Welcome, Logistics, and Industry Day Goals
Nancy Mendonca, Research Portfolio Manager, NASA Aeronautics Research Mission Directorate

Nov 1-2, 2018
Industry Day Goals

*Our goals for this event are to:

Communicate goals of Grand Challenge Series.

Provide details on current plans so that participants can provide input to improve the series.
   - What, Where, When, Why, How....
   - Who – will you join us?

Introduce Request For Information and government processes, contracting teams, program managers, and other relevant NASA points of contact.

Improve communication across the community.
Industry Day Participants

- **47** Aircraft Developers
- **23** Comm/Nav/Surveillance Providers
- **22** Integrated Automation & Operations Developers
- **18** ATM Developers (both traditional and UAM)
- **12** Universities
- **10** Fleet Operations Providers
- **10** Test Site Representatives
- **8** Manufacturers
- **6** Propulsion System Developers
- **5** Media
- **5** Federal Agencies
- **5** Local Governments
- **5** Airspace Designers
- **3** Vertiport Designers
- **2** Trade Associations

*As of October 23, 2018*
Questions?

Today’s Industry Day materials will be posted on FBO
ARMD Urban Air Mobility Grand Challenge Request for Information (RFI)
https://www.fbo.gov
Search Solicitation Number: 18AFRC19S0001
Overview of Aeronautics Vision
Dr. Jaiwon Shin, Associate Administrator, NASA Aeronautics Research Mission Directorate

Nov 1, 2018
DAWN OF A NEW ERA OF AVIATION

Jaiwon Shin
NASA HQ
November 1, 2018
Building the NASA Aeronautics Strategic Implementation Plan
Analysis and Stakeholder Dialogue – 2013 Rollout, 2017 Update

**Key Trends (Not Exhaustive)**

- Increasingly Urbanized World
- Rising Global Middle Class Driven by Asia-Pacific
- Urban Transportation Increasingly Congested
- Continuing Pressure to Reduce Noise and Local Air Quality Impacts
- Aviation Industry Sets Challenging CO₂ Reduction Goals through Mid-Century
- Networked Com and Sensors, Embedded Artificial Intelligence, and Big Data Converging with Traditional Systems and Technologies
- On-Demand Service Models Disrupting Traditional Industries

**Aviation Mega-Divers**

**Analysis & Community Dialogue**

- Industry / Gov’t Execs
  - What’s Needed?
- Industry / Gov’t SMEs
  - What’s Possible?
- Systems Analysis

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**Community Vision**

- Safe, Efficient Growth in Global Operations
- Innovation in Commercial Supersonic Aircraft
- Ultra-Efficient Commercial Aircraft
- Transition to Alternative Propulsion and Energy
- In-Time System-Wide Safety Assurance
- Assured Autonomy for Aviation Transformation
A New Era of Flight is Emerging

NASA Aeronautics’ vision and leadership have stimulated national and international aviation and non-aviation communities to pursue a new era of aviation.

NASA led the U.S. community with the UAS Traffic Management (UTM) & UAS in the NAS projects:

• Integration of commercial systems is now beginning to emerge
• UTM is now the accepted concept all over the world

Urban Air Mobility (UAM) is fast on the heals of UAS integration:

• U.S. industry looking for NASA leadership now to help overcome key barriers
A New Era of Flight is Emerging

NASA Aeronautics’ vision and leadership have stimulated national and international aviation and non-aviation communities to pursue a new era of aviation

Industry innovation in the reemergence of supersonic flight is underway
- NASA must sustain aggressive schedule to complete overland supersonic noise database and enable overland supersonic flight

NASA studies, research and advancements in Electric Aircraft have led to an acceleration of U.S. industry interest and investment
- Focused effort to bring MW level power and propulsion to flight demonstration is now the highest priority for future generation air transport
MARKET: LARGE UAS & HALE

HALE UAS

LARGE UAS

LARGE UAS

UPPER CLASS E AIRSPACE

CLASS A AIRSPACE

MARKET: THIN / SHORT HAUL

MARKET: URBAN AIR MOBILITY

MARKET: SMALL / MEDIUM UAS

AIRPORT

URBAN VERTIPORT

SMALL AIRPORT

DRONEPORT

DISTRIBUTION CENTER
Urban Air Mobility Rapidly Developing

Just in This Year……..

• 2nd Uber Elevate Summit in L.A.
  - Attended by well over 1,000 people with Uber announcing the new 6th vehicle
development partner, Karem Airacrft in addition to the five existing partners (Aurora
Flight Sciences, Embraer, Bell, Pipistrel Aircraft, and Mooney)

• Boeing announces formation of Boeing NeXt at Farnborough Air Show to take
a lead position in Urban Air Mobility
  - Leverage Boeing HorizonX and acquisition of Aurora Flight Sciences to accelerate
  progress

• Rolls Royce and Aston Martin announced plan to develop UAM vehicles at
Farnborough Air Show

• Airbus formed a new UAM business unit in May

• Japanese government announced a plan to invest $40M to accelerate UAM
development

• Well funded new entrants continue vehicle development and flight test
  - Kitty Hawk Cora, Joby S4, Terrafugia TF-2, Lilium Jet, etc
NASA Leadership in Urban Air Mobility

• Demonstrated community leadership with UTM and UAS in the NAS
• Major market studies with McKinsey and Booz Allen
• ARMD led systems studies and industry roadmapping activities
• Formation of National Academies Aeronautics Research and Technology Roundtable (ARTR) focused on UAM
• Cross Program and Center Coordination was chartered
  – Urban Air Mobility Coordination and Analysis Team (UCAT)
  – Achieved significant progress in developing ARMD UAM strategy and planning UAM Proving Ground and Grand Challenge series
  – First Grand Challenge planned for FY 2020
• Industry Day is organized
• Programs/Projects actively pivoting research portfolio to address key UAM Issues
  – ATM-X, SWS, RVLT, etc
- Safety Standards
- Certification
- Methods and Costs
- Infrastructure
- Noise and Visual Barriers
- Cybersecurity
- Privacy
Grand Challenge Overview
Davis Hackenberg, UAM Strategic Advisor, Aeronautics Research Mission Directorate
Nov 1, 2018
Commercial Operating Environments (OE)

- **FL-600**
  - HIGH ALTITUDE
  - LONG ENDURANCE
  - Cooperative Traffic

- **18K' MSL**
  - IFR-LIKE
  - Cooperative Traffic

- **10K' MSL**
  - VFR-LIKE
  - Cooperative Traffic
  - Non-Cooperative Traffic

- **TOP OF CLASS G**
  - LOW ALTITUDE RURAL
  - GA Aircraft
  - Hot air Balloon
  - Helicopters

- **500' AGL**
  - LOW ALTITUDE URBAN
  - URBAN PASSENGER TRANSPORT
  - VLOS

- **TOP OF URBAN AIRSPACE**
  - Terminal Airspace
  - Airport
ARMD has funded two Urban Air Mobility market studies that included several air taxi/metro models, air ambulance, and last-mile package delivery.

