Procedure Design Concepts for Logan Airport Community Noise Reduction

R. John Hansman
rjhans@mit.edu

Technical support from MIT ICAT students, HMMH, and Massport
RNAV Track Concentration

2010

2015
Noise Complaints at BOS: One Dot per Address

Each dot represents an address that registered at least one complaint during period

Departures

Arrivals

Complaint Data: August 2015–July 2016
Track Data: ASDE-X from 12 days of operation, 2015-2016
Technical Approach

- Collect Data and Evaluate Baseline Conditions
  - Pre and Post RNAV
  - Community Input (Meetings and MCAC)
- Identify Candidate Procedure Modifications
  - Block 1
    - Clear noise benefit, no equity issues, limited operational/technical barriers
  - Block 2
    - More complex due to potential operational/technical barriers or equity issues
- Model Noise Impact
  - Standard and Supplemental Metrics
- Evaluate Implementation Barriers
  - Aircraft Performance
  - Navigation and Flight Management (FMS)
  - Flight Crew Workload
  - Safety
  - Procedure Design
  - Air Traffic Control Workload
- Recommend Procedural Modifications to Massport and FAA
- Repeat for Block 2
Outreach (Partial List)

• Community
  – Community Meetings
  – Massport Community Advisory Committee
  – Public Officials
  – ASCENT

• FAA
  – ATO Air Traffic (HQ, TRACON, Tower, Center, Region)
  – AJV Flight Procedures
  – AFS Flight Standards
  – AEE Environment and Energy

• Airlines
  – Technical Pilot Group
### Procedures Under Consideration

#### Block 1
- **Departure Mods**
  - 33L and 27
    - Reduced speed departures (1-D1)
  - 15R
    - RNAV waypoint relocation (1-D2)
  - 22L/R
    - RNAV waypoint relocation
      - Climb to intercept course (1-D3a)
      - Climb to altitude then direct (1-D3b)
    - Heading-based departure (1-D3c)
- **Arrival Mods**
  - 33L Low-noise overwater approach procedures
    - Overwater RNAV Instrument Approach Procedure with RNP Overlay (1-A1a)
    - Overwater RNAV Visual Procedure (1-A1b)

#### Block 2
- **Departure Mods**
  - 33L and 27
    - Introduce dispersion with Open SID or direct-to flexibility on RNAV procedures
- **Arrival Mods**
  - Low-noise overwater approach procedures
    - 4R
      - RNAV approach to 4R with RNP Overlay
    - RNP approach to 4R
    - 22L
      - RNAV approach to 22L with RNP Overlay

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*Preliminary/Subject to Change*
Block 1: Reduced Speed Departures (1-D1)
• Standard departure procedures vary by airline

• **Baseline:** Typical profile includes thrust reduction at 1,000’ AGL followed by an acceleration to **250 kt climb speed** and **flap retraction**

• **Proposal:** Thrust reduction at 1,000’ AGL followed by an acceleration to **220 kt climb speed** or minimum clean operating speed, whichever is greater until a TBD altitude (i.e. 6,000’ or 10,000’)

**Simulator Tested for Flyability**
Increasing Speed Increases Airframe Noise

DEPARTURES

Boeing 737-800

LA_{MAX} Departure Contours by Source: 160 KTAS

160 KTAS

LA_{MAX} Departure Contours by Source: 190 KTAS

190 KTAS

LA_{MAX} Departure Contours by Source: 220 KTAS

220 KTAS

LA_{MAX} Departure Contours by Source: 250 KTAS

250 KTAS
Reduced-Speed Departures

**Summary:** Limit climb speed on RNAV SID departures to reduce airframe noise contribution (i.e. 220 Knots through 10,000’)

160 Knots: Engine Noise Dominates

250 Knots: Airframe Noise Dominates

**Boeing 737-800 Departure**

**Benefits Mechanism**
- Reduced noise along centerline of departure
- Effect observed for most aircraft types (single speed limit for all types)

**Potential Operational Constraints**
- Increased fuel burn
- Increased flight time
- Potential implications for departure throughput

**LMAX Contours**
- Blue: 250 Knot Target Climb Speed
- Red: 220 Knot Target Climb Speed
737-800: Delayed Acceleration Climb – 220 knots

**Aircraft** | B737-800
---|---
**Metric** | $L_{A,\text{MAX}}$
**Noise Model** | ANOPP
**Notes** | Runway 33L: Maintain Standard Climb Thrust & 220 KIAS to 10,000'

