National Aeronautics and Space Administration



Unmanned Aircraft Systems Traffic Management (UTM)

Concepts and Architecture Overview

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JARUS Working Group Meetings at Ames
March 2018

DJI-1017
IPR2023-01227

Low Altitude UAS Operations

FAA 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 safety structures in airspace

Operational concept being developed to address beyond-visual-line-of-sight (BVLOS) UAS operations at low altitude in uncontrolled airspace using UTM construct

Challenges with Expanding Operations

Visual Line of Sight

14 CFR Part 91
[Hobbyists]
14 CFR Part 107
[Commercial]



No Operations over People
Daylight Only
Up to 400 ft AGL
Operation in controlled airspace allowed



Operations Near Airports

Beyond Visual Line of Sight



Separation



Weather

Command and Control



Awareness



Aircraft Performance

Operations over People

Tracking and UAS Identification

What is UAS Traffic Management?

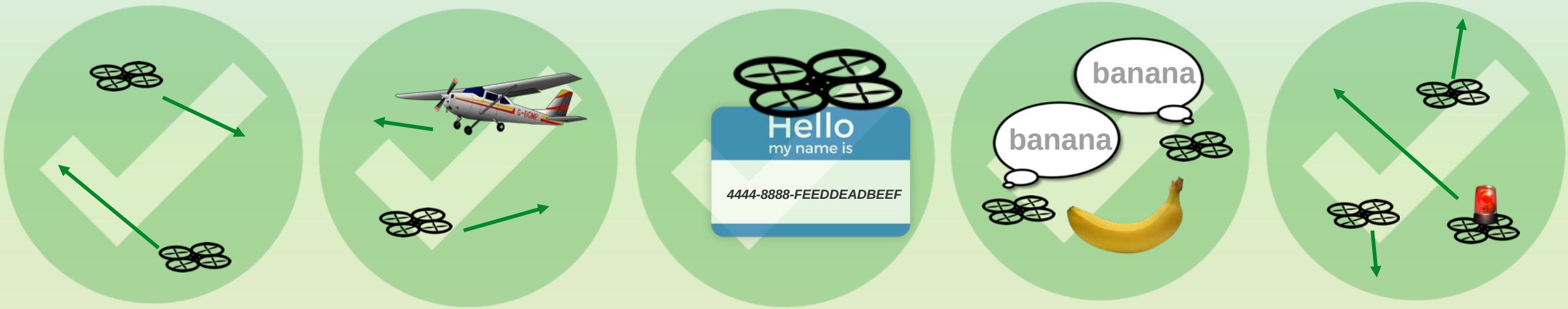
UTM is an “air traffic management” ecosystem for uncontrolled operations

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 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)



