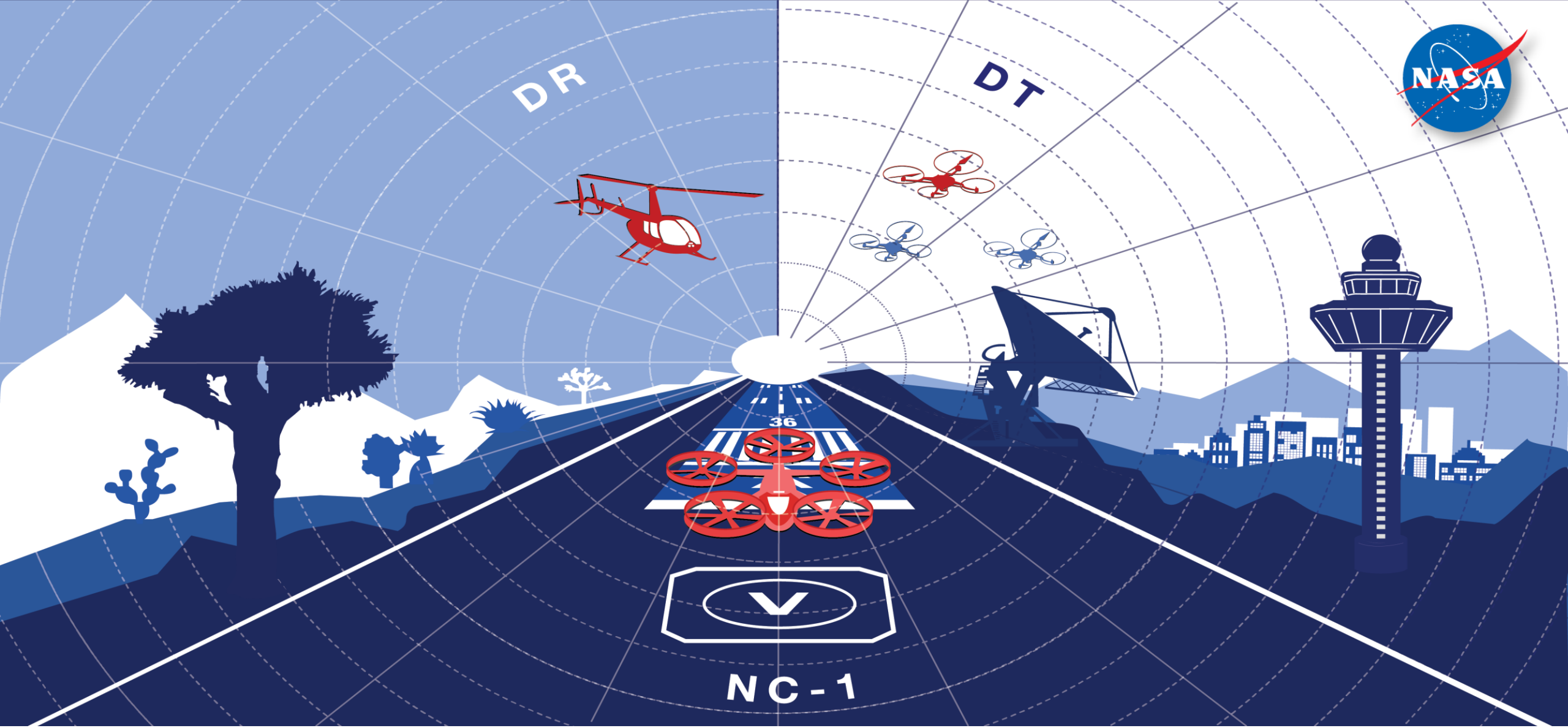
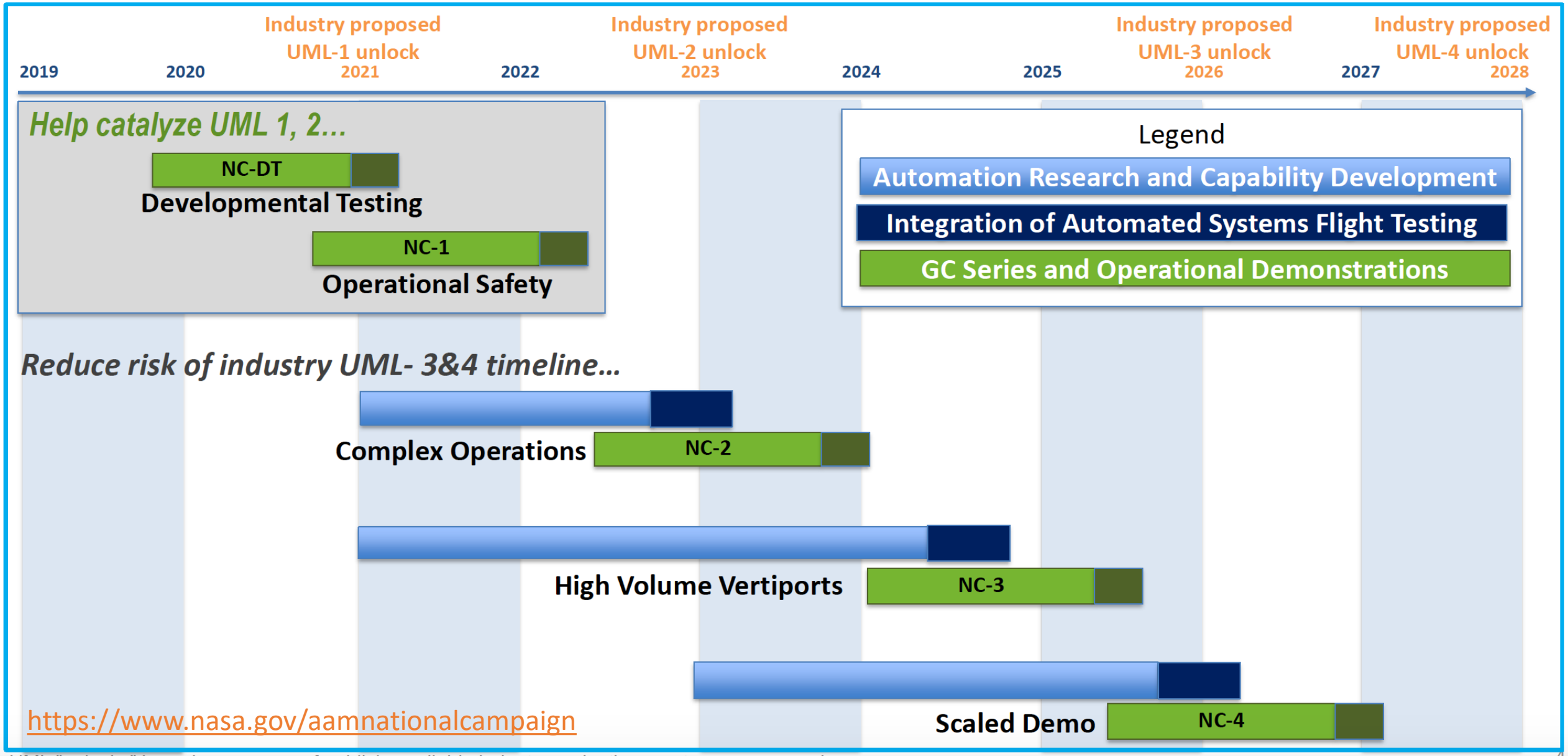


NASA Eco-System Working Group National Campaign Breakout Group Overview

Starr Ginn
Advanced Air Mobility National Campaign Lead

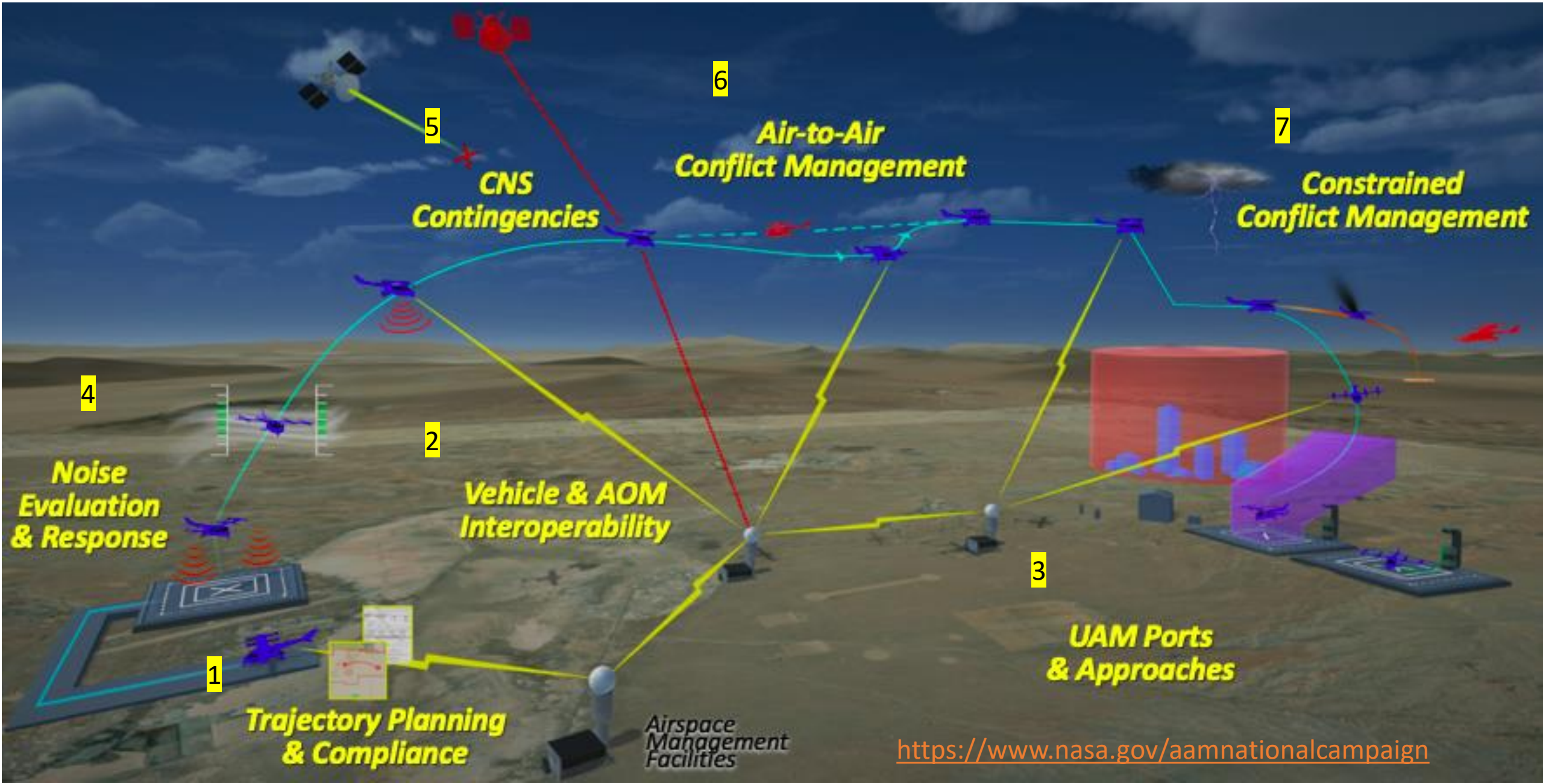
https://www.nasa.gov/aamnationalcampaign