<table>
<thead>
<tr>
<th>Population Exposure</th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Departure</td>
<td>237,952</td>
<td>105,869</td>
<td>38,599</td>
</tr>
<tr>
<td>Delayed Acceleration</td>
<td>190,128</td>
<td>75,469</td>
<td>28,239</td>
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<tr>
<td>Reduction</td>
<td>47,824</td>
<td>30,401</td>
<td>10,359</td>
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</table>
777-300: Delayed Acceleration Climb – 220 knots

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>B777-300</th>
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<tbody>
<tr>
<td>Metric</td>
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<tr>
<td>Noise Model</td>
<td>ANOPP</td>
</tr>
<tr>
<td>Notes</td>
<td>Runway 33L: Maintain Standard Climb Thrust &amp; 220 KIAS to 10,000'</td>
</tr>
</tbody>
</table>

**Population Exposure**

<table>
<thead>
<tr>
<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Departure</td>
<td>455,746</td>
<td>275,879</td>
<td>118,685</td>
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<tr>
<td>Delayed Acceleration</td>
<td>437,415</td>
<td>262,310</td>
<td>105,182</td>
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<tr>
<td>Reduction</td>
<td>18,331</td>
<td>13,569</td>
<td>13,502</td>
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</table>
E-170: Delayed Acceleration Climb – 220 knots

<table>
<thead>
<tr>
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<th>E-170</th>
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</thead>
<tbody>
<tr>
<td>Metric</td>
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<tr>
<td>Noise Model</td>
<td>ANOPP</td>
</tr>
<tr>
<td>Notes</td>
<td>Runway 33L: Maintain Standard Climb Thrust &amp; 220 KIAS to 10,000'</td>
</tr>
</tbody>
</table>

Population Exposure

<table>
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<tr>
<th></th>
<th>60dB</th>
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<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Departure</td>
<td>147,222</td>
<td>58,441</td>
<td>10,437</td>
</tr>
<tr>
<td>Delayed Acceleration</td>
<td>97,728</td>
<td>33,306</td>
<td>9,298</td>
</tr>
<tr>
<td>Reduction</td>
<td>49,493</td>
<td>25,135</td>
<td>1,139</td>
</tr>
</tbody>
</table>
Runway 27 Departures: 2010-2015
Delayed Acceleration Climb – 220 knots

**Aircraft**
- B737-800

**Metric**
- \( L_{A,\text{MAX}} \)

**Noise Model**
- ANOPP

**Notes**
- Runway 27: Maintain Standard Climb Thrust & 220 KIAS to 10,000’

### Population Exposure

<table>
<thead>
<tr>
<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Departure</td>
<td>200,576</td>
<td>102,274</td>
<td>37,078</td>
</tr>
<tr>
<td>Delayed Acceleration</td>
<td>187,400</td>
<td>76,261</td>
<td>21,066</td>
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<tr>
<td>Difference</td>
<td>13,177</td>
<td>26,014</td>
<td>16,011</td>
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</tbody>
</table>

**Preliminary**
Fuel Burn and Time Impact

- Reduced speed climb profiles impact total trip fuel burn and flight time
- Magnitude varies by speed and aircraft type

<table>
<thead>
<tr>
<th>Climb Speed</th>
<th>B738</th>
<th>E170</th>
<th>B773</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fuel Burn Increase (kg)</td>
<td>Time Increase (s)</td>
<td>Fuel Burn Increase (kg)</td>
</tr>
<tr>
<td>180 kts</td>
<td>141</td>
<td>121</td>
<td>55</td>
</tr>
<tr>
<td>200 kts</td>
<td>54</td>
<td>65</td>
<td>12</td>
</tr>
<tr>
<td>220 kts</td>
<td>21</td>
<td>30</td>
<td>4</td>
</tr>
<tr>
<td>240 kts</td>
<td>4</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>
Open Issues

• **Issues**
  - Increased fuel burn and flight time
  - Potential throughput reduction
  - Nonstandard relative to normal operating procedures

• **Pending Analysis**
  - Determining minimum clean operating speed for set of representative aircraft types
  - Historical radar analysis for throughput impact assessment
  - Comparing noise impact of NADP-1 relative to proposed procedure
    - Will recommend NADP-1 adoption if benefits are equivalent
NADP1 vs. 220 Knots to 10,000ft: B737-800 Noise Exposure