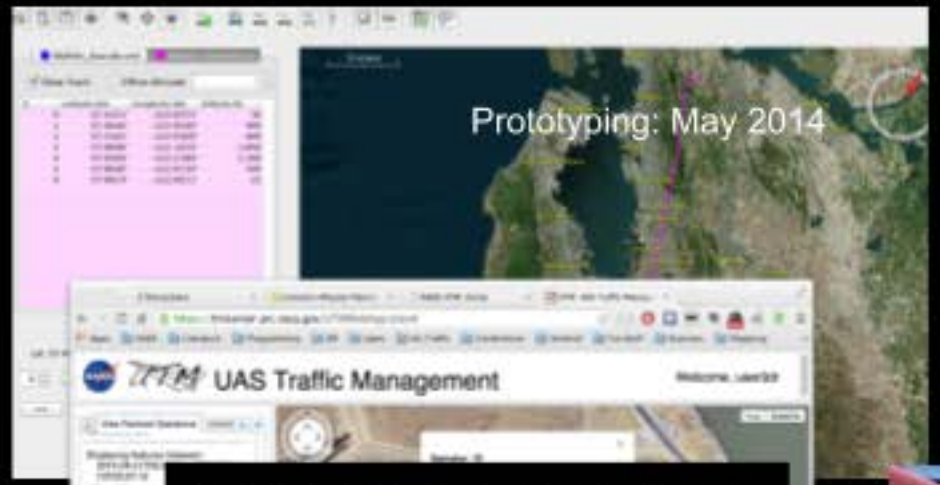


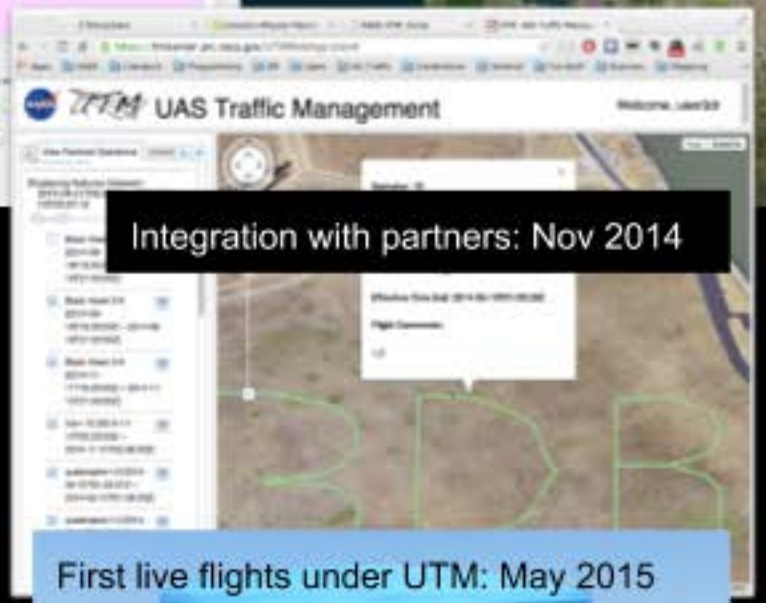






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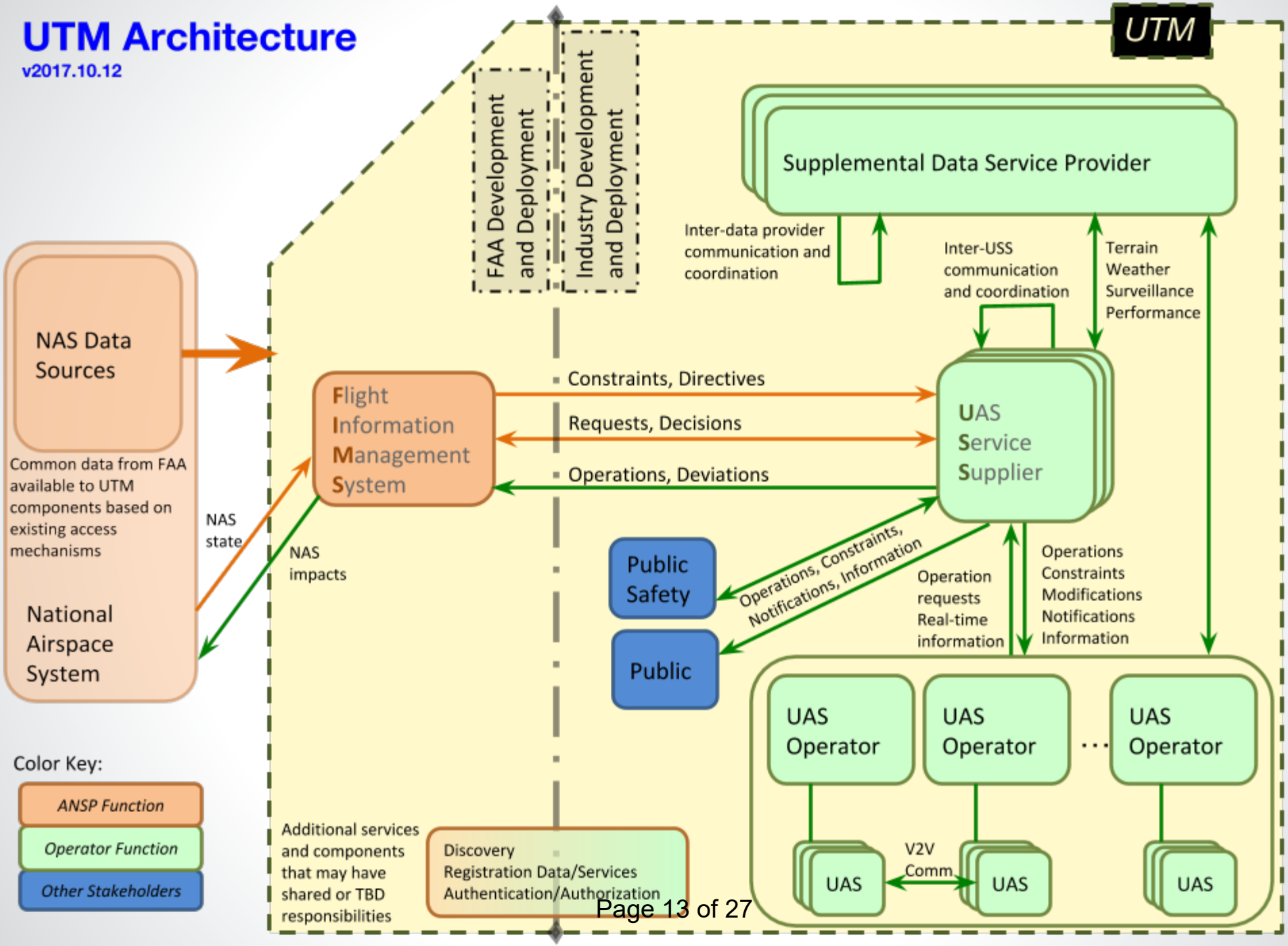