Studies include:
- A range of urban areas and business models, technology requirements, legal and regulatory barriers, social acceptance issues.
- Assumptions for issues such as autonomy, batteries, weather, infrastructure, operating costs, passenger adoption rates, etc.

Generally speaking, UAM markets were found to have viable and profitable use cases.
- By ~2028 “air metro” could be profitable and by ~2030 result in ~750M annual passenger trips in 15 metro areas.
- Air ambulance model may not be profitable, but have high impact on public good.
- By ~2030 “last mile package delivery” could be profitable and result in ~500M deliveries annually.
- Large variability across studies based on differences in assumptions, e.g., infrastructure.
UAM Reference Missions

Non-Passenger Carrying Reference Missions
- INITIAL STATE
  - e.g. PUBLIC SAFETY VEHICLES
- INTERMEDIATE STATE
  - e.g. SMALL PACKAGE DELIVERY
- MATURE STATE
  - e.g. UAS MULTI-PACKAGE DELIVERY

Passenger Carrying Reference Missions
- INITIAL STATE
  - e.g. AIR MEDICAL TRANSPORT
- INTERMEDIATE STATE
  - e.g. INTRA-METRO AIR SHUTTLE
- MATURE STATE
  - e.g. UBIQUITOUS INTRA-METRO TAXI
UAM Vision and Framework

Urban Air Mobility (UAM) Vision
Revolutionize mobility around metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system for passengers and cargo

Design, development, and implementation of infrastructure to enable safe and efficient multi-vehicle UAM operations

Societal integration and acceptance of UAM operations

Operations and management of multiple vehicles within a UAM system that enable safe and efficient sharing of airspace and other system resources

Air Traffic & Fleet Operations Management

Individual Vehicle Management & Operations

Design, manufacture, and system readiness of UAM vehicles

Community Integration

Vehicle Development & Production

Airspace System Design & Implementation

Operations and maintenance of a single UAM vehicle, independent of the sharing of airspace or other system resources
UAM Framework and Barriers

1. Safe Urban Flight Management
2. Scalable Vehicle Ops
3. Certification & Ops Approval
4. Ground Ops & Maintenance

1. Vehicle Design & Integration
2. Airworthiness Standards & Certification
3. Manufacturing
4. Vehicle Noise
5. Weather-Tolerant Vehicles
6. Cabin Acceptability

1. Airspace Design
2. Operational Rules, Roles, & Procedures
3. CNS & Control Facility Infrastructure
4. UAM Port Design

1. Public Acceptance
2. Supporting Infrastructure
3. Operational Integration
4. Local Regulatory Environment & Liability

1. Safe ATM Ops
2. Efficient ATM Ops
3. Scalable ATM Ops
4. Fleet Management
5. Urban Weather Prediction

Security
Affordability
Noise
Autonomy
UAM Ports
Safety
Regulations/Certification

Air Traffic & Fleet Operations Management
Individual Vehicle Management & Operations
Vehicle Development & Production
Airspace System Design & Implementation
Community Integration

13
## Community Landscape - Passenger Carrying Focus

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**Manufacturing**
- Boeing
- Ford
- GM
- Airbus
- Chrysler
- Honda
- Nissan
- Siemens
- Toyota

**Subsystems: Airframe & Propulsion**
- ES Aero
- GE Aviation
- LaunchPoint
- MAGSAll
- S-RAM Dynamics
- Thin Gap
- United Technologies
- Embraer
- Rolls Royce
- Siemens
- Safran

**Airspace System Design & Implementation**
- Avionyx
- Avidyne Corporation
- Dynon Avionics
- Echodyne
- Garmin
- Material Systems
- Honeywell/Bendix King
- Iris Automation
- Near Earth Autonomy
- Rockwell Collins
- Sandia Avionics
- TruTrak Flight Systems
- Teinn
- BAE

**Air Traffic & Fleet Operations Management**
- AGI
- Astronautics
- AT&T
- Circonia
- Clear-Com
- Echodyne
- Fortisim
- GE Aviation
- SAGE

**Community Integration Local/National**
- UAM Range Test Sites
- Arizona Commerce Authority
- Chotchow (UK)
- Siemens
- Texas
- University of Maryland MUS Test Site
- FAA Test Sites: Alaska Center for UAS Integration, Lone Star Center UAS of Excel and Innov, Mid-Atlantic Avia Partnership (VA), Nevada Institute for Autonomous Sys, No. Plains UAS Test Site (ND), New Mexico State Univ. UAS Test Site, NUAir Alliance (NY), Pan-Pacific UAS Test Range (OR)

**Community Integration National/International**
- Mayors/City Councils/Boards of Supervisors
- Tribal Councils
- Departments of Transportation
- National League of Cities (2000+ cities, 49 states with additional cities)
- Port Authority (of various big cities)
- US Conference of Mayors
- National Governors Association
- European Aviation Safety Agency (EASA) (Europe)
- European Organization for Civil Aviation Equipment (EUROCAE) (Europe)

**Influencers**
- Chambers of Commerce
- Eurocontrol (Europe)
- FAA/FFP: Chotchow, San Diego, IEVA (VA), KS DoT, Ft Myers (FL), Memphis Airport (TN), NC DoT, ND DoT, Reno (NV), UAF (Fairbanks, AK)
- Uber

**Influencers (National)**
- Israeli Airline Pilot Association
- German Airspace Center (DLR)
- International Forum for Aviation Research (IFAR)
- Japan Aerospace Exploration Agency (JAXA)
- Korea Aerospace Research Institute (KARI)
- Netherland's Aerospace Center (NLR)
- ONERA (French Aerospace Center)

**Influencers (Global)**
- International Air Transport Association (IATA) - Airlines
- International Telecommunication Union (ITU)
- Joint Authorities for Rulemaking on Unmanned Systems (JARUS)
# UAM State of the Art Assessment

