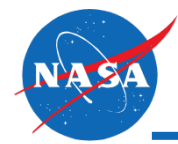




NASA Urban Air Mobility (UAM) Strategy Update ARTR

September 25, 2018

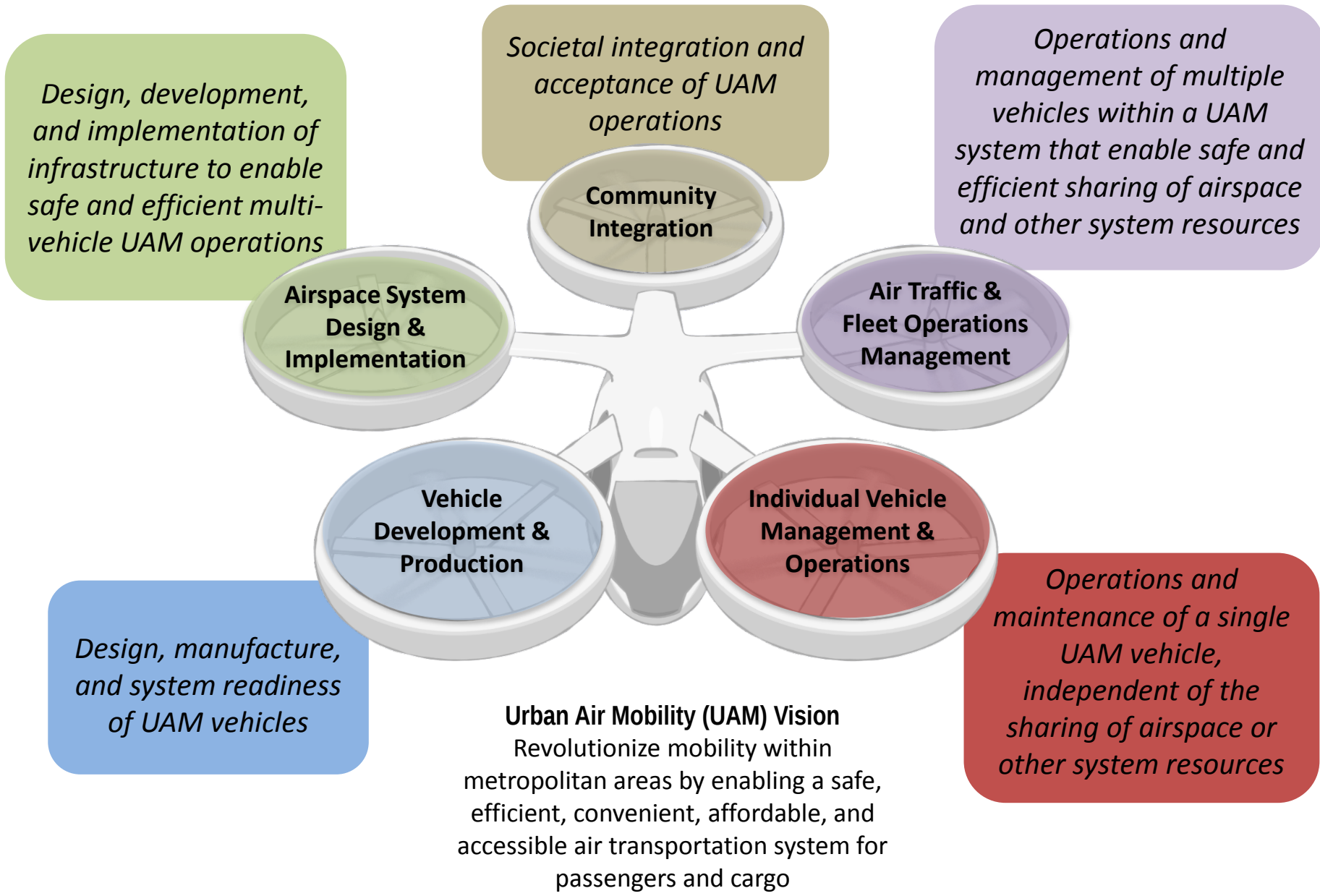


Introduction

- 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

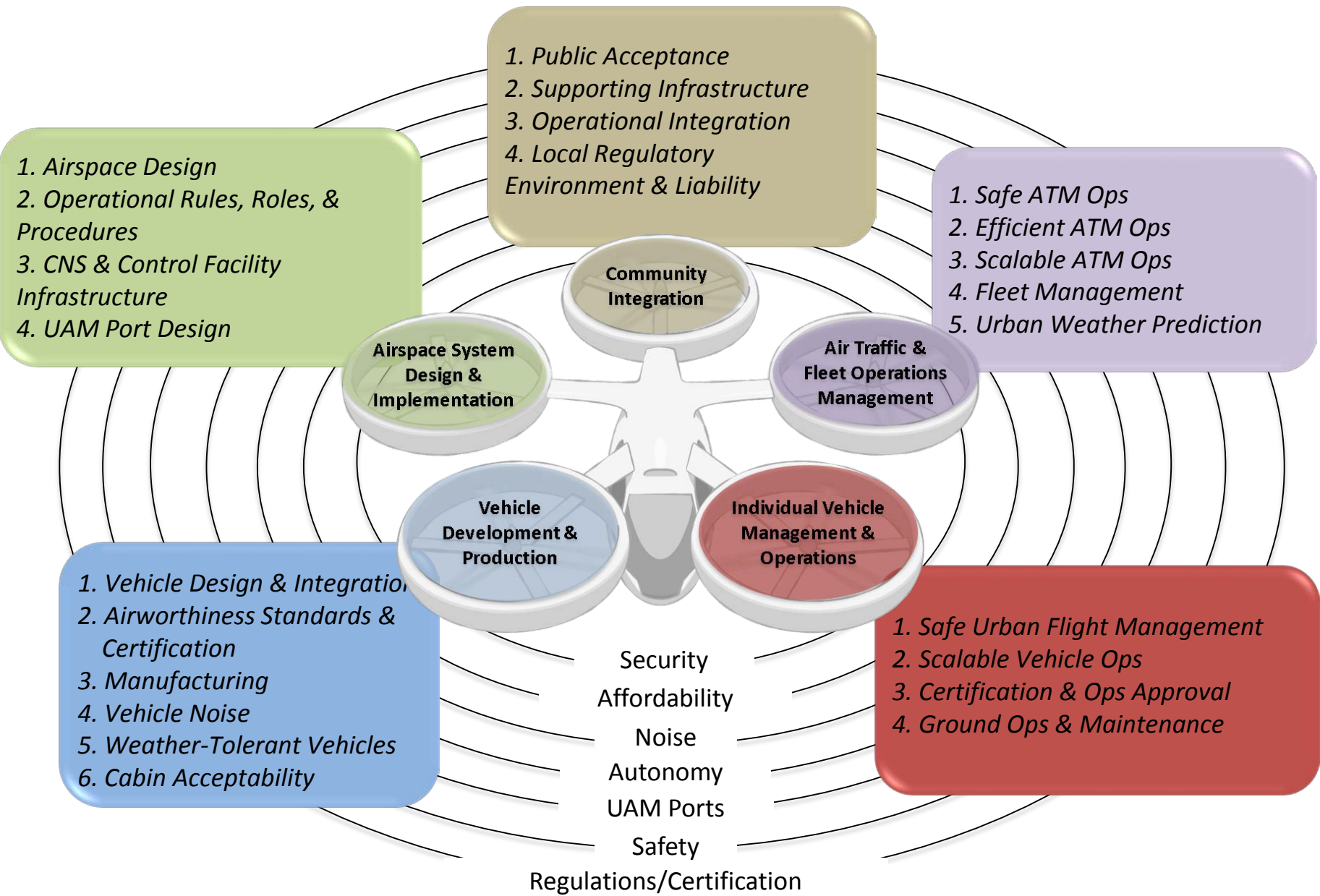


UAM Vision and Framework





UAM Framework and Barriers



UAM Reference Missions

Non-Passenger Carrying Reference Missions



INITIAL STATE



INTERMEDIATE STATE



MATURE STATE

Passenger Carrying Reference Missions



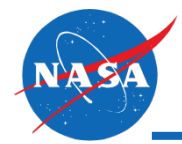


Community Landscape - Passenger Carrying Focus

Vehicle Development & Production	Individual Vehicle Management & Operations	Airspace System Design & Implementation	Air Traffic & Fleet Operations Management	Community Integration	
				Local	National/International
Government: FAA/AIR, DoD Standards: ASTM, RTCA, SAE, EUROCAE, ICAO Aircraft Developers - AirspaceX/Mobi - Amazon prime air - Apex Unmanned - Bell Helicopter - Boeing/Aurora RW - Elroy Air - Google X - Intel ventures - Joby – S4 - Karmen.Aero - Kittyhawk/Zee Aero - Cora - Matternet - Opener - BlackFly - Sikorsky - Trimble - Trumbull Unmanned - Workhorse/Surefly - Zipline - A3 (F) - eHang (F) - Embraer (F) - Lilium (F) - Pipistrel (F) - Rolls-Royce (F) - Terafugia (F) - Vimana (F) - Volocopter/Intel (F) Subsystems: Airframe & Propulsion - Emrax - ES Aero - GE - LaunchPoint - MAGicALL - Thin Gap - Rolls Royce (F) - Siemens (F) - Safan (F) Manufacturing - Ford - GM - Chrysler (F) - Honda (F) - Nissan (F) - Siemens (F) - Toyota (F)	Government: FAA/AIR/AFS Standards: ASTM, RTCA, SAE, EUROCAE, ICAO