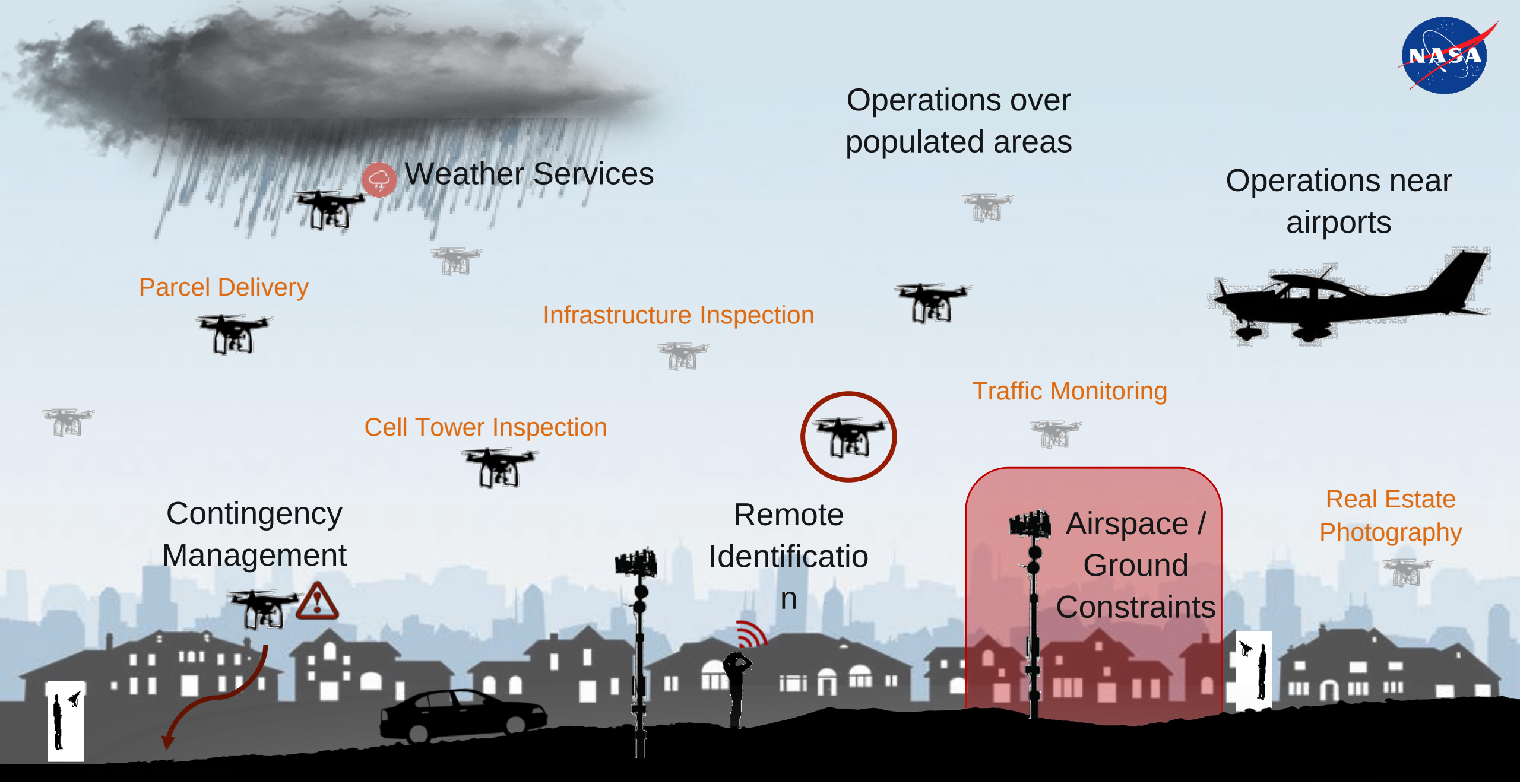
UTM Architecture

v2017.10.12

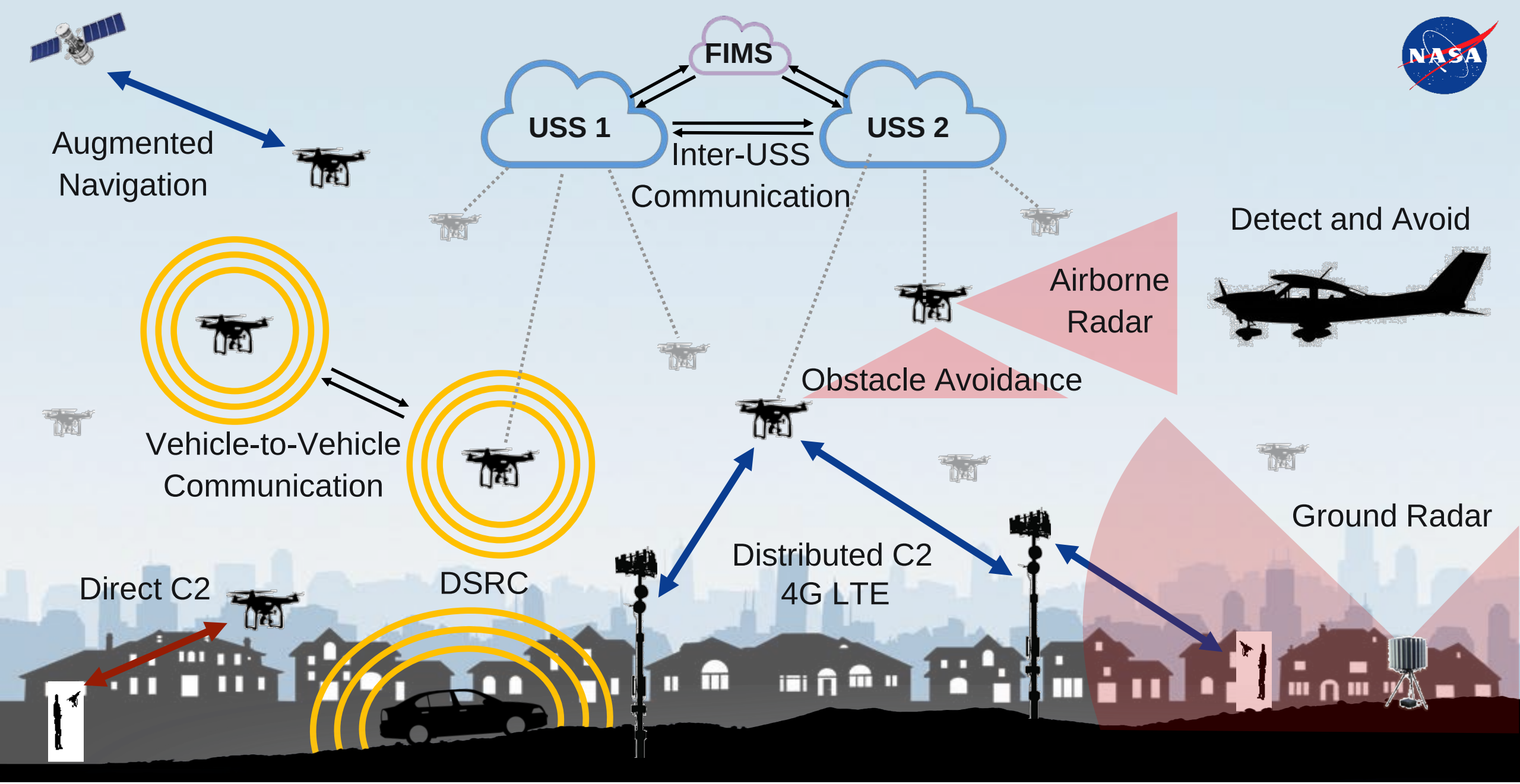


Technical Capability Level 3 Flight Test

Evaluate the feasibility of multiple BVLOS operations near airports and in suburban environments using a UTM research platform



echnical Capability Level 3 Research Areas for BVLOS Ops



Technical Capability Level 3 Flight Tests

TCL 3 Demonstration DAT/CON Tests

- DAT1: End-to-end UREP
- DAT2: FIMS failover
- DAT3: USS failover
- DAT4: UAS ID
- DAT5: USS-USS Negotiation
- DAT6: Wx Service

- CON1: BVLOS Landing
- CON2: Contingency Initiation
- CON3: Public Portal
- CON4: Multiple TCL 2/TCL 3 Operations for a Sustained Period
- CON5: FIMS/USS Interaction When a Vehicle Heads Towards Controlled or Unauthorized Airspace

NASA UTM Research Platform

Key implementation choices

REST APIs + JSON Data Exchanges

- Key Internet Technologies
- Easy to implement, test, deploy, maintain
- Code generation from documentation

Cloud Native

- Infrastructure as code
