Innovate Relentlessly

Enabling Innovation in Aviation While Respecting It’s Safety Tradition

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Daily Flight Demand for All Users in 2025
SMALL UNMANNED AIRCRAFT SYSTEMS
Connections & communications are internet-based & built on industry standards & protocols
Technology Capability Levels (TCLs)

- TCL 1, 2 and 3 (in progress)
- TCL 3 UAS towards controlled airspace
- TCL3 March 2018
- TCL3 First Responders
- Participating Orgs:
  - TCL 1: 19
  - TCL 2: 42
  - TCL 3: 35
Transformation – Urban Air Mobility

Increasingly autonomous – focused on access, safety and scalability
Emerging and Heritage Users

- Commercial Space Operations
- Supersonics and Hypersonics
- High Altitude Operations (upper E)
- Subsonic Transport Aviation
- Urban Air Mobility
- Small Unmanned Aircraft Systems

Economy
Affordability
Ubiquitous

Access

Scalability

Efficiency

Safety

Air Navigation Service Provider
Autonomy alone will not lead to efficiency and large-scale disturbance management. Connectivity is crucial – air/ground/cloud/infrastructure integration will be key.
### 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
Increasingly Autonomous and Connected Operations
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

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

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

Automation addresses off-nominal and contingencies
- Users collaborate/cooperate for efficiency, intra-user preferences for flights into constrained resources

User or third party services
- New paradigm: digital and connected ecosystems-outside apps, scalability

Human address off-nominal and contingencies
- Very little interaction among users, and 3rd party services

Separation
- Flow management
- Sequencing, and spacing
- User participation strategic Separation (e.g., oceanic)
Airspace Operations: Much Room for Impact

Barbara S. Wiles mailboat on Skaneateles Lake to retire; new boat launches July 1

The sign on the only cafe in town reads "No Fries "TIl Mail." Life in the community of Supai, Arizona, literally survives on its mail--in fact, inhabitants eat more "mail" than they read.

SPECIAL DELIVERY
Inter-island Autonomous Cargo Delivery

single pilot, off-board manager, or fully autonomous
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

<table>
<thead>
<tr>
<th>Space Traffic Management</th>
</tr>
</thead>
<tbody>
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</tr>
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</tbody>
</table>

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
embracing innovation in aviation while respecting it’s safety tradition
BACK UP
Scalable, Safe, and Efficient Autonomous Operations
Goal: Enable autonomous operations in the national airspace system

• **Motivation:**
  - Smaller and medium size autonomous cargo delivery market is emerging
  - Use of upper and lower airspace is increasing where there are no services
  - Pilot shortage is looming – Regular transport category for short/long haul flights
  - Future urban air mobility operations business case depends on autonomous operation

• **Enable autonomous freighter operations** by integrated air/ground/cloud
  - Rationale: Regardless of level of autonomy, integration is key - SWA
  - Initial operational evaluation (TRL 4)
  - Demonstration leading up to daily use operations (TRL 6+)

• **Autonomous urban air mobility vehicle operations** – cargo and/or passengers through integrated air/ground/cloud capabilities under nominal and off-nominal condition
SMALL UNMANNED AIRCRAFT SYSTEMS
URBAN AIR MOBILITY: SMALL DRONES TO LARGER PASSENGER CARRYING VTOLS
Transformation – Urban Air Mobility

Increasingly autonomous – focused on access, safety and scalability