RNP-based Parallel Instrument Approaches: Concepts and Benefits

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3 May 2005
Current Parallel Operations

- Problem: Simultaneous approaches to closely spaced parallel runways are stopped in marginal and instrument weather conditions (or when ILS is out of service)

- Example: Seattle-Tacoma (KSEA) uses single arrival stream when ceilings are below approx. 4500’
  - Capacity drops from 44 to 36 arrivals/hour

- Extending simultaneous arrivals to MVMC and IMC would increase capacity and reduce delays
Current Requirements for Simultaneous ILS Approaches in IMC

- Minimum spacing: 4300’ (3400’ with PRM)
- ILS Course
- Normal Operating Zone (NOZ) ≥ 1150’ (700’ w/ PRM)
- Missed Approach Point (MAP)
- Non-Transgression Zone (NTZ) centered between runways
  - 2000’
  - ≥ 1150’ (700’ w/ PRM)
- Min. spacing 4300’ (3400’ with PRM)
RNP Approach Procedures

- Required Navigational Performance (RNP) is an important element of performance based navigation
  - Fly point to point
  - Monitor navigation accuracy
  - Alert pilot if aircraft deviates from nominal path
- RNP instrument approach procedures need not rely on ground-based navaids
  - Allow narrower approach segments
  - Segments can be straight or curved
  - Will improve capacity and access
  - Will be classified as Special Aircraft and Aircrew Authorization Required (SAAAR)
RNP Parallel Approach with Transition (RPAT)

- Provides up to 60% greater capacity over single runway
- Applicable to parallel runways spaced as close as 750 feet
- Provides standard ILS approach to accommodate mixed equipage
- Maintains second arrival stream if one ILS is out of service

Weather Minima: ~2000’ and 4-5 miles visibility

NOZ ends at FAF
(Not centered between runways)

Clear of Clouds
Final Approach Fix (FAF): Pilot given visual separation responsibility at this point

MITRE
RNP Parallel Approach without Transition (ILS/RPA)

- Provides up to twice the capacity of a single runway in IMC (250’ and mile)
- Provides standard ILS approach to accommodate mixed equipage
- Provides backup for ILS

<table>
<thead>
<tr>
<th>Level</th>
<th>NTZ+RNP NOZ</th>
<th>Required Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>RNP-0.3</td>
<td>3150+1800</td>
<td>4950</td>
</tr>
<tr>
<td>RNP-0.2</td>
<td>3150+1200</td>
<td>4350</td>
</tr>
<tr>
<td>RNP-0.15</td>
<td>3150+900</td>
<td>4050</td>
</tr>
<tr>
<td>RNP-0.1</td>
<td>3150+600</td>
<td>3750</td>
</tr>
</tbody>
</table>
Future RPA Concept

- Applicable to runways spaced as close as 2400’ with RNP-0.1 approach procedures
- Provides up to twice the capacity of a single runway in IMC (250’ and 1 mile)
- No ILS necessary, but requires high participation rates

<table>
<thead>
<tr>
<th>Level</th>
<th>4xRNP</th>
<th>Required Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>RNP-0.3</td>
<td>3600+3600</td>
<td>7200</td>
</tr>
<tr>
<td>RNP-0.2</td>
<td>2400+2400</td>
<td>4800</td>
</tr>
<tr>
<td>RNP-0.15</td>
<td>1800+1800</td>
<td>3600</td>
</tr>
<tr>
<td>RNP-0.1</td>
<td>1200+1200</td>
<td>2400</td>
</tr>
</tbody>
</table>
Candidate Airports and Delay Benefits

- MITRE was sponsored by FAA to analyze RPAT/RPA benefits and to determine a list of candidate airports for implementation.
- Found 12 RPAT, 6 RPA candidates, based on traffic level, runway spacing, and runway length.
- Delay reduction benefit calculated by modeling:
  - RPAT arrival capacity determined at each candidate airport by Monte Carlo simulation.
  - New capacities were applied to 2003 ASPM airport data replacing historical arrival rates when RPAT/RPA applied.
  - Higher throughput translates to fewer delayed flights.
## Candidate Airports and Delay Benefits (concluded)