**Population Exposure (L\text{MAX})**

<table>
<thead>
<tr>
<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Departure</td>
<td>234,915</td>
<td>117,504</td>
<td>46,584</td>
</tr>
<tr>
<td>NADP-1</td>
<td>230,253</td>
<td>96,202</td>
<td>26,299</td>
</tr>
<tr>
<td>Difference</td>
<td>4,662</td>
<td>21,302</td>
<td>20,285</td>
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</table>

220kt to 10,000’ (B737-800) Noise Model: ANOPP

<table>
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<tbody>
<tr>
<td>Baseline Departure</td>
<td>234,915</td>
<td>117,504</td>
<td>46,584</td>
</tr>
<tr>
<td>220kt to 10k ft</td>
<td>180,729</td>
<td>74,409</td>
<td>25,634</td>
</tr>
<tr>
<td>Difference</td>
<td>54,186</td>
<td>43,095</td>
<td>20,950</td>
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</table>
Block 1: Runway 15R RNAV Waypoint Relocation (1-D2)
**Summary:** Relocate initial waypoint on RNAV SID from FOXXX to BRRRO in order to provide noise relief at Hull

**Population Exposure**

<table>
<thead>
<tr>
<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
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<tbody>
<tr>
<td>Baseline RNAV SID</td>
<td>5,372</td>
<td>299</td>
<td>116</td>
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<tr>
<td>Modified Procedure</td>
<td>4,058</td>
<td>288</td>
<td>116</td>
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<tr>
<td>Reduction</td>
<td>1,314</td>
<td>11</td>
<td>0</td>
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**Boeing 737-800 (L\textsubscript{A,MAX})**

**Noise Model:** AEDT

**Potential Operational Constraints**

- None anticipated

**Benefits Mechanism**

- Reduced noise at Hull due to waypoint relocation
Block 1: Runway 22L/R RNAV SID Modification
Runway 22R Departures: 2010-2015
**Runway 22L/22R SID Modification Options**

**Summary:** Relocate initial waypoint on RNAV SID from in order to provide noise relief at Hull while initiating post-takeoff turn as early as practical to reduce impact in South Boston

Three potential procedure options

A. Climb on runway heading to intercept an outbound course

B. Climb on runway heading to 500’ AGL, then direct to waypoint on SID

C. Historical heading-based departure procedure

Potential Operational Constraints

- Spacing with Runway 27 arrivals
- Compliance with procedure design criteria due to short leg lengths
Baseline Procedure Geometry

51°

47°

Localizer Rwy27
273°

1.5 NM

2.0 NM

ATC Sector Boundary

144° to TJAYV
140° to TJAYV

TJAYV

FOXXX

RRRR

Option A - Climb to Intercept Course (1-D3a): Definition

Preliminary Procedure Geometry

- Localizer Rwy 27
- 273°
- 45°
- 1.5 NM
- ATC Sector Boundary
- 1.5 NM

S. Boston

Geography

Simulator Tested for Flyability
Option A - Climb to Intercept Course (1-D3a): Noise Impact

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>B737-800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric</td>
<td>$L_{A,\text{MAX}}$</td>
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<tr>
<td>Noise Model</td>
<td>AEDT</td>
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<tr>
<td>Notes</td>
<td>Vertical departure profile derived from median or historical radar data</td>
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### Population Exposure ($L_{\text{MAX}}$)

<table>
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<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline RNAV SID</td>
<td>17,761</td>
<td>6,042</td>
<td>1,802</td>
</tr>
<tr>
<td>Modified Procedure</td>
<td>16,248</td>
<td>5,992</td>
<td>1,802</td>
</tr>
<tr>
<td>Reduction</td>
<td>1,513</td>
<td>50</td>
<td>0</td>
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</table>
Option B - Climb to Altitude Then Direct (1-D3b): Definition
Option B - Climb to Altitude Then Direct (1-D3b): Noise Impact

<table>
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<th>B737-800</th>
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<tbody>
<tr>
<td>Metric</td>
<td>L_{A,\text{MAX}}</td>
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<tr>
<td>Noise Model</td>
<td>AEDT</td>
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<tr>
<td>Notes</td>
<td>Vertical departure profile derived from median or historical radar data</td>
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### Population Exposure (L_{\text{MAX}})

