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
ARMD Organizational Structure, Programs Overview

MISSION PROGRAMS

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

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

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

SEEDLING PROGRAM

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

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

Enabling Full Integration of UAS for civil / commercial operations within the NAS by ~2025
Civil Manned Airspace Environment

- **FL-600**: Cooperative Traffic
- **18K’ MSL**: Cooperative Traffic
- **10K’ MSL**: Non-cooperative Traffic
- **TOP OF CLASS G**: Non-cooperative Traffic

**RURAL** to **URBAN**

- **Agricultural Aircraft**
- **Helicopters**
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)

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)
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 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

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<th>OE: Low Altitude Rural</th>
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<td>Industry</td>
<td>Industry needs to develop necessary technologies for robust geofencing, secure communications, hazard avoidance, and etc.</td>
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<td>FAA</td>
<td>The FAA needs to define the methodology for risk-based safety standards which allow for trade-offs between population density and necessary vehicle performance.</td>
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<td>NASA</td>
<td>NASA needs to develop integrated test results which demonstrate that the industry-developed technologies are sufficient to satisfy the risk-based safety standards.</td>
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Low Altitude Urban Path Forward

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<td>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.</td>
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Achieving the Next Era of Aviation

- **UAS Integration** is the foundation for the revolution of the aviation industry.

**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)

SATCOM C2 Data Link

Communications Satellite

Cooperative Traffic

Ku/Ka SATCOM Link

Terrestrial C2 Data Link

Terrestrial C2 Data Link Network

"VFR-like" UAS

"IFR-like" UAS

Top of Class G

FL-600

18K’ MSL

10K’ MSL

SATCOMBRLOS Link

C-Band SATCOM Link

Non-cooperative Traffic

"VFR-like" UAS

Terrestrial C2 Data Link

UAS Ground Control Station

UAS Ground Control Station

CNPC Ground Stations

CNPC Network

SATCOM Transmitter

Land Line

UAS Ground Control Station
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

UAS Ground Control Station

GBDAA Data

C2 Datalink

C2 Datalink

Ground Based Radar

Terminal Area Ops

Cooperative Traffic

Non-cooperative Aircraft

C2 Datalink

ACAS Xu

ADS-B & ACAS Xu

ACAS Xu

ADS-B & TCAS–II

“VFR-like” UAS

Alternative DAA Sensors

Cooperative Traffic

Airborne Radar

Legend
Phase 1 MOPS Research Areas (FY14 – FY16)
Phase 2 MOPS Research Areas (FY17 – FY20)
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)
### UTM Technical Capability Levels (TCLs)

#### 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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Deputy Project Manager
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