Unmanned Aircraft Systems Traffic Management (UTM)

SAFELY ENABLING UAS OPERATIONS IN LOW-ALTITUDE AIRSPACE

Parimal Kopardekar, Ph.D.

NASA Senior Technologist, Air Transportation System, and UAS Traffic Management Principal Investigator
Outline

• Overview
• 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

<table>
<thead>
<tr>
<th>UAS Operator</th>
<th>Regulator/Air Navigation Service Provider</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Assure communication, navigation, and surveillance (CNS) for vehicle</td>
<td>• Define and inform airspace constraints</td>
</tr>
<tr>
<td>• Register</td>
<td>• Facilitate collaboration among UAS operators for de-confliction</td>
</tr>
<tr>
<td>• Train/qualify to operate</td>
<td>• If future demand warrants, provide air traffic management</td>
</tr>
<tr>
<td>• Avoid other aircraft, terrain, and obstacles</td>
<td>• Through near real-time airspace control</td>
</tr>
<tr>
<td>• Comply with airspace constraints</td>
<td>• Through air traffic control integrated with manned aircraft traffic control, where needed</td>
</tr>
<tr>
<td>• Avoid incompatible weather</td>
<td></td>
</tr>
</tbody>
</table>

Third-party entities may provide support services but are not separately categorized or regulated
**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

National Airspace System - ATM
NAS Data Sources
Flight Information Management System (FIMS) - FAA
Supplemental Data Service Provider

Color Key:
- ANSP Function
- Operator Function
- Other Stakeholders
- FAA Development & Deployment
- Industry Development & Deployment

NAS Data Sources
Common data
NAS state
NAS impact

UAS Service Supplier (USS)
Constraints, Directives
Requests, Decisions
Operations, Deviations

Terrain Weather Surveillance Performance
Operations, Constraints, Notifications, Information
Operation requests Real-time information

Public Safety
Public

Public Safety
Public

UAS Operator
UAS Operator
UAS Operator

UTM
Inter-data provider communication and coordination
Inter-USS communication and coordination

UAS
UAS
UAS
UAS
UTM Approach and Schedule
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
Progress and Next Steps
• 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

Longer-term: 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
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.
- **Contingency Alerts**: Simulated in-flight emergency reported to the UTM research prototype and relayed to impacted operations.
- **Intruder Alerts**: Alert triggered from radar submitted warning regions to UTM research prototype.
- **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
Embracing innovation in aviation while respecting its safety tradition