Introduction

• Summary of Last meeting (6/18/18)
  – Discussed NASA UAM Framework and Barriers
  – Introduced NASA Grand Challenge concept
  – Several “themes” included: Autonomy, noise, path to commercialization, manufacturing, and the NASA role in UAM

• Goals of today
  – Update on NASA strategic considerations
    • Discuss elements to NASA UAM strategy
    • Conversation on UAM Maturity Levels
  – Update on approach to Grand Challenge (GC) Series
    • Conversation on the approach to the GC series
    • Conversation on the execution of GC2020
    • Conversation on data and Intellectual Property (IP)
  – Emphasize of themes from 6/18 ARTR where appropriate
Urban Air Mobility (UAM) Vision
Revolutionize mobility within metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system for passengers and cargo.
UAM Framework and Barriers

Airspace Design
1. Airspace System Design & Implementation
2. Air Traffic & Fleet Operations Management
3. Vehicle Development & Production
4. Individual Vehicle Management & Operations

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

CNS & Control Facility Infrastructure
1. Safe ATM Ops
2. Efficient ATM Ops
3. Scalable ATM Ops
4. Fleet Management
5. Urban Weather Prediction

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

UAM Ports
1. UAM Port Design
2. Operational Integration
3. Infrastructure
4. UAM Port Design

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

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

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

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

Regulations/Certification
1. Safe ATM Ops
2. Efficient ATM Ops
3. Scalable ATM Ops
4. Fleet Management
5. Urban Weather Prediction
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
### Community Landscape - Passenger Carrying Focus

#### Vehicle Development & Production

<table>
<thead>
<tr>
<th>Government: FAA/AIR, DoD Standards: ASTM, RTCA, SAE, EUROCAE, ICAO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Automation &amp; Aircraft Operations: Bell Helicopter, Boeing/Aurora, Joby, Kitty Hawk, Sikorsky, Uber, A3, Terafugia (F)</td>
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</tbody>
</table>

#### Individual Vehicle Management & Operations

<table>
<thead>
<tr>
<th>Government: FAA/AIR/AES Standards: ASTM, RTCA, SAE, EUROCAE, ICAO</th>
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</table>

#### Airspace System Design & Implementation

<table>
<thead>
<tr>
<th>Government: FAA/AIR/ATO Standards: RTCA, ICAO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airspace Design: A6i, Airmap, ANRA, GE/Airnas, Harris, Lockheed, M2C Aerospace, Metron, Skyward, A3 (F), Terafugia (F)</td>
</tr>
</tbody>
</table>

#### Air Traffic & Fleet Operations Management

<table>
<thead>
<tr>
<th>Government: FAA/AIR, DoD Standards: RTCA, ICAO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight Procedures Development: Hughes Aerospace, Jeppesen, Global Airspace Solutions (F)</td>
</tr>
<tr>
<td>Vertiport Design: Blade Helicopter NM, Burns and McDonnell, HellExperts, Near earth autonomy, Uber Elevate</td>
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#### Community Integration

