Urban Air Mobility: Grand Challenge

Shivanjli Sharma

UAM Maturity Levels (UML)

GC Series Focus

UAM Framework and Barriers

Vehicles	Airspace	Community

INITIAL STATE

UML-1

Late-Stage Certification Testing and Operational Demonstrations in Limited Environments
Aircraft certification testing and operational evaluations with conforming prototypes; procedural and technology innovation supporting future airspace operations (e.g. UTM-inspired); community/market demonstrations and data collection

UML-2

Low Density and Complexity Commercial Operations with Assistive Automation
Type certified aircraft; initial Part 135 operation approvals; limited markets with favorable weather and regulation; small UAM network serving urban periphery; UTM Construct and UAM corridors supporting self-managed operations through controlled airspace

INTERMEDIATE STATE

UML-3

Low Density, Medium Complexity Operations with Comprehensive Safety Assurance Automation
Operations into urban core; operational validation of airspace, UTM inspired ATM, CNS, C^2, and automation for scalable, weather-tolerant operations; closely space UAM pads, ports; noise compatible with urban soundscape; model-local regulations

UML-4

Medium Density and Complexity Operations with Collaborative and Responsible Automated Systems
100s of simultaneous operations; expanded networks including high-capacity UAM ports; many UTM inspired ATM services available, simplified vehicle operations for credit; low-visibility operations

MATURE STATE

UML-5

High Density and Complexity Operations with Highly-Integrated Automated Networks
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

UML-6

Ubiquitous UAM Operations with System-Wide Automated Optimization
10,000s of simultaneous operations (capacity limited by physical infrastructure); ad hoc landing sites; noise compatible with suburban/rural operations; private ownership & operation models enabled; societal expectation
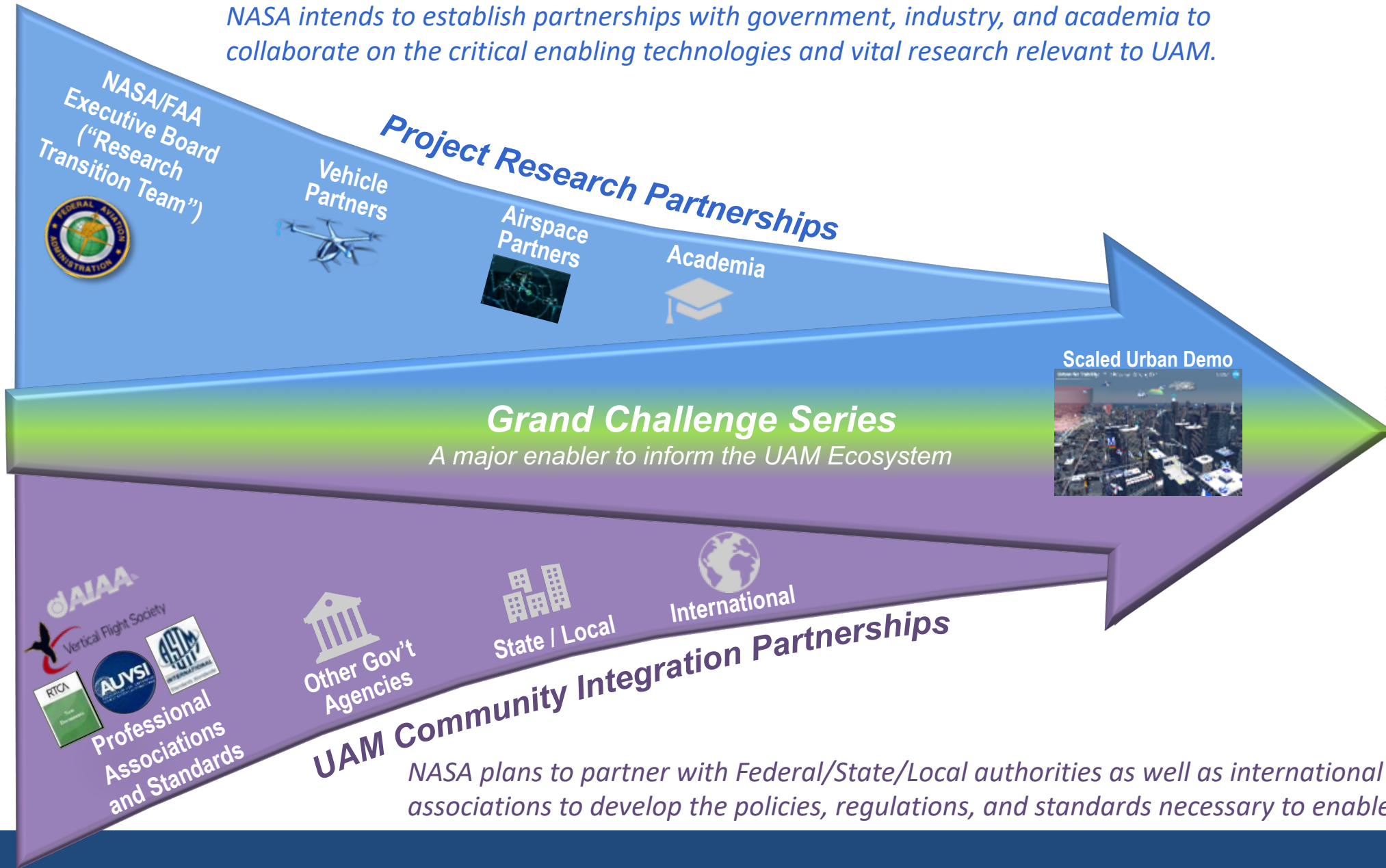
NASA UAM Ecosystem Partnership Approach

