

Embracing Innovation in Aviation While Respecting Its Safety Tradition

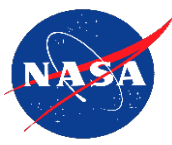
Parimal Kopardekar, Ph.D.

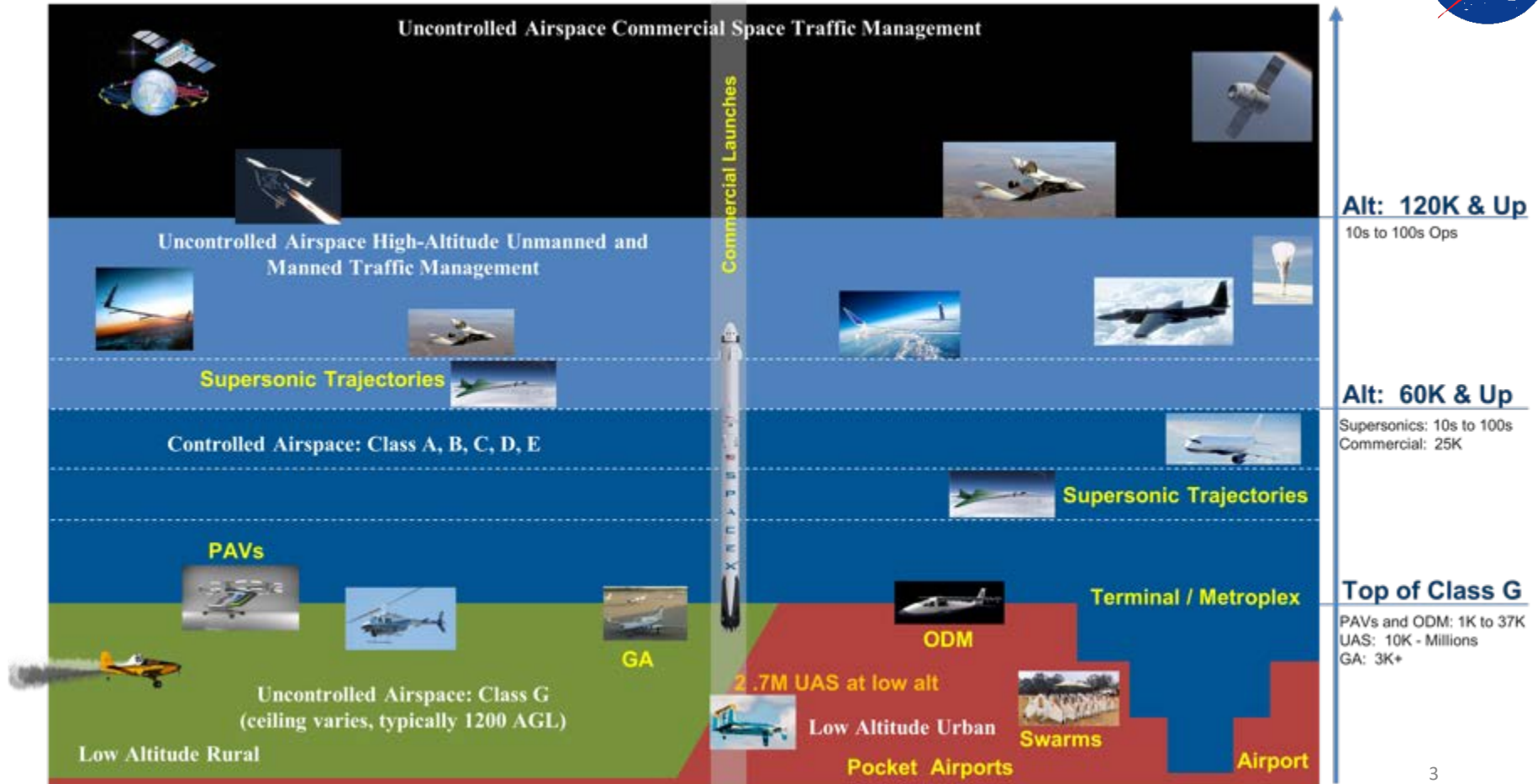
NASA Senior Technologist for Air Transportation System

