



# **Unmanned Aircraft Systems Traffic Management (UTM)**

## **SAFELY ENABLING UAS OPERATIONS IN LOW-ALTITUDE AIRSPACE**

Parimal Kopardekar, Ph.D.

NASA Senior Technologist, Air Transportation System, and  
UAS Traffic Management Principal Investigator

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# Overview

# Low Altitude UAS Operations

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- Small UAS forecast – 7M total, 2.6M commercial by 2020
- Vehicles are automated and airspace integration is necessary
- New entrants desire access and flexibility for operations
- Current users want to ensure safety and continued access
- Regulators need a way to put structures as needed
- Operational concept being developed to address beyond visual line of sight UAS operations under 400 ft AGL in uncontrolled airspace using UTM construct

# What is UTM?

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- UTM is an “air traffic management” ecosystem for uncontrolled airspace
- UTM utilizes industry’s ability to supply services under FAA’s regulatory authority where these services do not exist
- UTM development will ultimately identify services, roles/responsibilities, information architecture, data exchange protocols, software functions, infrastructure, and performance requirements for enabling the management of low-altitude uncontrolled UAS operations

UTM addresses critical gaps associated with lack of support for uncontrolled operations  
*How to enable multiple BVLOS operations in low-altitude airspace?*

# Key Operational Assumptions



- FAA maintains regulatory *AND* operational authority for airspace and traffic operations
- UTM is used by FAA to issue directives, constraints, and airspace configurations
- Air traffic controllers **are not required** to actively “control” every UAS in uncontrolled airspace or uncontrolled operations inside controlled airspace
- FAA has on-demand access to airspace users and can maintain situation awareness through UTM
- UTM roles/responsibilities: Regulator, UAS Operator, and UAS Service Supplier (USS)
- FAA Air Traffic can institute operational constraints for safety reasons anytime

Key principle is safely integrate UAS in uncontrolled airspace without burdening current ATM

## Principles

- ☐ Users operate in airspace volumes as specified in authorizations, which are issued based on type of operation and operator/vehicle performance
- ☐ UAS stay clear of each other
- ☐ UAS and manned aircraft stay clear of each other
- ☐ UAS operator has complete awareness of airspace and other constraints
- ☐ Public safety UAS have priority over other UAS

## Key UAS-related services

- ☐ Authorization/Authentication
- ☐ Airspace configuration and static and dynamic geo-fence definitions
- ☐ Track and locate
- ☐ Communications and control (spectrum)
- ☐ Weather and wind prediction and sensing
- ☐ Conflict avoidance (e.g., airspace notification)
- ☐ Demand/capacity management
- ☐ Large-scale contingency management (e.g., GPS or cell outage)



# Defining Operator and Regulator/ANSP Roles



## UAS Operator

- Assure communication, navigation, and surveillance (CNS) for vehicle
- Register
- Train/qualify to operate
- Avoid other aircraft, terrain, and obstacles
- Comply with airspace constraints
- Avoid incompatible weather

## Regulator/Air Navigation Service Provider

- Define and inform airspace constraints
- Facilitate collaboration among UAS operators for de-confliction
- If future demand warrants, provide air traffic management
  - Through near real-time airspace control
  - Through air traffic control integrated with manned aircraft traffic control, where needed