NASA intends to establish partnerships with government, industry, and academia to collaborate on the critical enabling technologies and vital research relevant to UAM.

NASA/FAA Executive Board ("Research Transition Team")

Project Research Partnerships

Vehicle Partners

Airspace Partners

Academia

Grand Challenge Series
A major enabler to inform the UAM Ecosystem

Scaled Urban Demo

Community Outcome
UML-4 Book of Requirements

Policy

Ecosystem-wide partnerships are required to enable UML-4

AIAA
Vertical Flight Society
RTCA
AUVSI
ASTM

Professional Associations and Standards

Other Gov't Agencies

State / Local

International

UAM Community Integration Partnerships

NASA plans to partner with Federal/State/Local authorities as well as international & professional associations to develop the policies, regulations, and standards necessary to enable the UAM market.

UAM GC Series support of Industry Proposed timeline

Based on a range of publicly available industry projections; not a consensus view

| 2019 | 2020 | Industry proposed UML-1 unlock 2021 | 2022 | Industry proposed UML-2 unlock 2023 | 2024 | 2025 | Industry proposed UML-3 unlock 2026 | 2027 | Industry proposed UML-4 unlock 2028 |

Grand Challenge

Developmental Testing
GC-DT

Operational Safety
GC-1

Complex Operations
GC-2

High Volume Vertiports
GC-3

Scaled Urban Demo
GC-4

Grand Challenge Series
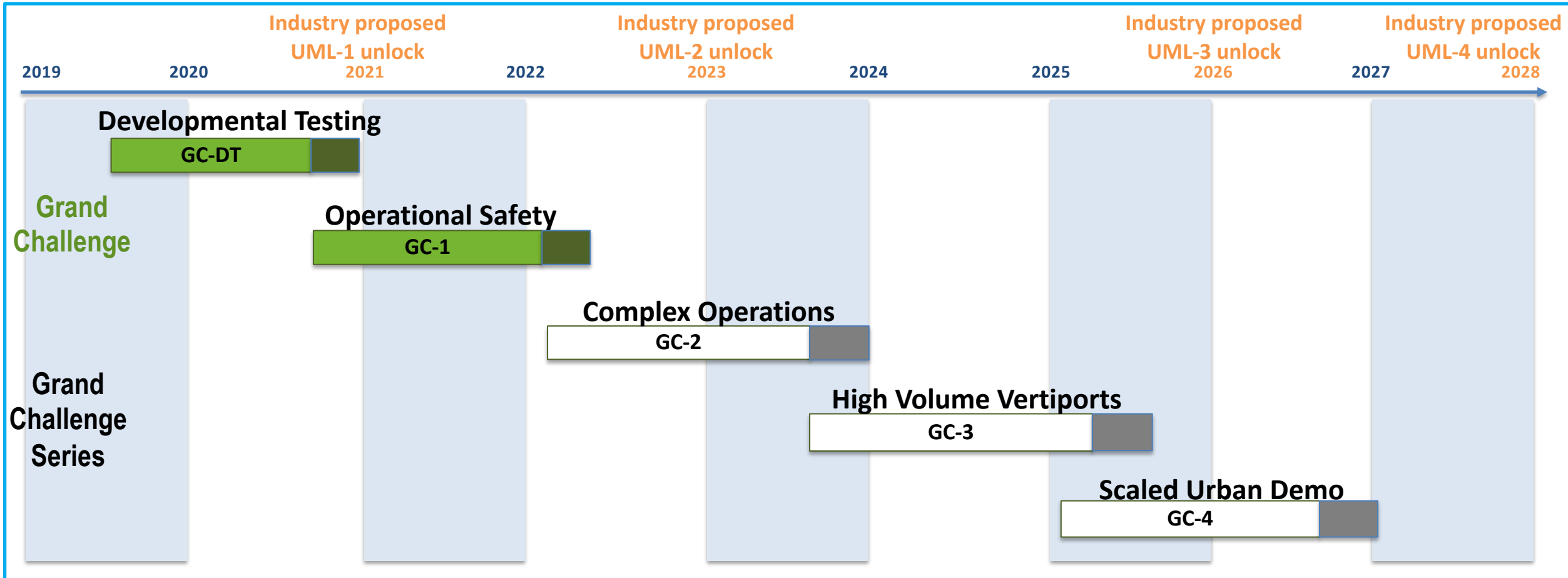
- **GC-DT and GC-1 are designed to accelerate safe operational integration concepts for UAM**
- GC Series progression defined, but intended to remain flexible/agile:
  - GC focused on achieving UML-4
  - Each GC can be an "off-ramp" to relevant UML unlocks, but GC progression is dependent on industry readiness and commitments

Grand Challenge 1 Goals & Objectives

Goal

Improve UAM safety and accelerate scalability through integrated demonstrations of candidate operational concepts provided by industry participants and scenarios representative of nominal and expected off-nominal situations

Objectives

- **Accelerate Certification and Approval.** Develop and assess an integrated approach to vehicle certification and operational approval

- **Develop Flight Procedure Guidelines.** Develop preliminary guidelines for flight procedures and related airspace design criteria

- **Evaluate the CNS Trade-Space.** Explore and evaluate communication, navigation, and surveillance requirements, options, and trade-offs

- **Demonstrate an Airspace Management Architecture.** Demonstrate and document an airspace system architecture capable of safely managing scalable UAM operations without burdening the current air traffic management system

