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

Dr. Marcus Johnson

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

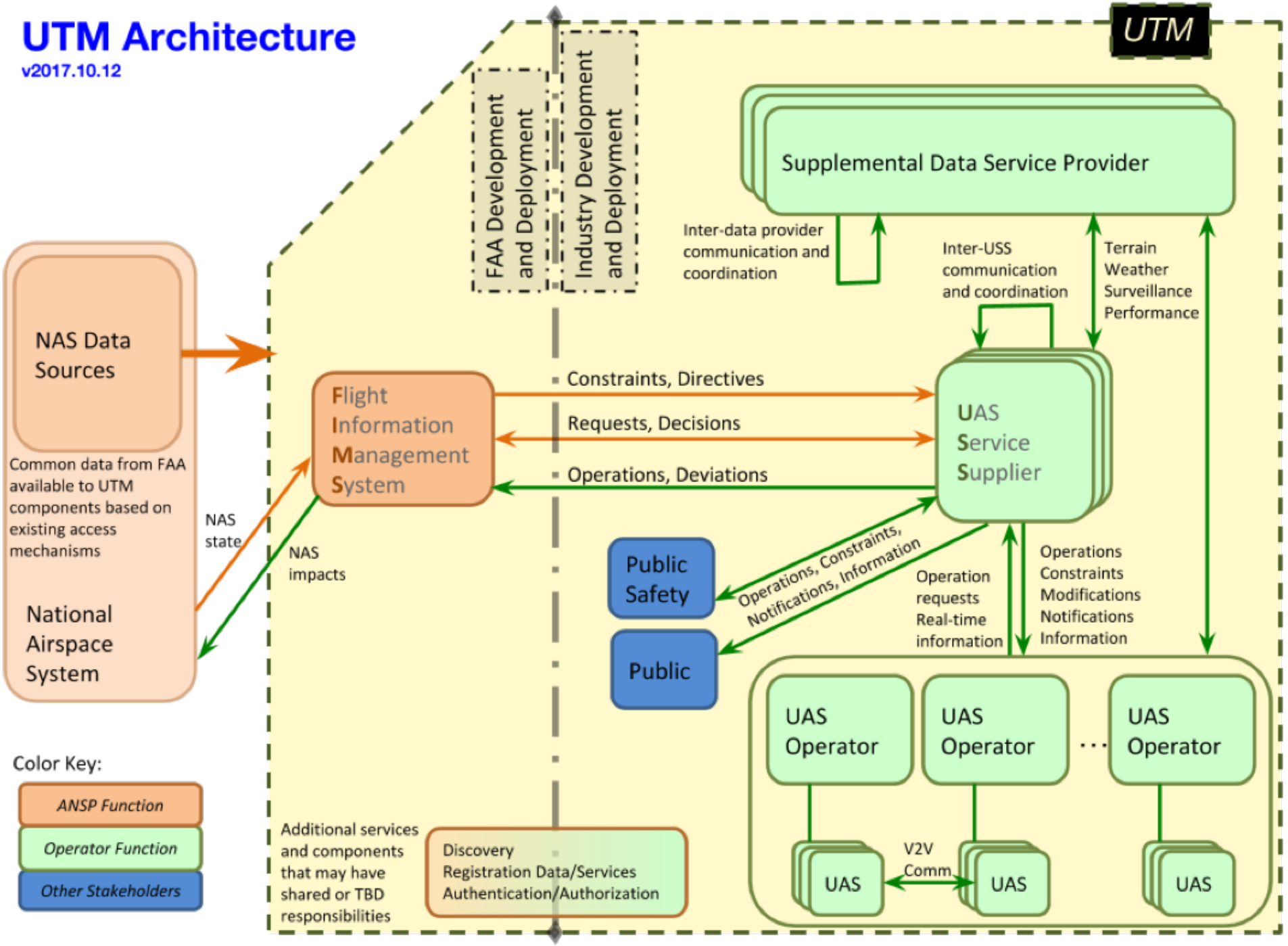
UTM Principles

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

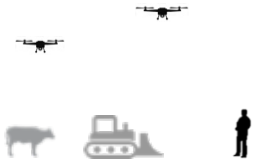
VS

UTM Architecture

v2017.10.12



Risk-based Conflict Mitigation Strategy



TCL1 (Remote)