**Third-party entities may provide support services but are not separately categorized or regulated**

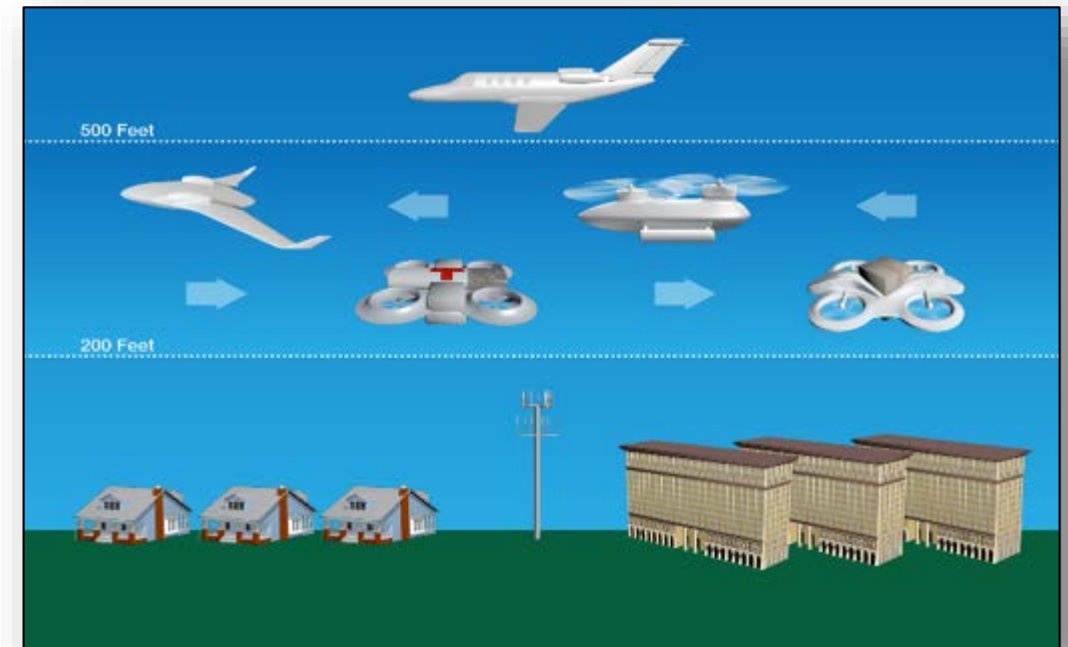


# Supporting Functions



## WIND & WEATHER INTEGRATION

- Operator responsibility, may be provided by third party
- Actual and predicted winds/weather
- No unique approval required



## Operations Considerations

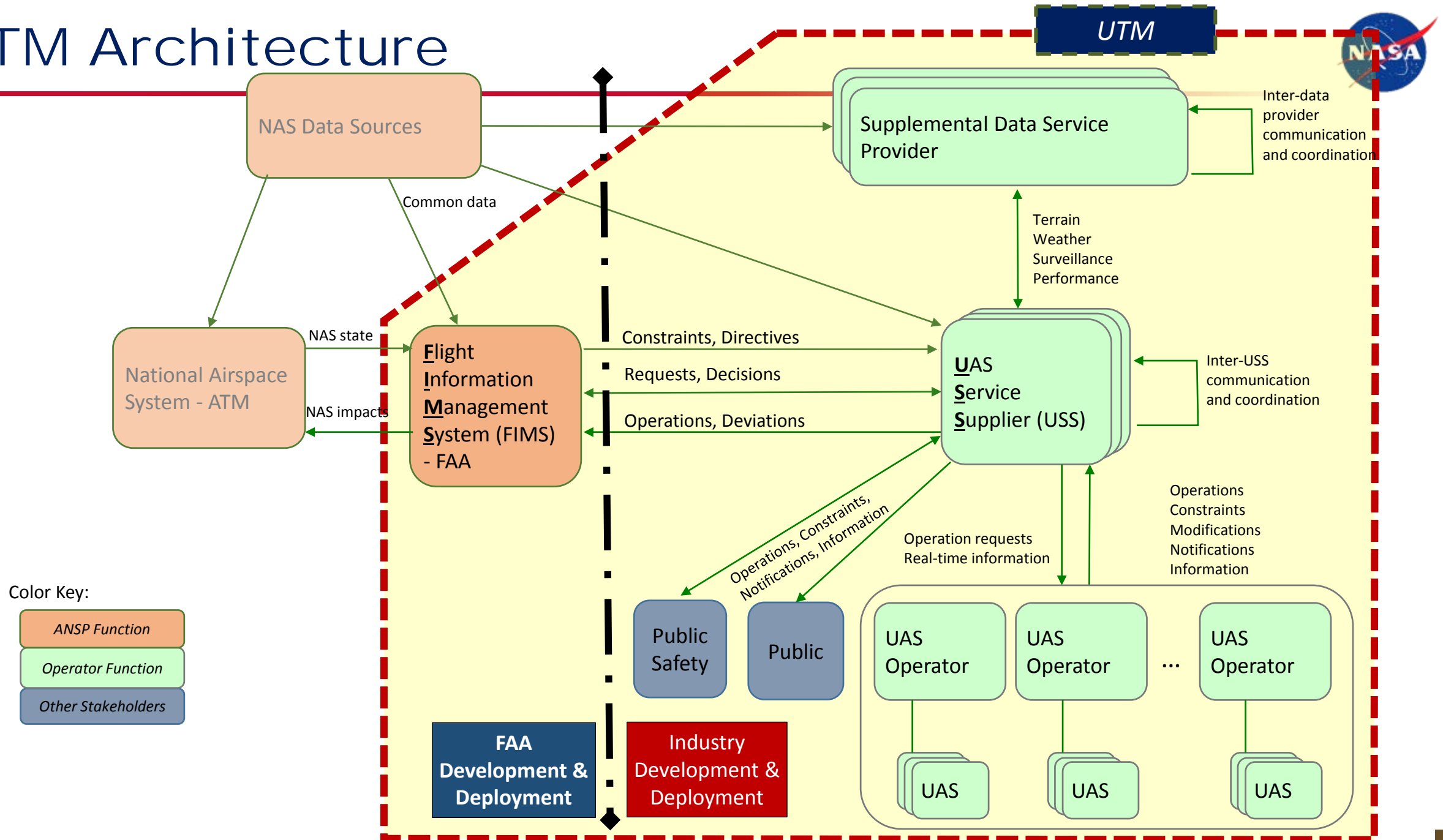
- Overarching architecture
- Scheduling and planning
- Dynamic constraints
- Real-time tracking integration
- Weather and wind
- Alerts:
  - Demand/capacity alerts
  - Safety critical events
  - Priority access enabling (public safety)
  - All clear or all land alerts
- Data exchange protocols
- Cyber security
- Connection to FAA systems