Acting Director, NASA Aeronautics Research Institute

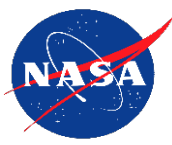
Parimal.H.Kopardekar@nasa.gov

CURRENT AIRSPACE OPERATIONS

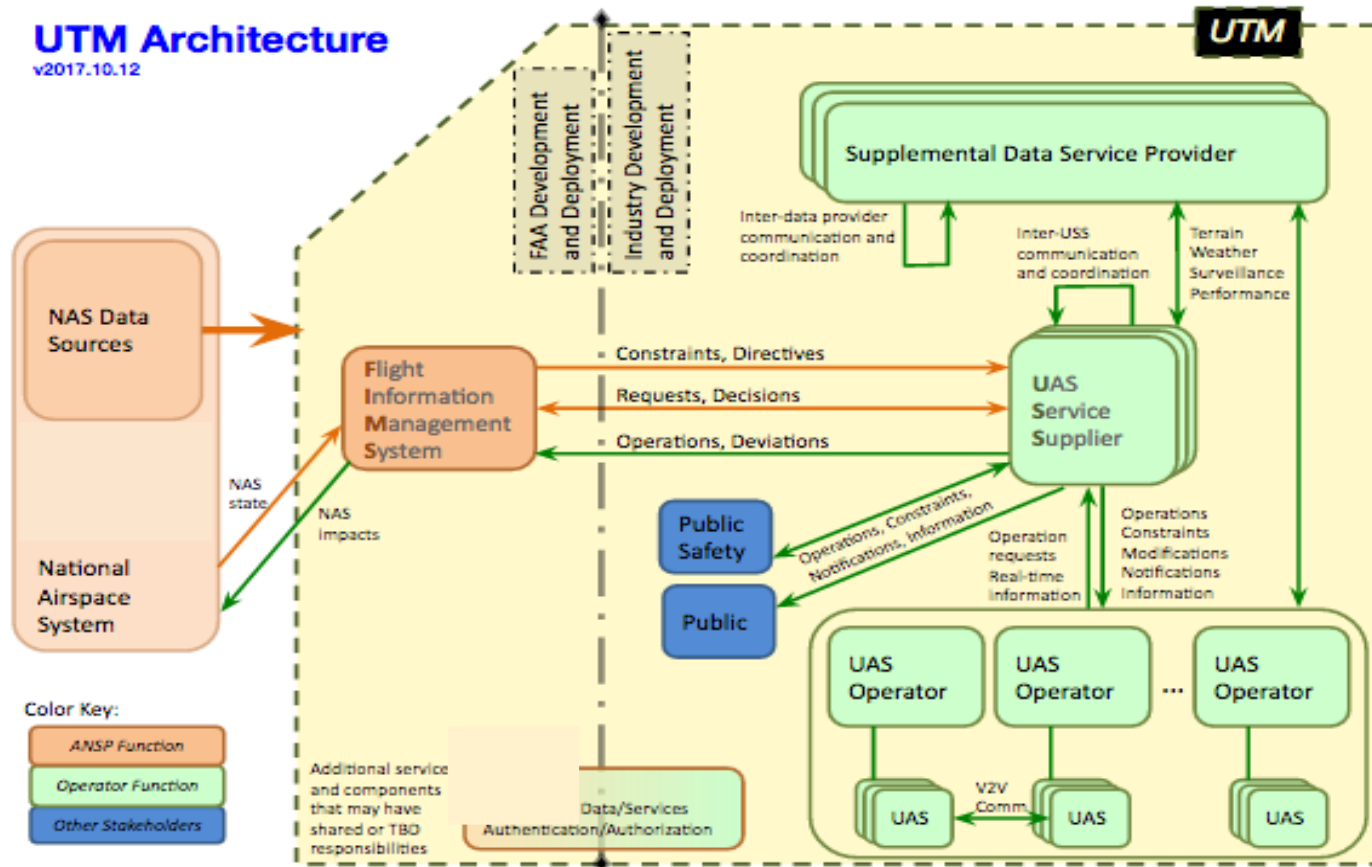




SMALL UNMANNED AIRCRAFT SYSTEMS



UAS Traffic Management Architecture



*Connections & communications are internet-based & built on industry standards & protocols