NASA Research to enable National Campaigns



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

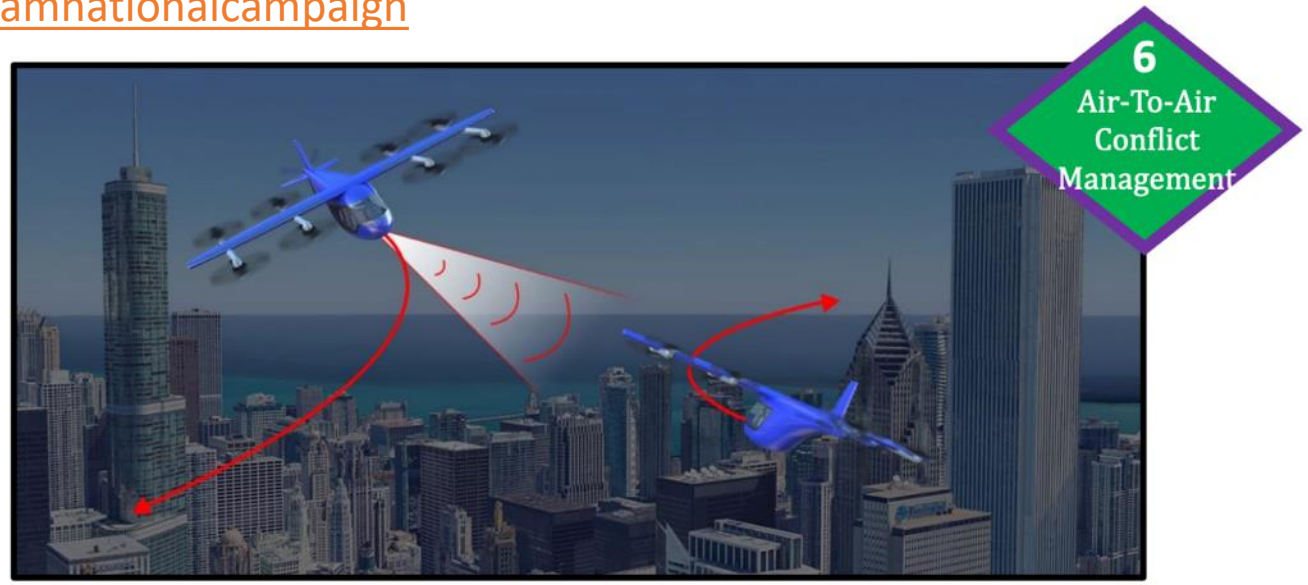
National Campaign Operational Concept - 1



https://www.nasa.gov/aamnationalcampaign

Scenario 6 – Air-to-Air Conflict Management

Demonstrate individualized components of traffic conflict management in order to evaluate interplay between essential layers of separation assurance and collision avoidance



IGC Aircraft Functional Objectives

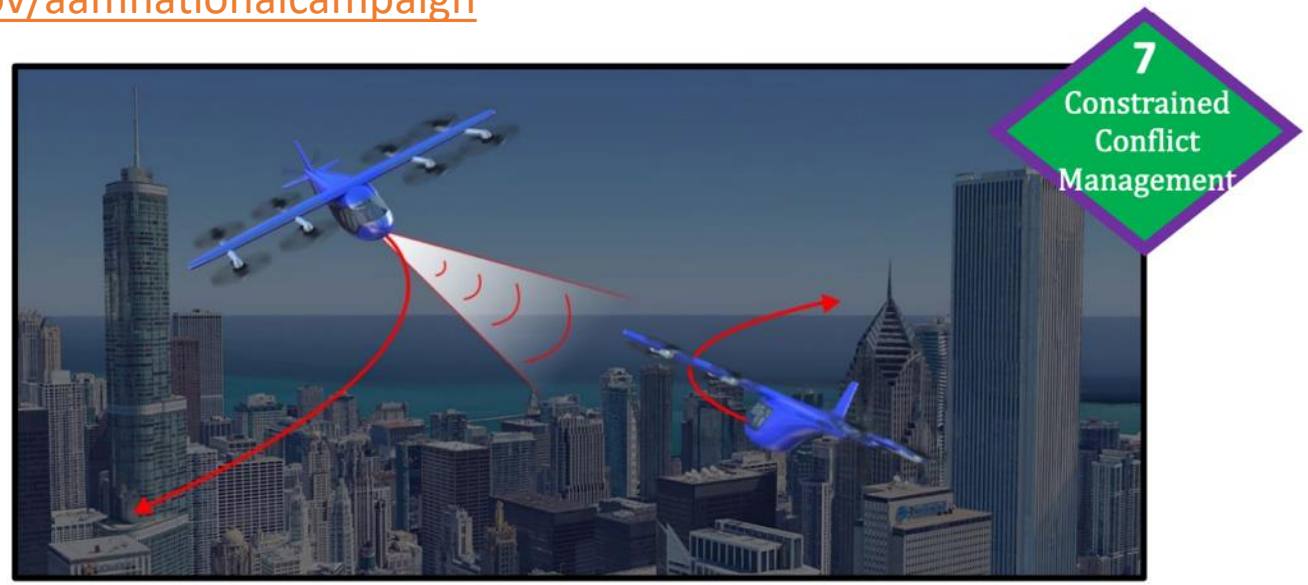
- Intra-Urban Tactical Conflict Management – Demonstrate in-flight separation assurance, collision avoidance, and appropriate airspace management information exchange (i.e., flight plan amendments) including:
  - Various geometry setups, test altitudes, aircraft sizes (general aviation, sUAS, Urban Passenger transport), cooperative and non-cooperative and speed of airborne intruders
  - Various environment backgrounds (sun, clouds, terrain clutter, etc.)
- Legacy Aircraft Tactical Conflict Management – Demonstrate interoperability with legacy aircraft (e.g. commercial, general aviation, etc), specifically when operating in terminal areas, including coordination with ATC, TCAS/ACAS interoperability, etc

IGC Airspace Functional Objectives

- Intra-Urban Tactical Conflict Management – Demonstrate in-flight separation assurance services, ability of airspace management system to support/provide traffic conflict management, provide airspace advisories, and detect secondary conflicts
- Legacy Aircraft Tactical Conflict Management – Demonstrate interoperability of UAM aircraft with legacy aircraft (e.g. commercial, general aviation, etc), specifically when operating in terminal areas, including coordination with legacy ATC, TCAS/ACAS interoperability, etc
- Scheduling - Demonstrate ability of UAM AOM system scheduling to respond to traffic conflict resolutions including negotiating route updates and STA's for all impacted aircraft

Scenario 7 – Constrained Conflict Management

Conflict management that considers simultaneous issues across the aircraft and AOM that must be solved together while considering spatial constraints (e.g., no-fly zones), temporal constraints (e.g., sequencing and scheduling), service boundaries (e.g., CNS service areas), and aircraft state of health (e.g., when aircraft is in a degraded mode). Builds upon Scenario 6, increasing complexity of operations.



IGC Aircraft Functional Objectives

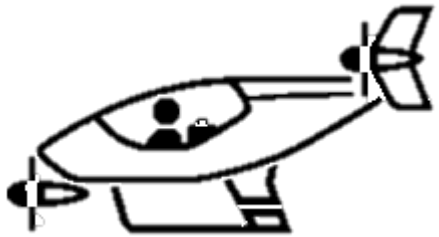
- Obstacle and Aircraft Avoidance – Demonstrate ability to detect and avoid ground and air obstacles, including non-cooperative intruder aircraft intersecting intended flight path.
- Cooperation with other UAM aircraft – demonstrate ability of UAM aircraft to perform tactical collision avoidance maneuvers without triggering follow-on collision avoidance maneuvers, including when the aircraft is in a degraded state
- Cooperation with AOM service supplier – demonstrate ability to perform tactical collision avoidance without creating cascading effects to the AOM system, including when the aircraft is in a degraded state

IGC Airspace Functional Objectives

- Obstacle and Aircraft Avoidance – AOM system responds appropriately to avoid cascading failures when a aircraft depart from planned trajectories due to an obstacle/aircraft avoidance maneuver
- Cooperation with other AOM service suppliers – AOM can interoperate with other AOM service suppliers, not sending instructions to aircraft that will disrupt other AOM service supplier's traffic management
- Cooperation with UAM aircraft – demonstrate ability to send directions to aircraft that do not create cascading impacts of tactical maneuvers from aircraft to avoid collisions, including when aircraft are in degraded states

Key Areas of Automation Development to Support the NC Series

PILOT

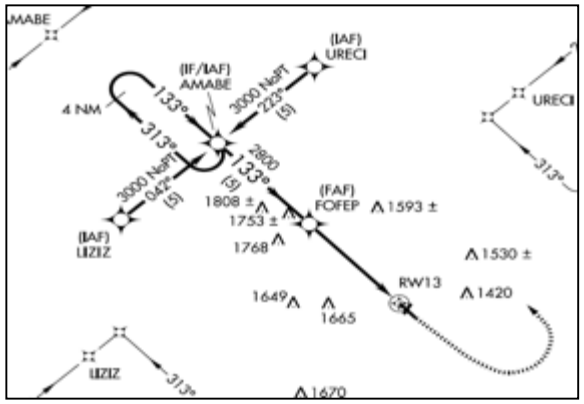


1. **Aviate**
2. **Navigate**
3. **Communicate**

CONTROLLER

1. **Locate**
2. **Separate**
3. **Allocate**

TERPSTER



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

NASA/FAA will work with industry to identify the agreed/expected tasks that are envisioned to be automated for each UML step, or Scenario. The technical maturity levels for aircraft, sensors, and UTM are key, *but the current regulatory restrictions and airspace infrastructure are also key to consider when deciding what UML levels are possible/conceivable*

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

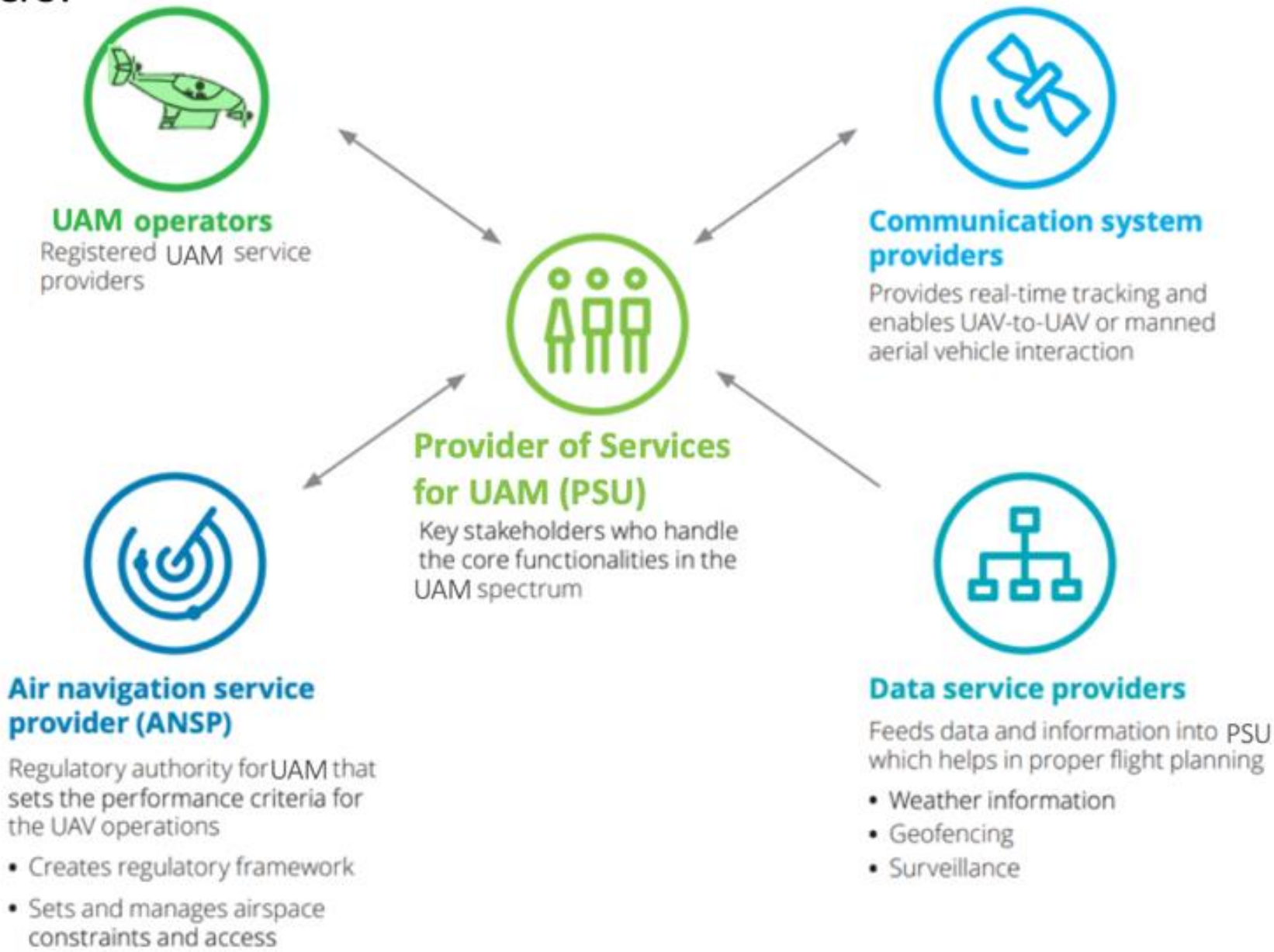
- **Plan Mission**
  - Interpret mission objectives
  - Path finding
  - AI
- **Follow Mission Plan**
  - Pilot commands
  - Waypoint following
  - Intelligent routing
  - Etc.
- **Coordinate Mission with other Agents**
  - Formation flying
  - Interactive re-routing
  - Surveillance/tracking
  - Etc.

