NASA Eco-System Workshop #1
AAM National Campaign Lead
Starr Ginn

The AAM National Campaigns (NC)

Goal Ensure AAM safety and accelerate scalability through integrated demonstrations of candidate operational concepts and scenarios

Objectives

1. Accelerate Certification and Approval
2. Develop Flight Procedure Guidelines
3. Evaluate the CNS Trade-Space
4. Demonstrate an Airspace Operations Management (AOM) Architecture
5. Characterize Community Concerns

https://www.nasa.gov/aamnationalcampaign

UAM Maturity Levels (UML)

NC 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

UNLOCKING UML-4 HELPS ENABLE ‡ OTHER UAM MISSIONS

‡Enable refers to critical technologies that can be engineered to extend to other missions.

"Rural" Missions

UML-4
Wide-scale on-demand, regional air transportation network.

UML-3
Limited inter-city eCTOL networks. Limited "feeder networks" between rural areas to nearest city. Public service missions.

UML-2
Cargo delivery to/from warehouses & distribution centers in non-urban areas. Increased utility & safety of General Aviation.

Determine appropriate Controllability standards that allow for confined space operations in Urban environments

UML-1
No new commercial rural missions enabled.

Urban Missions

UML-4
Increasing network of eVTOL operations to smaller vertiports in IMC. Increase in previous missions. (e.g., early on-demand urban air taxi network, wide-scale, distributed small package delivery)

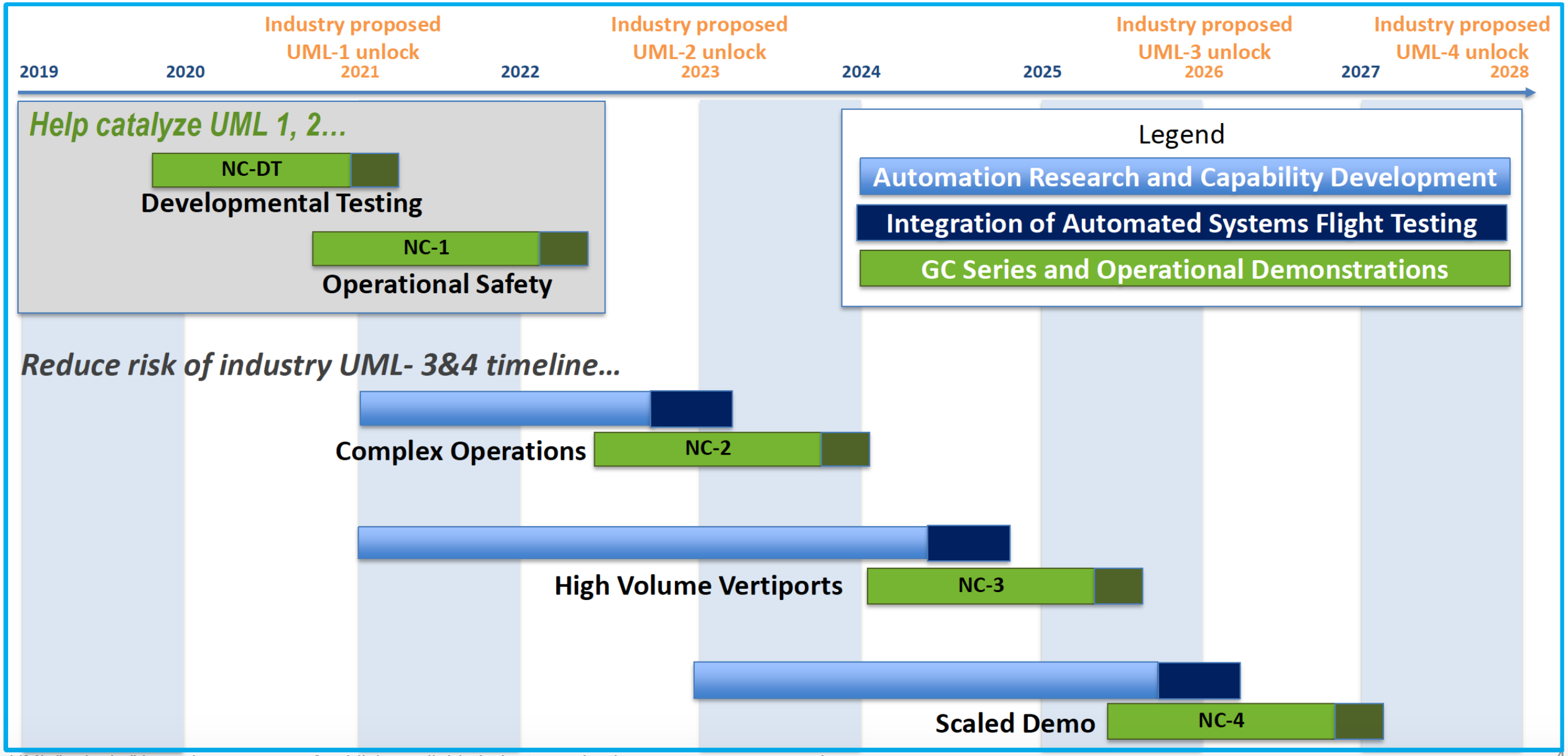
UML-3
Initial eVTOL fleet operations from urban vertiports. (e.g., airport transfer, cargo delivery, initial urban air metro); Public service missions (e.g., air ambulance, disaster relief)

UML-2
Initial, commercial UAM flights using eVTOL, eSTOL, and eCTOL aircraft. (e.g., ex-urban airport transfers, medical transport, , cross-metro transfers)

UML-1
No new commercial urban missions enabled.

