National Aeronautics and Space Administration

Unmanned Aircraft Systems Traffic Management (UTM)

NASA Ames Research Center

February 2018

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 101(e)
[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?

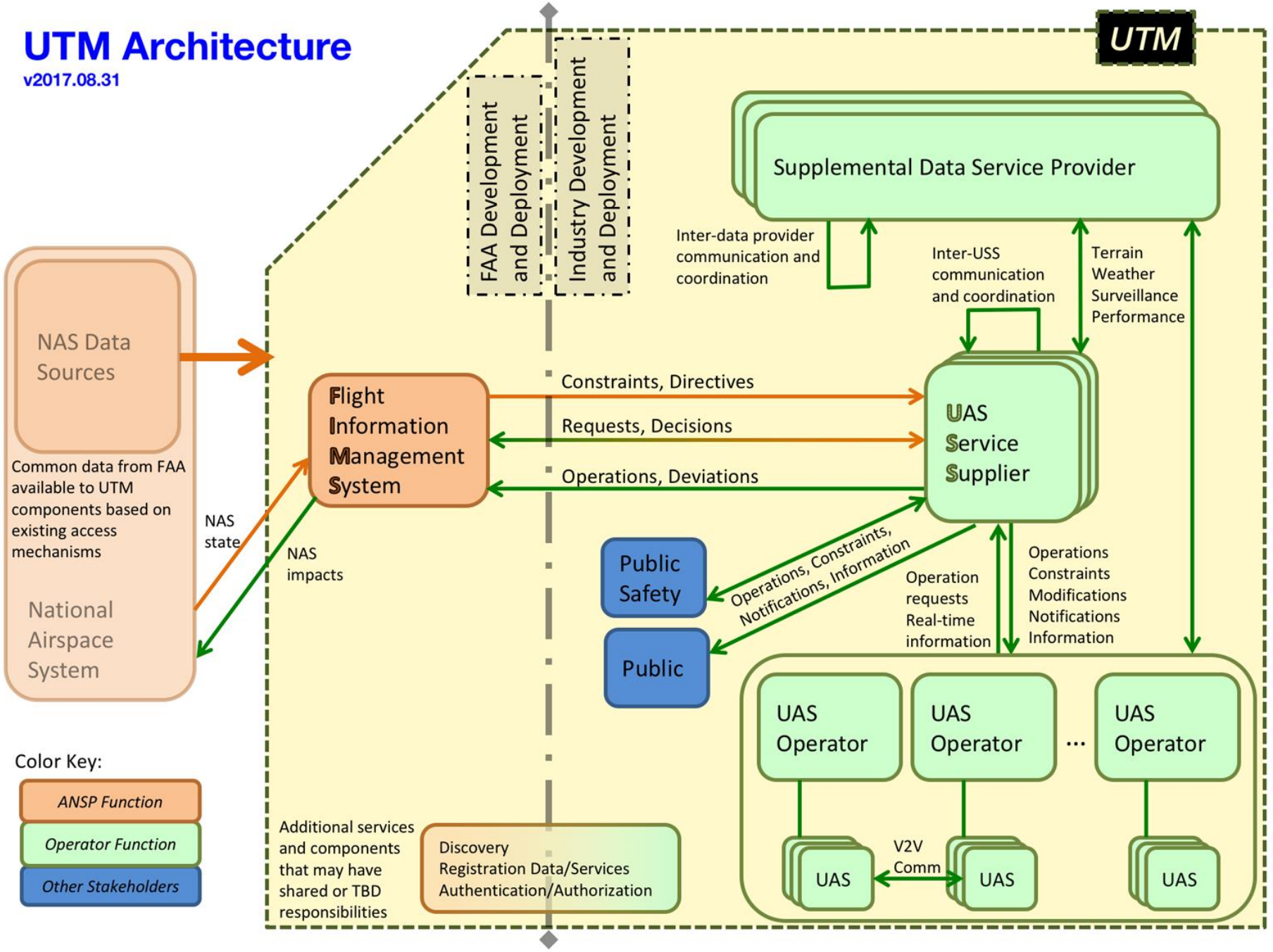
- **UTM is an "air traffic management" ecosystem for uncontrolled operations**
- UTM utilizes industry's ability to supply services under FAA's regulatory authority where these services do not exist
- UTM development will ultimately enable the management of large scale, low-altitude UAS operations
  - Operational concept will address beyond visual line of sight UAS operations under 400 ft. AGL
  - Information architecture, data exchange protocols, software functions
  - Roles/responsibilities of FAA and operators
  - Performance requirements