- **Characterize Community Considerations.** Conduct initial characterization of passenger and community considerations through measurements of vehicle ground noise
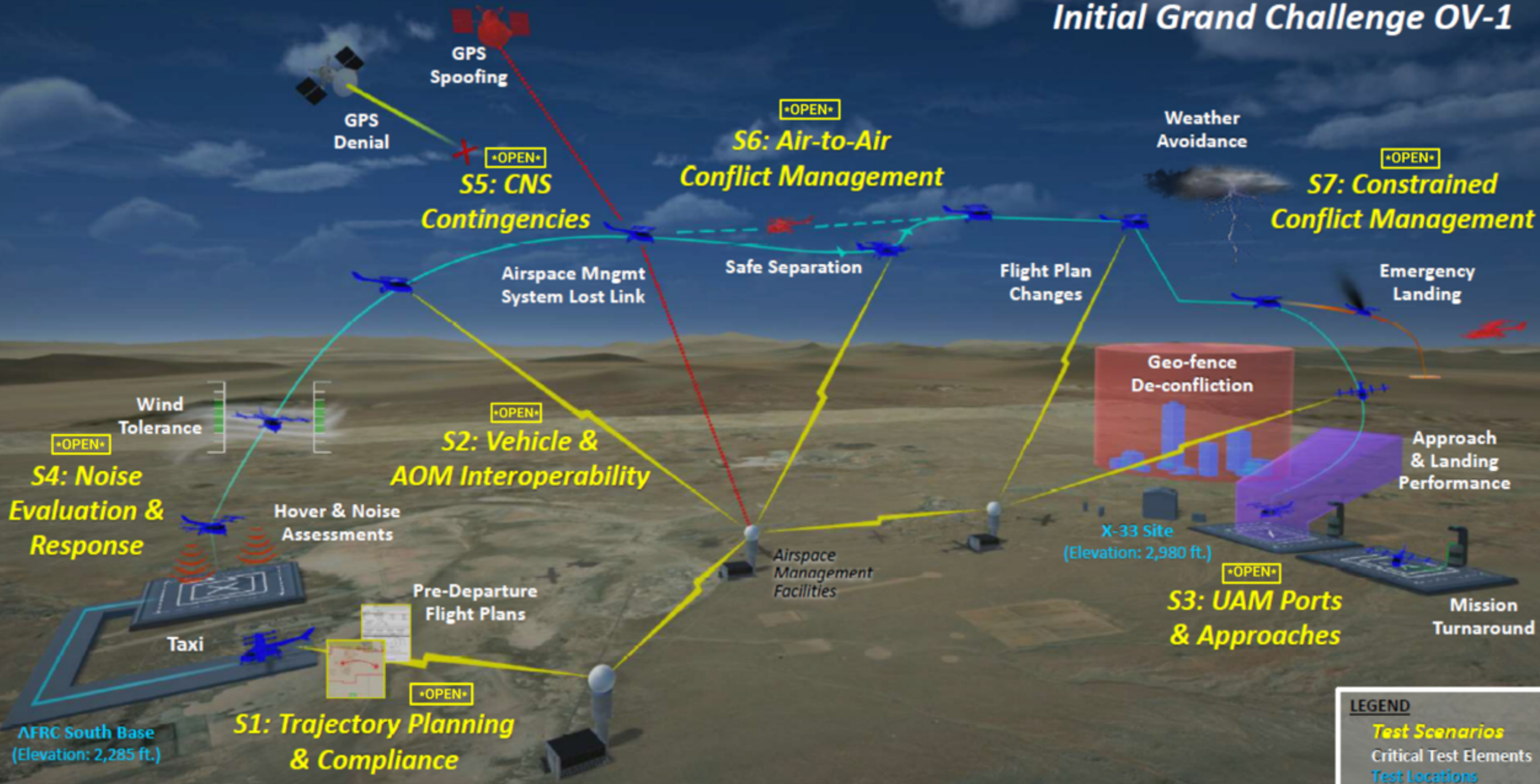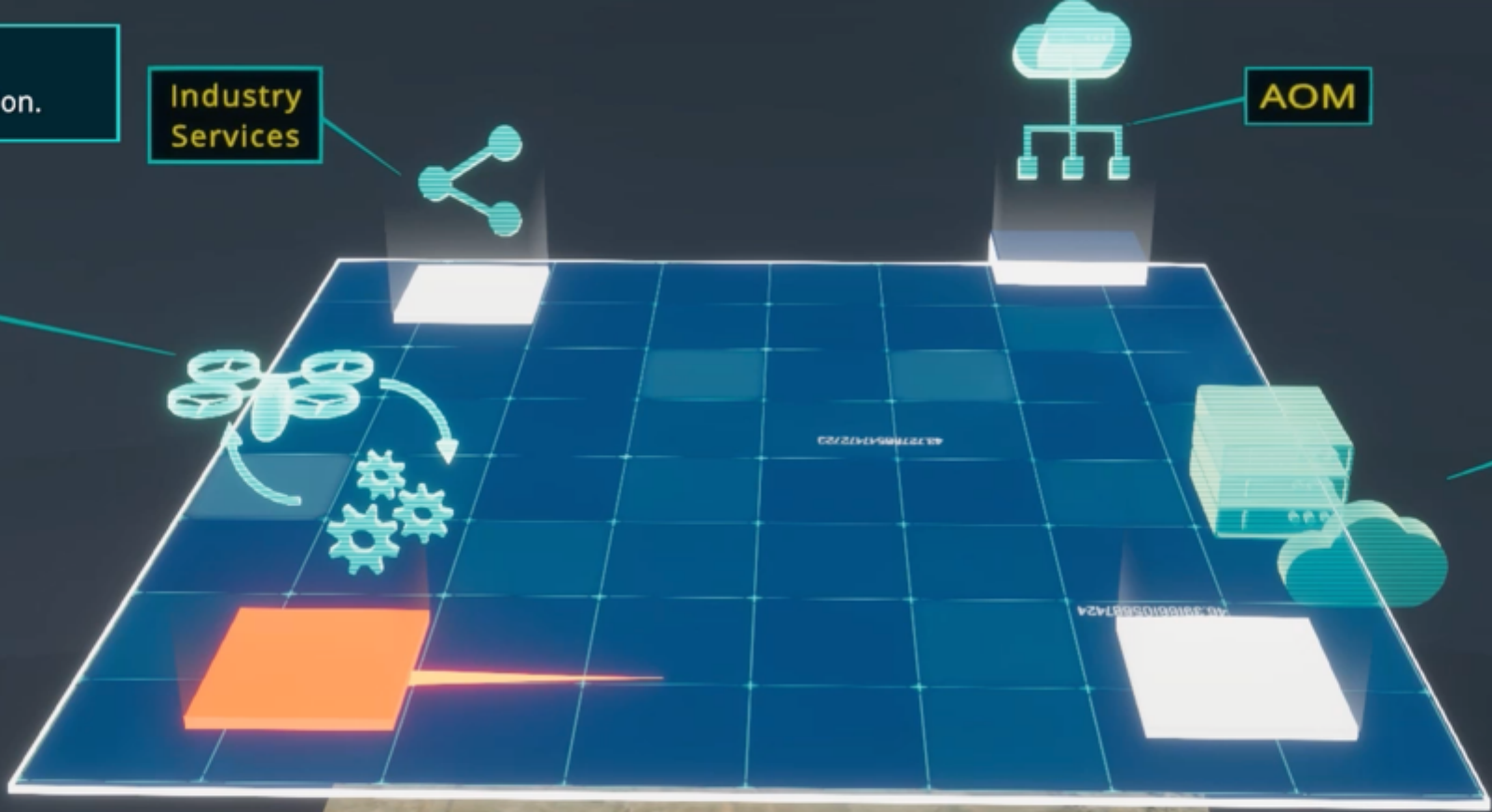
PRE-FLIGHT
Flight planning and communication.