Integrated Automation & Aircraft Operations - Bell Helicopter - Boeing/Aurora RW - Joby - Kittyhawk - Sikorsky - Uber - A3 (F) - Terafugia (F) (Note, majority of vehicle developers are pursuing some level of IVMO and may be partnership candidates. Full list of developers is not repeated here. Above companies tend to be most active in eVTOL community) Subsystems: Flight Automation - Aspen Avionics - Avidyne Corporation - Dynon Avionics - Echodyne - Garmin - GE Aviation Systems - Genesys Aerosystems - Honeywell/Bendix King - Iris Automation - Near Earth Autonomy - Rockwell Collins - Sandel Avionics - TruTrak Flight Systems - UTRC - BAE (F)	Government: FAA/AIR/ATO Standards: RTCA, ICAO Airspace Design - A6I - Airmap - ANRA - GE/Airxos - Harris - Lockheed - M2C Aerospace - Metron - Skyward - A3 (F) Flight Procedures Development - Hughes Aerospace - Jeppesen - Global Airspace Solutions (F) Vertiport Design - Blade Helicopter NM - Burns and McDonnell - HeliExperts - Near earth autonomy - Uber Elevate Subsystems: CNS - ARINC - Fortem - Gogo - Gryphon sensors/SRC - Higher ground - NextNav - Primal Systems - R3 - Raytheon - SmartSky - Skyward - UTRC - Verizon - XWing	Government: FAA/ATO, DoD, DHS Standards: RTCA, ICAO ATM Suppliers - GE/AIROXS - Harris - Jet Blue Technology Ventures - Lockheed - M2C Aerospace - Microsoft - NeXt (Boeing)/SparkCognition - Raytheon USS Providers - Analytical Graphics Inc. (OneSky) - Climacell - GE/AirXOS - GE non-AirXos - Raytheon - Rockwell - Simulzye - TruWeather - Uber Elevate - UTRC - UAS Sidekick - WSI - XM WX ATM Automation Development - Metron Fleet