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The Future of Aviation: A Paradigm for Unmanned Aviation Systems and Urban Air Mobility

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MD: ARMD

Date: 06/27/17

TIME: 00:00 PST

***NOTE**: All presentations will undergo a review by the MDL and then by ITAR/EAR.*

Topic Overview

- Air Traffic Management (ATM)
- Unmanned Aircraft System Traffic Management (UTM)
- Urban Air Mobility Operations
- Paradigm for Beyond

What is UTM?

- UTM is an “air traffic management” ecosystem for uncontrolled airspace
- 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 for enabling the management of low-altitude uncontrolled UAS operations

Key Operational Assumptions

- FAA maintains regulatory *AND* operational authority for airspace and traffic operations
- UTM is used by FAA to issue directives, constraints, and airspace configurations
- Air traffic controllers **are not required** to actively "control" every UAS in uncontrolled airspace or uncontrolled operations inside controlled airspace
- FAA has on-demand access to airspace users and can maintain situation awareness through UTM
- UTM roles/responsibilities: Regulator, UAS Operator, and UAS Service Supplier (USS)
- FAA Air Traffic can institute operational constraints for safety reasons anytime

Key principle is safely integrate UAS in uncontrolled airspace without burdening current ATM

UTM Principles and Services

Principles

- Users operate in airspace volumes as specified in authorizations, which are issued based on type of operation and operator/vehicle performance
- UAS stay clear of each other
- UAS and manned aircraft stay clear of each other
- UAS operator has complete awareness of airspace and other constraints
- Public safety UAS have priority over other UAS

Key UAS-related 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)

Defining Operator and Regulator/ANSP Roles

UAS Operator

- Assure communication, navigation, and surveillance (CNS) for vehicle
- Register
- Train/qualify to operate
- Avoid other aircraft, terrain, and obstacles
- Comply with airspace constraints
- Avoid incompatible weather

Regulator/Air Navigation Service Provider

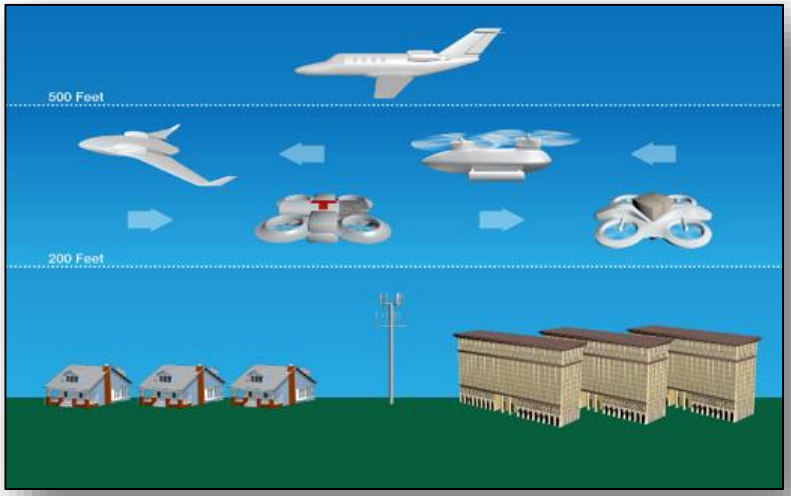
- Define and inform airspace constraints
- Facilitate collaboration among UAS operators for de-confliction
- If future demand warrants, provide air traffic management
  - Through near real-time airspace control
  - Through air traffic control integrated with manned aircraft traffic control, where needed

Third-party entities may provide support services but are not separately categorized or regulated

