AIRSPACE INTEGRATION

ENABLING SCALABLE, EFFICIENT, AND SAFE ACCESS TO AIRSPACE

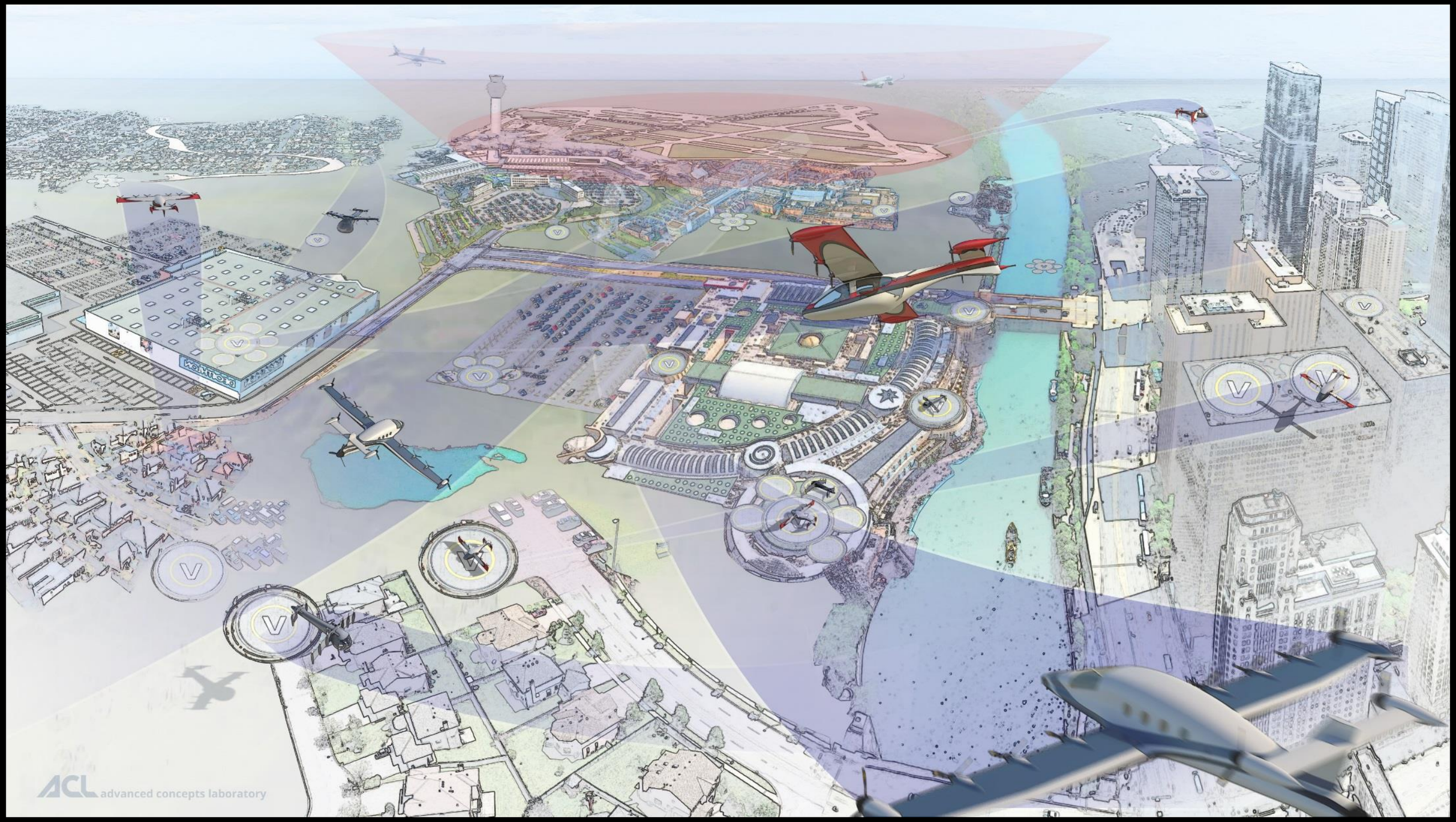
Parimal Kopardekar, Ph.D.
NASA Senior Technologist for Air Transportation System

