



May 20, 2020

NC SCENARIOS FOR DRY RUN

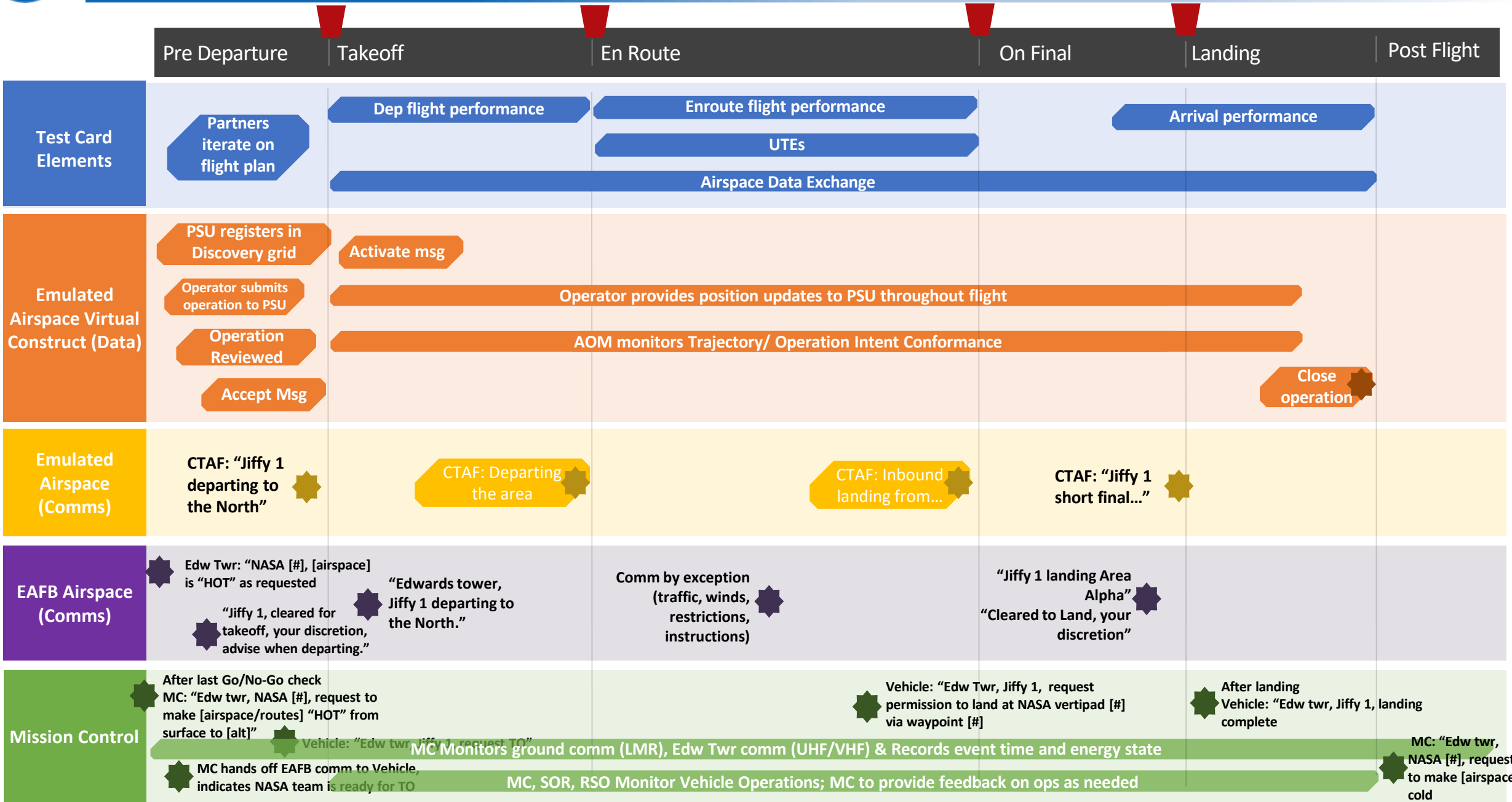


NC DT – Scenarios 1

Scenario Variation	Description	Airspace Assumptions	ATC Interactions	Background Traffic
Scenario 1	Point-to-point, nominal operations in uncontrolled airspace	Class G Day VFR	Class G communications	IFR and VFR traffic