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

TCL 2 (Rural)

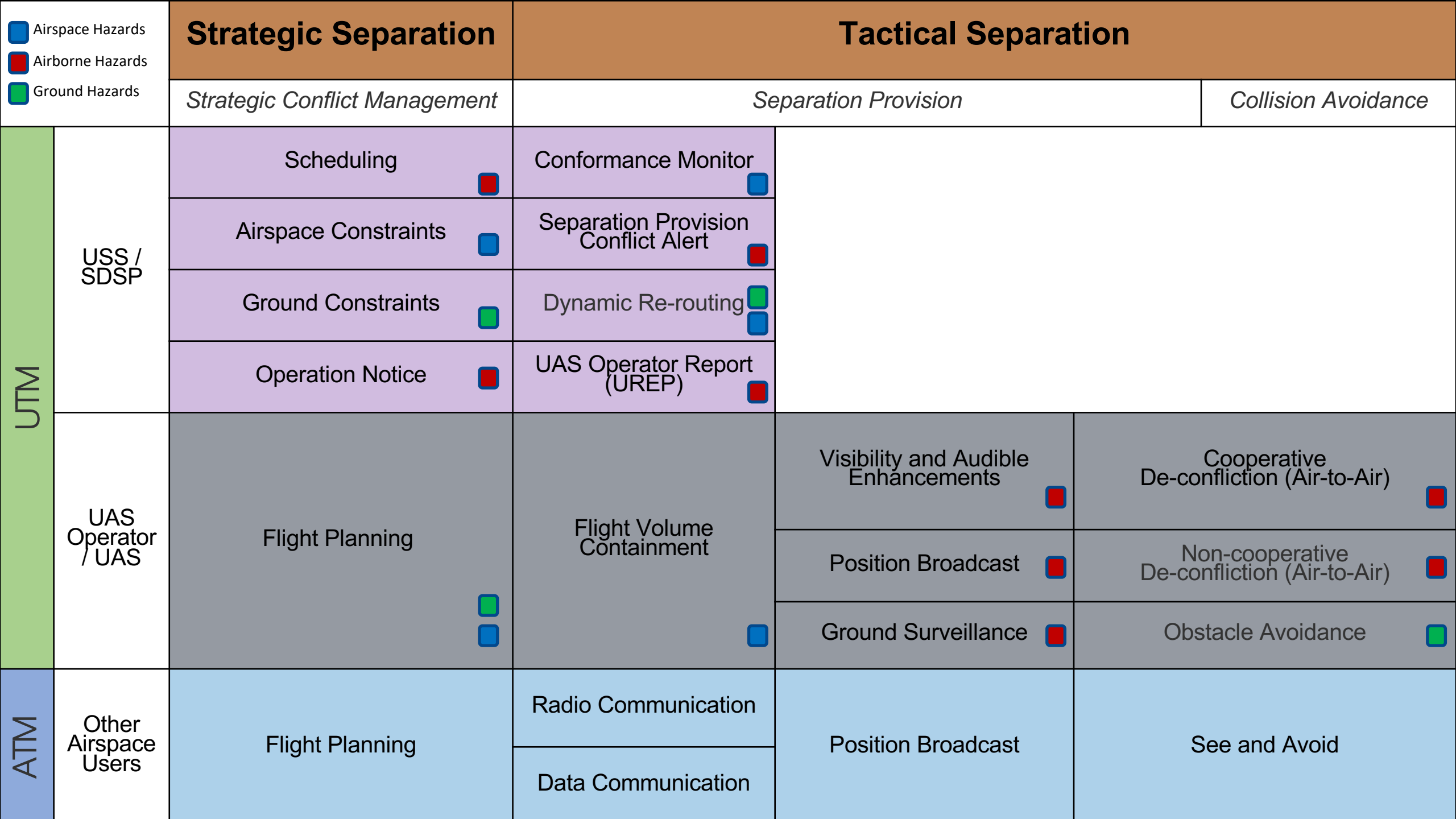
- Beyond Visual Line of Sight
- Intent Sharing
- Strategic De-confliction
- Geographic Containment