Parimal.H.Kopardekar@nasa.gov

CURRENT AIRSPACE OPERATIONS

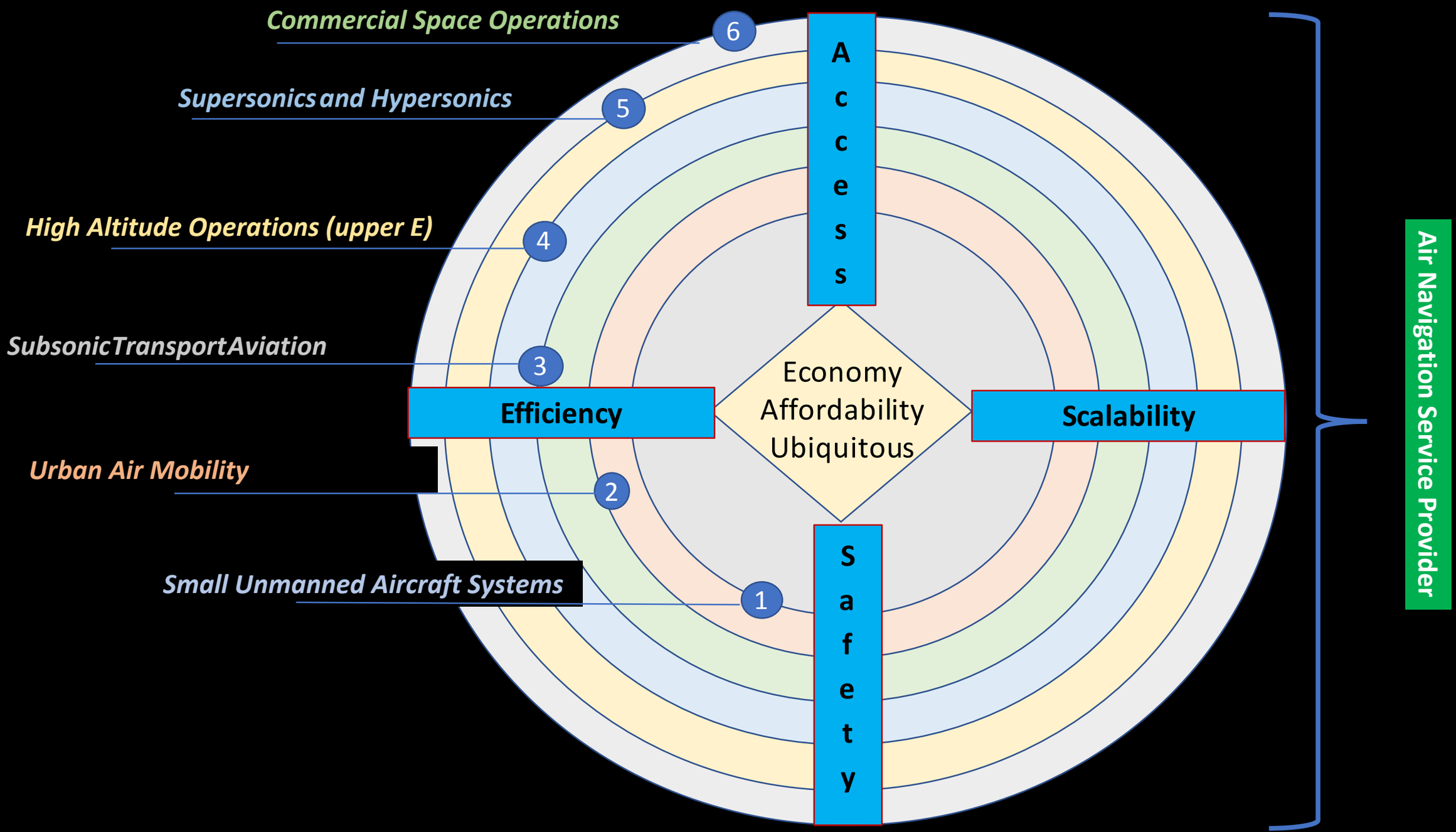
SMALL UNMANNED AIRCRAFT SYSTEMS

VERTICAL TAKE OFF AND LANDING (VTOLS)