- Elasticity of resources
- Natural parallel environments

Security Baked In

- Continuous Integration, Continuous Deployment
- Static Code Analysis with quality gates
- Threat Modeling
- NASA Secure Coding Practices
- Data Classification

Volume-Based Operations

- Naturally fits sUAS paradigm
- Intuitive strategic conflict management
- GeoJSON supports design goals

Delegated Authority

- USSs will eventually do as much as possible
- Does not add burden to existing NAS
- Phased deployment of responsibilities

Rules-based Environment

- USSs as a collective manage operations
- Each USS arrives at same conclusions
- Automation supports rapid decisions

NASA-FAA Data Working Group

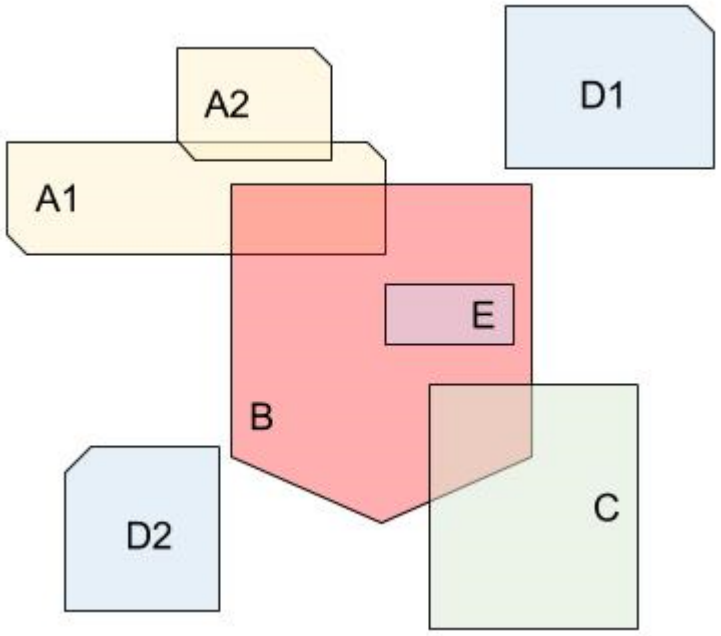
- **Traditionally “ahead” of other working groups**
- **Bi-weekly tagups**
- **Core group designing and running UTM Pilot Program**
- **NASA develops and test concepts**
- **FAA reviews and prepares for palatability to NAS**
- **Tight interactions with other Working Groups**