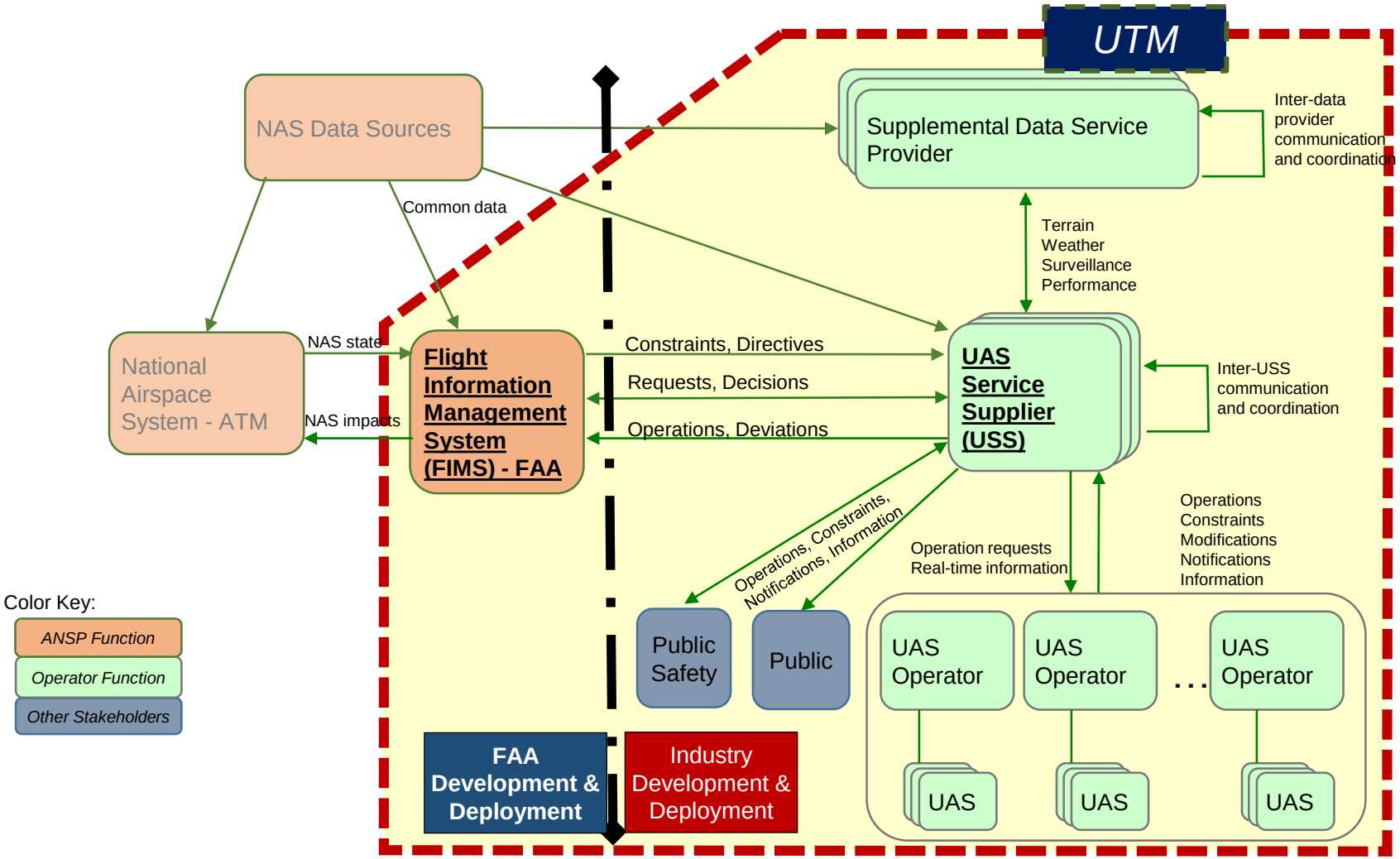
Supporting Functions

Wind & Weather Integration

- Operator responsibility, may be provided by third party
- Actual and predicted winds/weather
- No unique approval required



UTM Architecture



UTM Technical Capability Levels

Capability 1: Demonstrated how to enable multiple operations under constraints

- Notification of area of operation
- Over unpopulated land or water
- Minimal general aviation traffic in area
- Contingencies handled by UAS pilot