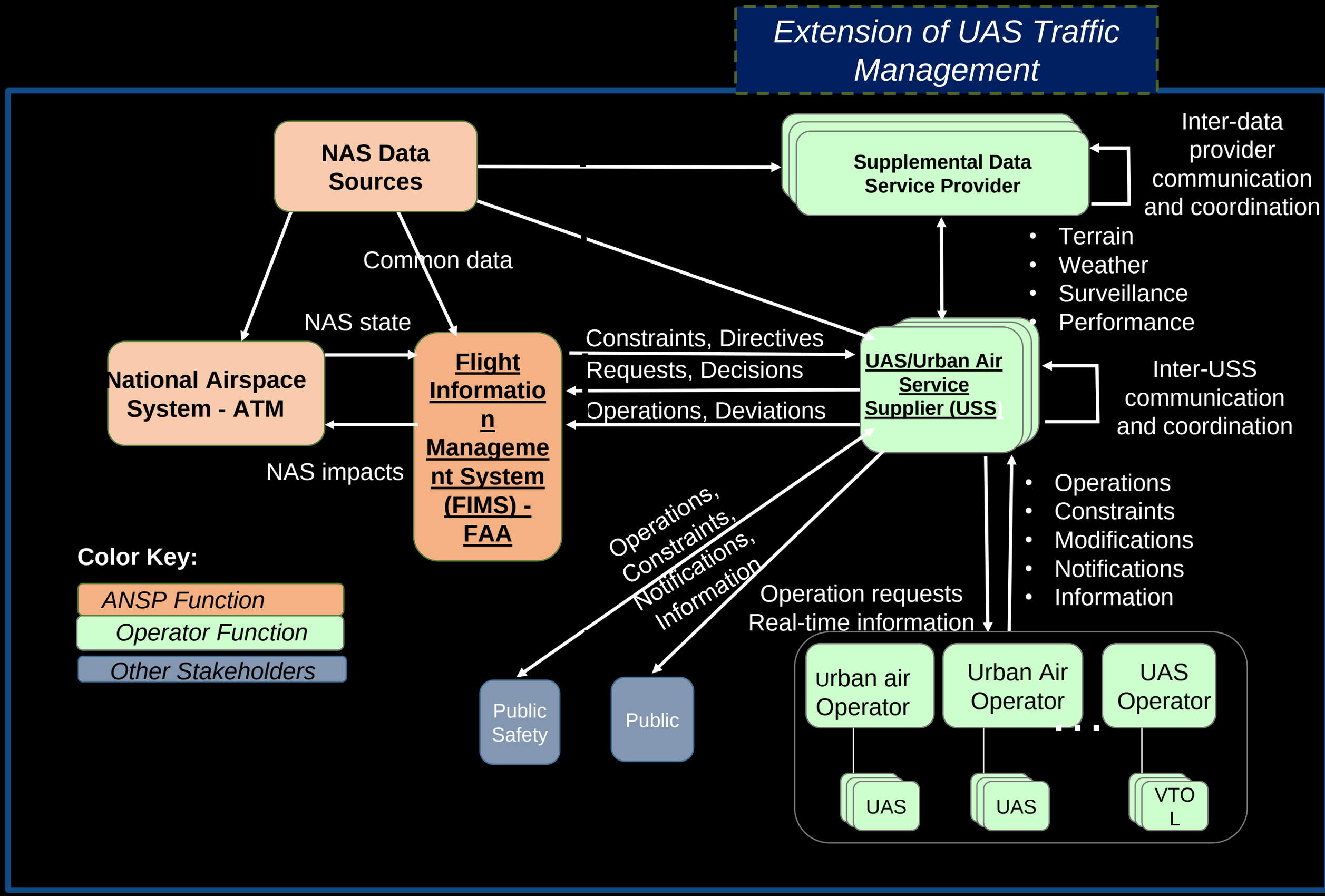


URBAN AIR MOBILITY: SMALL DRONES TO LARGER PASSENGER CARRYING VTOLS