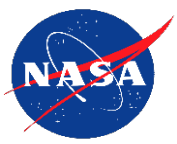
Technology Capability Levels (TCLs)

TCL 1, 2 and 3 (in progress)



Transformation – Urban Air Mobility

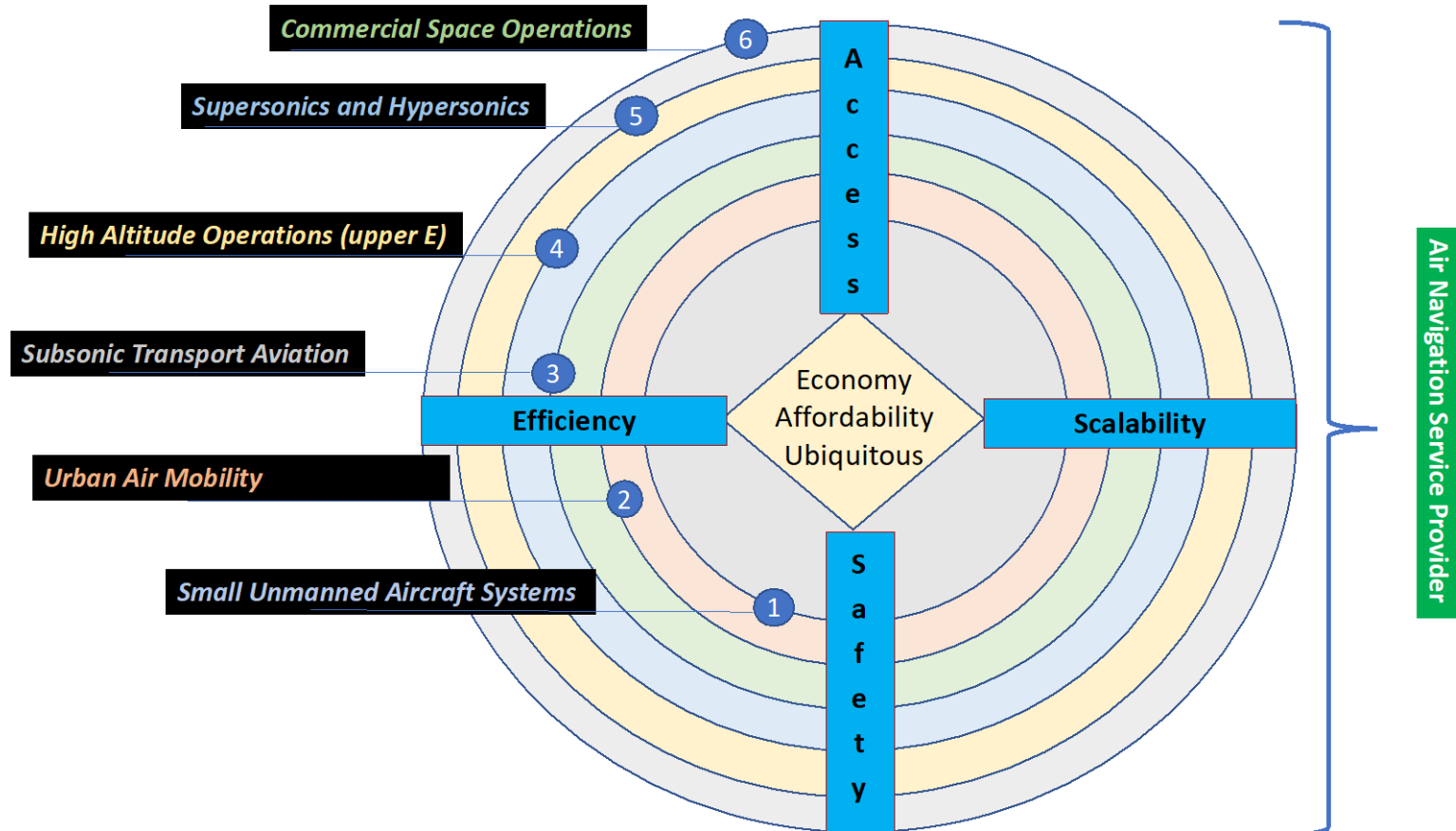
Increasingly autonomous – focused on access, safety and scalability

