National Aeronautics and Space Administration

Unmanned Aircraft Systems Traffic Management (UTM)

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SARP Research Exchange on Multiple UAS

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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

Command and Control

Aircraft Performance

Tracking and UAS Identification

Beyond Visual Line of Sight

Separation

Weather

Awareness

Operations over People

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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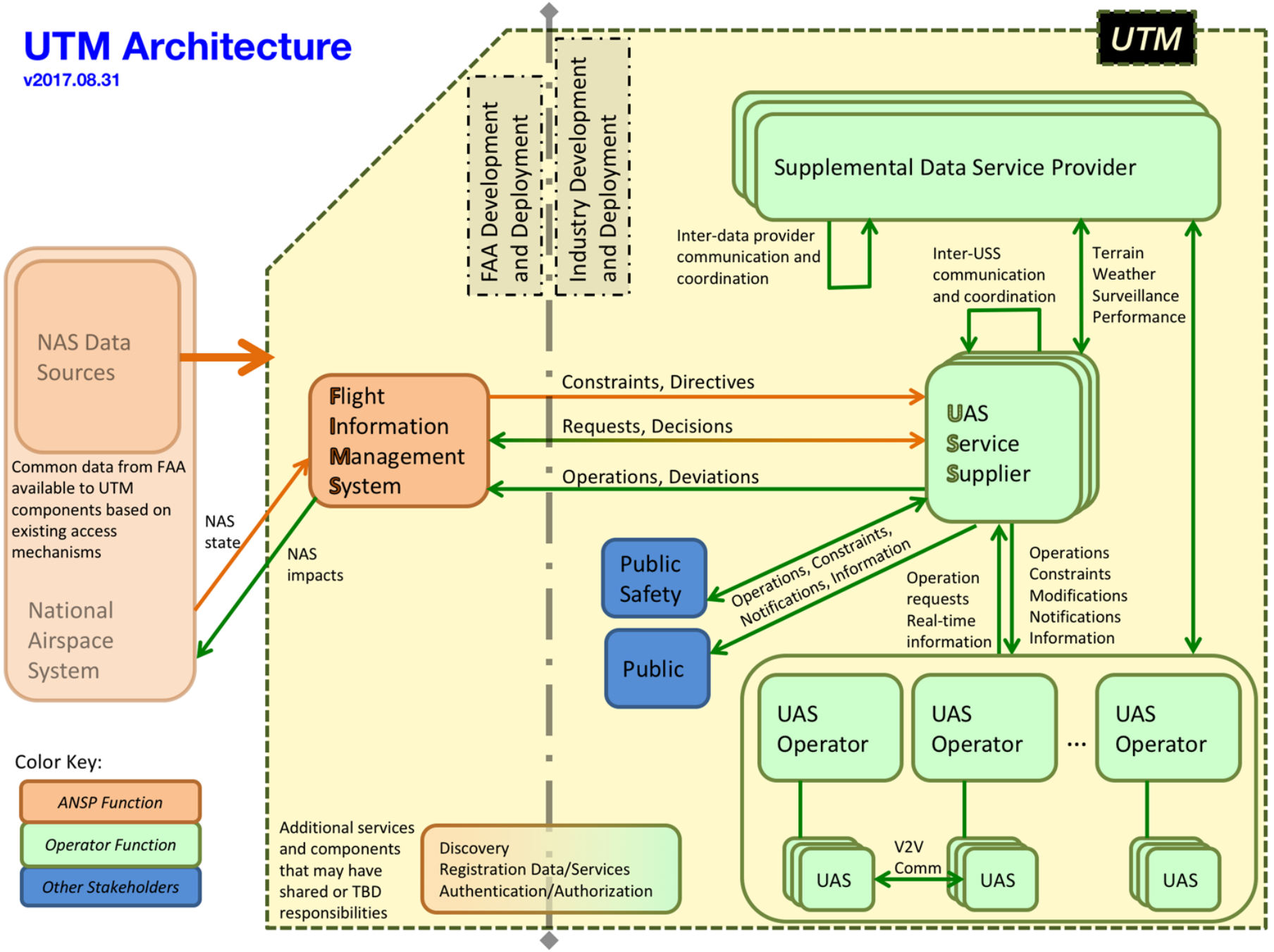


Flight Information Management System

- → 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.)