## Vehicle Considerations

- Low SWAP DAA
- Vehicle tracking: cell, satellite, ADS-B, pseudo-lites
- Reliable control system
- Geo-fencing conformance
- Safe landing
- Cyber secure communications
- Ultra-noise vehicles
- Long endurance
- GPS free/degraded conditions
- Autonomous last/first 50 feet operations

# Architecture

# UTM Architecture



# UTM Approach and Schedule

# UTM Technical Capability Levels (TCLs)



## CAPABILITY 1: DEMONSTRATED HOW TO ENABLE MULTIPLE OPERATIONS UNDER CONSTRAINTS

- Notification of area of operation
- Over unpopulated land or water
- Minimal general aviation traffic in area
- Contingencies handled by UAS pilot

**Product: Overall con ops, architecture, and roles**

## CAPABILITY 3: FOCUSES ON HOW TO ENABLE MULTIPLE HETEROGENEOUS OPERATIONS

- Beyond visual line of sight/expanded
- Over moderately populated land
- Some interaction with manned aircraft
- Tracking, V2V, V2UTM and internet connected

**Product: Requirements for heterogeneous operations**

## CAPABILITY 2: DEMONSTRATED HOW TO ENABLE EXPANDED MULTIPLE OPERATIONS

- Beyond visual line-of-sight
- Tracking and low density operations
- Sparsely populated areas
- Procedures and “rules-of-the road”
- Longer range applications

**Product: Requirements for multiple BVLOS operations including off-nominal dynamic changes**

## CAPABILITY 4: FOCUSES ON ENABLING MULTIPLE HETEROGENEOUS HIGH DENSITY URBAN OPERATIONS

- Beyond visual line of sight
- Urban environments, higher density
- Autonomous V2V, internet connected
- Large-scale contingencies mitigation
- Urban use cases

**Product: Requirements to manage contingencies in high density, heterogeneous, and constrained operations**

**Risk-based approach: depends on application and geography**



# UTM TCL2: Scheduling and Executing Multiple BVLOS Operations



## Conflict Alerts

Alert triggered by proximity to other aircraft

## Intruder Alerts

Alert triggered from radar submitted warning regions to UTM research prototype

## Contingency Alerts

Simulated in-flight emergency reported to the UTM research prototype and relayed to impacted operations