DT Scenario 1 Timeline





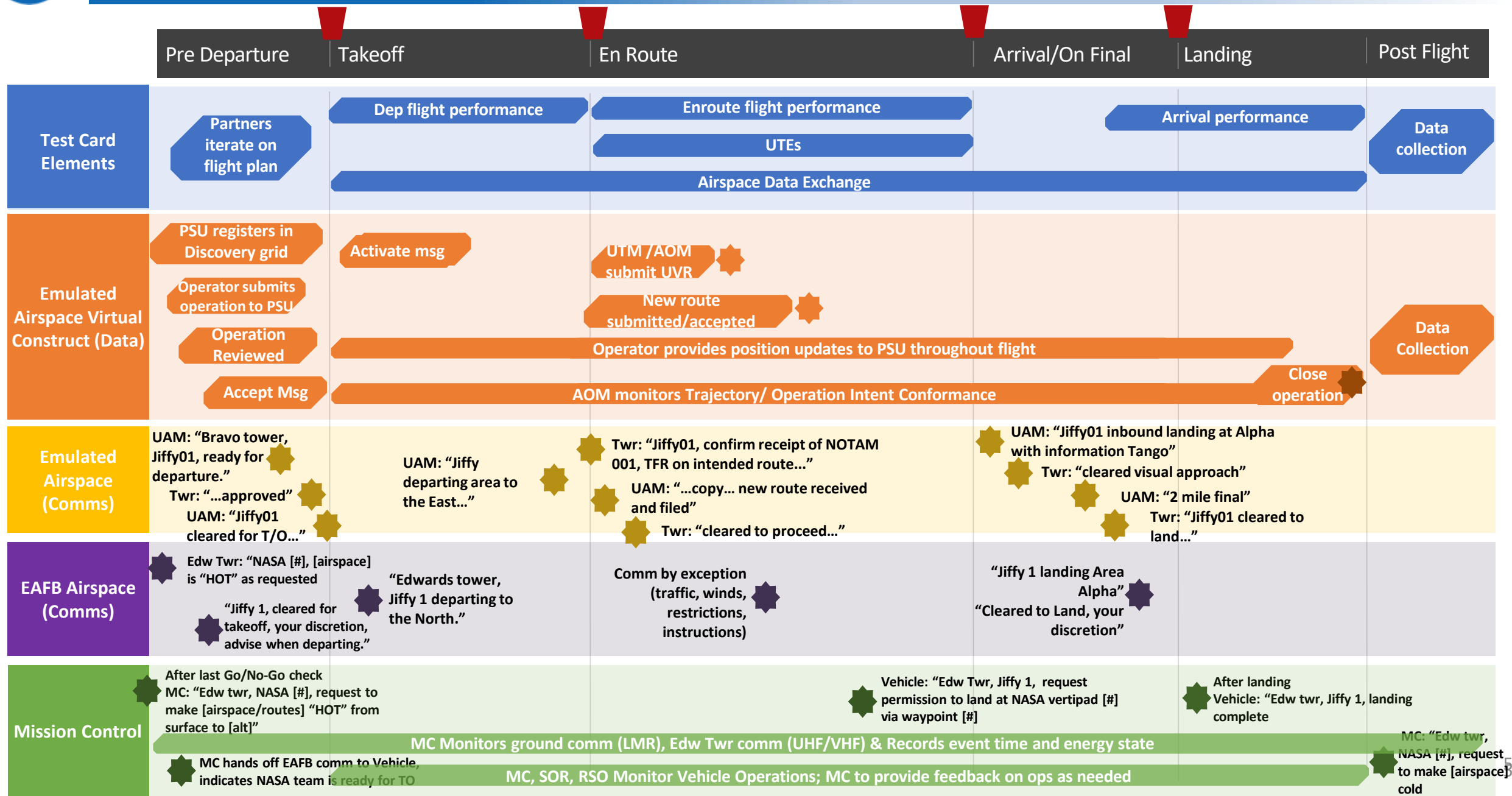
NC DT – Scenarios 2

Scenario Variation	Description	Airspace Assumptions	ATC Interactions	Background Traffic
Scenario 2	The scenario will include an AOM/ATM initiated strategic re-route during en-route flight due to a NOTAM indicating that a fire is causing the UAM corridor to be closed • NOTAM will initiate after departure while vehicle is within D • AOM will submit a UVR (UAM Volume Reservation) to emulate the closing airspace to airspace partners • Flight is re-routed away from then back to original route	Class D/G Day VFR	• Exit of the UAM corridor will prompt UAM vehicle and ATC interaction in Class D airspace • Using standard phraseology ATC will communicate to UAM aircraft regarding the re-route and re-joining of the corridor using a known fix or transition point	IFR and VFR traffic



