National Aeronautics and Space Administration

Unmanned Aircraft Systems Traffic Management (UTM)

SAFELY ENABLING UAS OPERATIONS IN LOW-ALTITUDE AIRSPACE

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Outline

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- Architecture
- Approach and schedule
- FAA-NASA Research Transition Team deliverables
- Progress and next steps
- Summary

Overview

Low Altitude UAS Operations

- 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?

- 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

UTM Principles and Services

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

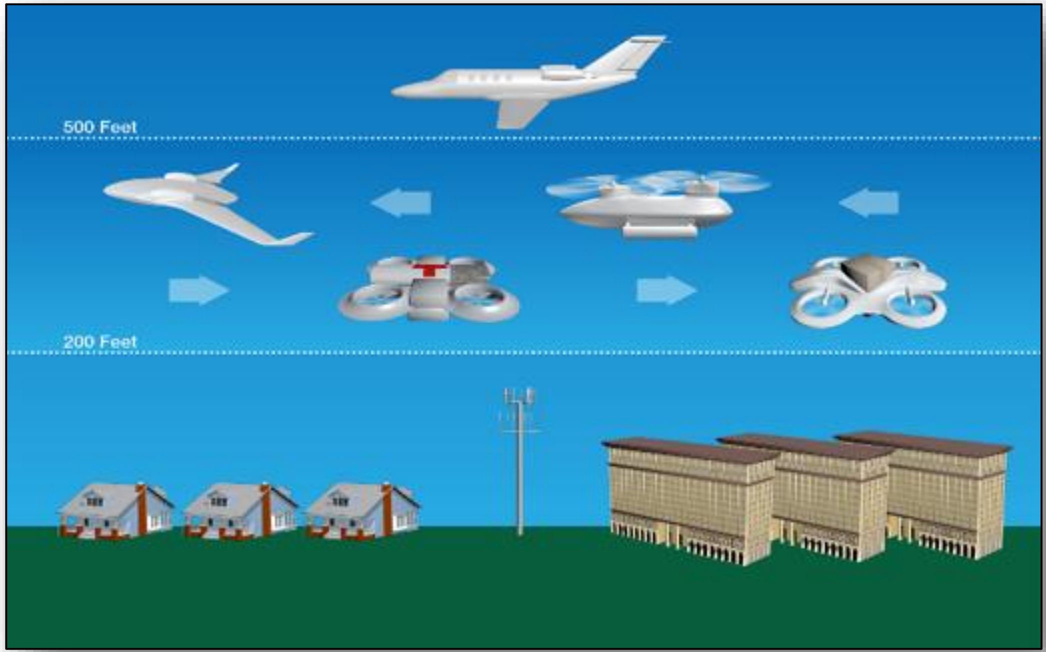
- Define and inform airspace constraints
- Facilitate collaboration among UAS operators for de-confliction
- If future demand warrants, provide air traffic management
  - Through near real-time airspace control
  - Through air traffic control integrated with manned aircraft traffic control, where needed