Operations - Analytical Graphics Inc - Amazon Prime Air - Blade Helicopter - Boeing/Horizon X - Boeing/Jeppesen - FexEx - Uber Elevate - A3/Vahana (F) Airspace Test Sites - Choctaw Nation - FAA Test Sites - Alaska, North Dakota, Nevada, New Mexico, New York, Texas, Virginia	Decision Makers - City of San Diego - Choctaw - National League of Cities (2000+ 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) Influencers - Chambers of Commerce - Eurocontrol (Europe) - FAA/IPP - Choctaw, San Diego, IEIA (VA), KS DoT, Ft Myers (FL), Memphis Airport (TN), NC DoT, ND DoT, Reno (NV), UAF (Fairbanks, AK) - NUAIR Alliance (NY) - Uber Incubators - Defense Innovation Experimental (DUIx) - Starburst	Decision Makers - US Congress - DOT/FAA – AIR, AFS, ATO - DOC/NTIA (public/federal spectrum) - FCC (commercial spectrum) - DHS - DOJ/FBI 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) Influencers (Domestic) - American Association of Airport Executives (AAAE) - American Institute of Aeronautics and Astronautics (AIAA) - Aircraft Owners and Pilots Assoc (AOPA) - Commercial Drone Alliance - Coalition of UAS Professionals - Environmental Groups (e.g. Sierra Club) - Experimental Aircraft Association (EAA) - NASA - National Academies-Transportation Research Board - National Institutes of Standards and Technologies (NIST)/Smart Cities - National Transportation Safety Board (NTSB) - Vertical Flight Society (AHS) Influencers (International) - Airports Council International (ACI) - Association for Unmanned Vehicle Systems International (AUUSI) - 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)