AIRSPACE USER TYPES ARE INCREASING



BASIC ARCHITECTURE

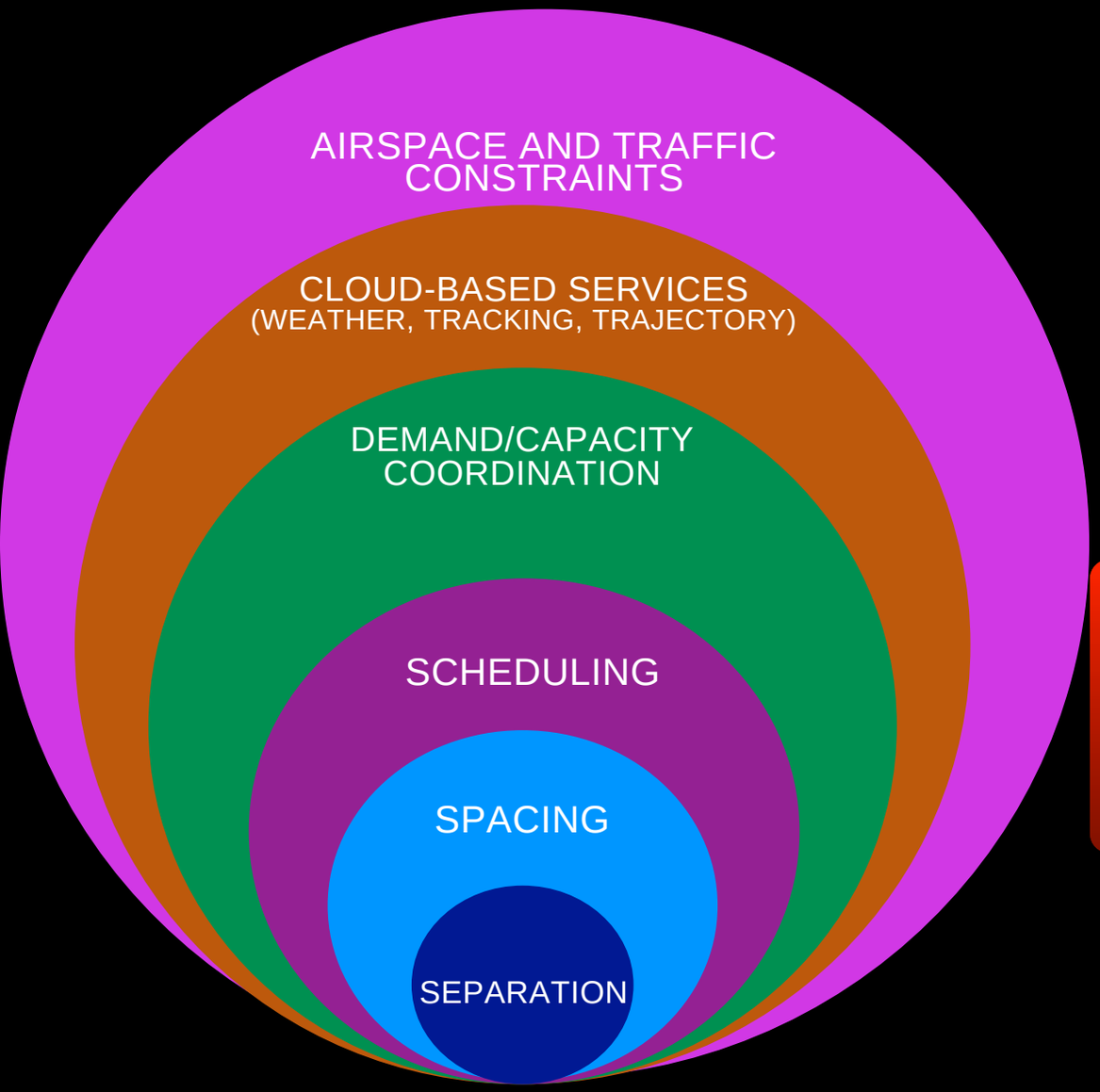


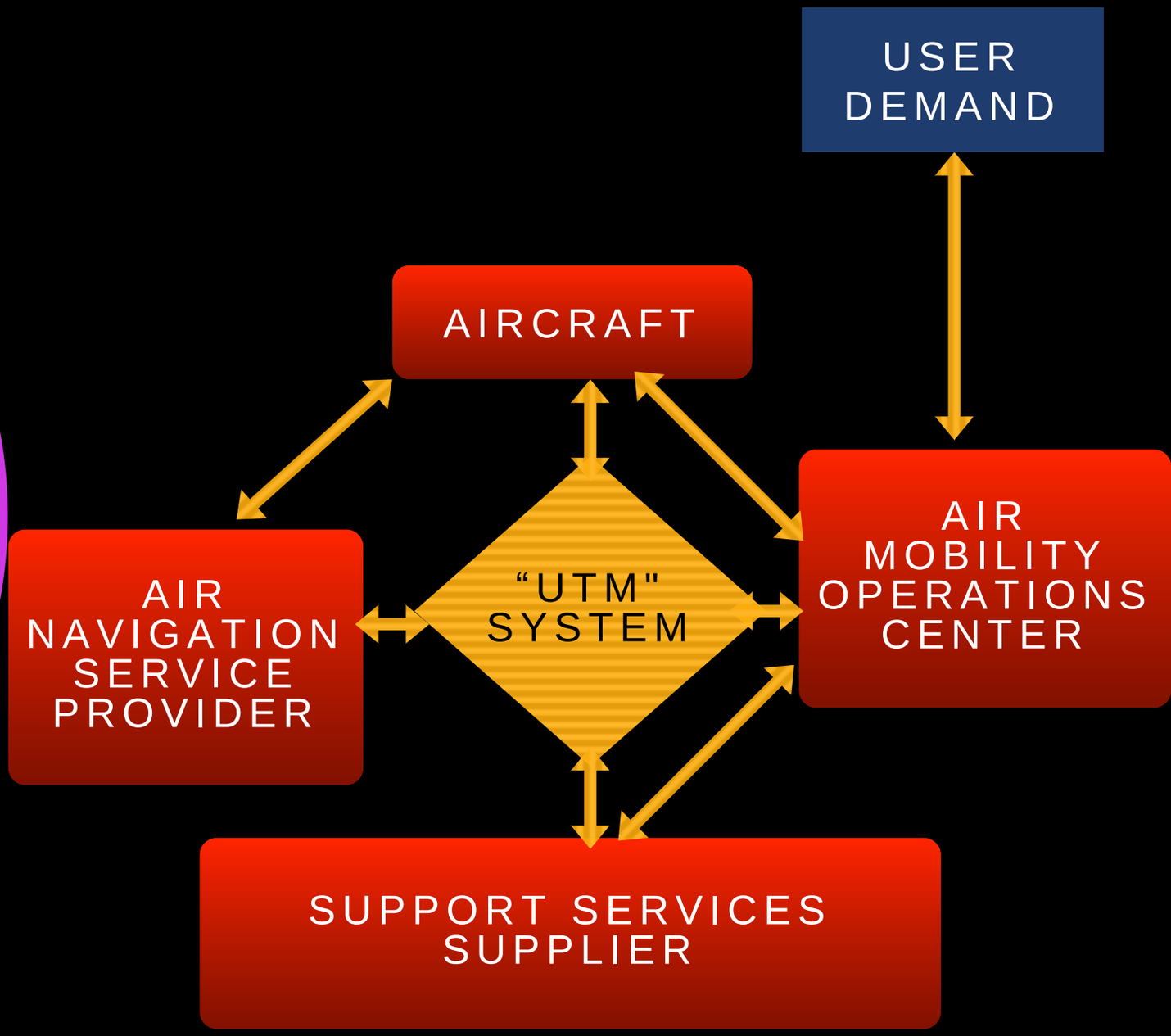