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

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



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

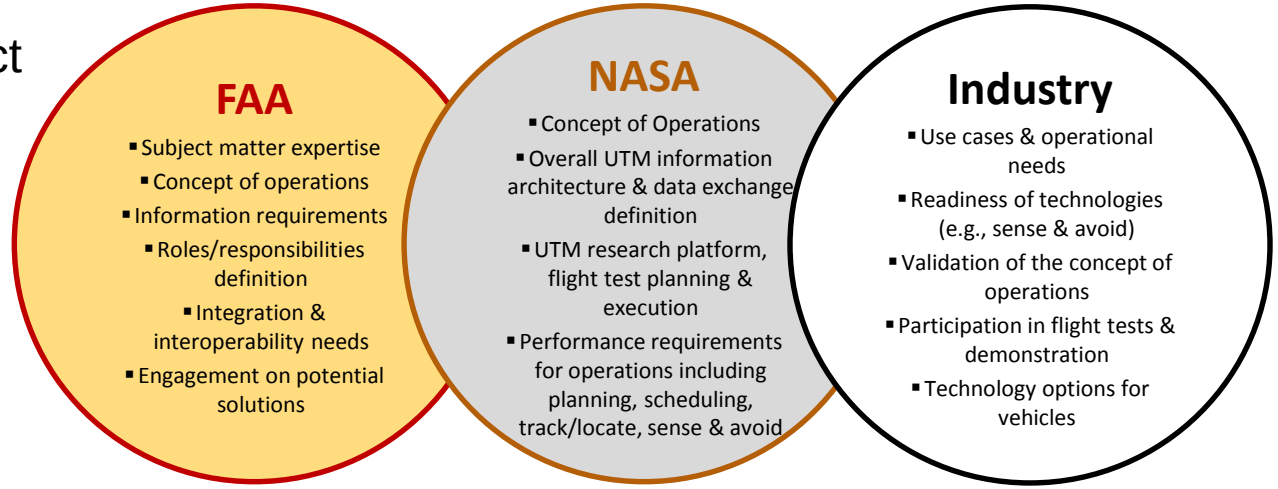
- → Supplies supplemental data to USS and UAS Operator to support operations

UAS / UAS Operator

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

UTM Partners

- Very close collaboration with FAA through Research Transition Teams (RTT) working groups. The working groups have over 40 partner organizations
- Over 250 UTM partners in industry, government and academia with RFI responses or space act agreements
- Close to 100 Space Act Agreements
- Funded six FAA UAS test sites for TCL-2,3 National Campaigns
- Each site collaborates with NASA partners



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UTM Outcomes

Research Activities

Research Transition Team Working Groups
- Concepts and Use Cases
- Data and Information Exchange
- Sense and Avoid
- Communications and Navigation

Concept and Software Development
- Flight Information Management System
- UAS Service Supplier
- Supplemental Data Service Providers
- Public Portal

Field Testing and Technology Evaluation
- TCL Field Demonstrations
- Targeted Technology Evaluations

Simulation and Risk Analysis
- Real-time and Fast-time Studies
- Hazard Analysis.

Products

Software Prototypes
- FIMS Prototype
- NASA UAS Service Supplier (USS)
- USS Discovery Service
- UAS Operator Client
- Authentication/Authorization Service

ICDs and APIs
- USS-FIMS Specification
- USS-USS Specification
- Weather and Surveillance SDSP ICD
- V2V Communication Specification

Concept Documents
- UTM CONOPS and Use Cases
- USS Onboarding Process
- Communication and Navigation Model
- UTM Conflict Mitigation Model
- Hazard Identification and Analysis

Reference Technology Implementations
- UAS Detect and Avoid System
- Urban Operations UAS System

Outcomes

Fielded Systems
- FAA to use UTM in their Pilot Program (UPP) demonstration in FY2019
- DoT/FAA expected to use UTM system for the Integrated Pilot Program (IPP)

UAS Rule Making
- Beyond Part 107 (BVLOS)
- FIMS/USS Roles and Responsibilities

Industry Guidance
- Safety Case Development
- Data Exchange and Protocols
- Industry Standards

International Harmonization
- UTM Construct and Architecture (e.g. ICAO)
- Use Cases

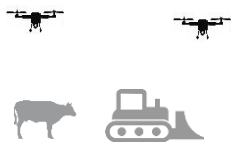
UTM Progression

Goal:

Safely enabling large scale visual and beyond visual line of sight operations in the low altitude airspace