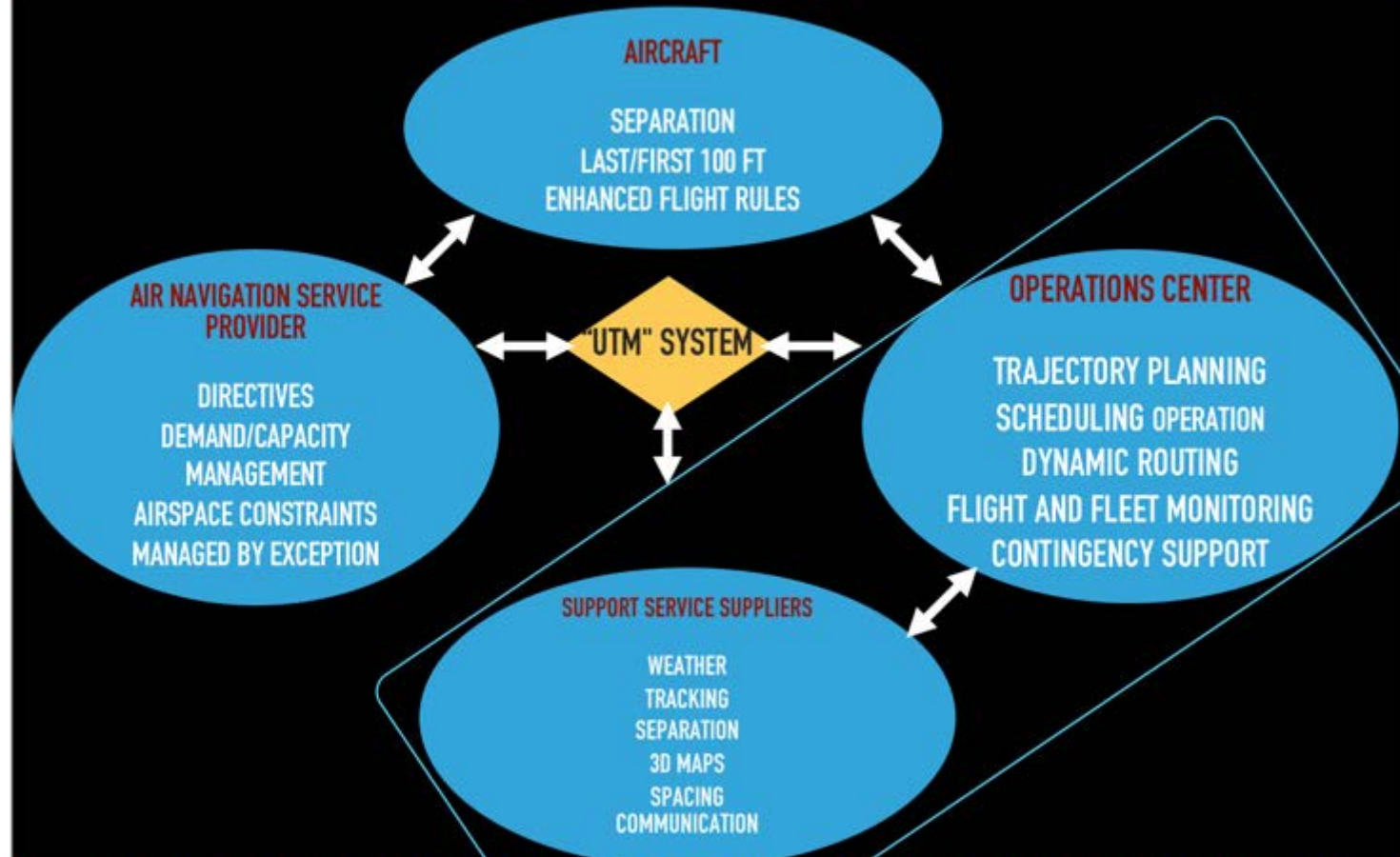
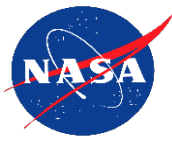