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



UTM Research and Development

Operations Considerations

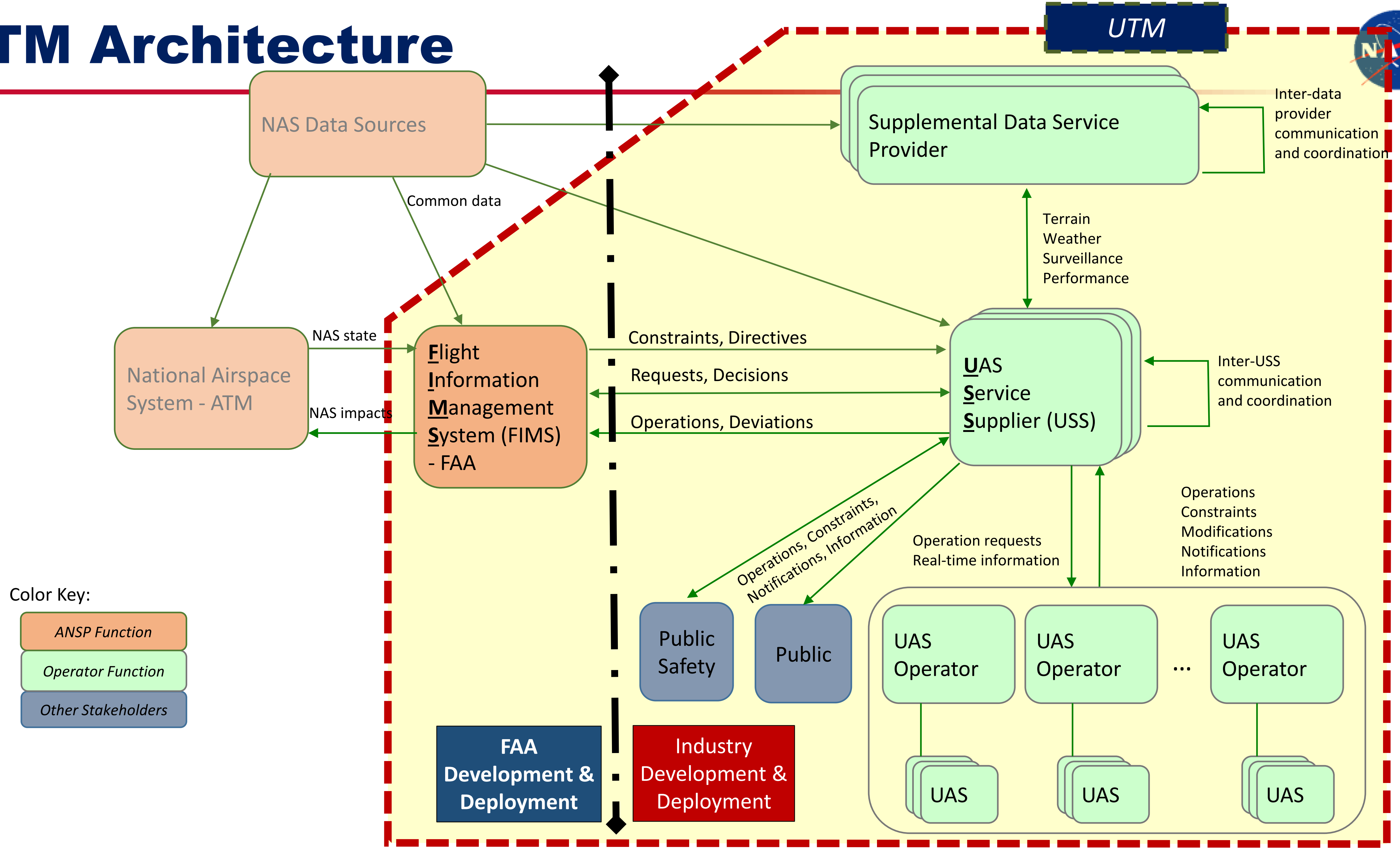
- Overarching architecture
- Scheduling and planning
- Dynamic constraints
- Real-time tracking integration
- Weather and wind
- Alerts:
  - Demand/capacity alerts
  - Safety critical events
  - Priority access enabling (public safety)
  - All clear or all land alerts
- Data exchange protocols
- Cyber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

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

- 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

<u>Longer-term</u>: 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

National Safe UAS Integration Campaign

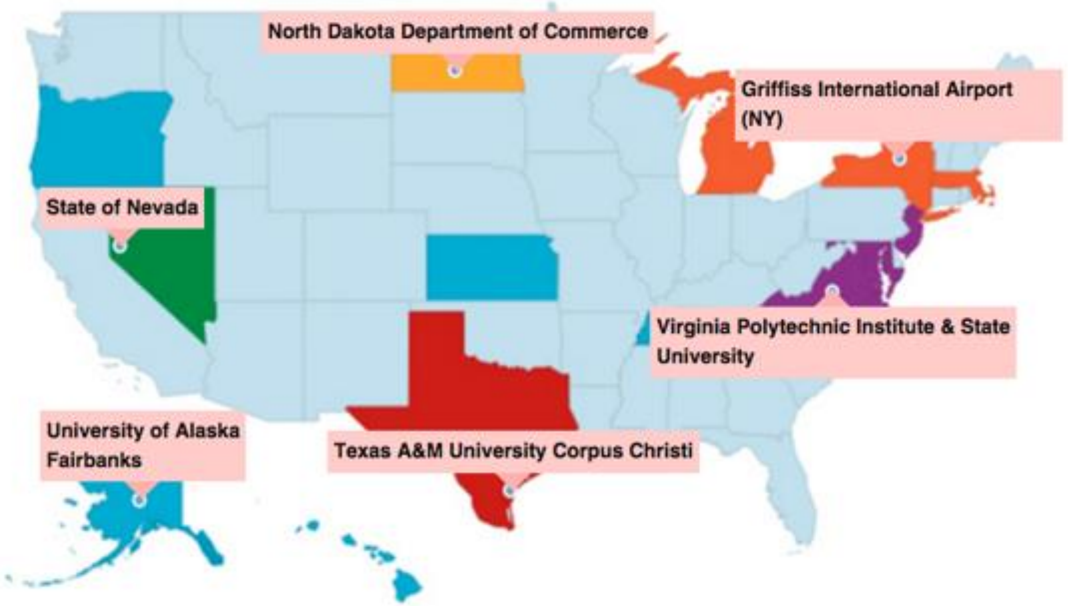
What: Demonstrated management of geographically diverse operations, 4 vehicles from each site flown simultaneously under UTM