(F) – Foreign
(I) - International

Incomplete list of Stakeholders



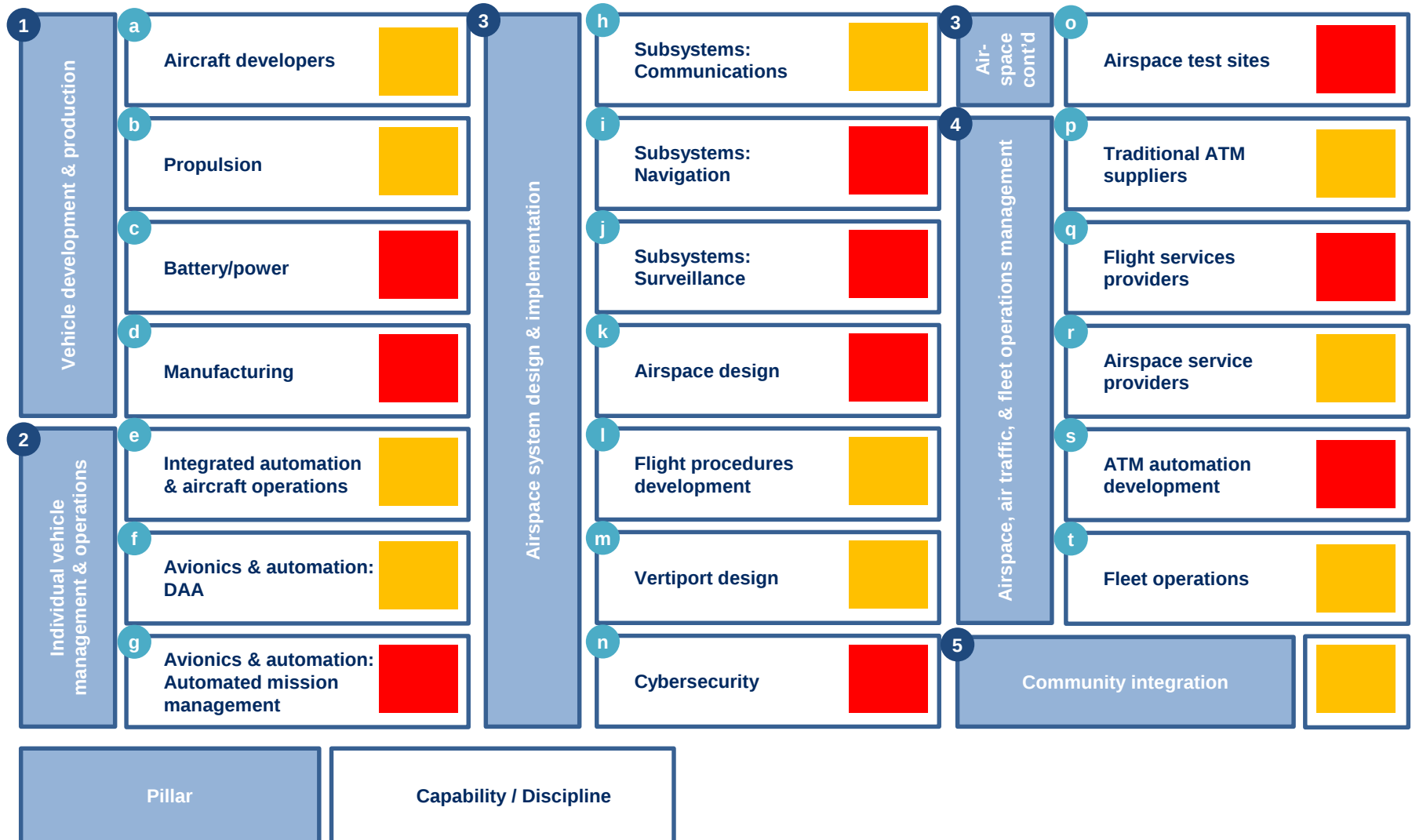
UAM State of the Art Assessment

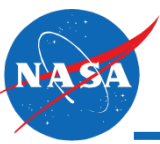