TCL 3 (Suburban)

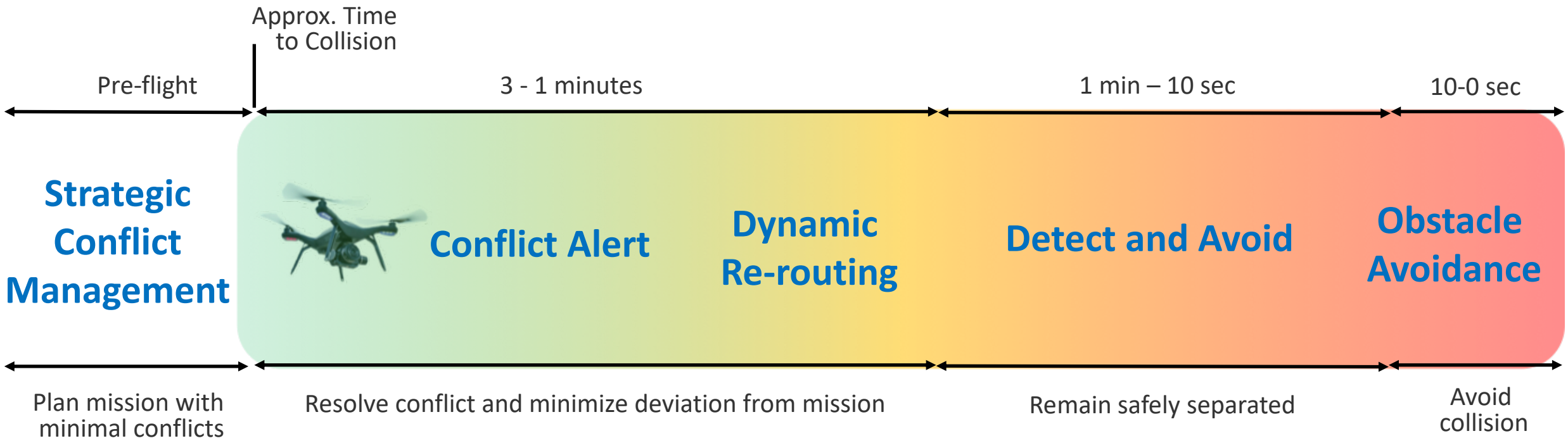
- Beyond Visual Line of Sight
- Intent Sharing
- Strategic De-confliction
- Geographic Containment
- Conflict Alert
- Detect and Avoid (DAA)
- Vehicle-to-Vehicle (V2V)