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

*Are there new roles or relevant roles that are not covered here?

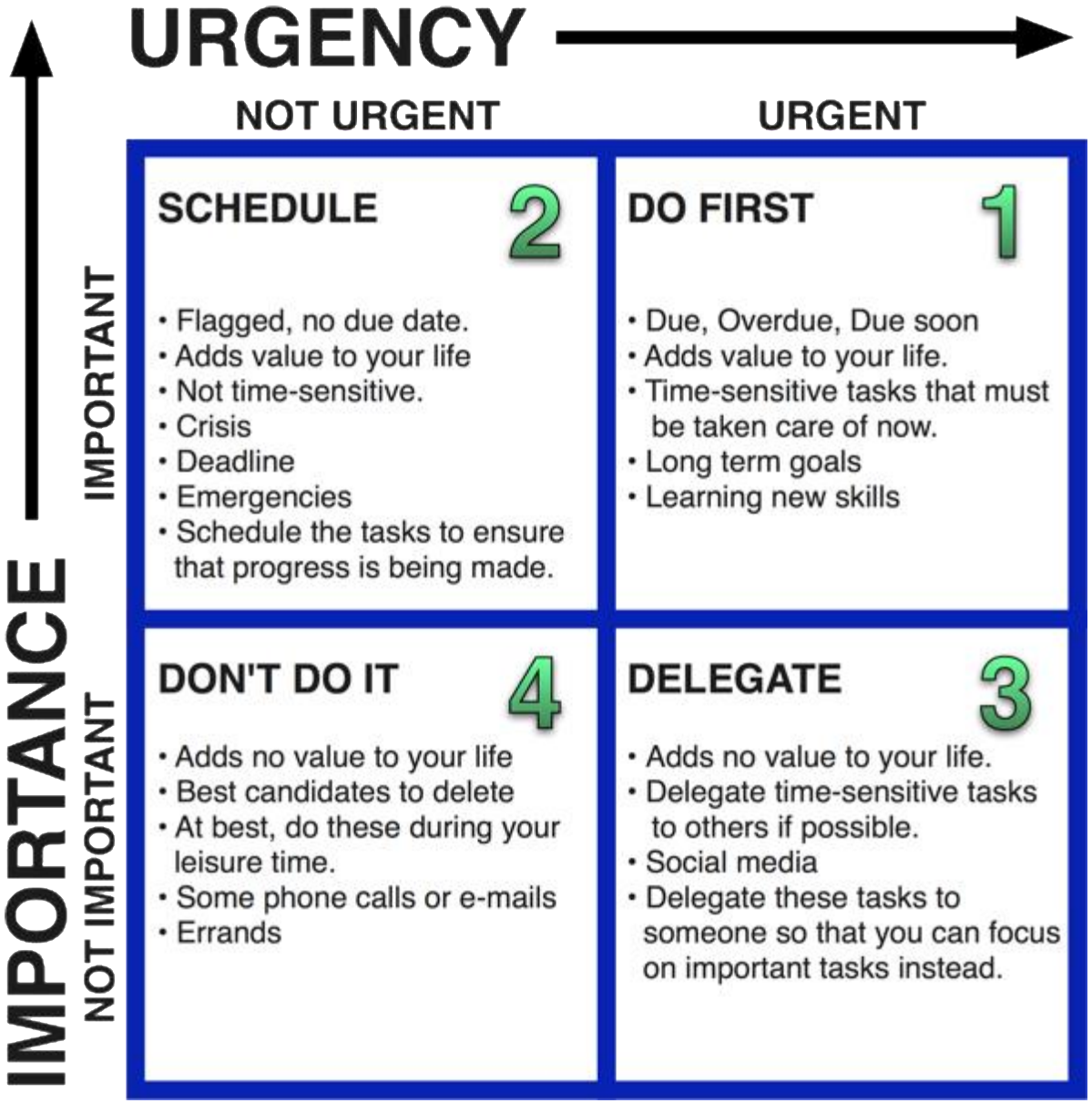


UML 1 (x): VMC, Piloted, Controlled/Uncontrolled, ports are located in uncontrolled or non movement areas if on airport surface. Break up by phase of flight

	Authorization	Clearances	Flight Planning	Surface Ops	Arrival/Dep procedures	Notification/Messaging (TFR)	Scheduling	Flow Management for UAM* (GDP, EDCTs)	Airspace Separation	Contingency Manag	Airspace Structures	Weather
Port Ops		Advisory for a non movement like area	Advisory	Prime	Primary – preferred UAM routes	Co-prime (NOTAM, ATIS)	2nd					
ANSP	Prime	Prime			Co-prime	Prime		Prime	Prime (in controlled)	Prime (in controlled)	Prime	
Vehicle												
Pilot	R	R	R	Co-prime	Co-prime	R	R	R	Co-Primary (as delegated by ANSP)*	Prime		Prime
Fleet Ops			Prime	2nd	2nd	2nd	2nd	2nd		2nd		Co-prime
PSU/UAM Ecosystem	2nd – enable authorization	2nd	2nd (discovery, intent)	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd
Other Users					Third party interest							

All Break Out Groups – Use the Same Exercise To Evaluate the NC Series

The EISENHOWER Matrix
How to Make Decisions on What's URGENT & IMPORTANT



VEHICLE

NOT URGENT URGENCY URGENT

IMPORTANCE

IMPORTANT	SCHEDULE 2	DO FIRST 1
NOT IMPORTANT	DON’T DO IT 4	DELIGATE 3

AIRMEN

NOT URGENT — URGENCY → URGENT

IMPORTANCE ↑

	NOT URGENT	URGENT
IMPORTANT	SCHEDULE 2	DO FIRST 1
NOT IMPORTANT	DON’T DO IT 4	DELIGATE 3

AIRSPACE

NOT URGENT URGENCY URGENT

IMPORTANCE

IMPORTANT	SCHEDULE 2	DO FIRST 1
NOT IMPORTANT	DON’T DO IT 4	DELIGATE 3

INFRASTRUCTURE

NOT URGENT URGENCY URGENT

IMPORTANCE

IMPORTANT

NOT IMPORTANT

SCHEDULE 2	DO FIRST 1
DON’T DO IT 4	DELIGATE 3

COMMUNITY

NOT URGENT URGENCY URGENT

IMPORTANCE

IMPORTANT

NOT IMPORTANT

SCHEDULE 2	DO FIRST 1
DON’T DO IT 4	DELIGATE 3

Evolutionary Steps to enable a Revolutionary Market

White Board: Use these bold titles as categories participants will fill in an Eisenhower Matrix with their thoughts on priority, we have a few examples below

Vehicle

- Define Stability, Control and Performance standards
- IFR approaches to zero altitude/zero airspeed above the Touchdown Point (TDP)
- Ability to safely fly ? glide path angle
- Controllability standards for confined space operations in Urban environments
- Reserves

Airmen

- Define Pilot/Vehicle interface standards for highly complex, highly augmented, vehicles
- Refinement of Powered-Lift licensing requirements
- Implementation of Simplified Vehicle Operations (SVO)

Airspace

- Roles and responsibilities of airspace services and ATC integration at existing airports and urban environments
- Identify airspace service providers flight critical software

Infrastructure

- Refine Heliport and Vertiport design criteria to reflect UAM needs
- Improve Urban “Micro-”weather forecasting, now-casting, and broadcasting
- Define standardized approach procedures for UAM

Community

- Integrate smart cities
- Understand acoustic and visual noise

POLL #1

POLL #1

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

POLL #1

‡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)

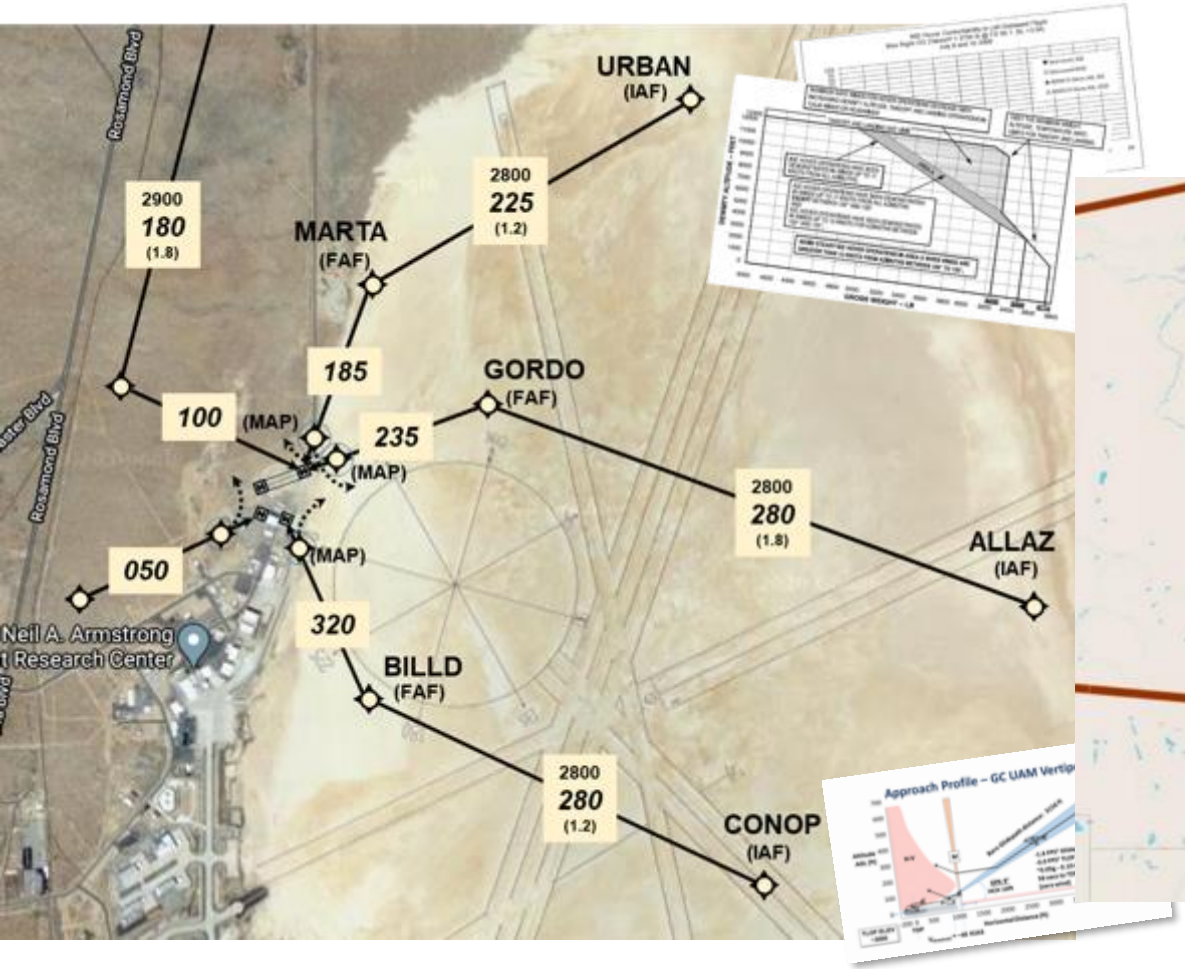
UML-1
No new commercial urban missions enabled.