URBAN AIR MOBILITY: SMALL DRONES TO LARGER PASSENGER CARRYING VTOLS



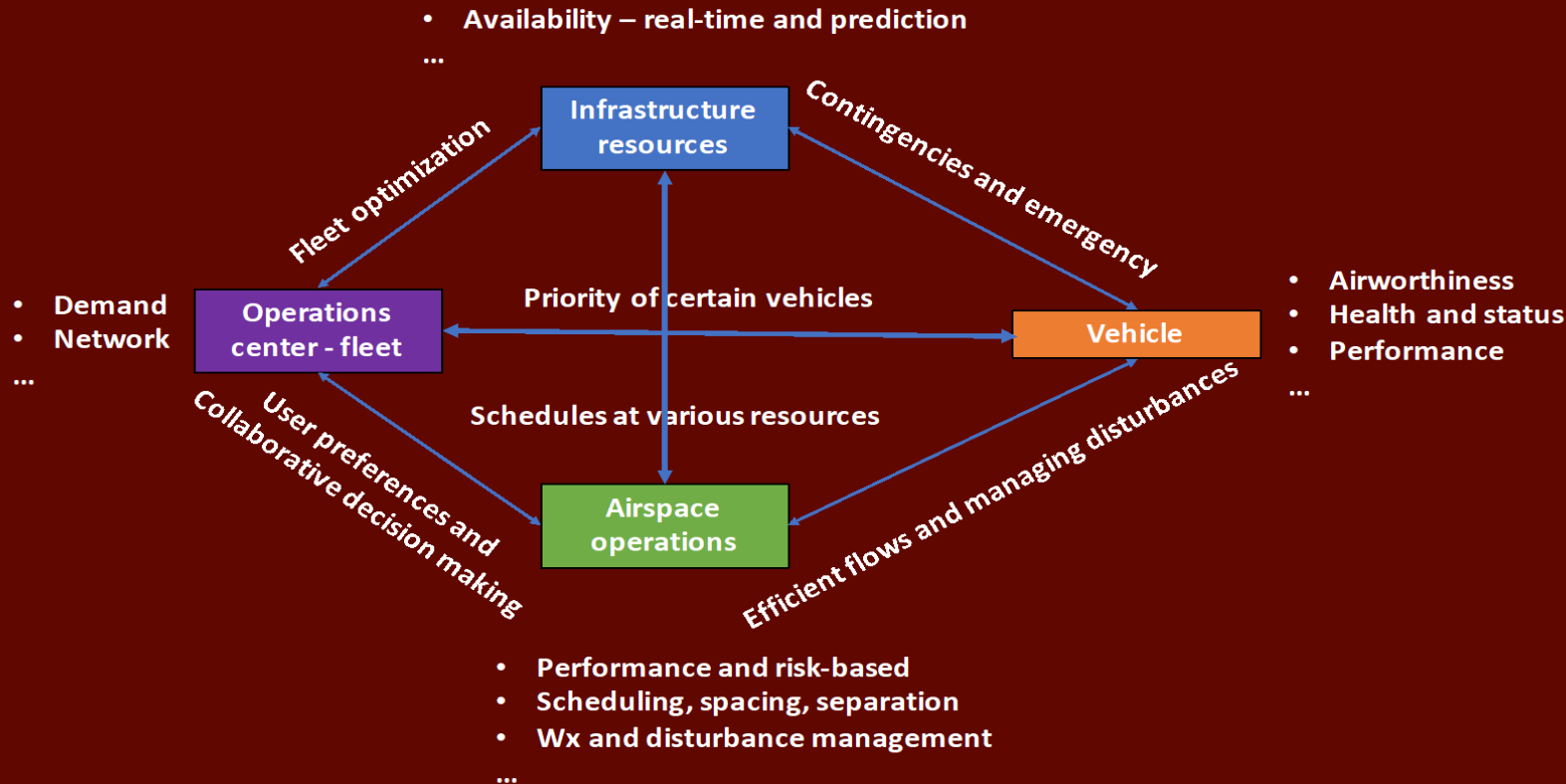
Emerging and Heritage Users



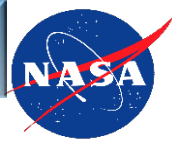


RESEARCH TO DETERMINE SERVICES, PERFORMANCE NEEDS, AUTOMATION CAPABILITIES FOR SCALED OPERATIONS

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



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

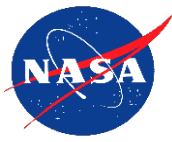
Space Traffic Management

High Altitude UTM (Upper E)

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

Urban Air Mobility

Low-altitude small UAS



Increasingly Autonomous and Connected Operations

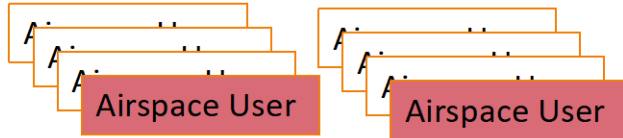
Current ATM

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

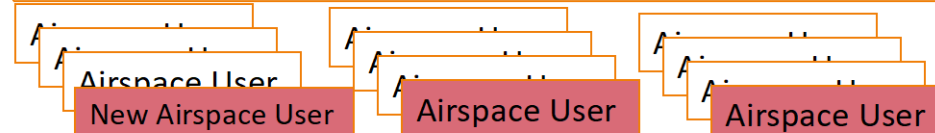
- Airspace directives/constraints
- Resource availability and changes to resources (e.g., arrival/departure rates, resource schedules)
- Separation

FAA Systems

User or third party services

- Flow management
- Sequencing, and spacing
- User participation strategic Separation (e.g., oceanic)

Automation addresses off-nominal and contingencies



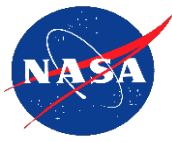
Users collaborate/cooperate for efficiency, intra-user preferences for flights into constrained resources

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

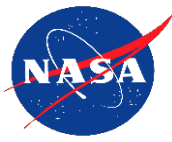
NASA Unique Role: Architecture, data exchange, service allocation/roles/responsibilities, rules of engagement, service performance requirements, automation for contingency management and disruption handling, machine learning environment and algorithms for continuous improvement, safety assurance, certification/acceptance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

