Benefits Assessment for Tailored Arrivals

A Year at San Francisco (Dec 3rd 2007 – Dec 31st 2008)

2009 Environmental Working Group Operations Standing Committee

July 28 – 29, 2009

Kevin Elmer
1. Data analysis included Tailored Arrivals flight candidates
   - ANA8, ANZ8, JAL2, JAL880, QFA73, SIA16, UAL (1404, 34, 72, 74, 76, 78, 830, 838, 852, 856, 856D, 858, 862, 870, 872, 886, 888, 892, 9816, 9822)
   - Flights that arrived via Woodside (OSI) or Point Reyes (PYE)
2. Primary data source: radar data from the SFO ANOMS8 system
   - 6 days (1/03/08, 1/24/08-1/26/08, 2/23/08 and 11/01/08) were missing due to ANOMS8 outages
3. Flights sorted by
   - Tailored Arrivals sort criteria using ATS clearances and ADS-C reports
   - Analysis of ANOMS8 radar data to verify and refine the initial sorting
4. Fuel consumption calculations:
   - For low speed performance below 10,000 ft altitude, using the Boeing Climbout Program (BCOP)
   - Above 10,000 ft altitude, using the Boeing INFLT tool for cruise & descent.
   - Vertical profile generated from BCOP and INFLT was matched to the mean descent paths of the collective ANOMS8 radar data
   - Common start point at cruise
5. Tailored Arrivals (TA) sort criteria, using ATS clearances and ADS-C data
   • Non participating - Opted out of procedure or were ineligible
     *Note: As ineligible flights are included in the above statistics, numbers should not be interpreted as pilot participation in Tailored Arrivals*
   • Partial Tailored Arrival – Met SOME of the TA criteria
   • Full Tailored Arrival – Met ALL of the TA criteria

6. **Environmental Criterion:** Radar data shows no more than ONE Level Flight Segment and that is no more than $\frac{1}{2}$ Nmi.

7. Evaluated all the ANOMS8 data to check if met **Environmental Criterion** including Non-Tailored Arrivals.
### SFO Tailored Arrival Environmental Statistics

<table>
<thead>
<tr>
<th>Data Collected</th>
<th>Total Flights*</th>
<th>% of Total Eligible Flights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-TA**</td>
<td>3027</td>
<td>70%</td>
</tr>
<tr>
<td>Partial TA</td>
<td>675</td>
<td>16%</td>
</tr>
<tr>
<td>Tailored Arrival</td>
<td>391</td>
<td>9%</td>
</tr>
<tr>
<td>Bad-Holding or Wrong Runway</td>
<td>223</td>
<td>5%</td>
</tr>
<tr>
<td>Not Eligible (Routed through PYE)</td>
<td>1235</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* ANOMS8 Data collected for **5551** Total Flights from December 4, 2007 to December 31, 2008
** Non-TA included non-participating flights and data collected prior to TA start date
## Airline Tailored Arrival Environmental Statistics

<table>
<thead>
<tr>
<th>Airline</th>
<th>Airplane</th>
<th># Tailored Arrivals</th>
<th># Requested TA**</th>
<th>% ENV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air New Zealand</td>
<td>777-200ER</td>
<td>80</td>
<td>246</td>
<td>33%</td>
</tr>
<tr>
<td>United Airlines</td>
<td>777-200ER</td>
<td>182</td>
<td>376</td>
<td>48%</td>
</tr>
<tr>
<td>United Airlines</td>
<td>747-400</td>
<td>104</td>
<td>345</td>
<td>30%</td>
</tr>
<tr>
<td>Japan Airlines</td>
<td>747-400</td>
<td>9</td>
<td>33</td>
<td>27%</td>
</tr>
<tr>
<td>Qantas</td>
<td>747-400</td>
<td>16</td>
<td>67</td>
<td>24%</td>
</tr>
</tbody>
</table>

* Env – Met Criterion for Environmental Performance
** Total of Full TA and Partial TA – These are the total flights that requested the TA
SFO Airport Noise Monitoring System (ANOMS 8) Data

Lateral Tracks

Altitude Profile

Ground Speed

Typical Level Flight (5-10 NM)
Extended Level Flight (10-130 NM)
Baseline Arrivals
RW28R
RW28L
RW19L
Full TA
Partial TA
SFO Airport Noise Monitoring System (ANOMS 8) Data, Cont.