Define Stability, Control and Performance standards that guarantee ability to safely fly ? degree IFR approaches to zero altitude/zero airspeed above the Touchdown Point (TDP)

NASA Research to enable National Campaigns



UML "unlocks" based on a range of publicly available industry projections; not a consensus view

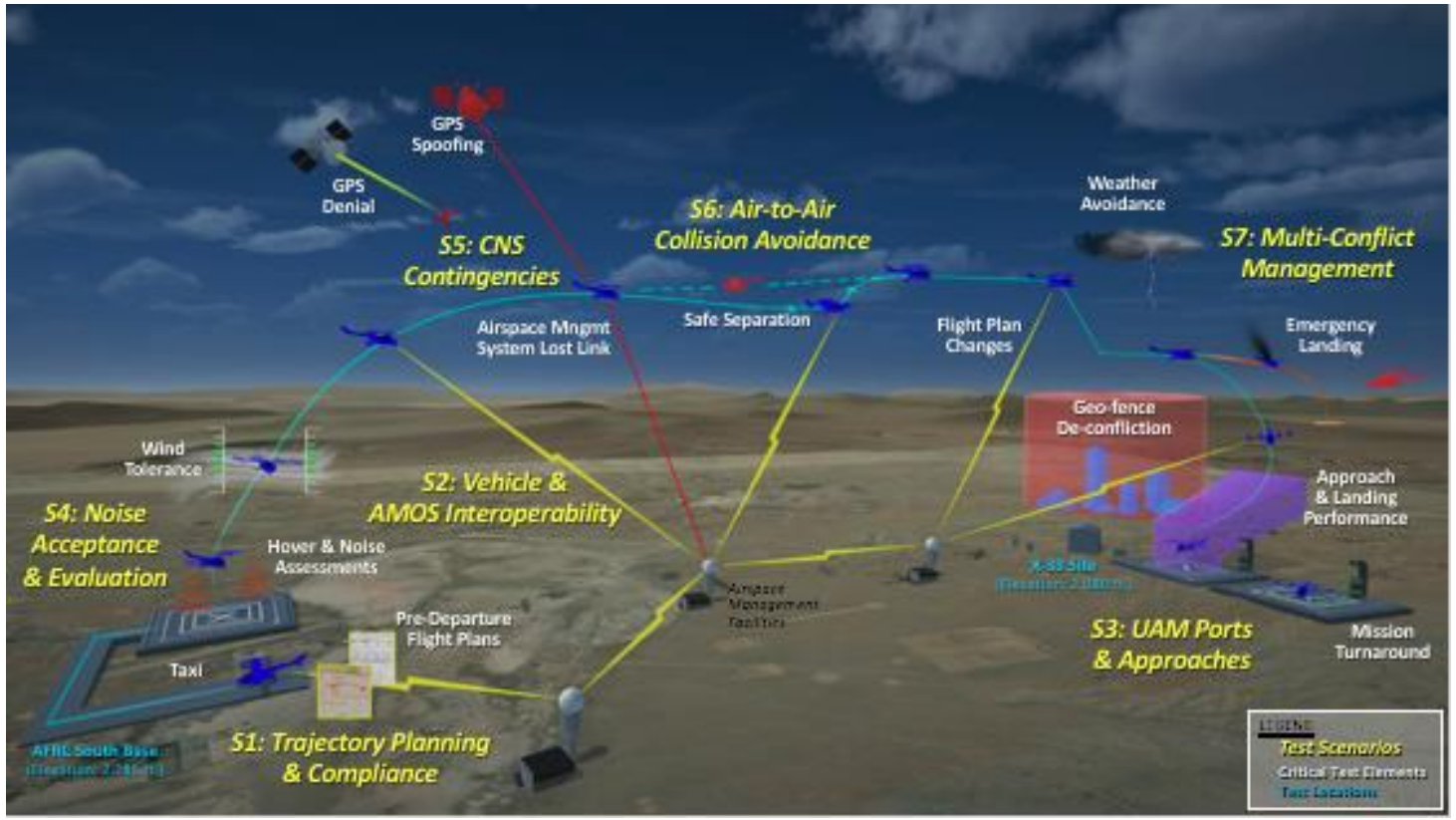
National Campaign Developmental Test

- Readiness for NASA deployment to external range(s) for NC-1
- Readiness to define impactful operationally relevant scenarios for NC-1
- Readiness to collect comprehensive data during NC-1
- Assessment of partner and community readiness to execute NC-1 testing
- Readiness of external ranges to support NC-1