## Reference Mission Two – Passenger-Carrying

### Intermediate State

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<th>Number</th>
<th>Pillar</th>
<th>Capability / Discipline</th>
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<tr>
<td>1</td>
<td>Vehicle development &amp; production</td>
<td>High maturity</td>
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<td>2</td>
<td>Individual vehicle management &amp; operations</td>
<td>Medium maturity</td>
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<td>3</td>
<td>Airspace system design &amp; implementation</td>
<td>Low maturity</td>
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<tr>
<td>4</td>
<td>Airspace, air traffic, &amp; fleet operations management</td>
<td>Medium maturity</td>
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<tr>
<td>5</td>
<td>Community integration</td>
<td>Low maturity</td>
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<td>AMM</td>
<td>Automated Mission Management</td>
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<td>DAA</td>
<td>Detect and Avoid</td>
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| 1 | Aircraft developers | Yellow |
| 2 | Propulsion          | Yellow |
| 3 | Battery/power      | Red    |
| 4 | Manufacturing       | Yellow |
| 5 | Integrated automation & aircraft operations | Yellow |
| 6 | Avionics & automation: DAA | Yellow |
| 7 | Avionics & automation: AMM | Red    |
| 8 | Subsystems: Communications | Yellow |
| 9 | Subsystems: Navigation    | Red    |
| 10 | Subsystems: Surveillance | Yellow |
| 11 | Airspace design         | Yellow |
| 12 | Flight procedures development | Yellow |
| 13 | Vertiport design        | Yellow |
| 14 | Cybersecurity           | Red    |
| 15 | Airspace test sites     | Red    |
| 16 | Traditional ATM suppliers | Yellow |
| 17 | Flight services providers | Red    |
| 18 | Airspace service providers | Yellow |
| 19 | ATM automation development | Red    |
| 20 | Fleet operations        | Yellow |

*Draft*
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<th>UML</th>
<th>Initial State</th>
<th>Vehicles</th>
<th>Airspace</th>
<th>Community</th>
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<td>High Density and Complexity Operations with Highly-Integrated Automated Networks</td>
<td>• 1,000s of simultaneous operations; large-scale, highly-distributed networks; high-density UTM inspired ATM; autonomous aircraft and remote, M:N fleet management; high-weather tolerance including icing; high-volume manufacturing</td>
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<td><strong>UML-6</strong></td>
<td>Ubiquitous UAM Operations with System-Wide Automated Optimization</td>
<td>• 10,000s of simultaneous operations (limited by physical infrastructure, scaled ATM); essential ownership models enabled, ad hoc landing sites; noise compatible with suburban/rural operations; societal expectation</td>
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The UAM “Grand Challenge”

• Challenging the industry to execute ecosystem-wide systems level safety and integration scenarios

• Raises the water level for all

• Builds knowledge base for requirements and standards

• No purse or prize money
**Grand Challenge (GC) Series Overview**

**Vehicles**
functional UAM vehicles with threshold level of demonstrated airworthiness

**Airspace Management**
airspace and air traffic management technologies and services built and simulated to a threshold level of UAM ATM requirements

**Safety and Integration Scenarios**
airworthiness processes and realistic UML-4 scenarios designed in concert with the FAA, with range(s) and Testbeds as a UAM proving ground

**Stakeholder Integration**
societal integration and acceptance of UAM Operations including public acceptance, supporting infrastructure, operational integration, standards organizations, the local regulatory environment, etc.

- **Industry Provided**
- **NASA Provided**
- **Ecosystem Wide Support**
2020 Grand Challenge (GC-1) Overview

**Vehicles**
functional UAM vehicles with threshold level of demonstrated airworthiness

**NASA Systems & Interfaces**
UTM interfaces through Testbed

**Airspace Management**
airspace and air traffic management technologies and services built and simulated to a threshold level of UAM ATM requirements

**Safety and Integration Scenarios**
airworthiness processes, realistic UML-4 scenarios, and a range(s) designed in concert with the FAA to support UAM testing

**Stakeholder Integration**
societal integration and acceptance of UAM Operations including public acceptance, supporting infrastructure, operational integration, standards organizations, the local regulatory environment, etc.

- Industry Provided
- NASA Provided
- Ecosystem Wide Support
GC Vehicle and Airspace Management Participants

**Vehicles**

functional UAM vehicles with threshold level of demonstrated airworthiness

- Provide vehicle design and development data to support airworthiness approvals
- Conduct “experimental” class flights to benchmark vehicles and demonstrate ability to handle simple failures and contingencies
- Conduct Safety and Integration Scenarios for Grand Challenge including pre-defined interfaces with Airspace Management systems

**Airspace Management**

airspace and air traffic management technologies and services built and simulated to a threshold level of UAM ATM requirements

- Provide UAM ATM technologies that meet initial ATM-X provided requirements and Interface Control Documents (ICD)
- Demonstrate capabilities will meet the ICD benchmark and contingency simulations or live testing
- Conduct Safety and Integration Scenarios for Grand Challenge including pre-defined interfaces with vehicle systems
<table>
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<th>Design Readiness Reviews</th>
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- Weather
- Cyber-Security
- Conditional Autonomy
- Cabin Acceptability
- Automatic Recovery
- Crashworthiness
- Fleet Management
- Others...
- Human Autonomy Teaming
- Scalability
- CNS Contingencies
- Conflict Management
- Trajectory Planning and Compliance
- Vehicle and ATM Interoperability
- UAM Ports and Approaches
- Noise Evaluation and Acceptance
- 1-A System Connection
- 2-A System Simulation
- 0-A System Design Documentation
- 0-V Airworthiness
- 1-V Vehicle Design Readiness
- 2-V Vehicle Design Robustness
- V: Vehicle
- A: Airspace

GC-1 Scenarios (Qualification at Participant Location)

Future GC Series Scenarios

GC-2 System Scenarios

Design Readiness Reviews
Grand Challenge Series progresses through scenarios that increase in number, complexity, technology readiness, operational readiness, and standards and regulatory emphasis.
Societal integration and acceptance of UAM Operations including public acceptance, supporting infrastructure, operational integration, standards organizations, and the local regulatory environment

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<th>Grand Challenge Relationship</th>
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<td>Supporting infrastructure</td>
<td>Infrastructure elements such as vertiports and charging stations could be provided by stakeholders</td>
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<td>Local communities</td>
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<td>Operational integration</td>
<td>Connectivity and infrastructure requirements for smart city initiatives, multi-modal, etc.</td>
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<td>Standards organizations</td>
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<td>Local government</td>
<td>Local regulators will have the opportunity to assess complete lists of current local regulations and consider ways to approach legislation and long-term planning consideration for the future</td>
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NASA UAM Grand Challenge Timeline

**Industry Day**
Discuss GC-1 plans, objectives, & execution strategy. Outline participation requirements, objectives, expectations, execution strategy, & schedules.

