



Massachusetts Port Authority
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October 22nd, 2018

Via Electronic Mail
David Carlon, Chairman
Massport Community Advisory Committee
dcarlonmcac@gmail.com

RE: *RNAV Presentation Provided to the Massport CAC on October 18th, 2018*

Dear Chairman Carlon:

As requested, please see the attached presentation deck. This presentation provided by MIT (Massport and the FAA's lead technical consultant) at the October 18th Massport CAC meeting includes material identified by MIT as "(a) preliminary example to evaluate methodology only (and) should not be considered a representative case."

We strongly urge the Massport CAC and its members to avoid drawing any specific conclusions from this preliminary material or using the material to advocate for or against any specific idea. We look forward to the Massport CAC providing Massport with feedback and further suggestions for evaluation as Block 2 progresses.

Sincerely,

A handwritten signature in black ink, appearing to read "Anthony J. Gallagher", with a long horizontal line extending to the right.

Anthony J. Gallagher
Massport Community Relations

Cc: (Via Electronic Mail)
Flavio Leo, Elizabeth Becker



MIT

International Center for
Air Transportation

Procedure Design Concepts for Logan Airport Community Noise Reduction

R. John Hansman

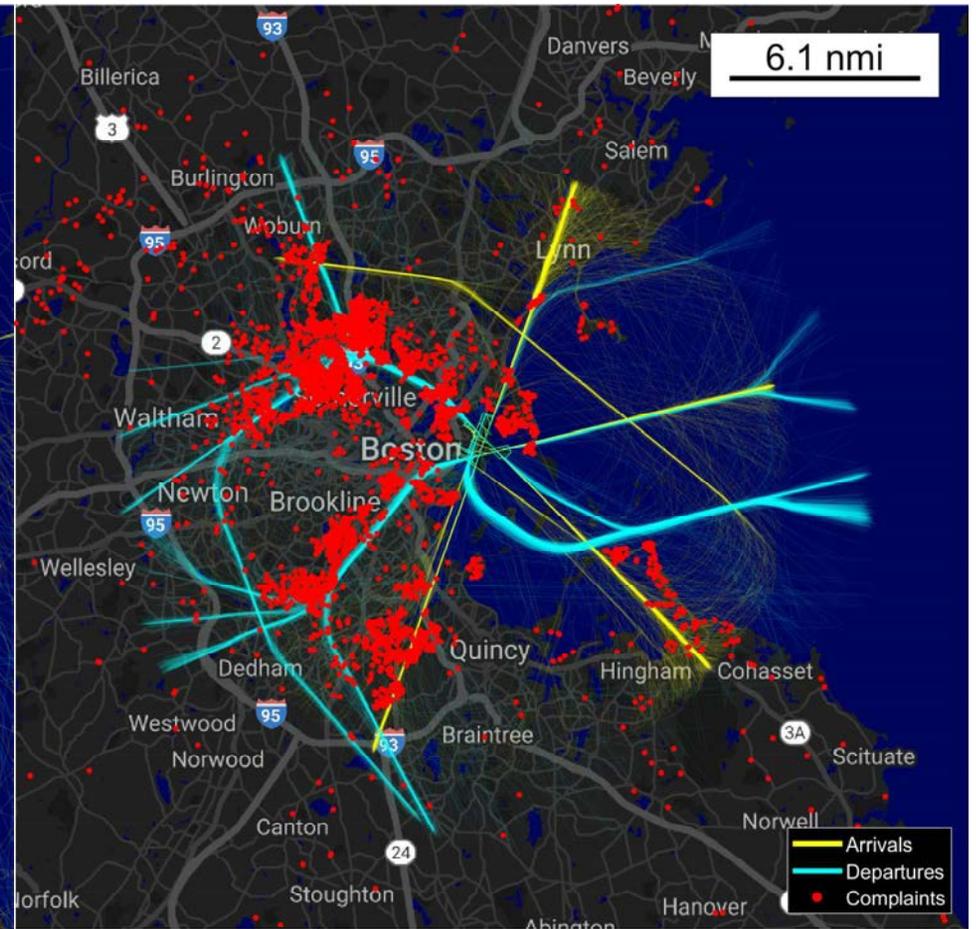
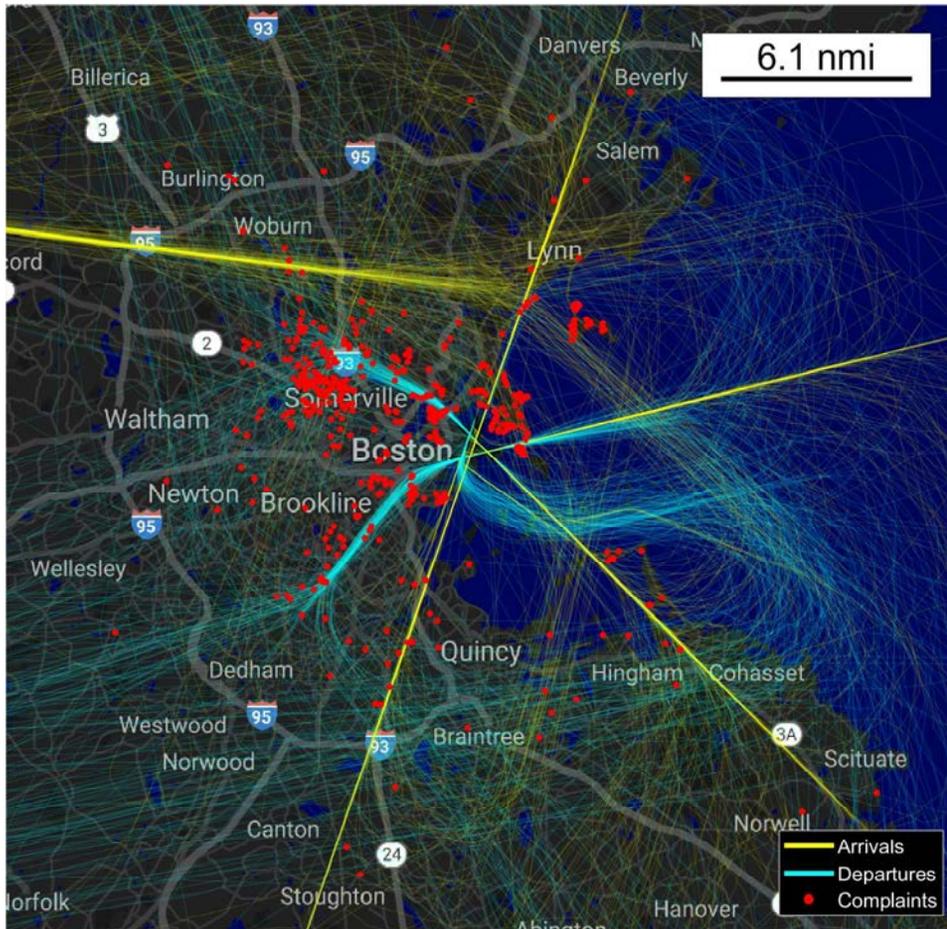
rjhans@mit.edu

Technical support from MIT ICAT students, HMMH, and Massport

RNAV Track Concentration

2010

2017



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



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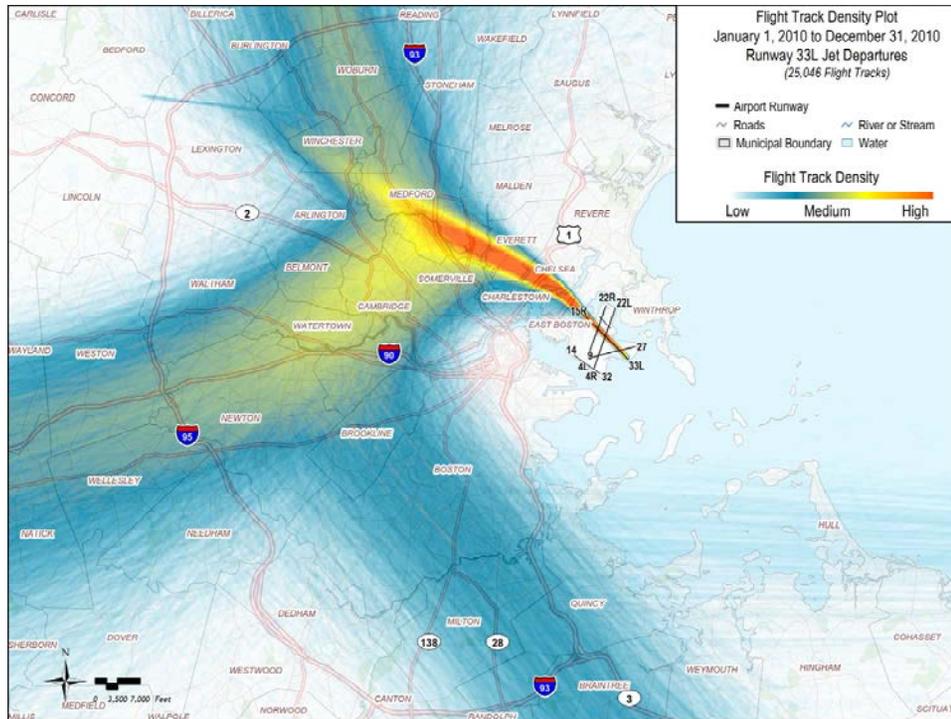
Block 2

More complex due to potential operational/technical barriers or equity issues

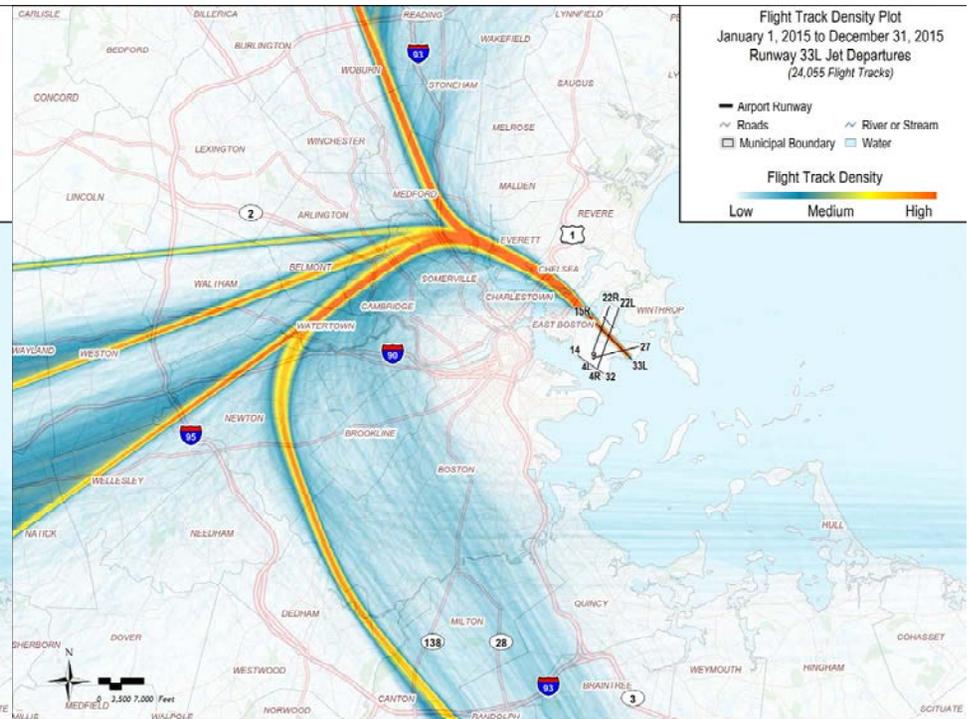
Need for Integrated Exposure Metrics

In order to study impact of flight track concentration, need integrated exposure metrics and analysis which consider cumulative effects of multiple overflights

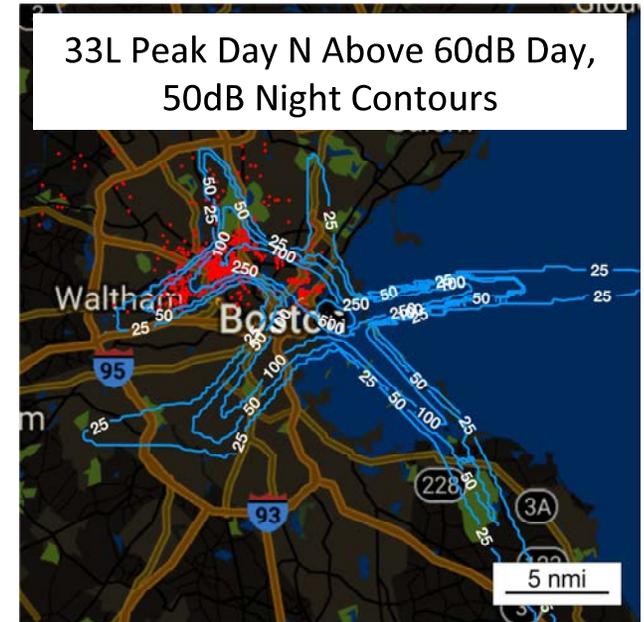
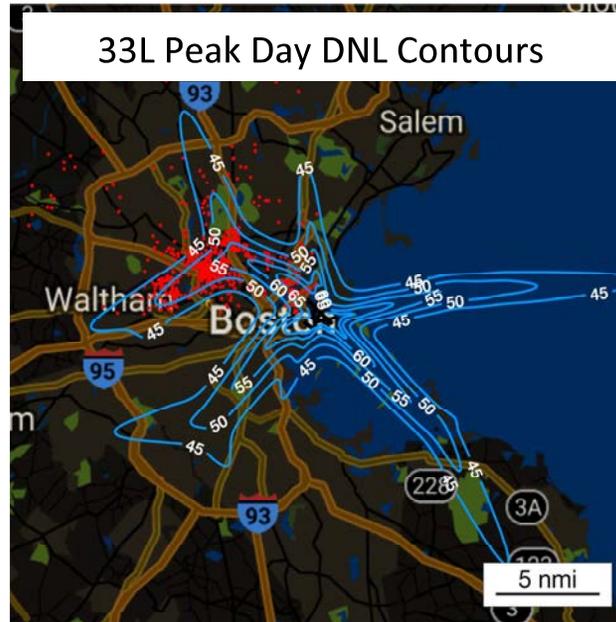
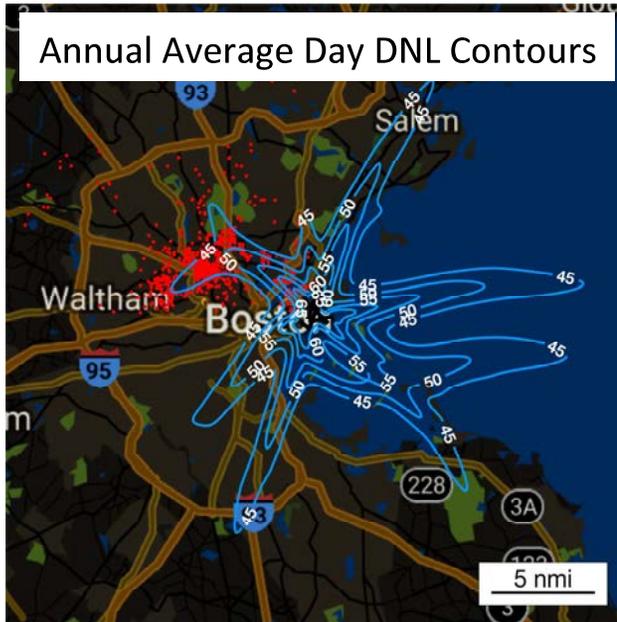
2010



2015



Metrics Based on Peak Day Runway Use



- Peak Day N_{Above} of 50 flights at the 60dB $L_{A,\text{max}}$ day, 50dB $L_{A,\text{max}}$ night appears to capture over 80 % of complaints
 - N_{above} analysis was performed on multiple runway ends at BOS, MSP, and CLT

33L Departures Complainant Coverage for Peak Day by N Above Thresholds

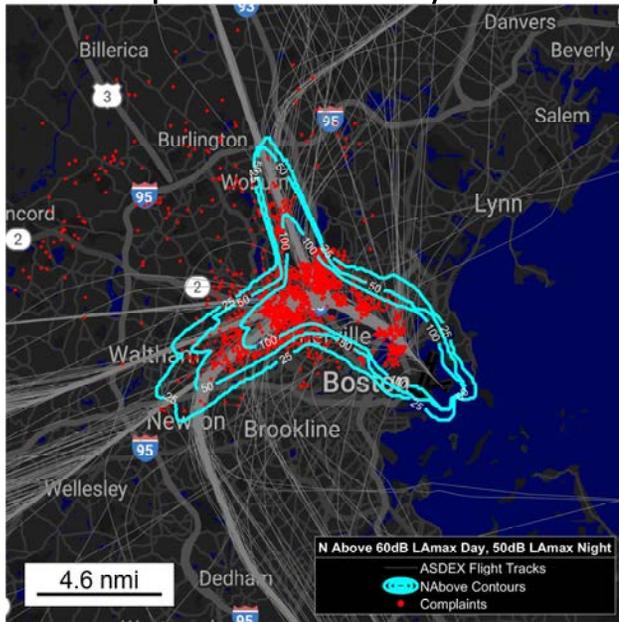
Peak Day N Above	Complaints Captured
25x	90.0%
50x	83.8%
100x	59.9%

2017 Data

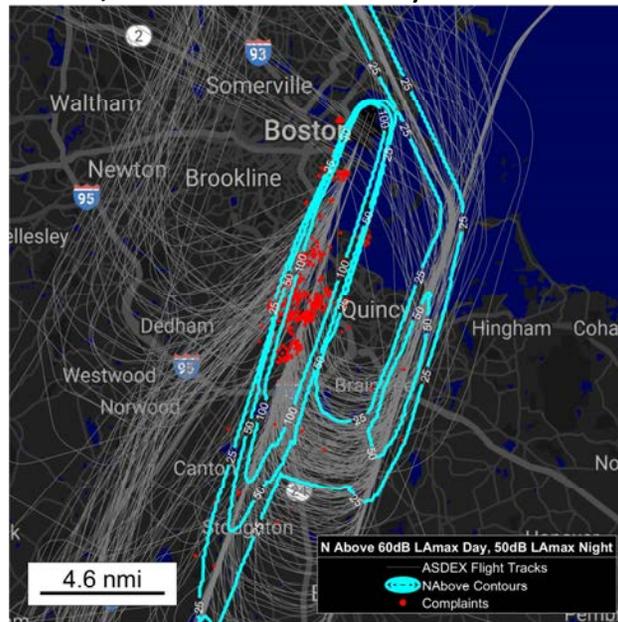
BOS N Above Thresholds

- **50** N_{Above} 60dB $L_{A,max}$ day, 50dB $L_{A,max}$ night on a **peak day** appears to capture complaint threshold in dispersion analysis

