impact
HDV Stakeholders and Deliverables

<table>
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<tr>
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**FAA**
- UAM Coordinated CONOPS v2.0
- Research CONOPS v2.0
- UAM Research CONOPS v3.0
- UAM Research CONOPS v4.0

**Heliport AC**
- Vertiport Interim Guidance
- Vertiport Advisory Circular (AC)

**ASTM**
- Vertiport Services v1.0

**Joint Authorities for UAS Rulemaking (JARUS)**
- Specific Operation Risk Assessment (SORA) v3.0

**Stakeholder Milestone**
- HDV Deliverable

- Draft Vertiport Automation Architecture
- BVLOS Safety Case
- AOA Flight Test Report
- Expanded BVLOS Safety Case
- Initial Vertiport Automation Architecture
- Final Vertiport Automation Architecture
- Vertiport CONOPS
- VO Flight Test Report
- IAS-2 Testing

**Vertiport Services**
- Vertiport Interim Guidance
- Vertiport Advisory Circular (AC)
• Data redacted
HDV Current Status

- Data redacted
AAM Delta Project Approval KDP Outline

- Project Organization, Goal and L1 Requirements, Project Document Maturity
- Partnership Strategy, Public Outreach, Cybersecurity, Facilities, Budget and Resources
- Automated Flight and Contingency Management Subproject and Technical Challenge
- High Density Vertiplex Subproject and Technical Challenge
- National Campaign Subproject
- Summary
- Backup
National Campaign L1 and L2 Milestone Schedule through FY2030

• Data Redacted
National Campaign Execution

Legend
- Research and Capability Development
- Integration of Automated Systems (IAS) Flight Testing
- Airspace Simulation Series (X Series with ATM-X)
- NC Series Development
- NC Series Operational Demonstrations

Dry Run
- NC Developmental Test (DT)
- X3
- DT

NC-1 Operational Safety
- X4
- NC-1
- IAS-1

NC-2 Complex Operations
- X5
- NC-2
- IAS-2
- IAS-3

NC-3 High Volume Vertiports
- X6
- NC-3
- IAS-4
- IAS-5

NC-4 Scaled Urban Demo
- X7
- NC-4

Legend
- L1
- L2
NC Interfaces

Industry

- Vehicle, Airspace, and Infrastructure Industry Partners (ACO-2 for NC-1 Participation)
- Research Collaboration to Inform NC-2 (ACO-3)
- Data Buys: Bell & FLE
- AAM Ecosystem Working Groups (AEWG)
- Standards: GAMA and ASTM
- eVTOL Flight Test Committee (VFS/SFTE)

National Campaign

- Integration of Automated Systems
- Flight Test Infrastructure (Range & ATI) and Data for Operational Demos
- NASA UAM Task Elements
- FAA UAM Task Elements

FAA

- Anchored Policies and Standards
- Evolving Policies and Standards

AAM

- Automated Flight Contingency Management (AFCM)
- High Density Vertiplex (HDV)

NASA Mission Projects

- ATM-X UAM
- SWS
- RVLT

Legend

- Information & Data
- Software/Hardware
As the NC progresses into more complex operations there is a large degree of uncertainty if industry aircraft, airspace, and infrastructure partners will advance in lock step with the NC schedule for meeting the UML progression timelines.

The NC maintains a posture of **agility** and **flexibility** to account for these uncertainties:

- Adapting the scheduled flight window to vehicle partner needs for the NC Campaigns
- Expanding the NASA developed NC Flight Test Infrastructure to fill gaps in technology development
- Pursuing an incremental flight-testing approach through IAS and the NC to test and collect data on the AAM ecosystem as a system of systems
Formalizing Interfaces – NASA/FAA Agreement

Interagency Umbrella and Annex between NASA and FAA
Complete and Signed

- Collaboration throughout all stages of the AAM National Campaign, from planning and scenario validation to execution across multiple lines of business
- SME and technical support from the FAA to advance objectives and ensure information captured from lessons learned informs FAA
- Shared data collection will help inform the FAA for development of appropriate policies and procedures to enable integration of concepts into the National Airspace System (NAS)
Joint Management Plan (JMP) between AAM NC and ATM-X UAM Baseline and Signed