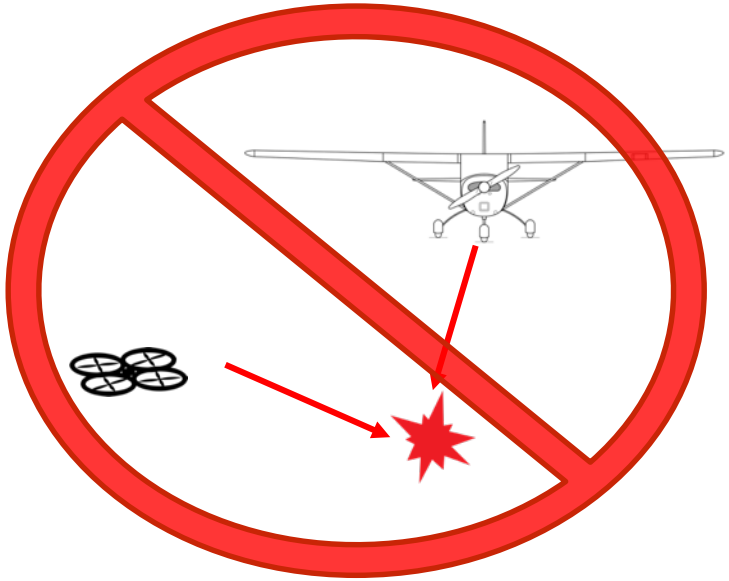
Supplemental Data Service Provider

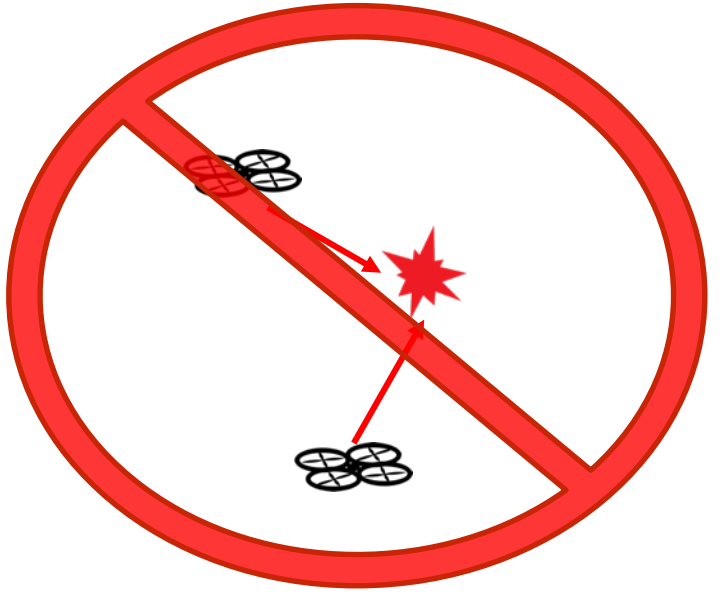
- → Supplies supplemental data to USS and UAS Operator to support operations

