Regulatory Considerations for Future Regional Air Mobility Aircraft

Nicholas K. Borer, Nathaniel J. Blaesser, Michael D. Patterson
Aeronautics Systems Analysis Branch
NASA Langley Research Center

12 June 2023

This material is a work of the U.S. Government and is not subject to copyright protection in the United States.
Introduction

- 2021 vision for Regional Air Mobility (RAM)
  - Diverse group of contributors
  - Confluence of opportunities

- Trends with Urban Air Mobility (UAM)
  - New propulsion types
  - New operational paradigms
  - Focus on community impact

- RAM enablers and assumptions
  - Existing takeoff/landing infrastructure
  - Potential for conventional takeoff/landing
  - Conterminous United States (CONUS)

Goal is to develop comprehensive set of regulatory considerations for future vehicle sizing studies
“Regional” Air Mobility

- Re-entering the lexicon
  - Post-World War II
  - “Deregulation” and Essential Air Service (EAS)
  - Small Aircraft Transportation System (SATS)
  - Advanced Air Mobility (AAM)

- What is “regional?”
  - Origin/Destination (O/D) pair distance?
  - Aircraft and/or payload size?
  - Type of operator?
  - Purpose of trip?
  - Population served?

Equitable, economical, environmentally-friendly access to air commerce at local airports

Derived from Aultman-Hall et al., 2018
Scheduled commercial operations with less than 10 passengers enables access to 10x more airports

- Public use airport (4457)
- Part 139 airport (457)
- 95th percentile CONUS cargo (75)
- 95th percentile CONUS enplanements (98)
Security

- Transportation Security Administration (TSA) rules: Title 49 of the Code of Federal Regulations (49 CFR) § 1540, § 1544
  - More than 30 passengers
  - More than 101,309.3 pounds Maximum Certified Takeoff Weight (MCTW) all-cargo
  - More than 12,500 pounds MCTW
  - Enplane from/deplane to a secure area

Local airports may not have facilities or personnel for security programs required for larger airplanes.
Range, Reserves, Speed, Altitude

- Limited CONUS RAM markets today
  - Bureau of Transportation Statistics DB1B database
    - Non-EAS: 27-224 nmi (511 datapoints)
    - EAS: 81-368 nmi (270 datapoints)
  - Other sources

- Other range and endurance factors
  - Non-direct routing
  - Headwinds
  - Reserve energy requirements

- Speed and altitude
  - 250 knot limit under 10,000 ft mean sea level
  - Supplemental oxygen & pressurization
  - In-flight lavatory and endurance vs. range

Most O/D pairs < 300 nmi, speed < 250 knots, but passenger comfort is key consideration
Runway Length and Field Elevation

- Runway surface and hours of operation
  - Takeoff, landing field length

- Airport elevation and max temperature
  - Maximum density altitude considerations

Landing field length much lower than Part 139 airports; density altitude a significant consideration
Flight Crew
- Single pilot operations possible with fewer than 10 passengers
- Airline Transport Pilot rating (1,500 total experience) vs. Commercial Pilot rating, types of operation
- Flight attendants

Airworthiness
- Normal category vs. Transport category airplanes
  - Normal category certification levels
  - Normal category speed levels

Equipment
- Multi-axis autopilot
- Collision avoidance
- Assurance level

Plan to use these requirements in future study of RAM aircraft design
Thank you to NASA’s Aeronautics Research Mission Directorate for providing funding for this effort via these projects/programs:

- Intercenter Systems Analysis Team of the Portfolio Analysis and Management Office
- Convergent Aeronautics Solutions Project of the Transformational Aeronautics Concepts Program

Thank you to Jacob Wishart, Kendall Mahavier, Seamus McGovern, Larry Barr, David Pace, and Claire Roycroft from the U.S. Department of Transportation Volpe Center for their assistance with the market analysis, in particular with interpreting results from the DB1B database.
### Summary of regulatory requirements and considerations from paper