<table>
<thead>
<tr>
<th>Local</th>
<th>National/International</th>
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</thead>
<tbody>
<tr>
<td>Decision Makers: City of San Diego, Chocotaw, National League of Cities (200+ cities, 49 states with additional cities), North Carolina – Greensboro, 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)</td>
<td></td>
</tr>
<tr>
<td>ATM Suppliers: GE/AIRXOS, NA, Jet Blue Technology Ventures, N2X (Boeing)/SparkCognition, Raytheon, Microsoft, XTRIC, UAS Sadorick, WSI, XM WX</td>
<td></td>
</tr>
<tr>
<td>USS Providers: Analytical Graphics Inc. (OneSky), Climenick, GE/AIRXOS, Ge non-AirXos, Raytheon, Rockwell, Simulze, TrueWeather, Uber Elevate, UTRC, UAS Sadorick, WSI, XM WX</td>
<td></td>
</tr>
<tr>
<td>Decision Makers: LA Congreso, DOT/FAA – AIR, APS, ATO, DOC/NITA (public/federal spectrum), FCC (commercial spectrum), FAA, DOT/FB</td>
<td></td>
</tr>
<tr>
<td>Standards: American Society for Testing and Materials (ASTM) (I), Radio Technical Commission for Aeronautics (RTCA) (I), Society of Automotive Engineers (SAE) (I), International Civil Aviation Organization (ICAO) (I)</td>
<td></td>
</tr>
<tr>
<td>Influencers: Chambers of Commerce, Eurocontrol (Europe), FAA/JPAA, Chocotaw, San Diego, IDEA (VA), KS DoT, Ft Myers (FL), Memphis Airport (TN), NC DoT, ND DoT, Reno (NV), UAF (Fairbanks, AK), NLAIR Alliance (NY), Uber</td>
<td></td>
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<tr>
<td>Incubators: Defense Innovation Experimental (DUIx), Starburst</td>
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<tr>
<td>Influencers (Domestic): American Association of Airport Executives (AAA), American Institute of Aeronautics and Astronautics (AIAA), Aircraft Owners and Pilots Assoc (AOPA), Commercial Drone Alliance, Coalition of UAS Professionals, Environmental Group (e.g. Sierra Club), Experimental Aircraft Association (EAA), NASA, National Academies-Transportation Research Board, National Institutes of Standards and Technology (NIST)/Smart Cities, National Transportation Safety Board (NTSB), Vertical Flight Society (VFS)</td>
<td></td>
</tr>
<tr>
<td>Influencers (International): Airports Council International (ACI), Association for Unmanned Vehicle Systems International (AUVSI), Civil Air Navigation Services Organization (CANSO) – ANSP providers, Environmental (Greenpeace, WWF), General Aviation Manufacturers Association (GAMA), German Aerospace Center (DLR), International Air Transport Association (IATA) – Airlines, International Telecommunication Union (ITU), Joint Authorities for Rulemaking on Unmanned Systems (JARUS)</td>
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#### Manufacturing

| Ford, GM, Chrysler (F), Honda (F), Nissan (F), Siemens (F), Toyota (F) |

#### Incomplete list of Stakeholders (F) - Foreign (I) - International
UAM Maturity Levels (UML)

**INITIAL STATE**

- **UML-1**
  - Early UAM operations in a limited environment
    - Vehicle benchmarking and airworthiness, traditional airspace features and procedures, community data, largely exploratory operations

- **UML-2**
  - Low-density, low complexity UAM operations by partial automation
    - Integrated air/ground/cloud, simultaneous multiple vehicle operations, multiple foundational airspace services integrated, community acceptance data and learning

**INTERMEDIATE STATE**

- **UML-3**
  - Low density, medium complexity UAM operations by limited automation
    - Safe urban flight management systems, CNS denied, demand capacity management, contingency management

- **UML-4**
  - Medium density, medium complexity UAM operations by conditional automation
    - Complex dynamic conditions, scaled CNS solutions, weather tolerant, noise, standards complete, efficient ground operations, urban infrastructure, community acceptance

**MATURE STATE**

- **UML-5**
  - Medium density, high complexity UAM operations by high automation
    - Automated air/ground operations, automation on-demand services and infrastructure, stable policy and regulatory environment

- **UML-6**
  - High density, high complexity UAM Operations by full automation
    - Ecosystem-wide multi-modal autonomy, extensive infrastructure, high production manufacturing, public acceptance and benefit
Urban Air Mobility
NASA Strategic Overview

- **Airspace Operations Capabilities**: Leverage UTM and ATM experience to enable UAM requirements for airspace management systems that enable autonomy.

- **Aircraft Technology & Methods**: Develop research and technology products on key challenges (autonomy, safety, noise, adverse weather operations etc.).

- **Partnerships and Standards**: Establish robust private partnership (PPP) model to develop and V&V critical industry standards and policy.