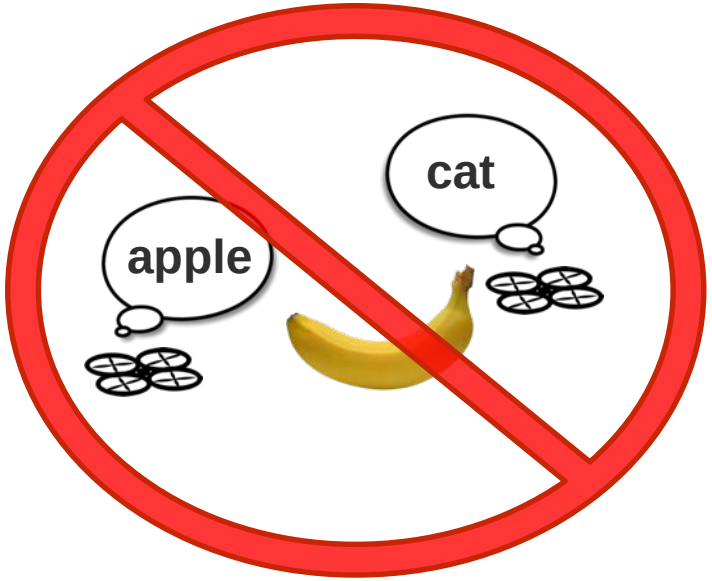
UAS / UAS Operator

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

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







Technical Capability Level 1 Flight Test

Evaluate the feasibility of multiple VLOS operations using scheduling and planning through an API connection to the UTM research platform