**Qualification and A/W**
Participants signing SAAs will begin qualification scenarios and NASA’s Airworthiness (A/W) process. The process has to be completed prior to flying in GC-1. There are additional follow-on requirements that will occur before each GC flight.

**GC-2**
Future challenges in this series are anticipated to address key safety and integration barriers across the UAM ecosystem while also emphasizing critical operational challenges.

**Jan 2021**
This would be for participants new to the Grand Challenge desiring to participate in GC-2 or, if needed, to update SAAs with GC-1 participants continuing on to GC-2.

**Jan 2020**
GC-1 is anticipated to challenge industry and other community participants to address foundational UAM vehicle design readiness and robustness for UAM operations.

**Jan 2019**
This activity includes drafting Space Act Agreement (SAA) templates, participants identifying the desire to sign an SAA, the negotiation and signing of specific SAAs.

**GC-2 SAAs**

**GC-1**

**Industry Day**

**Qualification and A/W**

**GC-1 SAAs**

**RFI Responses Due**

**Webinar/Set Up Working Groups**

**GC-2**

**Nov 1-2 2018**

**Nov 16**

**Jan 2018**

**Jan 2019**

**Nov 16**

**Feb 2019**

**Jan 2020**

**Nov 1-2 2020**

**Nov 16**

**Jan 2021**

**Nov 1-2 2021**

**Nov 16**

**Jan 2022**

**Nov 1-2 2022**

**Nov 16**

**Jan 2023**

**Nov 1-2 2023**

**Nov 16**

Questions?
NASA and FAA Grand Challenge Panel
Dr. Michael Romanowski, Earl Lawrence, Steve Bradford, Jay Dryer, Dr. Parimal Kopardekar

Nov 1, 2018
Request for Information (RFI) Overview
Dr. Colin Theodore, Associate PM, Technical Integration for the Revolutionary Vertical Lift Technology (RVLT) Project
Nov 1, 2018
Primary Goals of RFI Process

- Gauge the level of interest from the UAM community in participating in the Grand Challenge, their ability to bring vehicle, airspace and infrastructure assets, and their anticipated capabilities.

- Allow the government to assess the state-of-the-art of the UAM ecosystem, including vehicle development, airspace capabilities development, and community integration.

- Collect industry and broader community input to help refine and optimize the Grand Challenge to best enhance and add value to industry efforts in accelerating UAM.
RFI Respondent Expectations

The RFI is seeking responses from the entire UAM community and stakeholders:

- UAM vehicle developers/operators
- Aircraft sub-system developers
- Ground station system and vehicle command and control developers
- UAS avionics and middleware industry representatives
- Airspace system developers and airspace service providers
- Ground and aircraft sensor manufacturers
- Communication/navigation/surveillance service and equipment providers
- Test range operators and other entities that could provide a test range
- Ground infrastructure (e.g., UAM port) developers and operators
- Other organizations: local and state governments, universities, Smart Cities, etc.
- Additional UAM stakeholders
• Most Important Questions:
  – Do you plan to participate in the Grand Challenge Series, in particular GC-1?
  – Comment on the timing of the Grand Challenge with GC-1 targeted for ~late 2020.
  – Describe the elements of the Grand Challenge that are most important to you.

• More focused questions:
  – Describe what capabilities you could bring to the Grand Challenge, in particular GC-1.
  – Which scenarios can your company/organization complete or contribute to?
  – Provide any feedback, comments, suggestions that would be helpful to NASA in preparing the Grand Challenge.
  – UAM Vehicle Developer & Airspace System/Service Provider specific questions.
  – Additional UAM Stakeholder Community members: Ground Infrastructure, Range, Local Governments and “Smart Cities”.

RFI Questionnaire
Grand Challenge Development Timeline

• RFI Released: October 15, 2018
• Grand Challenge Industry Day: November 1-2, 2018
• RFI Responses due: November 16, 2018
  – Submit responses in electronic format (Microsoft Word/PowerPoint, PDF)
  – RFI responses to be submitted by email – Email addresses provided in RFI
  – All responses will be treated as proprietary and confidential
  – This is your best chance to influence the Grand Challenge process
• Webinar for Grand Challenge Updates: ~January 2019
• Public Notice: ~March 2019
• Partnership Agreements Signed: ~July 2019

GC-1 Execution: ~Late 2020
Scenarios and Approach Panel
Dr. Michael Patterson, Starr Ginn, Karen Cate, Ken Goodrich

Nov 1, 2018
Scenarios and Approach Introduction and Overview

Dr. Michael Patterson, Lead Analyst for the Urban Air Mobility Coordination and Assessment Team
michael.d.patterson@nasa.gov

Nov 1, 2018
Grand Challenge (GC) Mission and Goal

**GC Mission**
Purpose for those in the organization and the public

Promote public confidence in UAM safety and facilitate community-wide learning while capturing the public’s imagination

**GC Strategic Goal**
What does the GC do for the UAM community?

UAM community participants address ecosystem wide safety and integration barriers in a robust and relevant environment

**Why Participate?**

Obtain critical insights into UAM systems via realistic scenarios focused on enabling future FAA safety, certification, and operational approvals
Grand Challenge Test Scenarios

- **Weather**
- **Human Autonomy Teaming**
- **Cyber-Security**
- **Scalability**
- **Conditional Autonomy**
- **Cabin Acceptability**
- **Automatic Recovery**
- **Crashworthiness**
- **Fleet Management**
- **Others...**

- **Trajectory Planning and Compliance**
- **Vehicle and ATM Interoperability**
- **Noise Evaluation and Acceptance**
- **CNS Contingencies**
- **UAM Ports and Approaches**
- **Conflict Management**

- **Design Readiness Reviews**
- **GC-1 Scenarios (Qualification at Participant Location)**
- **GC-2 Airspace Qualification Scenarios**
- **GC-2 System Scenarios**
- **Future GC Series Scenarios**

- **Vehicle Design Readiness**
- **Vehicle Design Robustness**
- **Airworthiness**
- **System Connection**
- **System Design Documentation**

- **System and ATM Interoperability**

**A**: Airspace

**V**: Vehicle

**GC-1**

**GC-2**

**Future GC Series**
Selection of GC-1 Scenarios

- Selecting fundamental items for practical, safe individual vehicle operations
- Initial challenge of series – “crawl, walk, run”
- Results of GC-1:
  - Help move vehicles toward certification
  - Initial tests of vehicle to airspace system connection
  - Data to inform standards, means/methods of compliance, and airspace management system development
Selection of GC-2 Scenarios

