



# Flight Test Evaluation of an Unmanned Aircraft System Traffic Management (UTM) Concept for Multiple Beyond-Visual-Line-of-Sight (BVLOS) Operations

NEXTGEN

**Dr. Marcus Johnson**

Dr. Jaewoo Jung, Dr. Joseph Rios, Joey Mercer, Jeffrey Homola,  
Dr. Thomas Prevot, Daniel Mulfinger, and Dr. Parimal Kopardekar

**NASA Ames Research Center**

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# Low Altitude UAS Operations

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## **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

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Visual Line of Sight  
14 CFR Part 107



BVLOS



Separation



Weather

Command and Control



Awareness



Aircraft Performance

Operations over People





# What is UAS Traffic Management? \_\_\_\_\_

## **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 to enable the management of low-altitude uncontrolled UAS operations

**UTM addresses critical gaps associated with lack of support for UAS operations in uncontrolled airspace**

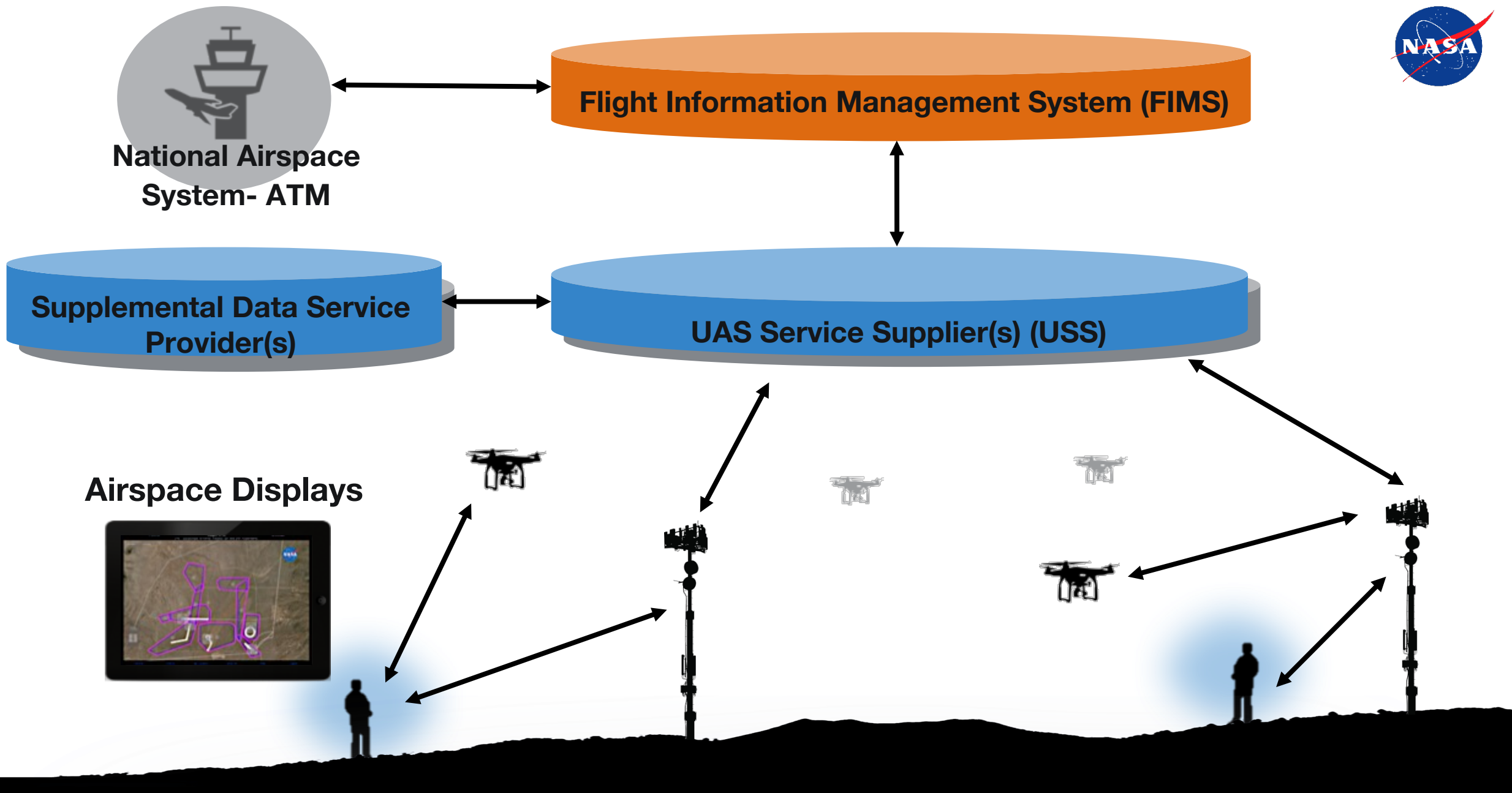


## Principles

- ☐ 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

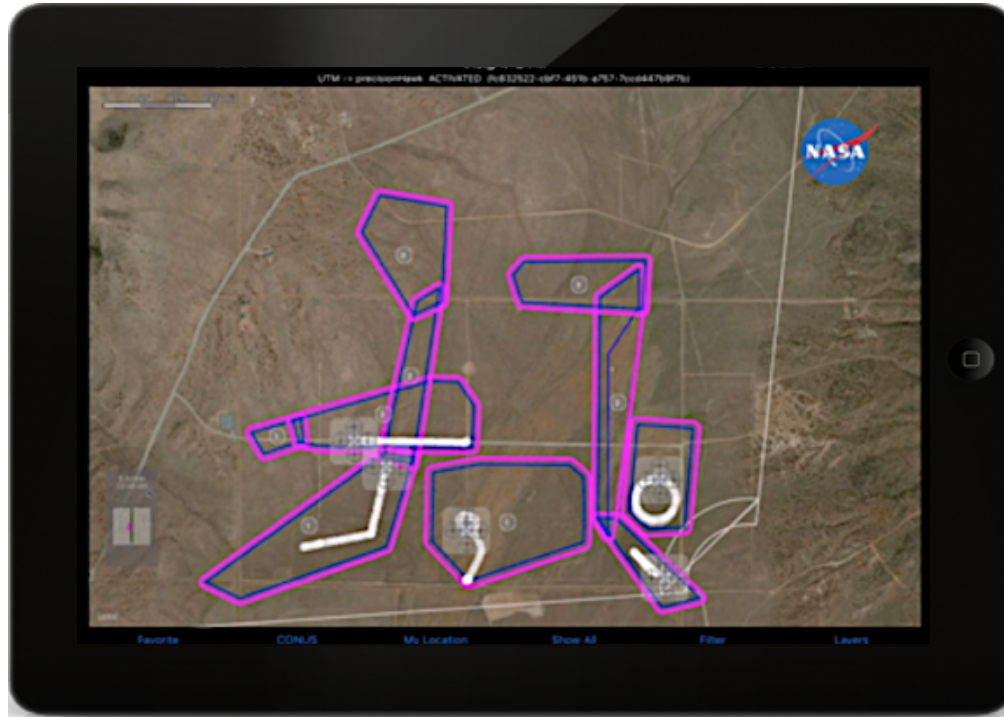
## **TCL3: *multiple BVLOS, near airports, suburban***

- Routine BVLOS
- Detect and Avoid (DAA) / Vehicle to Vehicle (V2V)
- Avoid static obstacles