TCL1

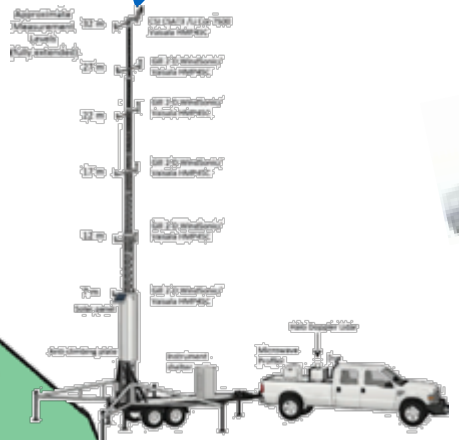
August 2015

UAS Range

Elevation: 166 feet MSL

Flat Agricultural Farmland

Operations at 2 Locations



Weather Sensors

100 ft Weather Tower

Radiosonde Weather Balloon

Remote Automated Weather Station

Acoustic Sensors

SRHawk Radar

Used to detect small UAS

UTM TCL 1 Demonstration Highlights

Days of Flight
8

11 Partner Organizations

2 Simultaneous VLOS Operations

10 UAS Platforms

4
Test Conditions

108
Flights

18
Flight Hours

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

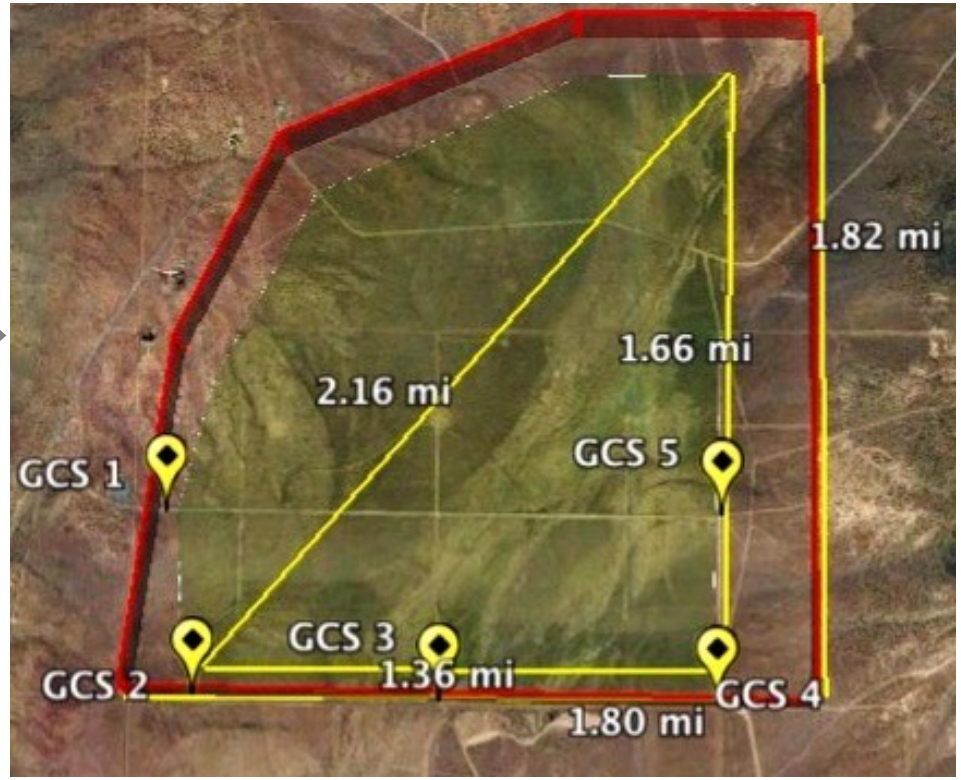
Operations at 5 Locations

SRHawk Radar

Weather Equipment

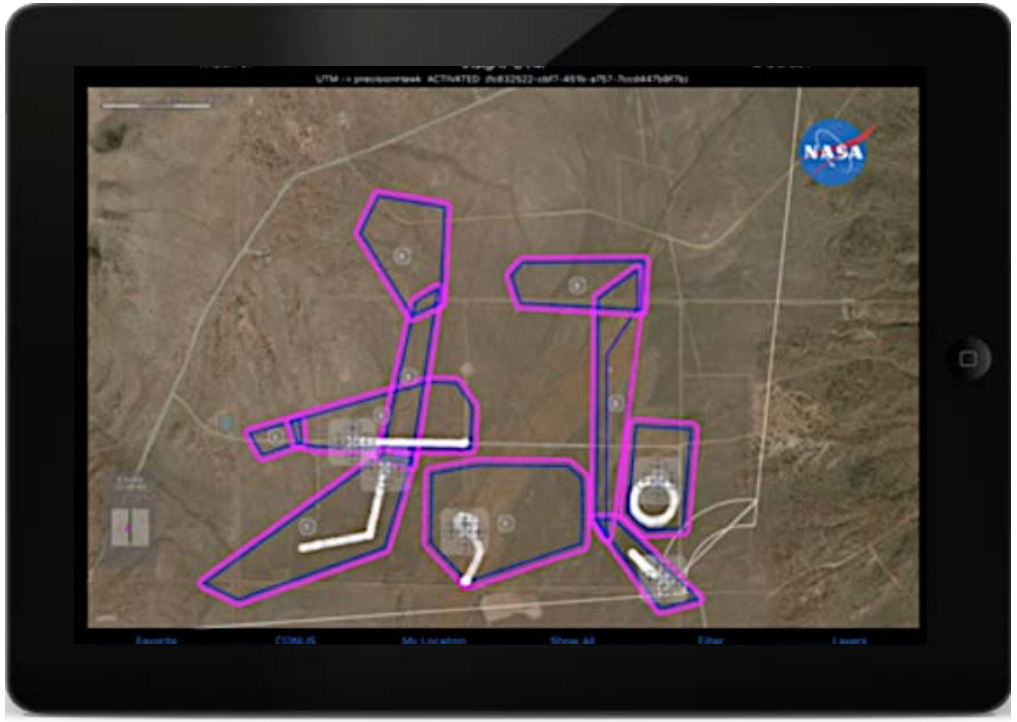
LSTAR Radar

Nevada UAS Test Range

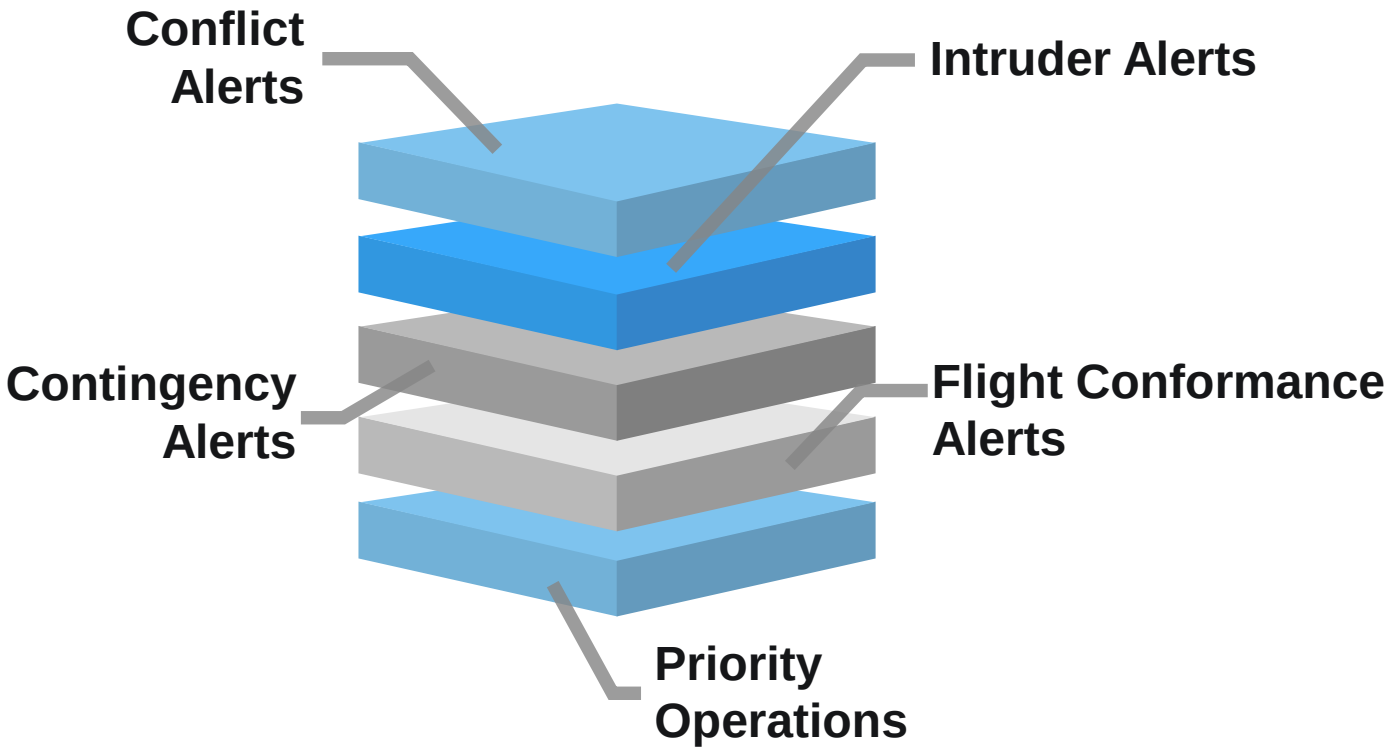


October 2016

TCL 2 UTM Functionality



UTM Mobile Application



Scheduling and Planning, Tracking, and Contingency Management

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: **74**

UAS Vehicles: **11**

Partnerships: **14**