Risk-based approach along four distinct **Technical Capability Levels (TCL)**

UTM Technical Capability Level Progression



TCL1

Remote Population

Low Traffic Density

Rural Applications

Multiple VLOS Operations

Notification-based Operations

TCL 2

Sparse Population

Moderate-Low Traffic Density

Rural / Industrial Applications

Multiple BVLOS Operations

Tracking and Operational Procedures

TCL 3

Moderate Population

Moderate Traffic Density

Suburban Applications

Mixed Operations

Vehicle to Vehicle Communication

Public Safety Operations

TCL 4

Dense Population

High Traffic Density

Urban Applications

Dense BVLOS Operations

Large Scale Contingency Management

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

TCL 1

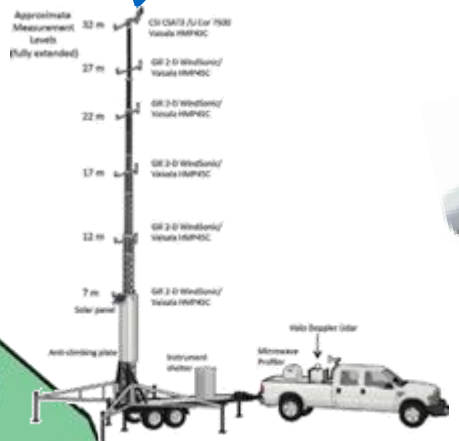
August 2015

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

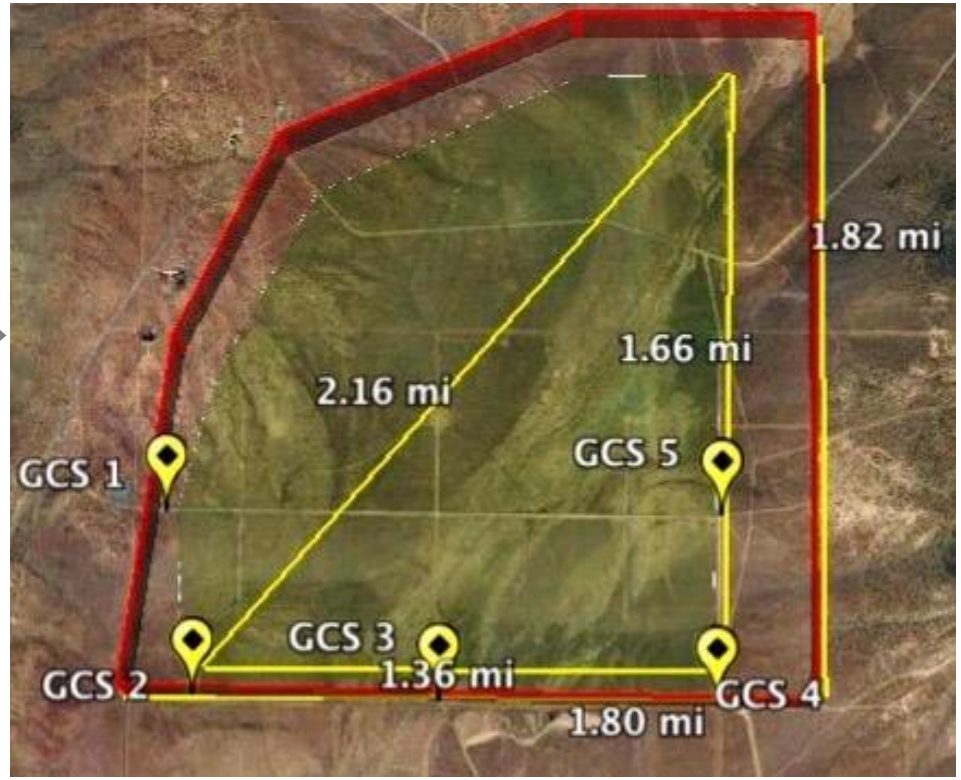
Operations at 5 Locations

SRHawk Radar

Weather Equipment

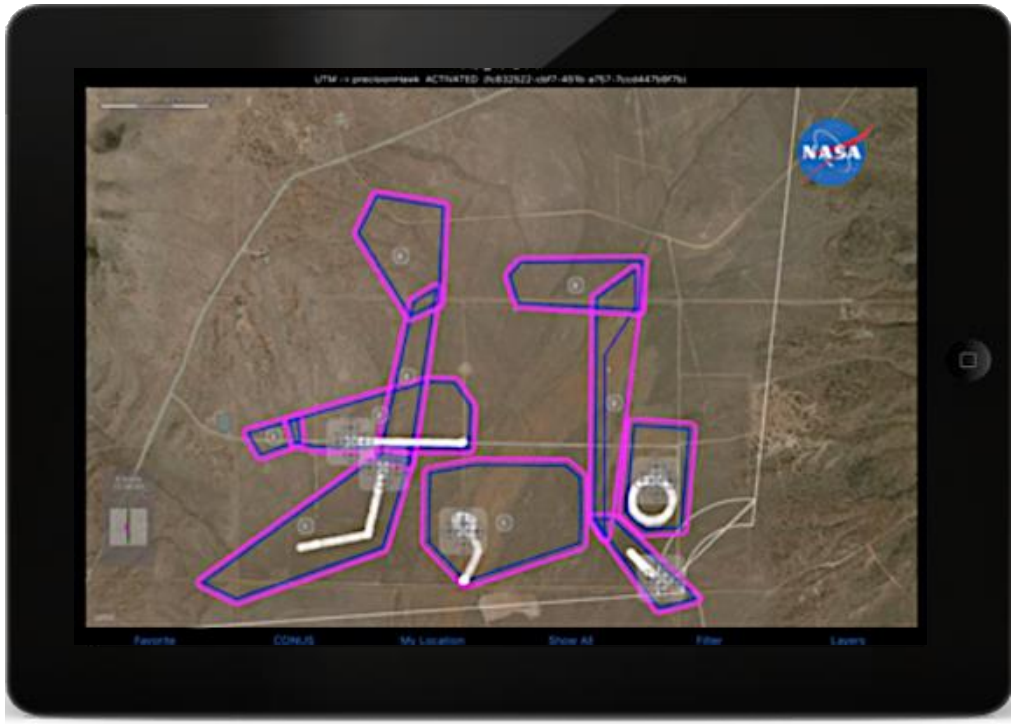
LSTAR Radar