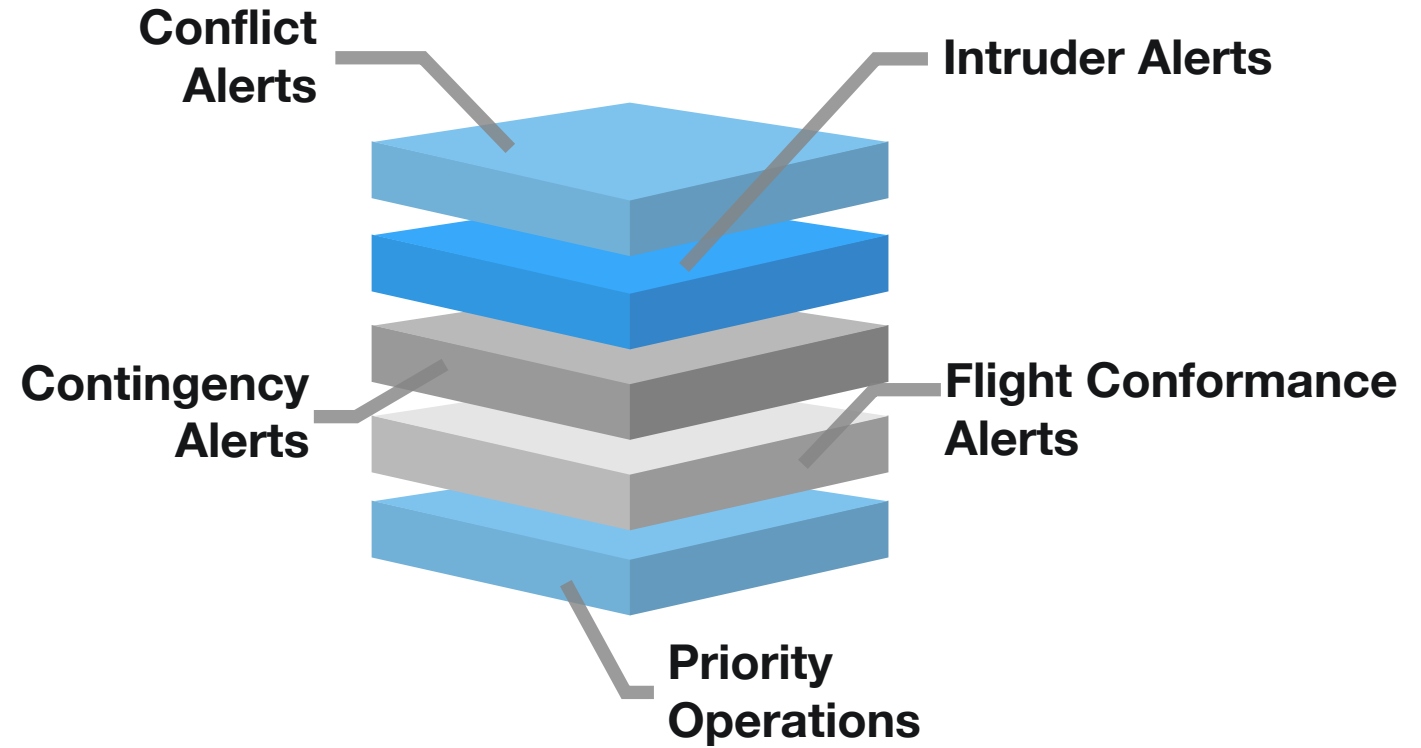
## **TCL4: *complex urban BVLOS***

- BVLOS to doorstep
- Track and locate
- Avoiding dynamic obstacles
- Large scale contingencies

