NASA UAS Integration Efforts

NASA ARMD Cohesive UAS Integration Strategy
Discussion Topics

• NASA Organization

• NASA UAS Integration Strategy
  – Scope / Outcome
  – Current Landscape and Future Vision
  – UAS Demand and Key Challenges
  – Overarching UAS Community Strategy

• UAS Integration in the NAS Project Overview

• UTM Project Overview
MISSION PROGRAMS

Airspace Operations and Safety Program (AOSP)
- Safe, Efficient Growth in Global Operations
- Real-Time System-Wide Safety Assurance
- Assured Autonomy for Aviation Transformation

Advanced Air Vehicles Program (AAVP)
- Ultra-Efficient Commercial Vehicles
- Innovation in Commercial Supersonic Aircraft
- Transition to Low-Carbon Propulsion
- Assured Autonomy for Aviation Transformation

Integrated Aviation Systems Program (IASP)
- Flight research-oriented, integrated, system-level R&T that supports all six thrusts
- X-planes/test environment

Transformative Aeronautics Concepts Program (TACP)
- High-risk, leap-frog ideas that support all six thrusts
- Critical cross-cutting tool development

SEEDLING PROGRAM

IASP Projects
- UAS-NAS
- Flight Demonstrations & Capabilities (FDC)
**Scope**: Focus on what is needed to enable full integration of UAS for civil / commercial operations within the NAS by ~2025

- Top level strategy that assesses stakeholder needs, FAA UAS Integration Strategy, Concept of Operations, Implementation Plans, etc.
- Leverage information from Government-wide R&D Analysis (ExCom) and FAA R&D Roadmap

**Outcome**: A Vision, Strategic Plan and Communication Strategy

- Routine UAS access within the NAS
- Concept for transitioning UAS access advancements towards the integration of highly autonomous systems and on-demand mobility
Civil Manned Airspace Environment

FL-600

18K' MSL

10K' MSL

TOP OF CLASS G

Agricultural Aircraft

Helicopters

Non-cooperative Traffic

Cooperative Traffic

Cooperative Traffic

Non-cooperative Traffic

Non-cooperative Traffic

Terminal Airspace

Airport

RURAL

URBAN
Current Civil UAS Airspace Environment

VLOS Operations in accordance with 14CFR Part 107 restrictions. Note: Some limited EVLOS/BVLOS Civil Ops in very remote areas.
These UAS will operate at altitudes below critical NAS infrastructure and will need to routinely integrate with both cooperative and non-cooperative aircraft. (Example Use Case: Infrastructure Surveillance)

These UAS will be expected to meet certification standards and operate safely with traditional air traffic and ATM services. (Example Use Case: Communication Relay / Cargo Transport)

Must interface with dense controlled air traffic environments as well as operate safely in uncontrolled airspace. (Example Use Case: Traffic Monitoring / Package Delivery)

Low risk BVLOS rural operations with or without aviation services. (Example Use Case: Agriculture)
Demand Drivers:
• There is a significant demand for visual line of sight flights to conduct precision agriculture, photography, and surveillance missions. This has been evident through the FAA’s incremental approval process from COAs to Section 333 to 14CFR Part 107.
• The demand for these missions to expand the approval envelope to include operations beyond visual line of sight has been increasing.

Representative Markets / Companies:
• Precision Agriculture (PrecisionHawk, Elbit)
• Wildlife Surveillance (NWF, Fish & Game)
• Aerial Photography (GoPro, Roofing, Real Estate)
• Remote Surveillance (Pipelines, Railroads, Power lines, Mining)
• Vertical Infrastructure (Oil /Gas refineries, Bridges)
**Demand Drivers:**
- Beyond DoD, many organizations (e.g. DOI, NOAA, NASA, FedEx, DHL) have expressed an interest in using IFR-Like operations for surveillance, science, and cargo delivery missions.
- Industry is also very interested in using HALE UAS as a more reliable option to satellite communications for remote parts of the globe.

**Representative Markets / Companies:**
- Communications Relay (Facebook, Google, AeroVironment)
- Cargo & Passenger Transport (FedEx, DHL, Medical Supply, Thin Haul)
- Broad Area Surveillance (DOI, DHS)
- Weather Monitoring (NOAA, NASA)
- Emergency Response & Assessment (Land Management, FEMA, Insurance)
**UAS Demand**

*Low Altitude Urban Operations*

**Demand Drivers:**
- The most prominent example of UAS demand has been in the package delivery trade space. Amazon, Google, Walmart, and others have plans to use the low altitude volume of airspace for on-demand, door-to-door delivery of goods.
- Several public service applications exist such as news gathering, traffic monitoring and photogrammetry.