Nevada UAS Test Range

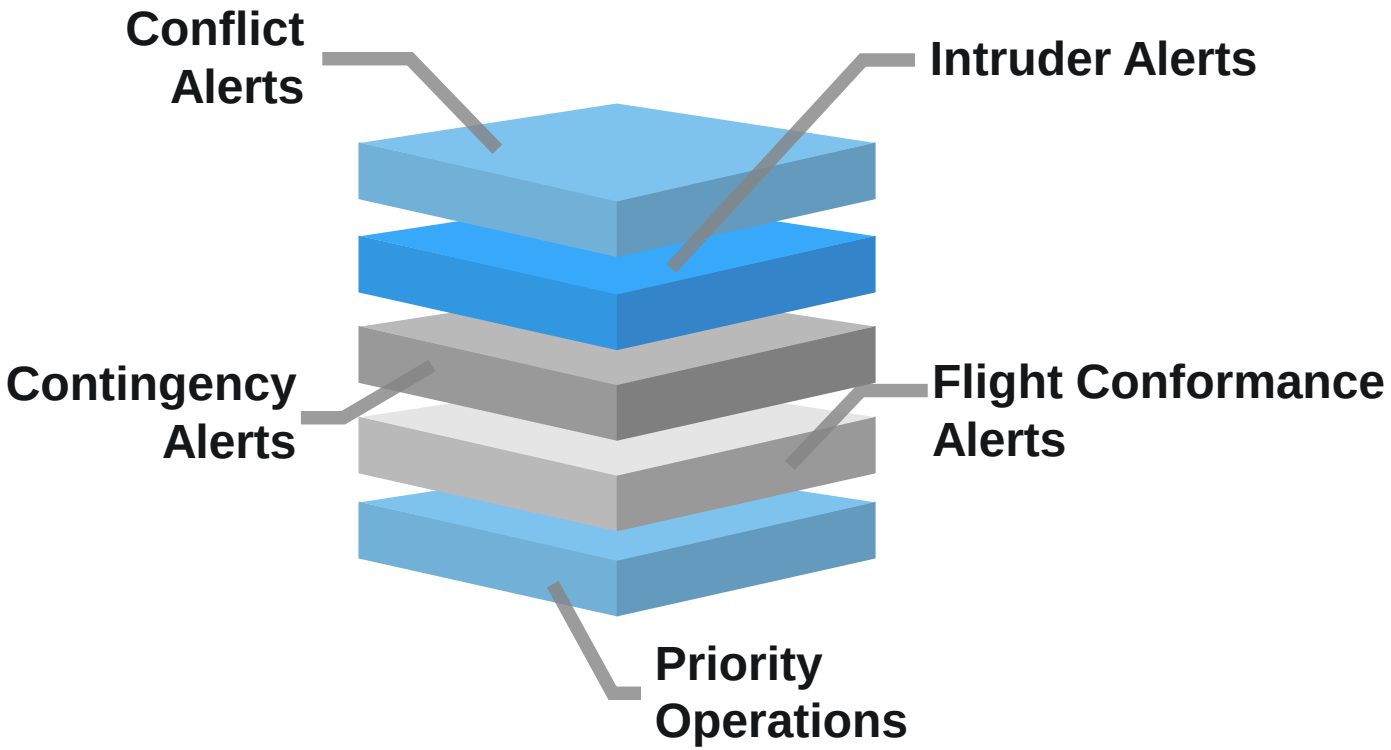


October 2016

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**

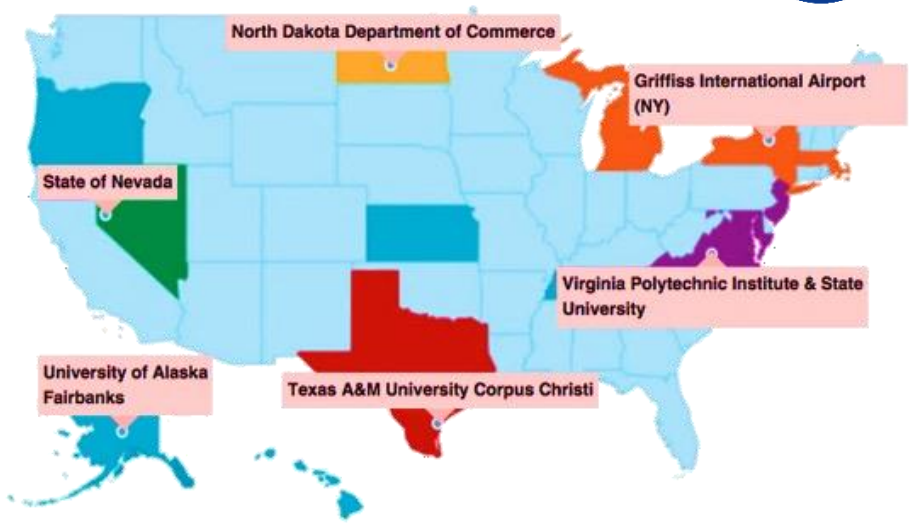
Flights	UAS Vehicles	Partnerships
74	11	14

Scenarios	Minutes per scenario	Days of Flight
4	30	5

TCL 2 National Campaign

May 15th – June 9th 2017

- ~40 partners total across 6 testing locations
- 6 USS Implementers
- NASA USS and FIMS run in the cloud
- Data feeds monitored in UTM lab and at each location
- Multiple Media days