Industry Services

AOM

USS

Discovery Service

UAM Pilot

Scenario 3:
UAM Ports and Approaches

UAM Ports & Approaches

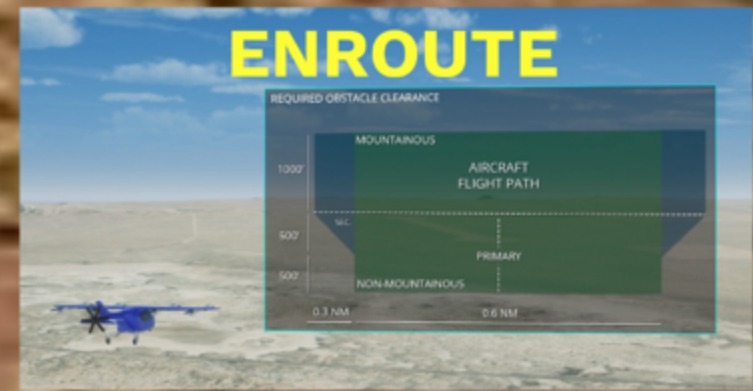**DEPARTURE**

OPEN

APPROACH

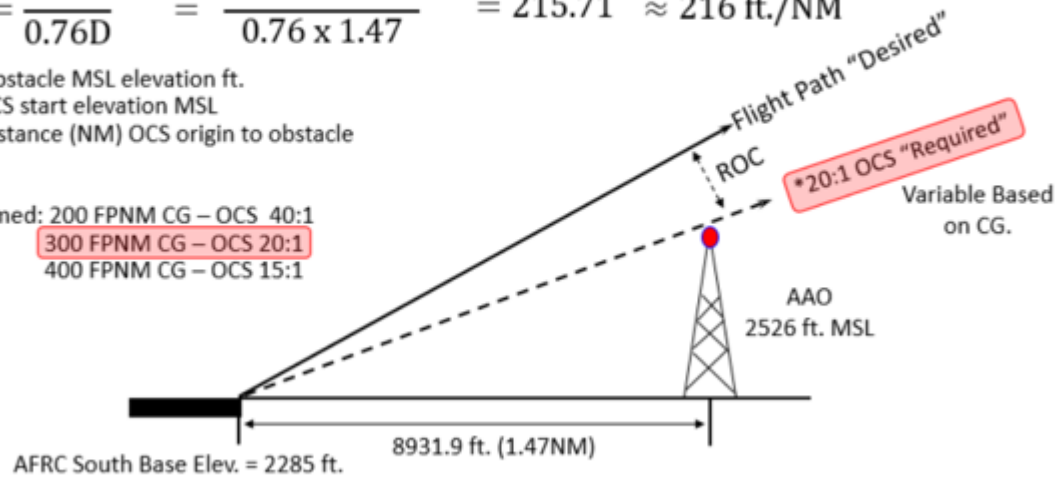*OPEN*

ENROUTE
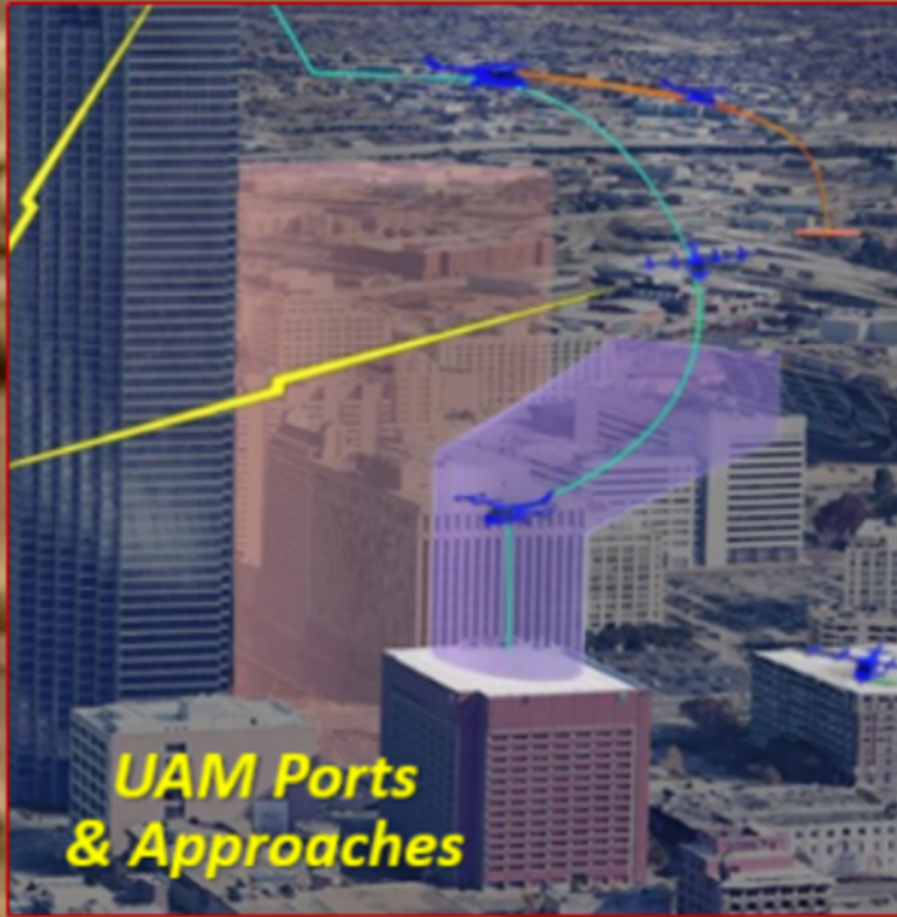
OPEN

OPEN

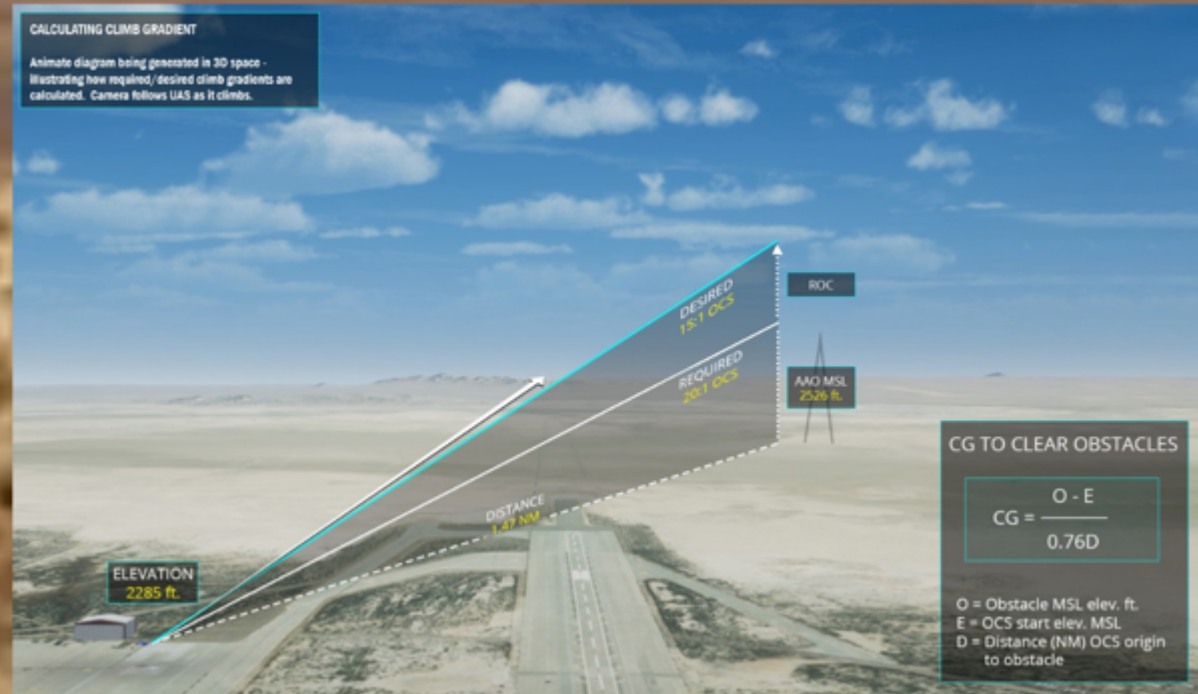$$CG = \frac{O - E}{0.76D} = \frac{2526 - 2285}{0.76 \times 1.47} = 215.71 \approx 216 \text{ ft./NM}$$

O = Obstacle MSL elevation ft.
E = OCS start elevation MSL
D = Distance (NM) OCS origin to obstacle

*Assumed: 200 FPNM CG – OCS 40:1
300 FPNM CG – OCS 20:1
400 FPNM CG – OCS 15:1

