National Aeronautics and Space Administration


# Unmanned Aircraft Systems Traffic Management (UTM)

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Countering Drones
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NASA Ames Research Center

# Low Altitude UAS Operations

**FAA 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 safety structures in airspace

Operational concept being developed to address beyond-visual-line-of-sight (BVLOS) UAS operations at low altitude in uncontrolled airspace using UTM construct

# Challenges with Expanding Operations

**Visual Line of Sight**

14 CFR Part 91
[Hobbyists]
14 CFR Part 107
[Commercial]

No Operations over People
Daylight Only
Up to 400 ft AGL
Operation in controlled airspace allowed

Operations Near Airports

**Beyond Visual Line of Sight**

Separation

Weather

Command and Control

Awareness

Aircraft Performance

Operations over People

Tracking and UAS Identification

# What is UAS Traffic Management?

**UTM is an “air traffic management” ecosystem for uncontrolled operations**

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 to enable the management of low-altitude uncontrolled UAS operations

**UTM addresses critical gaps associated with lack of support for small UAS**

# Why is NASA doing these air traffic management/UTM things?

*“…not because they are easy, but because they are hard...”*

- NASA has a history of air traffic management research.
- NASA Ames may have the highest concentration of ATM researchers in the world.
- ATM is an often overlooked aspect of aeronautics research, but is vital when considering collections of aircraft accessing limited resources.
- ATM research is cross-discipline: aeronautics, computer science, operations research, physics, human factors, economics, meteorology, etc.

