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Air Transportation

Procedure Design Concepts for Logan Airport Community Noise Reduction

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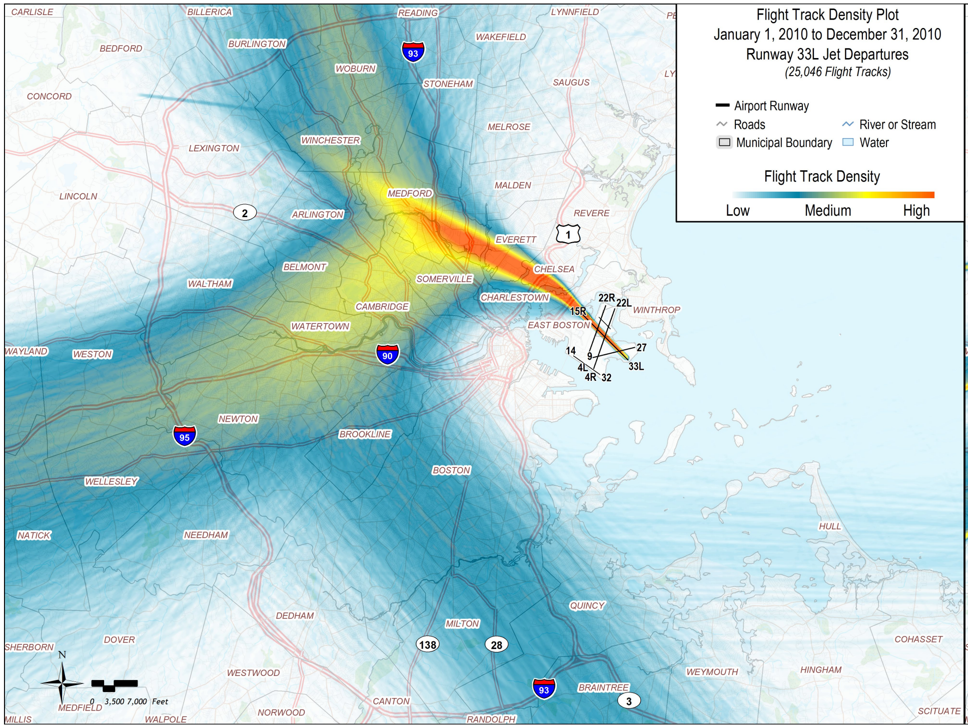
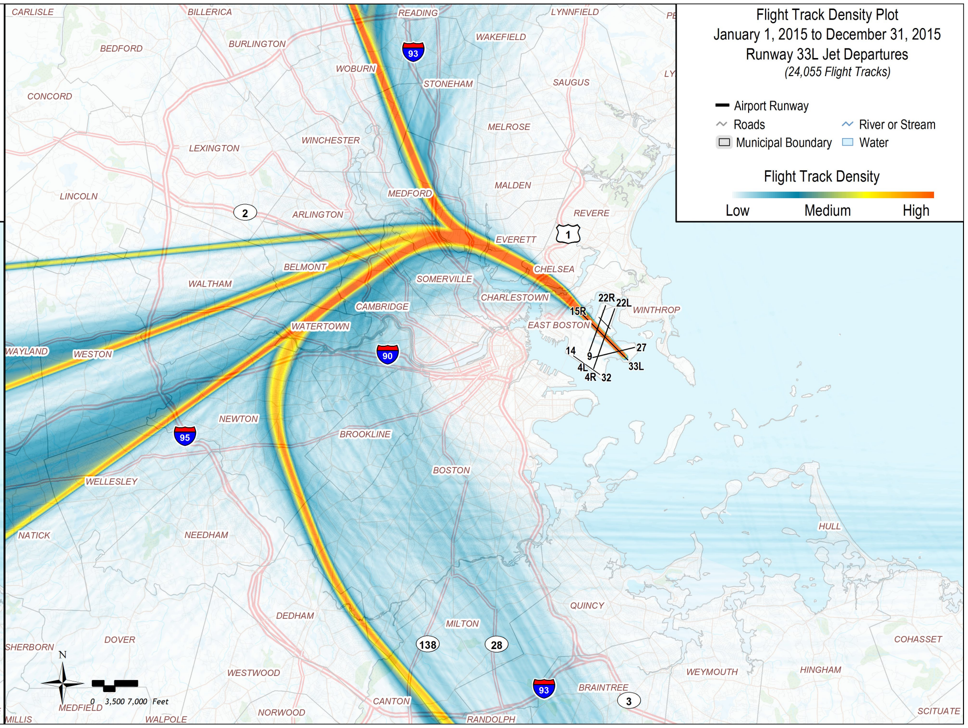
Technical support from MIT ICAT students, HMMH, and Massport