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Rules</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 CFR §135</td>
<td>Public passenger operation possible at airports other than 14 CFR §139 airports (only 457 in CONUS vs 4,457 public-use airports)</td>
<td></td>
</tr>
<tr>
<td>Distance between O/D pairs</td>
<td>100 nmi</td>
<td>Meets current niche RAM markets with constrained geography</td>
</tr>
<tr>
<td>300 nmi</td>
<td>Meets majority of current RAM markets</td>
<td></td>
</tr>
<tr>
<td>Non-direct distance between O/D pair</td>
<td>20-40%</td>
<td>For O/D pairs under 200 nmi</td>
</tr>
<tr>
<td>5%</td>
<td>For portion of O/D pair distance over 200 nmi</td>
<td></td>
</tr>
<tr>
<td>Reserve mission energy</td>
<td>30 min at normal cruising speed</td>
<td>VFR day reserve requirement</td>
</tr>
<tr>
<td>45 min at normal cruising speed</td>
<td>VFR night reserve requirement</td>
<td></td>
</tr>
<tr>
<td>50 (to be refined) nmi alternate + 45 min at cruising speed</td>
<td>IFR reserve requirement if alternate airport required (forecast weather at destination does not meet certain criteria)</td>
<td></td>
</tr>
<tr>
<td>Maximum operating speed</td>
<td>250 knots calibrated airspeed or less</td>
<td>Speed limit for all operations under 10,000 ft MSL</td>
</tr>
<tr>
<td>Enables certification under low-speed criteria in 14 CFR §23 (also M≤0.6 if aircraft uses Mach)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum flight time</td>
<td>99 min</td>
<td>For aircraft without an onboard lavatory</td>
</tr>
<tr>
<td>Maximum operating altitude</td>
<td>8,000 ft MSL</td>
<td>Maximum cabin altitude for pressurized aircraft under 14 CFR §121</td>
</tr>
<tr>
<td>12,500 ft MSL</td>
<td>Crew must use supplemental oxygen if operating more than 30 min</td>
<td></td>
</tr>
<tr>
<td>14,000 ft MSL</td>
<td>Crew must use supplemental oxygen regardless of operating time</td>
<td></td>
</tr>
<tr>
<td>15,000 ft MSL</td>
<td>Passengers must be provided with supplemental oxygen</td>
<td></td>
</tr>
<tr>
<td>18,000 ft MSL</td>
<td>Class A airspace begins; additional air traffic management requirements</td>
<td></td>
</tr>
<tr>
<td>25,000 ft MSL</td>
<td>Pressurized cabin required for Normal Category airplanes (14 CFR §23)</td>
<td></td>
</tr>
<tr>
<td>Runway environment</td>
<td>2,665 ft runway at 4,100 ft density altitude</td>
<td>Accounts for 75% of public use, hard-surfaced, lighted CONUS airports per maximum temperature observed from 2010-2020</td>
</tr>
<tr>
<td>3,364 ft runway at 3,100 ft density altitude</td>
<td>Accounts for 50% of public use, hard-surfaced, lighted CONUS airports per maximum temperature observed from 2010-2020</td>
<td></td>
</tr>
</tbody>
</table>

### Questions?

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Passenger Seating</td>
<td>≤ 9</td>
<td>Scheduled passenger operations under 14 CFR §135 possible</td>
</tr>
<tr>
<td>Enables Certification Level 3 under 14 CFR §23 (Normal Category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-pilot operations possible under 14 CFR §135 (rather than 2 otherwise); multi-axis autopilot required for single-pilot IFR operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 19</td>
<td>Enables certification Level 4 under 14 CFR §23 (Normal Category)</td>
<td></td>
</tr>
<tr>
<td>No flight attendant required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 20,000 lbs</td>
<td>Enables operation at airports without a security program under 49 CFR §1544 other than based on certified takeoff weight</td>
<td></td>
</tr>
<tr>
<td>≤ 19,000 lbs</td>
<td>Enables certification under 14 CFR §23 (Normal Category)</td>
<td></td>
</tr>
<tr>
<td>≤ 33,000 lbs</td>
<td>Collision avoidance system not required for non-turbine-powered aircraft</td>
<td></td>
</tr>
<tr>
<td>≤ 101,309.3 lbs</td>
<td>Reduced security program required for all-cargo operations</td>
<td></td>
</tr>
<tr>
<td>14 CFR §23 (Normal Category)</td>
<td>Level 3 (≤ 9 passenger seats ≤ 19,000 lbs)</td>
<td>Development Assurance Level for critical hardware and software of 1 failure per 100 million flight hours for catastrophic failures (otherwise 1 per billion per Level 4 or §25 Transport Category)</td>
</tr>
</tbody>
</table>