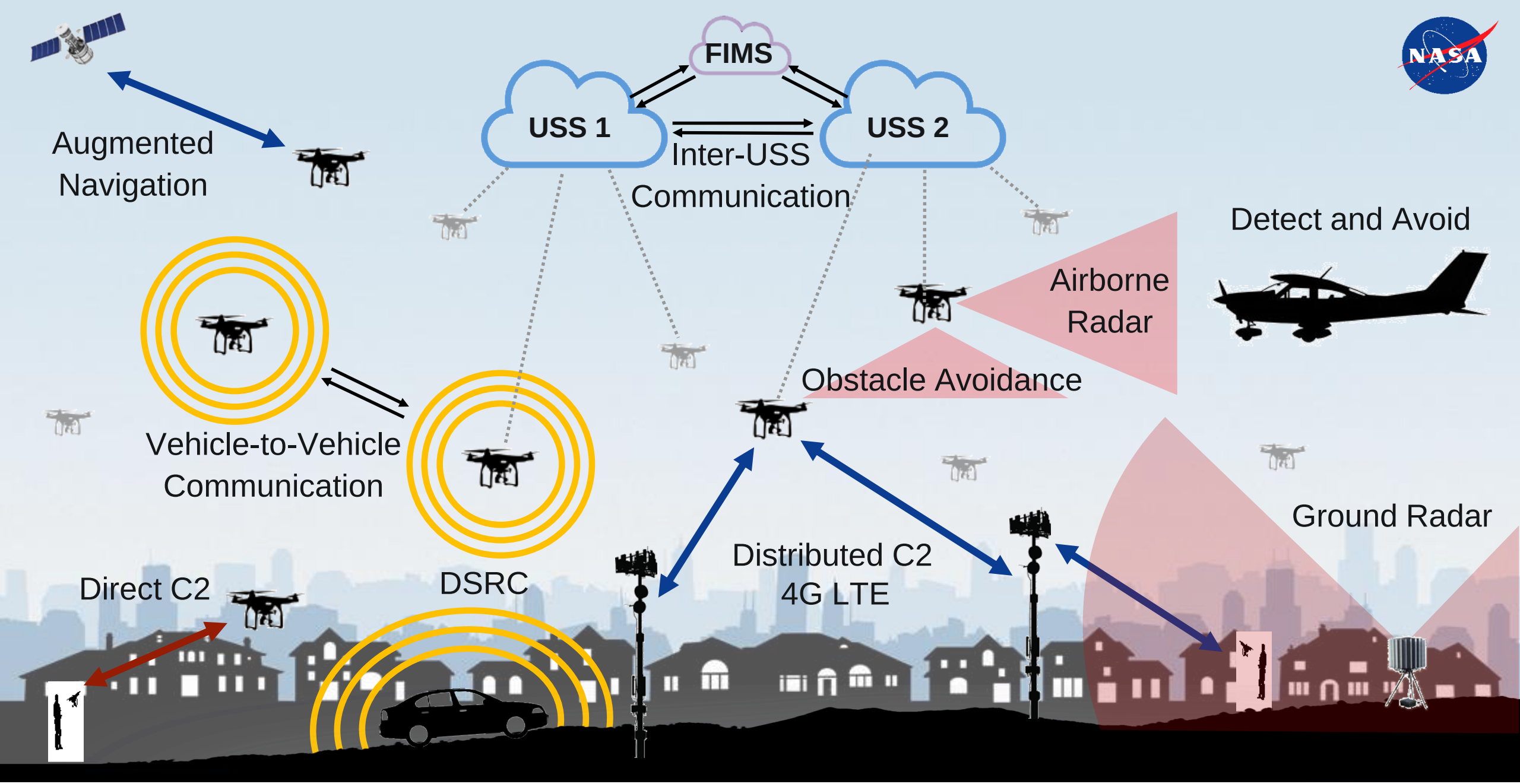


Test Sites	USS Technology	Geofence Technology	Ground-based Sense & Avoid	Airborne Sense & Avoid	Communication, Navigation, Surveillance	Human Factors
Alaska	✓	✓	✓	✓	✓	✓
Nevada	✓	✓	✓	✓	✓	✓
New York		✓			✓	
North Dakota	✓	✓	✓		✓	✓
Texas				✓		
Virginia	✓		✓	✓		✓

Technical Capability Level 3 Flight Test

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

Mar-May 2018



Technical Capability Level 3 Test Objectives

Technical Capability Level 4 Flight Test

Evaluate the feasibility of multiple BVLOS operations in urban environments and large scale contingency mitigations using a UTM research platform

Mid-2019

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)

Collaboration on Use Cases

These Use Cases have operational and technical challenges that would be important to test:

- **Operations in Mountainous Areas**
- **Operations in Maritime Environment**

UAS Operations in Designated Mountainous Areas

Operations Challenges

- → Disruption due to information latency and drop-outs
- → Contingency management procedures given intermittent communications
- → Failover of safety-critical and non-safety critical services
- → Localized and Area-wide weather impacts (e.g. density altitude, thermals, icing, canyon wind effects)
- → Limited UAS Operator situation awareness

Technology Challenges

- → Intermittent and degraded communications (e.g. beyond radio line of sight)
- → Degraded navigation (e.g. multi-pathing, GPS-denied environment)
- → Intermittent surveillance and tracking (e.g. impeded line of sight)
- → Flight planning and separation mitigations (e.g. terrain avoidance, altitude consistency, etc.)

UAS Operations in Maritime Environments

Operations Challenges

- → Disruption due to information latency and drop-outs
- → Contingency management procedures given intermittent communications
- → Failover of safety-critical and non-safety critical services
- → Localized and Area-wide weather impacts (e.g.)
- → Limited UAS Operator situation awareness

Technology Challenges

- → Degraded navigation (e.g. localization, mobile ground control station)
- → Surveillance limitations (e.g. coastal radar limits, incomplete/inconsistent coverage)
- → Command and control limitations (e.g. SATCOM)
- → Flight planning and separation mitigations (e.g. battery management, detect and avoid, V2V communication, etc.)