# UTM Architecture

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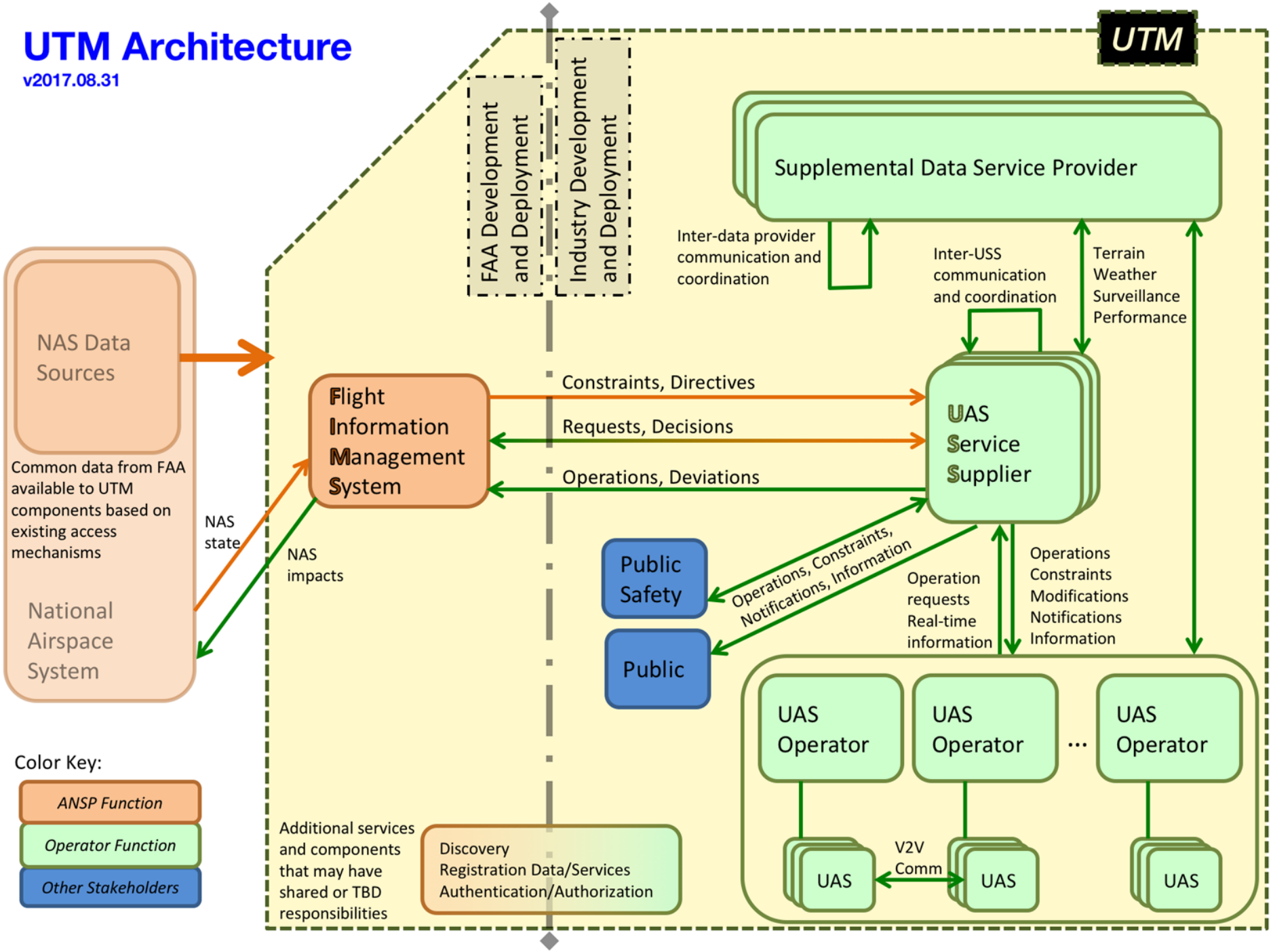
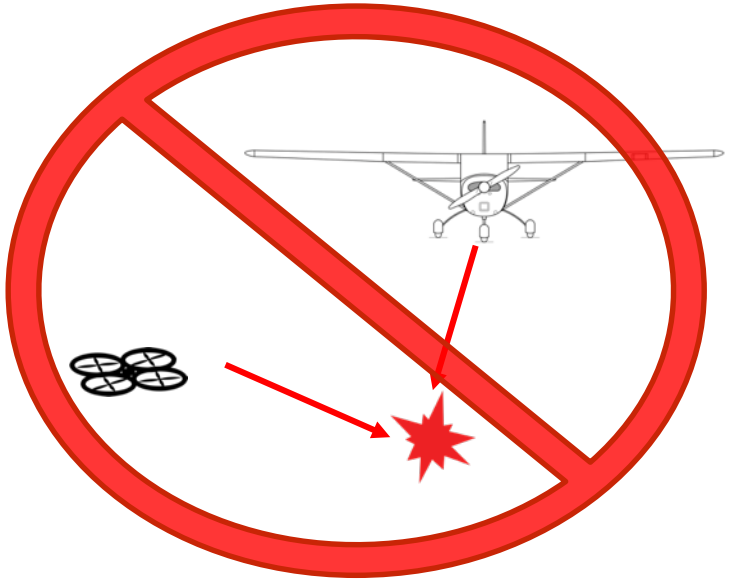
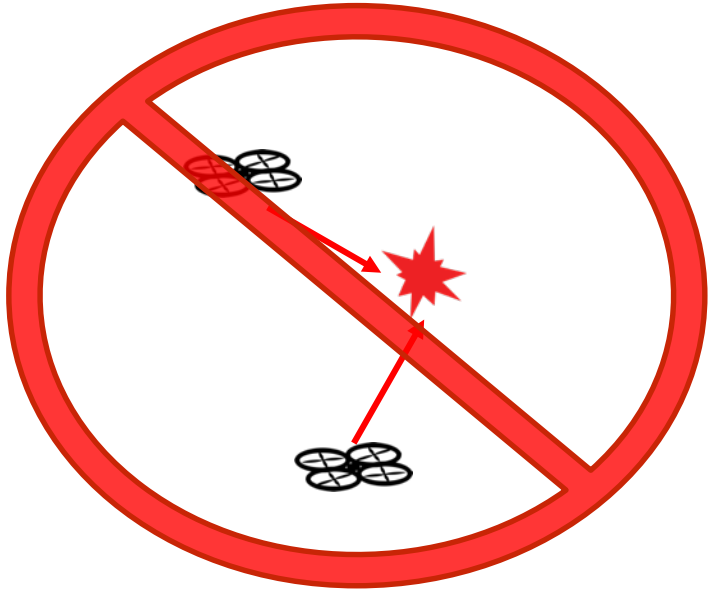
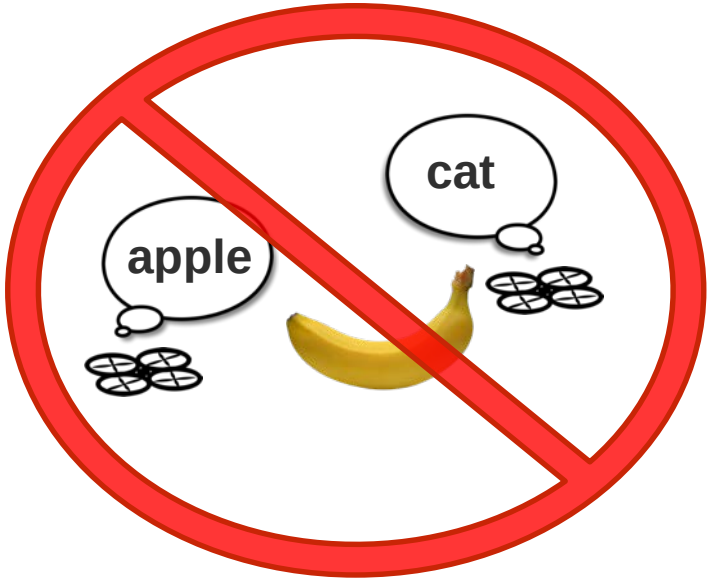