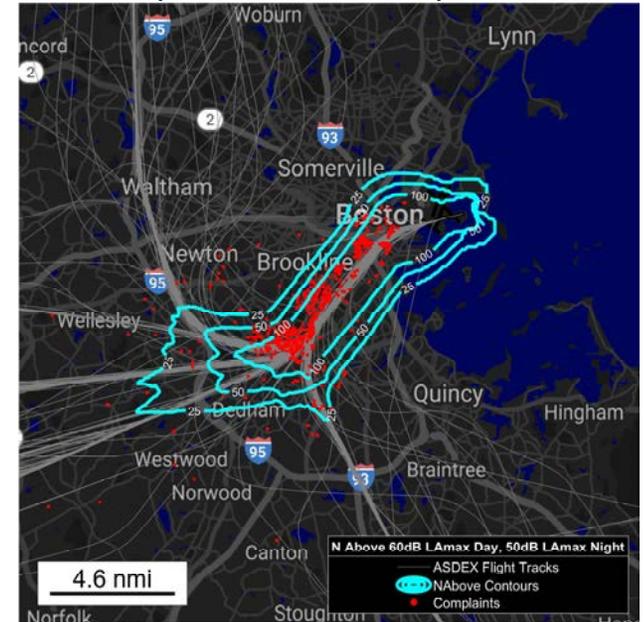
33L Departures Peak Day N Above



4L/R Arrivals Peak Day N Above



27 Departures Peak Day N Above



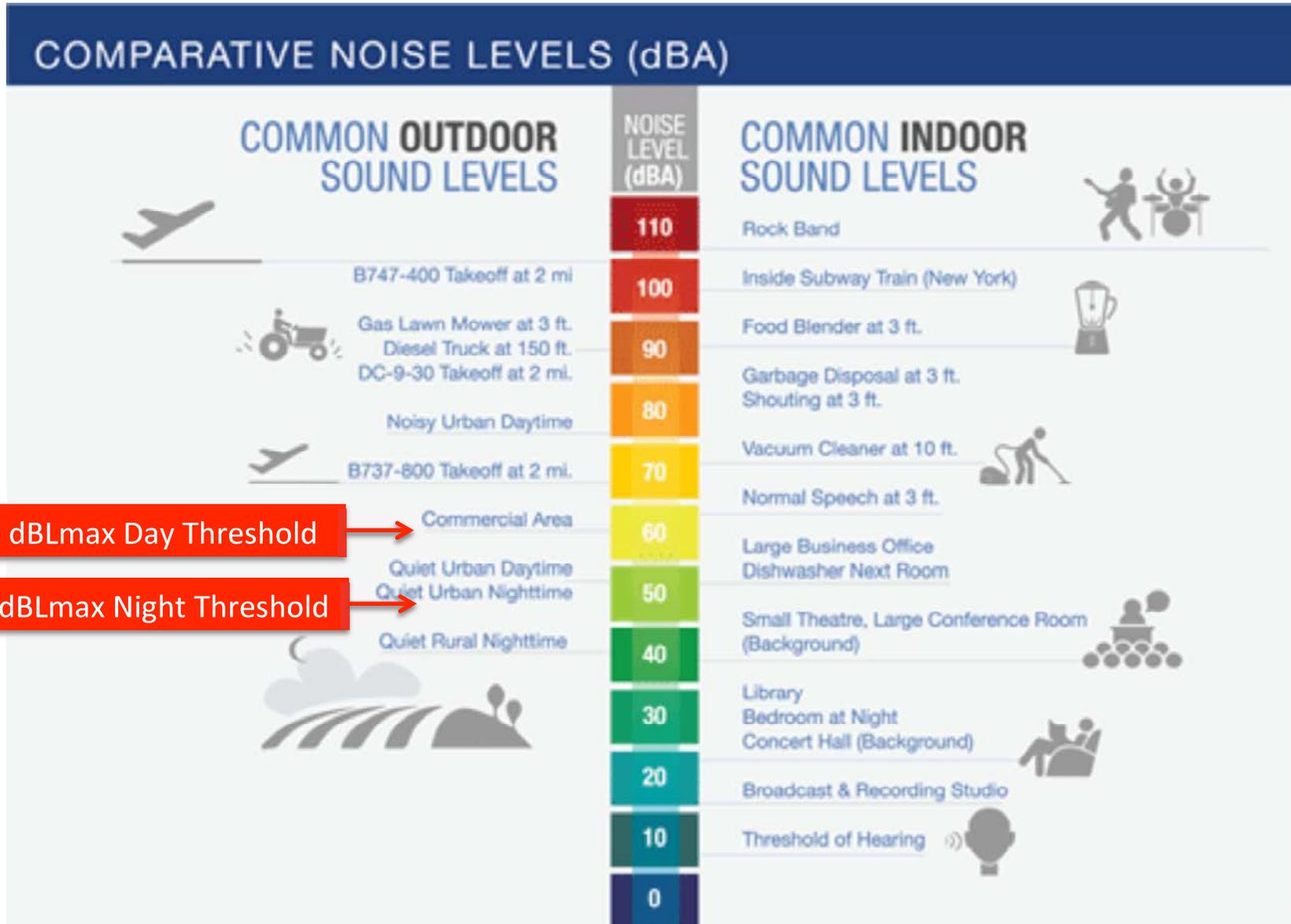
Peak Day N Above	Complaints Captured
25x	90.0%
50x	83.8%
100x	59.9%

Peak Day N Above	Complaints Captured
25x	91.3%
50x	81.3%
100x	70.6%

Peak Day N Above	Complaints Captured
25x	94.6%
50x	90.2%
100x	76.8%

2017 Data

Comparative Noise Levels



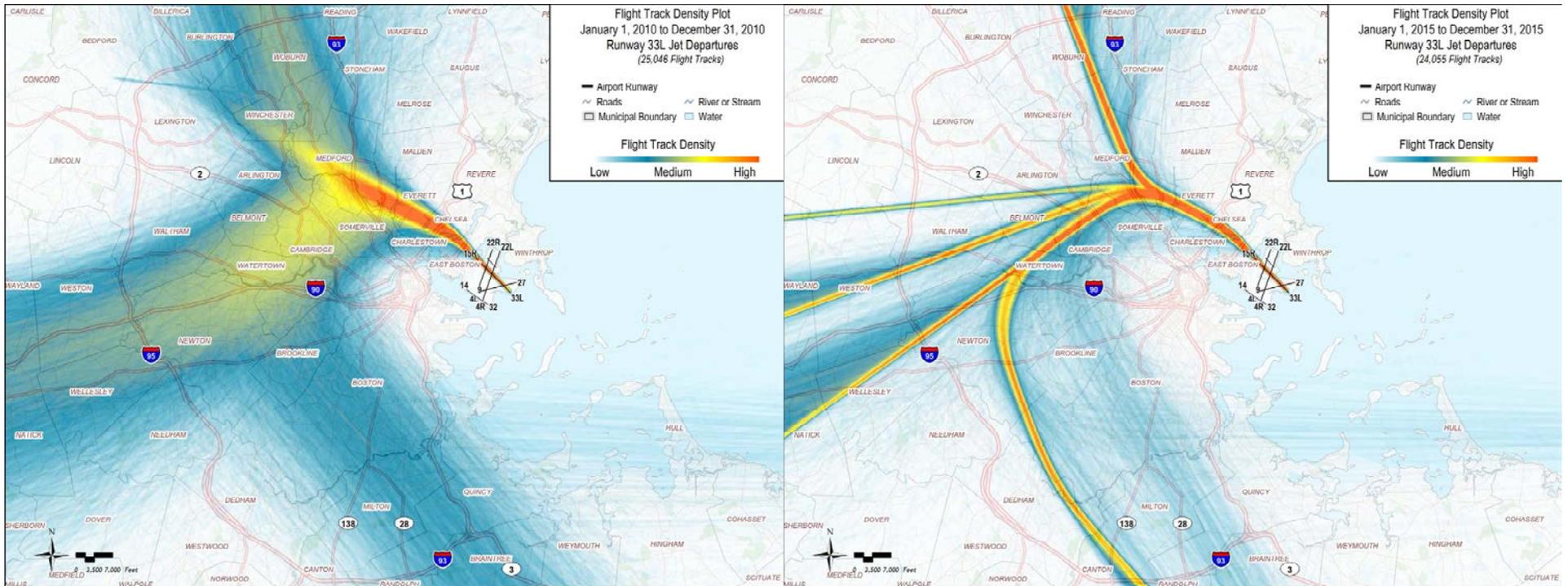
60 dBLmax Day Threshold

50 dBLmax Night Threshold

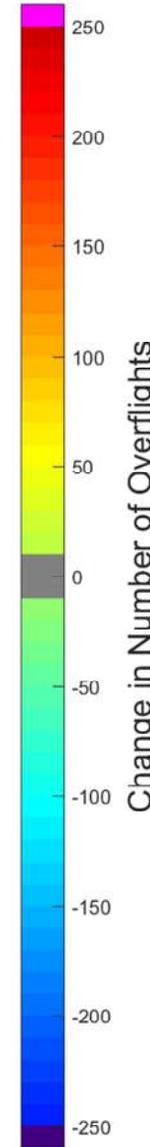
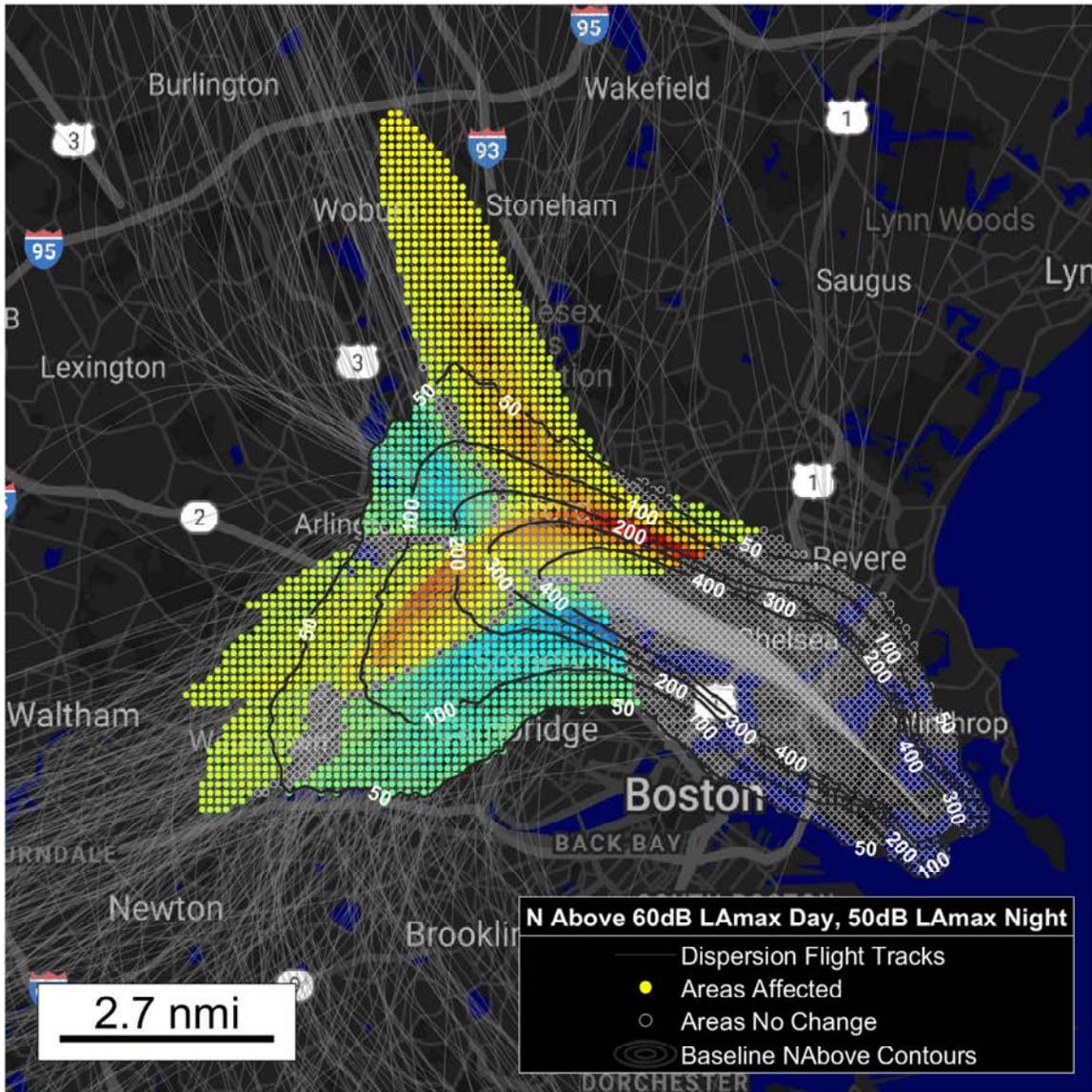
Impact of RNAV Concentration

2010

2017



Effect of RNAV on 33 Departures 2010 to 2017



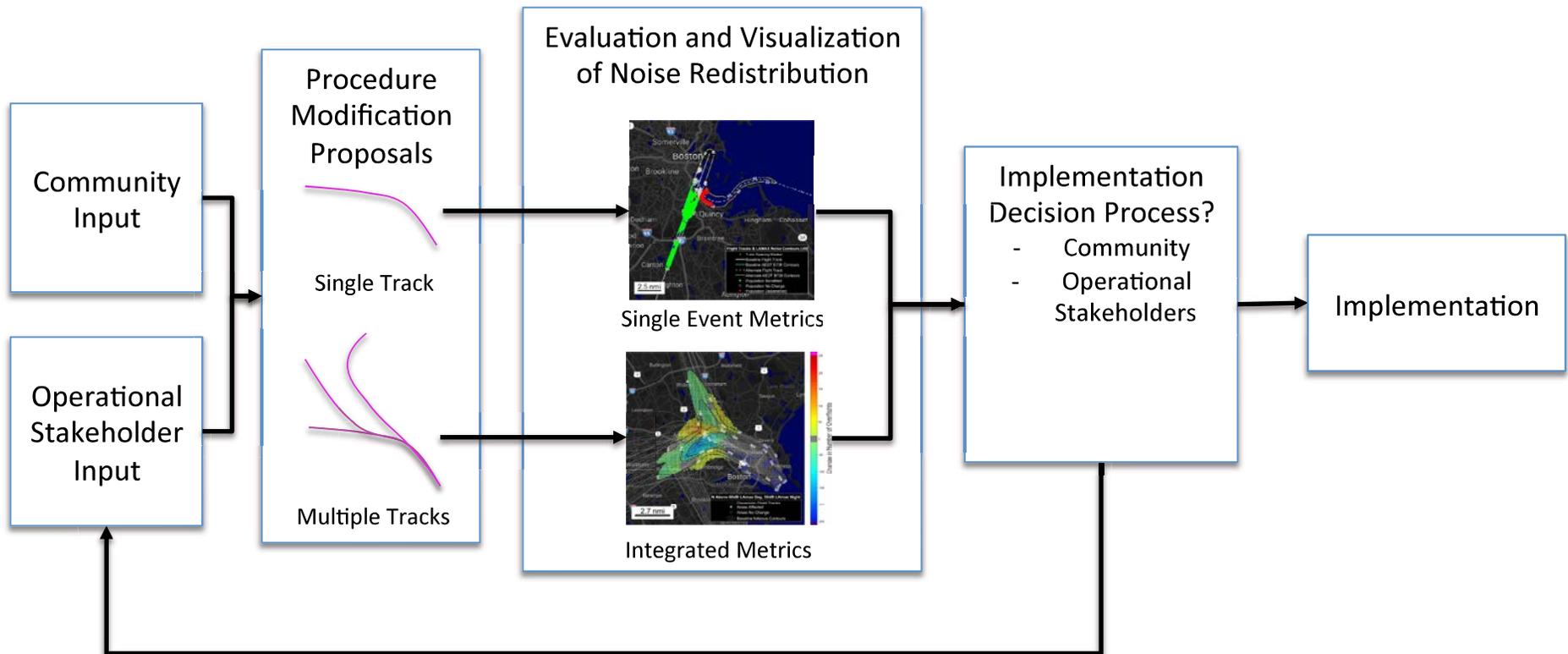
Population Exposure	
N Above	50x
Dispersion	356,960
RNAV	336,643
RNAV Benefit	20,317

Change In N Above	Population
+200x	1,844
+100x	19,167
+50x	65,338
-50x	77,428
-100x	20,566
-200x	290

Analysis based on peak day operations; only includes 33L departures

N_{Above} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night 10

Community Involvement in Procedures with Noise Redistribution



Block 2 Departure Mods

- Dispersion
 - Runway 33L and 27
 - Open SID or direct-to flexibility for ATC on RNAV procedures
 - Altitude-based dispersion
 - Controller-based dispersion
 - Divergent heading dispersion
- RNP SID
 - Runway 22
 - Recent addition base on Block 1 status

Block 2 Arrival Mods

- Low-noise overwater approach procedures
 - Runway 22L
 - RNAV approach with RNP Overlay
 - Runway 4L and/or 4R
 - RNAV approach with RNP Overlay
 - RNP approach
- Vertical Path Changes
 - Steep Approaches
 - Delayed Landing Gear Extension
 - Continuous Descent Profiles
 - RNP arrivals that would allow continuous descent procedures from the north