## Flight Conformance Alerts

Alert triggered from departing from operational area and relayed to impacted operations

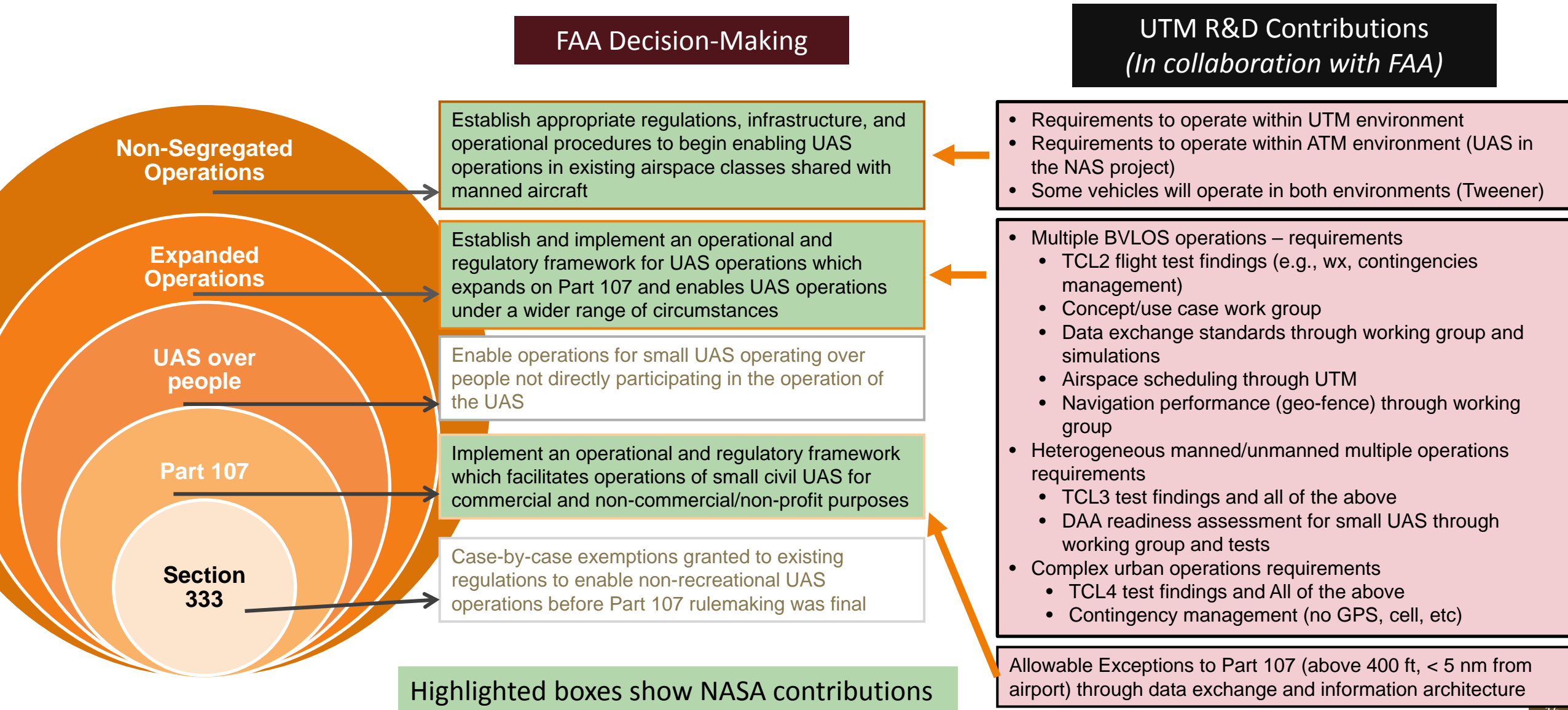
## Priority Operations

Users with special privileges are given priority of the airspace and impacted operations are informed of any conflicts