Flight Path "Desired"

ROC

*20:1 OCS "Required"   Variable Based on CG.

AAO
2526 ft. MSL

AFRC South Base Elev. = 2285 ft.

8931.9 ft. (1.47NM)

CALCULATING CLIMB GRADIENT

Animate diagram being generated in 3D space - illustrating how required/desired climb gradients are calculated. Camera follows UAS as it climbs.

ROC

DESIRED 15:1 OCS

REQUIRED 20:1 OCS

AAO MSL 2526 ft.

DISTANCE 1.47 NM

ELEVATION 2285 ft.

CG TO CLEAR OBSTACLES

$$CG = \frac{O - E}{0.76D}$$

O = Obstacle MSL elev. ft.
E = OCS start elev. MSL
D = Distance (NM) OCS origin to obstacle

FLIGHT PATH TRACKING

Show mean flight tracks that have been collected for different aircraft.

UAM 2
UAM 1

FLIGHT PATH TRACKING

Ground track overlay for all aircraft within containment area.

All mean tracks overlaid to create a vehicle agnostic containment surface

95% and 99.9% Containment with TERPS Surfaces

Longitudinal Distance to MAP (NM)
Lateral Distance to MAP (NM)

UAM 5
UAM 4
UAM 3
UAM 2
UAM 1

Task Elements are discrete test points which we will mix into the Grand Challenge Operational Scenarios

Required Performance:
- Included for NASA's consideration as a minimum entry parameter for safety of flight
- Generally is far less than what will eventually be required for FAA certification