Capability 2: Demonstrated How to Enable Expanded Multiple Operations

- Beyond visual line-of-sight
- Tracking and low density operations
- Sparsely populated areas
- Procedures and “rules-of-the road”
- Longer range applications

Product: Requirements for multiple BVLOS operations including off-nominal dynamic changes

Capability 3: Focuses on how to Enable Multiple Heterogeneous Operations

- Beyond visual line of sight/expanded
- Over moderately populated land
- Some interaction with manned aircraft
- Tracking, V2V, V2UTM and internet connected

Product: Requirements for heterogeneous operations

Capability 4: Focuses on Enabling Multiple Heterogeneous High Density Urban Operations

- Beyond visual line of sight
- Urban environments, higher density
- Autonomous V2V, internet connected
- Large-scale contingencies mitigation
- Urban use cases

Product: Requirements to manage contingencies in high density, heterogeneous, and constrained operations

Risk-based approach: depends on application and geography

Technical Capability Level (TCL) 2

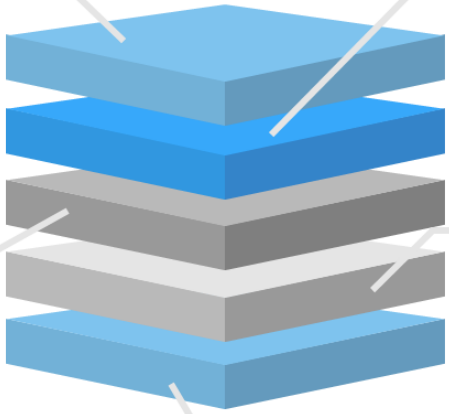
UTM TCL2: Scheduling and Executing Multiple BVLOS Operations

Conflict Alerts

Alert triggered by proximity to other aircraft

Intruder Alerts

Alert triggered from radar submitted warning regions to UTM research prototype



Contingency Alerts

Simulated in-flight emergency reported to the UTM research prototype and relayed to impacted operations

Flight Conformance Alerts

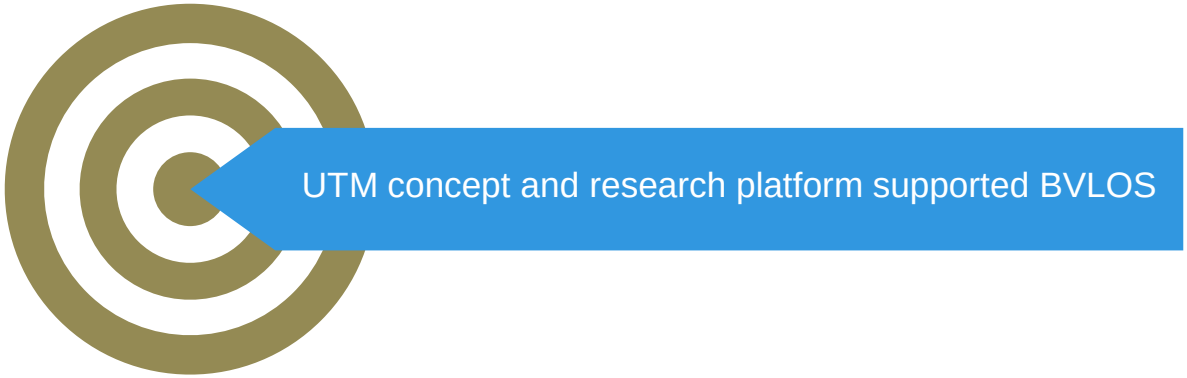
Alert triggered from departing from operational area and relayed to impacted operations

Priority Operations

Users with special privileges are given priority of the airspace and impacted operations are informed of any conflicts