Intermediate State

Preliminary Draft

REFERENCE MISSION TWO – PASSENGER-CARRYING

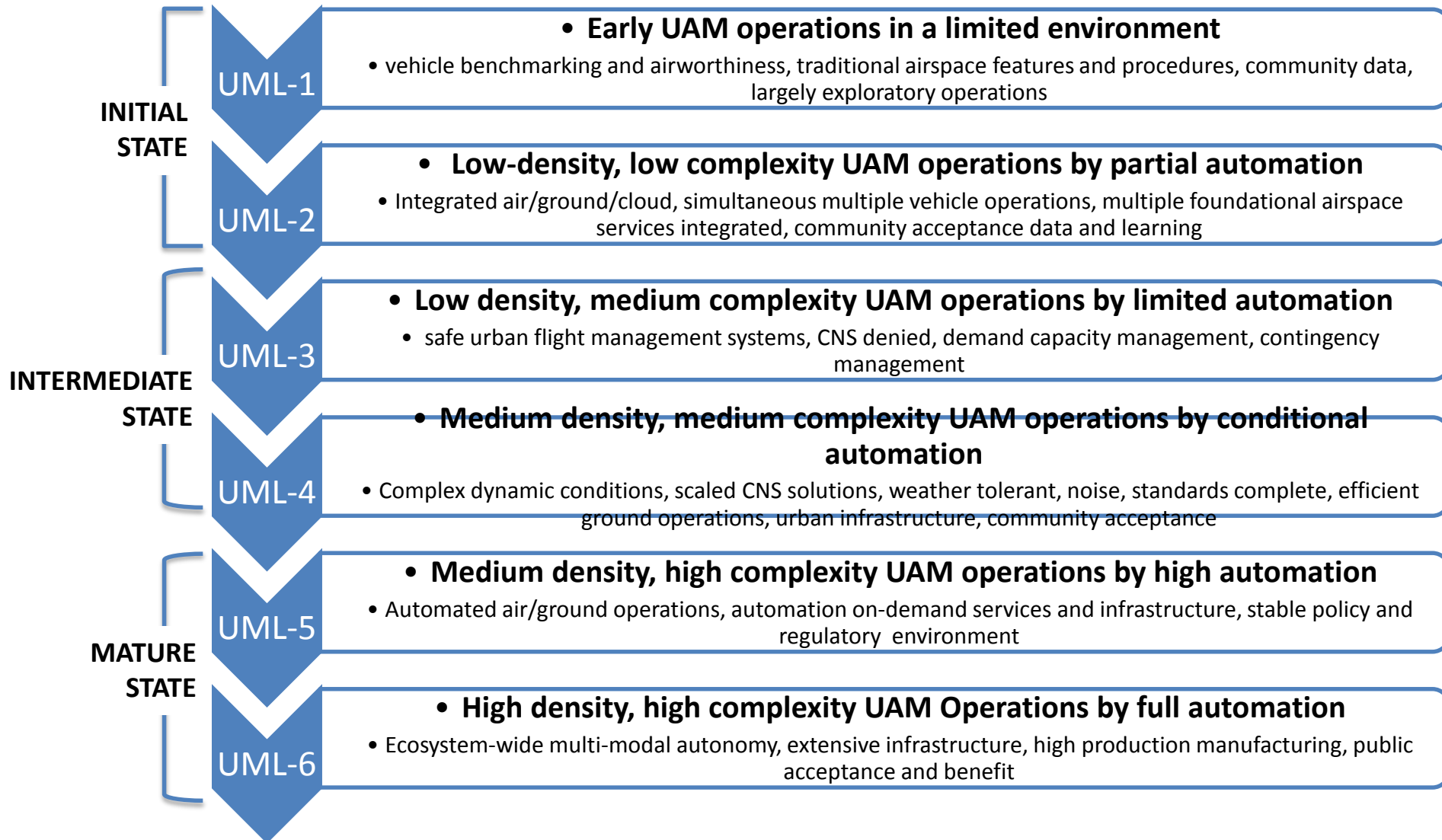
High maturity Medium maturity Low maturity