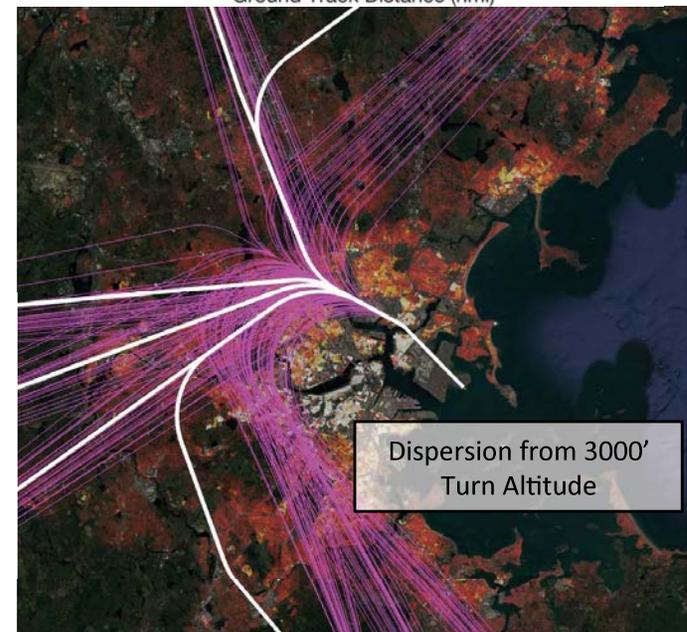
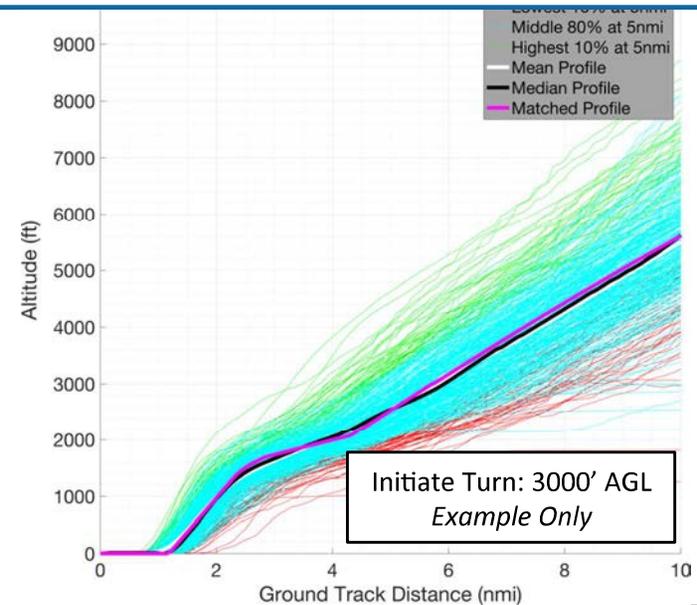
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Departure Dispersion: Runway 33L and 27

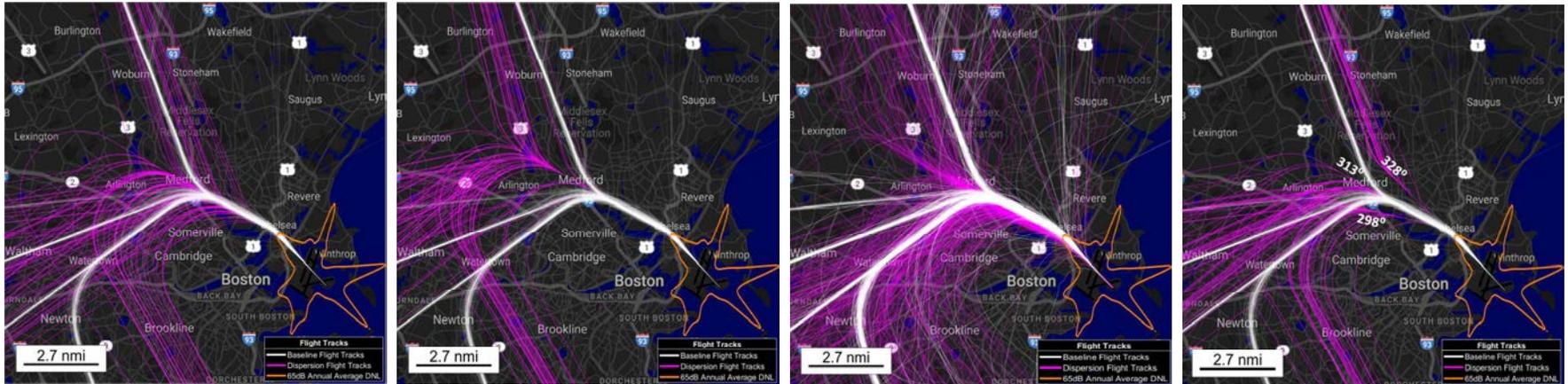
Dispersion Concepts

- Altitude-based dispersion
 - Direct routing to transition waypoint upon reaching specific altitude
- Controller-based dispersion
 - Dispersion arising from radar vectoring
 - 2010 flight track data normalized for comparison with 2017 data
 - Comparison between pre-RNAV and RNAV flight tracks
- Divergent heading dispersion
 - 15° divergent headings then direct routing to transition waypoint upon reaching 3000ft
 - Increases throughput capacity

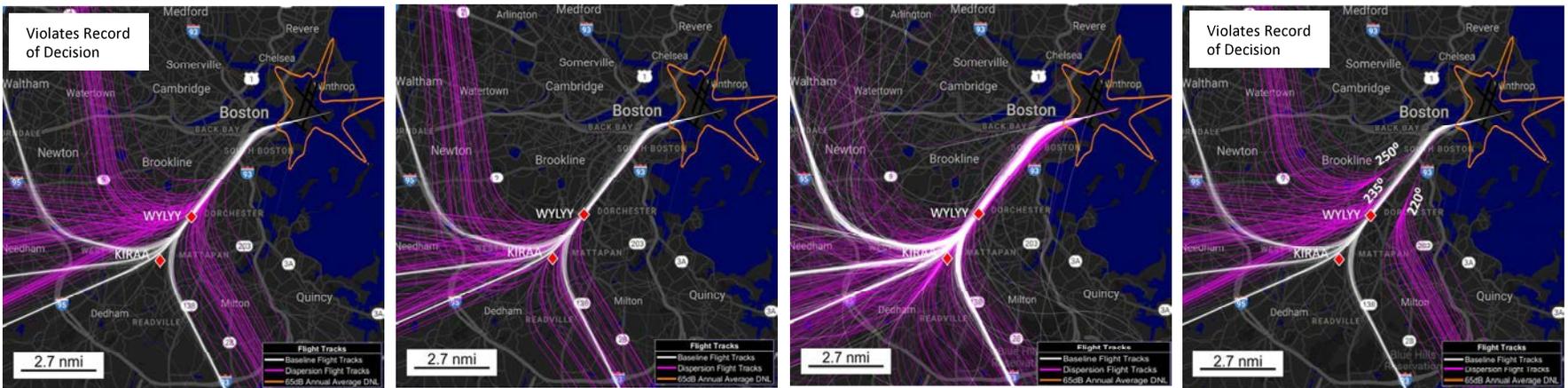


Dispersion Concepts

33L Departures



27 Departures



Altitude-Based 3000ft

Altitude-Based 4000ft

Controller-Based

Divergent Headings

Preliminary examples to evaluate methodology only. Should not be considered representative case.

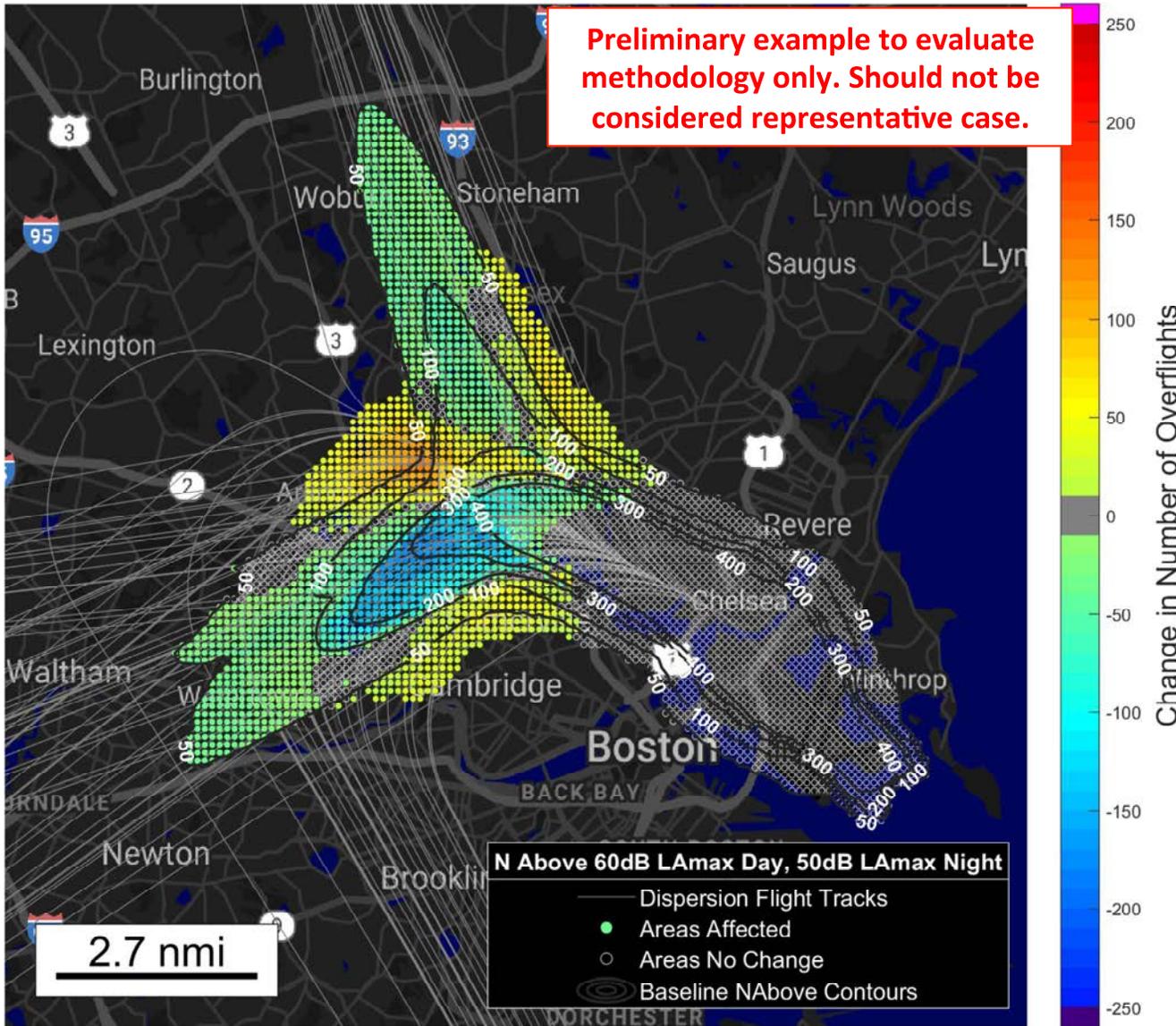


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33L Departures Dispersion Analysis

33L Departures Altitude-Based Dispersion at 3000ft Change in N_{Above}



Population Exposure

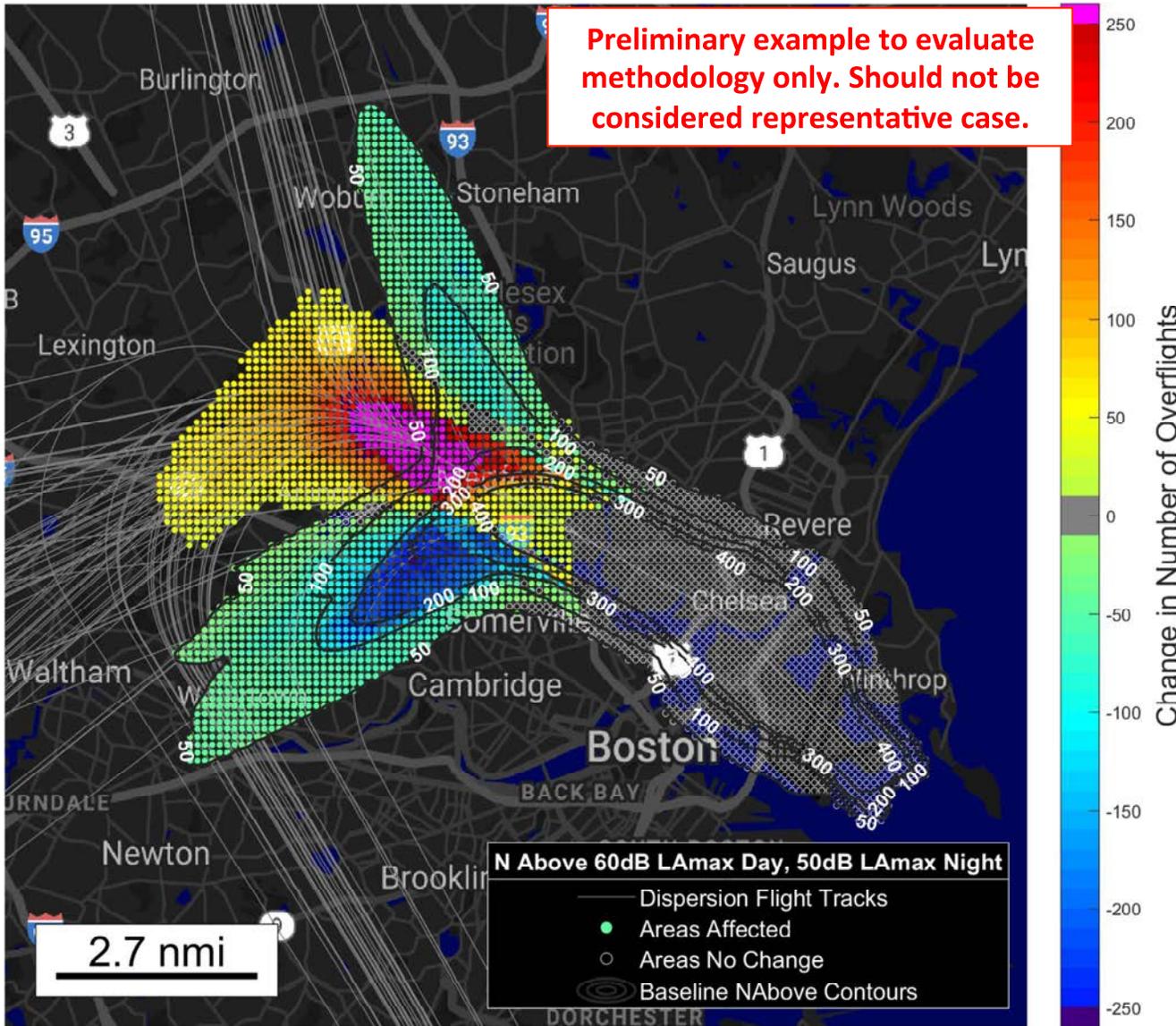
N Above	50x
Baseline	336,643
Dispersion	338,951
Baseline - Dispersion	-2,308

Change In N Above	Population
+200x	0
+100x	3,870
+50x	22,300
-50x	51,577
-100x	31,561
-200x	0

Analysis based on peak day operations; only includes 33L departures

N_{Above} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night

33L Departures Altitude-Based Dispersion at 4000ft Change in N_{Above}



Population Exposure

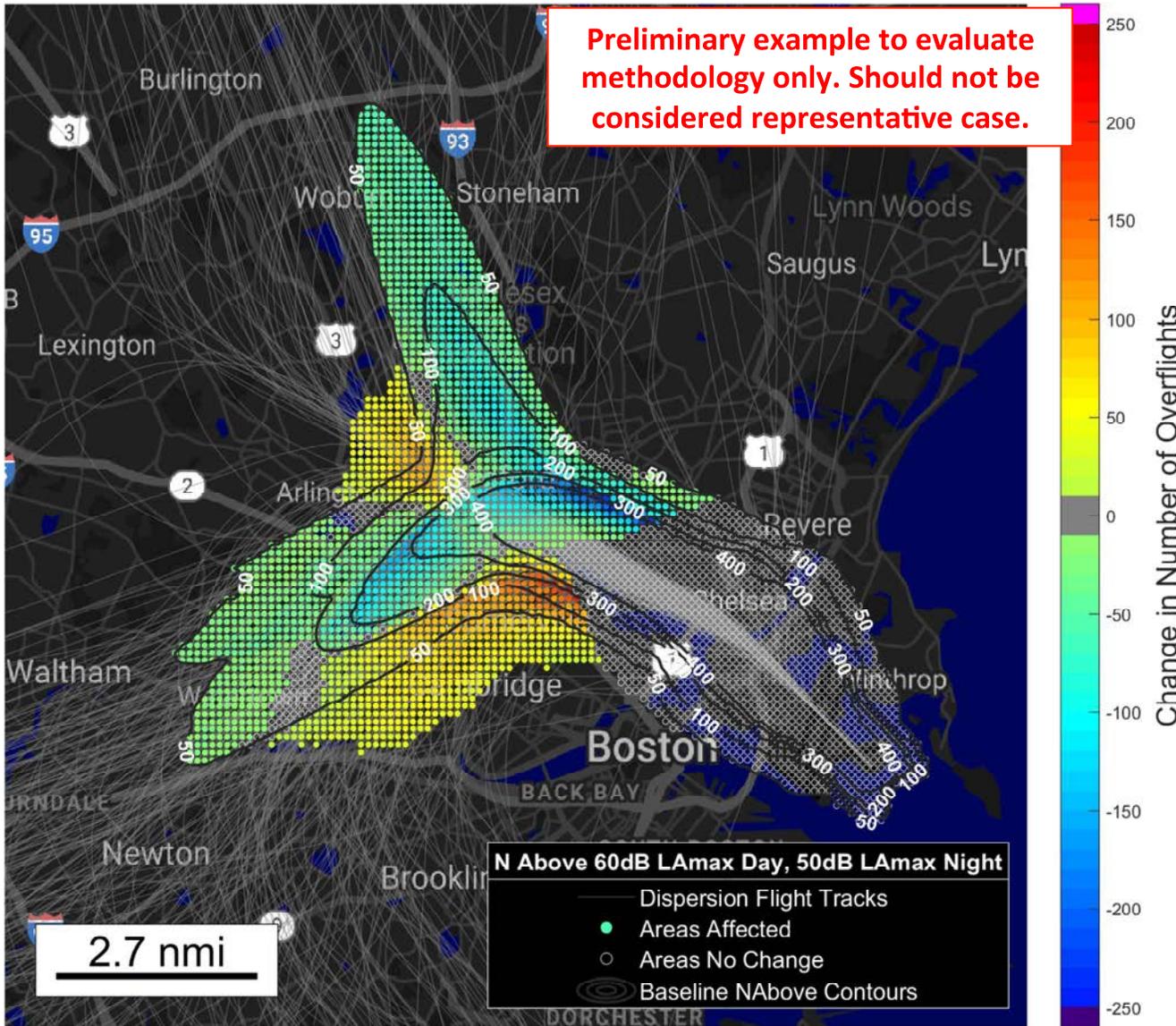
N Above	50x
Baseline	336,643
Dispersion	268,231
Baseline - Dispersion	68,412

Change In N Above	Population
+200x	14,621
+100x	29,097
+50x	63,377
-50x	108,207
-100x	46,702
-200x	24,427

