AIRSPACE INTEGRATION

ENABLING SCALABLE, EFFICIENT, AND SAFE ACCESS TO AIRSPACE

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CURRENT AIRSPACE OPERATIONS

[Map of current airspace operations across the United States]
SMALL UNMANNED AIRCRAFT SYSTEMS
VERTICAL TAKE OFF AND LANDING (VTOLs)
URBAN AIR MOBILITY: SMALL DRONES TO LARGER PASSENGER CARRYING VTOLs
AIRSPACE USER TYPES ARE INCREASING

- **Safety**
- **Efficiency**
- **Economy**
- **Affordability**
- **Ubiquitous**

1. **Small Unmanned Aircraft Systems**
2. **Urban Air Mobility**
3. **Subsonic Transport Aviation**
4. **High Altitude Operations (upper E)**
5. **Supersonics and Hypersonics**
6. **Commercial Space Operations**

Air Navigation Service Provider

Airspace User Types Are Increasing
Urban Air Mobility Airspace Integration Principles

- No burden on current system
- Cooperative and interoperable with other users
- Performance and risk-based
- Efficient
- Safe
- Scalability and sustainability

Build on the foundation of unmanned aircraft system traffic management (UTM)
CLOUD-BASED SERVICES (WEATHER, TRACKING, TRAJECTORY)

DEMAND/CAPACITY COORDINATION

SCHEDULING

SPACING

SEPARATION

AIRSPACE AND TRAFFIC CONSTRAINTS

CONNECTED SYSTEM FOR SCALABILITY

USER DEMAND

AIR MOBILITY OPERATIONS CENTER

SUPPORT SERVICES SUPPLIER

"UTM" SYSTEM

AIR NAVIGATION SERVICE PROVIDER

AIRCRAFT
Operational setup - fleet

Infrastructure resources

- Contingencies and emergency
- Fleet optimization
- Priority of certain vehicles
- Schedules at various resources
- Efficient flows and managing disturbances

Operations center - fleet

- Demand
- Network
- User preferences and collaborative decision making

Airspace operations

- Performance and risk-based
- Scheduling, spacing, separation
- Wx and disturbance management

Vehicle

- Airworthiness
- Health and status
- Performance

CONNECTIVITY IS KEY

Autonomy alone will not lead to efficiency and large-scale disturbance management
Connectivity is crucial – air/ground/cloud/infrastructure integration will be key
EMBRACING INNOVATION IN AVIATION WHILE RESPECTING ITS SAFETY TRADITION

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**Space Traffic Management**

**High Altitude UTM (upper E)**

**Conventional Manned Aviation**
(Class A, B, C, D, E)

**Urban Air Mobility**

**Low-altitude small UAS**

- Cooperative
- Intent-sharing
- Digital: data exchanges among operators
- Standardized application protocol interfaces
- Air/ground integrated
- Service-oriented architecture
- Role for third parties
• Architecture, roles/responsibilities and technology that allows self-management as much as possible

• Air traffic control interacts indirectly for the majority of flight - for constraints and directives, and airspace changes

• Operator plans and schedules operation through UTM

• Tracking via wireless, satellite, ADS-B, or beacon-based systems connected through UTM

• Air-ground-cloud integrated system for scalability (spacing, separation, flow management, etc)

• Last/first 100 feet for safe and automated take-off and landing

• Vertiport design and operations for multiple simultaneous arrivals and departures
Low-density: Initial Operational Capability
• Helicopter routes using today’s procedures
• Entry into controlled airspace thru UTM
• Users: conflict-free trajectories and own tracking

Medium-density: Interim Operational Capability
• User creates conflict-free trajectories
• Interoperable, cooperative, and intent sharing
• Self-managed operations

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
RESEARCH

- Scalable en route and arrival/departure operations
- Cooperative and interoperable operations
- Design of vertiports with multiple vertipads
- Weather tolerant operations (75% delays are due to Wx)
- Off-nominal conditions and contingency operations
  - High winds, wind shears, up drafts, etc.
  - Power depletion
  - Bird strikes
- Requirements (e.g. reserve fuel)
- Integrated air/ground/cloud/infrastructure connected system