National Campaign Developmental Test Flights

- Refinement of integrated operational scenarios to maximize impact on NC-1
- Dry Run to evaluate scenarios with “UTEs” representing the controls of the test and common data set in a known environment (Edwards)
- Supply early empirical data to help FAA determine how the UAM mission can be integrated into the existing NAS

- Determine network delays and vehicle measurement bias error build-up for airspace providers to update calculations for negotiations and redirecting traffic
- Airspace service providers will not be directing the aircraft trajectories



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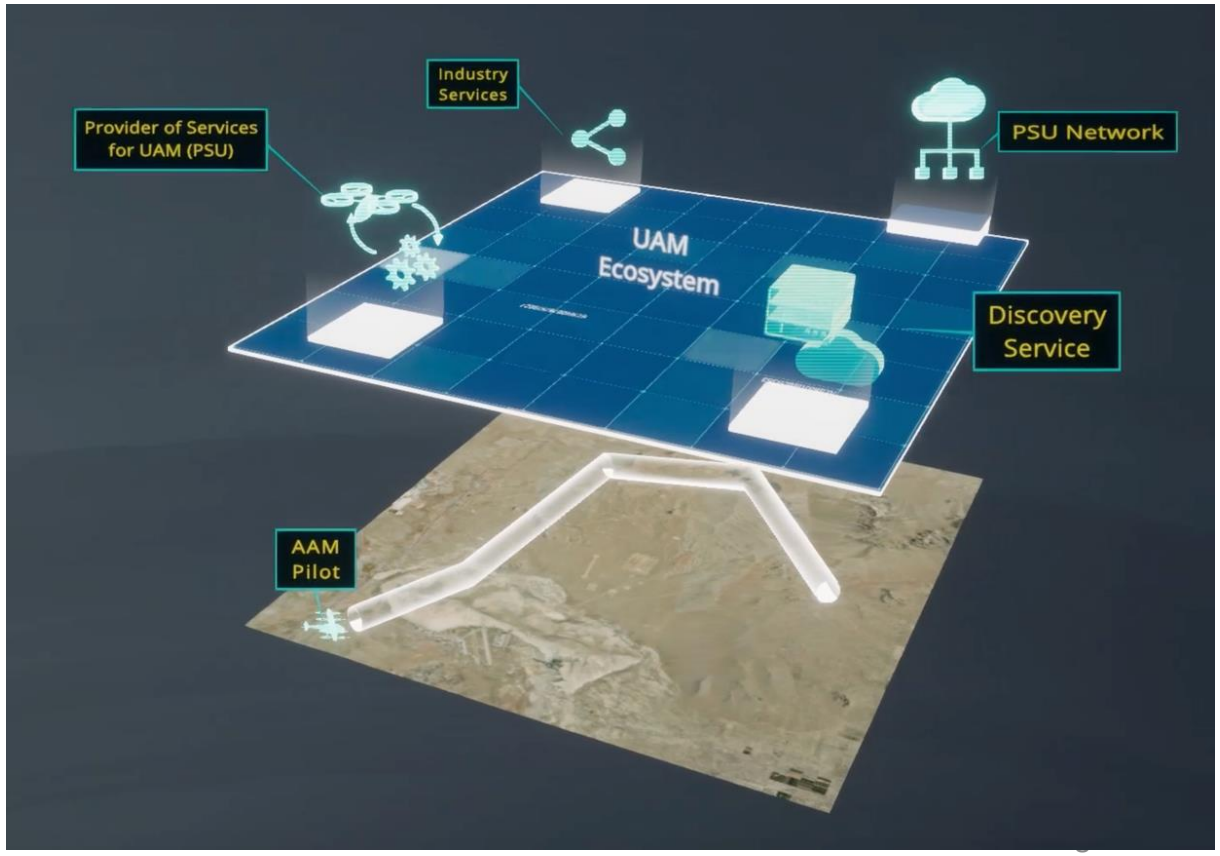
National Campaign Developmental Test Simulations

Verify participant integration compatibility with NC airspace environment

- Assessment of system connectivity, distributed latencies
- Evaluation of the airspace procedures and information exchanges to/from all stakeholders
- Assessment of format and content ingestion of airspace constraints, air traffic, and system negotiation of airspace rules and procedures

Early check against airspace services required for NC-1 scenarios

- NASA evaluation of scenario virtual components, virtual traffic density, and flight feasibility
- Demonstration of vehicle/airspace system integration in virtual and hardware in the loop environments
- Demonstration of extended UTM airspace capabilities in support of advanced NC-1 scenario requirements;
- Enable participants to prepare/develop required technologies for NC-1