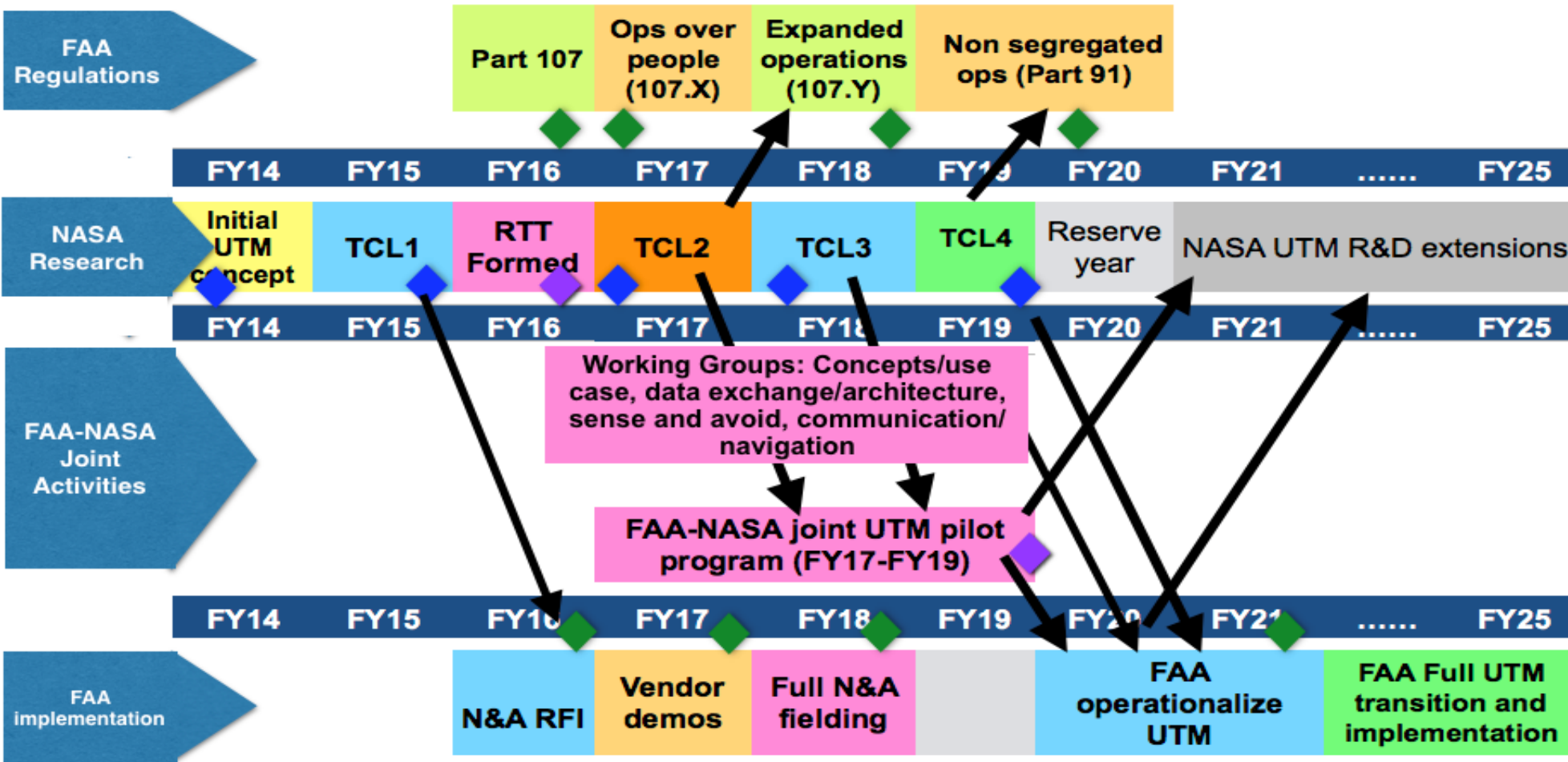
Scheduling and tracking operations and contingency management



# Contributions to FAA Decision-Making Process



# UTM Development and Implementation



**UTM research platform:** cloud-based architecture, standard data exchange, connection through APIs to support scheduling, planning, and tracking of multiple operations in the airspace