Analysis based on peak day operations; only includes 33L departures

N_{Above} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night 18

33L Departures Controller-Based Dispersion Change in N_{Above}



Population Exposure

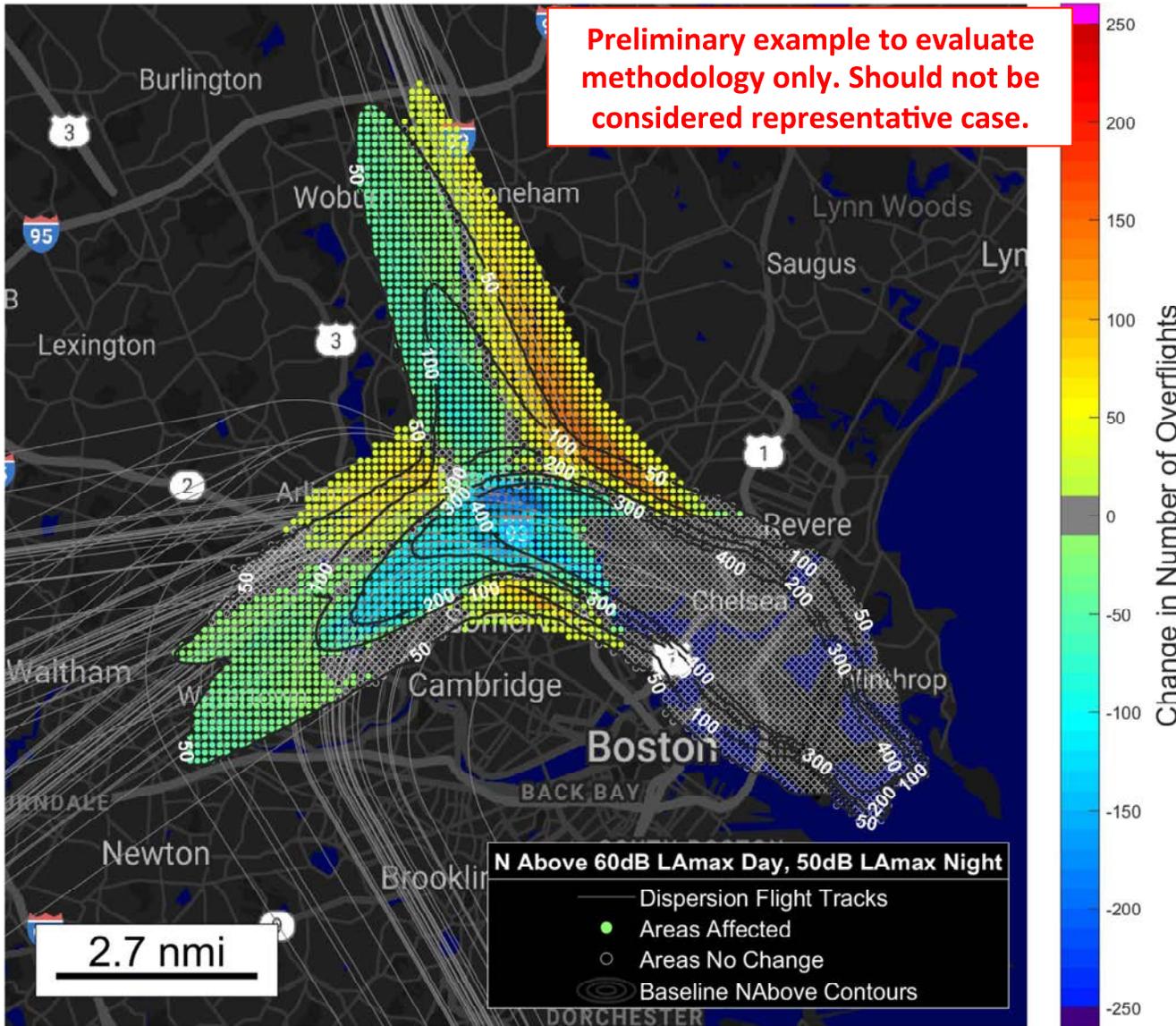
N Above	50x
Baseline	336,643
Dispersion	356,960
Baseline - Dispersion	-20,317

Change In N Above	Population
+200x	290
+100x	20,566
+50x	77,428
-50x	65,338
-100x	19,167
-200x	1,844

Analysis based on peak day operations; only includes 33L departures

N_{Above} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night 19

33L Departures Divergent Headings Dispersion Change in N_{Above}



Population Exposure

N Above	50x
Baseline	336,643
Dispersion	335,602
Baseline - Dispersion	1,041

Change In N Above	Population
+200x	0
+100x	13,651
+50x	47,885
-50x	62,772
-100x	31,545
-200x	0

Analysis based on peak day operations; only includes 33L departures

N_{Above} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night 20

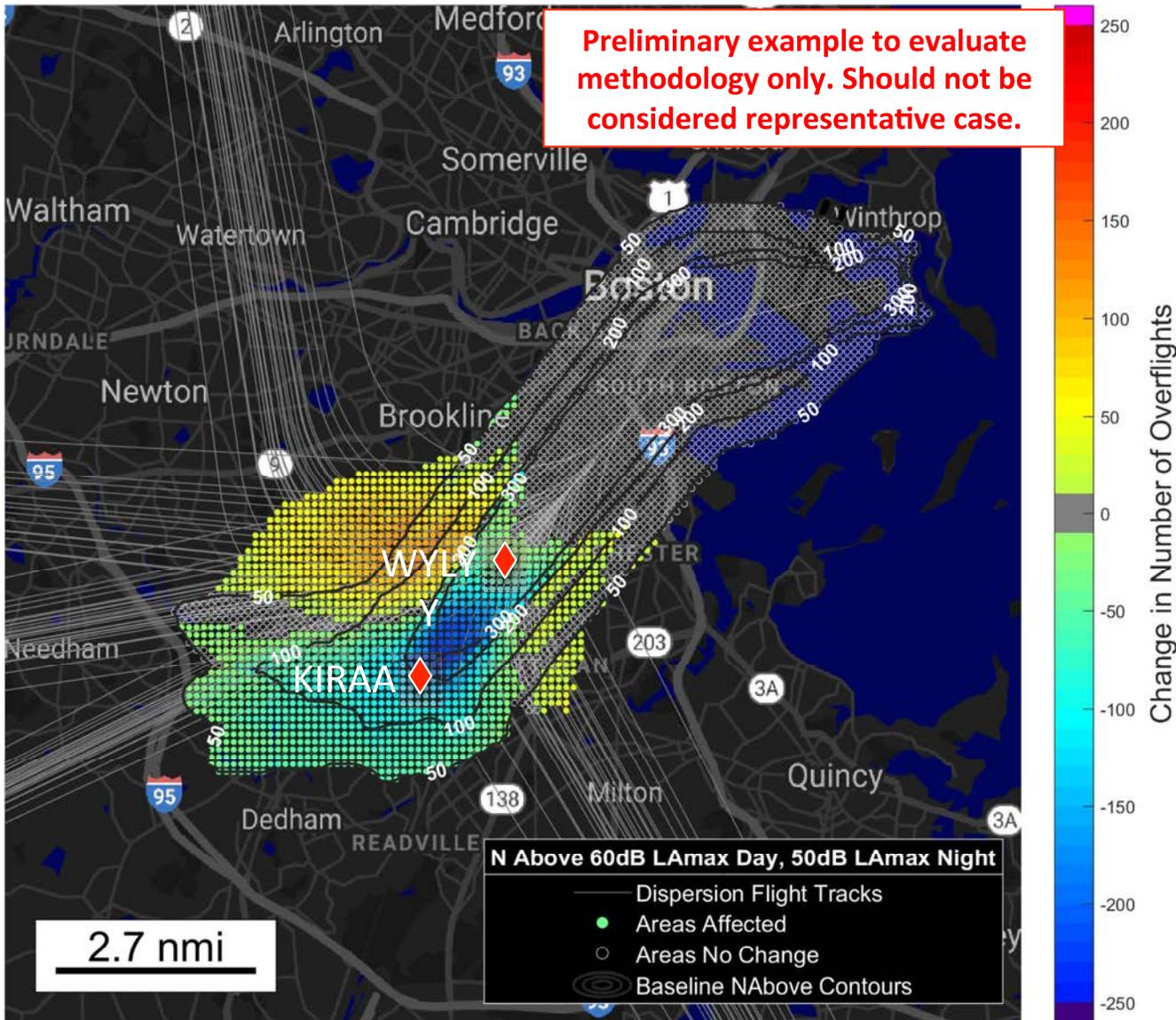


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27 Departures Dispersion Analysis

27 Departures Altitude-Based Dispersion at 3000ft Violates Record of Decision

Change in N_{Above}



Population Exposure

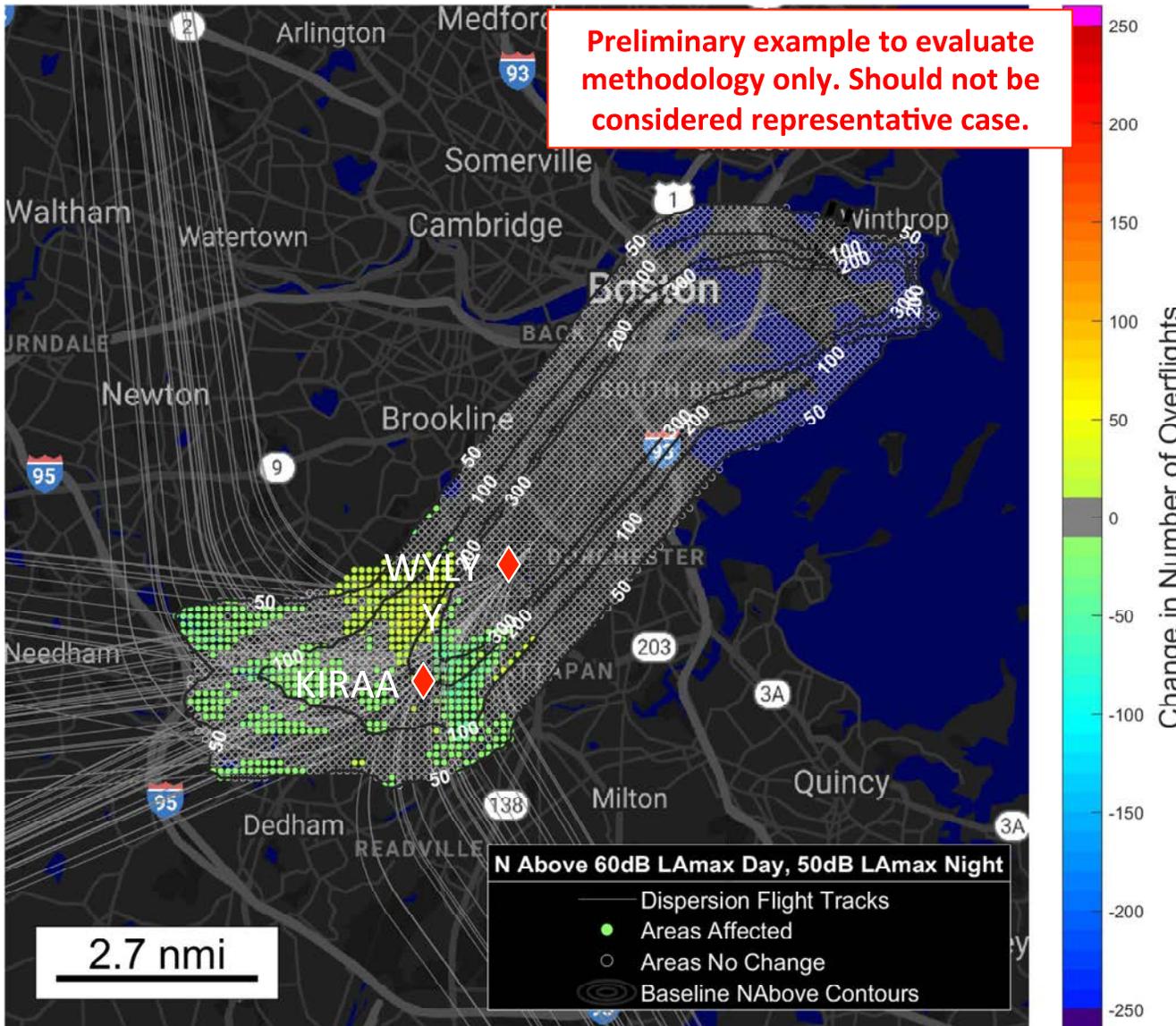
N Above	50x
Baseline	407,357
Dispersion	373,940
Baseline - Dispersion	33,417

Change In N Above	Population
+200x	0
+100x	2,232
+50x	22,084
-50x	56,292
-100x	22,475
-200x	4,368

Analysis based on peak day operations; only includes 27 departures

N_{Above} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night

27 Departures Altitude-Based Dispersion at 4000ft Change in N_{Above}



Population Exposure

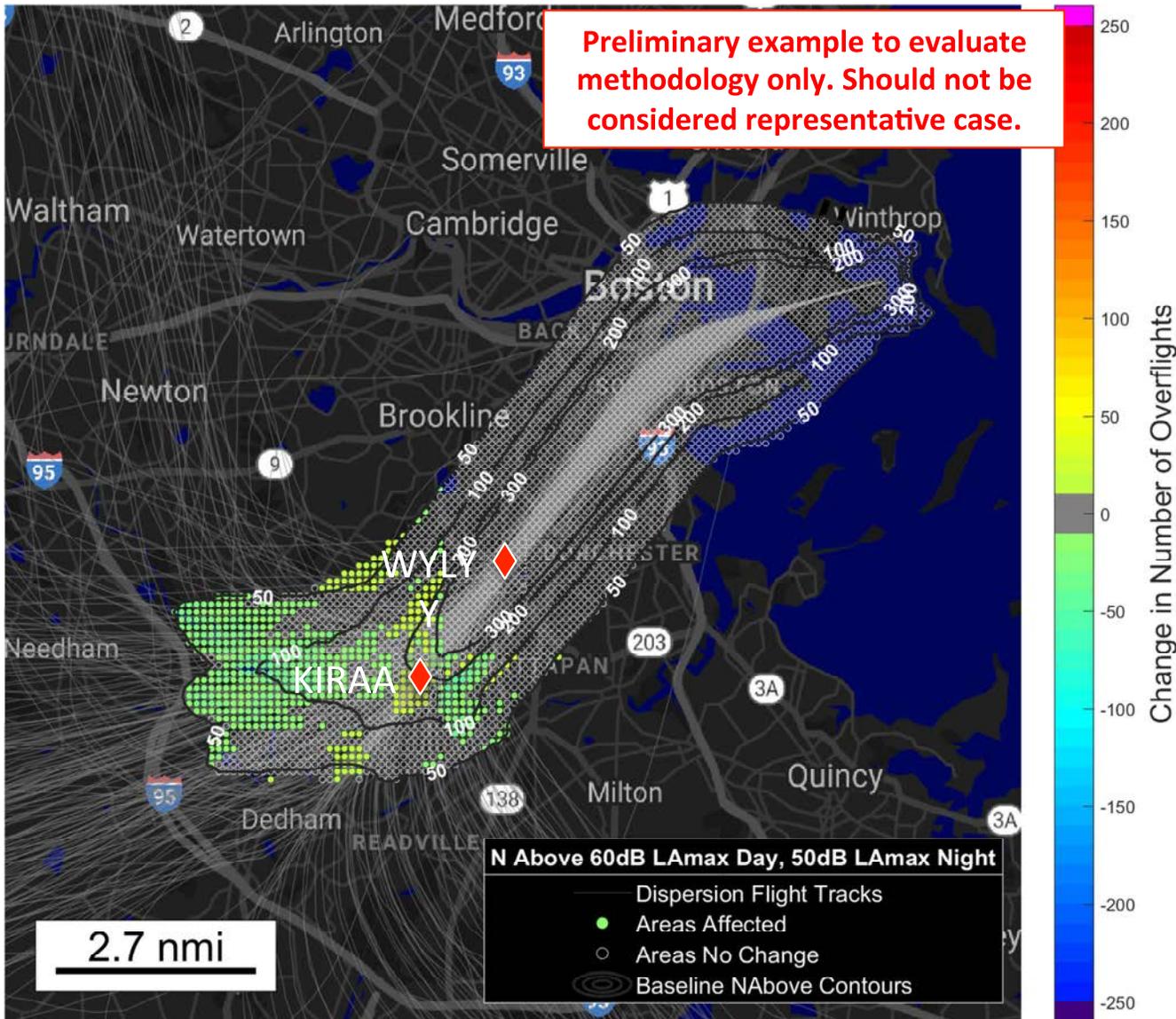
N_{Above}	50x
Baseline	407,357
Dispersion	393,053
Baseline - Dispersion	14,304

Change In N_{Above}	Population
+200x	0
+100x	0
+50x	0
+25x	5,708
-25x	6,876
-50x	0
-100x	0
-200x	0

