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

By

Unmanned Aerial System Traffic Management (UTM)

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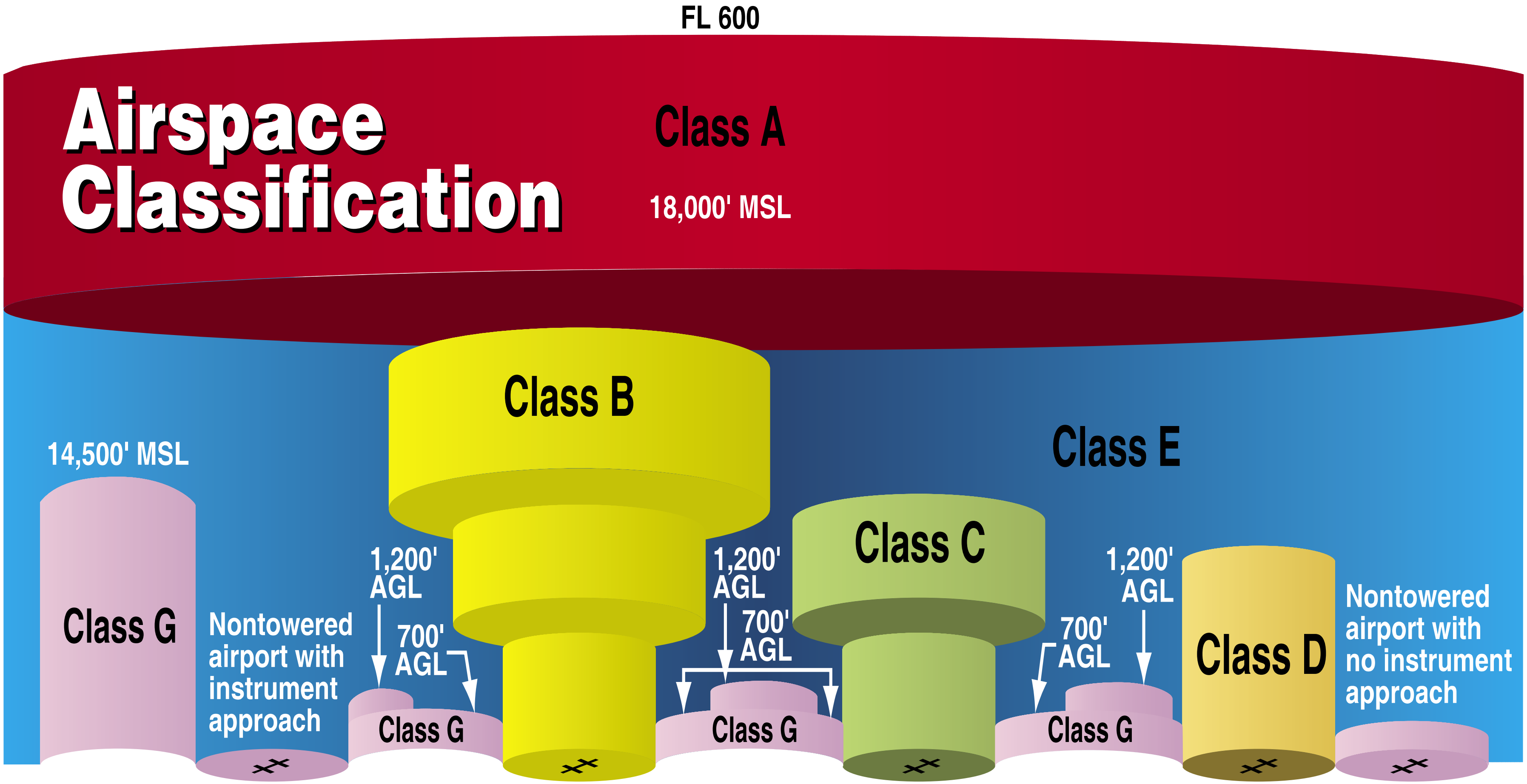
Airspace Classification



