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

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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
Risk-based Conflict Mitigation Strategy

TCL1 (Remote)
- Visual Line of Sight
- Notice of Operation
- Position-Sharing (Optional)

TCL 2 (Rural)
- Beyond Visual Line of Sight
- Intent Sharing
- Strategic De-confliction
- Geographic Containment

TCL 3 (Suburban)
- Beyond Visual Line of Sight
- Intent Sharing
- Strategic De-confliction
- Geographic Containment
- Conflict Alert
- Detect and Avoid (DAA)
- Vehicle-to-Vehicle (V2V)

TCL 4 (Urban)
- Beyond Visual Line of Sight
- Intent Sharing
- Strategic De-confliction
- Geographic Containment
- Detect and Avoid (DAA)
- Vehicle-to-Vehicle (V2V)
- Obstacle Avoidance
- Dynamic Re-routing
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- **Scheduling**: Conformance Monitor
- **Airspace Constraints**: Separation Provision, Conflict Alert
- **Ground Constraints**: Dynamic Re-routing
- **Operation Notice**: UAS Operator Report (UREP)
- **Flight Planning**: Flight Volume Containment
- **Radio Communication**: Position Broadcast
- **Data Communication**: Position Broadcast
- **Visibility and Audible Enhancements**: Cooperative De-confliction (Air-to-Air)
- **Position Broadcast**: Non-cooperative De-confliction (Air-to-Air)
- **Ground Surveillance**: Obstacle Avoidance
- **Data Communication**: See and Avoid

**Hazard Types**:
- Airspace Hazards
- Airborne Hazards
- Ground Hazards
Notional Conflict Timeline

Conflict management timeline could be slightly different based on target (unmanned, manned, obstacles) Conflict 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?

- 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
  - USS
  - Pilot in Command
  - UAS
Safety Layers in UTM

- Enables airspace controls
- Supports response in emergencies impacting NAS
- Supports UAS with services (e.g. separation, weather, flight planning, contingency management, etc.)

Communications/data exchanges in UTM

- 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 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
NASA Reference Implementation

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

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

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.
TCL 3 DAA Testing: NASA Testing

BVLOS flights over suburban-like environments using vehicle-to-vehicle communication and DAA algorithms on-going.

NASA Langley CERTAIN range
TCL 3 SAA Testing: FAA UAS Test Sites

- Test SAA1: Air to Air Conflict Mitigation Cooperative Technology for UAS-UAS Interaction \(\text{\{DSRC\}}\)

- Test SAA2: Air to Air Conflict Mitigation Cooperative Technology for UAS-Manned Interaction \(\text{\{ADS-B In / Out\}}\)

- Test SAA3: Air to Air Conflict Mitigation Non-Cooperative Technology for UAS-Manned Interaction \(\text{\{Airborne Radar\}}\)

- Test SAA4: Air to Ground Conflict Mitigation Non-Cooperative Technology for UAS-Manned Interaction \(\text{\{Ground Radar\}}\)

- 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 \(\text{\{Aerial DSRC+ Automobile DSRC\}}\)
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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