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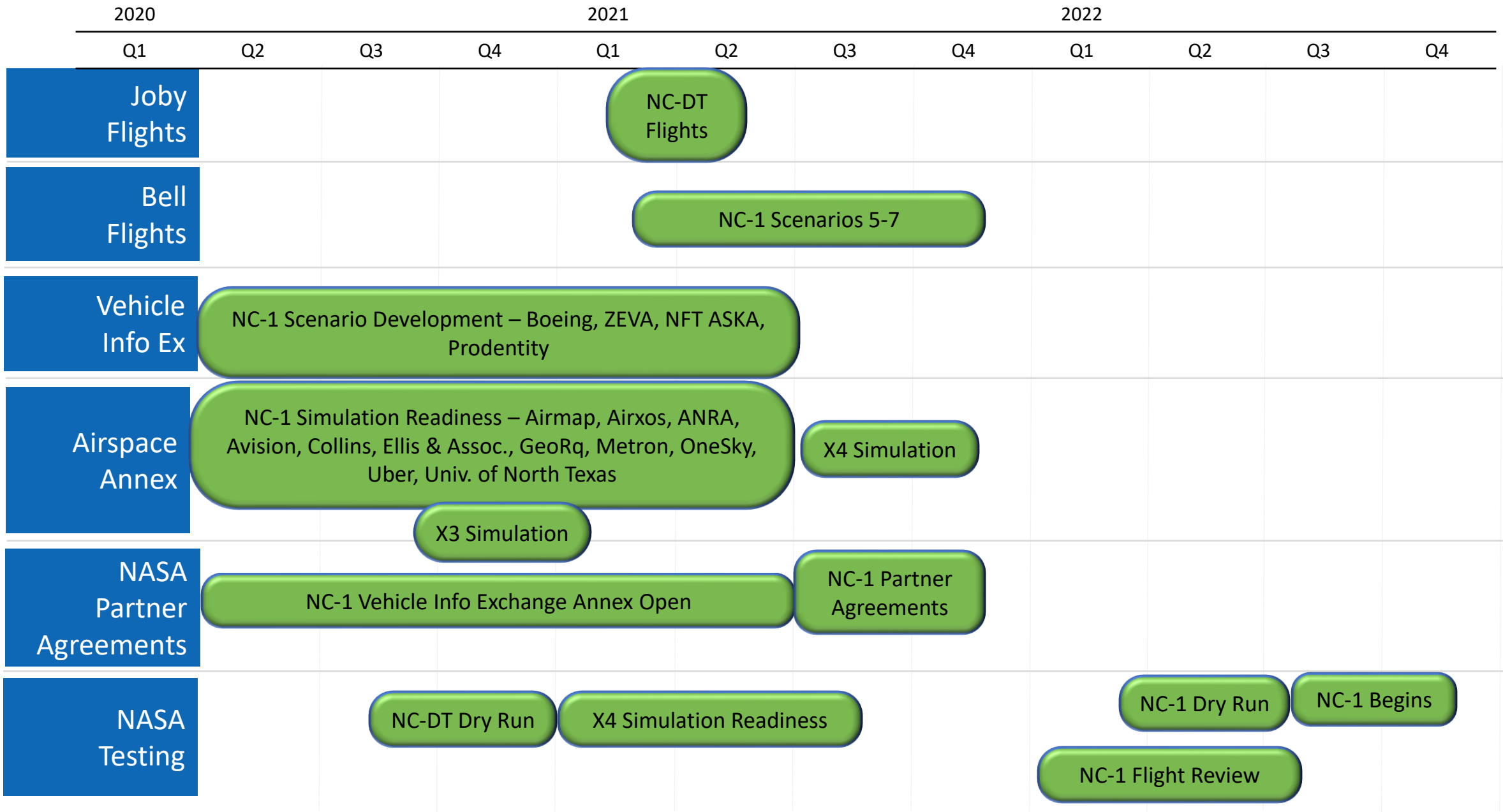
National Campaign Notional Schedule