NC DT Scenario 2 Timeline

T/O Class D, en route Class G (Discovery route),
return to land at Class D





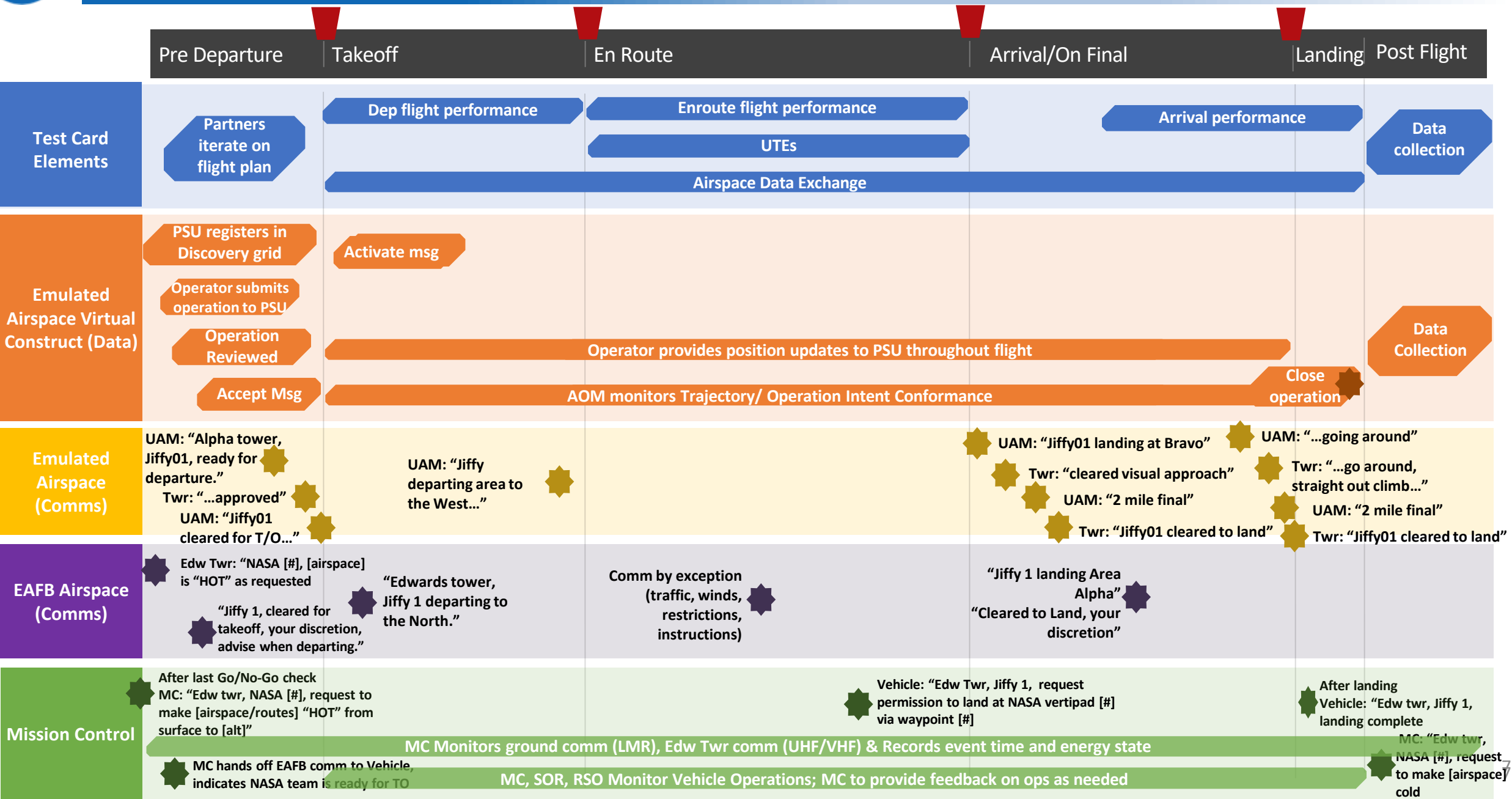
NC DT – Scenarios 3

Scenario Variation	Description	Airspace Assumptions	ATC Interactions	Background Traffic
Scenario 3	Scenario 3a: Go Around - Emulate occupied or obstructed vertipad that requires the UAM vehicle complete a go around and enter a loiter pattern - PSU provides a consistent off nominal approach as part of initial predeparture flight plan submission Scenario 3b: UAM vehicle divert to a runway - Emulate an emergency landing that requires priority sequencing and diversion to alternate landing location - Vehicle requires a runway landing due to limitations in controllability with given power conditions - UAM operator and vehicle will initiate interaction with ATC in Class D to obtain clearance for landing - The handoff and interactions between UAM operator, vehicle, and ATC need to be defined - Emulated environmental conditions require a balked landing to be executed	Day VFR UAM corridor has been established and is in us - o Allows for multiple UAM flights in the corridor - o No 2 way VHF/UHF comms req'd in nominal ops so UAM operator will resequence vehicle performing a go-around into stream of virtual traffic	3a: ATC Interaction may not be required 3b: ATC interaction required with vehicle and UAM operator	IFR, GA, and UAM virtual traffic. The IFR and GA traffic will emulate a Class D airport and the UAM virtual traffic will follow route and adjacent routes following a static schedule



NC DT Scenario 3a/b Timeline

T/O Class D, en route Class G (Discovery route), return to land at Class D & execute go-around