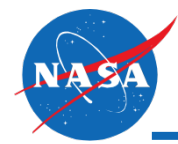




UAM Maturity Levels (UML)

Draft





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

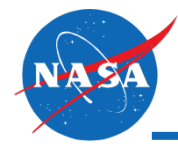
UAM community participants address ecosystem wide safety and integration barriers in a robust and relevant environment





NASA Urban Air Mobility (UAM) Grand Challenge Strategy Update ARTR

September 25, 2018



UAM Maturity Levels (UML)

Draft

Grand Challenge Participants

Vehicles

Airspace

Community

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

UML-3

- **Low density, medium complexity UAM operations by limited automation**

- safe urban flight management systems, CNS denied, demand capacity management, contingency management

INTERMEDIATE
STATE

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

UML-5

- **Medium density, high complexity UAM operations by high automation**

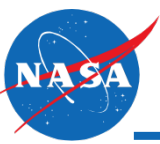
- Automated air/ground operations, automation on-demand services and infrastructure, stable policy and regulatory environment

MATURE
STATE

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



Grand Challenge (GC) Series Overview

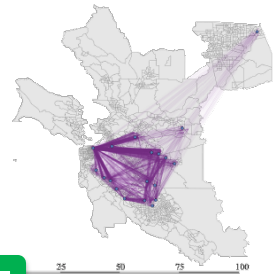
Vehicles

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



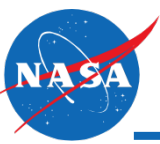
Stakeholder Integration

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

  Industry Provided

 NASA Provided

 Ecosystem Wide Support



2020 Grand Challenge (GC-1) Overview

Vehicles

functional UAM vehicles with threshold level of demonstrated airworthiness



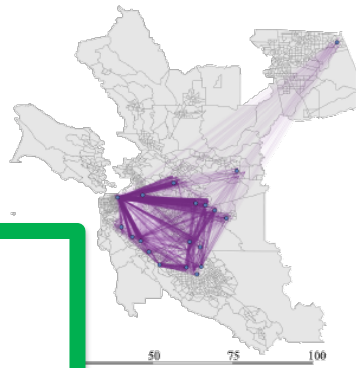
NASA Systems & Interfaces

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.