NASA-FAA Data Elements Workbook

Track Objectives for UAM Implementation

Identify Data Attributes for Procedures

Map for Analysis to Characterize & Integrate New Entrants and Ops

Research & Analysis	Ops Concepts & Req'mts	Standards	Procedures	Airspace	Systems	Policies	Security	Oversight Processes	HR Mgmnt & Trng	Outreach & Communication	Int'l Outreach & Engagment
Airspace Research	Ops Concepts, Scenarios, & Reqmnts Development	Airworthiness Certification Standards	Air Traffic Operations Procedures	Charting	ATM/CNS Systems/Capabilities	Air Traffic Policy	Cyber Security	Auditing Air Traffic & Navigation Services	ATO Training	Aviation Industry Outreach	Harmonization w/FAA Concepts, Rules & Procedures
Capabilities & Systems Research		Pilot School Certification Standards	Pilot in Command Procedures	Facility Maps	Support Systems	CFR Rulemaking AVS 10/31/18	Physical Security	Accident/Incidenent Investigation & Reporting	Flight Standards Training	General Public Outreach	Int'l Relationship & Outreach
Policy & Regs Research		SVO Airman Certs/Quals	Flight Stds Procedures			Waivers & Exemptions	UAS Detection and Tracking		Airports Traning	Outreach & Coordination with Federal, local and Tribal Gov	Bilateral Agreements & other
Procedures Research		Flt Instr Certs/Quals	Airport Procedures			Acs & Guidance	Remote ID		Resource Management	Internal FAA Outreach	
Standards Research		Training Center Certification Standards	Manufacturers Procedures			Environmental Policies				NEPA Compliance	
Training Research		Operator Certification	Owner Procedures							Communications Management	
Aircraft Certification Research		Maintenance Standards	Security Procedures							State & Local Law Enforcement Assistance Program.	
Air Traffic Management Research		Repair Station Standards	Hazardous Materials								
Environmental Research		Mechanic/Repariman Standards									
Security Research		Maintenance School Standards									
Safety Analysis		C2 Standards									
		DAA Standards									
		Environment Standards									
		Remote ID Standards 3.2.4 P/U (6-30-20)									
		Continued Op'l Safety Standards									

ADS-B Data — Surveillance Broadcast Services Monitor (SBSM)
NextGen Enterprise Surveillance Analysis Tool (NESAT)

Field Name	Description	Precision
IntegrityAccuracyParams-NIC	Navigation Integrity Category (NIC) is reported so that surveillance applications may determine whether the reported position has an acceptable level of integrity for the intended use. The value of the NIC parameter specifies an integrity containment radius, RC. For TISB always set to 0.	<20NM to <7.5NM
	0 = unknown	
	1=< 20NM	
	2=<8NM	

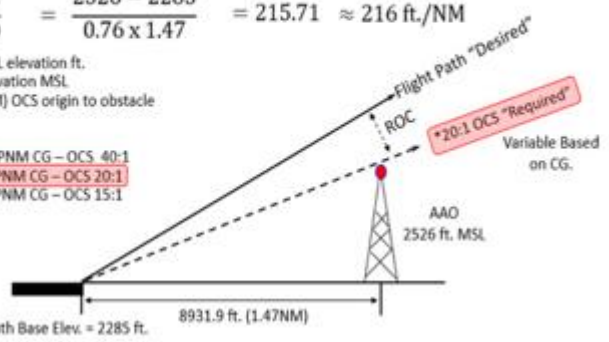
Inte
SILS

***Example:* CG to Clear Obstacles – NASA Grand Challenge**

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

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



Grand Challenge Data

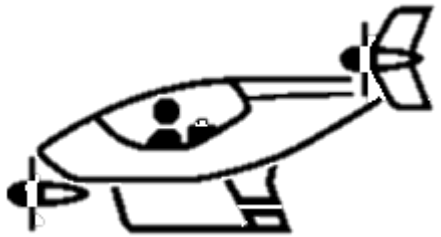
1. Operational Objectives
a. Trajectory and flight intent conformance
b. Telemetry/p
c. Takeoff and
d. Landing accu
e. Constant air
f. Operating co
i. Density altit temperatures th at TO, winds alof
g. Energy Rese
h. Time to turn
i. Operational this section
j. Maturity of from the Vehicle
i. Examples: Do Flight changes, r timelines
k. Thermal mar operationally ex
l. Maturity of Practical Procedu
m. Time to establish connection between the airspace and vehicle systems

Grand Challenge Data

2. Timeliness Objectives
a. Vehicle pre-flight
b. Vehicle taxi or tow to ramp (start of movement and conclusion of movement)
c. Vehicle power-up
d. Takeoff
e. Transition to forward flight
f. Beginning of cruise
g. Midpoint of mission
h. End of cruise
i. Transition to landing mode
j. Immediately after landing
k. Vehicle shutdown
l. Quantify time to "quick-turn" the aircraft for a new flight

Key Areas of Automation Development to Support the NC Series

PILOT

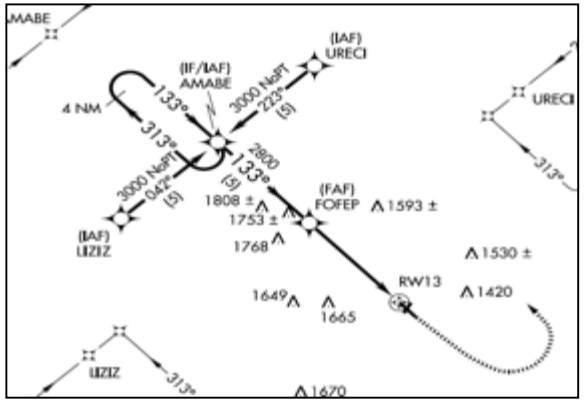


1. **Aviate**
2. **Navigate**
3. **Communicate**

CONTROLLER

1. **Locate**
2. **Separate**
3. **Communicate**

TERPSTER



1. **Populate**
2. **Evaluate**
3. **Mitigate**

Functional Decomposition of Piloting

Piloting

Aviate

- **A/C Control**
  - Stability
  - Structural limits
  - Flightpath control
  - *Stall*
  - Etc.
- **Observe Airmanship Rules**
  - Well clear
  - Minimum flight levels
  - Airspace boundaries
  - Etc.
- **Contingency Management**
  - *Tactical*
    - Air Traffic
    - Ground
    - Obstacles
    - Birds
  - *Strategic*
    - Onboard failures
    - Weather