- Collaboration through NC operational demonstrations, schedule, risk management, and milestones documented
- Roles and responsibilities across simulation and flight activities defined and documented
- Cross project system requirements exchange and bidirectional software delivery processes formalized and documented
Managing Cross Project Deliverables

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**ATM-X UAM Airspace Simulation Activities**

- Emulation Dev
  - Requirements Development
    - Selection
    - ISAs Complete
  - X3 Data Collection
    - Data Pipeline Delivery to UAM
- Initial X3 Req
- Final X3 Req

**NC-DT Flight Activities**

- Requirements Dev & Reviews with FRR
  - Functional Req Delivery to UAM
- IDA Review
- Dry Run Flight Testing
  - Data Pipeline Delivery
- DT Flight Testing
  - Integrated S/W for DT
- NC-DT ACO Released
- ASTM Airspace Delivery for Scenarios 1-2 to NC

**RVLT**

- Acoustic Instrumentation Defined
- Acoustics Data Collection

- IDA Review
- Functional Req Delivery to UAM
The National Campaign has established a MRB process to manage and track L3 deliverables across Mission Projects that are supporting NC activities.

There is the possibility that Mission Projects may not be able to meet the existing L3 schedule, to account for this possibility the NC:

- Developed an agile requirements and software process to get early insight in development timelines and anticipate schedule changes before they become formalized
- Developing contingency plans that allow NC flight activities to proceed without dependance on a specific component, this includes options with industry participants
- Expanding the NC Flight Test Infrastructure to fill gaps in technology development
- Leveraging a joint risk process that assists in evaluating dependencies on Mission Projects to assess impacts on schedule, technical objectives, and resources
Formalizing Interfaces – IAS-1

Integration of Automated Systems-1 (IAS-1) Collaboration and Documentation On Track

- IAS-1 milestones baselined and consistent with AFCM Subproject Plan
- Roles and responsibilities across simulation and flight activities defined and documented
- Mission Concept Review (MCR) scheduled for June 2021 to baseline stakeholders, contributing capabilities, objectives, and success criteria
Performing collaborative gap analysis for existing standards and policies across all lines of business in the FAA to enable UAM operations.
National Campaign Outreach

12 Print Pieces
Press releases, web features, center newsletters, and e-magazine

3 Video Pieces

242 Partnership Engagements

8 External Panels

14 Interviews & Podcasts

Totals over FY20 to current time period
AAM Delta Project Approval KDP Outline

• Project Organization, Goal and L1 Requirements, Project Document Maturity
• Partnership Strategy, Public Outreach, Cybersecurity, Facilities, Budget and Resources
• Automated Flight and Contingency Management Subproject and Technical Challenge
• High Density Vertiplex Subproject and Technical Challenge
• National Campaign Subproject
• Summary
• Backup
• Data redacted
BACKUP
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AAM Project Risk

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AAM Project Risk

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AAM Project Risk

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• Data redacted
AAM Project Execution - Key Decision Gates

- Data Redacted
• Data redacted
• Data Redacted
High-Level Functional Breakdown of Safe, Efficient UML-4 Flight Operations

(by Feary [https://doi.org/10.2514/6.2020-3249] )
AFCM Standards Activity and Collaborations

ACTIVE INVOLVEMENT IN ONGOING STANDARDS WRITING

AHO/IPR
• ASTM AC433 standards writing effort to revise F3173 standard to include winged eVTOL considerations and performance
• ASTM AC377 effort to develop a human-machine teaming standard which would serve as a “standard practice for defining specific criteria to assess how the human and machine will work together safely and efficiently in both nominal and off-nominal operations” described in ASTM AC377 published TR2 Developmental Pillars of Increased Autonomy for Aircraft Systems

HPA
• RTCA SC-228 is starting to initiate defining well-clear volumes for UAM operations in their Phase 3 (ad hoc only) and Phase 4 efforts
• RTCA SC-147 MOPS writing efforts for the Airborne Collision Avoidance System (ACAS)-X series, particularly as they begin to approach the Xr variant for eVTOL/UAM operations

FPM
• ASTM F38 AC 377 activity to produce a standard set of practices or guidance that align to the contextual framework described in ASTM AC377 published TR1 Autonomy Design and Operations in Aviation Terminology and Requirements Framework in June 2019
• Initiate and develop charter documents for an F44 committee to plan and evaluate an approach to flight path management and cooperative conflict management separation requirements and standards for UML-4 operations.