# Things that UTM will help with, a.k.a. UTM Principles…





# Technical Capability Level 2 Flight Test

**Evaluate the feasibility of multiple BVLOS operations using a UTM research platform**

# Flight Test Overview


## UAS Range

**Elevation: 5050 feet**

**Desert Terrain**

**Missions up to 500 ft**

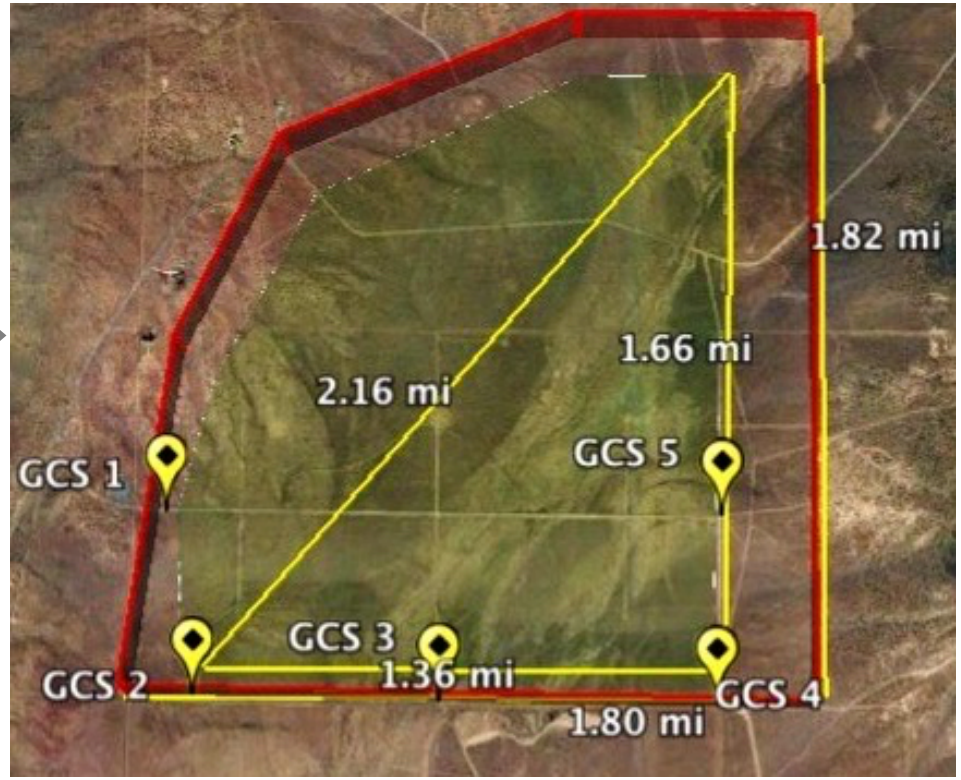
**Operations at 5 Locations**

SRHawk Radar

Weather Equipment

LSTAR Radar

## Nevada UAS Test Range




**October 2016**

# Flight Test Highlights

## Situation Awareness Displays

Critical alerts, operational plan information and map displays

## Altitude Stratified Operations

## Live-Virtual Constructive Environment

BVLOS **2** + Visual Line of Sight **3** = Simultaneous Operations **5**

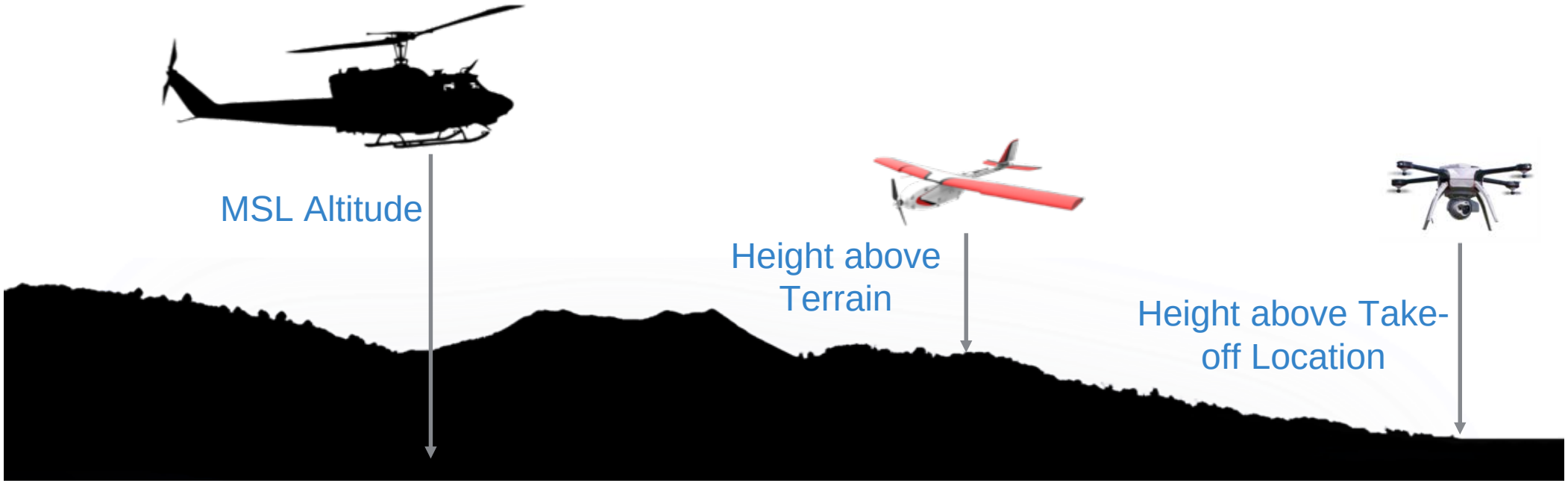
| Flights | UAS Vehicles | Partnerships |
|---|---|---|
| 74 | 11 | 14 |

| Scenarios | Minutes per scenario | Days of Flight |
|---|---|---|
| 4 | 30 | 5 |