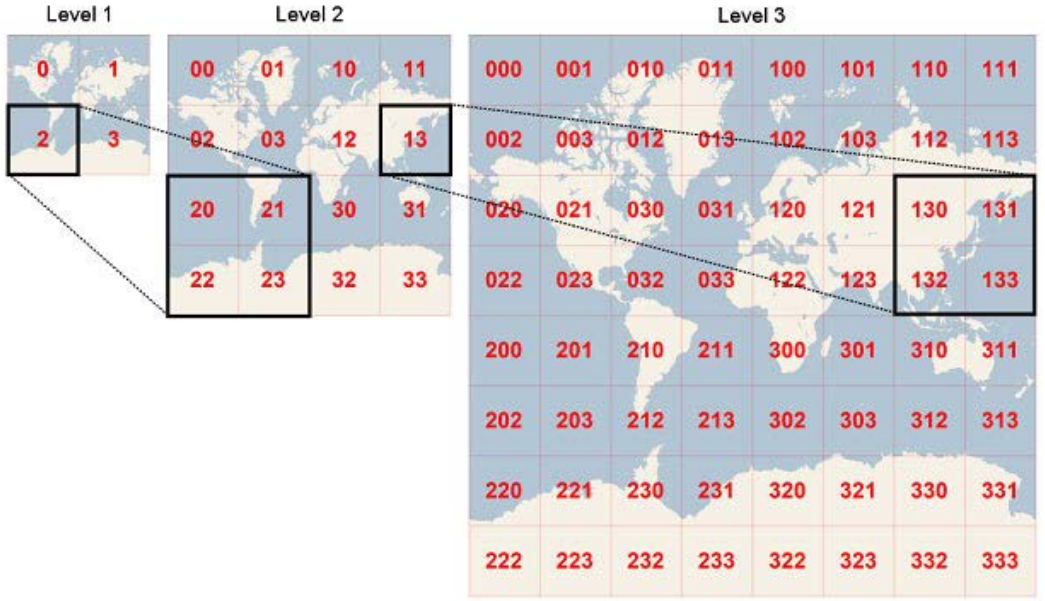




Local USS Network

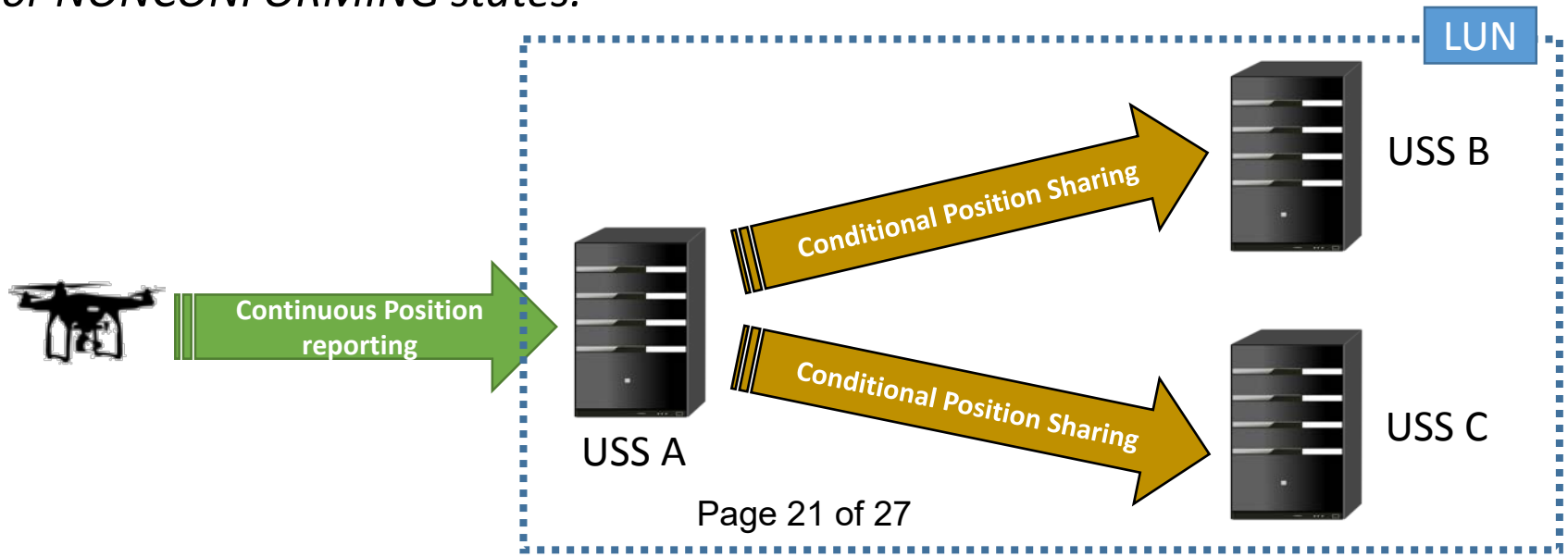
- The LUN is a concept to allow the scoping of data exchanges between USSs, discovery of USS Instances by stakeholders, and for operators to understand the coverage areas of a USS.
- There are multiple approaches to implementing the LUN concept.





Position Sharing

- *A USS MUST collect position updates from all ACTIVE Part 107X operations.*
- *A USS MUST provide access to all Part 107X operation position updates to FIMS upon request per the [USSREQ-API].*
- *A USS MUST provide access to position updates for a Part 107X operation (Operation A) to another USS upon request when that second USS has an active operation with an operation volume intersecting Operation A's operation volumes. (NOTE: 4D intersection)*
- *A USS MUST provide access to position updates (if available) to its LUN for all operations in the ROGUE or NONCONFORMING states.*