- Exploring fundamental items for safe multi-vehicle operations and interoperability between vehicles and airspace systems
- Stressing important items that need to be:
  - Solved prior to adding further complexity
  - Thought about earlier rather than later (e.g., noise)
- Results of GC-2:
  - Increased maturity of vehicles and airspace systems, including demonstration of vehicle-airspace system interoperability
  - Inform needs/desires/standards for future airspace systems
Scenarios and Approach Panel: Vehicle
Starr Ginn, Deputy Aeronautics Research Director

Nov 1, 2018
• Identify the relationship between aircraft performance and flight characteristics
• Means of demonstrating compliance
• Evaluate the robustness and operational readiness of vehicle designs
• Inform future certification standards and operational procedures

**Mission Task Elements - Fundamental Building Blocks**

MTE 1 – All Azimuth capability
MTE 2 – Taxi
MTE 3 – Takeoff Performance
MTE 4 – Level Flight
MTE 5 – Flight Path Changes
MTE 6 – Approach/Landing
MTE 7 – Landing – Quick Refuel (charge) – Takeoff
MTE 8 – Energy Storage, Battery Capacity
MTE 9 – Function & Reliability Demonstration
MTE 10 – Precautionary Landing
MTE 11 – Balked Landing
MTE 12 – Takeoff Failure Case
MTE 13 – Approach/Landing Failure Case
Overview of GC-1 Test Scenarios

- **Scenario 0-V – Vehicle Airworthiness**
  - Airworthiness and Flight Safety Review - AFG-7900.3-001
  - Company provided standards will be evaluated against margins of aircraft design. Hazard severity and mitigations will be evaluated.
  - Appendix B – Sample Questions for Review Board Members

- **Scenario 1-V – Vehicle Design Readiness**
  - Vehicle performance and flight envelope characterization for nominal mission attributes
  - Demonstrate ability to transmit state and intent data, including 4D flight plan

- **Scenario 2-V – Vehicle Design Robustness**
  - Demonstrate ability to safely mitigate simple vehicle failures and contingencies

Independent surveillance of Mission Task Elements, will be evaluated through a variety of dynamic environmental conditions
Scenarios and Approach Panel: Airspace
Karen Cate, Deputy Branch Chief, Aerospace Simulation Research and Development

Nov 1, 2018
Overview of GC-2 Test Scenarios

- Scenario 0-A – System Design Documentation
  - Evaluate airspace system assumptions and design documentation

- Scenario 1-A – System Connection
  - Verify airspace system integration through ingestion of (live) vehicle and range data

- Scenario 2-A – System Simulation
  - Demonstrate and verify functionality of the airspace system and components in simulation
Overview of GC-2 Test Scenarios

- **Scenario 3 – Trajectory Planning and Compliance**
  - Demonstrate flight planning that accommodates ATM and vehicle constraints, and precision of vehicle trajectory conformance to the flight plan

- **Scenario 4 – Vehicle & ATM Interoperability**
  - In-flight re-planning, negotiation and execution that accommodates ATM and vehicle constraints, and responds to real-world uncertainties

- **Scenario 5 – CNS Contingencies**
  - Identification, mitigation and response to contingencies related to degradation/loss of primary vehicle navigation, vehicle and airspace communications, and/or airspace surveillance
Overview of GC-2 Test Scenarios

- **Scenario 6 – Noise & Community Acceptance**
  - Evaluate vehicle noise and acceptance through typical UAM mission flight profiles

- **Scenario 7 – UAM Ports & Approaches**
  - Develop scalable UAM Port design and procedures, and explore influencing factors

- **Scenario 8 – Conflict Management**
  - Demonstrate individualized components of traffic conflict management
Scenarios and Approach Panel: Community

Ken Goodrich, Senior Researcher

k.goodrich@nasa.gov

Nov 1, 2018
Community Integration

• Federal government directly regulates airspace and airspace operations

• And, states and local government / communities determine where aircraft can takeoff and land, through a variety of mechanisms such as
  – Land use, zoning
  – Building codes and other requirements
  – Environmental regulations
  – Community referendums
  – Congressional representation
From edges...
Community Integration

...to core...
Community Integration

...to anywhere & any condition
Community Integration Barriers Identified by NASA

Not a traditional area for NASA, seeking community inputs & partners

1) **Public Acceptance (avoiding NIMBY)**
   - Safety (air and ground)
   - Noise (auditory, visual)
   - Privacy
   - Personal and public benefit

2) **Infrastructure**
   - UAM port standards, flight procedures, obstruction clearance requirements for all-weather operations
   - Supporting ground infrastructure standards (e.g. building & fire codes)
   - Electrical grid and generation
   - Etc....

3) **Mobility integration**
   - Door to door, not just port to port

4) **Local regulation**
   - Recommended practices, meeting local needs, tailorable to preferences
Grand Challenge RFI: *Community Inputs*

- Are we asking the right questions for your community to understand and integrate UAM?

- What data is needed to help answer these questions?

- How do you think NASA working with the broader UAM community can help answer these questions?
  - What role can the Grand Challenge series play?

- Is your community interested in being part of the Grand Challenge?
  - What could that participation look like?
Airworthiness, Safety and Certification Panel: Certification
Wes Ryan, FAA Policy & Innovation Division, Aircraft Certification Service
Nov 1, 2018
NASA Grand Challenge Industry Day
Airworthiness, Safety, Certification, and Operations Panel

Wes Ryan, UAS Certification Policy Lead, Aircraft Certification
FAA Policy and Innovation Division
Our Opportunity

• Collaboration between Industry, FAA, and NASA to advance development & certification for EVTOL/UAM
• Accelerate development for new entrants, particularly in areas where core technical/certification challenges exist
• Gather/apply knowledge and lessons learned into our efforts to develop certification requirements and integration strategies for UAM and future flight concepts
• Focus on readiness for operational use by standardized testing while identifying common requirements
Similar Benefits To Past Collaboration

- AGATE – Led to Revolution in GA, but took 20 years
- SATS – Before its time, but showed that technology can improve GA safety – led to many Cirrus SR-22 features
- ODM/Urban Air Mobility/Uber Elevate – “If we build it, they will come” mentality from 5 years ago taking root in Uber Elevate - Use Technology to Enhance Safety
- Grand Challenge – Proactive collaboration to accelerate UAM and Core Technology Requirements
How We Will Leverage Each Other