# TCL 2 Flight Test Lessons Learned

# Inconsistent Altitude Reporting

**Increased risk of controlled flight into terrain and airborne collision hazard**




**Altitude reporting should be consistent or translatable across airspace users**

# Weather Impact on UAS

## Nominal Aircraft Endurance

**Multi-Rotors: 20-40 minutes**

**Fixed-Wing: 45-200+ minutes**

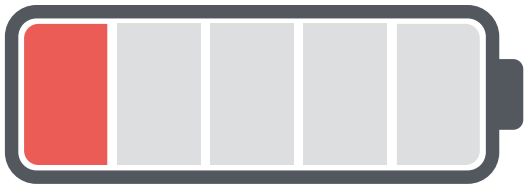
**Reno-Stead Elevation: 5,050 ft**

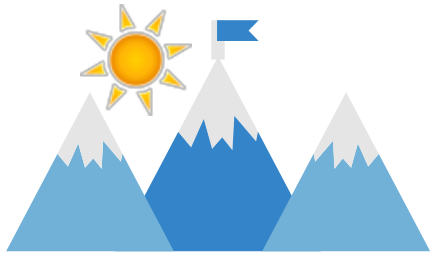
## Cool Temperatures

**Density Altitude: 4,000 ft**

**Winds: 5-35 knots**

Aircraft encountered **thermals**, **microbursts** and **high winds** which resulted in **reduced endurance** and degraded flight plan conformance





## Warm Temperatures

**Density Altitude: 9,000+ ft**

**Winds: 5-15 knots**

Aircraft experienced substantially **shorter endurance**

**UAS should be tested and rated against different operational environments**

# Recommendations for BVLOS Operations

1. Operators should **display airspace information** and have access to other operator's operational intent and contingency actions in off-nominal conditions

2. **Altitude reporting** should be **standardized** and consistent/translatable to current airspace users

3. In the absence of acceptable weather products, **atmospheric conditions** should be **self-reported from GCS and UAS**

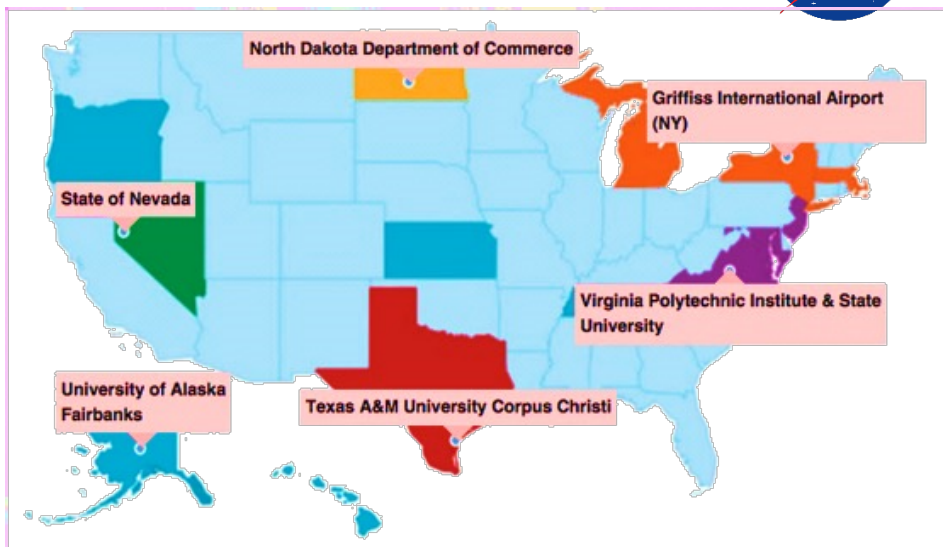
4. Initial BVLOS should **avoid altitude stratification**, until improved position sharing (e.g. V2V) and weather products

5. **Flight trajectories** should be **contained within geo-fence boundaries** that are shared with the UTM research platform **to support separation**