Strategic Deconfliction

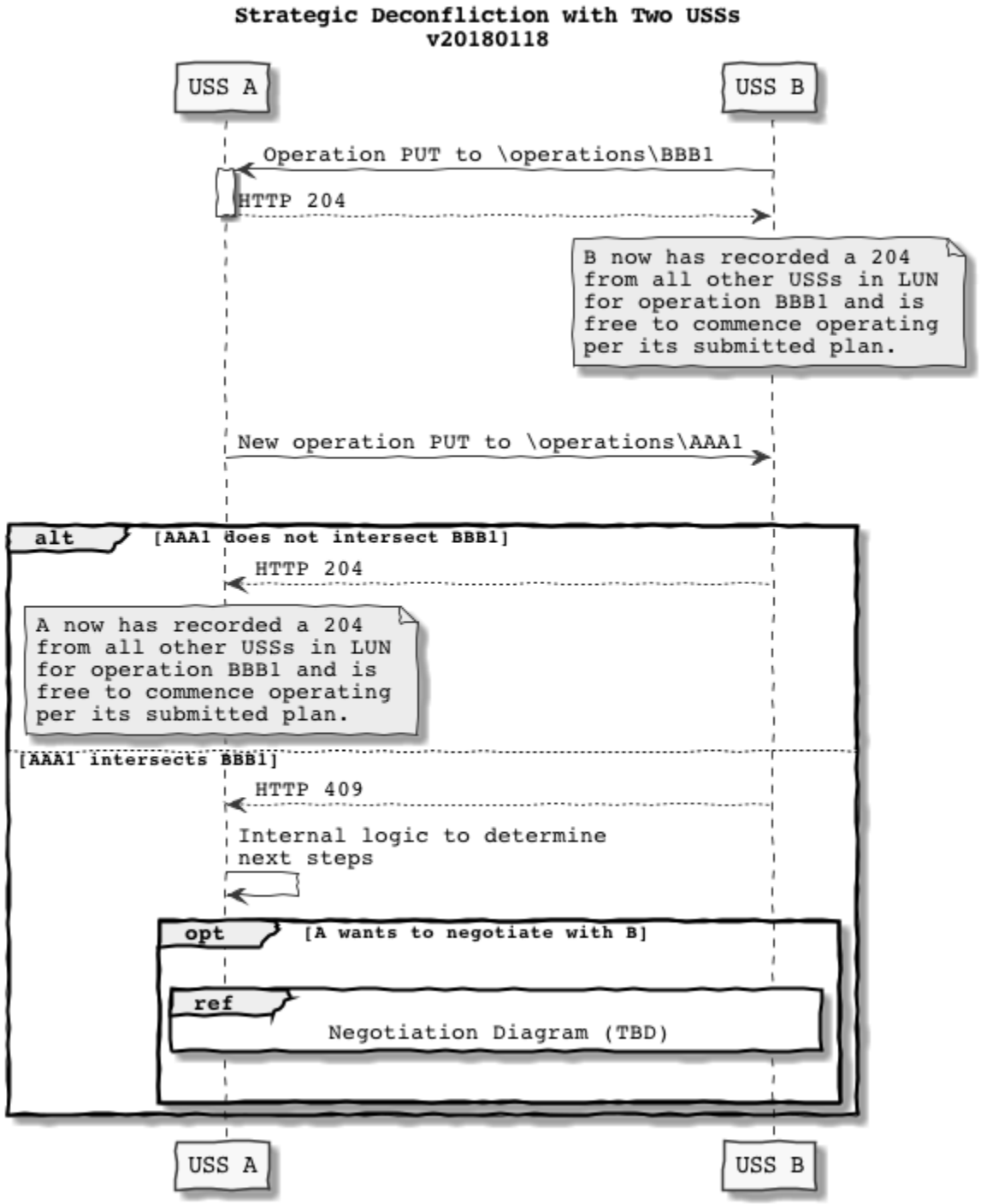
For TCL3, Strategic Conflict Management is achieved through RESTful data exchanges and HTTP response codes

HTTP 204: No problem with your plan, thanks.

HTTP 409: Conflict with one of my plans.

In a conflict scenario, negotiation may occur to deconflict while allowing both operations to execute.

Exploring an additional architecture in TCL3 at one test site for comparison



Separation Challenges

Airborne

Manned and unmanned aircraft

Airspace

Authorized Airspace, “No Fly Zones”, “No Land Zones”