Source: Pilot’s Handbook of Aeronautical Knowledge, FAA

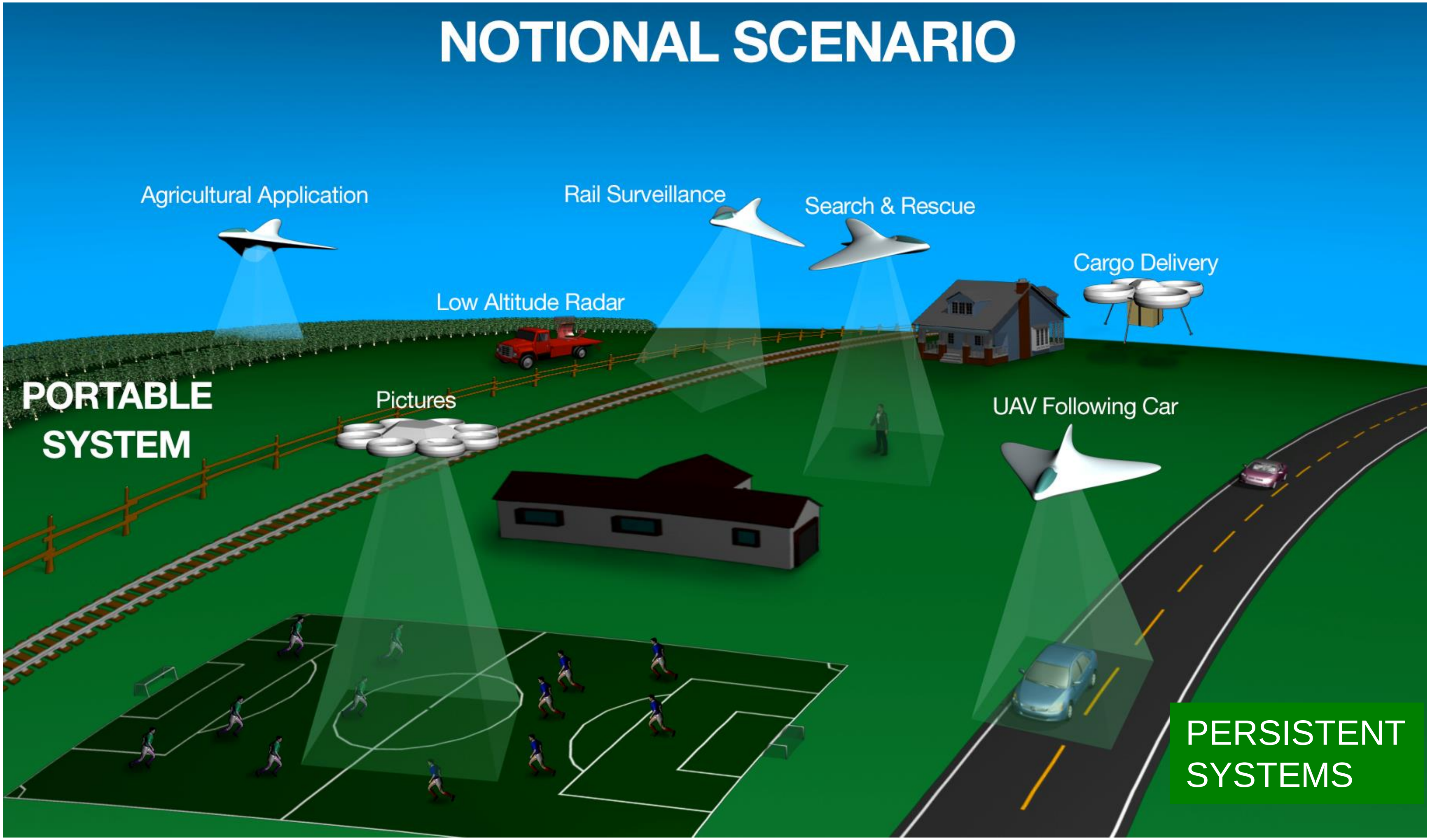
Outline

- Motivation
- Sense of Urgency and Goal
- UTM Design Key Functionality
- UTM Architecture Considerations
- Demonstration Stages
- Business Models
- Partnerships Opportunities
- ARMD's Next Steps
- Summary

