Unmanned Aircraft Systems Traffic Management (UTM): Conflict Mitigation Approach

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91.113 (Right of Way Rules) Mitigation by Technology Workshop

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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.
UTM Principles (a.k.a. Things That UTM Will Help With...)

VS

3
## Risk-based Conflict Mitigation Strategy

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<th>TCL 1 (Remote)</th>
<th>TCL 2 (Rural)</th>
<th>TCL 3 (Suburban)</th>
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<td>Operation Notice</td>
<td>UAS Operator Report (UREP)</td>
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**UTM**

**USS / SDSP**

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<tr>
<th><strong>UAS Operator / UAS</strong></th>
<th><strong>ATM</strong></th>
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<td>Flight Planning</td>
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<td>Flight Volume Containment</td>
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<td>Position Broadcast</td>
<td>Position Broadcast</td>
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<tr>
<td>Obstacle Avoidance</td>
<td>See and Avoid</td>
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**Airspace Hazards**

**Airborne Hazards**

**Ground Hazards**
Conflicts management timeline could be slightly different based on target (unmanned, manned, obstacles).
Conflicts management timeline could compress (or expand) based on density of operations and mission characteristics (e.g., cruise speed).
So...should I always maneuver when alerted to conflicts?

If you can read this you are not well clear

Maneuver:
- Other aircraft in Distress
- In violation of a separation requirement
- Other aircraft outside de-conflicted operation plan

Don't Maneuver:
- Other aircraft inside de-conflicted operation plan
- Other aircraft inside known airspace structure

Resolution Broker

UTM Information
- Threat Detection

Ground-based Information
- Threat Detection

Onboard Information
- Threat Detection

USS
- Pilot in Command
- UAS
NASA DAA Reference Implementation

Safety Layers in UTM

Strategic Safety Assurance

UAS Operations and Airspace Management

Supports UAS with services (e.g. separation, weather, flight planning, contingency management, etc.)

Tactical Safety Assurance

Contingency Management for BVLOS Operations

Mission Safety Responsibility

UAS Onboard Systems

ICAROUS
Dynamic constraint monitoring, DAA and contingency management

Autopilot
Autonomous Navigation

URAF*
Real time safety assessment and tracking,

Safeguard
Static, assured, constraint monitoring,

Safe 2 Ditch
Identification of a safe landing location

Communications/data exchanges in UTM

FIMS
Enables airspace controls
Supports response in emergencies impacting NAS

USS
Supports UAS with services (e.g. separation, weather, flight planning, contingency management, etc.)

Airspace controls
Emergencies impacting NAS

Airspace/geofences
Flight plans UAS with services (e.g. Weather information
Contingencies/emergencies
Flight plans, geofences, aircraft state, alerts, health status, emergencies

UAS Operator

Supports response in emergencies impacting NAS

Supports UAS with services (e.g. separation, weather, flight planning, contingency management, etc.)
**Sense and Avoid**

ICAROUS detects potential conflicts with aircraft in range and autonomously computes and executes conflict-free avoidance and return to mission maneuvers.

**Tracking, Merging and Spacing**

ICAROUS maintains a user provided distance to another UAS and coordinate to merge when converging to a shared destination.

**ICAROUS Core Functionality**

- Contingency Management
- Vehicle to vehicle coordination
- Collision Avoidance
- Dynamic Geo-fence Conformance
- DAA system connection to USS services, Interoperability with contingency management

**Conformance to Geofence Constraints**

ICAROUS uses the Polycarp algorithm to detect proximity to boundaries. ICAROUS monitors distance/time to to boundaries to ensure that the aircraft has enough time to prevent a violation.

**Stand-off Distance and Path Conformance**

- Stand-off Distance: Controls to a user provided, dynamically changing stand-off distance to a target.
- Path Conformance: Prevents large deviations from the active flight plan.

**NASA Reference Implementation**

- Sense and Avoid
  - Sense and Avoid
  - Stand-off Distance and Path Conformance
  - Tracking, Merging and Spacing
  - Conformance to Geofence Constraints
TCL 3 DAA Testing: NASA Testing

BVLOS flights over suburban-like environments using vehicle-to-vehicle communication and DAA algorithms on-going.
TCL 3 SAA Testing: FAA UAS Test Sites

- Test SAA1: Air to Air Conflict Mitigation Cooperative Technology for UAS-UAS Interaction {DSRC}
- Test SAA2: Air to Air Conflict Mitigation Cooperative Technology for UAS-Manned Interaction {ADS-B In / Out}
- Test SAA3: Air to Air Conflict Mitigation Non-Cooperative Technology for UAS-Manned Interaction {Airborne Radar}
- Test SAA4: Air to Ground Conflict Mitigation Non-Cooperative Technology for UAS-Manned Interaction {Ground Radar}
- Test SAA5: System Level Assessment and Off nominal conditions {End-to-End SAA Strategy+ Off-Nominals}
- Test SAA6: Air to Ground UAS Identification and interoperability with automobiles using cooperative technology {Aerial DSRC+ Automobile DSRC}
NASA TCL 3 SAA Testing

Objectives:

• Demonstrate the feasibility of the mitigation solution
• Quantify the performance and effectiveness of the technology for collision avoidance
• Quantify conflict timeline, identify roles and responsibilities, and identify information requirements
• Evaluate Human Factors with respect to: workload, information requirements, situation awareness, effective time resolving conflicts, perception of risk
• Demonstrate a complete separation strategy (strategic and tactical) using USS AND vehicle mitigations
• Evaluate interoperability between varying levels of equipage
• Evaluate interoperability with priority operations and dynamic airspace restrictions
• Establish and test procedures in off-nominal conditions
Challenges

→ Wide range of technologies and each technology has slightly different applicability

→ All-weather solutions and performance of on-board capabilities still pose a challenge given SWaP limitations

→ Inconsistent or non-existent metrics to evaluate the effectiveness of the conflict mitigation technology solutions

→ Scalability of operations and the impact on DAA solutions
Parting Thoughts

Geographic context matters for low altitude operations, DAA without geographic considerations (e.g. airspace constraints, ground risk, other operations intent) may do more harm then good

A one-size-fits-all approach to compliance with the intent of 91.113 may limit many business models and make UAS use cost-prohibitive

Risk-based safety methodologies allows for operators to innovate around their use cases

USS and SDSP services can reduce the performance burden of onboard (or ground-based) DAA equipage
Questions?

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