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<tbody>
<tr>
<td>Baseline RNAV SID</td>
<td>17,761</td>
<td>6,042</td>
<td>1,802</td>
</tr>
<tr>
<td>Modified Procedure</td>
<td>15,445</td>
<td>5,715</td>
<td>1,712</td>
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<tr>
<td>Reduction</td>
<td>2,316</td>
<td>327</td>
<td>90</td>
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</table>

2.5 nmi
Option C: Heading-based departure (1-D3c)

Definition

• **Concept**: During periods where runway 27 not in use for arrivals, issue takeoff clearance with heading (followed by vectors or direct-to on course)
Open Issues

• Issues
  – Option A: Climb to intercept course (1-D3a)
    • Waivers required for RNAV SID leg length
  – Option B: Climb to altitude, then direct (1-D3b)
    • Waivers required for RNAV SID turn arc radius
    • Variable track length impacting departure sequencing
  – Option C: Heading-based departure (1-D3c)
    • Only available when Runway 27 arrivals not in use

• Pending Analysis
  – Potential TARGETS assessment of criteria compliance
  – Historical runway configuration analysis to determine when procedure would be available
Block 1: RNAV Approach
Runway 33L
33L Low-Noise Overwater Approach Procedures

RNAV (GPS) Rw 33L approach under development based on current JetBlue RNAV special procedure.

No Criteria Compliance Constraints

No Current Mechanism for Public Distribution

VFR Weather Minimums

RNAV (GPS) IAP

TERPS & PBN Compliance Constraints

Non-Precision Minimums
Overwater RNAV Instrument Approach Procedure with RNP Overlay (1-A1a)

- RNAV (GPS) Rwy 33L approach under development based on current JetBlue RNAV special procedure
Overwater RNAV Instrument Approach Procedure with RNP Overlay (1-A1a) – Noise Exposure

Population Exposure ($L_{MAX}$)

<table>
<thead>
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<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
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</thead>
<tbody>
<tr>
<td>Straight In</td>
<td>2,241</td>
<td>154</td>
<td>0</td>
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<tr>
<td>Modified Procedure</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Reduction</td>
<td>2,239</td>
<td>154</td>
<td>0</td>
</tr>
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<table>
<thead>
<tr>
<th>Aircraft</th>
<th>B737-800</th>
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<tr>
<td>Metric</td>
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<td>Noise Model</td>
<td>AEDT</td>
</tr>
<tr>
<td>Notes</td>
<td>Standard AEDT arrival profile</td>
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</table>
Open Issues

• Issues
  – Option A: Overwater RNAV Instrument Approach Procedure with RNP Overlay
    • Waiver required for final approach intercept angle (39° vs. 30° criteria)
    • Current draft procedure waypoint JASEP increases noise over Nahant
    • Merging and spacing difficulties may only allow use during low demand periods
    • Lack of vertical guidance in procedure may reduce utilization
  – Option B: RNAV Visual Approach Procedure
    • No current mechanism to allow for public distribution

• Pending Analysis
  – Potential TARGETS assessment of criteria compliance
  – Identify potential JASEP waypoint alternative
Block 1 Discussion
<table>
<thead>
<tr>
<th>Proc. ID</th>
<th>Procedure</th>
<th>Issues</th>
<th>Pending Analysis</th>
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</table>
| 1-D1    | Reduced-speed departures (modified to 220 knots or minimum clean maneuvering speed, whichever is higher) | • Increased fuel burn and flight time  
• Potential throughput reduction  
• Nonstandard relative to normal operating procedures | • Determining minimum clean operating speed for set of representative aircraft types  
• Historical radar analysis for throughput impact assessment  
• Comparing noise impact of NADP-1 relative to proposed procedure |
| 1-D2    | Runway 15R RNAV waypoint relocation                                        | • No significant issues                                                                                                                   | • Potential TARGETS assessment of criteria compliance                                                                                         |
| 1-D3a   | Runway 22L/R RNAV waypoint relocation (climb to intercept course)          | • Waivers required for leg length criteria                                                                                              | • Potential TARGETS assessment of criteria compliance                                                                                         |
| 1-D3b   | Runway 22L/R RNAV waypoint relocation (climb to altitude then direct)     | • Waivers required for turn arc criteria  
• Variable track length impacting departure sequencing                                   | • Potential TARGETS assessment of criteria compliance                                                                                         |
| 1-D3c   | Runway 22L/R heading-based departure                                       | • Only available when Runway 27 arrivals not in use                                                                                      | • Historical runway configuration analysis to determine when procedure would be available                                                   |
| 1-A1a   | Runway 33L overwater RNAV instrument approach procedure with RNP overlay   | • Waiver required for final approach intercept angle (39° vs. 30° criteria)  
• Current draft procedure waypoint JASEP increases noise over Nahant  
• Merging and spacing difficulties may only allow use during low demand periods  
• Lack of vertical guidance in procedure may reduce utilization | • Potential TARGETS assessment of criteria compliance  
• Identify potential JASEP waypoint alternative                                                                                           |
| 1-A1b   | Runway 33L overwater RNAV visual procedure                                 | • No current mechanism for public distribution                                                                                           |                                                                                                                                              |
Block 2: Runway 33L and 27 Departures – Introduce Dispersion
Runway 33L Departures: 2010-2015