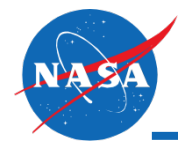
Industry Provided



NASA Provided



Ecosystem Wide Support



GC Vehicle and Airspace Management Participants

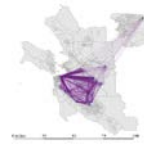
Vehicles



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



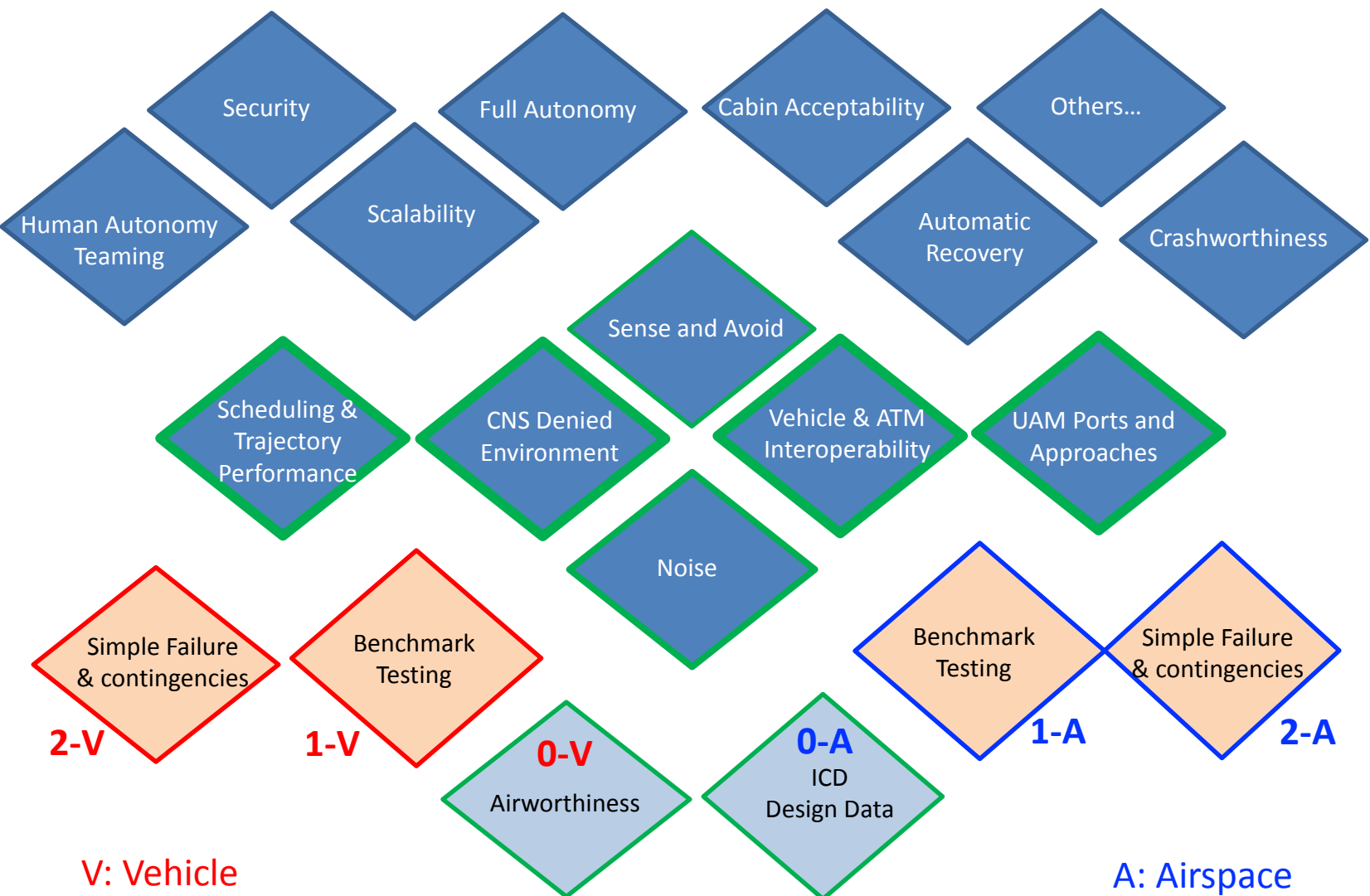
Safety and Integration Scenarios

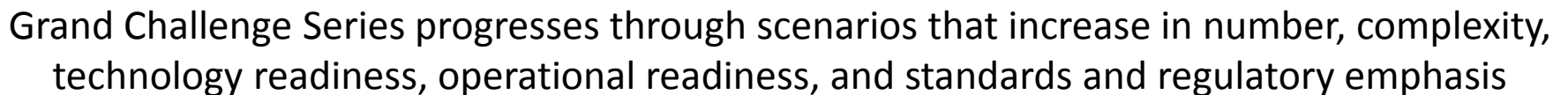
Stakeholder Integration

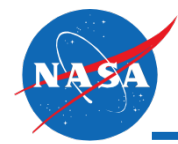


Grand Challenge Test Scenarios

Design Readiness A V Pre-Qualification @ participant location GC2020 Scenarios
GC Series Scenarios





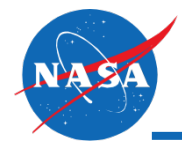


Stakeholder Integration

Societal integration and acceptance of UAM Operations including public acceptance, supporting infrastructure, operational integration, standards organizations, and the local regulatory environment

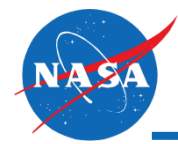
How do the components Grand Challenge provide benefit to each?

- 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



IP and Data Rights Philosophy

- 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