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)

Breakout #2 and #3

NC-DT Operational Safety & NC-1 Complex Operations

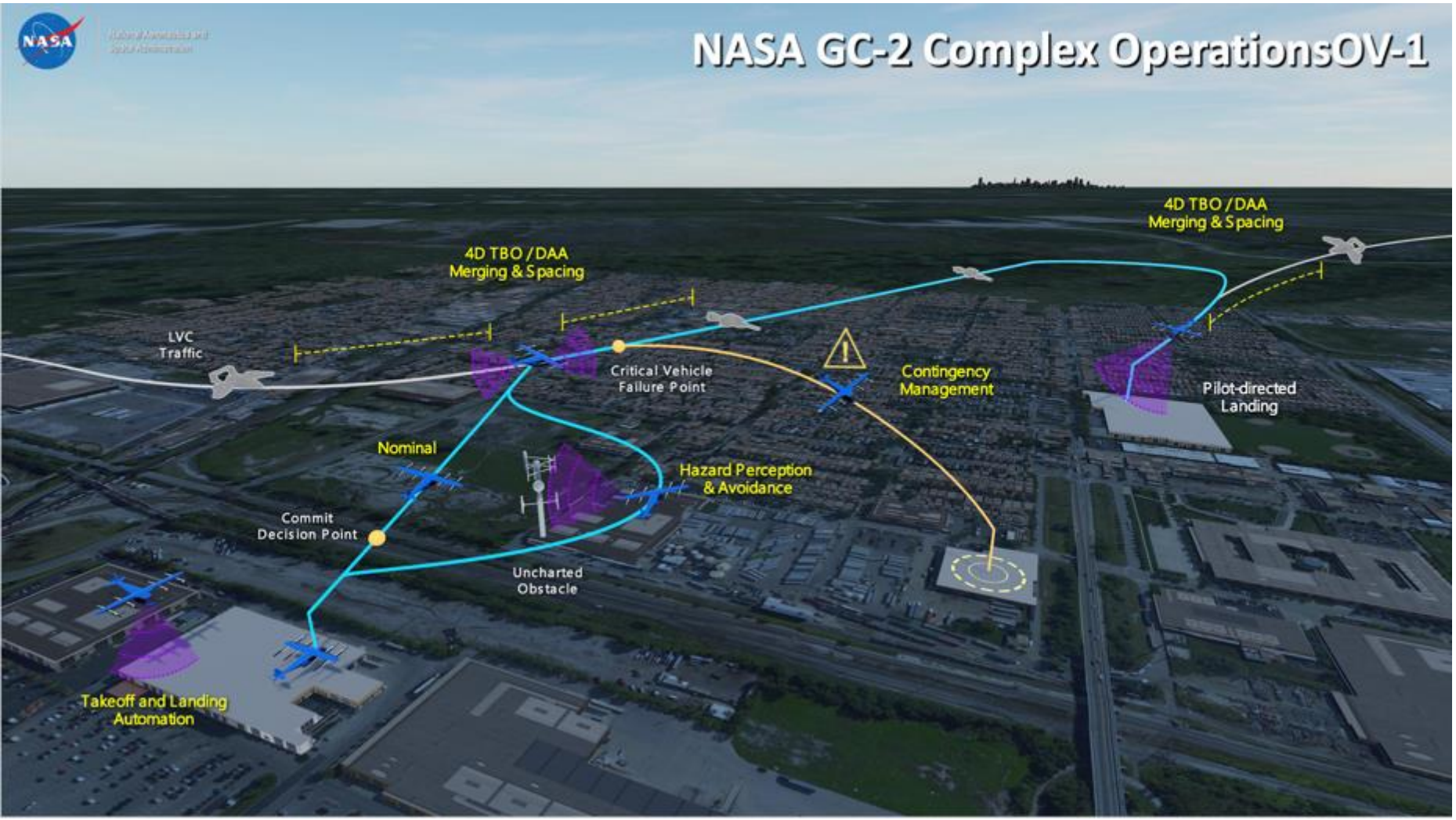
Building Blocks for the urban environment



Micro-Plex to one airport based on vehicle category

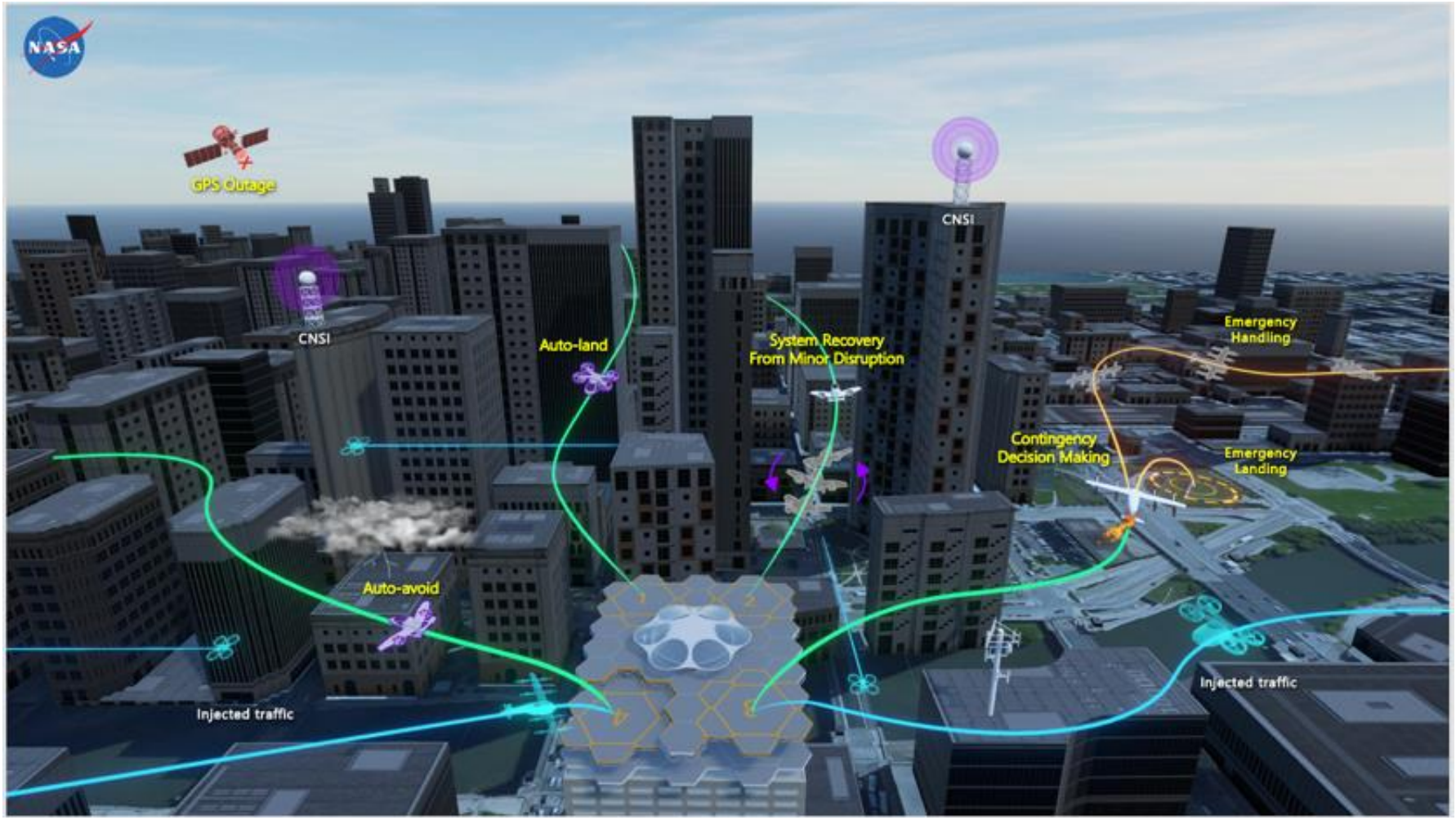
- New NextGen RNAV Arriva Procedures
- Mid View

NC-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

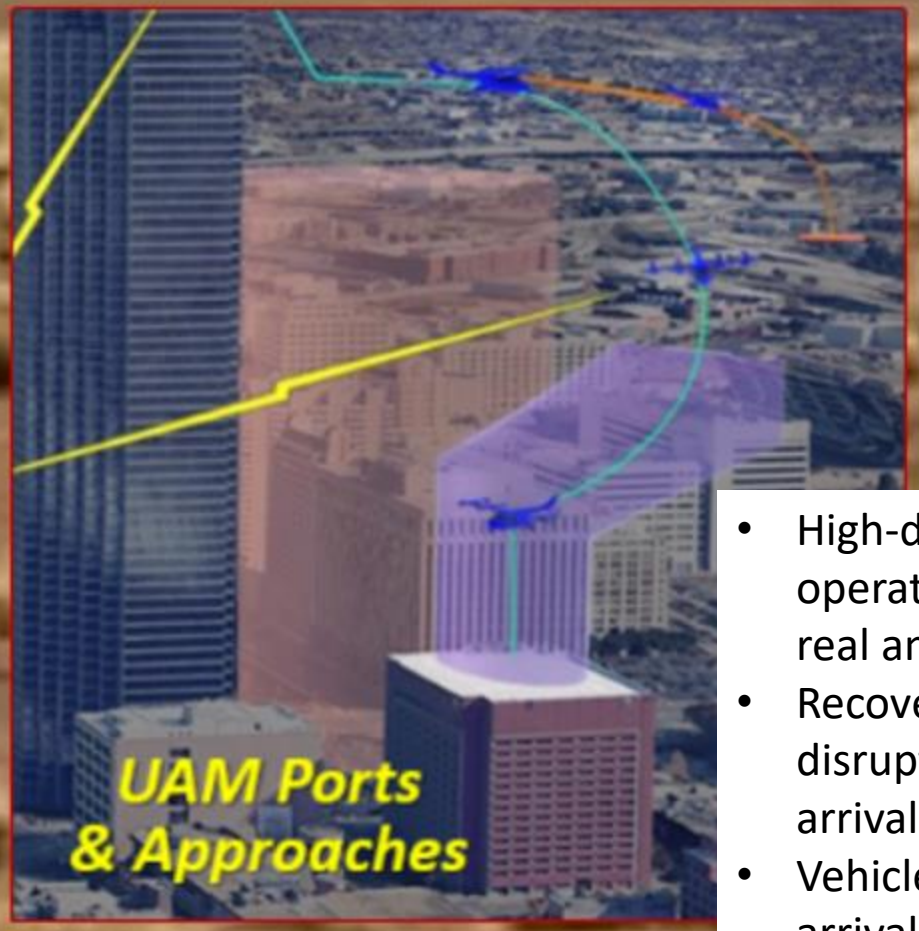
NC-3 High Volume Vertiports



- 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
- Etc….