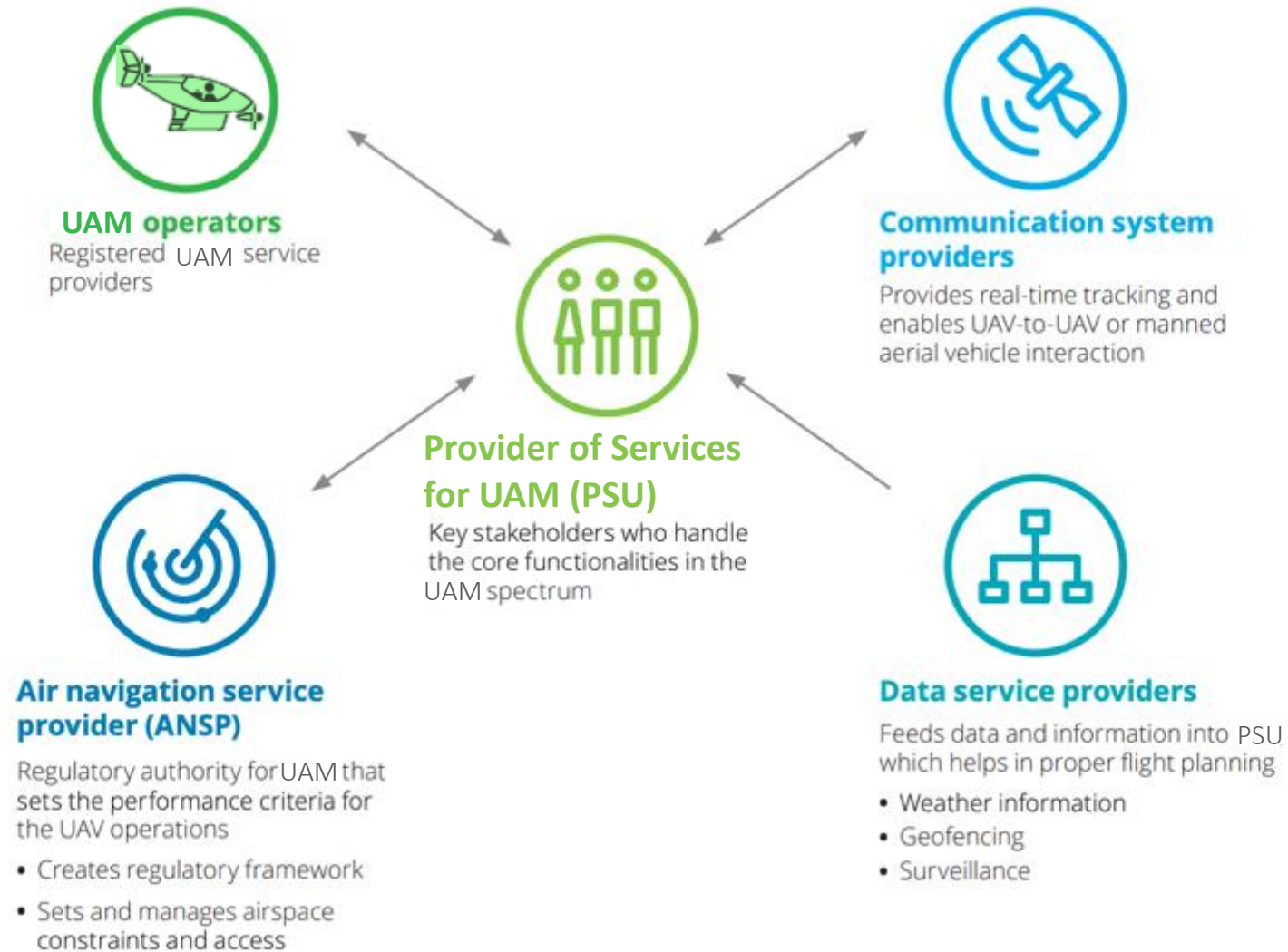




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NC EMULATIONS AND VIRTUAL DRY RUN

Roles and Responsibilities of UAM Entities





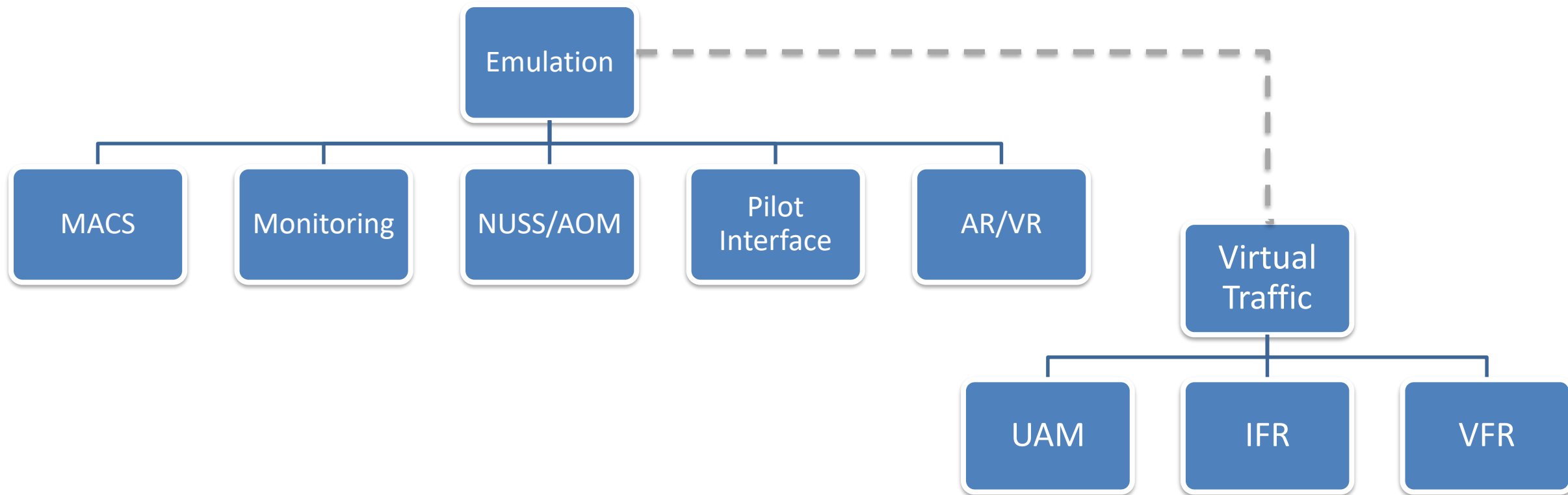
Airspace Emulation – Key Attributes

Emulation and virtual traffic can be described as a simulated environment with particular attributes needed to model airspace operations. The attributes include:

- Generic airspace characteristics
- Approach and departure procedures
- Origin/destination pairs
- Airspace restrictions and flow controls
- Virtual traffic mix with IFR, GA, and other UAM traffic
- Urban layer mask (geofence boundaries) to represent a generic urban cityscape
- Weather