Using Open SIDs or Flexible SIDs to Re-introduce Dispersion

2010

2015
Dispersion Concepts: Open SID or Increased Controller Flexibility

1. Open SIDs are RNAV departure procedures that include ATC radar vector segments.
   - Authorized by FAA in 2015
   - Proven in operation (e.g. CLT, LAX)

2. Dispersion may also be introduced by direct ATC instruction (vector-based or direct-to) based on aircraft altitude or other criteria
   - Allows greater ATC flexibility based on traffic levels and flows
   - Would result in track length reduction with corresponding fuel savings
Open Issues: Departure Track Dispersion

• **Issues**
  – Impact of noise redistribution

• **Pending Analysis**
  – Developing analysis method for dispersed departure tracks under Open SID and Flexible SID options
Block 2: Runway 4R & 22L Arrivals

Low-Noise Overwater Approach Procedures
Runway 4R Arrivals: 2010-2015
4R Low-Noise Overwater RNAV Approach with RNP Overlay

Simulator Tested for Flyability
### 4R Low-Noise Overwater RNAV Approach with RNP Overlay: Noise Exposure

#### Population Exposure ($L_{\text{MAX}}$)

<table>
<thead>
<tr>
<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Straight In</strong></td>
<td>30,239</td>
<td>7,468</td>
<td>530</td>
</tr>
<tr>
<td><strong>Modified Procedure</strong></td>
<td>18,283</td>
<td>5,792</td>
<td>529</td>
</tr>
<tr>
<td><strong>Reduction</strong></td>
<td>11,956</td>
<td>1,676</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Aircraft
- **Aircraft**: B737-800

#### Metric
- **Metric**: $L_{A,\text{MAX}}$

#### Noise Model
- **Noise Model**: AEDT

#### Notes
- Standard AEDT arrival profile
Runway 4R Departures: 2010-2015
Overlaying arrival corridor on existing 4R RNAV SID for 22L arrivals:

- Existing 22L Straight-in Route
- 55°
- 22L Proposed Route

Simulator Tested for Flyability
22L Low-Noise Offset RNAV Approach with RNP Overlay: Noise Exposure

Population Exposure ($L_{\text{MAX}}$)

<table>
<thead>
<tr>
<th>Aircraft Procedure</th>
<th>$60\text{dB}$</th>
<th>$65\text{dB}$</th>
<th>$70\text{dB}$</th>
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</thead>
<tbody>
<tr>
<td>Straight In</td>
<td>70,469</td>
<td>21,335</td>
<td>6,807</td>
</tr>
<tr>
<td>Modified Procedure</td>
<td>28,204</td>
<td>15,566</td>
<td>6,677</td>
</tr>
<tr>
<td>Reduction</td>
<td>42,265</td>
<td>5,769</td>
<td>130</td>
</tr>
</tbody>
</table>

Aircraft | B737-800
Metric | $L_{\text{A,MAX}}$
Noise Model | AEDT
Notes | Standard AEDT arrival profile
Canarsie RNAV (RNP) Special

Figure: Honeywell
Notional Low-Noise Overwater RNP: BOS Rwy 4R

- 0.95 nmi final
- 2.1 nmi radius RF
- Matched to Canarsie RNP 13L Special
4R Low-Noise Overwater RNP Approach: Noise Exposure