• Discuss Role in Each Phase of Project
• “Better Together” Coordination
• Warranted by New/Novel Design and Safety Challenges
• Leverage Individual Strengths
Proposed NASA & FAA Process Relationship for Challenge

Grand Challenge “Scenario Roadmap” Rosetta Stone

**NASA**

- **Design Readiness**
  - NASA 7900.3D CH1

- **Design Robustness**
  - NASA 7900.3D CH2

- **Operational Suitability**
  - NASA 7900.3D CH3 & 4

**Outcomes:**
- **Design Readiness**
  - Identify Design Issues, Airworthiness Requirements, Means of Validating Design + Performance (i.e. Subpart B)

- **Design Robustness**
  - Identify Operational/Performance Issues, Pilot Training Requirements, Suitability for Real World Use

- **Operational Suitability**
  - Determine Condition for Safe Flight – “Crew Rated”

**FAA**

- **Basic Airworthiness**
  - FAA Order 8130.34D
  - Outcome: Determination of Condition for Safe Flight – “Crew Rated”

- **Design Certification**
  - FAA Order 8110.4C
  - Outcome: Identify Design Issues, Airworthiness Requirements, Means of Validating Design + Performance (i.e. Subpart B)

- **Operational Approval**
  - Aircraft Evaluation Group
  - Outcome: Identify Operational/Performance Issues, Pilot Training Requirements, Suitability for Real World Use

**Type Certification & Operational Readiness**
FAA Efforts To Enable UAM/ETVOL Certification

• Regulatory improvements – Part 23 & FAST Team
  – Performance-based regulations - top-level safety goals
  – Customizable design/certification requirements through collaborative Means of Compliance

• Standards for Electric Propulsion/lift systems
  – Developing Requirements & Experience in UAS
  – Recognize potential safety/efficiency benefits

• Augmented flight path control & automation (“Autonomy”)
  – R&D and Collaboration for best practices, design requirements, architecture with industry, NASA, academia
  – Gradual transfer of pilot responsibility/workload to Automation
Leverage Core NASA Expertise

• Loss of Control Standard – Utilize their expertise in dynamic stability & handling qualities
• Safety Risk Analysis – Safety Targets for equipment and Operational Performance, ie. NOT 10E-9
• GAMA SVO – Decomposition of Pilot Function – methodical replacement with assured autonomy
• X-57 – Verify Core Design for EP and Motor Controls
• Flight Control Standards – Core Design, V&V, etc.
• Structural Dynamics & Aero elasticity – Unique Configs.
Is Evolution or Revolution the Right Methodology?

- Some are convinced they can jump straight to full automation without a human pilot in the loop “flying” the aircraft.
- Others recognize the challenge of replacing the pilot on board with an automated system that is reliable enough to handle all actions typically done by the pilot and the controller for all phases of flight.
Challenge - Humans/Machines Safely Trading Roles

- Automation May do More Than Human Capability
- Automation Replacing Humans
- What Will Residual Future Roles Be?

- Reduced Pilot Error/Operational Error
- Human Function
- Automation Function
- Pilot Mitigates Risk
- Automation Mitigates Risk

- Future Safety Gain?
- Human as Safety Monitor
- Velocity of Change
- Workload/Integrity of Function
- Time
- Current Systems
- Future Systems
Airworthiness, Safety and Certification Panel: Airworthiness
Brad Neal, Chief Engineer at NASA's Armstrong Flight Research Center
Nov 1, 2018
Armstrong AFSR Process Applied

One Process Many Applications
Airworthiness and Flight Safety Process

• Our goal is to provide a flexible, risk management based review process that...
  – Provides an airworthy vehicle that can be operated safely with the highest probability of mission success
  – Assesses, Communicates and Accepts the residual risks of vehicle test and operation

• This allows the project team to...
  – Select appropriate standards to design and build hardware, software and systems
  – Develop systems, test, procedures and documents, that will allow the project to validate those systems and meet its technical objectives
  – When the project believes it has accomplished sufficient validation in preparation for flight, it presents its plans and rationale for flight readiness to the appropriate reviewing body
Airworthiness and Flight Safety Process

Project Life Cycle

System Engineering Reviews

- Formulation
- Design
- Fabrication, Integration, and Testing

Airworthiness Reviews

- Airworthiness and Flight Safety Review
  - Flight Readiness Review
  - Critical Design Review
  - Preliminary Design Review
  - System Requirements Review

- Mission Concept Review
- Critical Design Review
- System Requirements Review
- Preliminary Design Review

- Crew Brief
- Tech Brief
- Post Flight Debrief
- Reports, Tech Transfer

Day-to-Day Airworthiness & Flight Safety Review Activities

NASA-led technical working group(s) will shepherd the NASA airworthiness and flight safety review process.
Airworthiness, Safety and Certification Panel: Safety
Dr. Natasha Neogi, NASA Research Scientist, SWS, UAS-NAS, TTT and Autonomous Systems Project
Nov 1, 2018
System Safety

• Safety must be designed into a system.
• Safety is an integral part of a system.
• Safety cannot be inspected into a system.
  – OEM/certificate holder is ultimately responsible for safety and safety management processes. (e.g., SMS etc.)
Primary aim of aircraft certification (Part 21 etc.) is to provide assurance of safety by: (1) assuring that items perform their intended (safe) functions under any foreseeable operating condition, and (2) assuring that unintended functions are improbable.
Safety Argument—Evidence Based Safety

• Demonstrate satisfaction of safety objectives derived from hazard analysis
• Justify acceptability of safety based on product-specific and targeted evidence
• (Potentially) justify the determination of objectives and the selection of evidence

“A Safety Case is a structured argument, supported by a body of evidence, that provides a compelling, comprehensible and valid case that the system is safe for a given application in a given operating environment.”