Scheduling and tracking operations and contingency management

UTM Research Platform



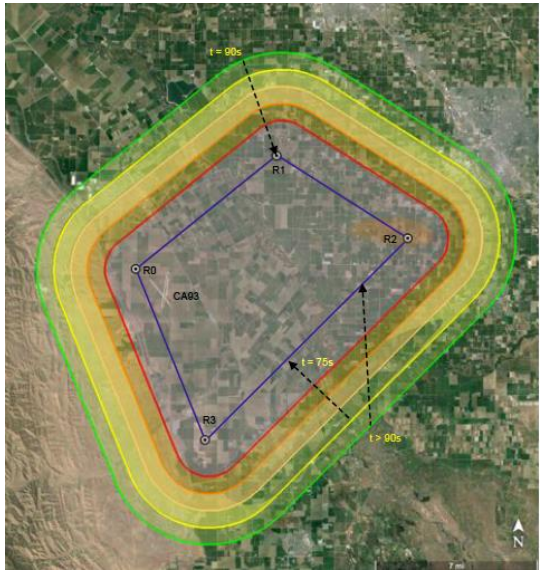
UTM Core Principles and Guiding Tenet	Tested Feature
UAS should avoid each other	Scheduling and Planning Conformance Alerting Proximity Alerting Separation by Segregation (e.g. Geo-fencing)
UAS should avoid manned aircraft	Intruder Alerting Separation by Notification (e.g. NOTAM)
UAS operators should have complete awareness of all constraints in the airspace	UTM Mobile Application Contingency Management Alerts
Public safety UAS have priority within the airspace	Priority Operations
Flexibility where possible and structure where necessary	Altitude Stratification Dynamic Re-routing 4D Segmented Flight Plans

TCL 3 Evaluations (preparations underway)

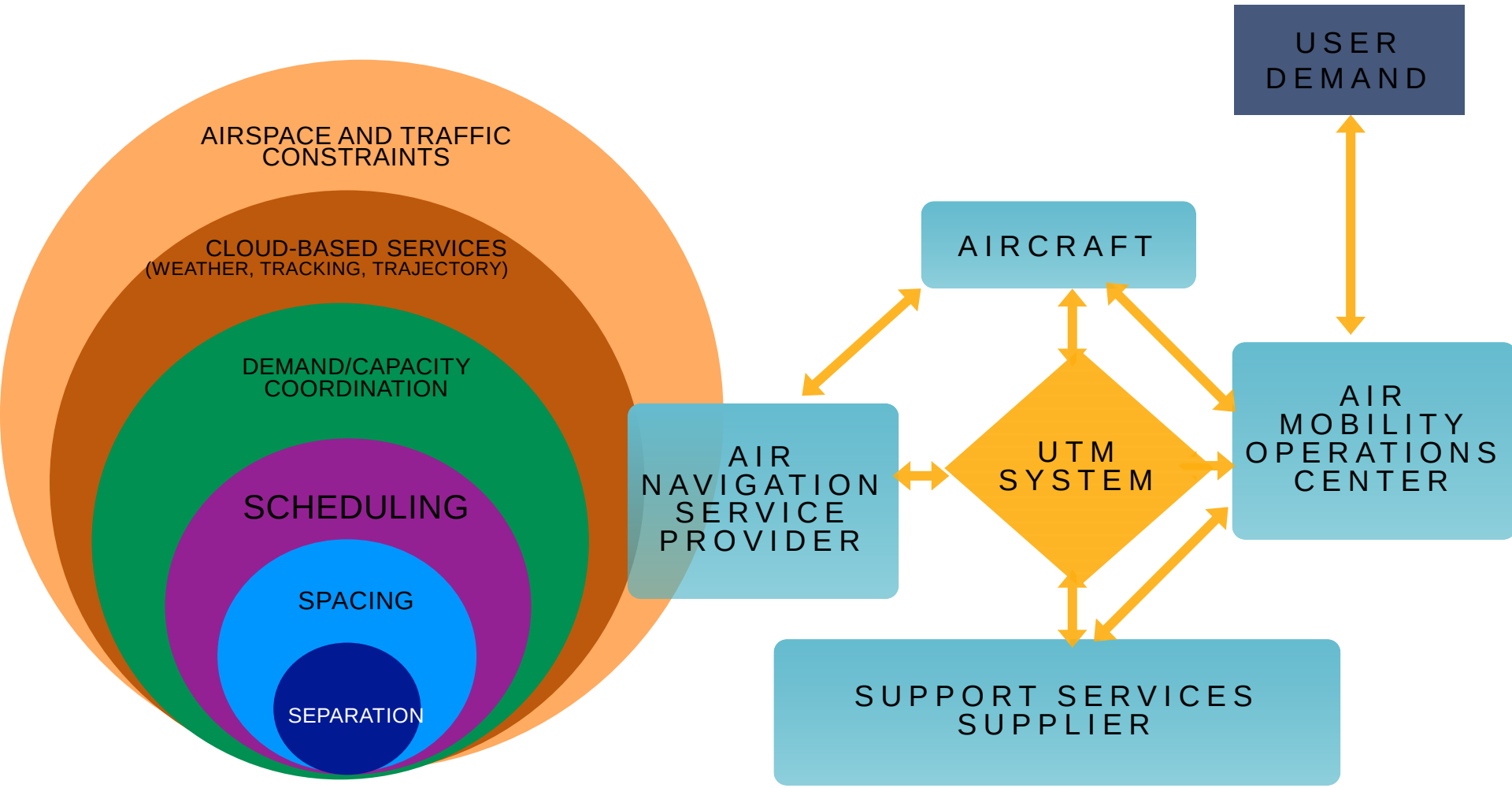
High level objectives of TCL 3 evaluations