Analysis based on peak day operations; only includes 27 departures

N_{Above} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night

27 Departures Controller-Based Dispersion Change in N_{Above}



Population Exposure

N_{Above}	50x
Baseline	407,357
Dispersion	396,394
Baseline - Dispersion	10,963

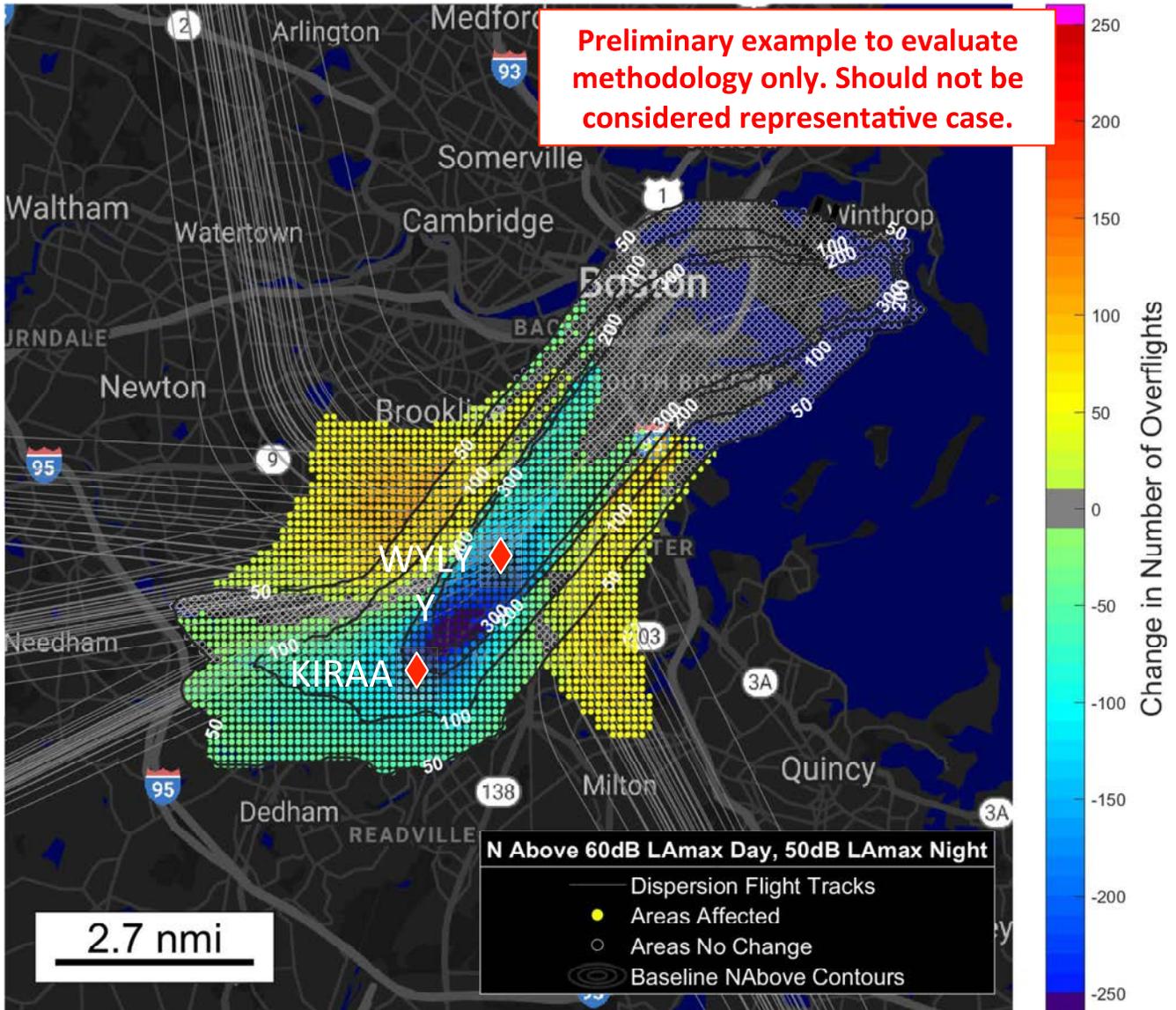
Change In N_{Above}	Population
+200x	0
+100x	0
+50x	109
-50x	0
-100x	0
-200x	0

Analysis based on peak day operations; only includes 27 departures

N_{Above} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night

27 Departures Divergent Headings Dispersion Violates Record of Decision

Change in N_{Above}



Population Exposure

N Above	50x
Baseline	407,357
Dispersion	399,229
Baseline - Dispersion	8,128

Change In N Above	Population
+200x	0
+100x	1,562
+50x	73,563
-50x	113,007
-100x	39,790
-200x	9,047

Analysis based on peak day operations; only includes 27 departures

N_{Above} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night



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Low-Noise Overwater Approach Procedure

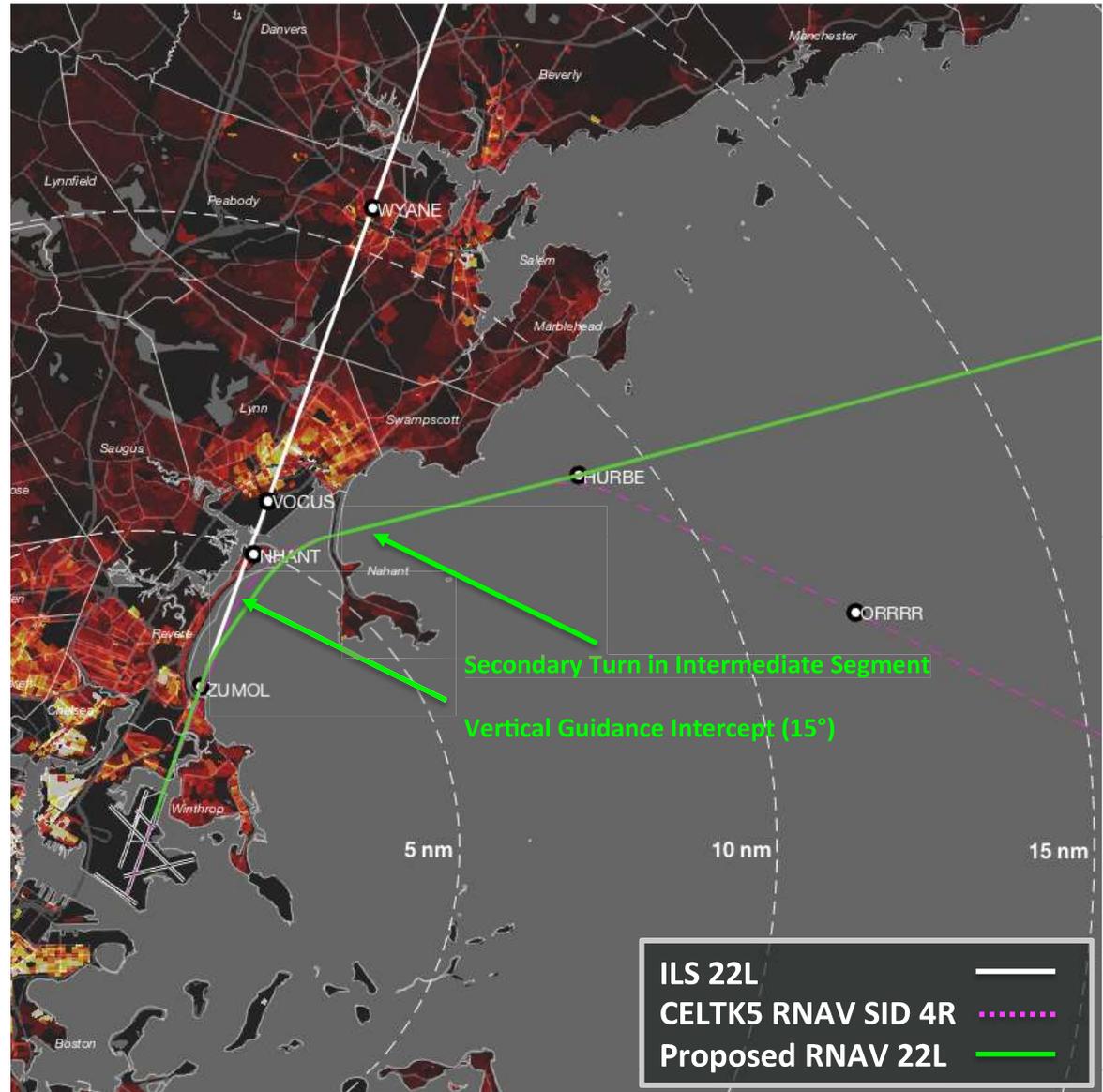
22L Arrival

22L Low-Noise Offset RNAV Approach with RNP Overlay

Overlaying arrival corridor on existing 4R RNAV SID for 22L arrivals

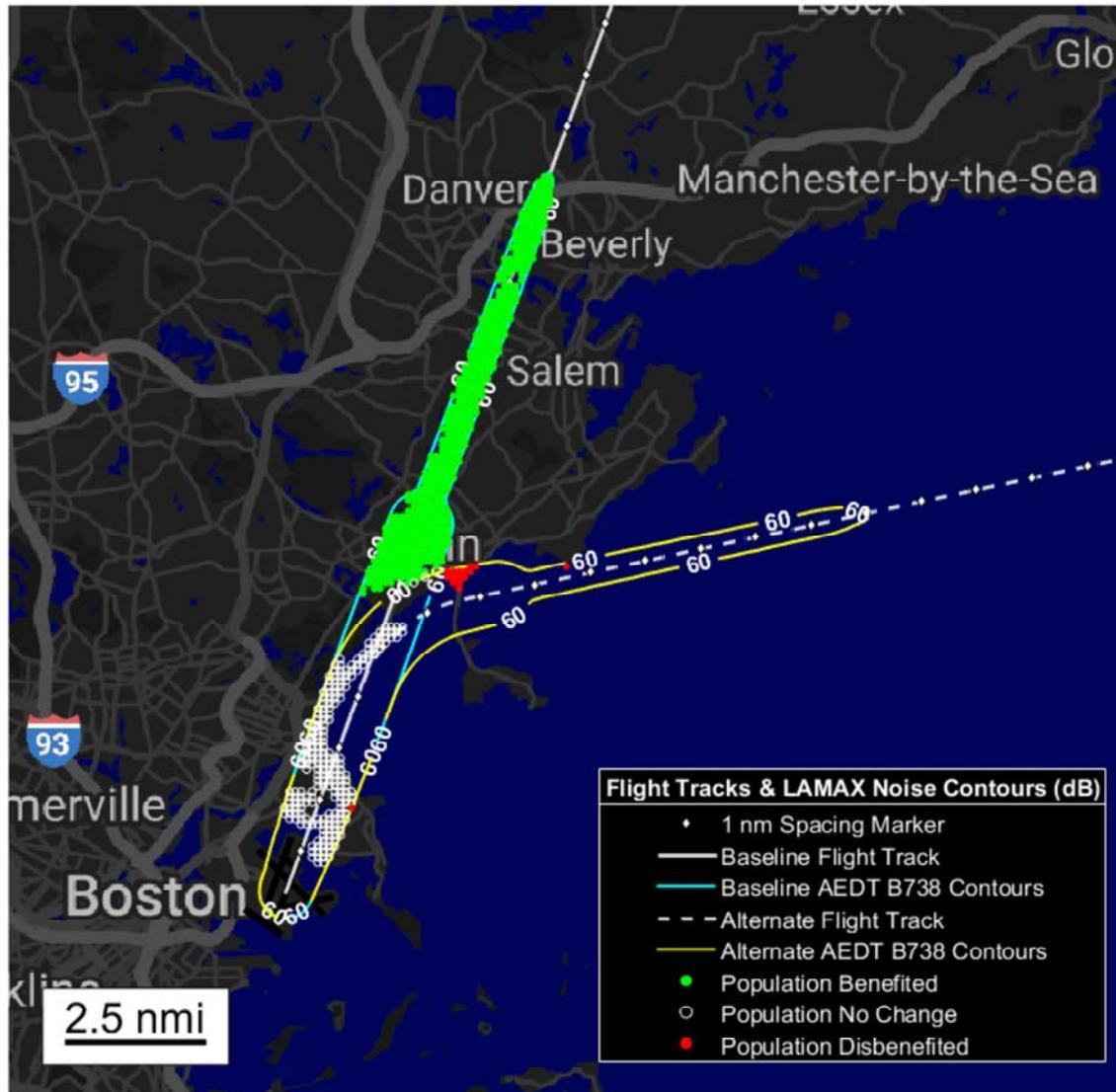
Notes:

- Intended to comply with design criteria for vertical-guidance RNAV
- Overflies midpoint of Nahant causeway at same location as 4R SID departure crossings



22L Arrival RNAV with RNP Overlay vs Straight In

B737-800 60dB $L_{A,max}$ Noise Exposure



**B737-800
Population Exposure ($L_{A,MAX}$)**

	60dB
Straight In	82,162
RNP	29,561
Difference (Straight In – RNP)	52,601



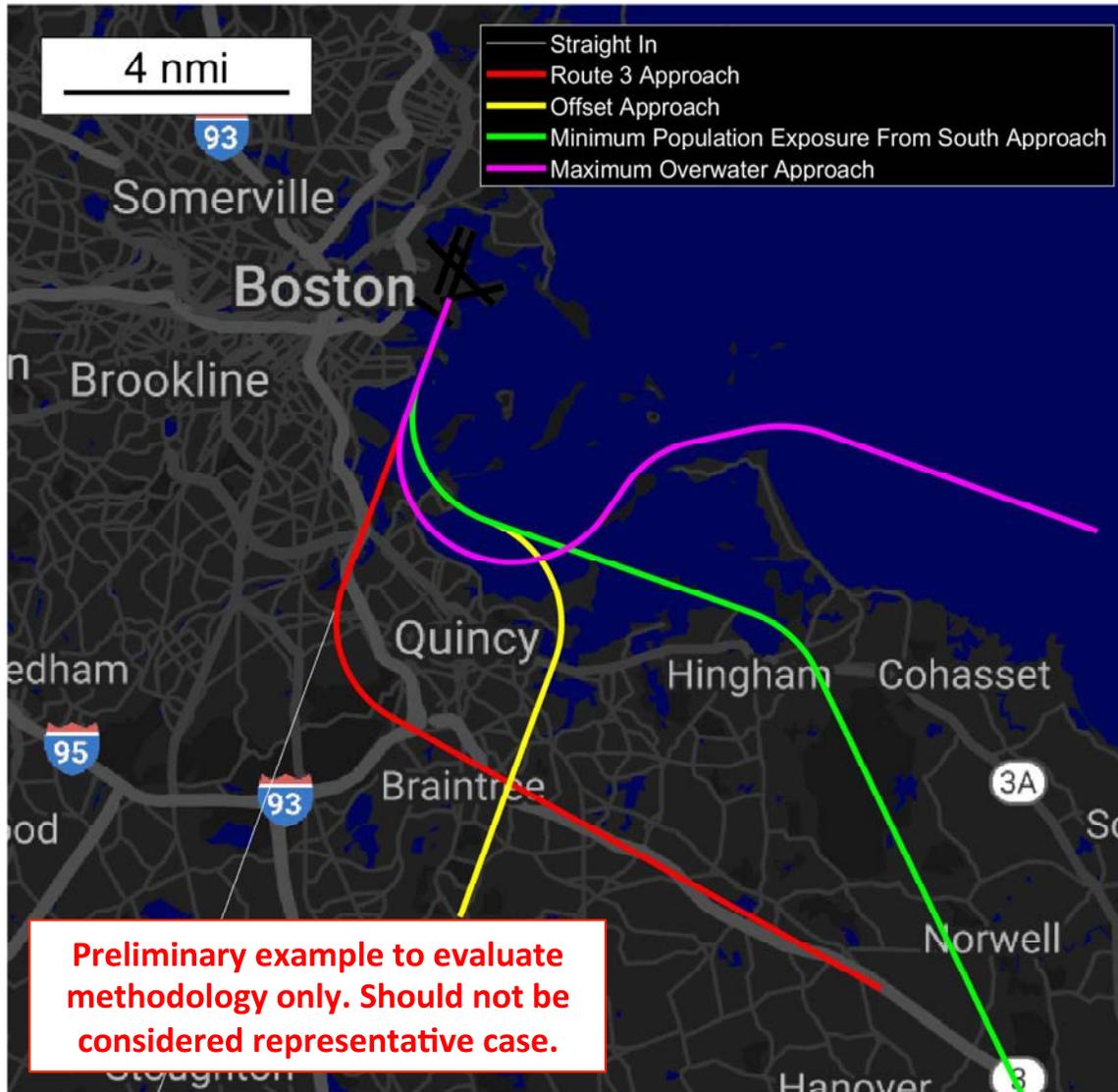
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International Center for
Air Transportation

Low-Noise Overwater Approach Procedure

4R Arrival

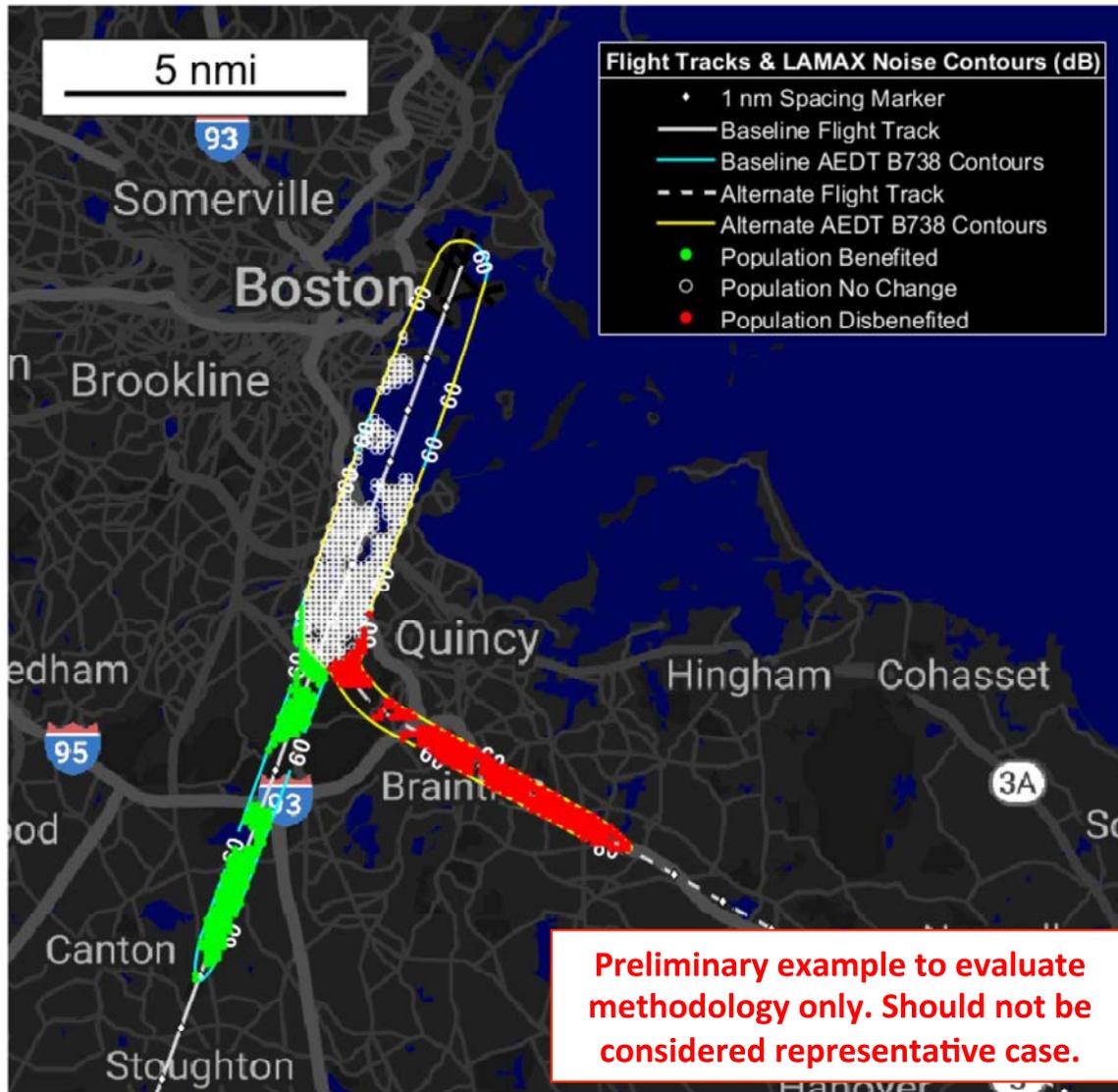
Example 4R RNP Approach



- Several RNP approaches to 4R shown as examples
- RNP technology allows approach to be kept overwater near final approach