URBAN AIR MOBILITY AIRSPACE INTEGRATION PRINCIPLES

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

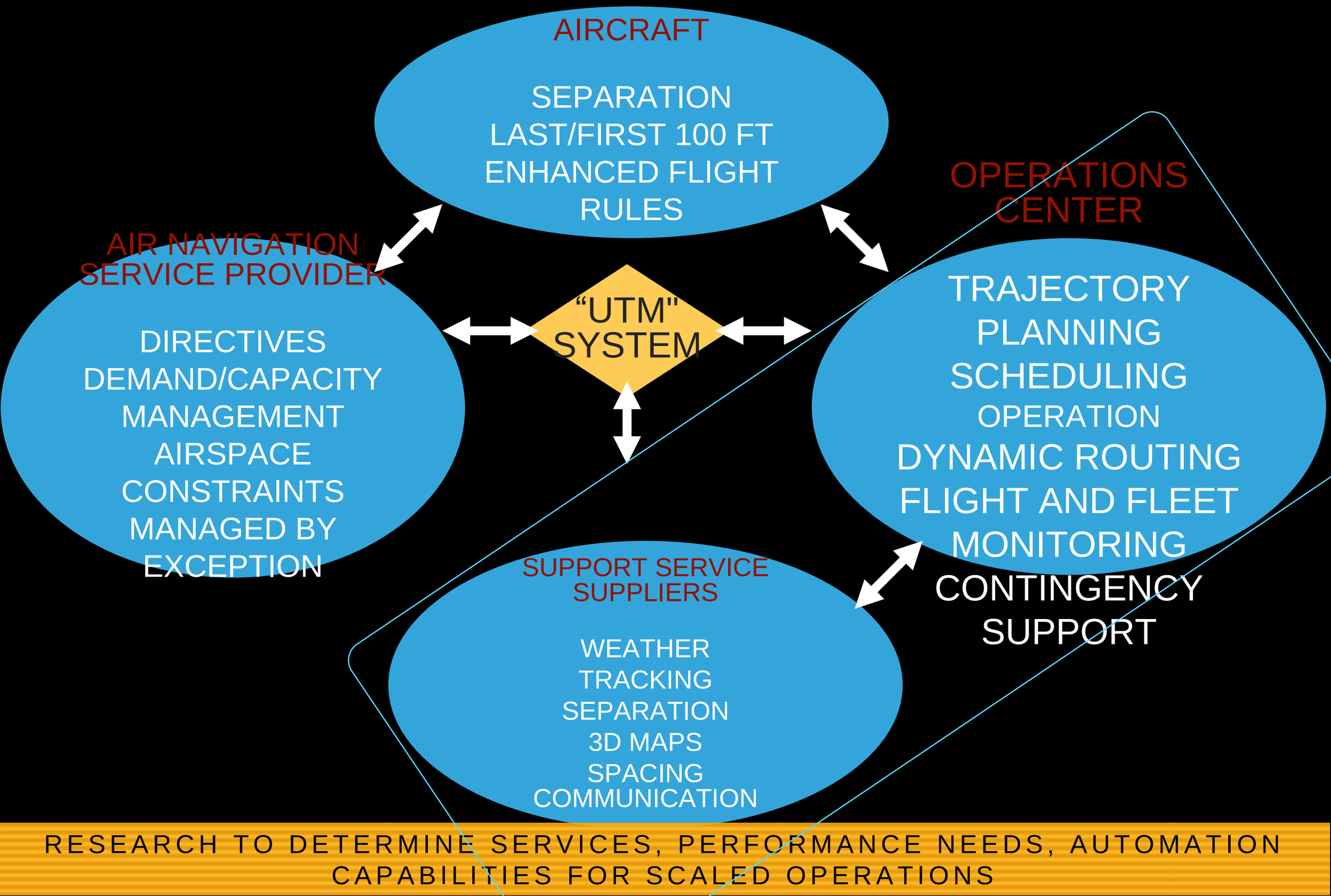
BUILD ON THE FOUNDATION OF
UNMANNED AIRCRAFT SYSTEM TRAFFIC MANAGEMENT (UTM)