### Population Exposure ($L_{\text{MAX}}$)

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<td>30,239</td>
<td>7,468</td>
<td>530</td>
</tr>
<tr>
<td>Modified Procedure</td>
<td>6,887</td>
<td>2,161</td>
<td>0</td>
</tr>
<tr>
<td>Reduction</td>
<td>23,352</td>
<td>5,307</td>
<td>530</td>
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</table>

### Aircraft
- **B737-800**

### Metric
- **$L_{\text{A,MAX}}$**

### Noise Model
- **AEDT**

### Notes
- Standard AEDT arrival profile
Open Issues: Block 2 Low-Noise Overwater Approach Procedures

• **Issues**
  – RNAV Procedures
    • Potential waiver requirements for final approach segment length and intercept angle
    • Merging and spacing difficulties may only allow use during low demand periods
  – RNP Procedures
    • Equipage and training levels prevent use by all operators

• **Pending Analysis**
  – Developing analysis method to evaluate tradeoffs between final approach design criteria and noise reduction potential
# Project Schedule/Work Plan Outline

**Updated September 28, 2017**

## Overview of Work Plan

<table>
<thead>
<tr>
<th>Work Plan</th>
<th>Schedule</th>
<th>Public Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAA/ Massport Discussions</td>
<td>Winter – Fall 2016</td>
<td>Press Event with Elected Officials, Massport, FAA, MCAC Leadership</td>
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<tr>
<td>Announcement</td>
<td>Oct 2016</td>
<td>Briefings to MCAC Aviation Subcommittee, Executive Committee, and General Meeting</td>
</tr>
<tr>
<td>Consultant Team Organization</td>
<td>Fall 2016</td>
<td>Public Hearing, 2/22</td>
</tr>
<tr>
<td>Historical Flight Comparison\Analysis</td>
<td>Dec to Feb 2016</td>
<td>Briefing to Aviation Subcommittee, 5/5</td>
</tr>
<tr>
<td>Block 1 Procedure Opportunity</td>
<td>Feb 2017</td>
<td>Summer 2017 Aviation Subcommittee</td>
</tr>
<tr>
<td>Block 1 Preliminary Recommendations</td>
<td>Apr-May 2017</td>
<td></td>
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<tr>
<td>Block 1 Detail Analysis/Implementation Barriers</td>
<td>Aug 2017</td>
<td></td>
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<tr>
<td>Block 2 Procedure Opportunity</td>
<td>Jun 2017</td>
<td></td>
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<tr>
<td>Block 2 Preliminary Recommendations</td>
<td>Summer 2018</td>
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<tr>
<td>FAA Review Process</td>
<td>Ongoing</td>
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<tr>
<td>Finalize Recommendations</td>
<td>Fall 2018</td>
<td></td>
</tr>
<tr>
<td>Implementation/Final Report</td>
<td>Fall 2018</td>
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</tr>
</tbody>
</table>

- FAA/ Massport Discussions: Winter – Fall 2016
- Announcement: Oct 2016
- Consultant Team Organization: Fall 2016
- Historical Flight Comparison\Analysis: Dec to Feb 2016
- Block 1 Procedure Opportunity: Feb 2017
  - Lower complexity w/ benefits, minimal/no impacts
  - DNL and alternative metrics (e.g. single event above)
- Block 1 Preliminary Recommendations: Apr-May 2017
  - Feedback from the Massport CAC
- Block 1 Detail Analysis/Implementation Barriers: Aug 2017
- Block 2 Procedure Opportunity: Jun 2017
  - More complex, benefits\negative impacts, noise equity
  - DNL and alternative metrics (e.g. single event above)
- Block 2 Preliminary Recommendations: Summer 2018
- FAA Review Process: Ongoing
- Finalize Recommendations: Fall 2018
- Implementation/Final Report: Fall 2018

**Today**

- Fall 2017 Aviation Subcommittee
- Fall 2017 MCAC
- Winter\Spring 2018 Aviation Subcommittee

WORK IN PROGRESS SUBJECT TO CHANGE
RNAV MOU Study-Process Next Steps

- Brief Massport CAC Aviation Operations Sub-Committee 9/28
- Finalize Block 1 ideas Fall 2017
  - MIT to make technical feasibility recommendation to FAA and Massport
- Continue work on Block 2 ideas
- Finalize Block 2 ideas by early/mid 2018
  - MIT to make technical feasibility recommendation to FAA and Massport
- Final Report with recommendations to FAA and Massport Summer/Fall 2018
- Seek FAA input and review along the entire study process
- Continue briefing MCAC, seek MCAC review/feedback
- FAA will evaluate final procedure recommendations from Study based on
  - Standard procedure design criteria
  - Safety and efficiency impacts on Logan and the NAS (National Airspace System)
  - NEPA (National Environmental Policy Act) requirements