# TCL 2 UTM Functionality



**UTM Mobile Application**



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



# TCL 2 Flight Test Objective

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

# Flight Test Overview

## Operational Area



## UAS Range

**Elevation: 5050 feet**

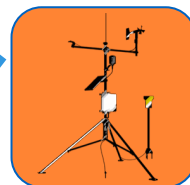
**Desert Terrain**

**Missions up to 500 ft**

**Operations at 5 Locations**



SRHawk  
Radar

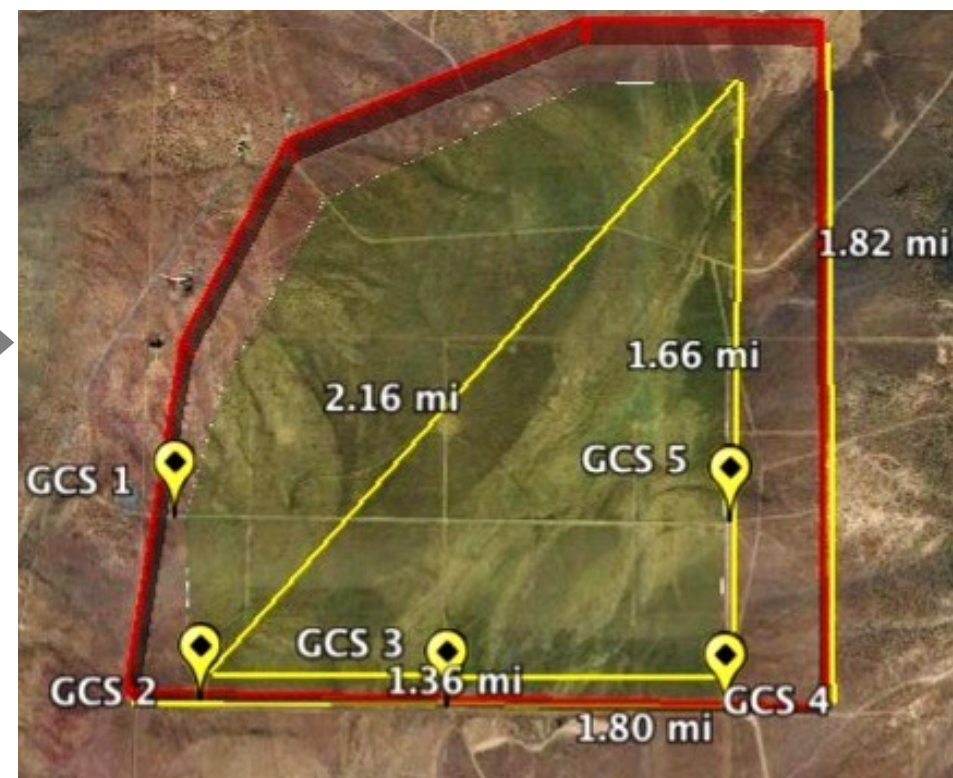


Weather  
Equipment



LSTAR Radar

## Nevada UAS Test Range



**October 2016**

# Flight Test Highlights



## Situation Awareness Displays

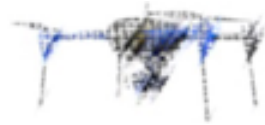
Critical alerts, operational plan information and map displays



## Altitude Stratified Operations



## Live-Virtual Constructive Environment



BVLOS



Visual Line of Sight



Simultaneous Operations



Flights

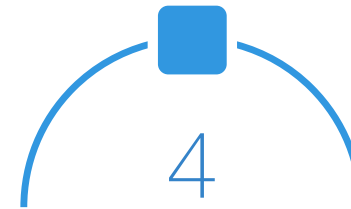
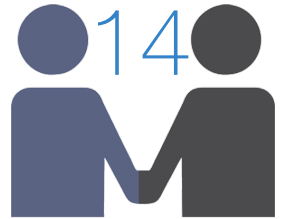


UAS Vehicles

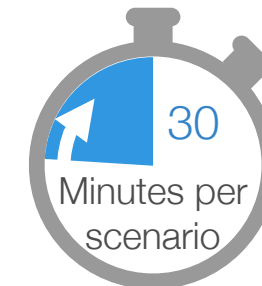
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Partnerships