4 Scenarios

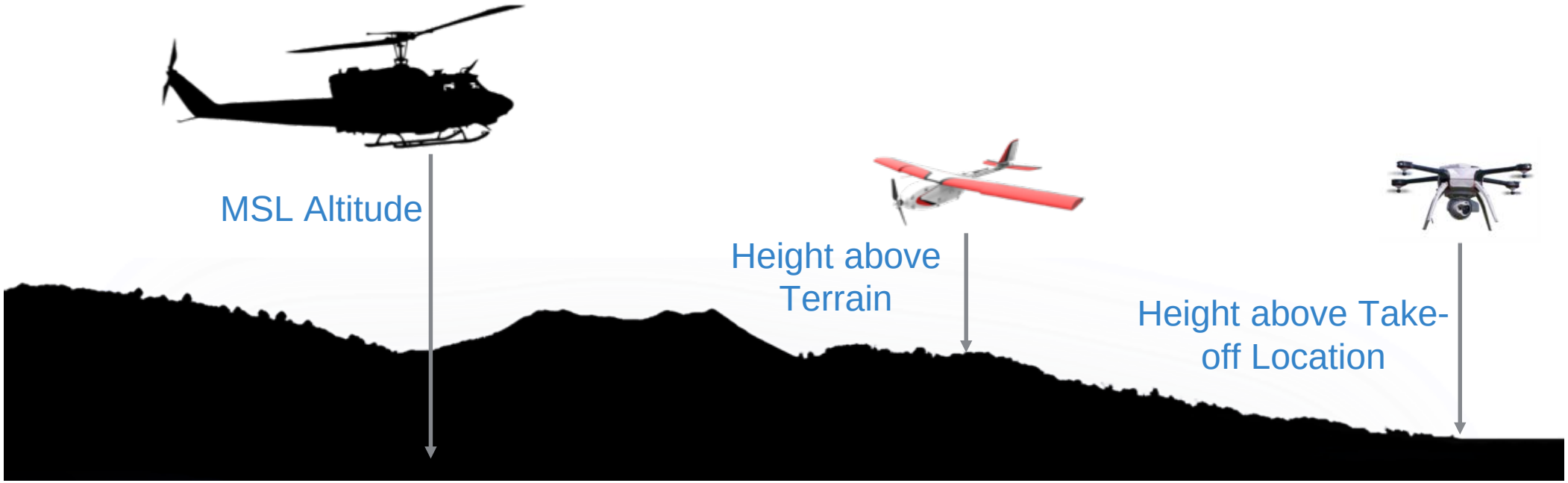
30 Minutes per scenario

Days of Flight: **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

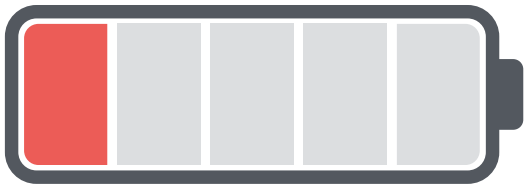
Reno-Stead Elevation: 5,050 ft

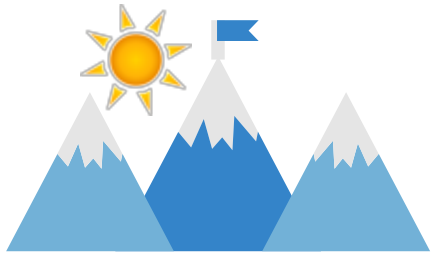
Cool Temperatures

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**

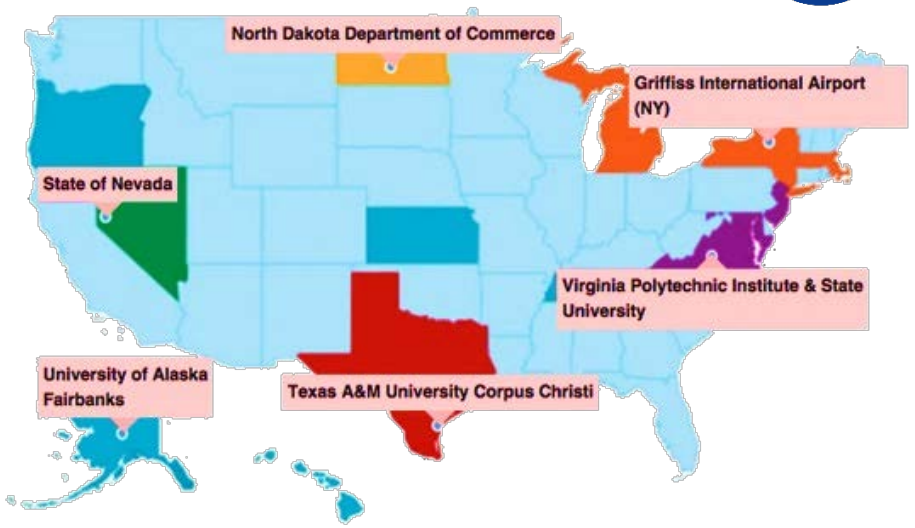
4. Initial BVLOS should **avoid altitude stratification**, until improved position sharing (e.g. V2V) and weather products