Desired Performance:
- Denotes level of performance that are approaching levels likely* required to gain FAA certification
  - *The FAA has not yet decided on applicable regulations nor minimum design standards for this emerging class of aircraft
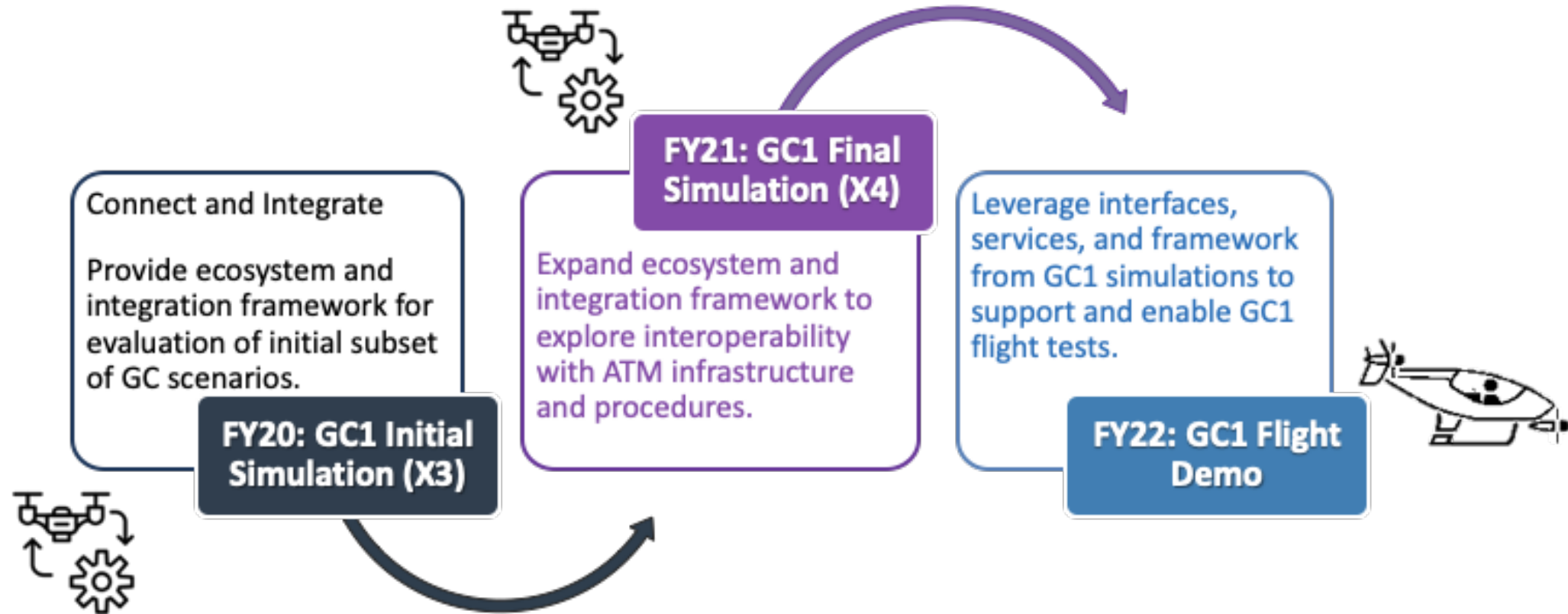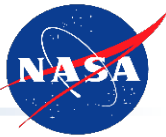- Similar performance level to conventional fixed or rotary wing aircraft

All Azimuth
Taxi
Takeoff Performance
Level Flight Decel/Accel
Flight Path ChangesSteep Turns, Pull Up, Push Over
Approach/Landing
Land-Quick Charge-TO
Energy Storage/Reserves
Function & Reliability
Precautionary landing
Balked Landing
Takeoff Failure Case
Landing Failure Case

Elements are designed to shed light on operational challenges that will drive future acceptable certification standards

BACKUP

ATM-X's Role in Grand Challenge

Connect and Integrate

Provide ecosystem and integration framework for evaluation of initial subset of GC scenarios.

FY20: GC1 Initial Simulation (X3)

FY21: GC1 Final Simulation (X4)

Expand ecosystem and integration framework to explore interoperability with ATM infrastructure and procedures.

Leverage interfaces, services, and framework from GC1 simulations to support and enable GC1 flight tests.

FY22: GC1 Flight Demo

Connect and Integrate
- Connectivity and sandbox sims with GC Airspace Participants using multiple GC scenarios

Prepare for Flight Test and Airspace Concepts Testing
- Implement and evaluate procedures
- Additional sims with partners and NASA as airspace partner

Vision for GC DT and X3 (FY20)

Develop ATI infrastructure and data pipeline

Dry Run at AFRC

Industry Partner

NASA

Integration with vehicle partner for flight at external range

ATMX Delivery of NUP for DT

ATI & ATMX UAM

X3: Simulation with Airspace Partners