Enabling Civilian Low-Altitude Airspace and Unmanned Aerial System (UAS) Operations

By

Unmanned Aerial System Traffic Management (UTM)

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Unmanned Aerial Systems Traffic Management (UTM)

- Many civilian applications of Unmanned Aerial System (UAS) are being considered
  - Humanitarian
  - Goods delivery
  - Agricultural services
  - Strategic assets surveillance (e.g., pipelines)
- Many UAS will operate at lower altitude (Class G, 2000 Feet)
  - Other low-altitude uses such as personal vehicles are emerging
- No infrastructure to safely support these operations is available
- Global interest (e.g., Australia, Japan, France, United Kingdom, Europe)
- Lesson from History: Air Traffic Management started after mid-air collision over Grand Canyon in 1956
- Need to have a system for civilian low-altitude airspace and UAS operations

UTM will enable low-altitude airspace operations
UTM Applications

NOTIONAL SCENARIO

• **Near-term Goal** – Initial low-altitude airspace and UAS operations with demonstrated safety as early as possible, within 5 years
• **Long-term Goal** – UAS operations with highest safety and overall airspace efficiency to accommodate increased demand (10-15 years)
UTM Design Functionality

• UAS operations will be safer if a UTM system is available to support the functions associated with
  – Airspace management and geo-fencing (reduce risk of accidents, impact to other operations, and community concerns)
  – Weather and severe wind integration (avoid severe weather areas based on prediction)
  – Predict and manage congestion (mission safety)
  – Terrain and man-made objects database and avoidance
  – Maintain safe separation (mission safety and assurance of other assets)
  – Allow only authenticated operations (avoid unauthorized airspace use)

• Analogy: Self driving or person driving a car does not eliminate roads, traffic lights, and rules

• Missing: Infrastructure to support operations at lower altitudes
## Near-term UTM Builds Evolution

<table>
<thead>
<tr>
<th>UTM Build</th>
<th>Capability Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UTM1</strong></td>
<td>Trajectory Manager: Planning and tracking</td>
</tr>
<tr>
<td></td>
<td>• Geo-fencing and airspace design</td>
</tr>
<tr>
<td></td>
<td>• Open and close airspace decision based on the weather/wind forecast</td>
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<td>• Altitude Rules of the road for procedural separation</td>
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<td>• Basic scheduling of vehicle trajectories</td>
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<tr>
<td></td>
<td>• Terrain/man-made objects database to verify obstruction-free initial trajectory</td>
</tr>
</tbody>
</table>

| **UTM2**  | Make dynamic adjustments and contingency management  |
|           | • All functionality from build 1  |
|           | • Dynamically adjust availability of airspace  |
|           | • Demand/capacity imbalance prediction and adjustments to scheduling of UAS where the expected demand very high  |
|           | • Management of contingencies – lost link, inconsistent link, vehicle failure  |
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| **UTM3** | Manage separation/collision by vehicle and/or ground-based capabilities  
• All functionality from build 2  
• Active monitoring of the trajectory conformance inside geo-fenced area and any dynamic adjustments  
• UTM web interface, which could be accessible by all other operators (e.g., helicopter, general aviation, etc.)  
• Management of separation of heterogeneous mix (e.g., prediction and management of conflicts based on predetermined separation standard) |
| **UTM4** | Manage large-scale contingencies  
• All functionality of build 3  
• Management of large-scale contingencies such as “all-land” scenario |
Summary

• Goal is to safely enable initial low-altitude operations within 1-5 years
• Strong support for UTM system research and development
• Partnerships in development, testing, and transfer of UTM to enable low altitude operations

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Airspace Classification

Class A
18,000' MSL

Class B

Class C

Class D

Class E

14,500' MSL

Nontowered airport with instrument approach

1,200' AGL
700' AGL

1,200' AGL
700' AGL

1,200' AGL
700' AGL

Nontowered airport with no instrument approach

Source: Pilot’s Handbook of Aeronautical Knowledge, FAA
Operator Perspective:
Low-altitude Airspace Operations

- Is airspace open or closed now and in the near-future?
- Which airspace they can operate, which airspace they should avoid?
- Will there be anyone else in the vicinity?
  - UAS, gliders, helicopters, and general aviation
- What should I do if I need to change my trajectory?
- How to manage a contingency?
- Who should operate the airspace and how?
UTM – One Design Option

Multiple customers
With diverse mission needs/profiles

Range of UAVs from disposable to autonomous

UAS 1
- Autonomicity:
  - Self Configuration
  - Self Optimization
  - Self Protection
  - Self Healing
  - Operational data recording

UAS 2
- Authentication
- Airspace design and geo fence definition
- Weather integration
- Constraint management
- Sequencing and spacing
- Trajectory changes
- Separation management
- Transit points/coordination with NAS
- Geofencing design and adjustments
- Contingency management

UAS 3

UAS n

Low altitude CNS options such as:
- Low altitude radar
- Surveillance coverage (satellite/ADS-B, cell)
- Navigation
- Communication

Real-time Wx and wind

Wx and wind Prediction

Airspace Constraints

3-D Maps:
Terrain, human-made structures

Other low-altitude operations

Transition between UTM and ATM airspace

Constraints based on community needs about noise, sensitive areas, privacy issues, etc.

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User Access to UTM

- Cloud-based: user accesses through internet
- Generates and files a nominal trajectory
- Adjusts trajectory in case of other congestion or pre-occupied airspace
- Verifies for fixed, human-made, or terrain avoidance
- Verifies for usable airspace and any airspace restrictions
- Verifies for wind/weather forecast and associated airspace constraints
- Monitors trajectory progress and adjust trajectory, if needed (contingency could be someone else’s)
- Supports contingency – rescue
- Allocated airspace changes dynamically as needs change
UTM Manager

- Airspace Design and Dynamic Adjustments
  - Right altitude for direction, geo-fencing definition, community concerns, airspace blockage due to severe weather/wind prediction or contingencies
  - Delegated airspace as the first possibility

- Support fleet operations as well as singular operators (analogy - airline operations center and flight service stations)

- Overall schedule driven system to ensure strategic de-conflictions (initially, overtime much more dynamic and agile)

- Management by exception
  - Operations stay within geo-fenced areas and do not interrupt other classes of airspace operations in the beginning stages
  - Supports contingency management
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• Open and close airspace decision based on the weather/wind forecast  
• Altitude Rules of the road for procedural separation  
• Basic scheduling of vehicle trajectories  
• Terrain/man-made objects database to verify obstruction-free initial trajectory |
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