# TCL 2 National Campaign

## May 15th – June 9th 2017

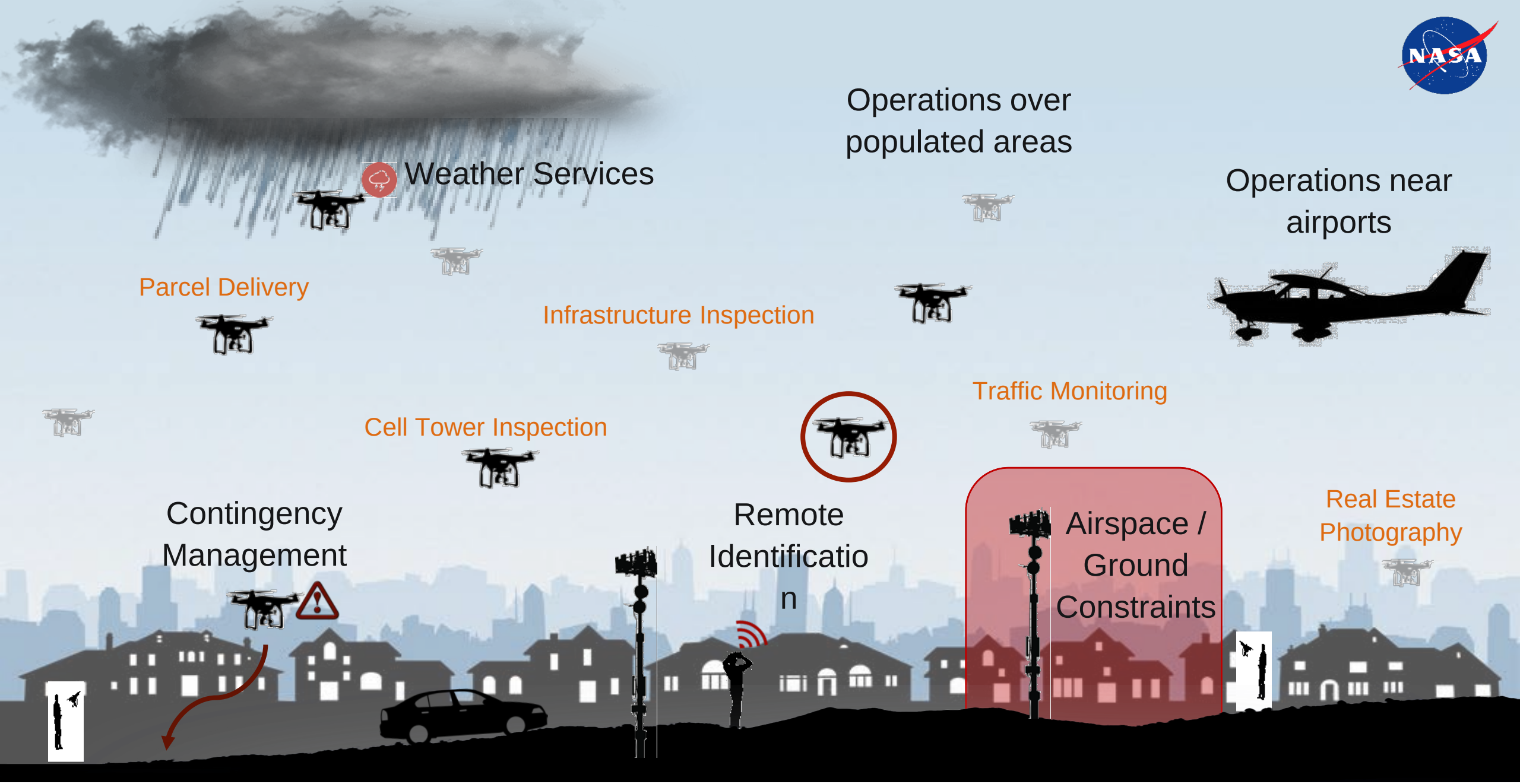
- ~40 partners total across 6 testing locations
- 6 USS Implementers (Amazon Prime Air, Google Project Wing, Airmap, Simulyze, ANRA, NASA)
- NASA USS and FIMS run in the cloud
- Data feeds monitored in UTM lab and at each location
- Multiple Media days