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
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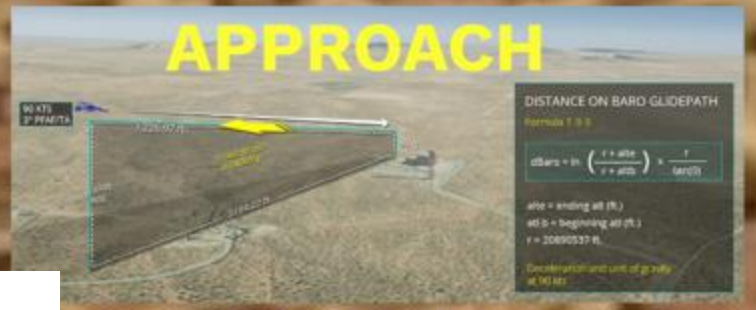
OPEN



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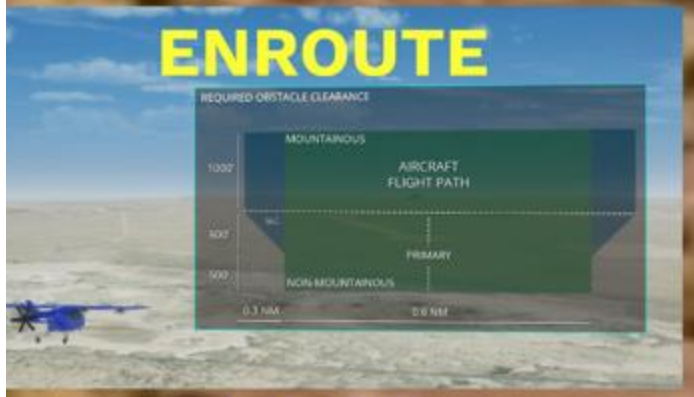


OPEN

POLL #2

POLL #2

What Aircraft/Airspace Use Case does you company plan to support? *You can select multiple choices.*

- Is the Aircraft Piloted or Remote Pilot?
- Do you prefer to land at a Heliport or Vertiport?
- What existing infrastructure will be used by 2023-2024 for operational flights?
- What airspace will be used for operational flights?

Aircraft Pilot/Type of Landing/Existing Infrastructure/Airspace

1) Aircraft/Landing @ Class G Airport/Class G to class B
    - 1a) Piloted Scenarios 1-4
    - 1b) Remote Scenarios 1-7
    - 1c) Heliport
    - 1d) Vertiport
2) Aircraft/Landing @ Class G Airport/Class G to Class C
    - 2a) Piloted Scenarios 1-4
    - 2b)Remote Scenarios 1-7
    - 2c) Heliport
    - 2d) Vertiport

POLL #2

3) Aircraft/Landing @ Class G Airport/Class G to Class D
    3a) Piloted Scenarios 1-4
    3b)Remote Piloted Scenarios 1-7
    3c) Heliport
    3d) Vertiport
4) Aircraft/Landing @ Class D Airport/Class D to class B
    4a) Piloted Scenarios 1-4
    4b)Remote Piloted Scenarios 1-7
    4c) Heliport
    4d) Vertiport
5) Aircraft/Landing @ Class D Airport/Class D to Class C
    5a) Piloted Scenarios 1-4
    5b)Remote Piloted Scenarios 1-7
    5c) Heliport
    5d) Vertiport
6) Aircraft/ Landing @ Class D Airport/Class C to Class D
    6a) Piloted Scenarios 1-4
    6b)Remote Piloted Scenarios 1-7
    6c) Heliport
    6d) Vertiport
7) Aircraft/ Landing @ Class C Airport/Class C to class B
    7a) Piloted Scenarios 1-4
    7b)Remote Piloted Scenarios 1-7
    7c) Heliport
    7d) Vertiport
8) Aircraft/ Landing @ Class C Airport/Class C to Class C
    8a) Piloted Scenarios 1-4
    8b)Remote Piloted Scenarios 1-7
    8c) Heliport
    8d) Vertiport
9) Aircraft/ Landing @ Class C Airport/Class D to Class D
    9a) Piloted Scenarios 1-4
    9b)Remote Piloted Scenarios 1-7
    9c) Heliport
    9d) Vertiport
10) Aircraft/ Landing @ Class B,C,D,G Airport to Class E (Rooftop)
    7a) Piloted Scenarios 1-4
    7b)Remote Piloted Scenarios 1-7
    7c) Heliport
    7d) Vertiport
11) Other

POLL #2

For purposes of the Initial AAM National Campaign, we have defined two (2) Terminal Areas, and two (2) Approaches that will be focus areas for initial flight demonstrations

AAM NC Terminal Areas/approaches:

AAM NC has defined a "UAM Heliport" – A symmetric Heliport whose dimensions and surface volumes are prescribed by standards contained in Advisory Circular no.150/5390-2C "Heliport Design."

AAM NC approaches to this terminal area are flown with the vehicle making a constantly decelerating approach on a fixed glidepath to a zero groundspeed point in space, in ground effect, directly above the touchdown point (TDP).

This approach builds on the assumption that UAM vehicles will demonstrate a redundancy of design, and vehicle characteristics, that enable safe accomplishment of precision UAM instrument approaches.

AAM NC is also defining a "UAM Vertiport" for initial flight demonstrations – Distinguished from the UAM Heliport by utilizing an extended TLOF and FATO.

Although the principles of the dimensions of the landing surface are governed by AC 150/5390-2C "Heliport Design," the AAM National Campaign is initially utilizing slightly different surface volumes that reflect past (cancelled) FAA Vertiport Design guidance material.

AAM NC approaches to this terminal area are flown with the vehicle respecting a manufacturer chosen Landing Decision Point (LDP), and/or a Minimum Speed, IMC ($V_{MIN\text{-}I}$) driven by failure condition/vehicle characteristics that will result in a forward speed as the vehicle crosses the threshold of the extended TLOF/FATO.

The vehicle will decelerate, in ground effect, above the landing surface to the TDP.

The assumption is published performance of a future certified UAM vehicle will prescribe the minimum length of the TLOF respecting weight, altitude, temperature and any other pertinent variables.

Prior to flight demonstrations of these approaches, specific Stability, Control, and Performance parameters will need to be understood in order to inform UAM vehicle standards development.

POLL #2

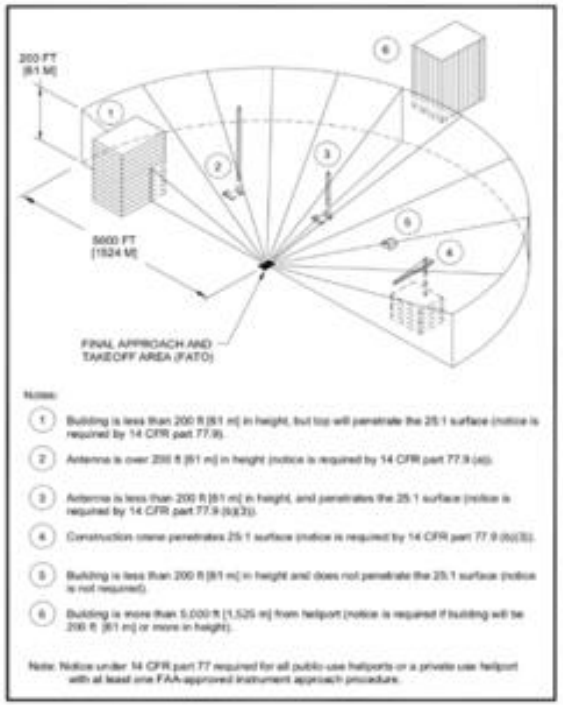


Figure 1–4. Offsite Development Requiring Notice to the FAA

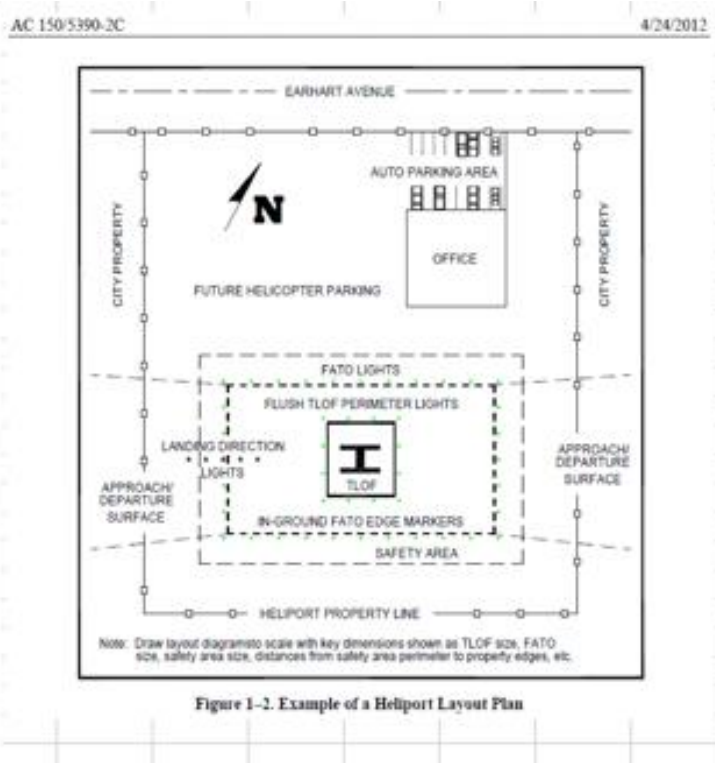


Figure 1–2. Example of a Heliport Layout Plan

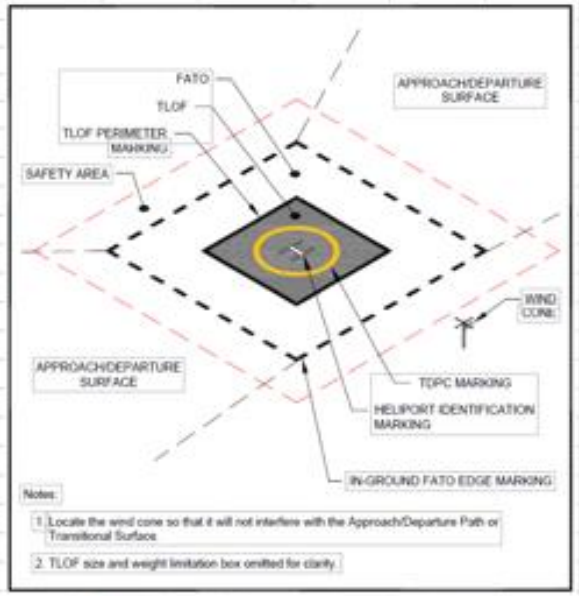
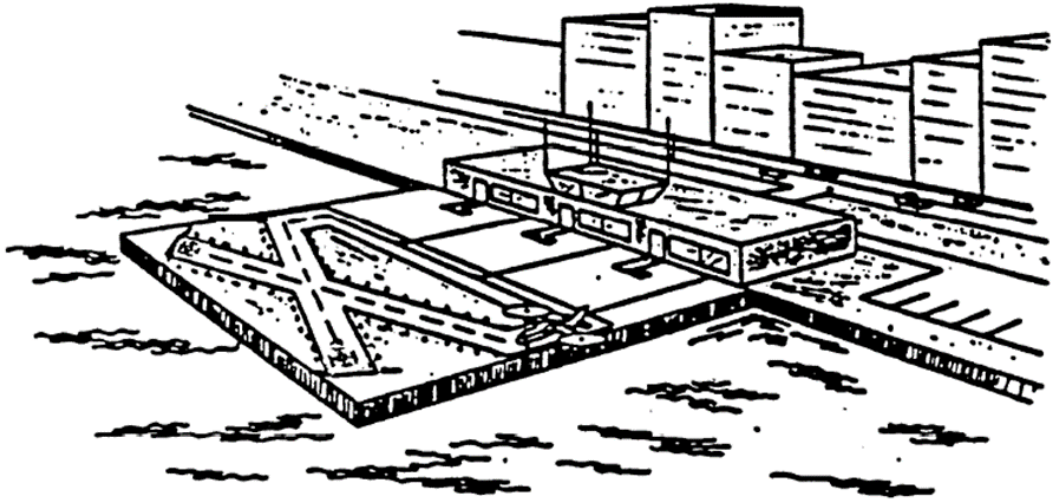