- TCL1:** Multiple operations with API, share information about area of operation and schedule
- TCL2:** Multiple BVLOS operations with API, and cloud-based architecture
- TCL3:** Multiple BVLOS operations with manned and unmanned operations
- TCL4:** Multiple BVLOS operations in complex urban settings

## Tech Transfer

- Information exchange standard
- Architecture
- Performance
- UTM Prototype

FAA milestones

NASA milestones

Joint FAA-NASA milestones

TCL: Technical Capability Level

# **FAA-NASA Research Transition Team (RTT) Deliverables**

# RTT Plan & Key Deliverables



- **Near-term priorities**

- Joint UTM Project Plan (JUMP) – December 2016 (Completed)
- RTT Research plan – January 2017
- UTM Pilot project – April 2017-2019

- **Execution**

- March 2016 – December 2020



- **Key RTT Deliverables (FAA needs)**

- Tech transfer- to FAA and industry
  - Concepts and requirements for data exchange and architecture, communication/navigation and detect/sense and avoid
    - Cloud-based architecture and Conops
    - Multiple, coordinated UAS BVLOS operations
    - Multiple BVLOS UAS and manned operations
    - Multiple operations in urban airspace
- Tech transfer to FAA
  - Flight Information Management System prototype (software prototype, application protocol interface description, algorithms, functional requirements)

- **FAA-NASA Key RTT Deliverable**

- Joint FAA-NASA UTM Pilot Program

RTT will culminate into key technical transfers to FAA and joint pilot program plan and execution

# Partnerships and Collaboration Approach

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- FAA and NASA are actively and closely collaborating
  - Over 200 collaborators: Gov't, industry, academia, FAA test sites, and FAA COE
- Industry is settling down: main players in commercial small UAS operators are emerging
- FAA and NASA will continue to collaborate to ensure agility and safety needs are balanced
- Other working groups
  - Information security group being formed
  - Weather group getting focused
  - Spectrum working group collaborating with CTIA

# Progress and Next Steps

# Value Proposition of UTM

(Agreed upon by stakeholders and FAA as discussed at OSTP panel)



- Unmanned vehicle operations coordination through agreed upon data/information exchanges about each others operations and with FAA systems
- Exceptions handling – entry into controlled airspace
  - Allowable exceptions to Part 107 operations (e.g., above 400 feet, less than 5 nm from airport)
- Beyond visual light of sight
- Manned and unmanned vehicle operations coordination
- Higher density operations

**Longer-term: Changing the paradigm of airspace operations**



# TCL 1 Demonstration



**What:** Demonstrated concept for management of airspace in lower risk environments and multiple UAS operations

**Where:** Crows Landing, CA

**Who:** NASA and several flying, weather, surveillance partners

**When:** Aug 2015



Collected state data for operations, weather conditions, communications with UTM System, sound readings

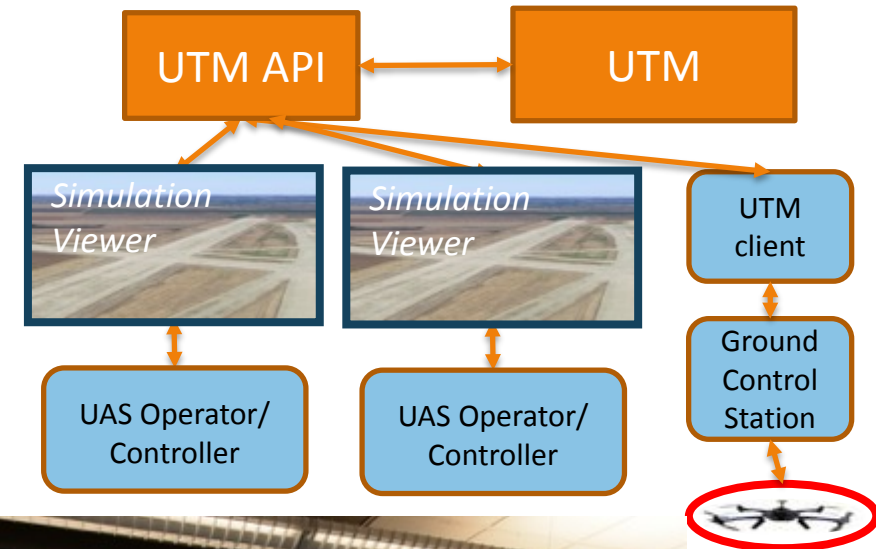
Built foundation for future demonstrations with proposed increased capabilities