Navigate

- **Plan Mission**
  - Interpret mission objectives
  - Path finding
  - AI
- **Follow Mission Plan**
  - Pilot commands
  - Waypoint following
  - Intelligent routing
  - Etc.
- **Coordinate Mission with other Agents**
  - Formation flying
  - Interactive re-routing
  - Surveillance/tracking
  - Etc.

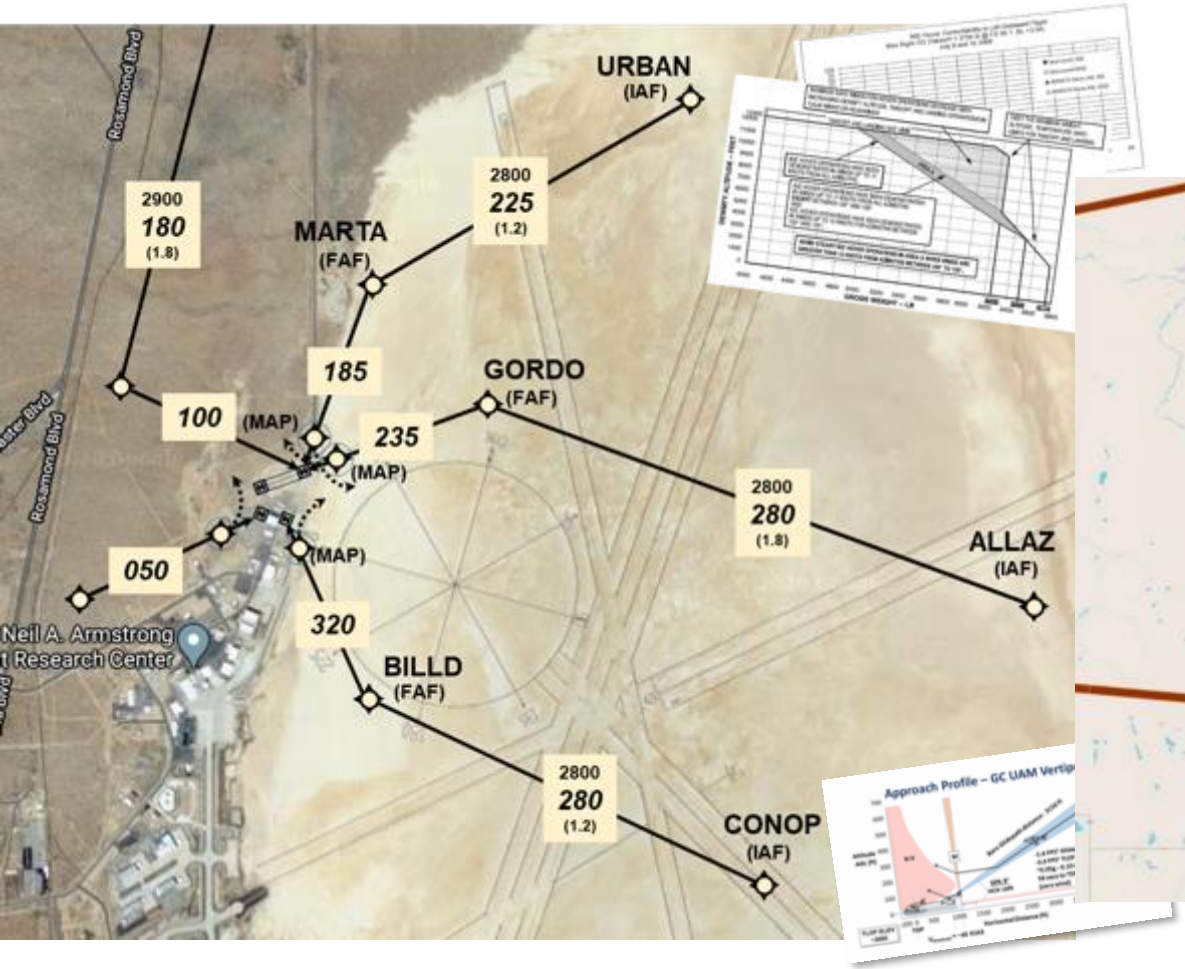
Communicate

- **Aircraft Controlling Entity**
  - Pilot in control
  - Company operations center
  - Etc.
- **Agents in Near Vicinity**
  - Nearby aircraft
  - Launch & recovery operator
  - Others?
- **Airspace Control Authority**
  - ATM
  - UTM
  - Etc.