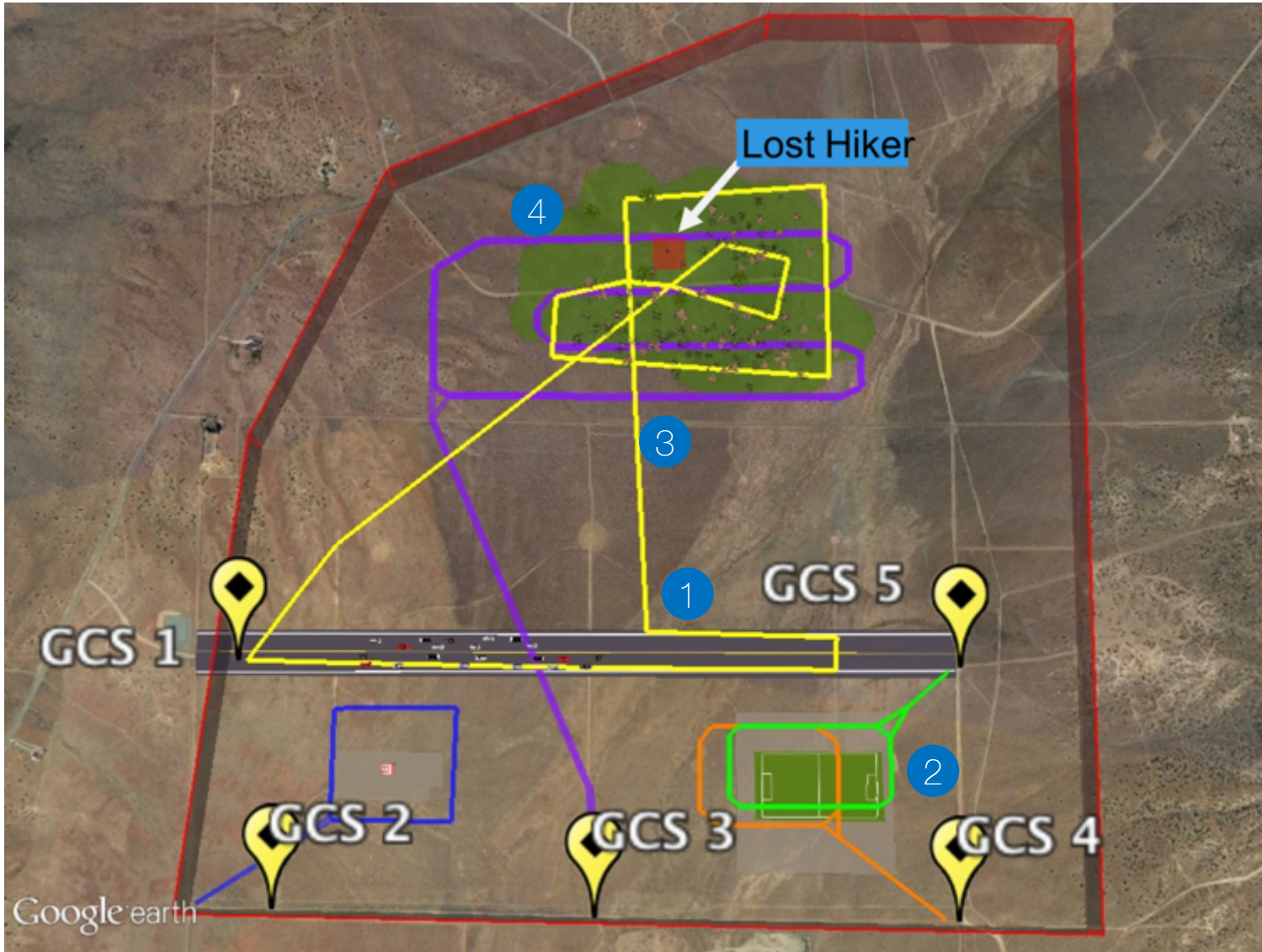


Scenarios



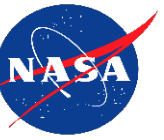


# Scenario 2: Lost Hiker



- 1 Dynamic Re-Routing
- 2 VLOS Altitude Stratification
- 3 Priority Operation
- 4 Constraint Notifications