Lateral Tracks

Altitude Profile

Ground Speed

Increased Path Predictability

Increased Altitude Assurance

Reduced Speed Variability

Extended Level Flight (10-60 NM)

Full TA
Partial TA
Partial TA
RW19L
## Fuel Consumption (Cruise to Top of Descent to Landing)

Fuel consumption was calculated using the Boeing Climbout Program (BCOP) for low speed performance below 10,000 ft altitude. Fuel consumption above 10,000 ft altitude was calculated using the Boeing INFLT tool for cruise and descent. The vertical profile generated from BCOP and INFLT was matched to the mean descent paths of the collective ANOMS8 radar data.

* Estimates derived from GE90-85B and PW4056 engine data.

### 777-200 vs. 747-400

<table>
<thead>
<tr>
<th></th>
<th>777-200</th>
<th>747-400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-TA</td>
<td>3,410 lbs</td>
<td>6,470 lbs</td>
</tr>
<tr>
<td>Partial TA</td>
<td>2,900 lbs</td>
<td>5,650 lbs</td>
</tr>
<tr>
<td>Full TA</td>
<td>1,980 lbs</td>
<td>3,670 lbs</td>
</tr>
</tbody>
</table>

### Fuel Saving from Tailored Arrival per Flight

<table>
<thead>
<tr>
<th></th>
<th>777-200</th>
<th>747-400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full TA</td>
<td>1,430 lbs</td>
<td>2,800 lbs</td>
</tr>
<tr>
<td>Partial TA</td>
<td>510 lbs</td>
<td>820 lbs</td>
</tr>
</tbody>
</table>
### Estimated Actual Fuel & CO2 Savings from SFO Tailored Arrivals

<table>
<thead>
<tr>
<th>Airline</th>
<th>Airplane</th>
<th>Fuel / CO2 Saved (lbs)</th>
<th>Fuel / CO2 Saved (kgs)</th>
</tr>
</thead>
</table>
Trajectory Comparison from Boeing Performance Software

Distance from Threshold, ft

Aircraft Height above Field Elevation, ft

- 777-200 TA
- 777-200 Non-TA
- 777-200 Partial TA
Emissions Analysis - CREAN to the Runway

- **CO2 (3.149*fuel) LBS**
  - Basic OTA Profile
  - OTA w/ EDA Profile (11k)
  - Min Congestion
  - Avg Congestion
  - Max Congestion

- **CO(g)**
  - Basic OTA Profile
  - OTA w/ EDA Profile (11k)
  - Min Congestion
  - Avg Congestion
  - Max Congestion

- **HC(g)**
  - Basic OTA Profile
  - OTA w/ EDA Profile (11k)
  - Min Congestion
  - Avg Congestion
  - Max Congestion

- **NOX(g)**
  - Basic OTA Profile
  - OTA w/ EDA Profile (11k)
  - Min Congestion
  - Avg Congestion
  - Max Congestion
Emissions Analysis - (10,000’ to Landing)

Local Emissions (below 10,000 ft)

Full TA
Partial TA
Noise Measurement Comparison - SEL (As Measured)

Sound Exposure Level (as Measured), dB

Non TA's
Full TA's
Partial TA's

Sample Size
913 (OSI) (665)
915 (74)
916 (168)
12 (1217)

(1688) (173) (263)

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Noise Contour Comparison- 20 Flights per Scenario

Non Tailored Arrival

Partial Tailored Arrival

Tailored Arrival
Full TA Scenario
Full TA Scenario with Non TA Track Overlay
Non TA Scenario
Full TA / Non TA Comparison

Acoustic Technology
Summary
First Year of Tailored Arrivals Operations at San Francisco

• Fuel Saved
  1,999,980 lbs (989,863 kgs)

• CO2 Emissions Saved
  6,309,937 lbs (3,123,016 kgs) Fuel Saved

• Noise Impact
  No Significant Change at a few temporary measurement sites
  Reduction in noise exposure area can be significant

• Air Quality
  • Overall reduction CO, HC, and NOx (From TOD or 10,000’)