Motivation

- 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, UK, Europe)
- Lesson from History: Air Traffic Management (ATM) started after mid-air collision over Grand Canyon in 1956
- Need to have a system for civilian low-altitude airspace and UAS operations

UTM Applications



Sense of Urgency

- Applications are emerging rapidly
- Global growth must be accommodated safely and now
- Certification of authorization (COA) process and visual line of sight is limiting
- Several efforts of integrating civilian UAS into the National Airspace System is underway
- Many argue that low-altitude operations could be dominant
- A system, rules, and regulations are urgently needed to enable the industry

- **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)

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 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

UTM System Requirements: Exaples

- Authentication
  - Similar to vehicle identification number, approved applications only
- Airspace design, adjustments, and geo-fencing
  - Corridors, rules of the road, altitude for direction, areas to avoid
- Communication, Navigation, and Surveillance
  - Needed to manage congestion, separation, performance characteristics, and monitoring conformance inside geo-fenced areas
- Separation management and sense and avoid
  - Many efforts underway – ground-based and UAS based – need to leverage
- Weather integration
  - Wind and weather detection and prediction for safe operations

UTM System Requirements: Examples

- Contingency Management
  - Lost link scenario, rogue operations, crossing over geo-fenced areas
  - Potential "9-11" all-land-immediately scenario

- Congestion Prediction
  - Anticipated events – by scheduling, reservations, etc.

- UTM Overall Design
  - Enable safe operations initially and subsequently scalability and expected massive growth in demand and applications
  - As minimalistic as possible and maintain affordability

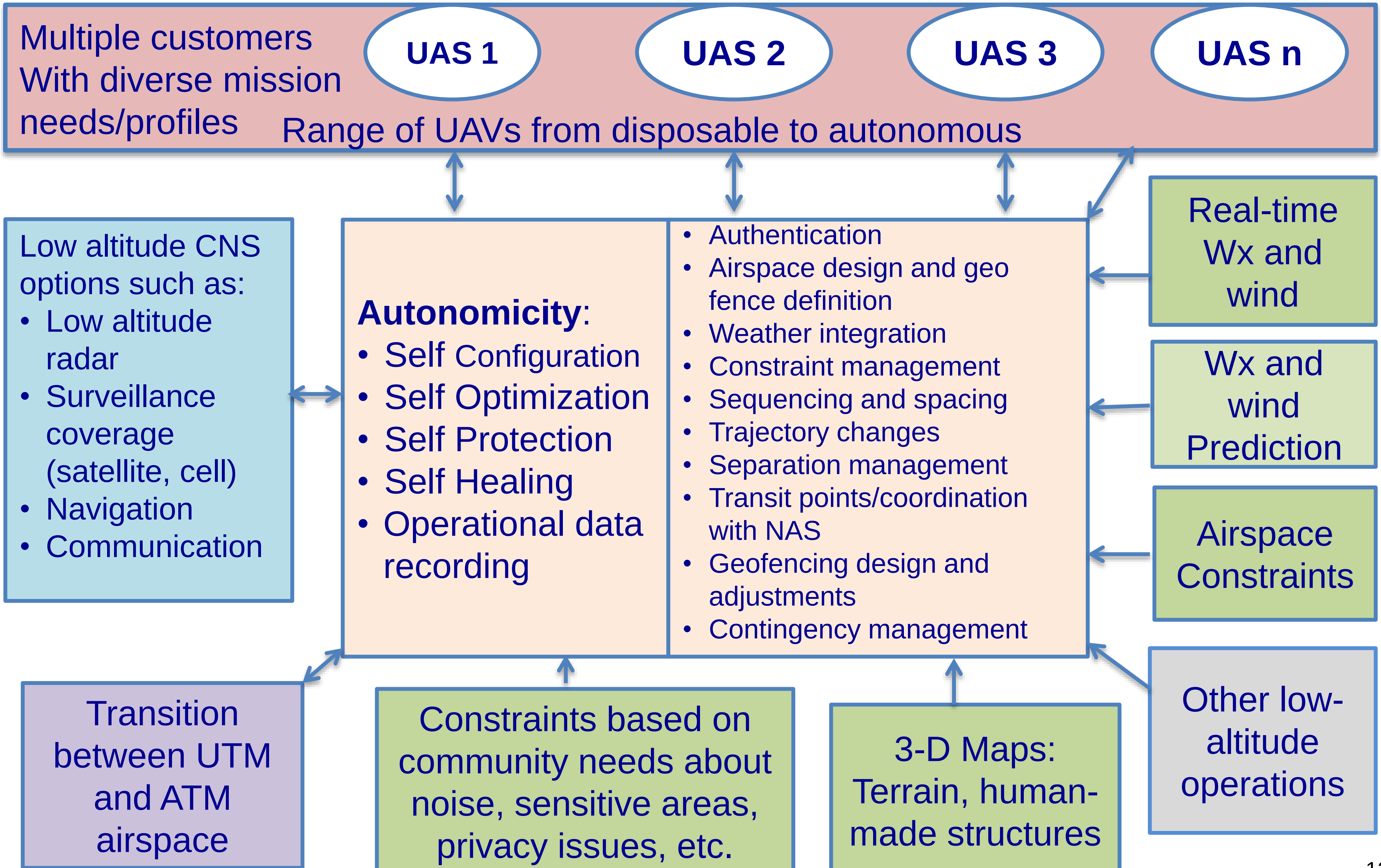
- Data Collection
  - Performance monitoring, airspace monitoring, etc.