ARA
• ASTM F44.50 and SAE S-18 are separately writing a software assurance means of compliance standard based on STAMP (Systems-Theoretic Accident Model and Processes)

GENERAL ENGAGEMENT AND COLLABORATION to include PRESENTATION/TECH TRANSFER OF AFCM DELIVERABLES

* Number of committees and efforts to be supported is heavily dependent upon PPBE resources

ASTM
AC433 Administrative Committee, Means of Compliance for eVTOL aircraft
AC377 Administrative Committee, Autonomy Design and Operations in Aviation
F38 Standards for Unmanned Aircraft Systems
F44.50 Standards for General Aviation Aircraft Systems and Equipment
F44.20 Standards for General Aviation Aircraft Flight

GAMA
SVO Subcommittee for Simplified Vehicle Operations

RTCA
SC147 Traffic Awareness and Collision Avoidance Systems for Piloted Air
SC228 Standards for Unmanned Aircraft

SAE
S-18 Aircraft and System Development and Safety Assessment Committee
S-34 Artificial Intelligence in Aviation Committee

ANSI/UL
UL4600 Standard for the Safety for the Evaluation of Autonomous Products
UL4601 Standard for the Evaluation of Autonomous Unmanned Aerial Systems
### AFCM MOC and Standards Development Maturity

<table>
<thead>
<tr>
<th>Development Phase</th>
<th>Beginning of AFCM TC</th>
<th>End of AFCM TC</th>
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<tbody>
<tr>
<td><strong>Phase One</strong></td>
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<tr>
<td>• Concept definition</td>
<td>Flight Path and Contingency Management (FPM)</td>
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<td>• Preliminary technology development</td>
<td>UAM Separation Assurance (FPM/HPA)</td>
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<td>Human Automation Interaction (IPR)</td>
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<td>Weather perception and avoid (HPA)</td>
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<td>eVTOL Pilot Interfaces (IPR)</td>
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<td>Winged eVTOL Autoland (AHO)</td>
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<td>Hazard Assessment of Use Cases (ARA)</td>
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<td>Winged eVTOL with Integrated Flight Controls (AHO)</td>
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| **Phase Two**     | Detect and Avoid/ Collision Avoid (HPA) | Hazard Assessment of Use Cases (ARA) |
|                   | Obstacle/terrain perception and avoid (HPA) | Winged VTOL Handling and Ops (IPR) |
|                   | Winged airplane with Integrated Flight Controls (IPR) | Winged eVTOL with Integrated Flight Controls (AHO) |
|                   | Design Time assurance application (ARA) | Flight Path and Contingency Management (FPM) |
|                   | Obstacle/terrain perception and avoid (HPA) | Weather perception and avoid (HPA) |
|                   | Winged eVTOL Pilot Interfaces (IPR) | eVTOL Pilot Interfaces (IPR) |
|                   | Winged eVTOL Autoland (AHO) | Winged eVTOL Autoland (AHO) |
|                   | Human Automation Interaction (IPR) |                                |

| **Phase Three**   | Detect and Avoid/ Collision Avoid (HPA) - preliminary | Winged airplane with Integrated Flight Controls (IPR) |
|                   | Detailed subsystem requirements and preliminary standards | Design Time assurance application (ARA) |
|                   | Obstacle/terrain perception and avoid (HPA) | Obstacle/terrain perception and avoid (HPA) |
|                   | Winged VTOL Handling and Ops (IPR) | UAM Separation Assurance (FPM/HPA) |

| **Phase Four**    | Means of compliance |                                |
|                   |                      |                                |
AFCM Work Area Maturity