<table>
<thead>
<tr>
<th>Site</th>
<th>Applicable Runways</th>
<th>Fraction of time RPAT is applicable</th>
<th>Potential Annual RPAT Airborne Delay Benefit (minutes)</th>
<th>Fraction of time RPA is applicable</th>
<th>Potential Annual RPA Airborne Delay Benefit (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta</td>
<td>26R/27L/28, 8L/9R/10 (Triples)</td>
<td>17%</td>
<td>120,000</td>
<td>37%</td>
<td>320,000</td>
</tr>
<tr>
<td>Boston</td>
<td>4L/R</td>
<td>6%</td>
<td>14,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cleveland</td>
<td>24L/R, 6L/R</td>
<td>14%</td>
<td>24,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Detroit</td>
<td>21L/R, 22L/R, 3L/R, 4L/R (Triples)</td>
<td>18%</td>
<td>43,000</td>
<td>34%</td>
<td>120,000</td>
</tr>
<tr>
<td>Newark</td>
<td>4L/R, 22L/R (possibly)</td>
<td>11%</td>
<td>28,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>JFK</td>
<td>4R/L, 22R/L</td>
<td>5%</td>
<td>3,400</td>
<td>67%</td>
<td>6,200</td>
</tr>
<tr>
<td>Las Vegas</td>
<td>25R/L, 19R/L, 7R/L, 1R/L</td>
<td>3%</td>
<td>6,700</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Portland</td>
<td>10R/L, 28R/L</td>
<td>23%</td>
<td>4,000</td>
<td>36%</td>
<td>11,000</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>26/27R</td>
<td>7%</td>
<td>11,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Seattle</td>
<td>16R/L or 16W/L*, 34R/L</td>
<td>23%</td>
<td>68,000</td>
<td>41%</td>
<td>100,000</td>
</tr>
<tr>
<td>San Francisco</td>
<td>10s, 28s, 1s, 19s</td>
<td>14%</td>
<td>33,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>St. Louis</td>
<td>12R/L, 30R/L</td>
<td>16%</td>
<td>22,000</td>
<td>31%</td>
<td>55,000</td>
</tr>
</tbody>
</table>

* 16W refers to the new runway at SEA scheduled for completion in 2008

Delay benefit calculated assuming 100% equipage and participation
Accommodating Mixed Equipage

• RNP-SAAAR procedures require advanced avionics equipment that has not been deployed by all operators
  – Dual flight management systems
  – GPS or Inertial guidance systems
  – Vertical Navigation (VNAV)
  – Radius-to-Fix RNAV leg capability

• Aircraft that are not RNP-SAAAR authorized must still have access to airports where RPAT/RPA are in use

• Unequipped flights would likely be worked into pattern, but would impact capacity
  – RPAT and ILS/RPA have ILS approach available, so only one flight of each pair needs to be equipped
  – Future-RPA procedures require both simultaneous arrivals be participating
Accommodating Mixed Equipage (concluded)

- Effect of mixed equipage upon delay benefit determined by modeling
- Actual RPAT benefit scales approximately linearly with equipage rate
- Future RPA benefit reduced strongly for equipage less than 90%
Implementation Issues

• RPAT is currently being studied for implementation in the near term
  – Uses existing separation and monitoring standards
  – Offset course may occupy new airspace, requiring environmental considerations
  – Wake vortex mitigation strategies are being studied
• RPA could provide greater benefits at a later time
  – Uses existing flight paths, less environmental impact
  – Applicable to runways closer than 3750 feet only with reduced NTZ, so updated “blunder” scenario needed
  – Requires new separation and monitoring standards on the final approach segment
Conclusion

• Utilization of closely spaced parallel runways is reduced in MVMC and IMC.
• RNP-SAAAR based approach procedures are being developed to extend use of simultaneous approaches
  – FAA RNP office is working toward RPAT implementation this year
• Current equipage rates will allow realization of partial benefit from RPAT and ILS/RPA.
• Most beneficial Future RPA procedures will require revision of “blunder” analysis and new separation standards based on aircraft containment