Ground Hazards

Man-made Structures, Terrain, Foliage, Moving Ground Objects

Weather

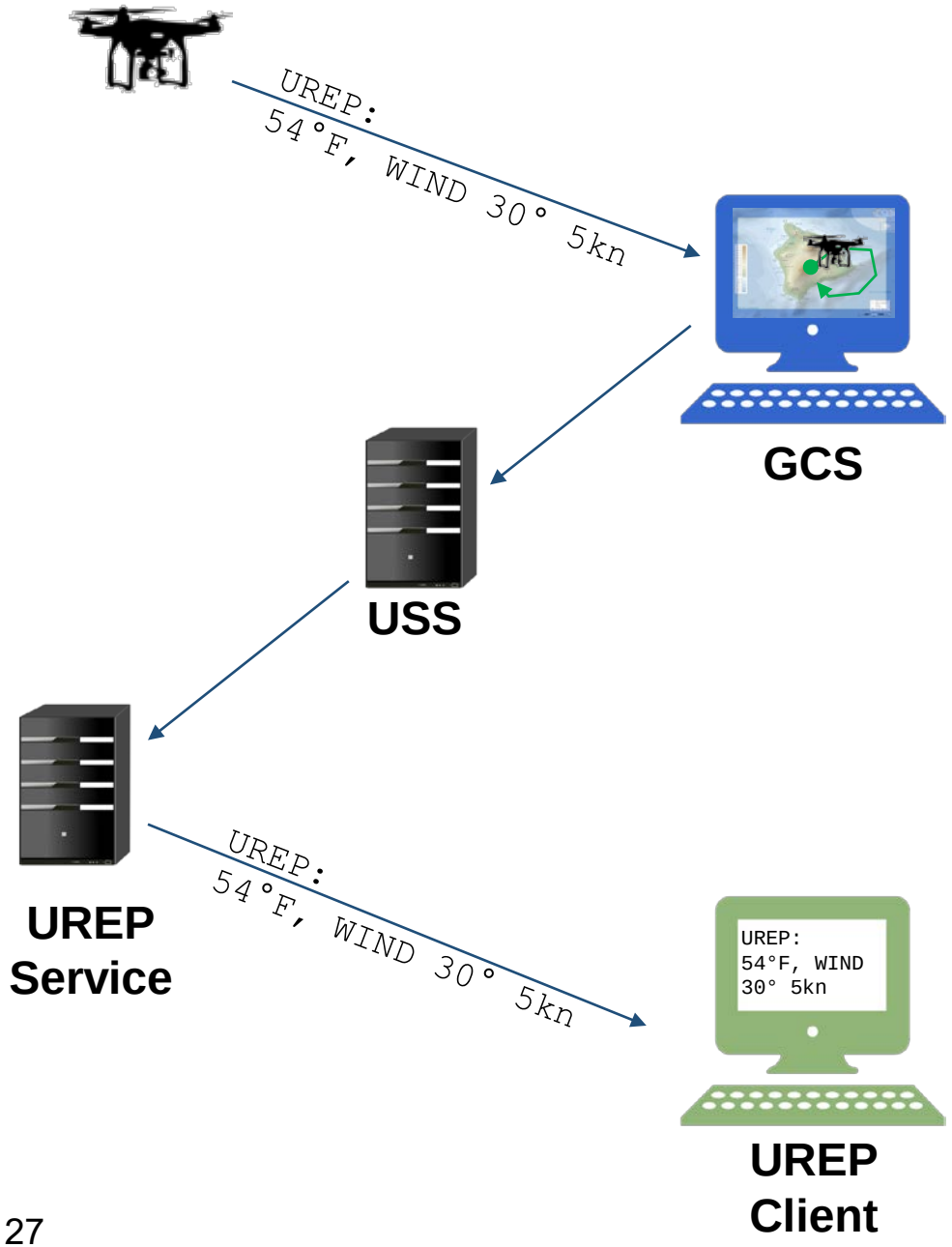
Communication

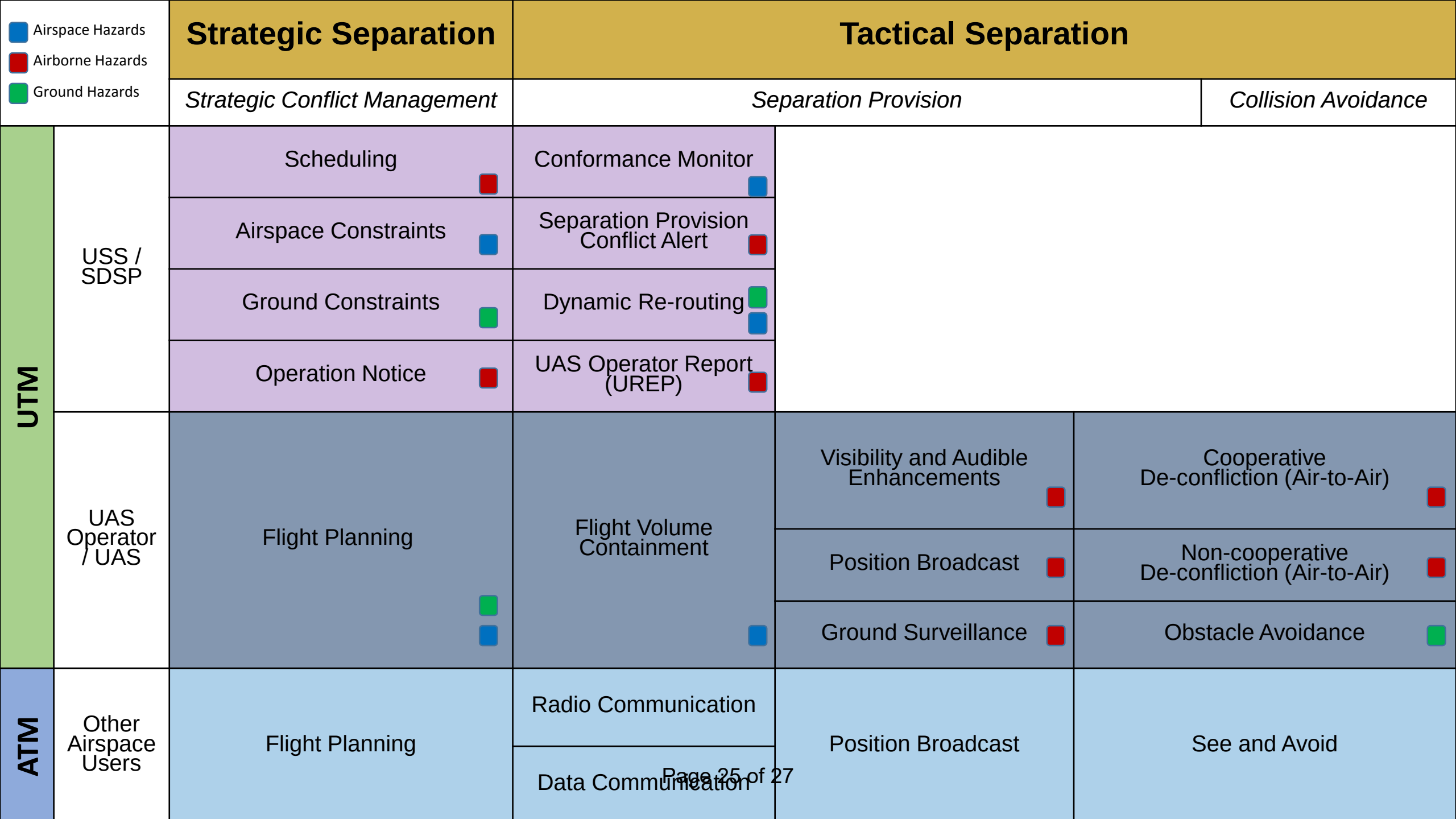
Navigation



UREPs: UAS Reports

- Modeled on PIREP concept
- Uses the complete PIREP model for wx elements
- Adds model for airspace sightings
- May be extended to report other elements to support traffic flow management
- Would support automated, frequent reports from multiple clients allowing UAS to become sensors within UTM