Use Case Hazard Assessment (ARA)
Winged VTOL Handling and Ops (IPR)

Human Automation Interaction (IPR)
Design Time assurance application (ARA)
Winged VTOL Handling and Ops (IPR)

eVTOL Pilot Interfaces (IPR)
Flight Path and Contingency Management (FPM)
UAM Separation Assurance (FPM/HPA)

Acceptance Level MOC development
Integration Level MOC development
Unit level MOC development
Detailed subsystem Development
Detailed Subsystem Design
Requirement Specification
Concept Definition

Validation
Operations evaluation

Maintenance and COS

Winged airplane w/ Integrated Flight Controls (IPR)
Detect and Avoid/ Collision Avoid (HPA)
Obstacle/ terrain perception and avoid (HPA)
Weather perception and avoid (HPA)
Winged eVTOL with Integrated Flight Controls (AHO)
Winged eVTOL Autoland (AHO)
# Progress Indicators for AFCM (at full success)

## Definition

Completing the following scored as 17% each:

1. **Define barriers to certification and stakeholders for** 1) eVTOL vehicles with advanced control schemes. 2) human-machine interfaces and interactions 3) HPA automation, separation standards and requirements and assumptions. 4) FPM automation and airspace interactions, CONOPS and separation assurance requirements and assumptions. 5) formal assurance methods, and identify specific UAM use cases applications and define method down-selection process. 6) integrated automation in UML-4 operating environment, CONOPSs requirements and assumptions ... and create a detailed test plan to address each barrier- including an SDO engagement strategy.

## Development

Completing the following scored as 17% each:

1. **Develop and implement** 1) L+C, quadrotor and tilt rotor models with both unified controls and EZ fly control schemes. 2) human machine interfaces such as displays, alerting and annunciations with complex automation and define a preliminary set of evaluation techniques. 3) toolset containing DAA/CA reference framework tailored to eVTOL passenger carrying missions with encounter geometries for cruise and terminal area. 4) a toolset containing flight path management reference framework with variable airspace constraints and interfaces, flight rules, and nominal and contingency management scenarios. 5) full hazard analysis and extend formal methods to a selected UAM eVTOL use case. 6) a toolset including an initial, integrated suite of key vehicle automation functions that includes DAA/CA and flight path management with airspace and initial test suite of complex UAM operational scenarios.

## Assessment and Sim/Flight Evaluation

Completing the following scored as 17% each:

1. **Validate and assess in sim/flight test** 1) implemented L+C, quadrotor and tilt rotor models with both unified controls and EZ fly control schemes and discriminatory HQTEs to evaluate handling of eVTOL vehicles (sim only) 2) human machine interfaces including pilot displays and alerting with newly developed system quality evaluation metrics (sim only). 3) toolset containing DAA/CA reference framework tailored to eVTOL passenger carrying missions and assess encounter geometries and well clear volumes. 4) toolset containing flight path management reference framework and assess variable airspace constraints and interfaces, flight rules, and nominal and contingency management scenarios. 5) formal methods application to a selected UAM eVTOL use case (in low-fidelity simulation only). 6) initial, integrated automation reference framework containing DAA/CA/flight path management and airspace and the test suite of complex UAM operational scenarios. ...to collect data in support of preliminary recommendations for requirements, design guidelines, test methods and performance standards as a means of compliance for certification.

## MOC Recommendations

Completing the following scored as 25% each:

1. **Document and present set of preliminary recommendations for requirements, design guidelines, test methods and performance standards on** 1) discriminatory HQTEs to evaluate handling of eVTOL vehicles for regulatory means of compliance. 2) handling quality and system quality evaluation techniques and preliminary reduced pilot training requirements. 3) DAA test techniques, preliminary MOPS, maneuver parameters and well clear geometries. 4) architecture requirements, CONOPS implementation of separation assurance, contingency management and PSU interfaces and methods for compliance evaluations of equivalent technology. 5) formal assurance methods, use case examples and application guidelines for means of compliance of complex automation. 6) integrated automation architecture and CONOPS requirements, design guidelines and methods for compliance evaluations of equivalent technology... to stakeholders identified in the subproject plan for each area.