**Representative Markets / Companies:**
- Local Package Delivery (Amazon, Walmart)
- Traffic Monitoring (Local News Stations, Waze)
- Search and Rescue (Law Enforcement, First Responders)
- Infrastructure Surveillance & Protection (Airports, Stadiums, Prisons, DHS CBP)
- Construction Site Monitoring (Land developers, Tax Assessment)
UAS Demand
VFR-Like Operations

**Demand Drivers:**
- Demand for VFR-Like UAS will largely depend on their ability to establish a business case that is competitive with many existing manned aircraft operations.
- Beyond Visual Line of Site (BVLOS) operations for horizontal infrastructure inspection, regional package delivery and transportation of people are current markets for this class of vehicle.

**Representative Markets / Companies:**
- Horizontal Infrastructure (Railways, Exxon Mobil, Duke Energy)
- Regional Cargo Delivery (Amazon, Walmart)
- Personal Transportation (Uber, AIRBUS, Ehang)
- Humanitarian Studies (Red Cross, Health Dept.)
- Wildfire Monitoring (Fire Rescue, State/Local Authorities)
UAS Airspace Access Enablers

UAS Technologies:
T01 - Airport Operations Technologies
T02 - Airworthiness Standards
T03 - Command, Control, Communications (C3)
T04 - Detect & Avoid (DAA)
T05 - Flight & Health Mngmt Systems
T06 - GCS Technologies
T07 - Hazard Avoidance
T08 - Highly Automated Architectures
T09 - Navigation
T10 - Power & Propulsion
T11 - Weather

ATM Services & Infrastructure:
I01 - Airport Infrastructure
I02 - ATM Infrastructure
I03 - Non-FAA Managed Airspace Infrastructure
I04 - RF Spectrum Availability
I05 - Test Ranges & M&S Facilities

Operational Regulations, Policies & Guidelines:
P01 - ATM Regulations / Policies / Procedures
P02 - Airworthiness Regulations / Policies / Guidelines
P03 - Operating Rules / Regulations / Procedures
P04 - Safety Risk Mngmt & Methods of Compliance

Public Acceptance & Trust:
A01 - Cybersecurity Criteria & Methods of Compliance
A02 - Legal & Privacy Rules / Guidelines
A03 - Noise Reductions
A04 - Physical Security Criteria & Methods of Compliance
A05 - Public Safety Confidence
The future civil UAS airspace environment is a complex picture with many unique considerations across the various operating environments. Operating environment attributes and community needs must be considered in order to provide routine access for a diverse set of UAS demand scenarios.

UAS airspace access pillars are a simple decomposition method to structure the broad needs of this diverse community. UAS Airspace Access Enablers provide another layer of detail to consider research elements necessary to achieve the routine access vision.

Assessing the intersections of the future civil UAS airspace environments and UAS airspace access pillars was the method chosen to develop the overarching UAS Community Strategy. Operating Environment Roadmaps were developed around these intersections and the community needs necessary to enable routine UAS access. Assessments were performed against “routine UAS access,” rather than an autonomous end state.
Recommended Operating Environment Roadmaps

Low Altitude Rural Path Forward

- Low Altitude Rural
  - UAS Technologies
    - UAS Vehicle Technologies
  - ATM Services & Infrastructure
    - Low Altitude ATM
  - Operational Policies, Regulations & Guidelines
    - FAA Implementation Plan
  - Public Acceptance & Trust
    - Vehicle Noise Reduction

Partner
- Industry: Industry needs to develop necessary technologies for robust geofencing, secure communications, hazard avoidance, and etc.
- FAA: The FAA needs to define the methodology for risk-based safety standards which allow for trade-offs between population density and necessary vehicle performance.
- NASA: NASA needs to develop integrated test results which demonstrate that the industry-developed technologies are sufficient to satisfy the risk-based safety standards.

Recommended Responsibility

IFR-Like Path Forward

- OE: IFR-Like
  - UAS Technologies
    - UAS Vehicle Technologies
  - ATM Services & Infrastructure
    - Power and Propulsion
  - Operational Policies, Regulations & Guidelines
    - FAA Implementation Plan
  - Public Acceptance & Trust
    - *Public Acceptance and Trust addressed by various elements above for this OE

Partner
- Industry: Industry needs to contribute technologies for DAA, C2, and flight/health management, etc. Industry also needs to engage in the certification process for these technologies.
- FAA: The FAA needs to develop ATM policies and procedures for this operational environment, including Upper Class E airspace. The FAA also needs to implement necessary policies and regulations for vehicles that will operate in this operational environment by working closely with industry throughout the certification process.
- NASA: NASA needs to team with industry on high-risk technology development in areas of DAA, C2, and flight/health management, etc. NASA also needs to develop integrated test results in a relevant environment to inform both industry and the FAA on the development of safety standards and interoperability practices.