Emulation and Virtual Traffic Elements



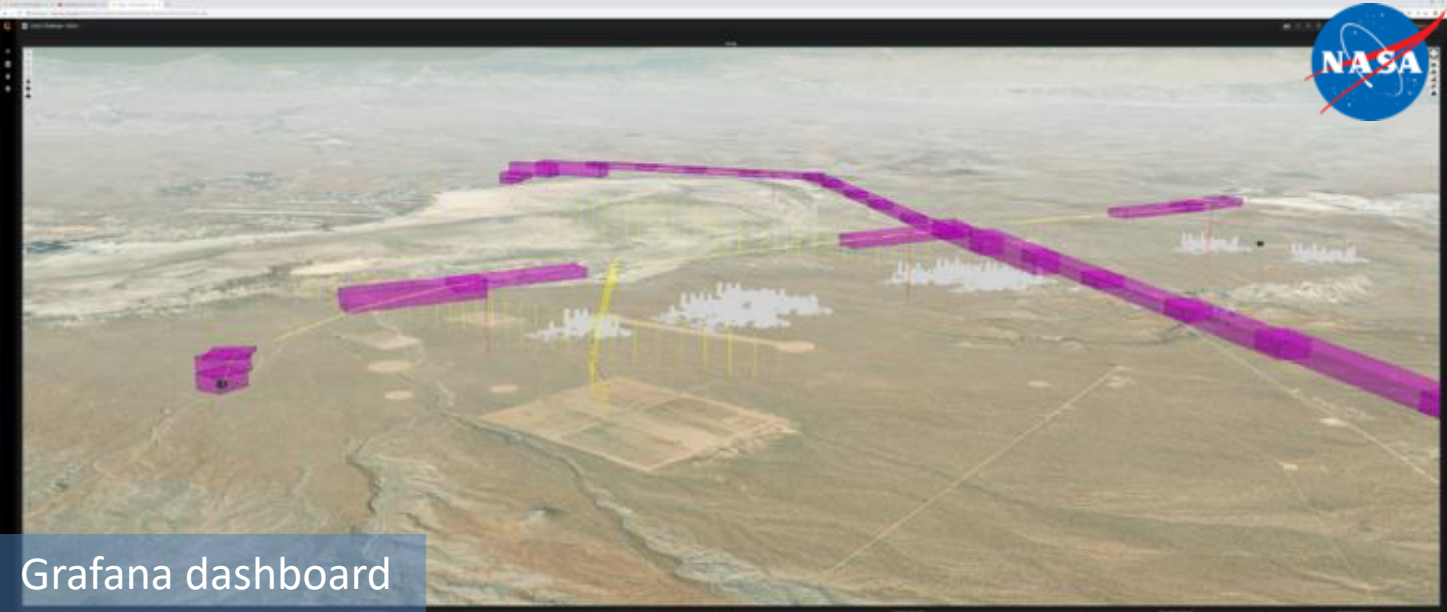
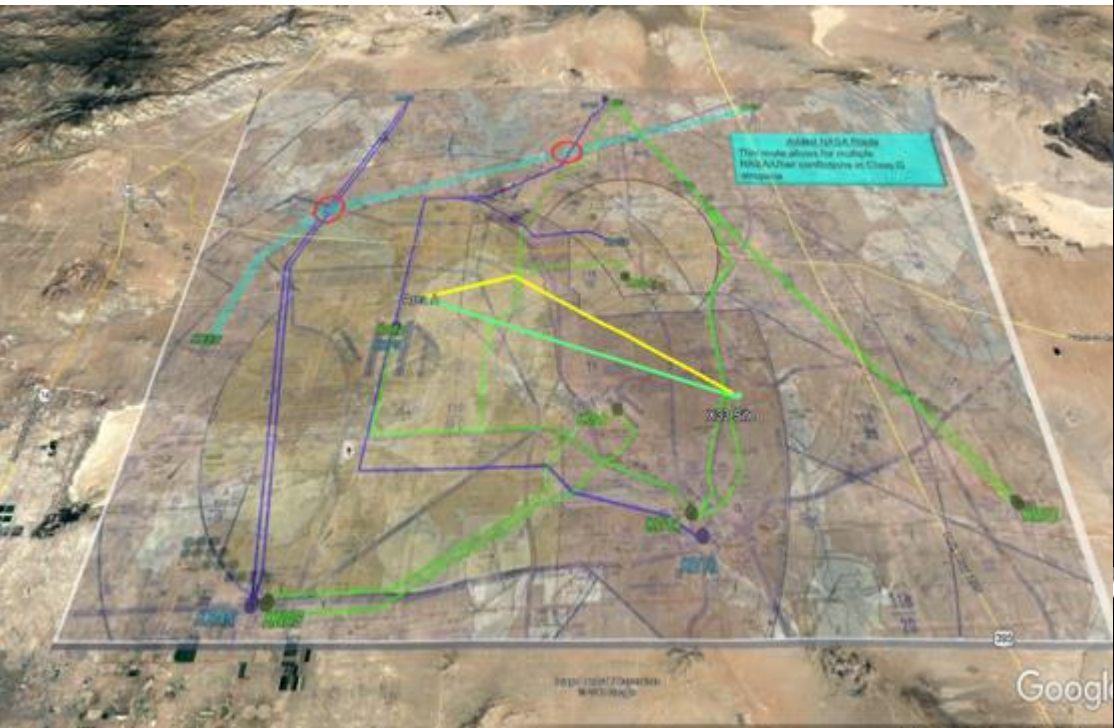