- Safety of Last 50 feet descent operation
  - In presence of moving or fixed objects, people, etc.

Initial Key Characteristics of UTM

- Must be able to support diverse missions, business trajectories, and airspace operations
- Must be able to support heterogeneous mix of UAS
- Must be able to reliably provide communication, navigation, and surveillance below 10,000 ft.
- Must be able to accommodate different types of UAS capabilities such as highly capable UAS with on-board collision avoidance and reroute planning and disposable UAS that has only flight critical hardware/software on board
- Must be able to provide safe airspace operations by procedures and airspace design that keep UAS separated from other UAS and general aviation, helicopter, gliders, etc.
- Must be able to provide congestion management, route planning and rerouting, conflict avoidance, collision avoidance, terrain avoidance, obstacle avoidance, severe weather and wind avoidance services based on needs of UAS operation and capability

UTM – One Design Option



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

UTM Concept Development - Status

PROGRESS

- Developed UTM vision document
- Defined initial UTM design characteristics
- Conducted an all-stakeholder workshop to gather feedback
  - 145 non-NASA stakeholder representatives

UTM Workshop: KEY FINDINGS

- Overwhelmingly positive response
- Stakeholders support NASA's leadership and vision
- Many partners are ready to engage
- There is urgency to put a system in place

PARTNERSHIPS

- UAS manufacturers
- Online retailers
- Communication/navigation/surveillance providers
- System integrators
- Emerging UAS operators
- Cargo operators
- FAA, NOAA, DoD
- UAS test sites
- Community representatives (privacy, insurance, city/urban planning)

Near-term UTM Builds Evolution

The UTM builds will begin with simpler functionality and evolve further. The following evolution is anticipated. As needed (based on the needs of field tests and simulations) functions could be adjusted among different builds. These are nominal builds, where the functionality and scope will be adjusted as needed.

UTM Build	Capability Goal
UTM1	Mostly show information that will affect the UAS trajectories • Geo-fencing and airspace design • 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
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

Near-term UTM Builds Evolution

UTM Build	Capability Goal
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 as well as NASA leadership by stakeholders
- Many partners are ready to engage
- Private-public-academia partnership strategy for development and field testing is ready