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

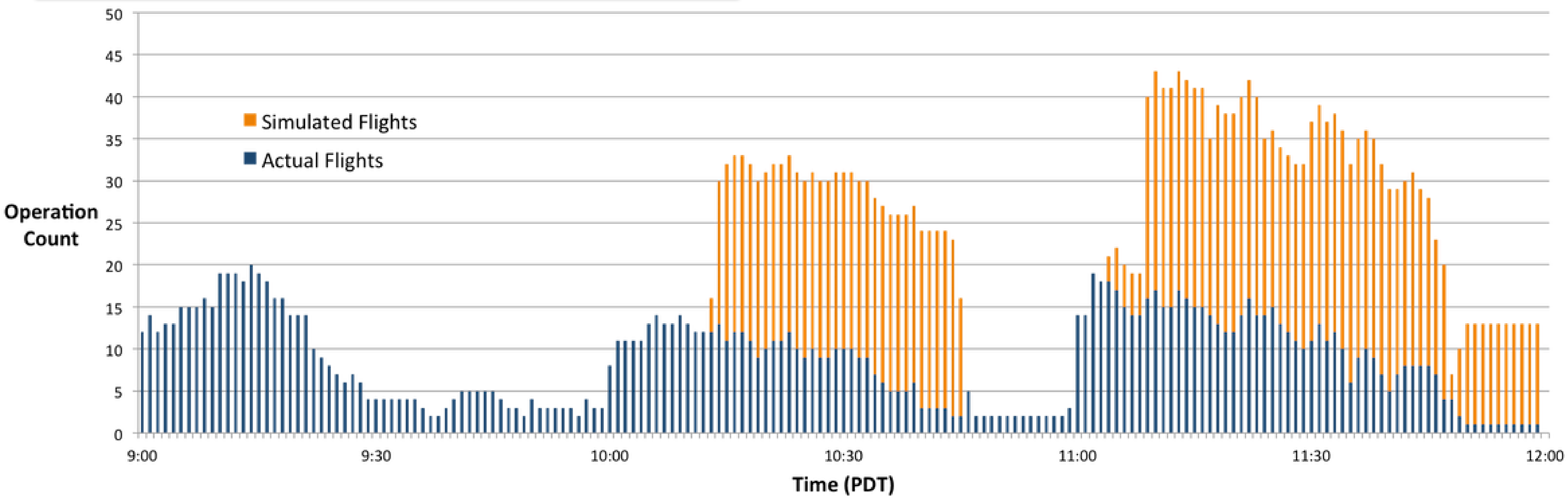
API based model worked well – enabled operator flexibility, exchanged information, and maintained safe operations

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

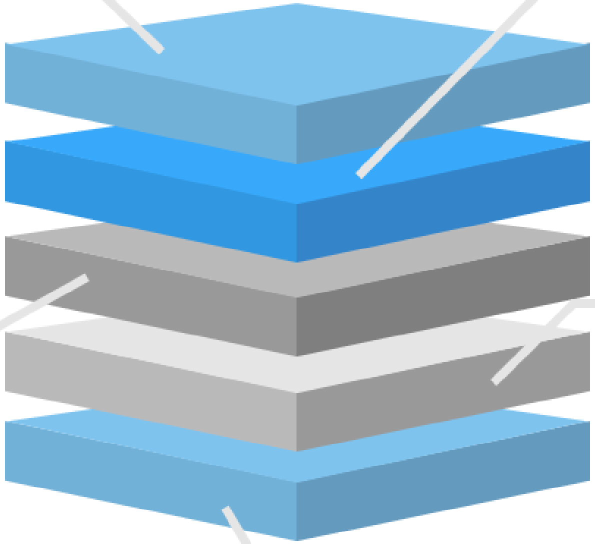
When: Oct 2016

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

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

Key Findings using UTM to support Expanded Operations

1

Information sharing provided situation awareness of airspace constraints

UTM clearly raised situation awareness and shifted flight crew's perspective of safety from a self-centered view to an airspace view.

2

Informative weather products are lacking

The test used numerous weather sensing equipment and weather products for forecasting, however the differences in local conditions and when the aircraft was aloft were dramatic.

3

User reported information enhanced safety

When users had the ability to communicate conflicts, like RF interference or weather conditions, it improved the safety and confidence in conducting operations. This was especially true in aggressive weather conditions.

4

Alerting is useful but alerting criteria is needed

Operators benefited from raised situation awareness due to notifications and alerts, but the frequency and severity diluted the usefulness for some operators.

A common awareness of all airspace constraints and hazards is essential for safe BVLOS operations

Key Findings using UTM to support Expanded Operations

5

Minimum set of GCS information is required

Mixed operations require additional information to maintain situation awareness. A minimum set of required display information and common units are needed to ensure each operator has a common dialect to communicate hazards in the airspace.

6

Differences reporting in altitude pose a hazard

A common altitude measure for information sharing and reporting, common units of measure, and an acceptable error tolerance for each measurement are needed.

7

Reliable and Redundant C2 Links

Even in favorable radio line of sight conditions lost link conditions occur and when operating in close proximity of other operations interference when aloft is an issue.

8

Vehicle performance should be rated by environment

Several vehicles greatly underperformed from what was listed by the manufacturers due to the environmental conditions. More uniformity and transparency as to how UAS are tested and at what conditions, is needed.

Industry standardization can reduce risk for BVLOS Operations

Key Lessons from TCL 2 (initial)

- 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

Summary

Key Takeaways

- 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
- Joint UTM pilot project will pave the way for initial multiple operations

QUESTIONS?

Embracing innovation in aviation while respecting its safety tradition