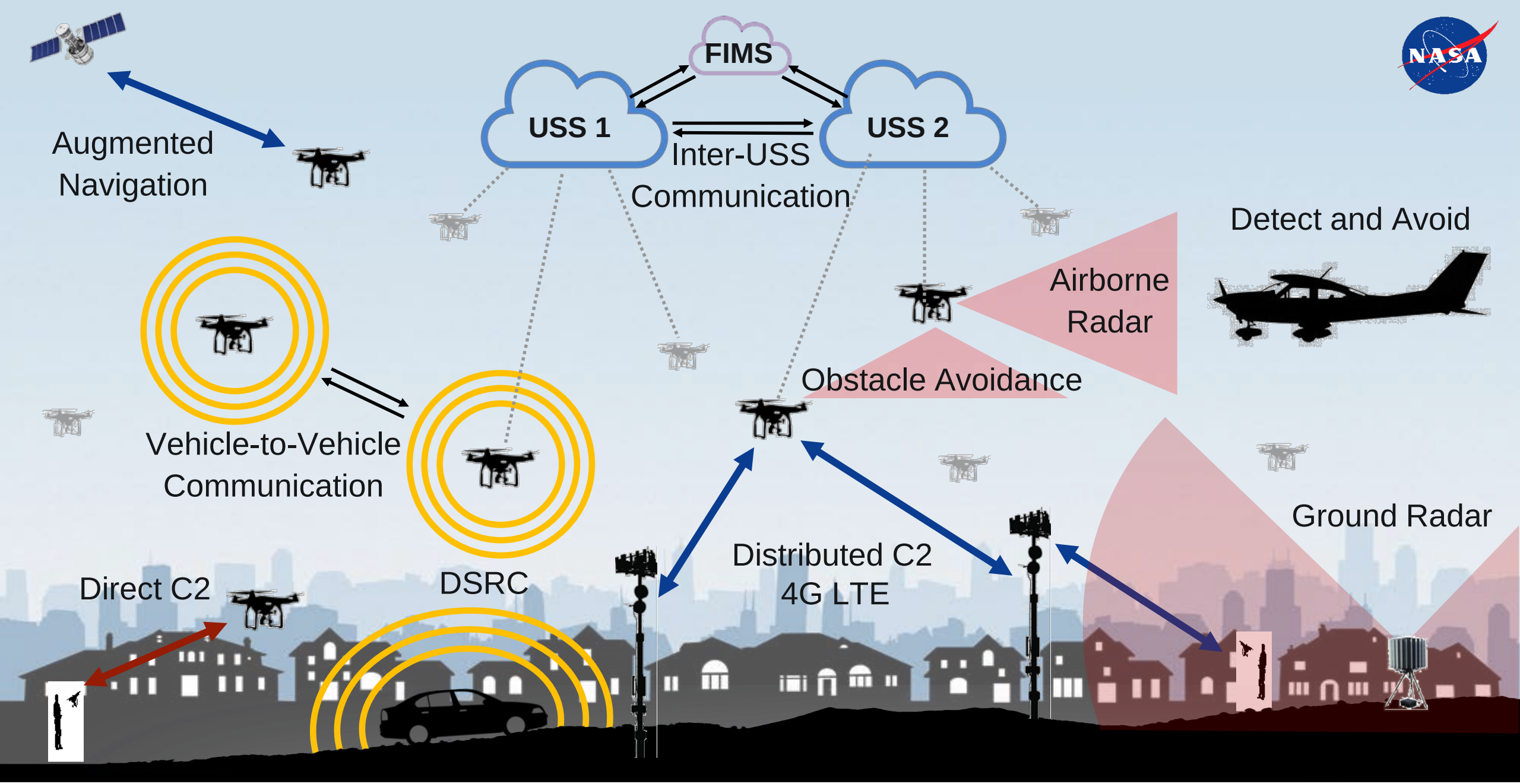




| Test Sites | USS Technology | Geofence Technology | Ground-based Sense & Avoid | Airborne Sense & Avoid | Communication, Navigation, Surveillance | Human Factors |
|---|---|---|---|---|---|---|
| Alaska | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Nevada | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| New York | | ✓ | | | ✓ | |
| North Dakota | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Texas | | | | ✓ | | |
| Virginia | ✓ | | ✓ | ✓ | | ✓ |

# Multiple BVLOS operations near airports and suburban areas (TCL 3)


Weather Services
Operations over populated areas
Operations near airports
Parcel Delivery
Infrastructure Inspection
Traffic Monitoring
Cell Tower Inspection
Contingency Management
Remote Identification
Airspace / Ground Constraints
Real Estate Photography


FIMS
USS 1
USS 2
Inter-USS
Communication
Augmented
Navigation
Detect and Avoid
Airborne
Radar
Obstacle Avoidance
Vehicle-to-Vehicle
Communication
DSRC
Direct C2
Distributed C2
4G LTE
Ground Radar

# Summary

**UAS Traffic Management** is an automated cloud-based “air traffic management” ecosystem for uncontrolled airspace where services do not exist

**TCL 2 Demonstration and TCL 2 National Campaign** successfully showed the feasibility of supporting multiple BVLOS operations in a rural environment, engaged industry to contribute to the development of UTM and highlighted areas of future research

**Next Steps** will evaluate the effectiveness and interoperability of technologies to support separation, communication, navigation, data-exchange, and airspace management in more complex operational environments (suburban and urban)

# Value of UTM to C-UAS Systems

C-UAS System confusion matrix

| Predicted/Sensed | Actual: Bad Drone | Actual: Good Drone |
|---|---|---|
| **Bad Drone** | *True Positives*<br><br>Mostly the domain of the C-UAS system, somewhat supported by UTM when it returns a negative operation lookup. | *False Positives*<br><br>C-UAS system can correlate sensed operation with known UTM operation, reducing the chance of false positives. |
| **Good Drone** | *False Negatives*<br><br>UTM should provide all “good drone” information to reduce false negatives. | *True Negatives*<br><br>UTM helps to confirm drones are where they should be and who they say they are. |

Likely UTM’s larger impact for C-UAS systems: ***increasing***


# Thank You

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https://utm.arc.nasa.gov

# UTM Principles and Services

## Principles

- Only authenticated UAS operations allowed
- UAS stay clear of each other
- UAS and manned aircraft stay clear of each other
- UAS operator has 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)

# Technical Capability Level (TCL) Progression

**TCL1: *multiple VLOS***

→ Networked Operations

→ Info sharing

**TCL2: *multiple BVLOS, rural***

→ Initial BVLOS

→ Intent sharing

→ Separation by geo-fencing

**TCL3: *multiple BVLOS, near airports, suburban***

→ Routine BVLOS

→ Detect and Avoid (DAA) / Vehicle to Vehicle (V2V)