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

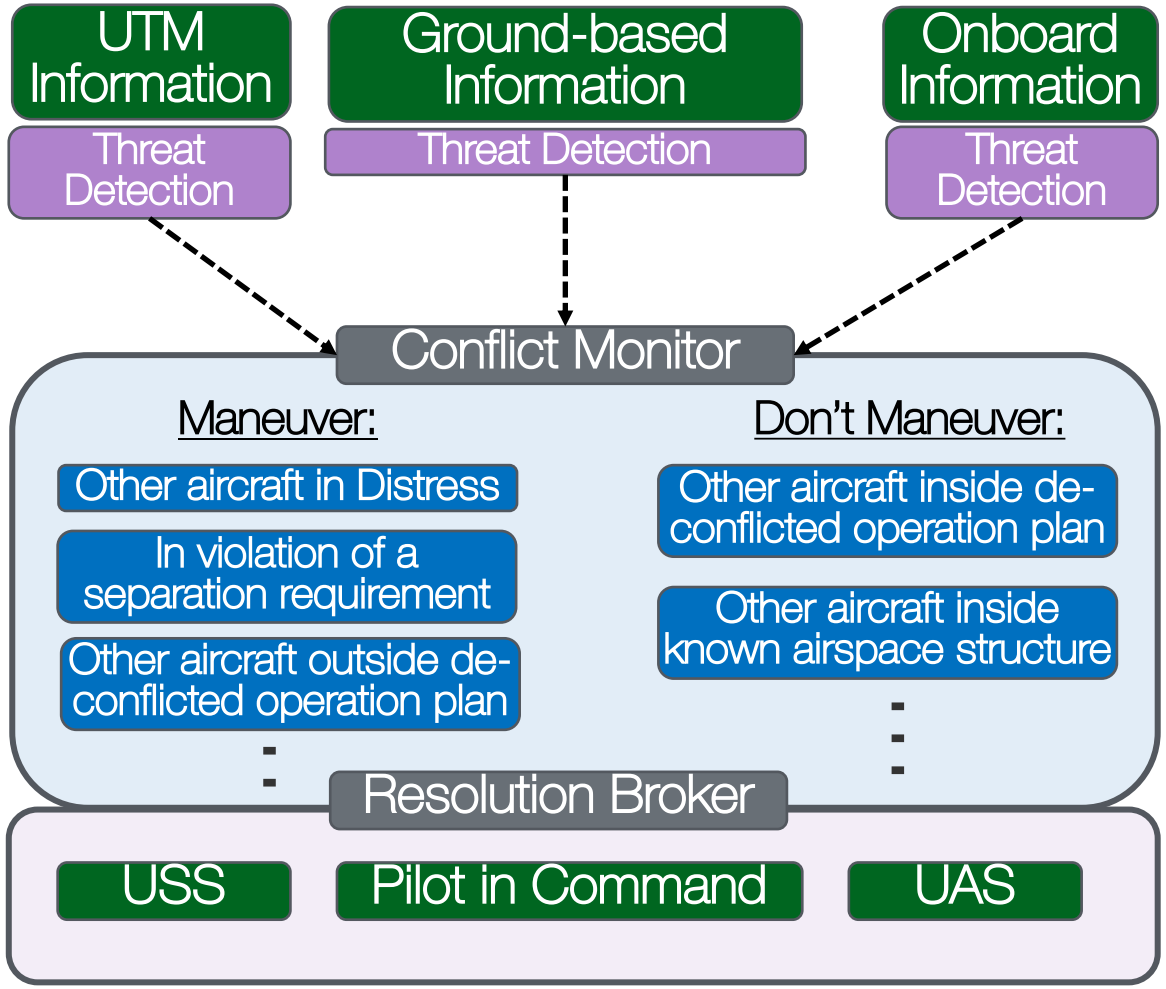

Airspace Hazards
Airborne Hazards
Ground Hazards
Strategic Separation
Tactical Separation
Strategic Conflict Management
Separation Provision
Collision Avoidance
UTM
USS / SDSP
Scheduling
Airspace Constraints
Ground Constraints
Operation Notice
Conformance Monitor
Separation Provision Conflict Alert
Dynamic Re-routing
UAS Operator Report (UREP)
UAS Operator / UAS
Flight Planning
Flight Volume Containment
Visibility and Audible Enhancements
Position Broadcast
Ground Surveillance
Cooperative De-confliction (Air-to-Air)
Non-cooperative De-confliction (Air-to-Air)
Obstacle Avoidance
ATM
Other Airspace Users
Flight Planning
Radio Communication
Data Communication
Position Broadcast
See and Avoid