Showed that operations that could represent many business cases are already enabled with the initial concept

# NASA UTM Simulation Capabilities



- Validation and Verification of UTM research prototype functions
- Develop, demonstrate, and evaluate advanced UTM services and operations
- Develop tools and procedures to manage UTM ops
- Accelerate and increase value of field tests and provide live virtual constructive (LVC) environments
- Simulate complex operations that cannot be done in the field (e.g. urban ops, 911 type scenarios)



# National Safe UAS Integration Campaign



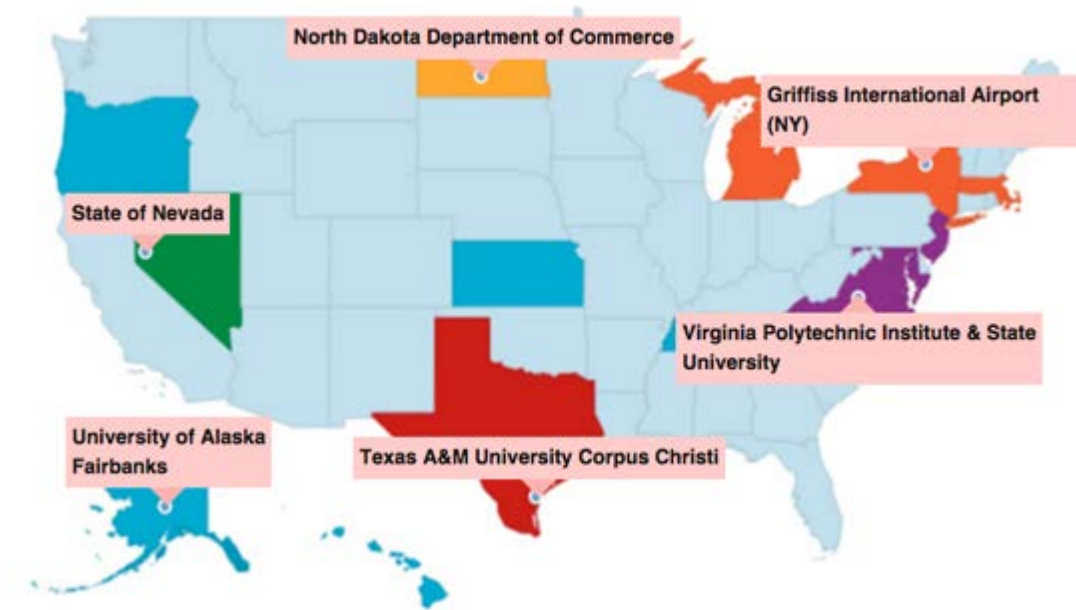
**What:** Demonstrated management of geographically diverse operations, 4 vehicles from each site flown simultaneously under UTM

**Where:** All 6 FAA UAS Test Sites

**Who:** NASA, Test Sites, support contractors

**When:** 19 April 2016

**24 live vehicles, over 100 live plus simulated flights under UTM in one hour –Highly successful**



Received positive feedback from the FAA Test Sites on the UTM concepts, technologies and operations

API based model worked well – enabled operator flexibility, exchanged information, and maintained safe operations