ATI: Emulation Component Description

	Description of Elements	Implementation for DT	Proposed Implementation for NC1
Airspace Characteristics	Generic airspace based on a metroplex area with the desired characteristics - Airspace boundaries - Formalized fixes for UAM flights (flight path planning purposes) - Inclusion and proximity to class D, C, or B airport? - Proximity to an urban center?	Adaptation file with the appropriate characteristics, fixes, and associated data shared with partners	Real time and dynamic airspace boundaries and flow configuration changes should be considered
Approach/Dep Procedures	Leverage TERPS work and develop appropriate routes to reflect the procedures	Procedures need to be developed into coded routes for the adaptation files and in ARNC format for vehicles	Real time updates to approach/dep procedures from AOM should be considered
Origin/Destination Pair	Reflect real take off and landing location at AFRC and the associated flight paths Dependent on site selection and locations at AFRC	Provide lat/lon locations of take off and landing locations	Real time updates and contingency planning for unplanned approaches to unknown destinations
Airspace Restrictions	Method of indicating restricted airspaces (i.e. Class B airspace) as well as dynamic restrictions (i.e. TFRs)	UVRs in current UTM implementation can be utilized	Develop new interface with ATMx and partners for real time restriction data
Virtual Traffic	Traffic mix with IFR, GA, and other UAM modeled flights IFR and GA flights can be taken from a day in the NAS leveraging SWIM	UAM traffic information shared through USS-USS In airspace system backbone additional data can be provided for IFR traffic flows (SWIM format); industry partner develops interface to ingest this data	
Urban Layer Mask	Geofence boundaries to represent a generic urban cityscape and terrain	File with lat/lon and boundary data for polygons	Develop new interface with ATMx and partners
Weather	Wind profiles across altitudes and gusts can be emulated	Wind sensors will provide data for flights at AFRC	Develop new interface with ATMx and partners



ATI Emulations





NC Virtual Dry Run and Dry Run Linkage to DT

The virtual dry run and helicopter dry run are complementary activities that support DT objectives and reduce risk for NC DT and NC-1

NC DT Dry Run Objectives



Virtual Dry Run

- NC DT **scenario assessment and revision** with pilot in the loop **with a representative UAM vehicle model** and flight controls
- Enables revision of scenarios, emulations, and development of test cards independent of MOF buildup and vehicle partners
- **End to end data collection** with high fidelity vehicle model and data sharing with the FAA