Low Altitude Urban Path Forward

- OE: Low Altitude Urban
  - UAS Technologies
    - UAS Vehicle Technologies
  - ATM Services & Infrastructure
    - UTM Safety and Standardization
  - Operational Policies, Regulations & Guidelines
    - FAA Implementation Plan
  - Public Acceptance & Trust
    - Vehicle Noise Reduction and policy
    - Cybersecurity
    - Counter-Drones
    - Education and Public Advocacy Program

Partner
- Industry: Industry needs to contribute vehicle technologies for addressing the unique challenges of operating in the first/last 50 feet. These include detecting and avoiding persons and property on the ground, and operating in and around varying weather conditions. Industry also needs to engage in the certification process for these technologies.
- FAA: The FAA needs to define the safety requirements for a UAS Traffic Management System and implement necessary policies and regulations for vehicles that will operate in this operational environment by working closely with industry throughout the certification process.
- NASA: NASA needs to foster development of the UAS Traffic Management System, in collaboration with both industry and the FAA, which allows for safe operations that are equitable across users within the low altitude volume of airspace. This includes developing concepts, modeling, simulation, and robust flight-testing.

Recommended Responsibility

VFR-Like Path Forward

- OE: VFR-Like
  - UAS Technologies
    - UAS Vehicle Technologies
  - ATM Services & Infrastructure
    - Power and Propulsion
    - ATM/UTM Interoperability
  - Operational Policies, Regulations & Guidelines
    - FAA Implementation Plan
  - Public Acceptance & Trust
    - *Public Acceptance and Trust addressed by various elements above for this OE

Partner
- Industry: Industry needs to contribute technologies for DAA solutions, and the expansion of terrestrial communications, etc. Industry also needs to engage in the certification process for these technologies.
- FAA: The FAA needs to develop ATM policies and procedures for this operational environment. The FAA also needs to implement necessary policies and regulations for vehicles that will operate in this operational environment by working closely with industry throughout the certification process.
- NASA: NASA needs to team with industry on high-risk technology development in areas of alternative ABSAA, and expanded terrestrial communications. NASA also needs to develop integrated test results in a relevant environment to inform both industry and the FAA on the development of safety standards and interoperability practices.
Achieving the Next Era of Aviation

On Demand Mobility - ODM will leverage UAS technologies and advancements in automation to enable the key technologies needed for the ODM business case to be realized.

Highly Autonomous Systems – advancements in automation will open the door for UAS to achieve their full potential and market expansion.

UAS Integration - UAS Integration is the foundation for the revolution of the aviation industry.
NASA Projects Overview

Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project

UAS Traffic Management (UTM) Project
UAS-NAS Command and Control Operating Environments (OE)

Legend
Phase 1 MOPS Research Areas (FY14 – FY16)
Phase 2 MOPS Research Areas (FY17 – FY20)
UAS-NAS Detect and Avoid (DAA)
Operating Environments (OE)

Legend
Phase 1 MOPS Research Areas (FY14 – FY16)
Phase 2 MOPS Research Areas (FY17 – FY20)

DAA System for Transition to Operational Altitude

HALE aircraft
FL-600
18K’ MSL
10K’ MSL
Top of Class G

DAA System for Operational Altitudes (> 500ft AGL)

“VFR-like” UAS
Alternative DAA Sensors
ADS-B & ACAS Xu
ACAS Xu

Cooperative Traffic
Non-cooperative Aircraft
Ground Based Radar
Terminal Area Ops

Cooperative Traffic

C2 Datalink
UAS Ground Control Station
GBDAA Data

ADS-B & TCAS-II
ADS-B & ACAS Xu
ACAS Xu
Goal:
Safely enabling large scale visual and beyond visual line of sight operations in the low altitude airspace

Risk-based approach along four distinct Technical Capability Levels (TCL)
**Capability 1: Demonstrated How To Enable Multiple Operations Under Constraints**
- Notification of area of operation
- Over unpopulated land or water
- Minimal general aviation traffic in area
- Contingencies handled by UAS pilot

Product: Overall concept of operations, architecture, and roles

**Capability 2: Demonstrated How To Enable Expanded Multiple Operations**
- Beyond visual line-of-sight
- Tracking and low density operations
- Sparsely populated areas
- Procedures and "rules-of-the road"
- Longer range applications

Product: Requirements for multiple BVLOS operations including off-nominal dynamic changes

**Capability 3: Focuses on How To Enable Multiple Heterogeneous Operations**
- Beyond visual line-of-sight/expanded
- Over moderately populated land
- Some interaction with manned aircraft
- Tracking, V2V, V2UTM and internet connected

Product: Requirements for heterogeneous operations

**Capability 4: Focuses on Enabling Multiple Heterogeneous High Density Urban Operations**
- Beyond visual line of sight
- Urban environments, higher density
- Autonomous V2V, internet connected
- Large-scale contingencies mitigation
- Urban use cases

Product: Requirements to manage contingencies in high density, heterogeneous, and constrained operations

Risk-based approach: depends on application and geography
Questions?

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