Figure 2–1. Essential Features of a Heliport: General Aviation

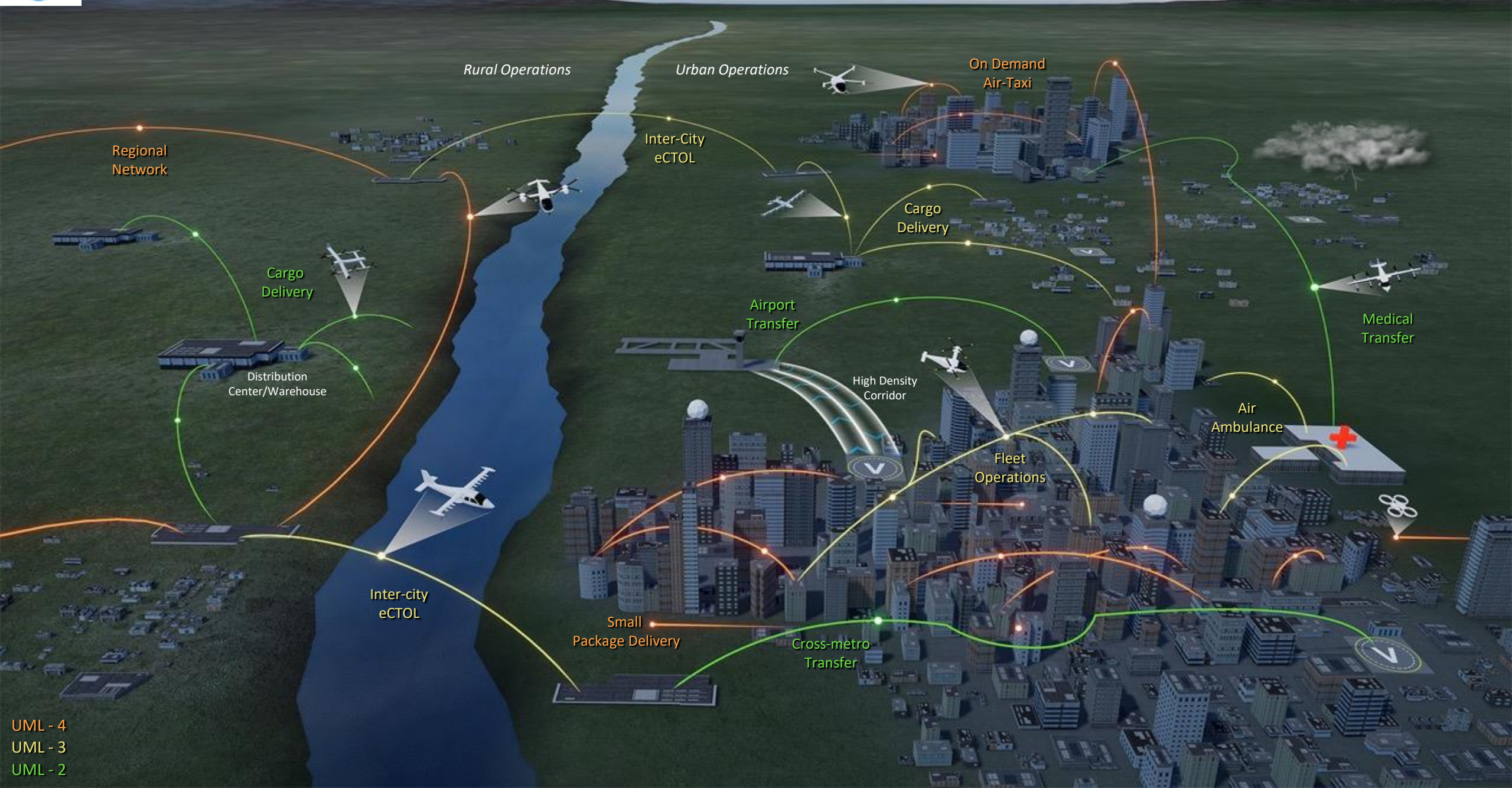
Advisory Circular no.150/5390-2C “Heliport Design



Ref. AC 150 5390-3 (cancelled)

Backup

Advanced Air Mobility Business Cases



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)
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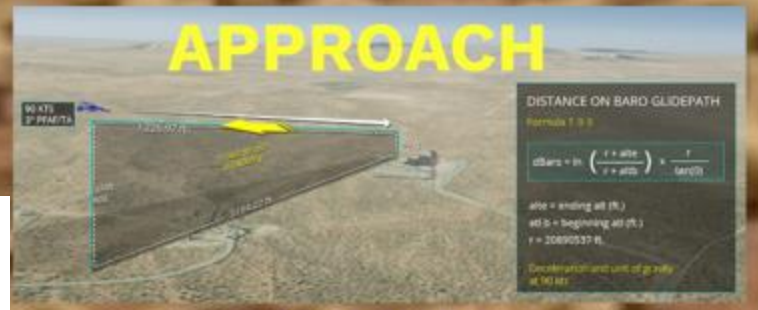
OPEN



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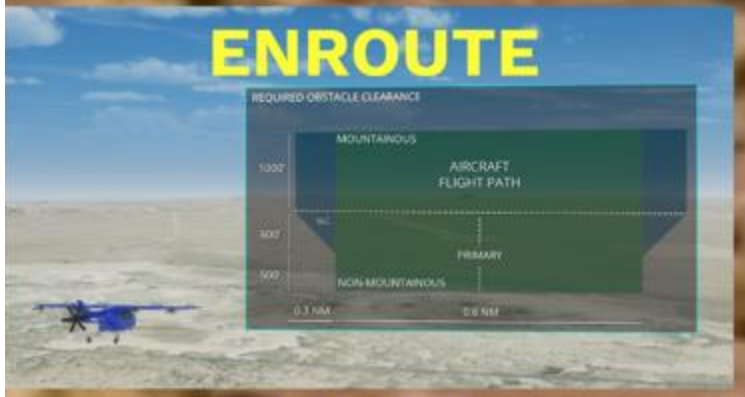


OPEN

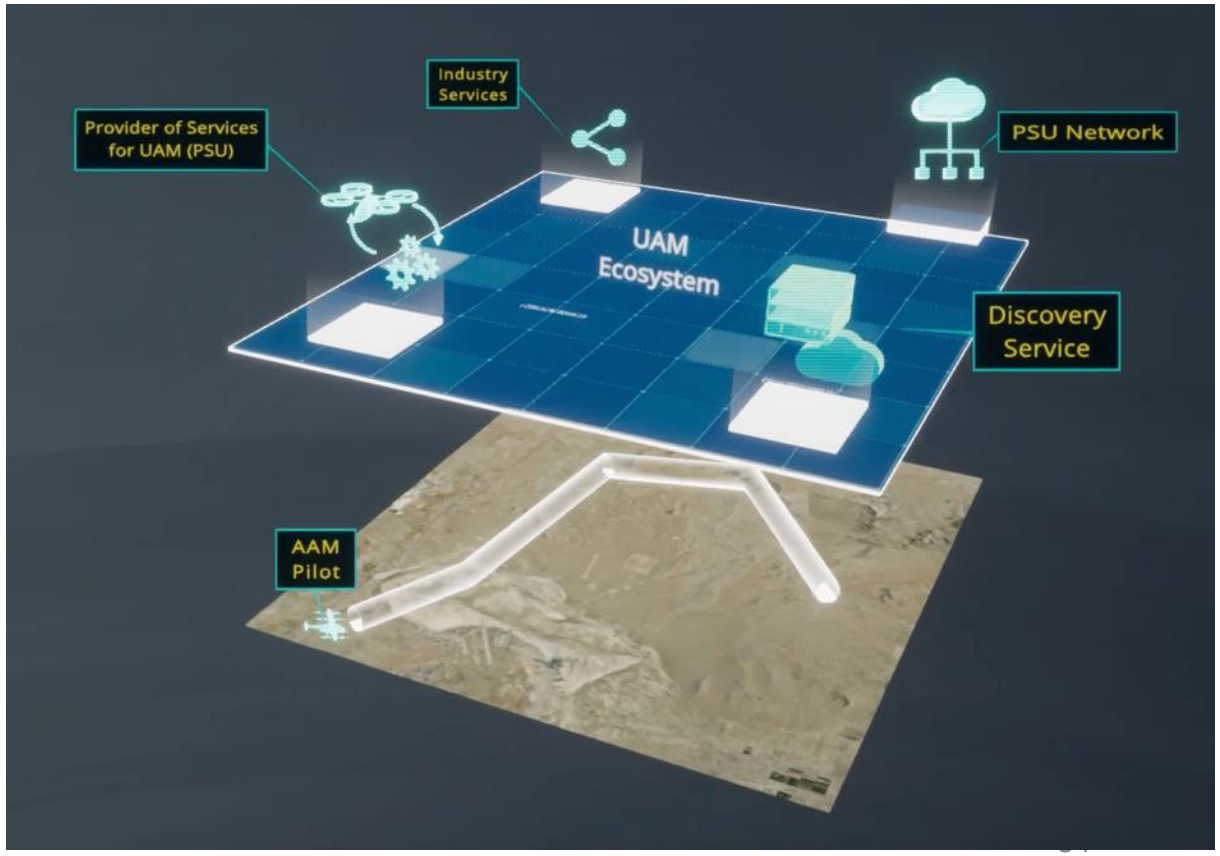
National Campaign Developmental Test Simulations

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

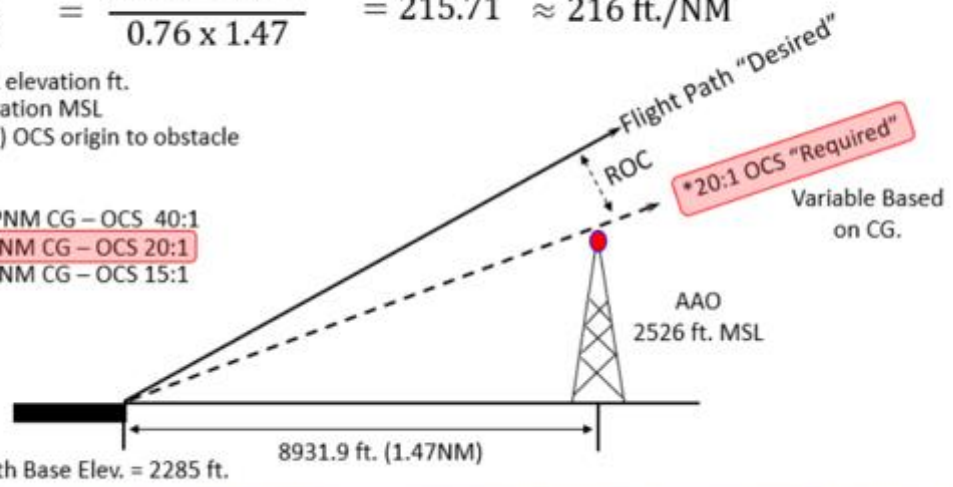
- NASA evaluation of scenario virtual components, virtual traffic density, and flight feasibility
- Demonstration of vehicle/airspace system integration in virtual and hardware in the loop environments
- Demonstration of extended UTM airspace capabilities in support of advanced NC-1 scenario requirements;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