- System Level Evaluation
  - Contingency Management /Off-Nominal Conditions
  - Priority Operations and Airspace and Ground Constraints
- Separation
  - Non-cooperative aircraft
  - Cooperative Aircraft
  - Ground Obstacles
- Communication and Navigation
  - Direct Communication and Control (e.g. radio controlled)
  - Distributed Communication (e.g. cellular network, mesh networks)
- Navigation (close to people and buildings, terrestrial and satellite-based)
  - Data gathering for modeling, measurement and forecasting of weather
  - UAS/USS weather integration

TCL 3 Evaluations will include testing at Crows Landing, CA in Fall 2017 using COA 2016-WSA-46 that authorizes NASA to conduct BVLOS operations with small UAS at Crows Landing, CA using a radar for separation (instead of visual observers)



Connected System for Scalability

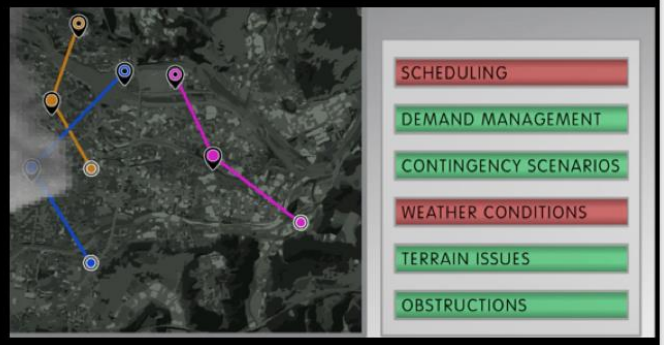


Research Approach

CRAWL-WALK-RUN APPROACH

Low-density: Initial Operational Capability
- Helicopter routes using today's procedures
- Clearance into controlled airspace (UTM - authorization and notification)
- User created conflict-free trajectories and own tracking