* SDO = Standards Development Organizations
HDV BACKUP
HDV Schedule

• Data Redacted
**TC End State:** Developed, verified, and (partially) validated to TRL Level 5, a Vertiport Reference Automation Architecture that demonstrates requirements, functions, services, and technologies that support UML-4 scale and complexity of vertiport operations

<table>
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<tr>
<th>Development</th>
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<tbody>
<tr>
<td>Completing the following scored as 20% each: (1) Use cases, and vertiport approach/departure procedures; (2) Vertiport automation architecture design and requirements (3) Vertiport infrastructure development and sensor instrumentation for situation awareness; (4) Vertiport services with hazard awareness and notification; (5) Vertiport services with hazard and resource management</td>
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<tr>
<td>Completing the following scored as 20% each: (1) Human and hardware in the loop (HHITL) simulation and flight test of automated approach and landing with automated UAS-fleet manager-PSU coordination; (2) Flight test of arrival procedures using multiple sUAS with automation and connected to fleet manager and PSU (3) HHITL and flight test of merging and spacing with automated sUAS-fleet manager-vertiport-PSU coordination; (4) HHITL and flight test of contingency decision-making procedures of vertiport automation architecture with medium scale surface movements (e.g. UML-4) in controlled testing vertiplex environment (5) Simulation and flight test of select use cases with full-scale AAM eVTOL aircraft communicating with prototype vertiport automation system in representative vertiplex environment</td>
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<tr>
<td>Completing the following scored as 25% each: (1) High Density Vertiport CONOPS; (2) Vertiport automation reference architecture and requirements; (3) Document results vertiport automation operational performance and recommendations for metrics; (4) MBSE Model of Vertiport Automation Reference Architecture</td>
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AOA Key Milestones and Development

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<tr>
<td>L3 Deliverables (In)</td>
<td>FY21 Q4</td>
<td>FY22 Q4</td>
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- **AOA Planning**
  - Mission Concept Review
  - Scenarios Document Completed

- **AOA Simulation**
  - Simulation Complete

- **Initial UAS Automation Architecture**
  - Delta Mission Concept Review

- **AOA Multi-UAS VLOS Flight Testing Begins**
  - UAS Ground/Flight System Testing Begins
  - Flight Readiness Review

- **End of AOA UAS Flight Testing**
  - Flight Test Documentation

- **SAO Planning**
  - SWS Deliverable-1
  - ATM-X Deliverable-1
  - TTT Deliverable-2 (Initial GCS)
  - NC Deliverable-1
  - TTT Deliverable-3 (Final GCS)
  - TTT Deliverable-4 (HF Analysis)

- **Vertiport Automation Trade Study**
- **Vertiport CONOPS**
- **Draft Vertiport Automation Architecture (MBSE)**
- **AOA Simulation Results**
- **Initial BVLOS Safety Case & COA Application**
- **AOA Multi-UAS VLOS Flight Testing Begins**
- **End of AOA UAS Flight Testing**
- **Flight Test Report**

- **SAO Planning**
  - Partnership Agreements

- **AOA Simulation**
  - Results

- **STEReO Deliverable-1**
- **ATM-X Deliverable-1**
- **TTT Deliverable-2** (M:n CONOPS)
- **NC Deliverable-1**
- **TTT Deliverable-3** (Final GCS)
Model-Based Systems Engineering (MBSE) Process

AAM Mission Integration Office (AMIO) MBSE

NUAIR
High-Density Automated Vertiport ConOps

(UAM Reference Architecture)
Vertiport Automation System Architecture
Vertiport Automation System Functional Requirements
System Requirements
Research Questions
Technical Performance Measures
Use Case Diagrams
Activity Diagrams (Scenarios)
Block Diagrams
Internal Block Diagrams
Sequence Diagrams
AAM Mission Integration Office (AMIO) MBSE

(HDV Physical Architecture)
Vertiport Automation System
HDV AOA OpsCon
Goal & Objectives
System Requirements
Technical Performance Measures
Other HDV Info
Activity Diagrams (Scenarios)
Block Diagrams
Internal Block Diagrams
Optional:
Sequence Diagrams
State Diagrams, Subsystem Level