CONNECTED SYSTEM FOR SCALABILITY





FLEXIBILITY WHERE POSSIBLE, STRUCTURE WHERE NECESSARY



RESEARCH TO DETERMINE SERVICES, PERFORMANCE NEEDS, AUTOMATION CAPABILITIES FOR SCALED OPERATIONS

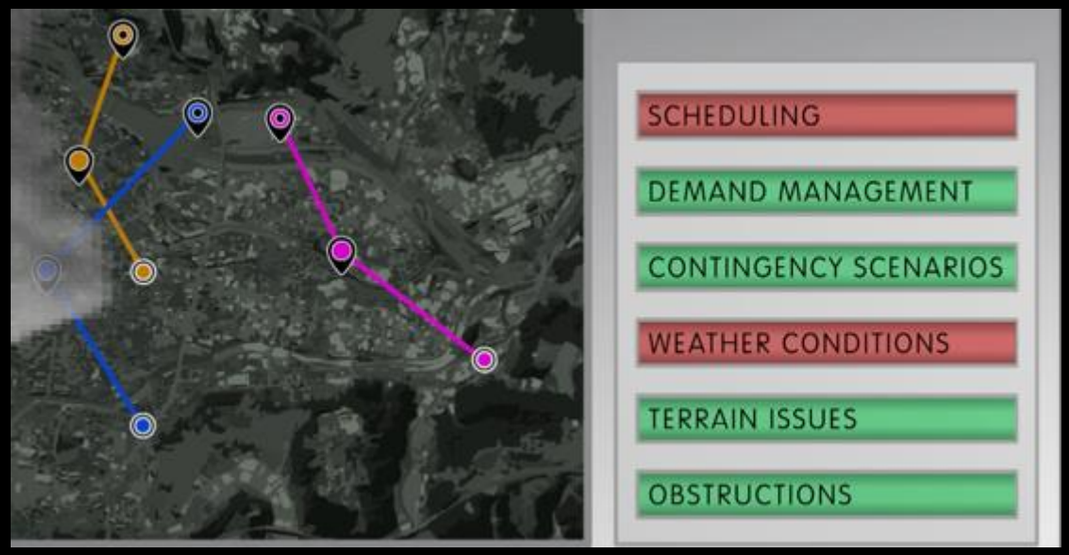
CRAWL-WALK-RUN APPROACH

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



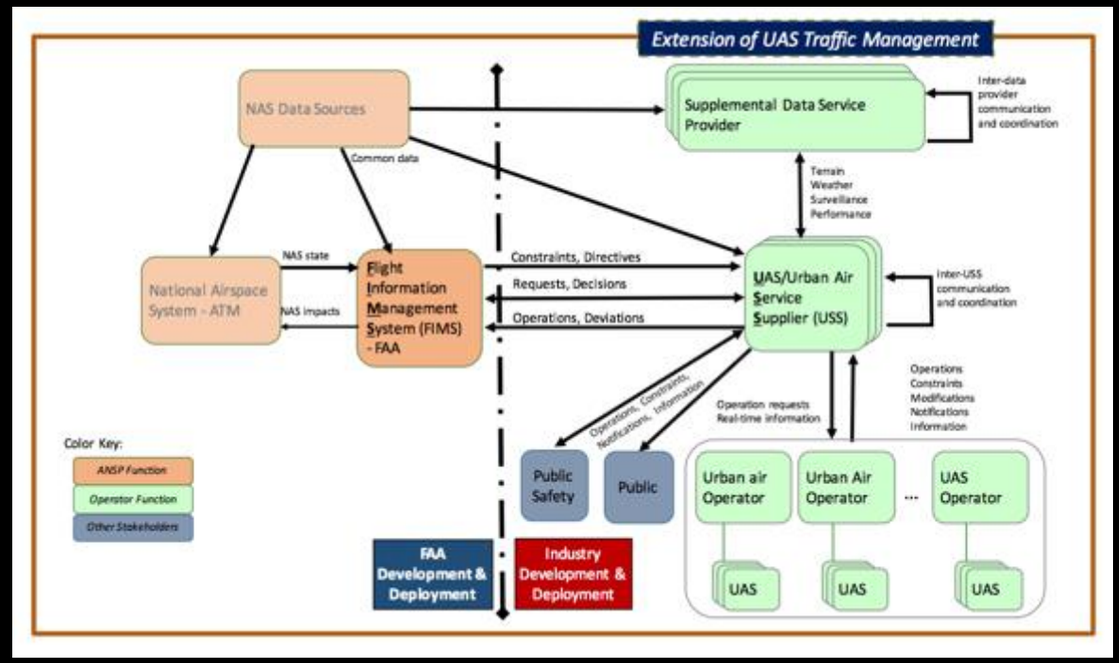
High-density: Mature Operational Capability

- 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

PATH FOR SCALABILITY

- 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

AIR, GROUND, CLOUD INTEGRATED OPERATIONS AND SYSTEM

UTM STYLE AIRSPACE OPERATIONS ENVIRONMENT

- **Cooperative**
- **Intent-sharing**
- **Digital: data exchanges among operators**
- **Standardized application protocol interfaces**
- **Air/ground integrated**
- **Service-oriented architecture**
- **Role for third parties**

Space Traffic Management

High Altitude UTM (upper E)

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

Urban Air Mobility

Low-altitude small UAS

CONNECTIVITY IS KEY

- Availability - Real-time and prediction

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Infrastructure resources

Fleet optimization

Contingencies and emergency

- Demand
- Network

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Operations center - fleet

Priority of certain vehicles

Vehicle

- Airworthiness
- Health and status
- Performance

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User preferences and Collaborative decision making

Schedules at various resources

Efficient flows and managing disturbances

Airspace operations

- Performance and risk-based
- Scheduling, spacing, separation

Wx and disturbance management

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Autonomy alone will not lead to efficiency and large-scale disturbance management

Connectivity is crucial - air/ground/cloud/infrastructure integration will be key

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

EMBRACING INNOVATION IN AVIATION WHILE RESPECTING ITS SAFETY TRADITION

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