Notional Conflict Timeline

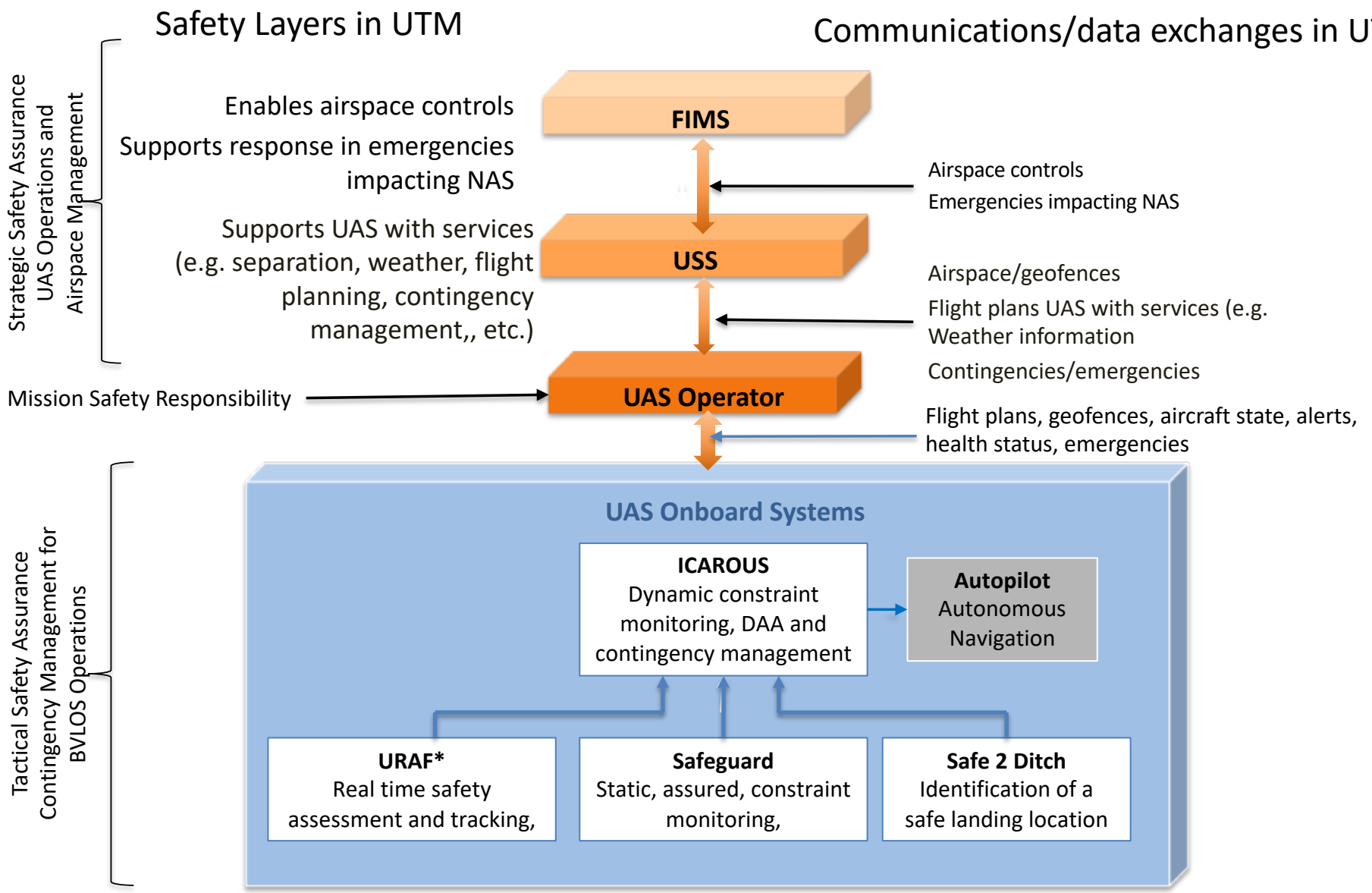


Conflict management timeline could be slightly different based on target (unmanned, manned, obstacles)
Conflict management timeline could compress (or expand) based on density of operations and mission characteristics (e.g. cruise speed)

So…should I always maneuver when alerted to conflicts?