NC DT Objectives



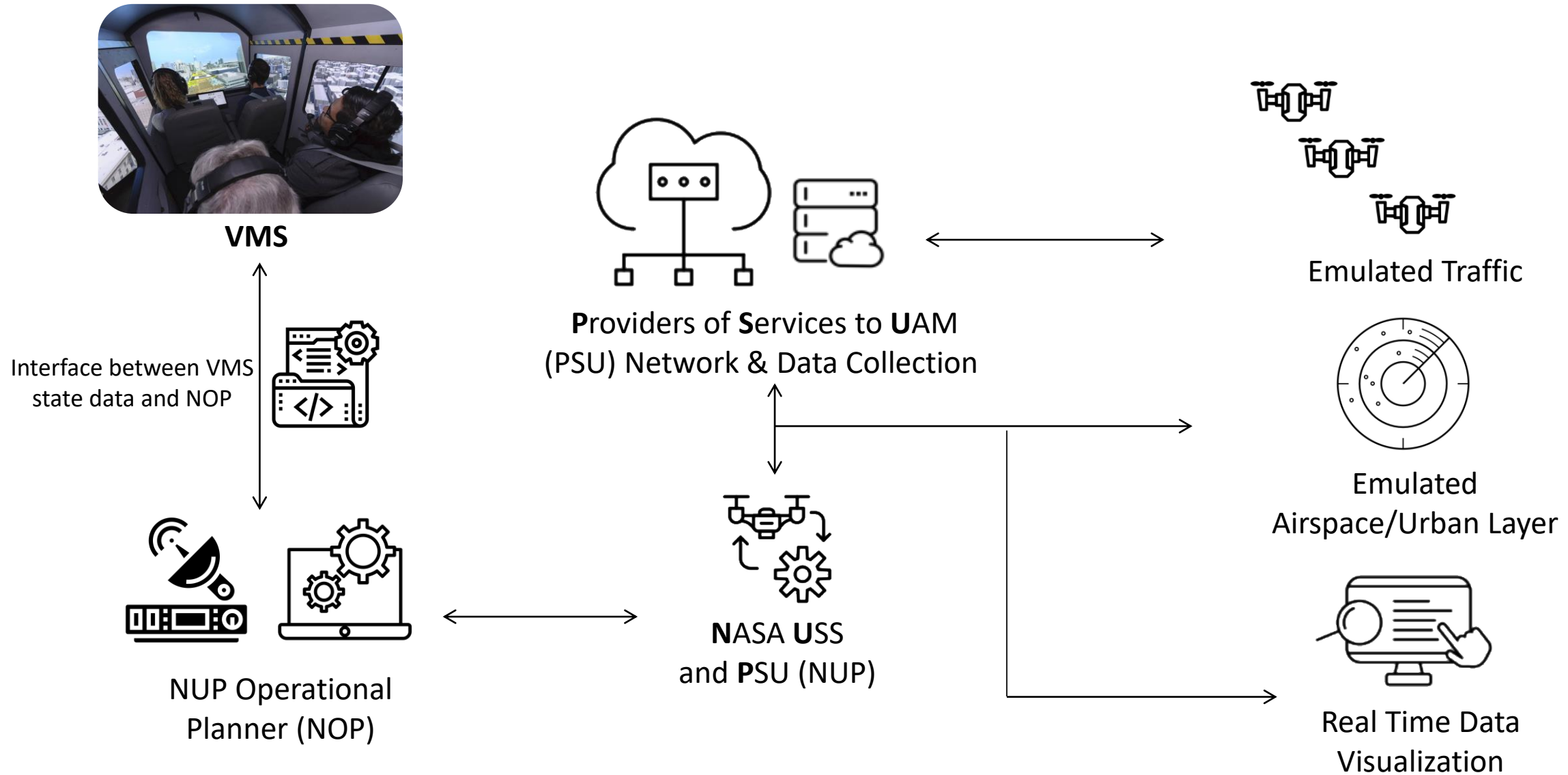
Dry Run at AFRC

- **Operational assessment** and revision with pilot in the loop of NC scenarios using a helicopter as a stand in representative vehicle
- Enables assessment and development of external MOF and its capabilities prior to deployment for NC activities
- **Assess operational processes** for integrated operations with vehicle and airspace and **data collection in the field**





ATI Infrastructure





Virtual Dry Run Simulation Goals

VG1: Test virtual cockpit to ground (NOP) and cloud (PSU) connectivity

- a. JSON-formatted state data to NOP
- b. NOP connectivity to AWS cloud-based PSU network
- c. AWS cloud-based PSU network to EFB-like tablet in cockpit

VG2: Provide a representative vehicle telemetry data package for FAA review

- a. Enables development and collection of data package from VMS
- b. Enables FAA to determine viability of future utilization of VMS for stab/controls/perf data

VG3: Validate scenario flight test operations

- a. Day-in-the-life flight test procedures
- b. Aircrew operation of tablet
- c. Ground crew (ATI) operation of NOP
- d. Range operations manager integrated operations
- e. Validation of approach and departure procedures
- f. Validation of test management procedures (brief, pre-departure sequence, test cards, etc)
- g. Fly-out of each scenario for safety, data collection...

VG4: Demonstrate eVTOL M&S capability to NC partners and stake holders

- a. NC Vehicle partners
- b. NC Information Exchange partners
- c. Other stake holders