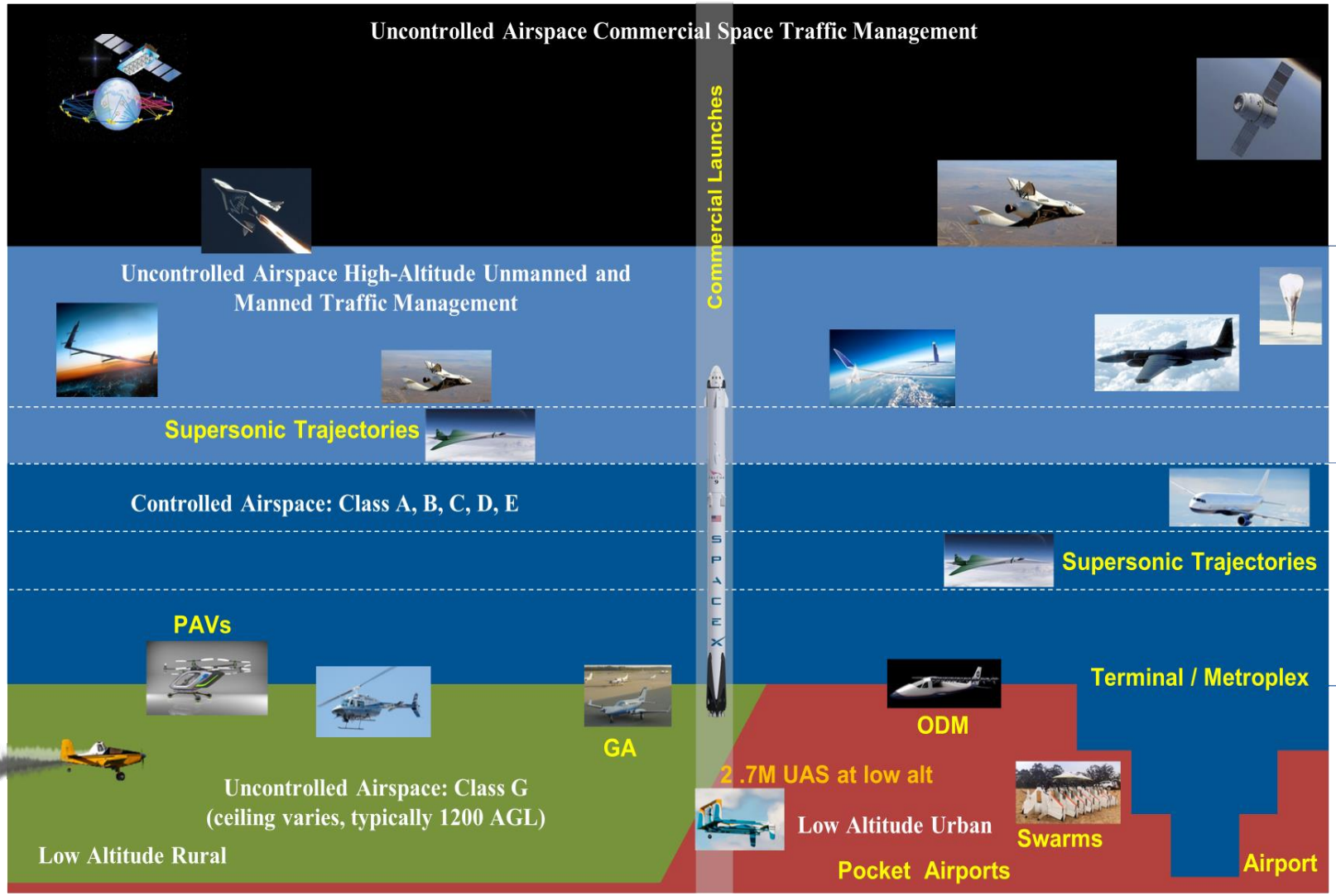
Medium-density: Interim Operational Capability
- User creates conflict-free trajectories
- Interoperable, cooperative, intent sharing through UTM
- Self-managed operations (e.g., detect and avoid, contingency management)



