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Paired Approach Flight Demonstration: Planning and Development Activities

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Presentation Outline

• Background
• Paired Approach Operational Concept
• Operational Concept vs. Flight Demonstration
• Safety and Training Considerations
• Development of Paired Approach Instrument Approach Procedures
• Assigned Spacing Goal Calculator
• Flight Demonstration Matrix
• Next Steps
Background (1/2)

- 700 ft < Closely Spaced Parallel Runways (CSPR) < 4300 ft
- Simultaneous arrivals to CSPR are permissible when visual approaches can be conducted and visual separation can be provided by flight crew
  - For runways < 2500 ft apart, flight crew must be aware of and avoid wake encounters
- When visual approaches cannot be conducted, instrument approach procedures are utilized
  - Reduce airport capacity because of increased separation needed to compensate for surveillance uncertainty and having a controller in the loop.
- FAA’s Improved Multiple Runway Operations portfolio has implemented simultaneous dependent approaches for CSPR < 2500 ft as defined in FAA Order 7110.308C
  - Lead aircraft restricted to certain wake categories
    - e.g., for KSFO .308 operations must be D (except B757), E, or F
    - Separation is reduced to 1 NM
- Paired Approach concept has been developed to more closely emulate visual approaches under IMC
  - Applies to a wider range of wake categories
Background (2/2)

- **Paired Approaches**
  - .308C with 1.0 NM stagger

- **Single Runway**

- **SOIA**

- **Visual Approaches**

Minima:
- ILS Cat I
- 1600 & 4
- 4000 & 7

Capacity:
- 56
- 48
- 36
- 30
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Paired Approach Operational Concept (1/4)
Paired Approach Operational Concept (2/4)

Open-loop segment – no assigned spacing goal, no speed guidance

End of 3 degree lateral offset

Collision safety limit

Wake safety limit

Planned termination point

FIM speed guidance – capture and maintain target aircraft

Initial spacing of Paired Approach aircraft

Upstream projection of downstream wake safety limit (no wake safety limit this far out)

~ 20 nm to runway threshold

Closely spaced parallel runways

0.5 nm to runway threshold

6.25 nm to runway threshold

Depiction not to scale

Normal operating zone

Non-transgression zone – controller action may be required to maintain separation
Paired Approach Operational Concept (4/4)

Open-loop segment – no assigned spacing goal, no speed guidance

Closely spaced parallel runways

End of 3 degree lateral offset

0.5 nm to runway threshold

Collision safety limit

Safe zone

Wake safety limit

Planned termination point

6.25 nm to runway threshold

Depiction not to scale

- Normal operating zone
- Non-transgression zone – controller action may be required to maintain separation
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Operational Concept vs. Flight Demonstration (1/2)

**Operational Concept**
- Conducted under IFR enabling dependent approaches to CSPRs down to Category I minima

**Flight Demonstration**
- Conducted in visual approach conditions and both Target and IM aircraft will be given visual approach clearances:
  - Reduced separation standard only achievable via a visual approach clearance
    - IM flight crew to assume separation responsibility
  - The FIM avionics for IM aircraft will be uncertified.
  - Experimental IAPs will be flown by both Target and IM aircraft.
Operational Concept

- Because controller maintains responsibility for separation, new controller automation to support PA procedure will be required
  - The requirements for new automation have not yet been determined
- ATC provides IM aircraft the ASG with PA clearance. ASG is determined by new ground automation

Flight Demonstration

- No changes to ground automation
  - IM flight crew has separation responsibility once the visual approach clearance is issued
- ASG is predetermined using ASG calculator
  - There may be updates to ASG within a given flight trial if difference between actual winds and forecasted winds exceed a threshold
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Safety and Training Considerations

• By keeping Target aircraft in sight, risk of FIM equipment failure or generating false information is mitigated

• Wake turbulence from Target aircraft is mitigated by IM aircraft staying above glideslope of Target aircraft
  – While IAPs are designed this way, it can be confirmed by visually noting Target aircraft is below end of runway in windscreen of IM aircraft.

• Training for flight crews
  – FIM equipment
  – New instrument approach procedures
  – Normal and abnormal procedures
  – Planned go-arounds when target aircraft reaches 100 ft
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Development of Paired Approach Instrument Approach Procedures (1/2)

- 4 experimental IAPs developed
  - 2 for Target aircraft
  - 2 for IM aircraft

**Target IAP**
- 2.85-degree glideslope
- 3-degree lateral offset intercepts extended runway centerline 0.5 NM from runway threshold.
- Create new waypoints with the following speed constraints: 210 knots at 20 NM, 190 knots at 14 NM, 170 knots constant speed segment between 8.5 and 6.25 NM.