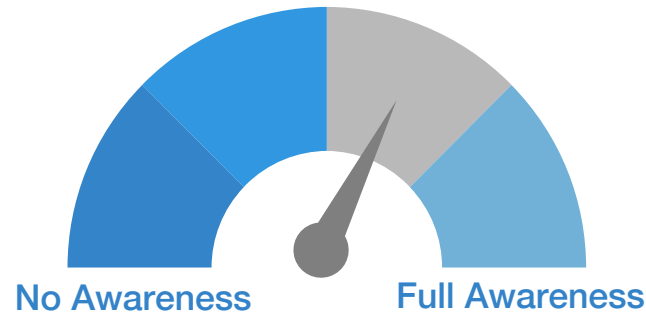




# TCL 2 Flight Test Lessons Learned

# Use of the UTM Research Platform

## Awareness of proximity to nearby operations



### Areas for improvement:

**Spectrum Usage**

**Contingency Management Actions**

**User reported information (e.g. UREP)**

**Integrated Airspace Display**

## Observations

Few flight crews had experience flying amongst other operations

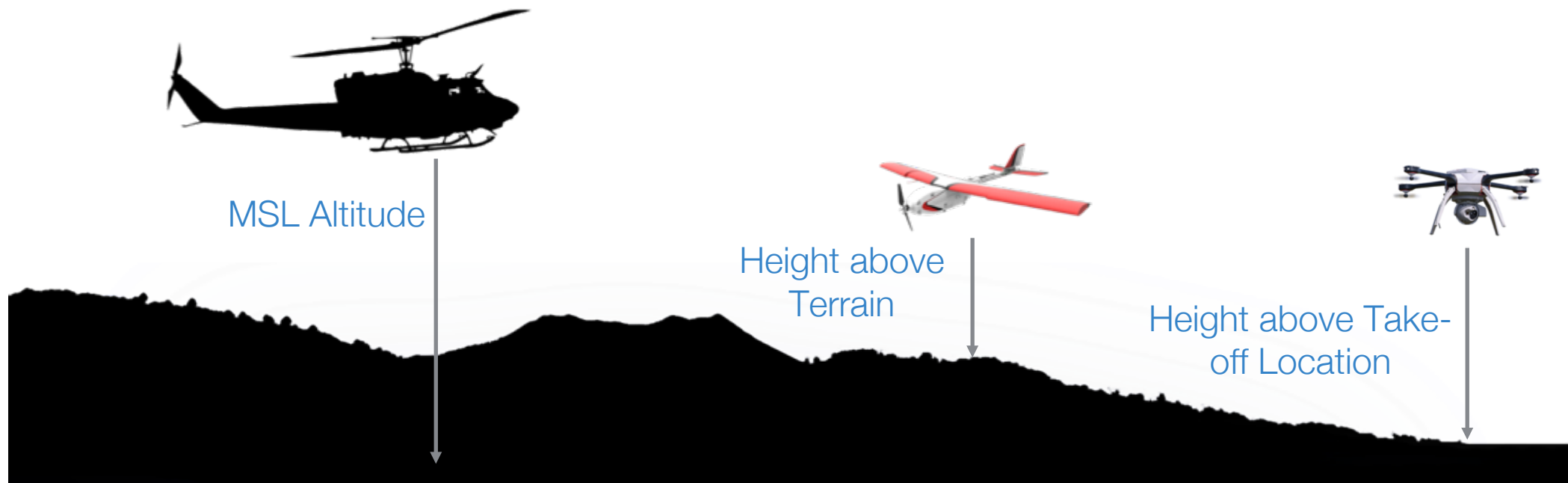
Due to differences in the equipment and practices of other operators information sharing was critical for safety

Flight crew progressed from reluctance to acceptance to endorsement of shared airspace information

**UTM provided situation awareness with respect to other operations that was generally accepted by operators**

# 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

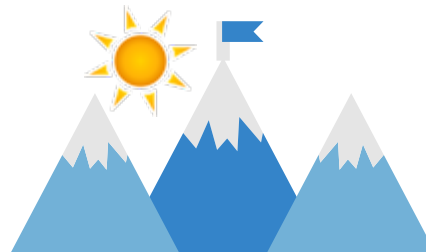
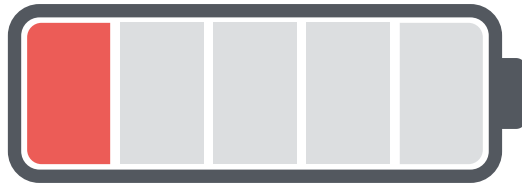