- **UAM Grand Challenge**: UAM community participants address ecosystem wide safety and integration barriers in a robust and relevant environment.

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**UAM Community Participants**

- Address ecosystem wide safety and integration barriers in a robust and relevant environment.

- Establish robust private partnership (PPP) model to develop and V&V critical industry standards and policy.

- Develop research and technology products on key challenges (autonomy, safety, noise, adverse weather operations etc.).

- Leverage UTM and ATM experience to enable UAM requirements for airspace management systems that enable autonomy.
UAM Maturity Levels (UML)

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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, 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 with icons and text]
2020 Grand Challenge (GC-1) Overview

Vehicles
functional UAM vehicles with threshold level of demonstrated airworthiness

NASA Systems & Interfaces
ATM-X UAM ATM, “Testbed/LVC”

Airspace Management
airspace and air traffic management technologies and services (FAA ATM + UTM) 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

**Safety and Integration Scenarios**

**Stakeholder Integration**
Grand Challenge Test Scenarios

**Design Readiness**
- Human Autonomy Teaming
- Scalability
- Sense and Avoid
- Full Autonomy
- Cabin Acceptability
- Automatic Recovery
- Crashworthiness
- Security
- Noise
- Others...
- Full Autonomy
- Pre-Qualification @ participant location

**Benchmark Testing**
- Simple Failure & contingencies
- Scheduling & Trajectory Performance
- CNS Denied Environment
- Vehicle & ATM Interoperability
- UAM Ports and Approaches
- Noise
- Benchmark Testing
- Simple Failure & contingencies

**GC2020 Scenarios**
- 1-V: Simple Failure & contingencies
- 2-V: Scheduling & Trajectory Performance
- 0-V: CNS Denied Environment
- 0-A: Vehicle & ATM Interoperability
- 1-A: UAM Ports and Approaches
- 2-A: Benchmark Testing

**GC Series Scenarios**
- A: Airspace
- V: Vehicle

**GC2020 Design Data**
- ICD Design Data

Pre-Qualification @ participant location
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

How do the components Grand Challenge provide benefit to each?

- **Supporting infrastructure** - Infrastructure elements such as vertiports and charging stations could be provided by partners.
- **Public acceptance** – GC will have a large public outreach campaign associated with it. Live events on “day of” are being considered. Opportunities to perform in local communities via ranges and Test Sites.
- **Operational integration** – smart city initiatives, multi-modal, etc. as part of Grand Challenge Series.
- **Standards organizations** - strategic partnership with standards and operational organizations for vehicles, airspace, vertiports, noise, vertiport design, fire codes.
- **Regulatory environments**, including Local government – 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.
The UAM industry needs a large pool of data in order to establish safety standards, and the Grand Challenge can be an effective option for generating this data for key components.

Specific attributable proprietary information would be protected, but the aggregated data may be pooled and leveraged to develop clear industry-wide safety standards.

Discussion topics:

- What potential concerns might industry have over a model like this?
- How can we best address those concerns, while still meeting our safety data objectives?
GC Path Forward

• Communicating and Coordinating with Industry and stakeholders
  – Request for Information (RFI) – Coordinating draft, release date anticipated for late August / early September 2018
  – Industry Nov 1, TBD Location (likely Seattle) - public notice to be released soon
  – Both will be opportunities to receive input on the scenarios NASA plans to focus on, and how they are implemented

• GC-1 Acquisition / participant agreements
  – Feb/Mar 2019 target date for GC public notice release
  – Jun/Jul 2019 for signed template Space Act Agreement’s with participant pool

• GC-1 Execution
  – 2019 NASA interfaces (i.e. range, UAM ATM via ATM-X Project, Testbed, etc) Planning and Development
  – Mid 2020 GC dry run (possibly find an anchor partner?)
  – Late 2020 GC Execution

• “A series of challenges”
  – Continue assessing interest of community and begin planning for future challenges