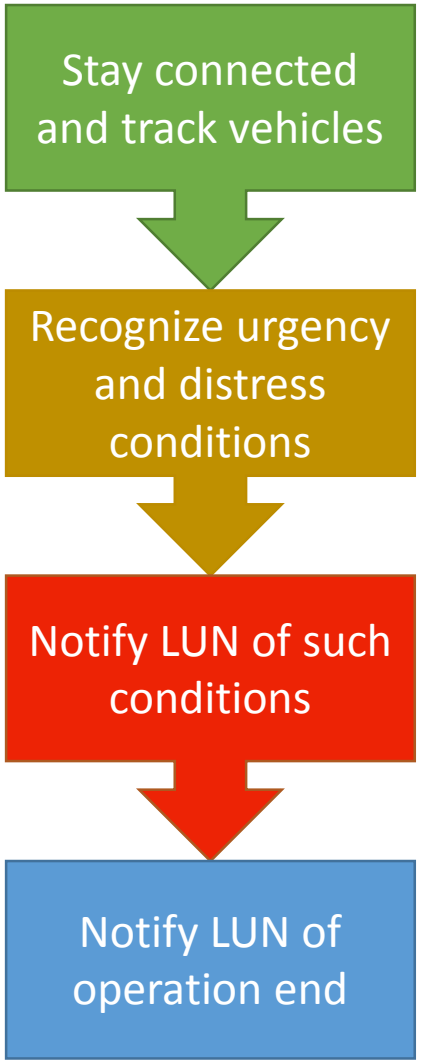



Airspace Hazards
Airborne Hazards
Ground Hazards
Strategic Separation
Tactical Separation
Strategic Conflict Management
Separation Provision
Collision Avoidance
UTM
USS / SDSP
Scheduling
Airspace Constraints
Ground Constraints
Operation Notice
Conformance Monitor
Separation Provision Conflict Alert
Dynamic 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

In-flight Emergencies

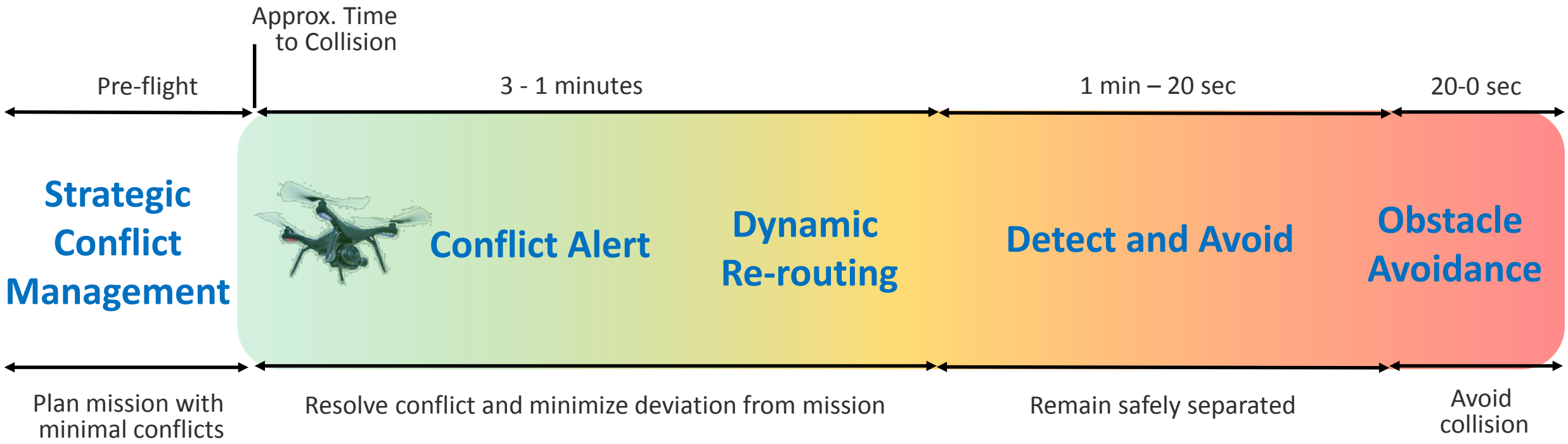
DRAFT REQUIREMENTS RELATED TO IN-FLIGHT EMERGENCIES

- *A USS MUST provide access to position updates (if available) for operations that it manages to its LUN for all operations in the ROGUE or NONCONFORMING states.*
- *A USS MUST send a message to its LUN when an in-flight emergency is determined for an operation under its management.*
- *A message describing an operation in an urgency condition MUST denote a severity level lower than EMERGENCY according to the UTM API documentation.*
- *A message describing an operation in a distress condition MUST denote a severity level of EMERGENCY.*
- *A USS MUST update the operation plan of an operation under its management that enters or exits an in-flight emergency state.*



We discussed and verbally agreed in meetings to elevate a NC or ROGUE operation to a priority operation. This would trigger the requirement to share position data.

Escalation of Risk



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)