A Safety Claim is a Proposition over variables:

This system deployed in This environment meets These criteria

Decomposed, traceable, integrated, organized support for this proposition
Safety Assurance Case—CD&R Sample (GC-S8)

- **Claims (goals), arguments** (inferences, strategies, warrants), **evidence** (data)
  - Decomposition
  - Binding and supporting
- **Top-level goal**
  - NASA to develop ‘Hazard Templates’ for relevant GC scenarios (root node)
- **Formats and notations**
Airworthiness, Safety and Certification Panel: Autonomy

Mark Ballin, Strategic Technical Advisor for NASA’s Transformative Aeronautics Concepts Program

Nov 1, 2018
Autonomy and UAM

• Autonomy: The ability of a system to achieve goals while operating independently of external control*
  – NOT artificial intelligence (AI), but may make use of AI methods
  – NOT automation, but often relies on automation as a building block

• UAM Need for Autonomy: Safe and Viable Systems that Scale

Examples:
  – Evolve from requiring expert pilots for each aircraft to remote supervision of many vehicles by a small number of people
  – Manage high volumes of UAM traffic by removing bottlenecks inherent in direct use of air traffic controllers

*From NASA Autonomous Systems Taxonomy, NASA Autonomous Systems coordination team (AS-MCLT)
Many Autonomy Challenges

• Understanding the operational needs for cutting edge automation technologies, and when they will be needed

• Operational trust and certification of comprehensive autonomous systems

• Redefinition of human operator roles and capabilities

• A regulatory framework for UAM operations employing autonomous systems
# UAM Maturity Levels (UML)

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<th>Ubiquitous UAM Operations with System-Wide Automated Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• 10,000s of simultaneous operations (limited by physical infrastructure, scaled ATM); essential ownership models enabled, ad hoc landing sites; noise compatible with suburban/rural operations; societal expectation</td>
</tr>
</tbody>
</table>
Grand Challenge RFI: Desired Autonomy Inputs

• What autonomous system capabilities are needed to make UAM viable?
  – What capabilities do your systems need to provide?
  – What capabilities or services are you expecting from others?
  – How do you envision technology advancing and maturing over time?

• What role could a Grand Challenge event play in gaining information or experience in autonomous systems?
  – Generate and disseminate data?
  – Gain insight into certification and approval approaches?

• What role should NASA play in answering these questions?

• What autonomous systems capabilities can you bring to a Grand Challenge event?
Range and Infrastructure Panel: Infrastructure

Jim Murphy, Technical Lead for NASA’s ATM TestBed, UAS-NAS Live Virtual Constructive Architect

jim.murphy@nasa.gov

Nov 1, 2018
Grand Challenge Infrastructure

Purpose: Provide environment to test candidate UAM aircraft and airspace systems through increasingly challenging scenarios

Challenge: Integrate systems from aircraft, airspace, and range partners and participants

* Google Earth
2020 Grand Challenge (GC-1) Overview

Vehicles
functional UAM vehicles with threshold level of demonstrated airworthiness

NASA Systems & Interfaces
UTM interfaces through Testbed

Airspace Management
airspace and air traffic management technologies and services built and simulated to a threshold level of UAM ATM requirements

Safety and Integration Scenarios
airworthiness processes, realistic UML-4 scenarios, and a range(s) designed in concert with the FAA to support UAM testing

Stakeholder Integration
societal integration and acceptance of UAM Operations including public acceptance, supporting infrastructure, operational integration, standards organizations, the local regulatory environment, etc.

Industry Provided
NASA Provided
Ecosystem Wide Support
Vehicle Participants

Vehicles
functional UAM vehicles with threshold level of demonstrated airworthiness

- Airworthy Vehicle
- Aircraft Communications
- Integration into Grand Challenge test infrastructure
- Range specific equipment
  - Detect and Avoid operational assumptions
Airspace Participants

- Airspace system operational assumptions to manage UAM traffic
- Interoperability with existing ATM and UTM systems
- Interface to support airspace/aircraft messaging to enable operational assumptions
- Integration of required secondary data (from test range)
Infrastructure Partners

• Range: Airspace to conduct GC scenarios
  – Controlled Airspace
  – Vertiport(s)
  – Mission support
  – Support for subset of scenarios may be acceptable

• Supporting Infrastructure
  – Communication/Navigation/Surveillance systems
  – Cybersecurity technologies
  – Fuel/Power technologies
  – Intruder aircraft for GC execution
  – Supplementary aircraft for dry-run
  – Advanced weather products
  – Live, Virtual, Constructive technologies

Stakeholder Integration
societal integration and acceptance of UAM Operations including public acceptance, supporting infrastructure, operational integration, standards organizations, the local regulatory environment, etc.
• Aircraft airworthiness processes
• Candidate Test Range: NASA Armstrong
• COA guidance (if needed)

Common Safety and Integration Scenarios
airworthiness processes, realistic UML-4 scenarios, and a range(s) designed in concert with the FAA to support UAM testing

• UAM Scenario definitions
• Test infrastructure for connecting aircraft and airspace systems

Provide system integration support among aircraft, airspace, range partners and participants
2020 Grand Challenge (GC-1) Overview

**Vehicles**
functional UAM vehicles with threshold level of demonstrated airworthiness

**NASA Systems & Interfaces**
UTM interfaces through Testbed

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airspace and air traffic management technologies and services built and simulated to a threshold level of UAM ATM requirements

**Safety and Integration Scenarios**
airworthiness processes, realistic UML-4 scenarios, and a range(s) designed in concert with the FAA to support UAM testing

**Stakeholder Integration**
societal integration and acceptance of UAM Operations including public acceptance, supporting infrastructure, operational integration, standards organizations, the local regulatory environment, etc.

[Diagram showing the integration of different aspects of the 2020 Grand Challenge (GC-1)]

- **Industry Provided**
- **NASA Provided**
- **Ecosystem Wide Support**
Range and Infrastructure Panel: C2 for UAM
Dr. Félix Miranda, *Communications and Intelligent Systems Division Deputy Chief*

Nov 1, 2018
Purpose: Provide necessary communications to conduct Grand Challenge along the following general guidelines

- Initially supports flights comprised of a single UAM vehicle; on-board or remote pilot
- Provides RF coverage over the entire Grand Challenge Airspace
- Anticipate possible beyond line of sight communications, including temporary loss of service
- Ground Control Station (GCS) will support C2 and voice services
- C2 and voice links may be provided by integrated or separate radio systems
- NASA is open to any implementation concepts (e.g., LTE, WiMax, Point-to-Point, etc.) compatible with the above general guidelines and range safety requirements.
Grand Challenge Communication Considerations

• Voice Communication
  – PIC to test Range ATC
  – PIC to Mission Control
  – Certified, aviation-grade voice radios required

• Command and Control (and data)
  – Aircraft to GCS
  – UTM Required Telemetry data
  – Other data (e.g., Telemetry from the DAA subsystem; Status messages from the avionics flight controller; Percentage of charge on the battery during flight; etc.)
  – Measure message latencies
  – Manned aircraft will need C2/datalink radio capabilities for data collection and connection to test infrastructure