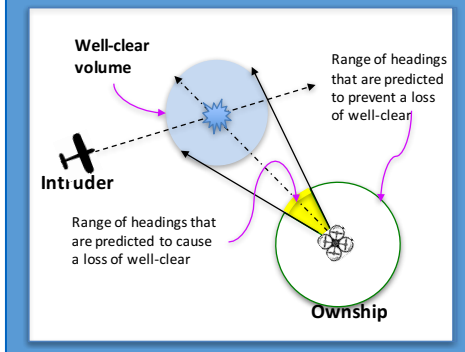


NASA DAA Reference Implementation



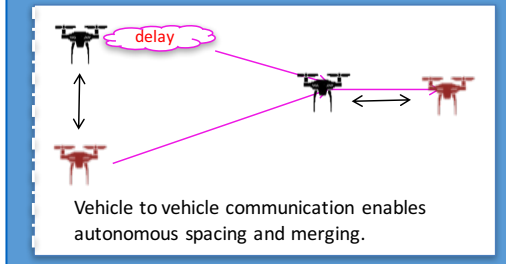
NASA Reference Implementation

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

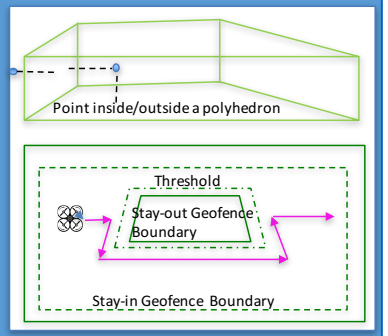
DAA system

connection to USS services,

Interoperability with contingency management

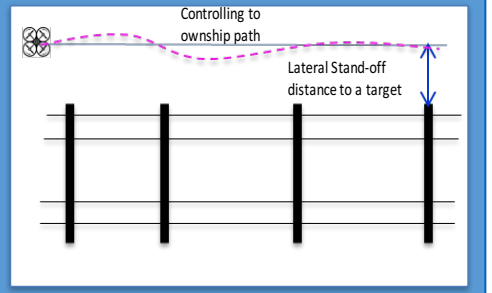
Conformance to Geofence Constraints

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

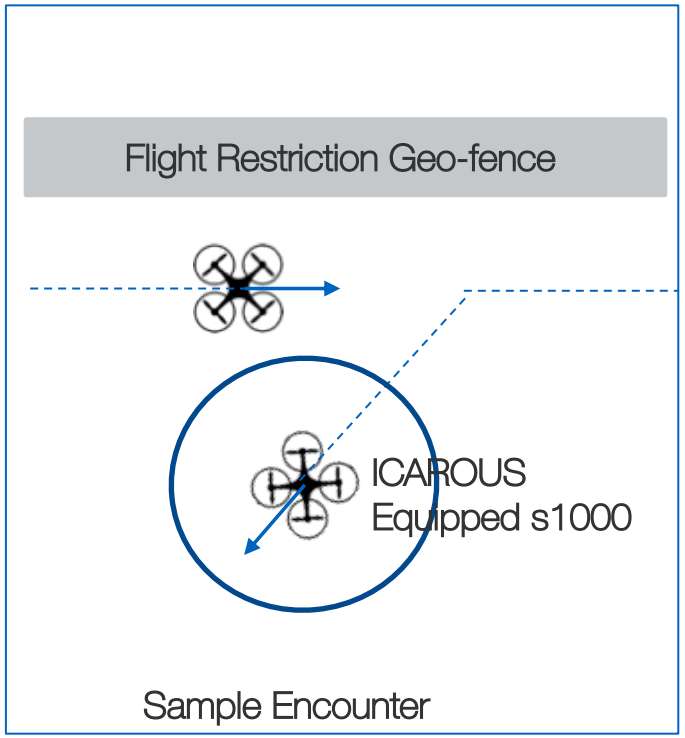
Stand-off Distance: Controls to a user provided, dynamically changing stand-off distance to a target.
Path Conformance: Prevents large deviations from the active flight plan.