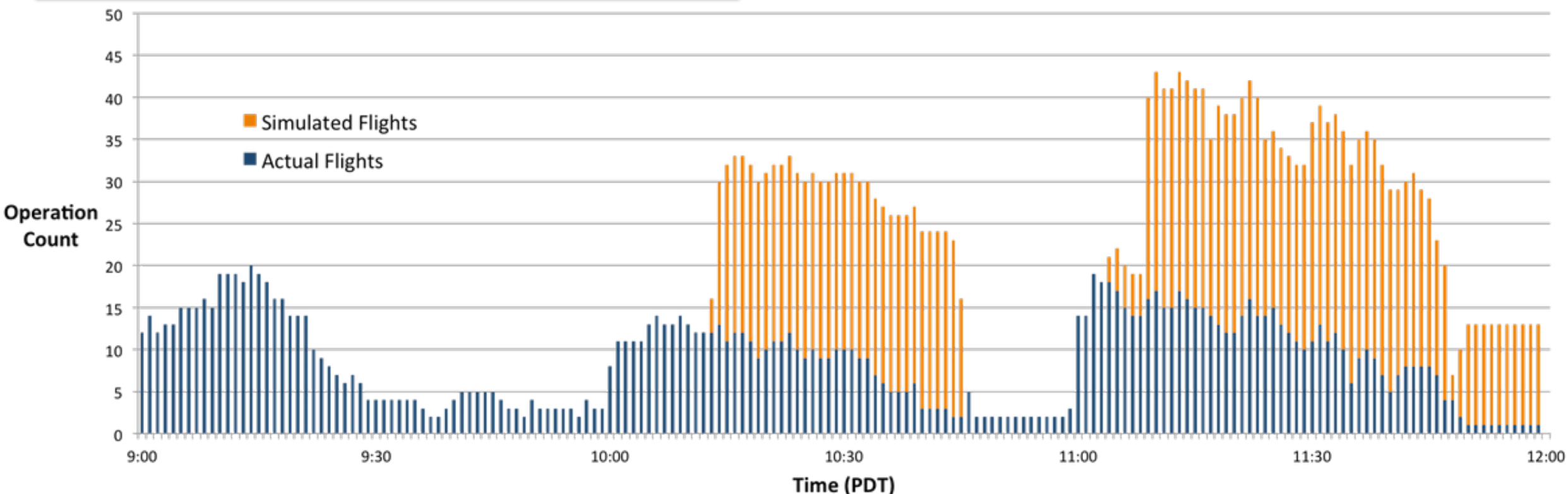
# Safe UAS Integration National Campaign



## National Campaign Statistics:

- 4 types of vehicles at each site
- 3 Hours
- 102 real, distinct flights

- 67 simulated operations injected
- About 31 hours of flight time
- 281.8 nmi flown



# TCL 2 Demonstration



**What:** Extension of TCL 1 to BVLOS. Will exercise handling of off-nominal scenarios, altitude stratification, initial wx integration, surveillance data, and other services.

**Where:** Likely Reno-Stead, Nevada

**Who:** NASA and several flying, weather, surveillance partners

**When:** Oct 2016

Demonstrate efficient airspace use through multi-segmented plans, altitude stratification, and other procedures

Incorporate input from surveillance systems to share awareness with all stakeholders within UTM

Fly BVLOS with multiple vehicles procedurally separated supported by data from the UTM System



# Key Lessons from TCL 2 (initial)

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- Still conducting analysis
- UTM's scheduling and planning capability was essential
- Collaborative airspace access appears to increase situation awareness
- Alerts of contingencies improved overall airspace safety
- Altitude standard is needed
- Impact of wind and weather: separation management
- Better forecasting of winds would be beneficial
- Expect the unexpected

# Next Steps

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- Additional TCL2 multiple BVLOS tests at all FAA test sites
  - Released statement of work recently
- TCL3 preparations ongoing
- Working groups continue: Join the collaborative innovation
- Continue to work closely with FAA on UTM pilot project



# Summary

# Key Takeaways

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- Close collaboration between FAA & NASA through RTT
- Close collaboration with industry, academia, COE, and test sites
- UTM RD&T and working group outcomes provide information that's time critical for FAA's acquisitions and path to safe access to all operations
- UTM RD&T provide validated requirements
  - Exceptions allowed under Part 107
  - Multiple beyond visual line of sight/expanded operations
  - Heterogeneous operations (manned and unmanned)
  - Urban operations
- Joint UTM pilot project will pave the way for initial multiple operations

# QUESTIONS?

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*Embracing innovation in aviation while respecting its safety tradition*