Preliminary/Subject to Change
Community Suggested Procedures
Under Review

Departure Mods
• 27 inclusion
  – Included in Block 1 and 2
• 4R conformance
  – Under review

Arrival Mods
• 4R alternative alignment
  – Under review

Note: Team also reviewed and rejected based on environmental or safety grounds
- Steeper approaches on arrivals
- R4R Arrivals Expressway alignment

Preliminary/Subject to Change
Procedure Concepts Found to Have Limited Benefit and/or Significant Operational Constraints
Community Proposed Procedures for 4R

ARRIVALS TO RUNWAY 4R:

- 4R(ACTUAL);
- 4R(GPS / REPORTED);
- 4R(ALTERNATE)
Community Proposed Procedures

2015 Flight Track Density

- 4R ILS/RNAV
- Track A
- 4R Proposal (4.4° offset)
Community Proposed Procedures for 4L

ARRIVALS TO RUNWAY 4L:
- 4L(VISUAL);
- 4L(ALTERNATE);
- 4L(GPS / REPORTED)

4L Visual
4L Proposal
4L ILS/RNAV
4R Community Proposed Procedure: Noise Exposure

Population Exposure ($L_{MAX}$)

<table>
<thead>
<tr>
<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight In</td>
<td>30,239</td>
<td>7,468</td>
<td>530</td>
</tr>
<tr>
<td>Modified Procedure</td>
<td>29,424</td>
<td>7,677</td>
<td>0</td>
</tr>
<tr>
<td>Reduction</td>
<td>815</td>
<td>-209</td>
<td>530</td>
</tr>
</tbody>
</table>

Aircraft | B737-800
---|---
Metric | $L_{A,MAX}$
Noise Model | AEDT
Notes | Standard AEDT arrival profile
4L Community Proposed Procedure: Noise Exposure

Population Exposure ($L_{MAX}$)

<table>
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<tr>
<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight In</td>
<td>40,702</td>
<td>19,074</td>
<td>4,500</td>
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<tr>
<td>Modified Procedure</td>
<td>84,483</td>
<td>43,471</td>
<td>11,814</td>
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<tr>
<td>Reduction</td>
<td>-43,781</td>
<td>-24,397</td>
<td>-7,314</td>
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</tbody>
</table>

- **Aircraft:** B737-800
- **Metric:** $L_{A,MAX}$
- **Noise Model:** AEDT
- **Notes:** Standard AEDT arrival profile
Community Proposed Procedure: Waypoint Locations

Documents waypoints for the 6 paths.

<table>
<thead>
<tr>
<th>Path Name</th>
<th>south waypoint</th>
<th>thru waypoint</th>
<th>north waypoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>4L(VISUAL)</td>
<td>HOCCY</td>
<td>FAMMR</td>
<td>SHYMT</td>
</tr>
<tr>
<td>4L(GPS/REPORTED)</td>
<td>LVRON</td>
<td>MTAPN</td>
<td>SHYMT</td>
</tr>
<tr>
<td>4L(ALTERNATE)</td>
<td>42.20232, -71.1193</td>
<td></td>
<td>42.31457, -71.04334</td>
</tr>
<tr>
<td>4R(GPS/REPORTED)</td>
<td>NABBO</td>
<td>MILTT</td>
<td>42.30905, -71.03176</td>
</tr>
<tr>
<td>4R(ACTUAL)</td>
<td>42.20232, -71.1193</td>
<td>42.26238, -71.06286</td>
<td>42.31032, -71.0351</td>
</tr>
<tr>
<td>4R(ALTERNATE)*</td>
<td>CHIKT</td>
<td>MILTT(ALT)</td>
<td></td>
</tr>
</tbody>
</table>

*Non-FAA Waypoints chosen for the purpose of this study

NOTES

[opennav.com] also 4L docs give lat/long

HOCCY 42.21514, -71.1613
LVRON 42.19867, -71.09969
NABBO 42.19518, -71.08699
FAMRR 42.27672, -71.08147
MTAPN 42.28098, -71.05566
MILTT 42.27365, -71.04919
SHYMT 42.3109, -71.03709
WITRR 42.2709, -71.0564