## Cool Temperatures

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

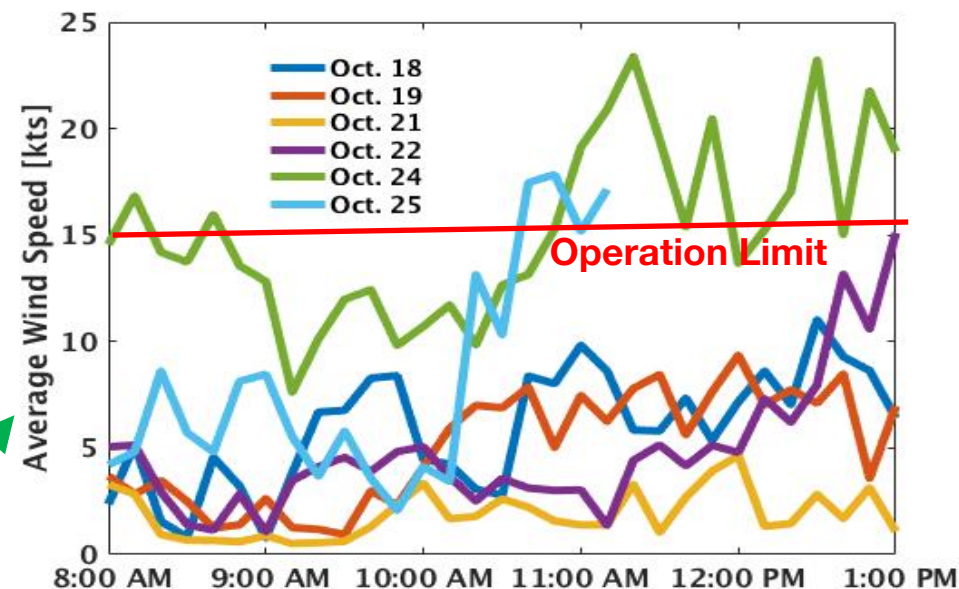
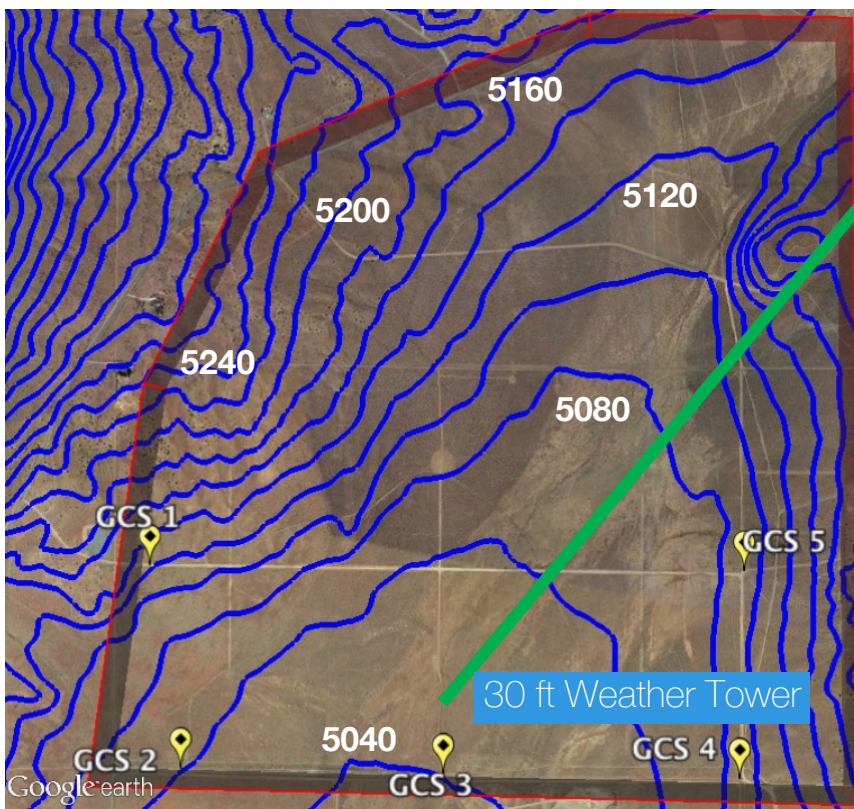
Aircraft experienced substantially **shorter endurance**