Legend
Source
HDV MBSE
AMIO MBSE
# Technical Readiness Level

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<th>Definition</th>
<th>Hardware Description</th>
<th>Software Description</th>
<th>Exit Criteria</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Basic principles observed and reported.</td>
<td>Scientific knowledge generated underpinning hardware technology concepts/applications.</td>
<td>Scientific knowledge generated underpinning basic properties of software architecture and mathematical formulation.</td>
<td>Peer reviewed publication of research underlying the proposed concept/application.</td>
</tr>
<tr>
<td>2</td>
<td>Technology concept and/or application formulated.</td>
<td>Invention begins, practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture</td>
<td>Practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture. Basic properties of algorithms, representations and concepts defined. Basic principles coded. Experiments performed with synthetic data.</td>
<td>Documented description of the application/concept that addresses feasibility and benefit.</td>
</tr>
<tr>
<td>3</td>
<td>Analytical and experimental critical function and/or characteristic proof of concept.</td>
<td>Analytical studies place the technology in an appropriate context and laboratory demonstrations, modeling and simulation validate analytical prediction.</td>
<td>Development of limited functionality to validate critical properties and predictions using non-integrated software components.</td>
<td>Documented analytical/experimental results validating predictions of key parameters.</td>
</tr>
<tr>
<td>4</td>
<td>Component and/or breadboard validation in laboratory environment</td>
<td>A low fidelity system/component breadboard is built and operated to demonstrate basic functionality and critical test environments, and associated performance predictions are defined relative to the final operating environment.</td>
<td>Key, functionally critical, software components are integrated, and functionally validated, to establish interoperability and begin architecture development. Relevant Environments defined and performance in this environment predicted.</td>
<td>Documented test performance demonstrating agreement with analytical predictions. Documented definition of relevant environment.</td>
</tr>
<tr>
<td>5</td>
<td>Component and/or breadboard validation in relevant environment.</td>
<td>A medium fidelity system/component brassboard is built and operated to demonstrate overall performance in a simulated operational environment with realistic support elements that demonstrates overall performance in critical areas. Performance predictions are made for subsequent development phases.</td>
<td>End-to-end software elements implemented and interfaced with existing systems/simulations conforming to target environment. End-to-end software system, tested in relevant environment, meeting predicted performance. Operational environment performance predicted. Prototype implementations developed.</td>
<td>Documented test performance demonstrating agreement with analytical predictions. Documented definition of scaling requirements.</td>
</tr>
</tbody>
</table>

https://esto.nasa.gov/trl/
Key Performance Indicators

Baseline Metrics
- MOP: Aircraft Movements per Hour
- TRL

Technical Challenge Maturity
- UML – UAM Maturity Level from UAM CONOPS

Key milestones
- Vertiport CONOPS
- AOA Flight Test
- Initial Vertiport Automation Architecture
- SAO Flight Test
- VO Flight Test
- Final Vertiport Automation Architecture
- IAS-2 Flight Test

Technical Performance Measure (TPM)

Key Deliverables
- Full success = 5
- Min success = 4

UML-2
UML-3
UML-4

KPP (Full success) = 120
KPP (Min success) = 80

MOP: Aircraft Movements per Hour

% Complete

FY21
FY22
FY23
FY24
FY25

Technical Challenge

Milestones

Milestone - Complete
**Airworthiness process**
By engaging with a Flight Readiness Review Board during Dry Run NC learned schedule and documentations requirements.

**Data Analysis**
Data analysis needed by the NC team and NASA SMEs to inform policies, guidelines, and standards.

**Partner Maturity**
Partners across vehicle, airspace, and infrastructure are at varying levels of maturity. To test the AAM ecosystem and the associated system of systems a build up approach will be needed.