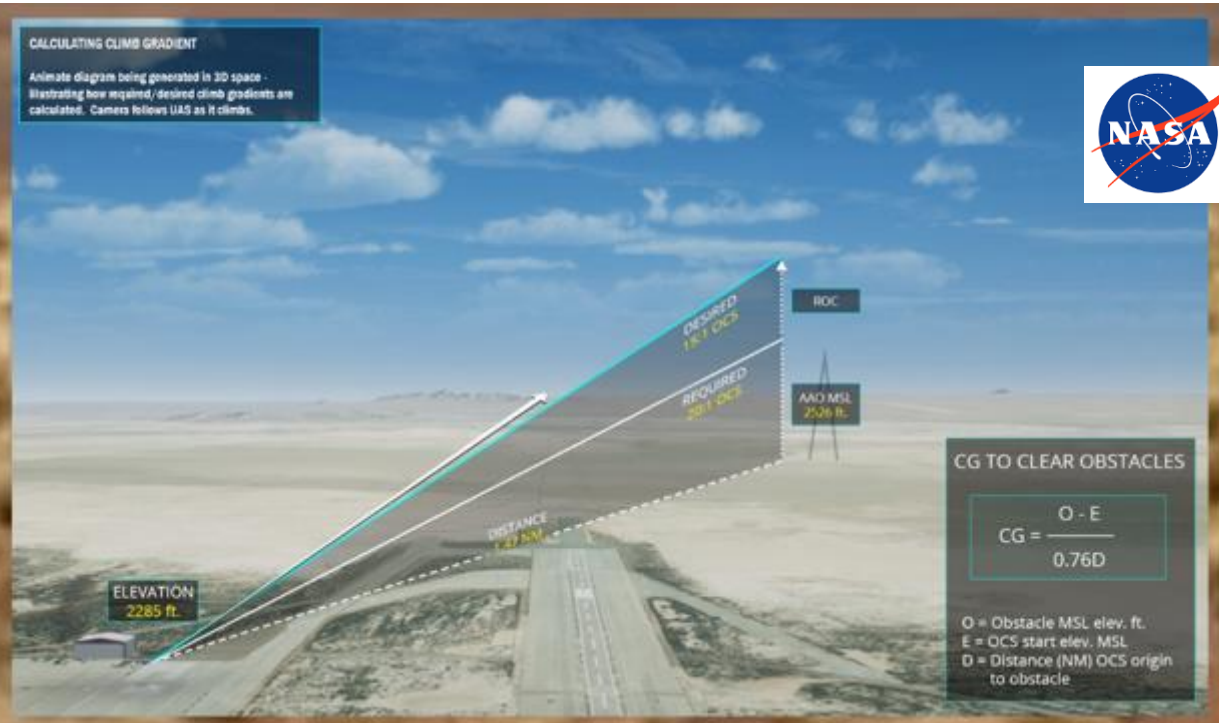


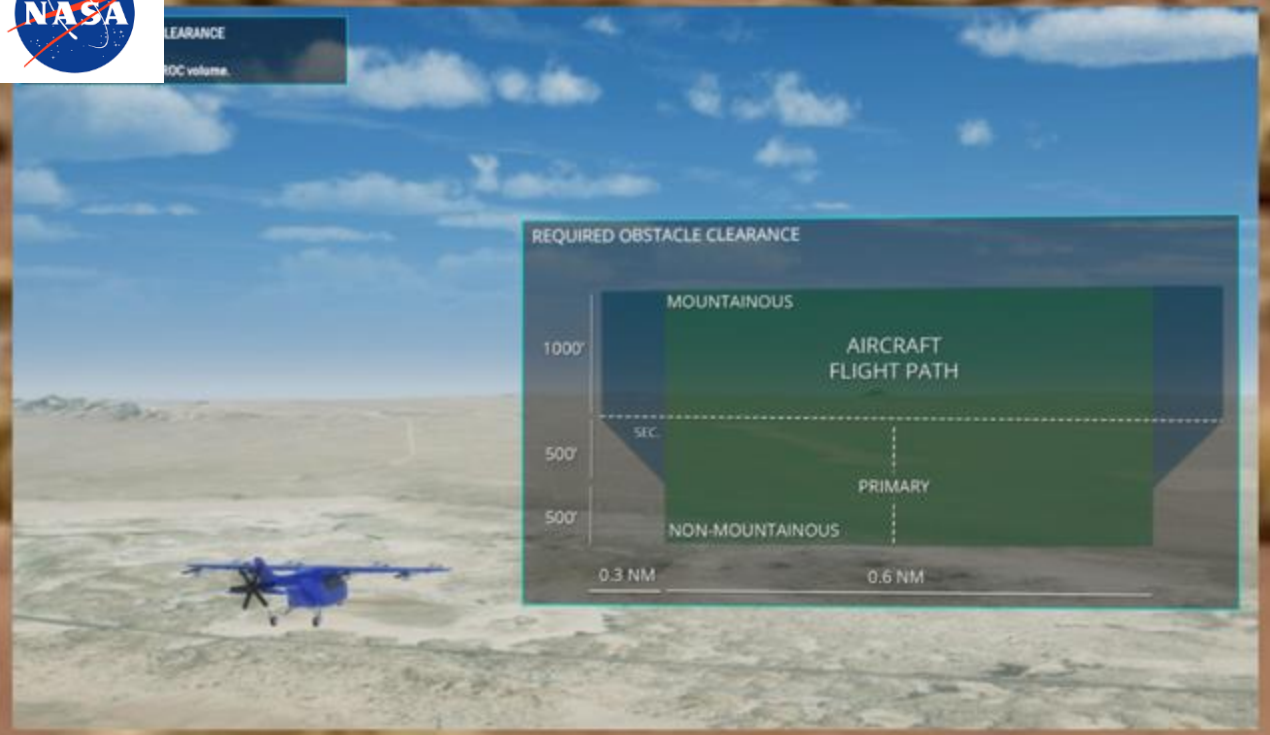
$$CG = \frac{O - E}{0.76D} = \frac{2526 - 2285}{0.76 \times 1.47} = 215.71 \approx 216 \text{ ft./NM}$$

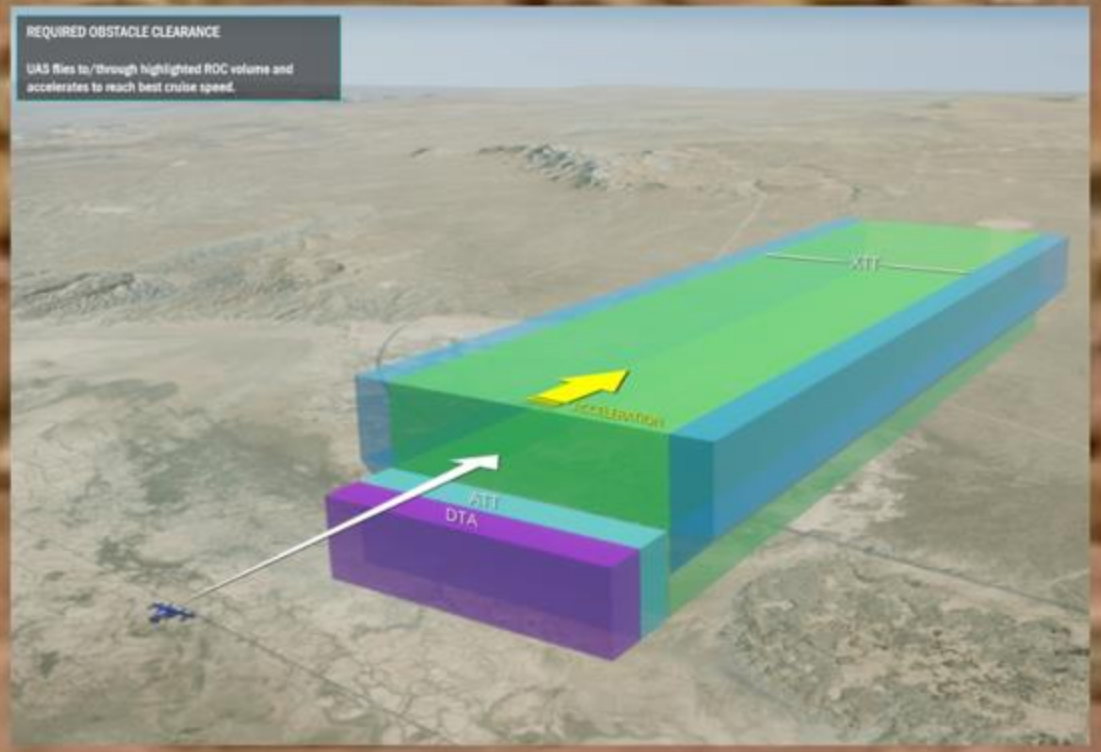
O = Obstacle MSL elevation ft.
E = OCS start elevation MSL
D = Distance (NM) OCS origin to obstacle

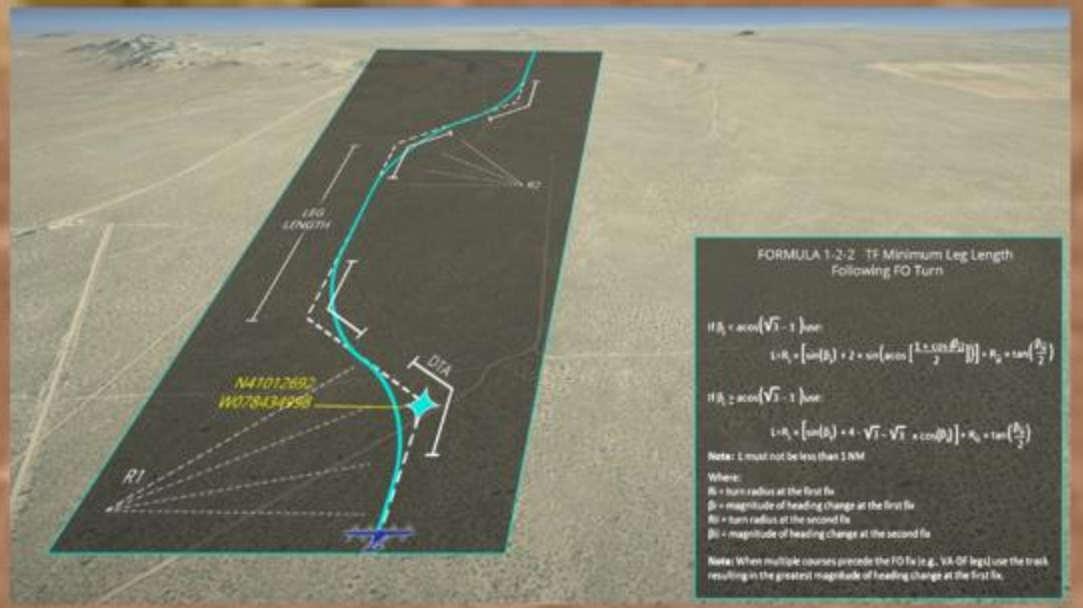
*Assumed: 200 FPNM CG – OCS 40:1
300 FPNM CG – OCS 20:1
400 FPNM CG – OCS 15:1