Inter-island Autonomous Cargo Delivery (2025+)

Larger vehicle – single pilot, off-board manager, or fully autonomous depending on vehicle size



Transformation – In stages – Initial Applications Larger than small drones (~2020+?)



Lowest risk – Grand Canyon or over water deliveries

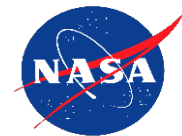


Mail delivery by mule train in
the Grand Canyon



JW Westcott mail delivery by boat

Future Airspace Operations?



- Scalable – increasingly autonomous
- Cooperative – information needs, and technologies for cooperation among vehicles, and operators, and service providers
- Digital – data exchanges and standardized application protocols
- Resilient – technologies and procedures for faster recovery from disruptions
- Manage by exception – flexibility where possible and structure where necessary
- Safety assurance – in-time data, prognostics, V&V of increasingly autonomous systems
- Air/ground/cloud integrated
- Service oriented architecture – third party

Space Traffic Management

High Altitude UTM (Upper E)

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

Urban Air Mobility

Low-altitude small UAS

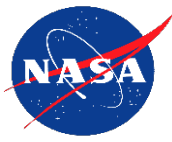
airspace operations...

....enabling beyond possible!



Concluding Remarks

- Need for change is real, current systems are not sustainable
- Sense of urgency due to emerging markets and diversity of operations
- Build-a-little-test-a-little and deploy
- Research issues remain – however goal should be “cross the finish line” to improve operations – research is means to an end and not an end in itself
- Highly scaled operations that are affordable and safe



Parimal.H.Kopardekar@nasa.gov

embracing innovation in aviation while respecting its safety tradition