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



# Locality Impact on Operations

**Basin and range topography yielded local micro-climates with observably different wind conditions**



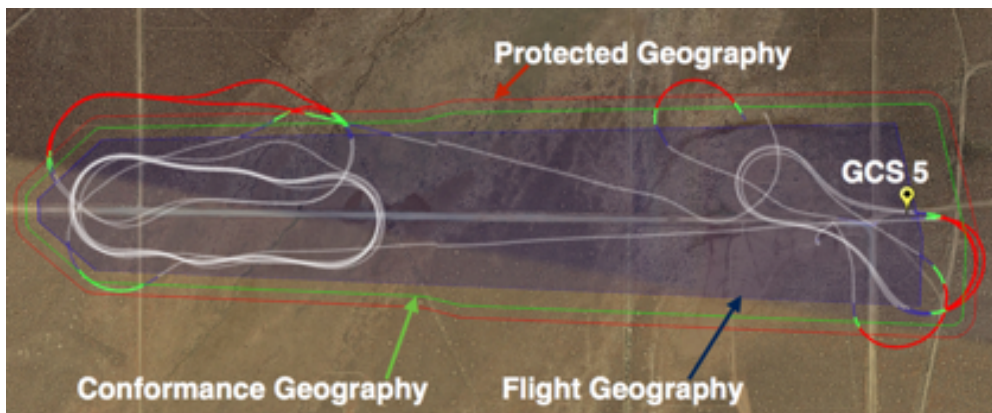
Local weather and national forecasts not indicative of observed conditions on site

**Ground reports were not indicative of conditions UAS experienced aloft**

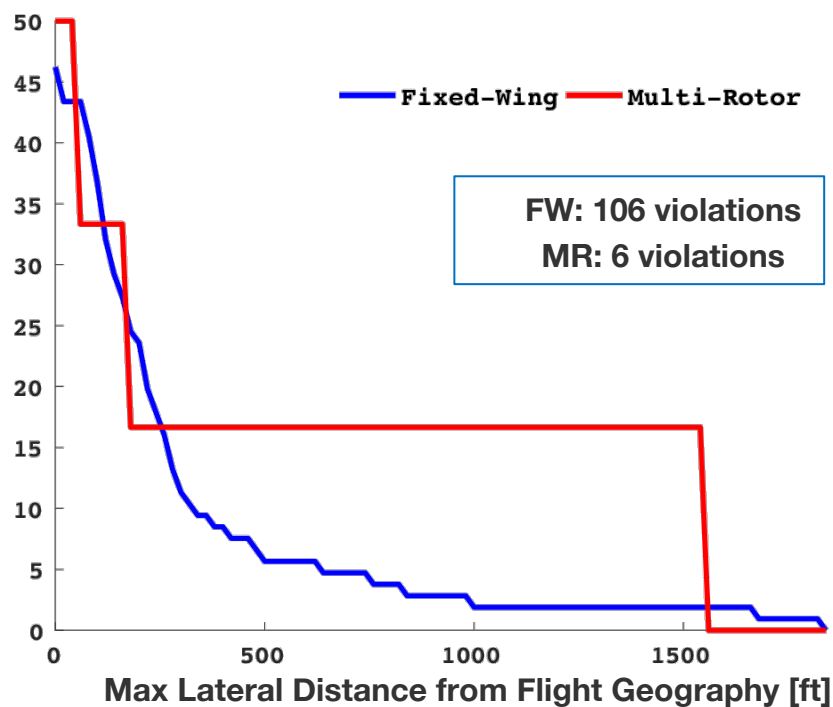
Ground reports local to GCS location was not indicative of conditions UAS experience while BVLOS

**Improvements in weather products are needed to support BVLOS**

# Conformance to Operational Plan



% of Flight Geography Violations



## 35 flights conducted for data collection

46% of data collection flights experienced at least 1 instance of a flight geography violation

Common Factors leading to violation:

- ☐ Vehicle Performance
- ☐ Erroneous Waypoint / Altitude
- ☐ Erroneous Flight Geography
- ☐ Changing Launch Direction
- ☐ Pilot Error in Manual Flight Mode
- ☐ Un-reported Contingency Management Actions

**Operational plans were not always consistent between UTM, GCS and UAS**

# 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**





# Summary

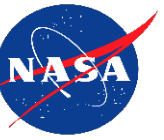
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**TCL 2 Demonstration** successfully showed the feasibility of supporting multiple BVLOS operations in a rural environment

**Areas of Improvement** successfully include weather products, industry standards, and engagement from UAS manufacturers in integrating UTM functionality to support BVLOS operations.

**Future work: (TCL 3 Demonstration)** will evaluate the effectiveness and interoperability of technologies to support separation, communication, navigation, data-exchange, and airspace management in a complex (suburban and near airports) operational environment





Questions?