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

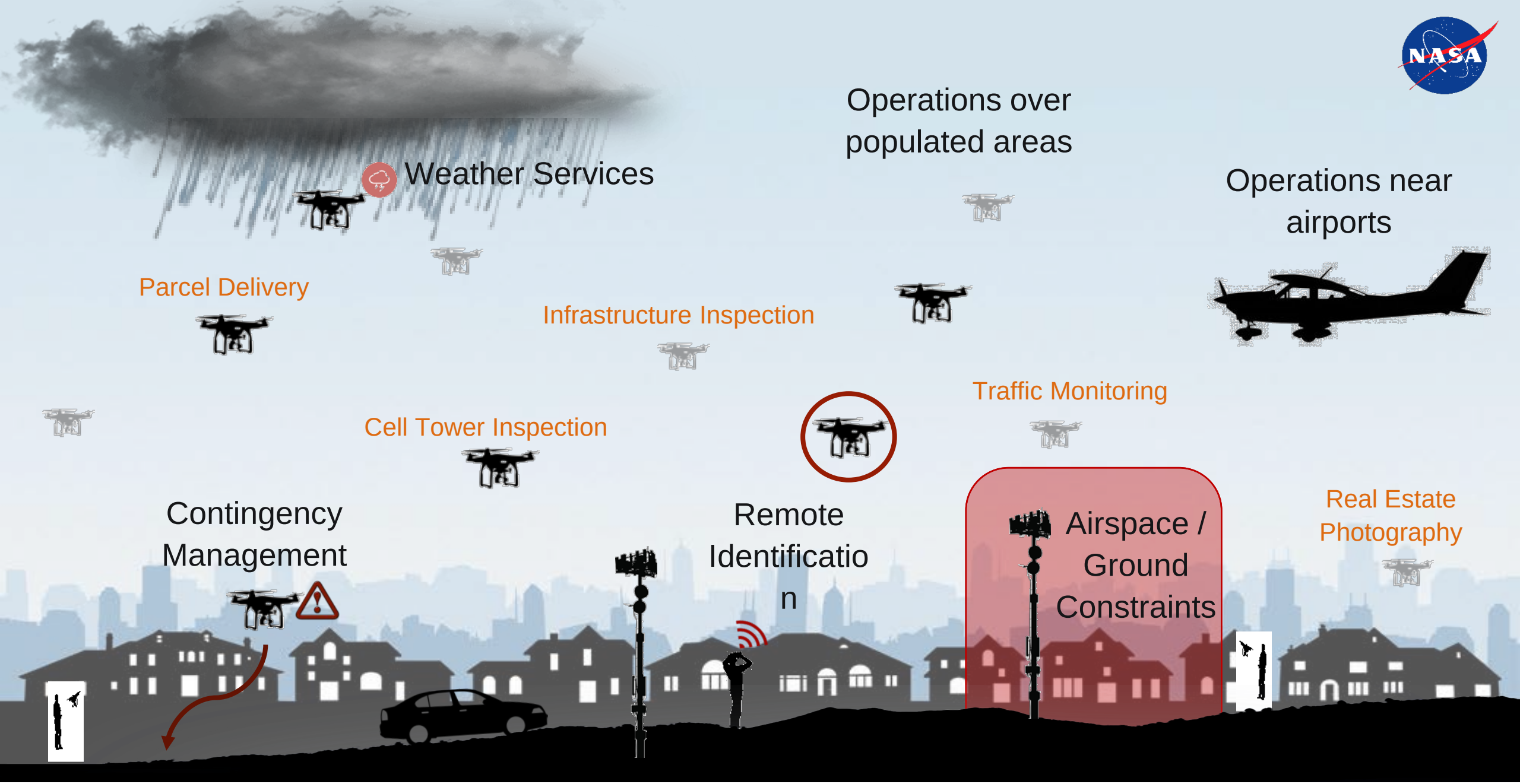
- ~40 partners total across 6 testing locations
- 6 USS Implementers (Amazon Prime Air, Google Project Wing, Airmap, Simulyze, ANRA, NASA)
- NASA USS and FIMS run in the cloud
- Data feeds monitored in UTM lab and at each location
- Multiple Media days



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	✓		✓	✓		✓

Technical Capability Level 3 Flight Test

Evaluate the feasibility of multiple BVLOS operations near airports and in suburban environments using a UTM research platform