**MBSE Approach**
Understanding best practices to capture NC system requirements, architecture, interfaces, and data to support the MBSE approach.
NC Execution in FY21 – NC Developmental Test

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<th>CY2022</th>
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<tr>
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- **NC Partnership Management**
  - ACO Release
  - Partner Selection
  - NC-1 Vehicle Information Exchange Engagements
  - NC-1 Partner Reviews & Prep
  - NC-1 Flight Testing

- **NASA Testing**
  - Dry Run Flight Testing
  - Flight Testing

- **NC DT with Joby**
  - DT Flight Testing

- **Data Buys: Bell & FLE Flights**
  - Scenario Development and Flight Test Objective Refinement
  - Bell Flight Testing
  - FLE Flight Testing

- **Airspace Simulation (X3 & X4)**
  - X3 Data Collection
  - X4 Data Collection
Operational assessment and revision of NC flight test plan using a helicopter as a stand in representative UAM vehicle

Assess operational processes for integrated operations with vehicle and airspace and data collection in the field

Capture foundational vehicle and operational data to support evolutions in vehicle, infrastructure, and airspace requirements that will enable the advent of UAM in the National Airspace System (NAS)
Dry Run - Lessons Learned

- Data Redacted
NC Developmental Test (DT) with eVTOL Flight Partner

NC DT Flights with Joby enables initial assessment and data collection of eVTOL performance characteristics and acoustic testing at Partner Test Site

- Developmental Test (NC DT) with partner Joby Aviation will include activities to prepare for NC-1 such as collaborating on objectives, exercising range deployment, and data collection protocols.

- Given the unmanned configuration for this flight test, the NC is leveraging a data buy like process that allows for flights under current certifications from the FAA and AFRL.
**National Campaign Series Fundamentals**

- **NC-Dry Run**: assesses NASA readiness in support of NC-1 and gains development of scenarios and collection of a baseline set of data using the performance of a representative eVTOL.

- **NC-DT**: assesses industry readiness in support of NC-1 and gains early verification of scenarios and contingencies with the performance of an eVTOL. *In Progress – Joby Flights in April*

- **NC-1 Operational Safety**: flight demonstrations with multiple partners using UAM verified scenarios and contingencies from DT while also safely integrating into the NAS with current rules while identifying gaps in FAA Standards.

- **NC-2-4**, and associated developmental testing, will progressively mature the automation needed to get to Medium Density Urban Operations.

*In Progress – Joby Flights in April*
Data Buys – Informing IAS-1 Development

Bell

Key Objectives:
• Flight test to gather GBSS data using a Bell instrumented helicopter and the APT-70
• Exercising sensors and hardware to determine gaps and needs for hazard perception
• Data collected will inform ground-based surveillance systems needed for flying remote operations in controlled airspace
• Data collected from a 4-axis autopilot helicopter to inform gaps in UAM IFR routes and procedures

Flight Level Engineering (FLE)

Key Objectives:
• Flight test to gather data on simplified vehicle operations
• Exercising a 5-DOF fully programmable flight control computer to assess UAM flight plans and instrument approaches
• Data collected will inform evolution needed for flight management and autopilot systems
• Data collected from a 3-axis autopilot fixed wing to inform gaps in UAM IFR routes and procedures

Integration of Automated Systems (IAS-1) to support Scenarios 1-3 with automation
National Campaign – Data and Information Exchange

Data Needs and Requirements

- FAA
- Industry Partners
- NASA Research Projects
- National Campaign Flight Test Infrastructure

National Campaign Operational Demos

- Data Collection & Analysis
- FAA access to shared database and collaborative analysis to inform gaps in policy and standards
- Sharing key outcomes with standards bodies
- Using data to inform NASA/FAA Working Groups including development of concept of operations
- Leveraging ULIs to ensure consistent development with research institutions
- Community engagement through AAM Ecosystem Working Groups

MBSE Approach for CC

Gap Analysis for Current Standards
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<td>4D TBO</td>
<td>Four-Dimensional Trajectory Based Operations</td>
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<td>AAM</td>
<td>Advanced Air Mobility</td>
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<td>AC</td>
<td>Aircraft</td>
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<td>ACO</td>
<td>Announcement of Collaborative Partnership Opportunities</td>
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<td>APL</td>
<td>FAA Policy, International Affairs and Environment Organization</td>
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<td>ASTM</td>
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