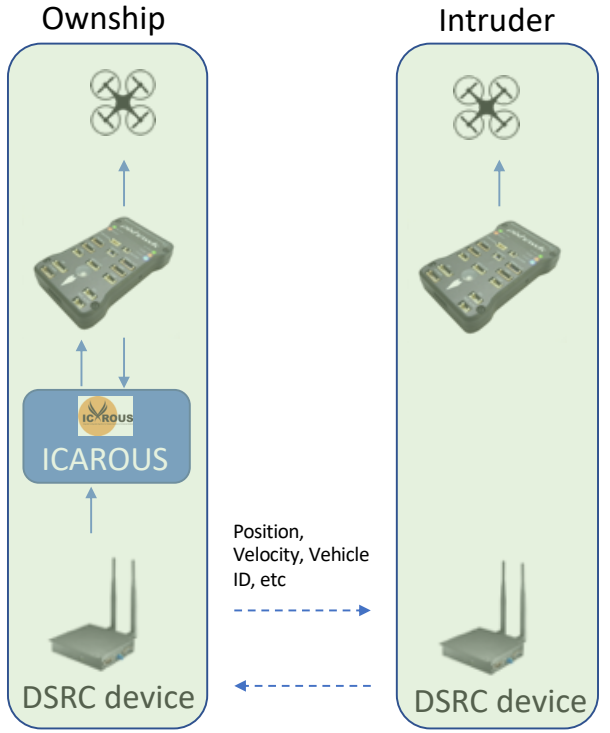


TCL 3 DAA Testing: NASA Testing

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

NASA Langley
CERTAIN range

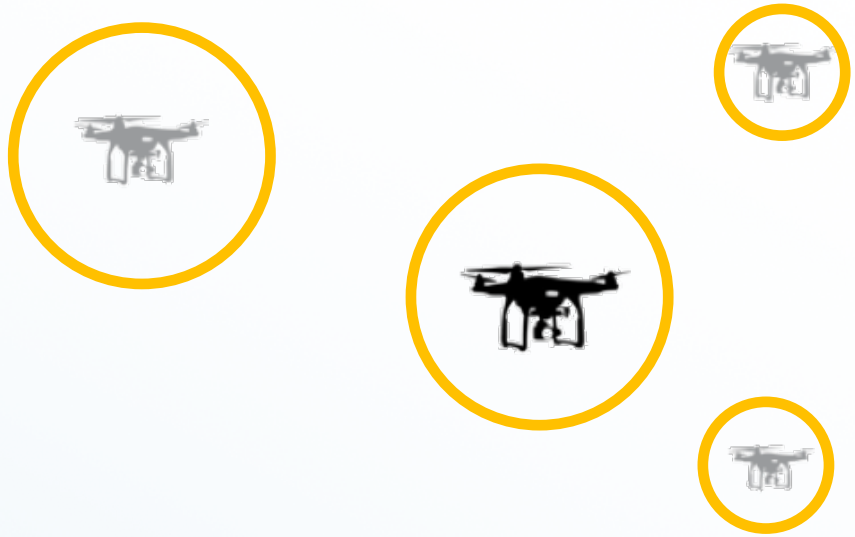




Both vehicles equipped with DSRC devices

TCL 3 SAA Testing: FAA UAS Test Sites

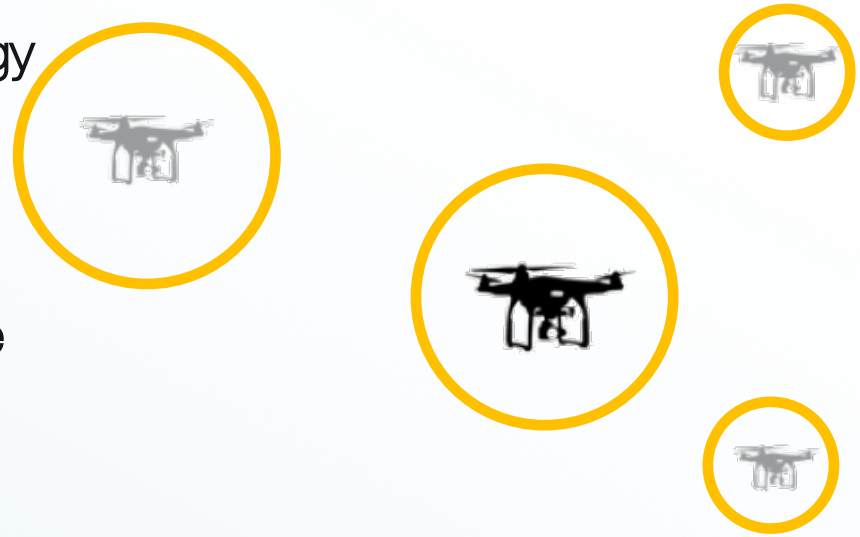
- Test SAA1: Air to Air Conflict Mitigation Cooperative Technology for UAS-UAS Interaction *{DSRC}*
- Test SAA2: Air to Air Conflict Mitigation Cooperative Technology for UAS-Manned Interaction *{ADS-B In / Out}*
- Test SAA3: Air to Air Conflict Mitigation Non-Cooperative Technology for UAS-Manned Interaction *{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?

marcus.johnson@nasa.gov