Action in one category can initiate other functional processes

NC-1 Operational Safety & NC-2 Complex Operations

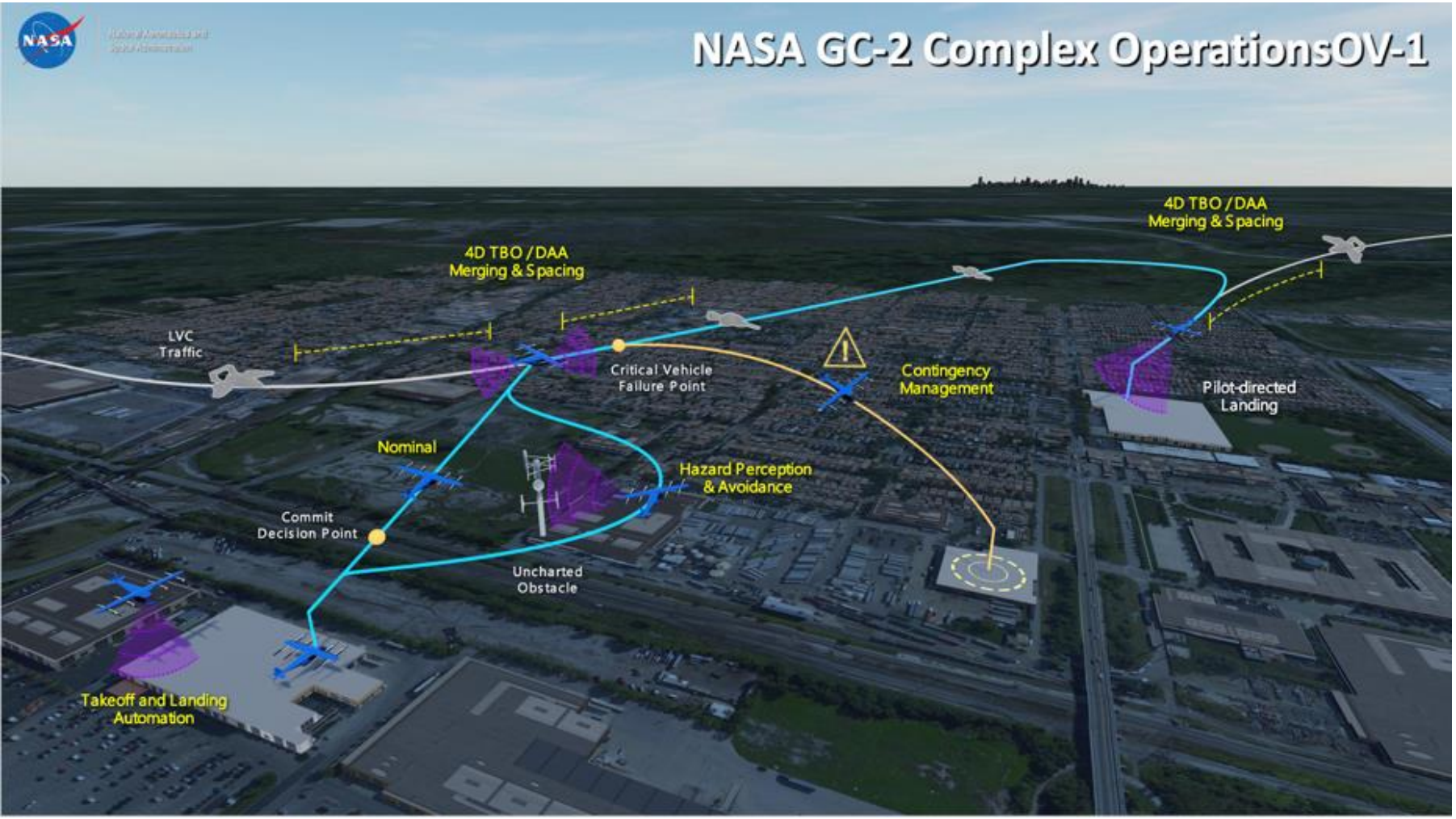
Building Blocks for the urban environment