**ILS 28L**
- 2.85-degree glideslope

**RNAV 28R**
- 2.7-degree glidepath
- 3-degree glidepath

**IM IAP**
- 2.85-degree glideslope
- 3-degree glidepath
Development of Paired Approach Instrument Approach Procedures (2/2)
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Assigned Spacing Goal Calculator (1/2)

- The ASG specifies desired spacing between Target and IM aircraft
  - Keep IM aircraft as close as safely possible to Target aircraft
- The ASG is a function of:
  - 4D trajectories of IM and Target aircraft
  - Collision safety limit, wake safety limit, and non-transgression zones
  - Winds
- CSL, WSL, and NTZ are known well before start of Flight Demonstration
- Predicted 4D trajectories for both IM and Target aircraft are calculated by ASG Calculator, based on inputs from Flight Demonstration research team:
  - Planned final approach speed (PFAS) of each aircraft
  - Wind magnitude and direction
  - Wake category of each aircraft
  - Target aircraft’s runway assignment
- Glideslope/glidepath of each aircraft is derived from Target aircraft’s runway assignment
- WSL is determined based on wake category of each aircraft.
**Assigned Spacing Goal Calculator (2/2)**

- IM tolerance for PA is expected to be 7 seconds, 95%
- Uncertainty in spacing between PTP and runway is determined using a Monte-Carlo simulation to vary factors that impact time it takes an aircraft to fly between PTP and runway threshold
  - PFAS is known within 5 knots, 95%
  - Deceleration rate is known with 0.3 knots per second, 95%
  - Deceleration point is known with 0.25 NM, 99.99%
  - Resulting uncertainty is 8.04 s, 95%
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Flight Demonstration Matrix (1/2)

• The Paired Approach Flight Demonstration is planned to be conducted over 4 trials
  – 1 trial per day
  – 6 Paired Approach runs being conducted during each trial
  – Weather and traffic permitting, 4 trials will be planned over a one-week period, most likely in February of 2019.
• Each trial will require approximately 2 hours of flight time for 6 PA runs
  – Approximately 20 minutes per run
  – First 5 runs are followed with planned go-arounds
  – The 6th run concludes with both aircraft landing on their respective runways
• The PFAS of Target and IM aircraft will be varied between runs of a given trial to ensure a variety of ASGs
  – Demonstrate spacing compression or decompression within NOZ during open-loop segment
## Flight Demonstration Matrix (2/2)

<table>
<thead>
<tr>
<th>Flight Demo Trial #</th>
<th>Target aircraft</th>
<th>Target aircraft wake category</th>
<th>IM aircraft</th>
<th>IM aircraft wake category</th>
<th>Rationale for including in flight demonstration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Honeywell B757</td>
<td>D (Emulated C)</td>
<td>Honeywell F900 or E170</td>
<td>E</td>
<td>B757 is not permitted to act as lead aircraft in .308 operations at KSFO. B757, a wake category D aircraft, does not require a WSL, but 3 of 6 runs in this trial will emulate B767 WSL.</td>
</tr>
<tr>
<td>2</td>
<td>United B777</td>
<td>B</td>
<td>Alaska A319, 320, or 321</td>
<td>D</td>
<td>Wake category B aircraft are not allowed as lead aircraft in .308 operations at KSFO.</td>
</tr>
<tr>
<td>3</td>
<td>Honeywell B757</td>
<td>D (Emulated C)</td>
<td>Alaska A319, 320, or 321</td>
<td>D</td>
<td>Similar to #1, but demonstrate with Airbus aircraft as IM aircraft.</td>
</tr>
<tr>
<td>4</td>
<td>United B777</td>
<td>B</td>
<td>Honeywell B757</td>
<td>D</td>
<td>Similar to #2, but demonstrate with Boeing aircraft as IM aircraft.</td>
</tr>
</tbody>
</table>
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Next Steps

• This presentation is the outcome of first phase
• The second phase is underway:
  – Installation of FIM hardware, FIM software development, testing and verification
  – Development of procedures unique to PA Flight Demonstration:
    o Identification of criteria for go/no-go decisions
  – Completing development of ASG Calculator
    o Determination of ASG values for individual runs within flight demonstration matrix
  – Selection of airports for engineering flight tests
  – Coordination with Northern California TRACON and KSFO Tower to identify dates and times for 4 desired days of flight trials
  – Development of pilot training material and controller briefing material
  – Testing experimental IAPs in a high fidelity simulator
• The third phase includes engineering flight tests, conduct of Flight Demonstration, data gathering activities, and results synthesis
  – Analysis and results will be published in a future conference paper or journal
Questions?

Thank you for interest!