High-density: Mature Operational Capability
- Fully-autonomous planning, scheduling, separations, entry/exit controlled airspace, interoperability, and contingency management
- Multiple, simultaneous take-offs and landings

RESEARCH NEEDED TO IDENTIFY REQUIREMENTS FOR SCALED OPERATIONS

Future Paradigm for Airspace Operations

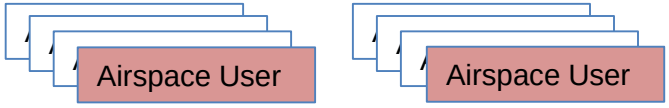


Current ATM

All services are provided by the FAA
- Traffic flow management
- Airspace directives/constraints
- Scheduling, sequencing and spacing
- Separation management
- Off-nominal management
- Every vehicle interaction in real-time

FAA Systems

Humans address off-nominal and contingencies



Very little interaction among users, and 3rd party services

- Human in the epi-center of information integration
- Every data moves through FAA systems for every vehicle
- Each change focused in on domain-specific FAA system

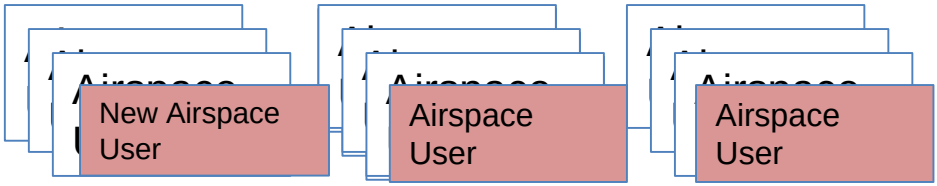
UTM-inspired-ATM

Some services are provided by FAA
- Airspace directives/constraints
- Resource availability and changes to resources (e.g., arrival/departure rates, resource schedules)
- Separation

FAA Systems

User or third party services
- Flow management
- Sequencing, and spacing
- User participation strategic separation

Automation addresses off-nominal and contingencies

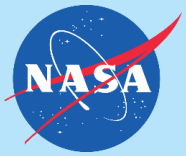


Users collaborate/cooperate for efficiency, intra-user preferences for flights into constrained resources

- Automation in the epi-center of information integration
- New paradigm: digital and connected ecosystems-outside apps, scalability

NASA Unique Role: Architecture, data exchange, service allocation/roles/responsibilities, rules of engagement, service performance requirements, automation for contingency management and disruption handling, machine learning environment and algorithms for continuous improvement, certification/acceptance approaches, and technology transitions

Rationale for Change



Current State of the Art

- Not scalable due to human-centric decisions and actions
- Virtually all interactions/data goes through FAA systems
- Does not leverage industry capabilities

Results In

- Does not accommodate new users and higher density of current users
- Modernization becomes slow process
- All costs are borne by government

Change is needed/Redefine

- Methods and techniques
- Interactions among operators and FAA system
- Service-oriented architecture
- Safety systems – increasing airspace access while ensuring safety

If we don’t change now, US global leadership will suffer

Big Picture – What's next?

- High altitude UTM – cooperative among operators above FL60,000 (Google Loon, Facebook Aquila, Aerovironment)
  - Cooperation through data exchanges, contingency management procedures and technologies
- Urban air mobility: Extension of UTM – cooperation through data exchange, regulator provides constraints and operator plans their own operation and avoids others and constraints
- Service-oriented architecture for current ATM operations – what can we learn from UTM for ATM

Summary

- Very active collaboration with FAA and industry
- UTM construct is adopted globally (e.g., J-UTM, K-UTM, SESAR, ICAO, etc.)
- FAA-NASA UTM RTT construct has been very productive
- Next steps will be UTM pilot and path towards initial operations
- Opportunity to extend UTM paradigm as appropriate

The End

THANK YOU FOR YOUR PARTICIPATION!

NOTE: *This presentation will be accessible through the Industry Day website.*