4R RNP Approach – Route 3 Initial

B737-800 60dB $L_{A,max}$ Noise Exposure



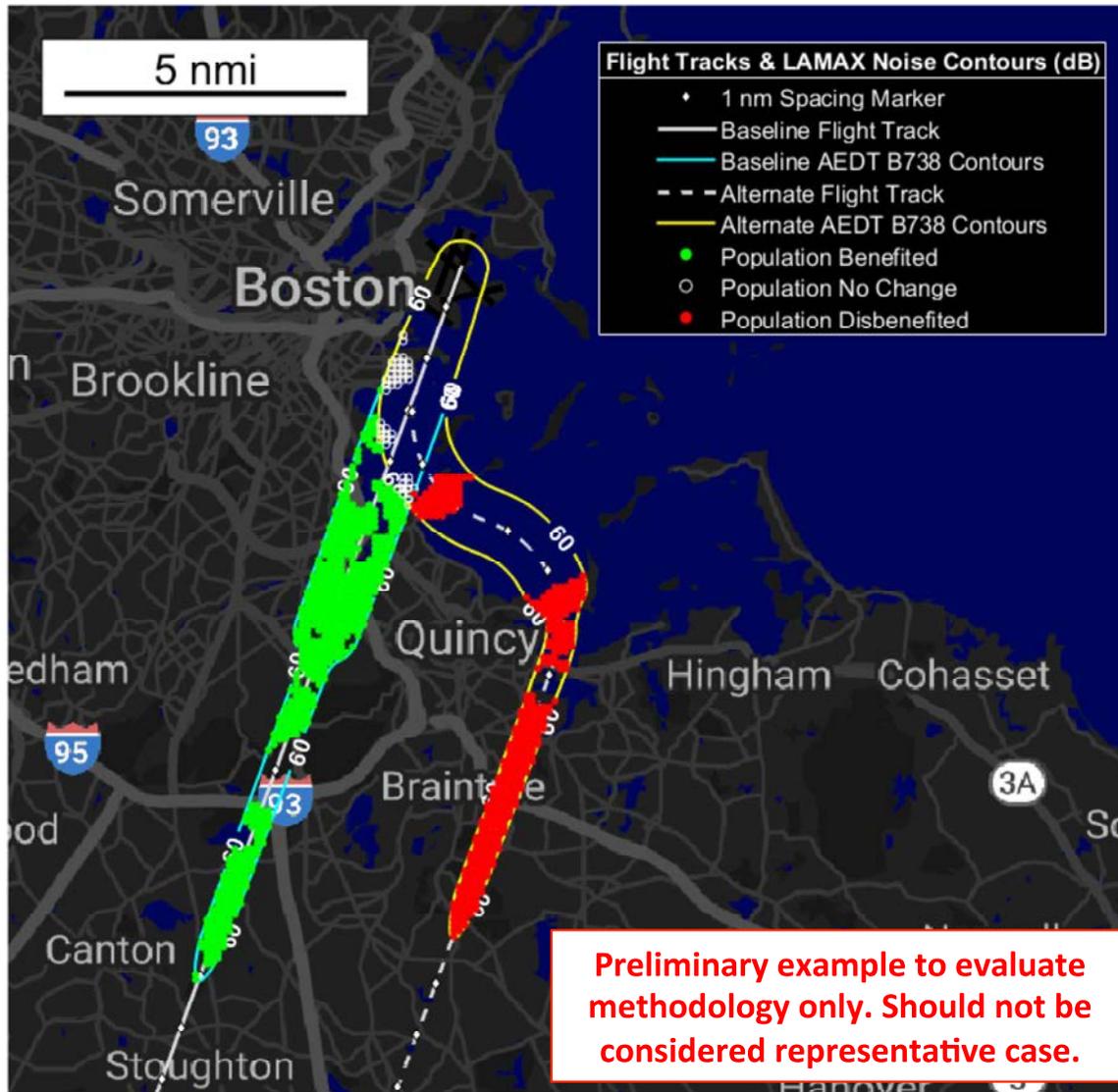
**B737-800
Population Exposure ($L_{A,MAX}$)**

	60dB
Straight In	32,232
RNP	38,353
Difference (Straight In – RNP)	-6,121

5.5nmi final segment
80° 2nmi radius-to-fix turn

4R RNP Approach – Offset Initial

B737-800 60dB $L_{A,max}$ Noise Exposure



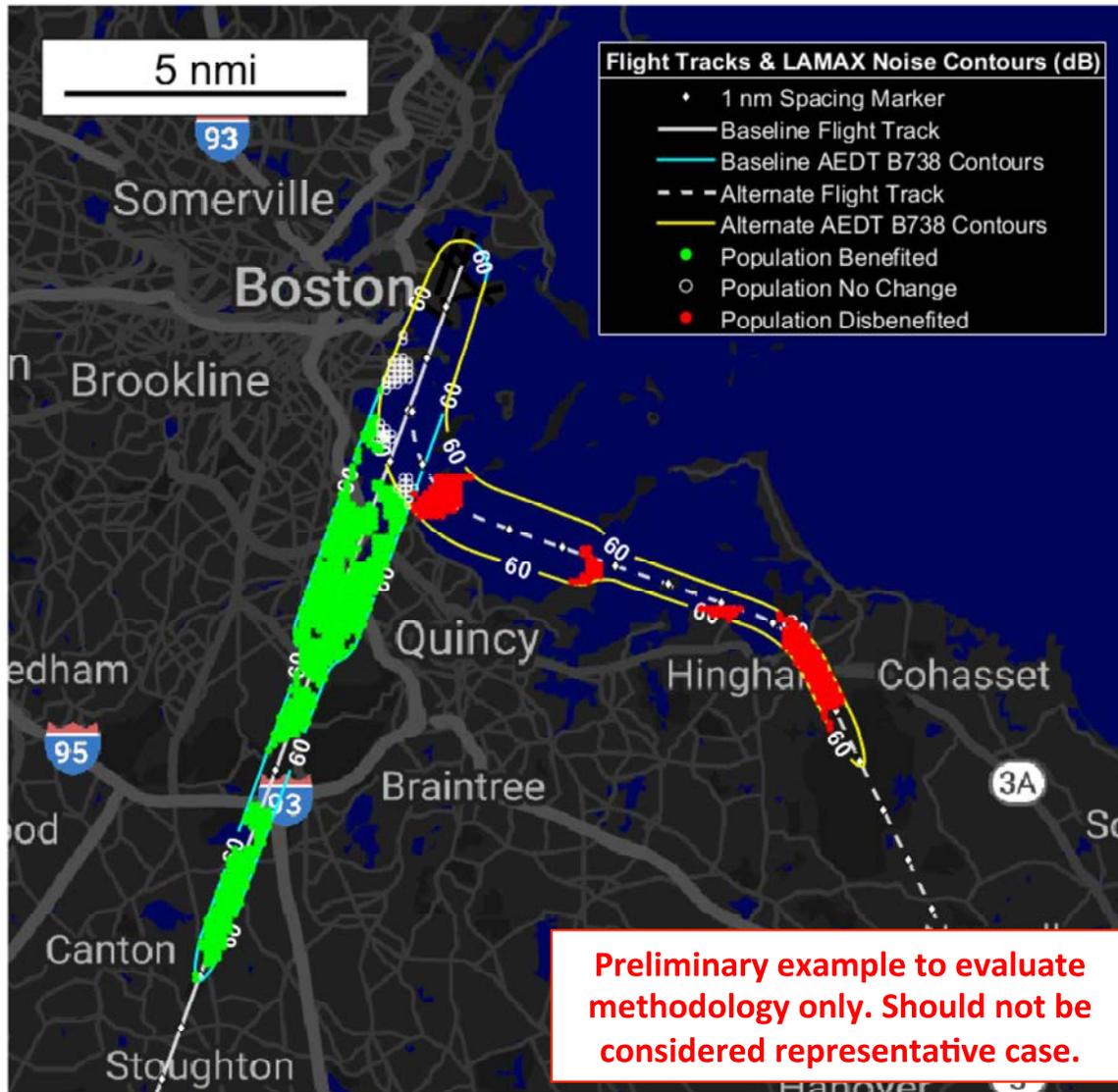
**B737-800
Population Exposure ($L_{A,MAX}$)**

	60dB
Straight In	32,232
RNP	25,106
Difference (Straight In – RNP)	7,126

1.5nmi final segment
 90° 2nmi radius-to-fix turn
 90° 2nmi radius-to-fix turn

4R RNP Approach – Min Population Exposure from South

B737-800 60dB $L_{A,max}$ Noise Exposure



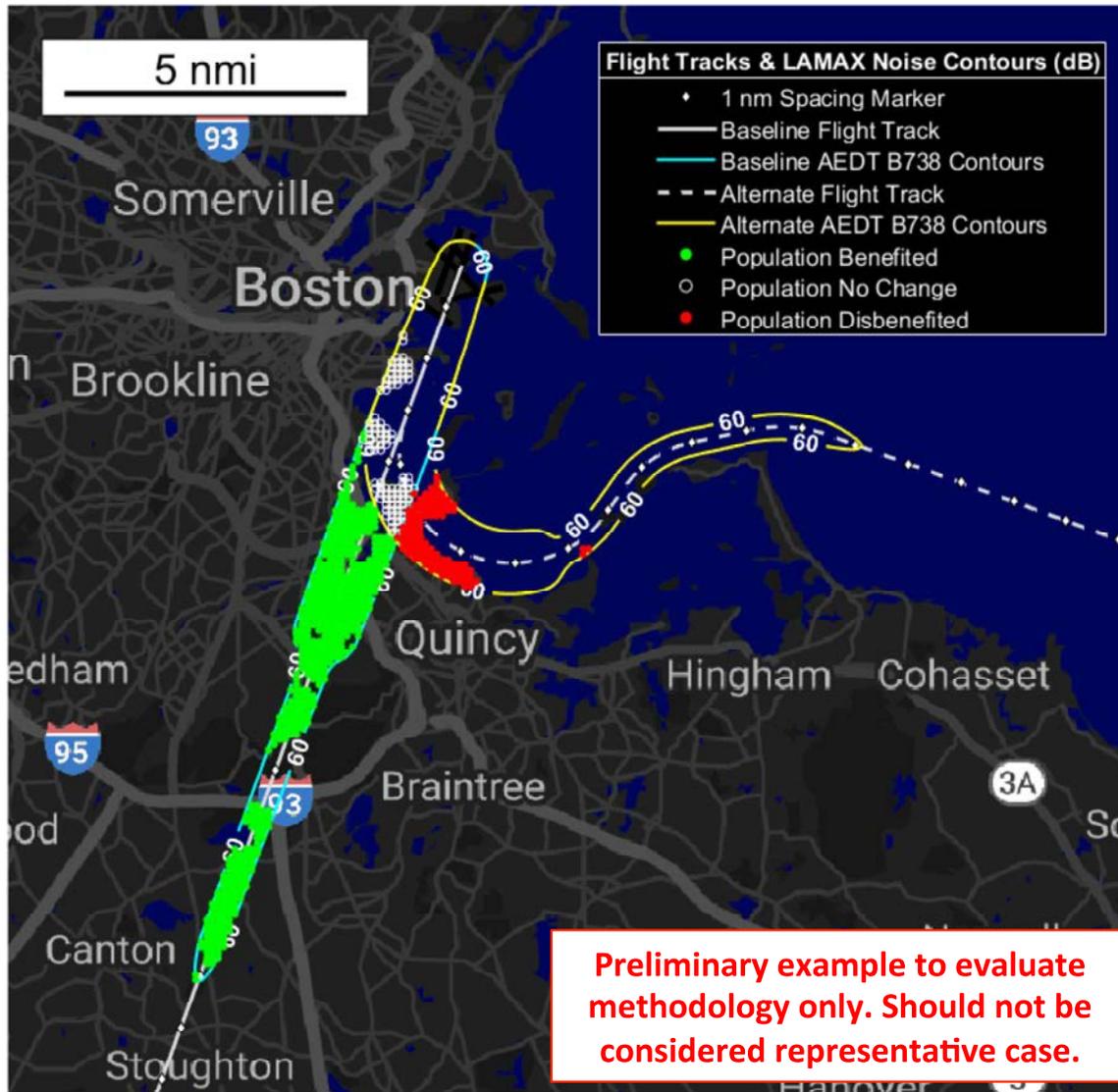
**B737-800
Population Exposure ($L_{A,MAX}$)**

	60dB
Straight In	32,232
RNP	11,682
Difference (Straight In – RNP)	20,550

1.5nmi final segment
 90° 2nmi radius-to-fix turn
 5nmi straight segment
 45° 2nmi radius-to-fix turn

4R Arrival RNP – Maximum Overwater

B737-800 60dB $L_{A,max}$ Noise Exposure



**B737-800
Population Exposure ($L_{A,MAX}$)**

	60dB
Straight In	32,144
RNP	20,754
Difference (Straight In – RNP)	11,390

Different routes for 4R arrivals still under analysis

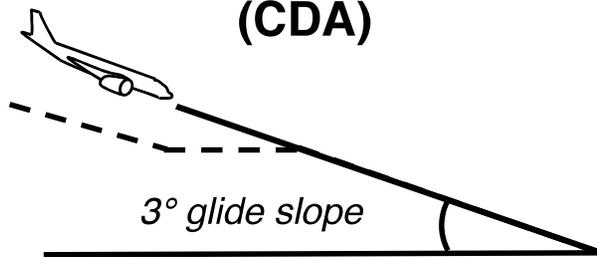


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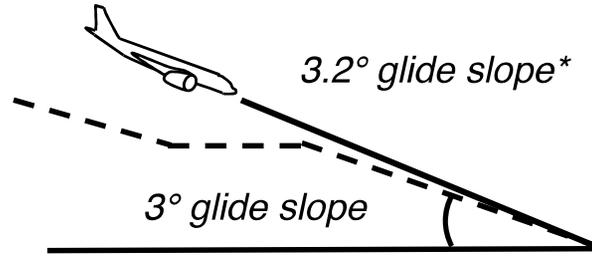
Vertical Path Changes Runway 4R

Vertical Path Change Options Evaluated

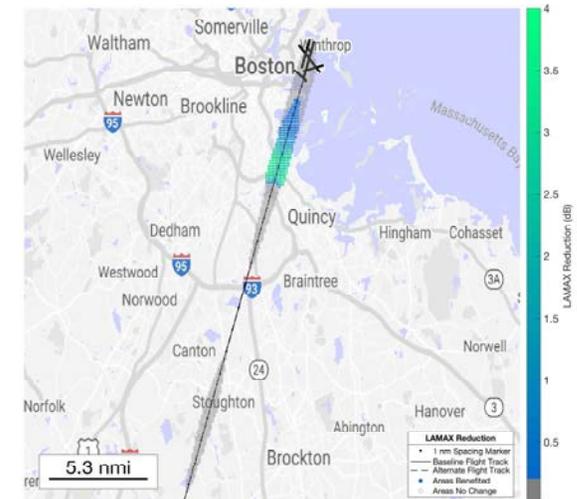
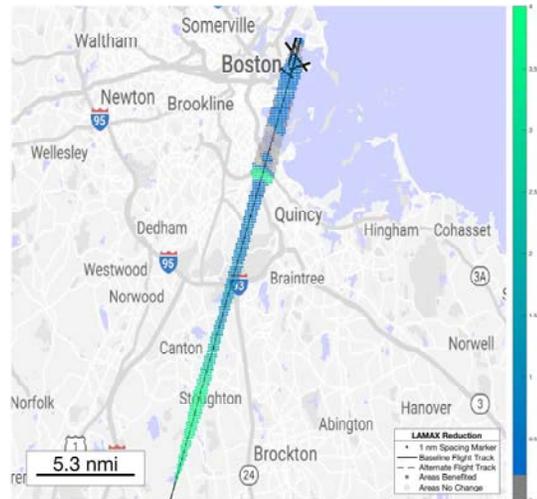
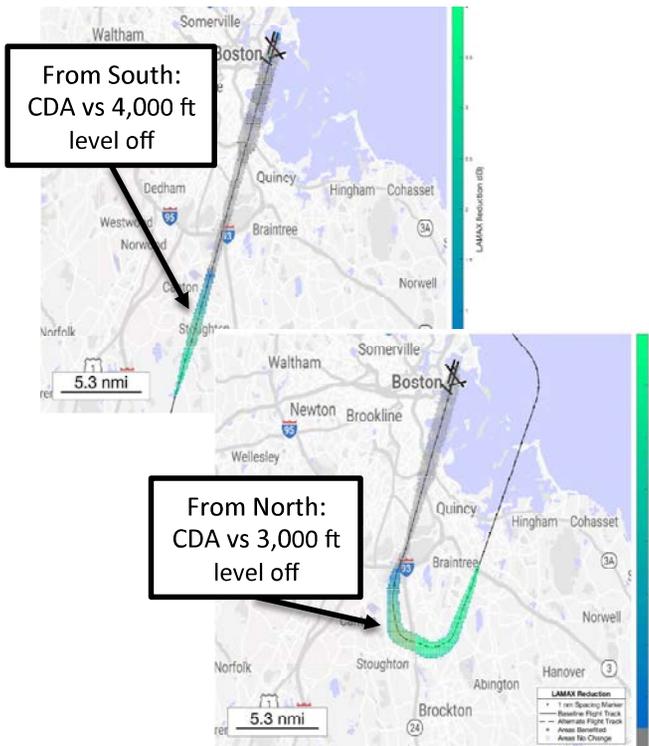
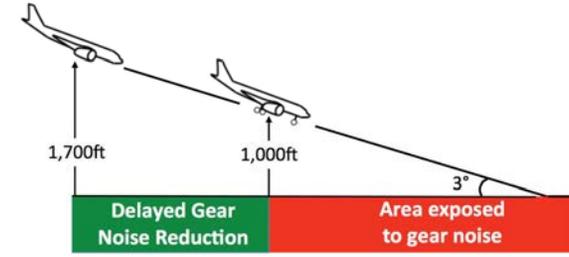
Continuous Descent (CDA)