Micro-Plex to one airport based on vehicle category

- New NextGen RNAV Arriva Procedures
- Mid View

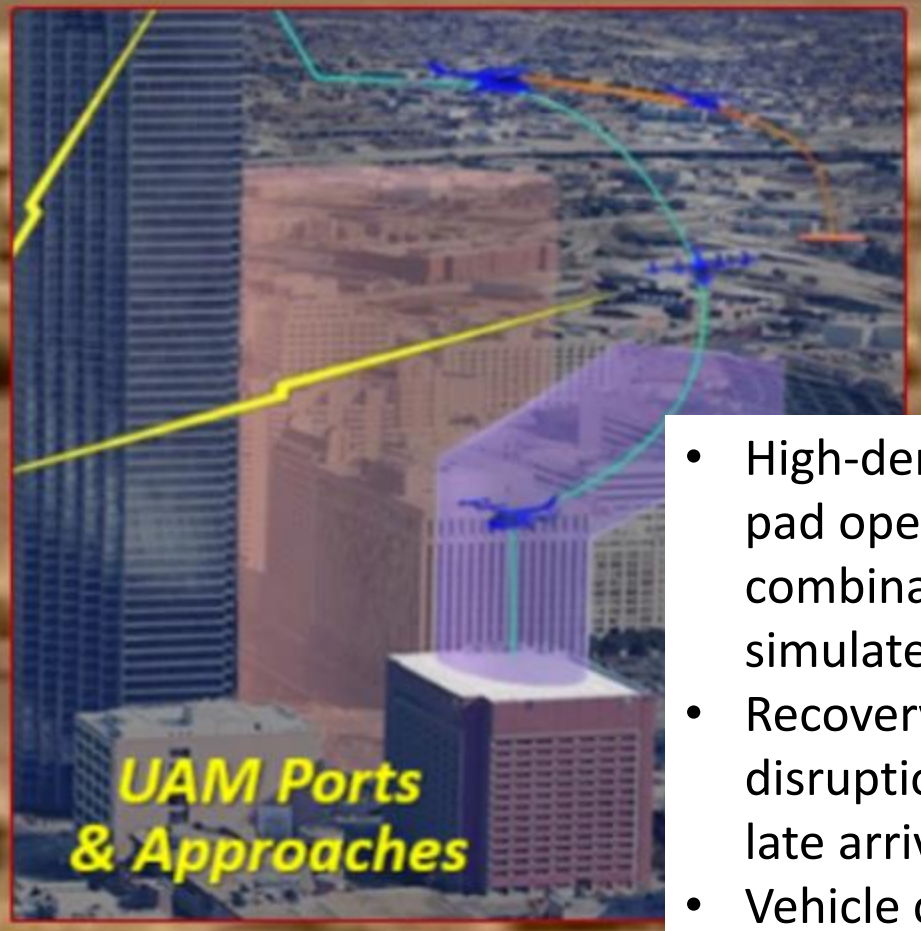
NC-1 Operational Safety & NC-2 Complex Operations



- Resilient air, ground, cloud CNSI
- UAM procedural leg library (TBO, 4D-TBO, Airborne M&S)
- Automated, arrival, approach and departure procedures
- Fail-operational, simplified vehicle controls and management
- DAA – airborne and surface hazards
- Adaptive trajectory planning and full-envelope auto-flight
- Automated contingency planning and execution

Terminal Base Operations Contingencies (Scenario 3)

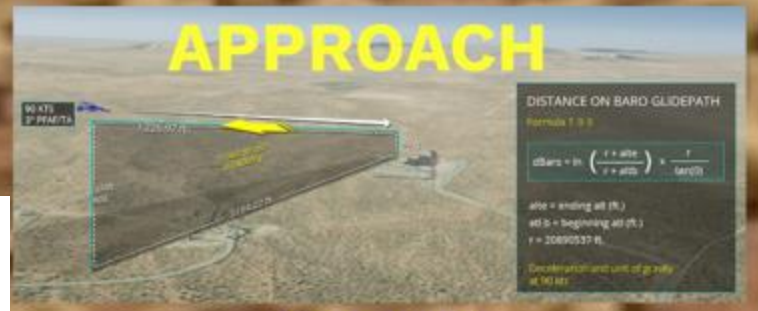
Scenario 3:
UAM Ports and Approaches



OPEN

- High-density vertiport and pad operations with combination of real and simulated aircraft
- Recovery from localized disruptions (e.g. rejected TO, late arrival)
- Vehicle contingency / emergency arrival and landing
- Wind shift / vertiport configuration change

OPEN



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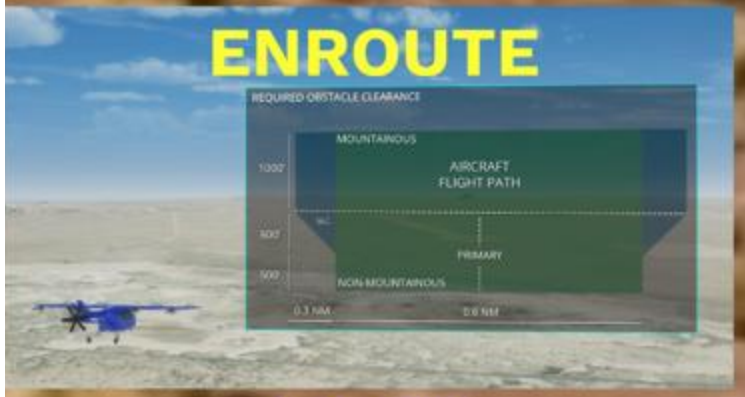

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