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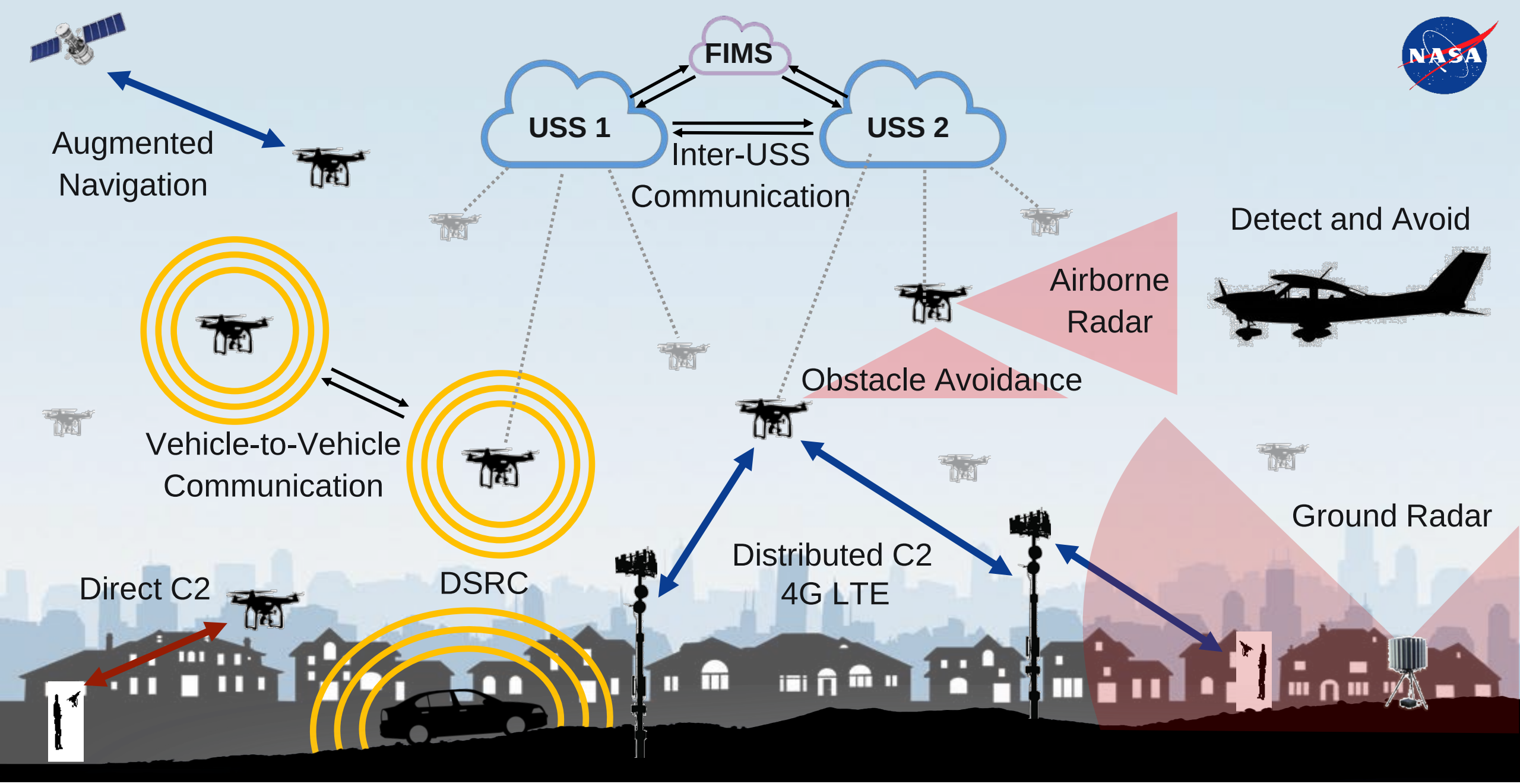

Technical Capability Level 3 Flight Tests

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)

Thank You

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

→ Large scale contingencies