Non-FAA Waypoints chosen for the purpose of this study

CHMNY 42.26238, -71.06286 4R(ACTUAL)
CHIKT 42.23226, -71.05562 4R(ALTERNATE) FOR 5/31/17 PRESENTATION
MILTT(ALTERNATIVE) 42.27362, -71.04035 4R(ALTERNATE) A/S MTG, BLOCK 1 WORK
Notional 4R Expressway Approach Path

- Concept: move arrival flows over regions of higher ambient noise
  - Highways
  - Industrial areas
- Currently developing prototype arrival profile definitions

Noise Exposure: 4R Expressway Approach

- 4R Expressway Approach
- Aircraft: B737-800
- Metric: LAMAX
- Noise Model: AEDT

- Potential environmental justice issues

Population Exposure

<table>
<thead>
<tr>
<th></th>
<th>60dB</th>
<th>65dB</th>
<th>70dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>46,039</td>
<td>21,207</td>
<td>5,159</td>
</tr>
<tr>
<td>Expressway</td>
<td>66,417</td>
<td>32,879</td>
<td>5,945</td>
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<tr>
<td>Difference</td>
<td>-20,377</td>
<td>-11,672</td>
<td>-786</td>
</tr>
</tbody>
</table>
3° and 3.77° Continuous Descent Approach Comparison

- BADA-4 model indicates that steeper glideslopes may be feasible for some aircraft types
- Feedback from operators: Airbus aircraft in planned descent autoflight mode cannot exceed 3.77° glideslope angle

**B757-200 Steep Approach**

Significant Concerns from Airline Technical Pilots and ATC for Operational Feasibility
Two-Segment Approach Concept

B757-200 Two Segment Steep Approaches

Altitude (ft)

Airspeed (KIAS)

Thrust (%)

Distance to Touchdown (nmi)

Significant Concerns from Airline Technical Pilots and ATC for Operational Feasibility
Fatalities by CICIT Aviation Occurrence Categories

- LOC-I: Abnormal Runway Contact
- CFIT: Controlled Flight Into or Toward Terrain
- F-NI: Fire/Smoke (Non-impact)
- LOC-I: Loss of Control -- in Flight
- MAC: Midair/Midair Collision
- OTH-R: Other
- RAMP: Ground Handling
- RE: Runway Excursion (Takeoff or Landing)
- RI-VAP: Runway Incursion—Vehicle, Aircraft, or Person
- SCF-PP: System/Component Failure or Malfunction (Powerplant)
- UNK: Unknown or Undetermined
- USOS: Undershoot/Overshoot
- WSTRW: Wind Shear or Thunderstorm

Note: Principal categories as assigned by CAST.

For a complete description of CAST/ICAO Common Taxonomy Team (CICIT) Aviation Occurrence Categories, go to www.intlaviationstandards.org.

Figure source: The Boeing Company [http://www.boeing.com/resources/boeingdotcom/company/about_bca/pdf/statsum.pdf](http://www.boeing.com/resources/boeingdotcom/company/about_bca/pdf/statsum.pdf)
Addendum A: Track Density Plots Presented in Average Daily Flights per Acre
Addendum B: Quantified Track Density vs. Raw Track Plots
Flight Track Density Plot
July 1, 2016 to July 31, 2016
Runway 22R Jet Departures
(4,752 Total Flight Tracks - 153/Day)

- Airport Runway
- Municipal Boundary
- Roads
- Water

1 Acre
(209 ft x 209 ft)

Flight Track Density (Average Daily Tracks per Acre)

0 1/4 1/2 1 2 4 8

July 2016
Addendum C: Runway 27 Flight Tracks with ROD Corridor
Flight Track Density Plot
January 1, 2010 to December 31, 2010
Runway 27 Jet Departures
(14,681 Total Flight Tracks - 40/day,
Percent of Flights through the corridor - 53.5%)

Airport Runway  
Municipal Boundary  
Roads  
1 Acre (205 ft x 209 ft)

Flight Track Density (Average Daily Tracks per Acre)

53.5% Jet Departures Within ROD Corridor
Flight Track Density Plot
January 1, 2015 to December 31, 2015
Runway 27 Jet Departures
(19,090 Total Flight Tracks - 52/Day,
Percent of Flights through the corridor - 76.8%)

76.8% Jet Departures Within ROD Corridor