→ Avoid static obstacles

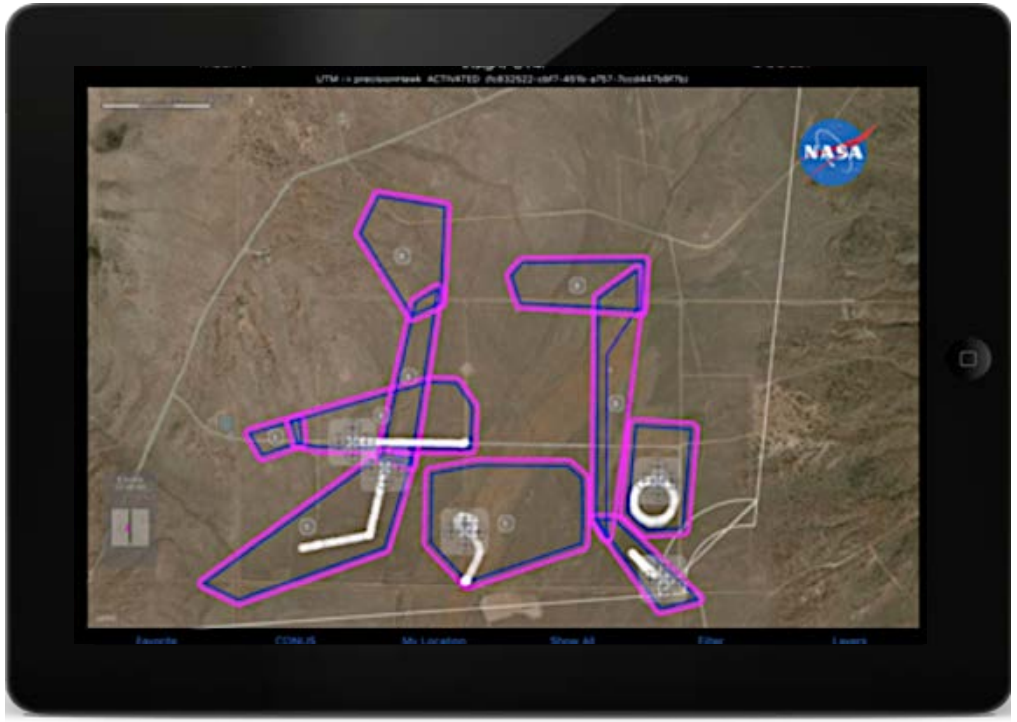
**TCL4: *complex urban BVLOS***

→ BVLOS to doorstep

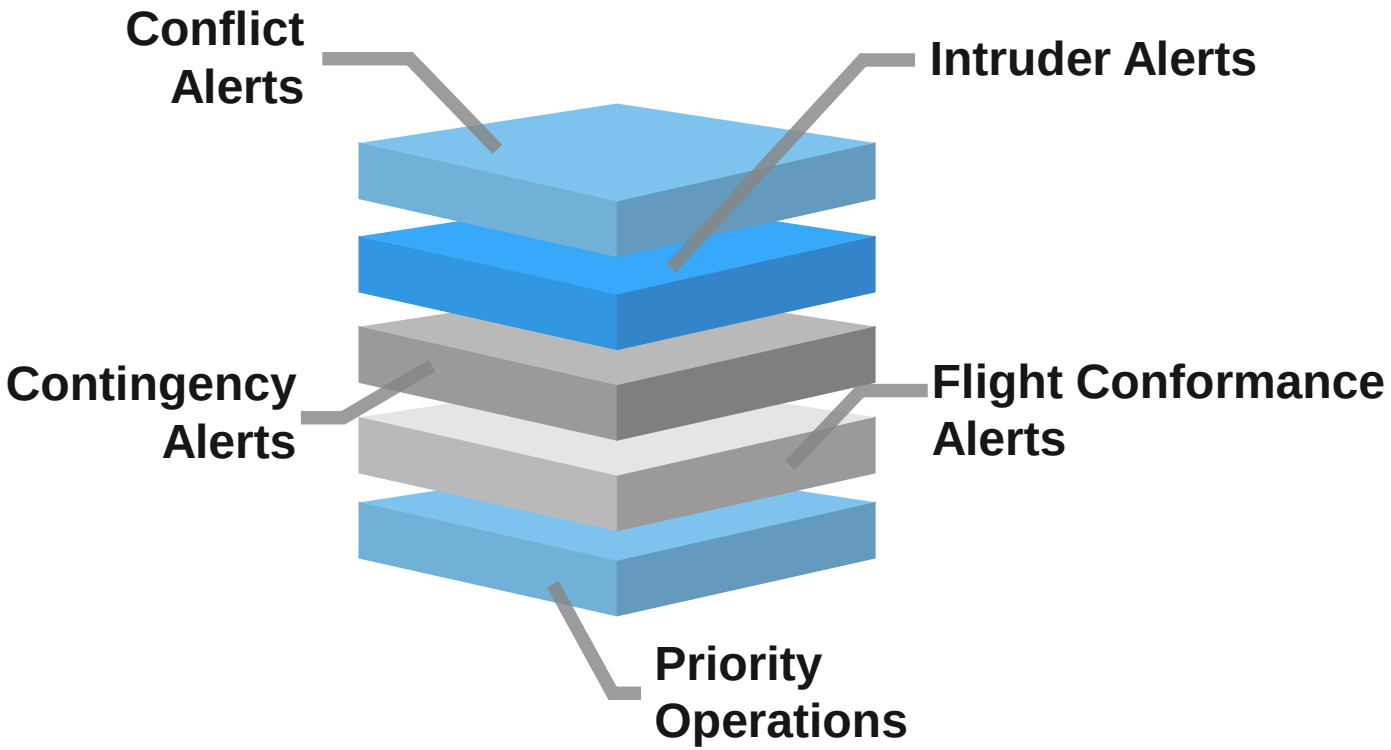
→ Track and locate

→ Avoiding dynamic obstacles

# TCL 2 UTM Functionality



UTM Mobile Application




**Scheduling and Planning, Tracking, and Contingency Management**

# UTM Architecture

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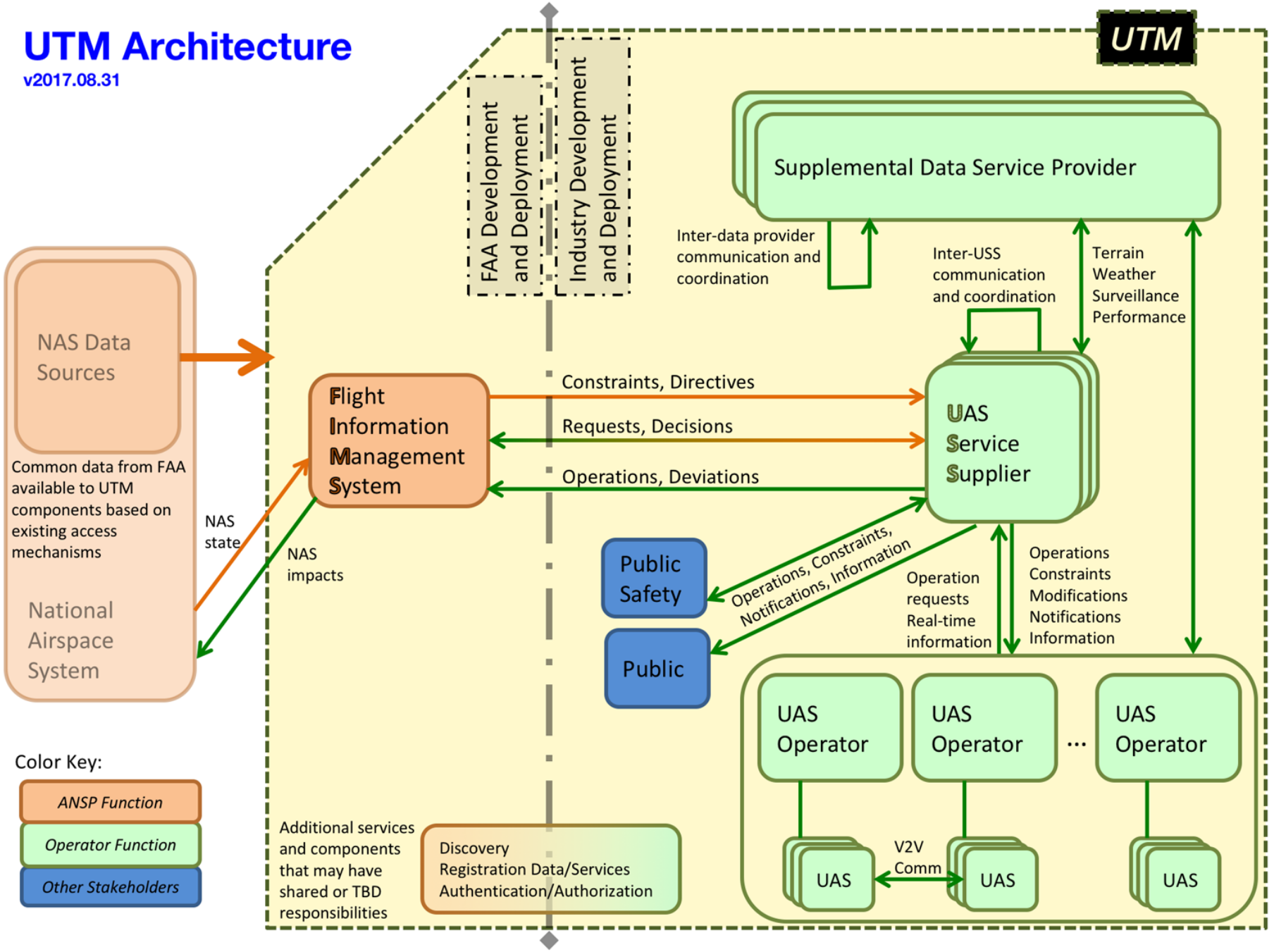


## Flight Information Management System

- → Enables airspace controls
- → Facilitates requests
- → Supports response in emergencies impacting NAS

## UAS Service Supplier

- → Federated Structure
- → Cloud-based system
- → Automated System
- → Supports UAS with services (e.g. separation, weather, flight planning, contingency management,, etc.)

## Supplemental Data Service Provider

- → Supplies supplemental data to USS and UAS Operator to support operations

## UAS / UAS Operator

- → Individual Operator
- → Fleet Management
- → On-board capabilities to support safe operations