Steeper Descent



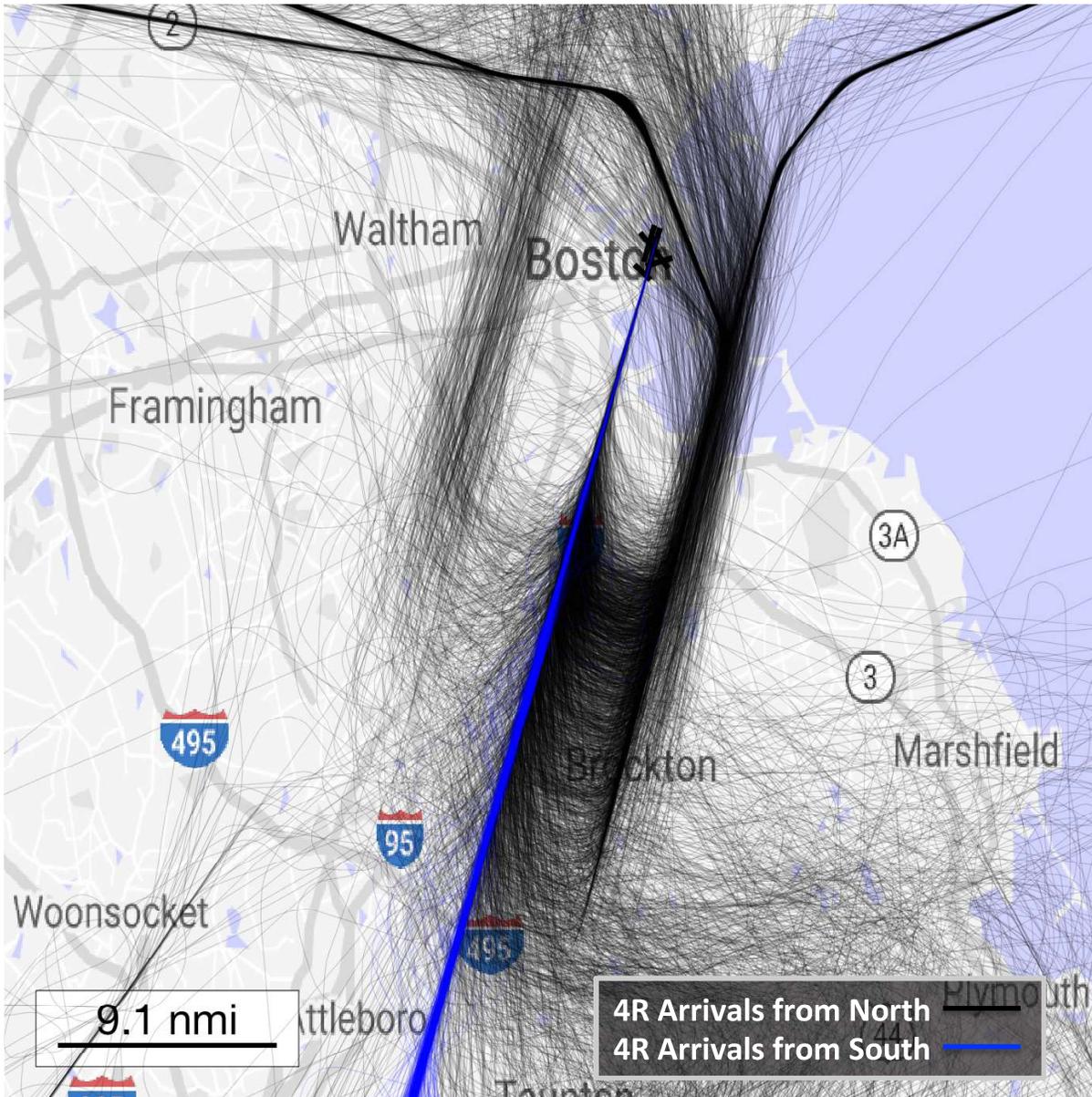
Delayed Gear



Preliminary examples to evaluate methodology only. Should not be considered representative case.

*Approval required to establish a glide path angle higher than 0.2° of VGSI (greater than 3.2° at BOS) (TERPS criteria page 2-47)

Baseline: 2017 Arrivals to Runway 4R

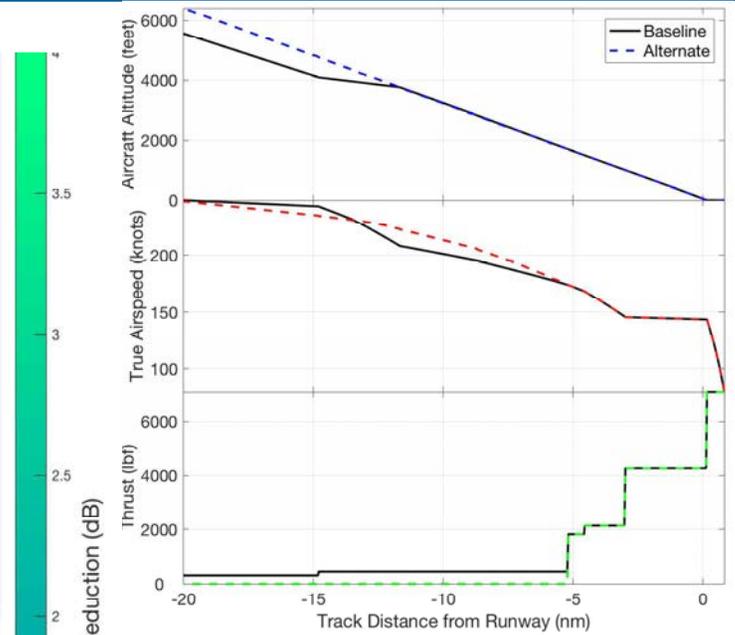
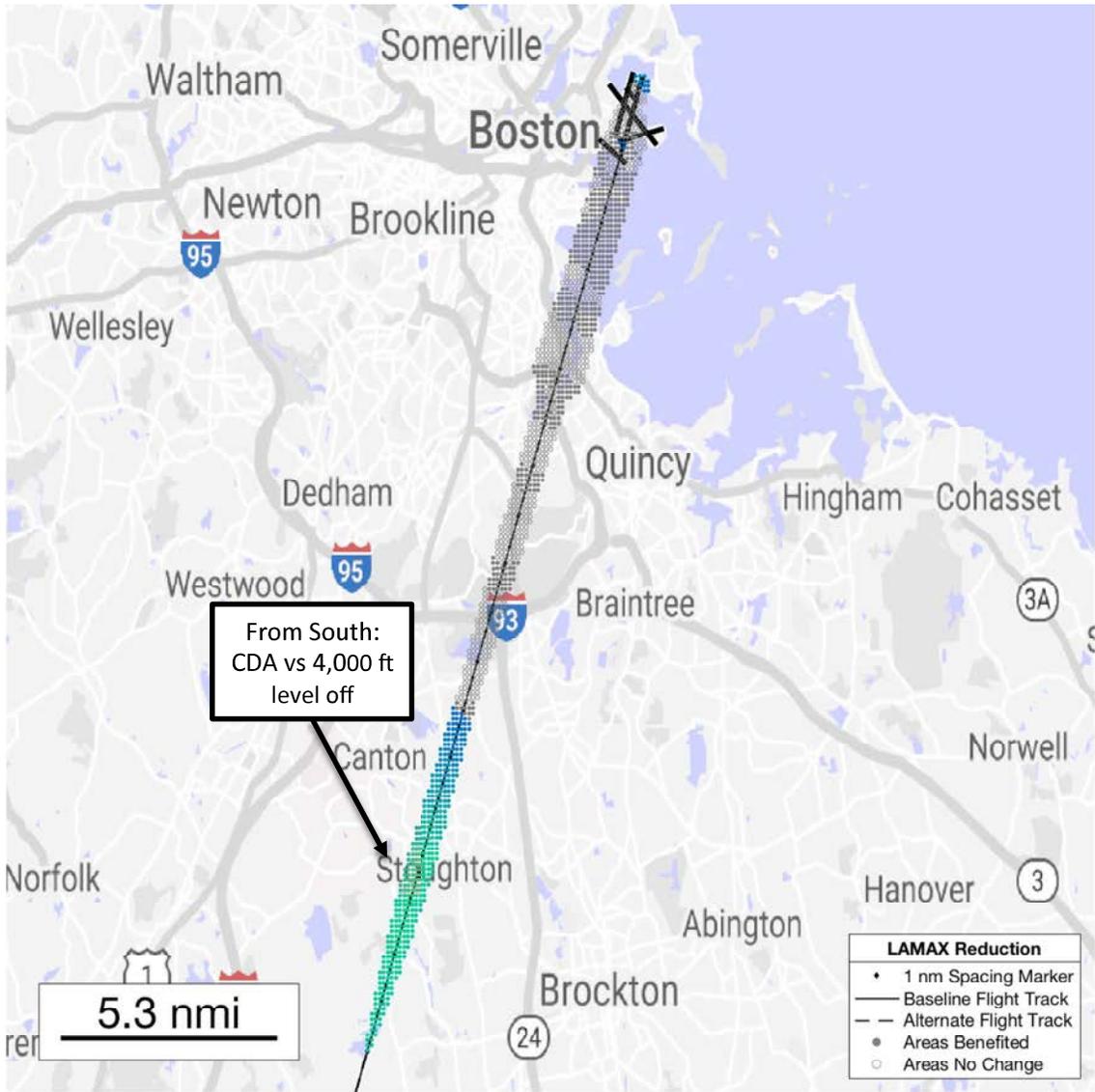


Notes:

- 39,615 Arrivals to Rwy 4R in 2017 (jet & prop):
- Figure shows 10% of all 2017 arrivals selected at random
- Data Source: Flight Tracks, Massport Noise and Operations Management System (NOMS)
- **51%** of Rwy4R arrivals came from south on a 2017 peak day

Altitude Profiles	Arrivals from South	Arrivals from North
% Continuous Descent Profiles	38	6
% Non-Continuous Descent (level-off) Profiles	62	94
Median level-off altitude (Non-Continuous Descent Profiles)	4,000 ft	3,000 ft

3.0° Continuous Descent from the South vs Baseline Stepped Descent LAMAX Reduction

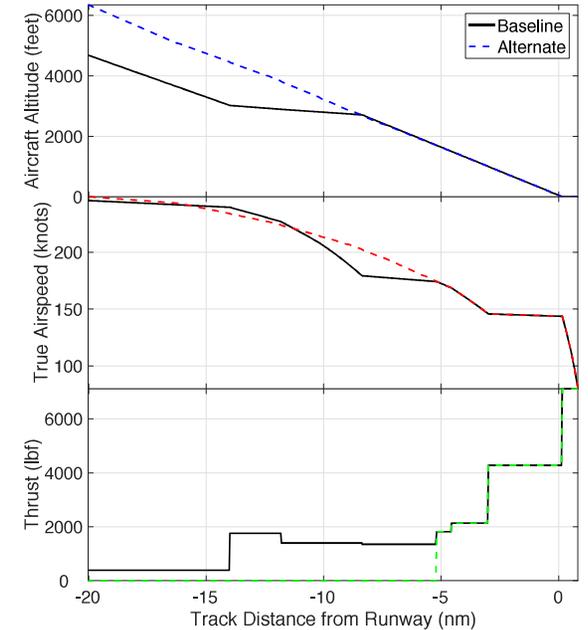
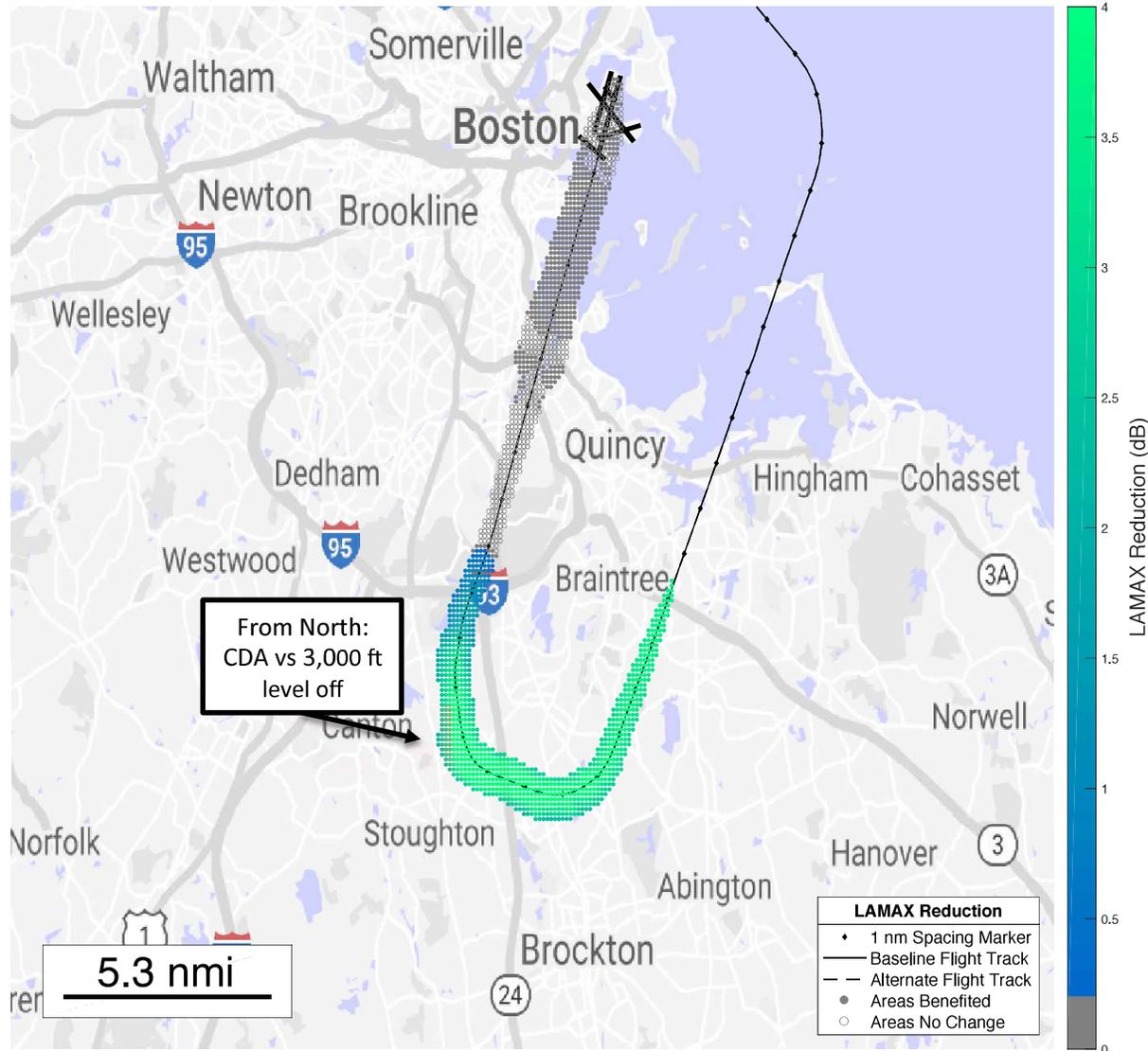


Population Exposure

LAMAX Reduction	Population Exposure
4dB	1,014
3dB	1,057
2dB	7,525
1dB	21,152

Preliminary example to evaluate methodology only. Should not be considered representative case.

3.0° Continuous Descent from the North vs Baseline Stepped Descent LAMAX Reduction

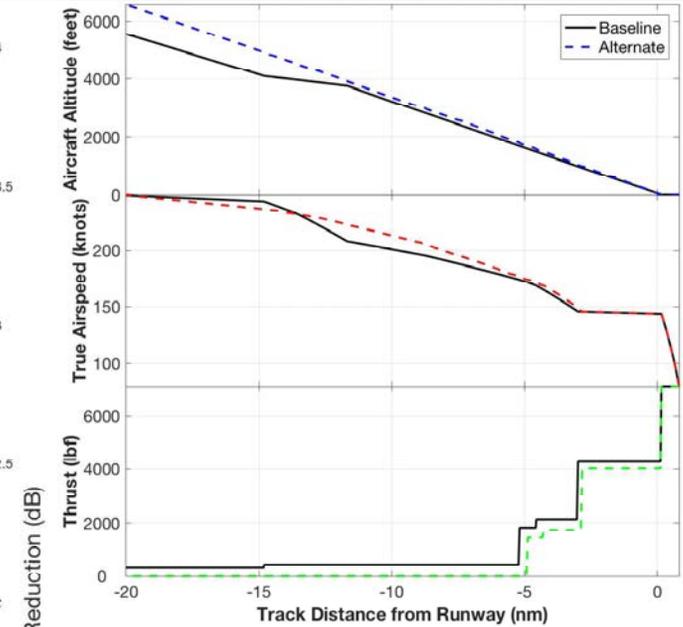
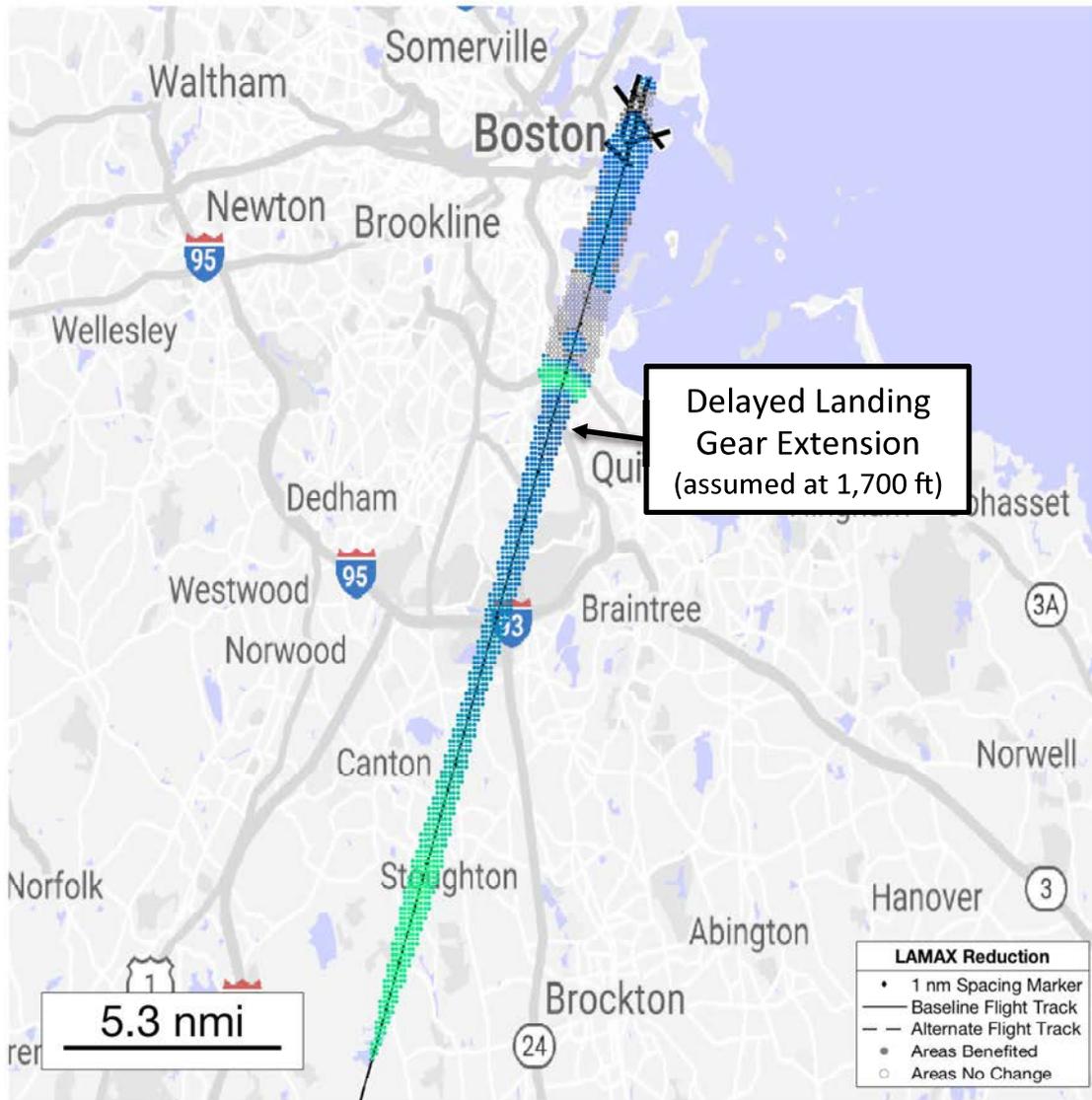


Population Exposure

LAMAX Reduction	Population Exposure
4dB	2,104
3dB	10,772
2dB	12,921
1dB	13,282

Preliminary example to evaluate methodology only. Should not be considered representative case.