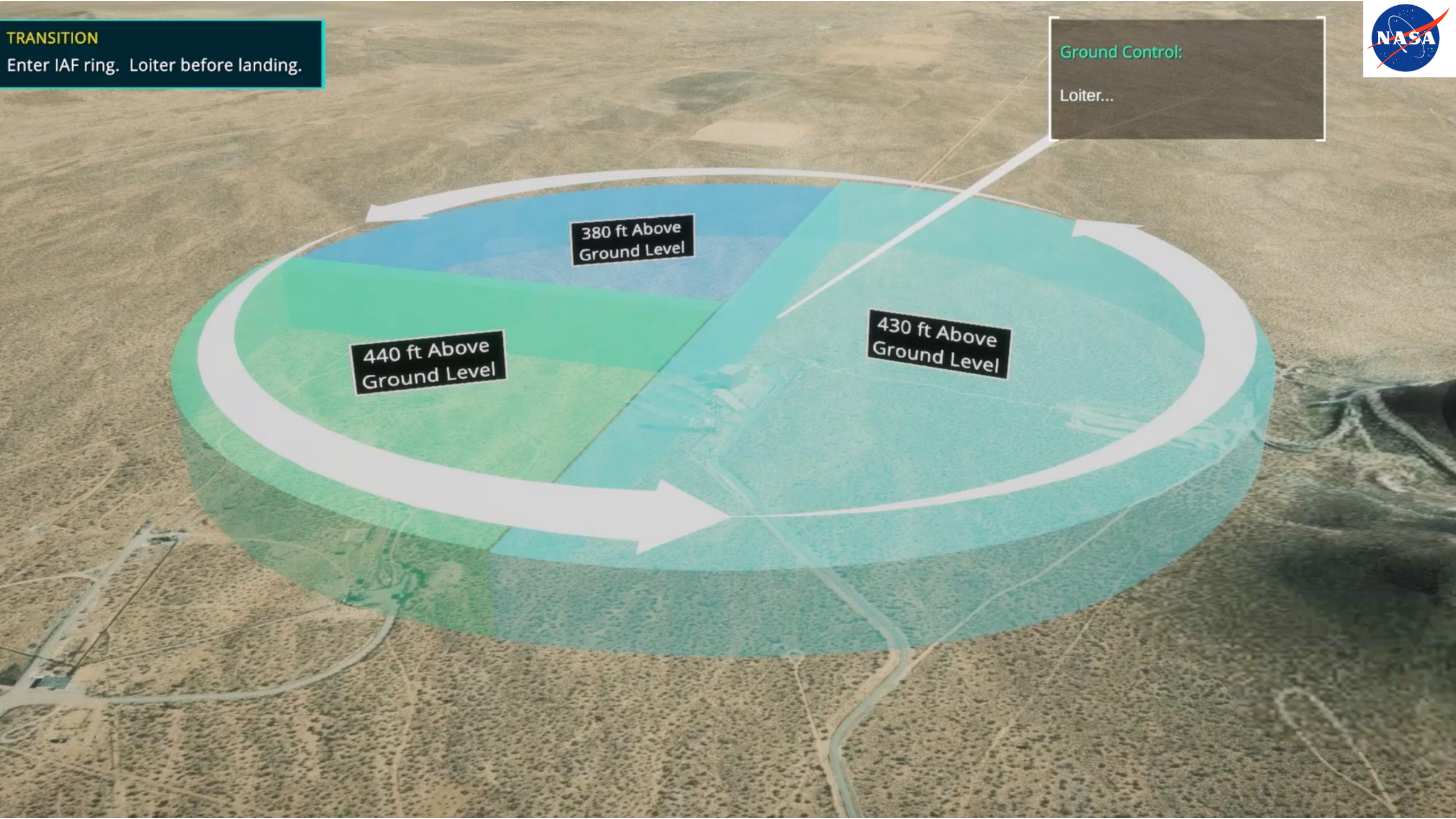



REQUIRED OBSTACLE CLEARANCE
MOUNTAINOUS
AIRCRAFT
FLIGHT PATH
1000'
500'
500'
SEC.
PRIMARY
NON-MOUNTAINOUS
0.3 NM
0.6 NM

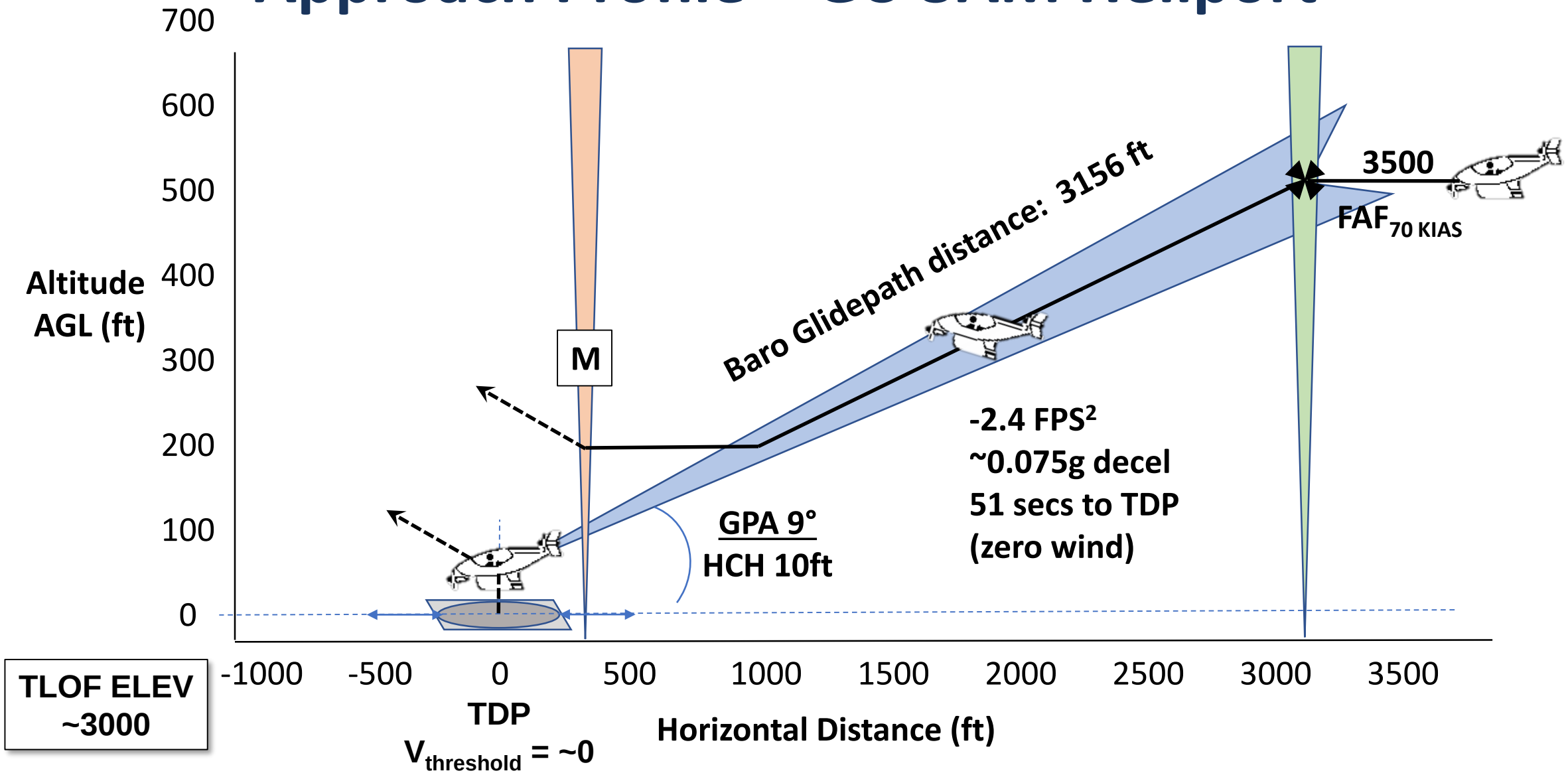

REQUIRED OBSTACLE CLEARANCE
UAS flies to/through highlighted ROC volume and accelerates to reach best cruise speed.
XTT
ATT
DTA


LEG LENGTH
DTA
N41012692
W07843499
R1
FORMULA 1-2-2 TF Minimum Leg Length Following FO Turn
Note: L must not be less than 1 NM
Where:
R1 = turn radius at the first fix
β1 = magnitude of heading change at the first fix
R2 = turn radius at the second fix
β2 = magnitude of heading change at the second fix
Note: When multiple courses precede the FO fix (e.g., VA-DF legs) use the track resulting in the greatest magnitude of heading change at the first fix.

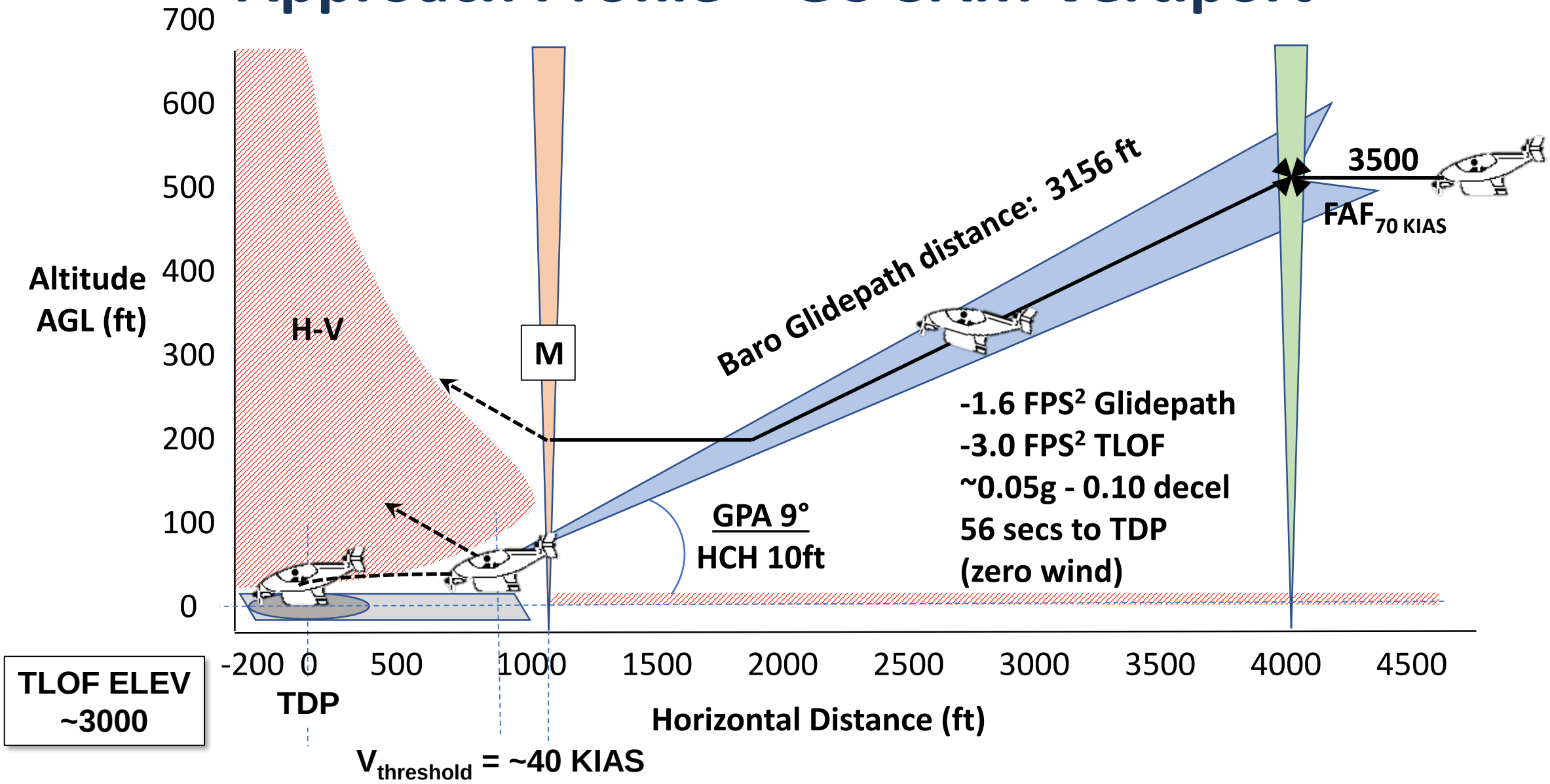
OPEN


TRANSITION
Enter IAF ring. Loiter before landing.
Ground Control:
Loiter...
380 ft Above Ground Level
440 ft Above Ground Level
430 ft Above Ground Level

Approach Profile – GC UAM Heliport



Approach Profile – GC UAM Vertiport



MICROPLEX DEFINED

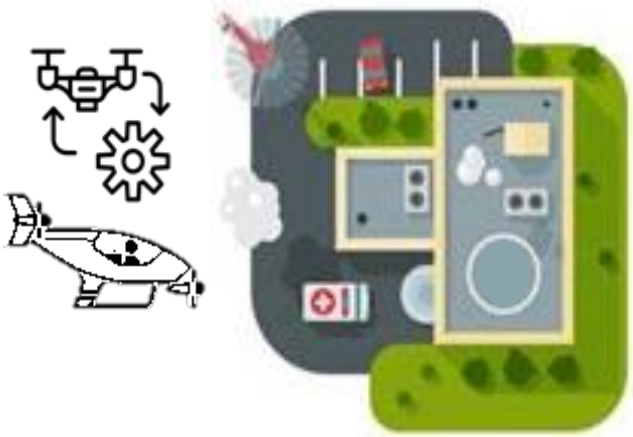
Airspace

Providing the appropriate constructs to enable:

- Airspace authroizations
- Routes and procedures
- Flight planning
- Traffic sequencing
- Data constructs for weather, NOTAM, TFR and other associated ANSP information

Throughput

Enable demand capacity balancing for increasing volumes of new entrants across various equipages. Through high precision performance bandwidth can be increased by educing lateral separation requirements, reduced vertical separation requirements (ROC), and overall efficiency gains.



Contingency Management

The safety cases needed to enable a microplex hinge on contingency management operations and procedures that account for rerouting , lost Communication, Go-around / Missed Approaches, all land scenarios, and priority sequencing for landing.