• Potential Frequency/Bandwidth Restrictions
  – Lower frequency (i.e. VHF/UHF) radios may be preferred due to range and terrain considerations.
  – May depend on site location; i.e., for a specific range (e.g., Edwards) if OGA is testing with in band and/or adjacent out of band radios there could be termination of the flight test.
Notional Grand Challenge Communications Responsibilities

NASA/Range Provides the Following:
- Evaluation of permitted radio/sensor frequencies
- Facility for GCS and/or datalink connection to aircraft
- Tower/mast for antennas
- Network interface between GCS and test environment
- Test environment and data recording

Expected From Each UAM Participant:
- Approved VHF/UHF voice radio for pilot’s use (for manned aircraft)
- C2 radio and avionics integration to meet the real-time data requirements
- Software to receive messages from datalink, format, and send to test environment per Interface Control Document (ICD)

• Data Recording Considerations
  – Measure datalink message latencies and packet loss/re-transmissions
  – Measure data throughput
Unmanned aircraft systems Traffic Management (UTM)

- Principle: Safely integrating UAS operations without burdening current ATM
  - **FAA maintains** regulatory **AND** operational **authority** for airspace and traffic operations
  - Air traffic controllers **are not required** to actively “control” every UAS in uncontrolled airspace or uncontrolled operations inside controlled airspace
  - FAA has on-demand access to airspace users and can **maintain** situation awareness and **issue** directives, constraints, and airspace configurations **through UTM** for safety reasons anytime
- NASA is developing a UTM ecosystem for uncontrolled operations (under 400 AGL)
  - The UTM system adopts **service-orientated architecture** and **utilizes industry’s ability** to supply services **under FAA’s regulatory authority** where these services do not exist.
  - **Goal:** **Safely enabling** large scale visual and beyond visual line of sight operations in the low altitude airspace
  - **Approach:** a risk-based approach along four distinct Technology Capability Level (TCL).
  - **Progress:** The system is progressing to TCL Four. Results are expected to be transferred to the FAA in 2020.
From UTM to UAM Airspace Management

• Shared principles:
  – Safely integrating operations without burdening current ATM
  – Air traffic controllers are not required to actively “control” every vehicle
  – Adopting service-orientated architecture and utilizing industry’s ability to supply services under FAA’s regulatory authority

• UAM extensions:
  – Operating beyond 400 feet AGL
  – Different categories of vehicles and higher standard of safety
  – Extension from volume-based operations
Connecting to UTM in Grand Challenge 1

Option #1:

Industry USS (NASA approved) → USS-USS ICD → NASA USS → Client → Vehicle

Vehicle manufacturers
- Airspace system developers
- NASA system

Option #2:

Industry USS (NASA approved) → USS-USS ICD → NASA USS → USS-Operator ICD → Client → Vehicle

Vehicle manufacturers
- Airspace system developers
- NASA system
Range and Infrastructure Panel: ATM-X
Rich Coppenbarger, Technical Lead, Air Traffic Management Exploration (ATM-X)
Nov 1, 2018
Background

- NASA will leverage airspace technologies developed in its UTM and Air Traffic Management - eXploration (ATM-X) projects to support Grand Challenge.
- Under the UAM subproject, ATM-X is conducting R&D focused on airspace integration of UAM operations.
- ATM-X is developing a reference implementation of a UAM Airspace Management System
  - Supports data sharing and integration to ‘plug and play’ multiple airspace services through specified ICDs
  - Allows NASA and community partners to collaborate on simulation studies
  - Builds upon existing software architecture and implementation of UTM and includes connection with Testbed
The NASA UAM Airspace Management System will serve as a government-furnished example of a generic air traffic management system for Grand Challenge purposes:

- Supports integrated vehicle and airspace scenarios in Grand Challenge 2 and beyond
- Provides data connectivity and relevant airspace management functions/services
- Does not presuppose end-state allocation of UAM traffic management roles/responsibilities between government and industry

Reasons for NASA-provided system:

- Reduce system integration complexity and risk
- Reduce initial costs/risks for airspace industry to participate in Grand Challenge
- Allow partner airspace services to potentially run in ‘shadow mode’ prior to actively supporting later Grand Challenge scenarios
- Provide standard data, services, and metrics for consistency across initial integrated vehicle and airspace scenarios
Notional Airspace Management System for GC Series

Airspace Management System Backbone (leveraging UTM + TestBed)

- ANSP/NAS Constraints
- Terrain and Obstacles
- Weather
- Surveillance
- Virtual Traffic

Data Services

- Traffic-Flow Management
- Strategic CD&R
- Tactical CD&R
- Conformance Monitoring
- Situational Display
- Other... TBD

Traffic Management Services

- UAM Operator Interface (client)
- 4D Flight Planning

- NASA
- Vehicle Operator
- Airspace Resource Provider
- NAS/FAA
Scenario 3: Trajectory Planning and Compliance
Notional Airspace Management System – GC-2 and beyond

Airspace Management System Backbone (leveraging UTM + TestBed)

- ANSP/NAS Constraints
- Terrain and Obstacles
- Weather
- Surveillance
- Virtual Traffic

Data Services

Traffic Management Services

UAM Operator Interface (client)

4D Flight Planning

Traffic-Flow Management

Strategic CD&R

Tactical CD&R

Conformance Monitoring

Situational Display

Other… TBD

NASA

Vehicle Operator

Airspace Resource Provider

NAS/FAA
NASA Airspace Management System Development

• Builds upon UTM foundation
• Leverages UAM airspace system development underway for ATM-X HITL simulations and/or other evaluations
  – Extending UTM volume-based paradigm to trajectory-based operations
  – Developing trajectory-based flow-management and separation services
  – Studying roles, responsibilities, procedures, and information needs for nominal operations and contingencies
  – Leveraging existing partnerships with FAA and industry
• Tests system for GC-2 in 2020 lab simulation(s), augmented by data collected during GC-1 through UTM interface with vehicles
• Expected to involve partnerships with industry stemming from two NASA RFIs:
  – UAM Grand Challenge RFI
  – ATM-X UAM airspace integration R&D collaboration RFI
Wrap Up and Next Steps

Nov 1, 2018
Industry Day 2 – Topic Areas

- Why Participate
- Timeline
- IP and Data Rights
- RFI
- Multiple “Vehicle” topics – MTEs, STOL and other unique vehicle considerations, pilots and autonomy, getting to standards
- ATM, UTM, and UAM ATM – NASA project boundaries, differentiators, timelines, certification/standards
- Community participation
- Possible Special topics and webinars