3.2° Continuous Descent vs Baseline Stepped Descent LAMAX Reduction

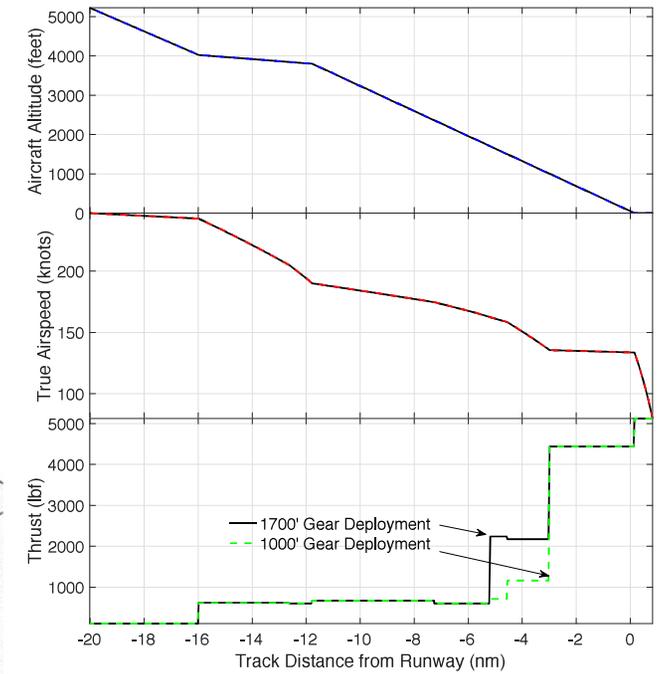
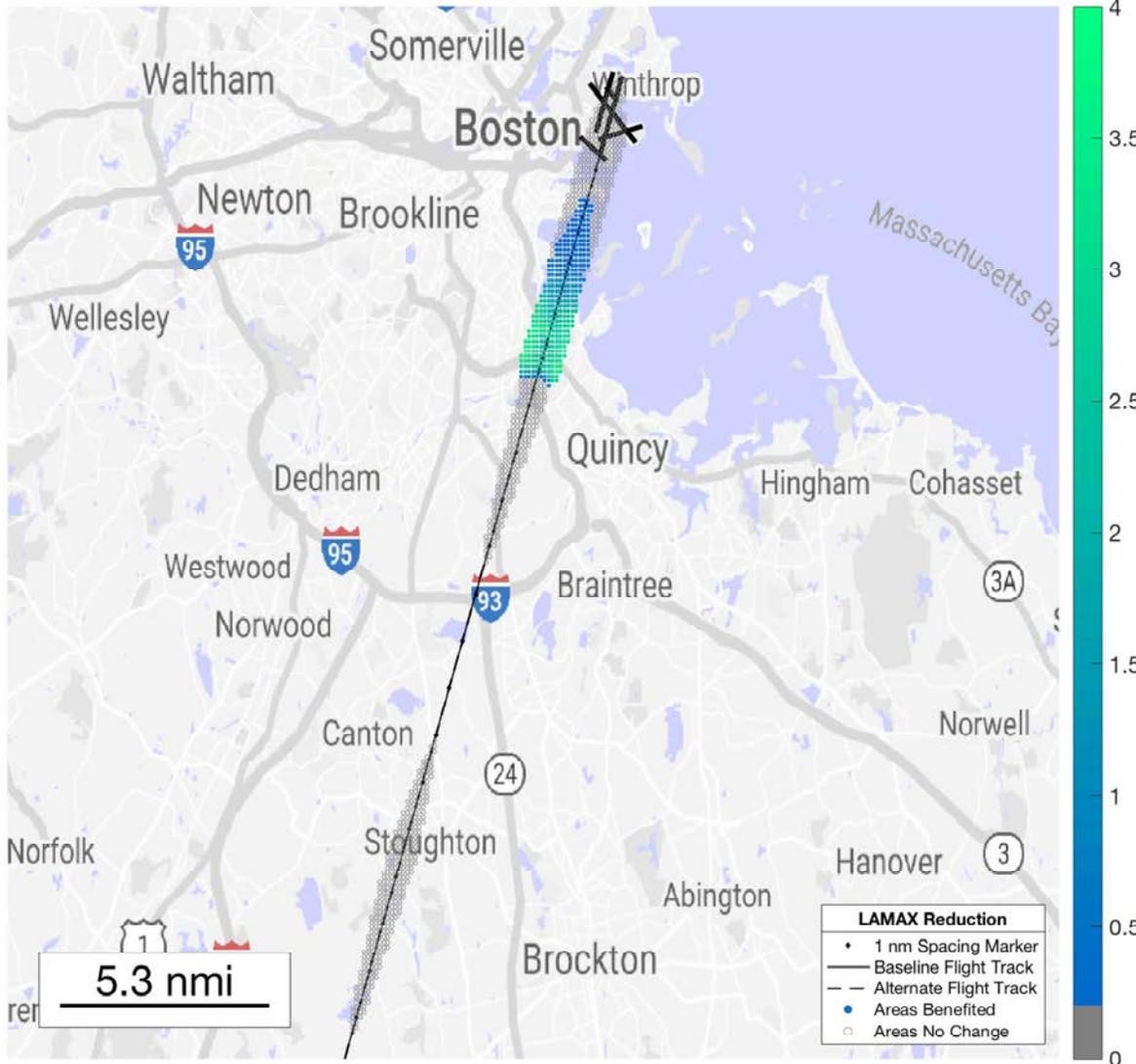


Population Exposure

LAMAX Reduction	Population Exposure
4dB	1,445
3dB	9,801
2dB	23,738
1dB	44,057

Preliminary example to evaluate methodology only. Should not be considered representative case.

1000' vs. 1700' Gear Deployment Stepped Descent LAMAX Reduction



Population Exposure

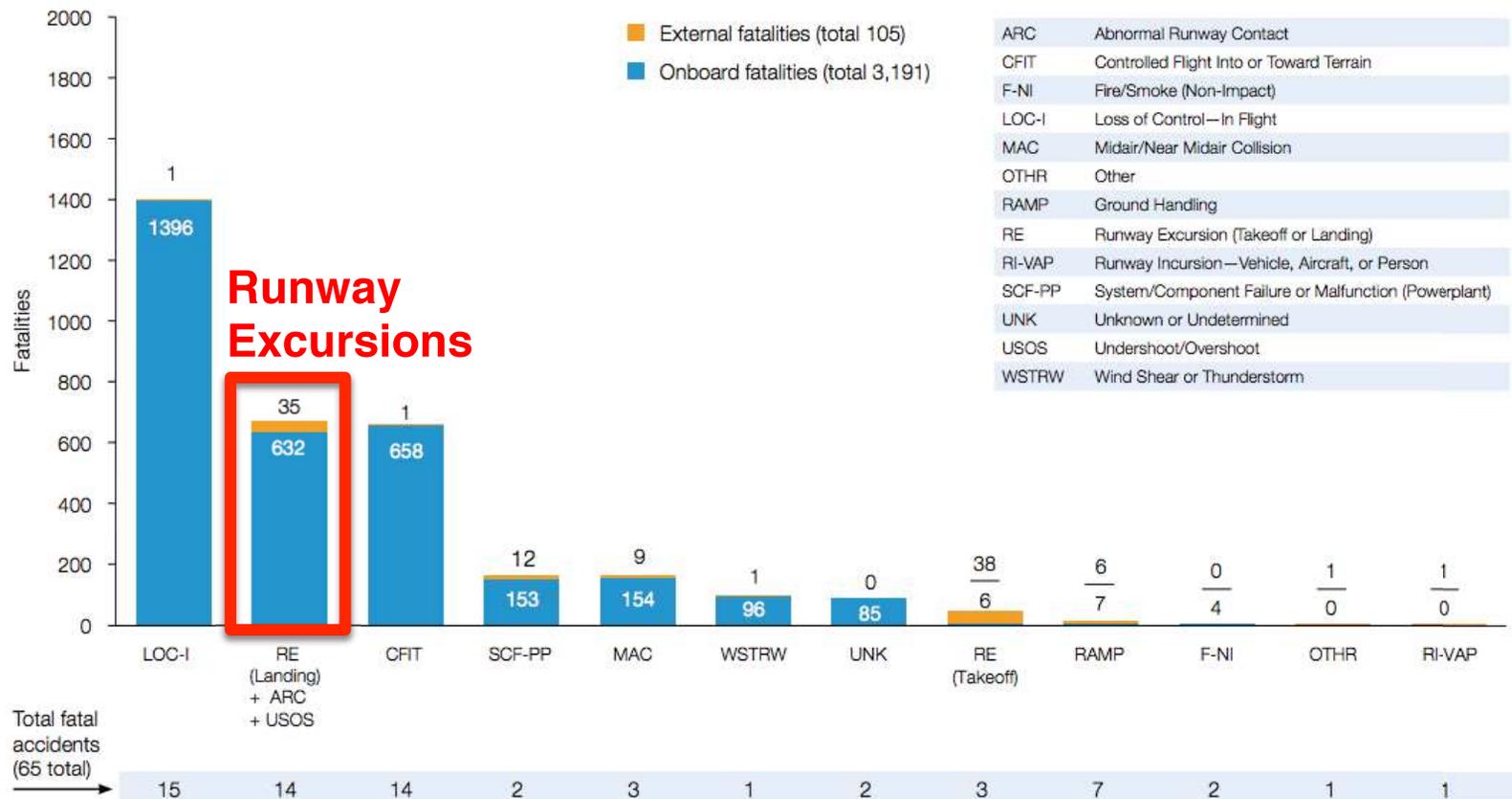
LAMAX Reduction	Population Exposure
4dB	14,468
3dB	38,841
2dB	46,777
1dB	48,626

Preliminary example to evaluate methodology only. Should not be considered representative case.

Significant Resistance from Pilot Unions on Steep or High Energy Procedures

Fatalities by CICTT Aviation Occurrence Categories

Fatal Accidents | Worldwide Commercial Jet Fleet | 2006 through 2015



Note: Principal categories as assigned by CAST.

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

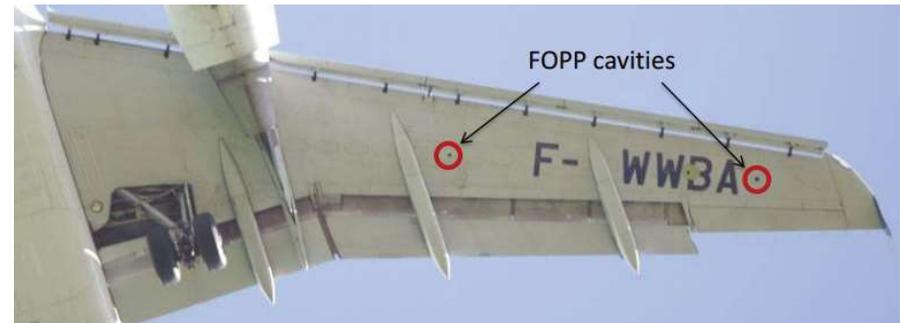


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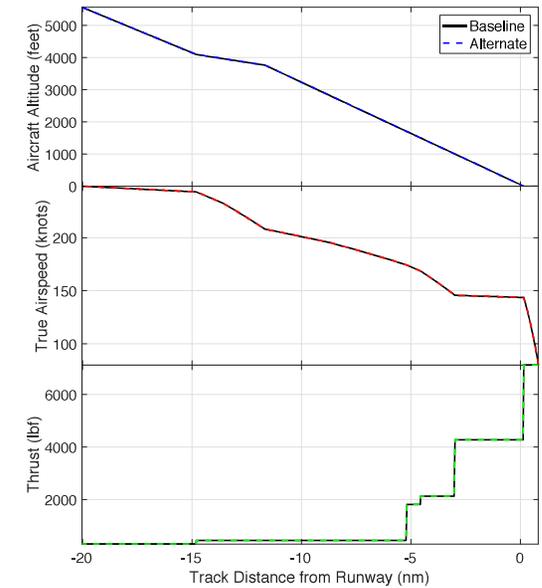
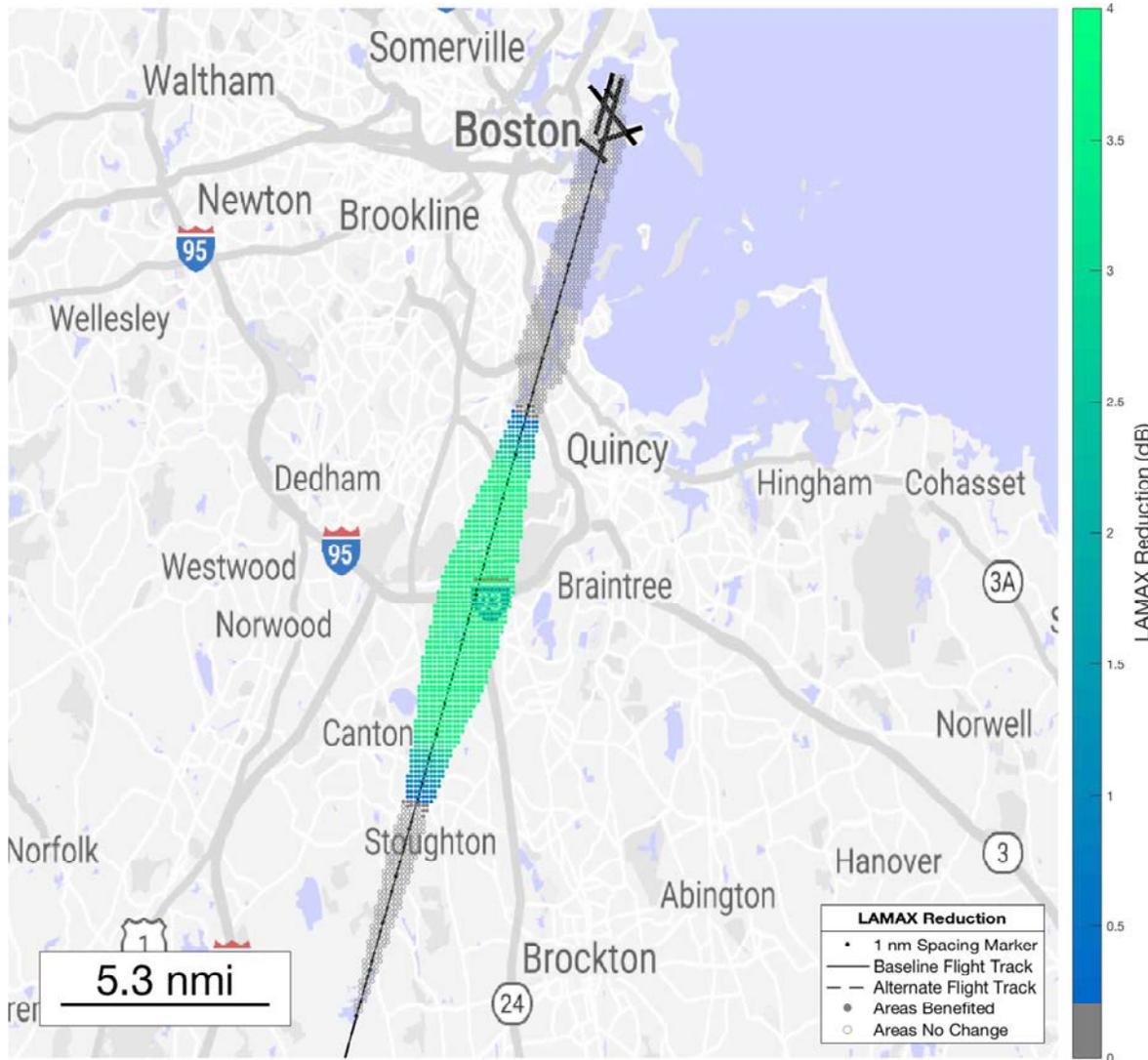
Vortex Generators

Vortex Generators Introduction

- Fuel Over-Pressure Ports (3.5" diameter) cause strong tonal noise peaks at 573 Hz
 - Perceived as a “whistling” tone louder than all other noise sources
- Tone only appears at specific speeds (180-220kts) and aircraft configurations
 - Strongest in clean configuration



Example Impact of Vortex Generators for A320s on 4R



Population Exposure

LAMAX Reduction	Population Exposure
4dB	6,916
3dB	8,482
2dB	9,964
1dB	11,723

Preliminary example to evaluate methodology only. Should not be considered representative case.



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Discussion