RNAV Track Concentration

2010

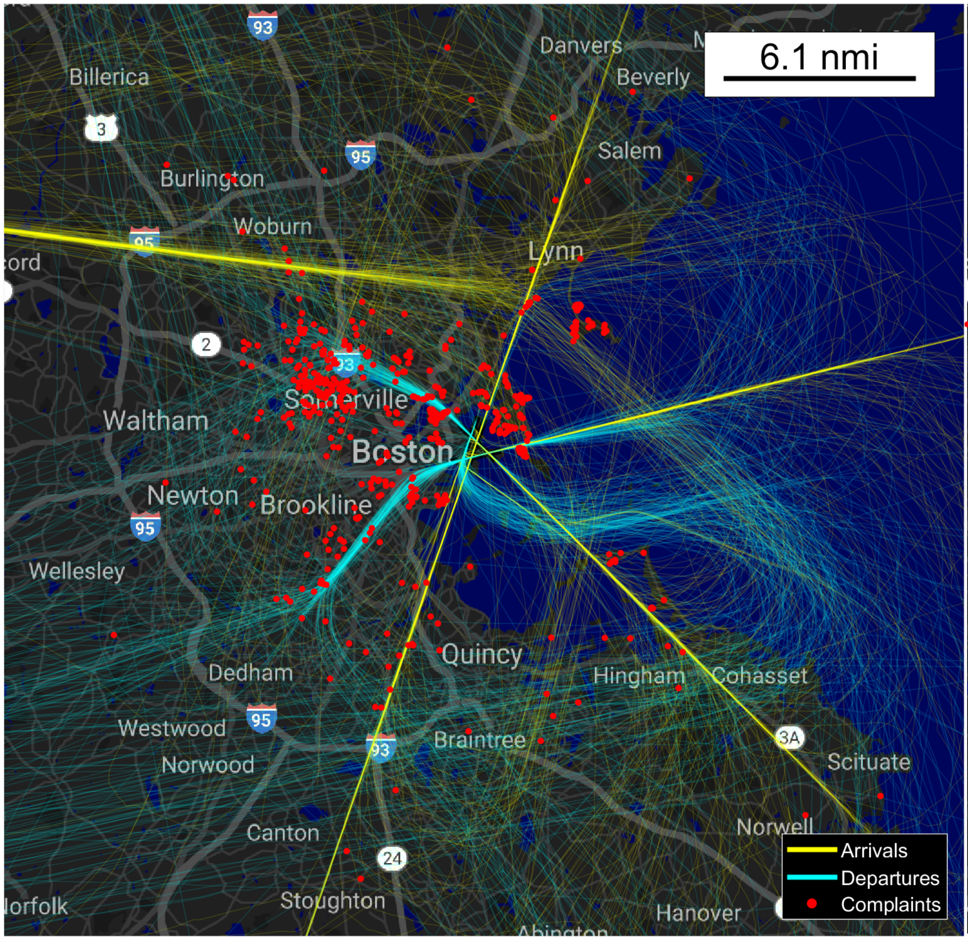


2015

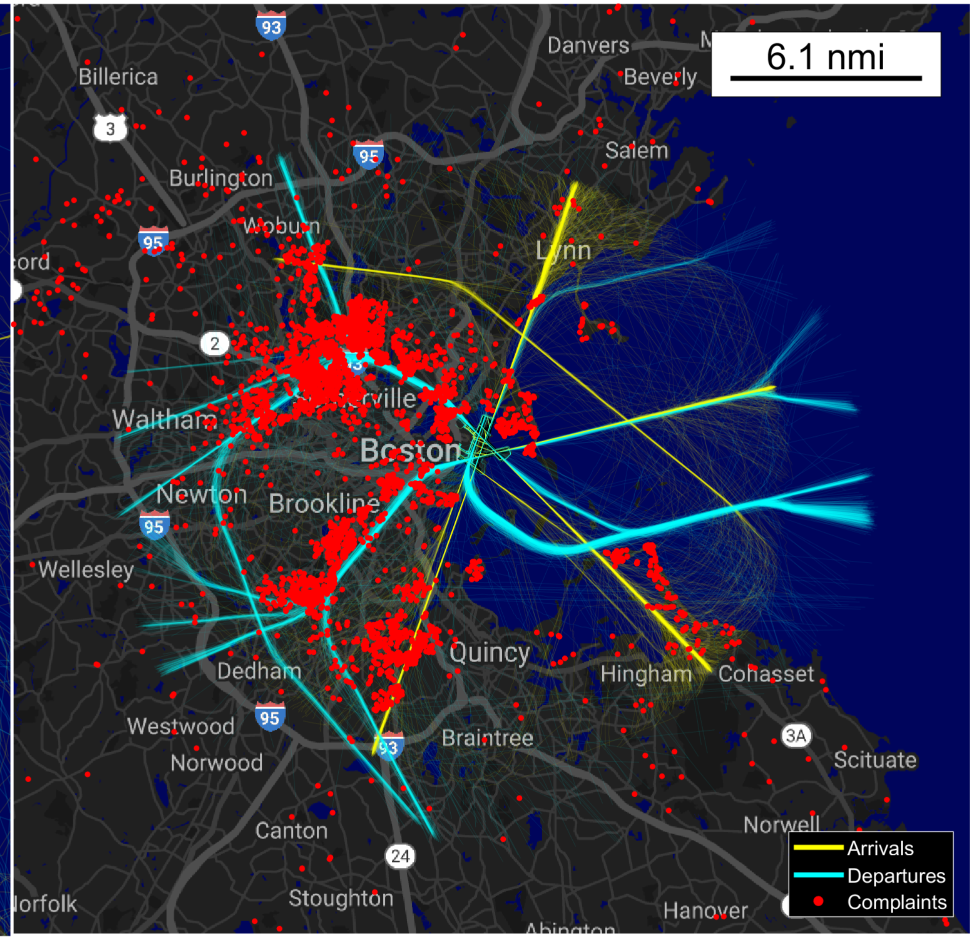


Noise Complaints and RNAV Track Concentration

2010

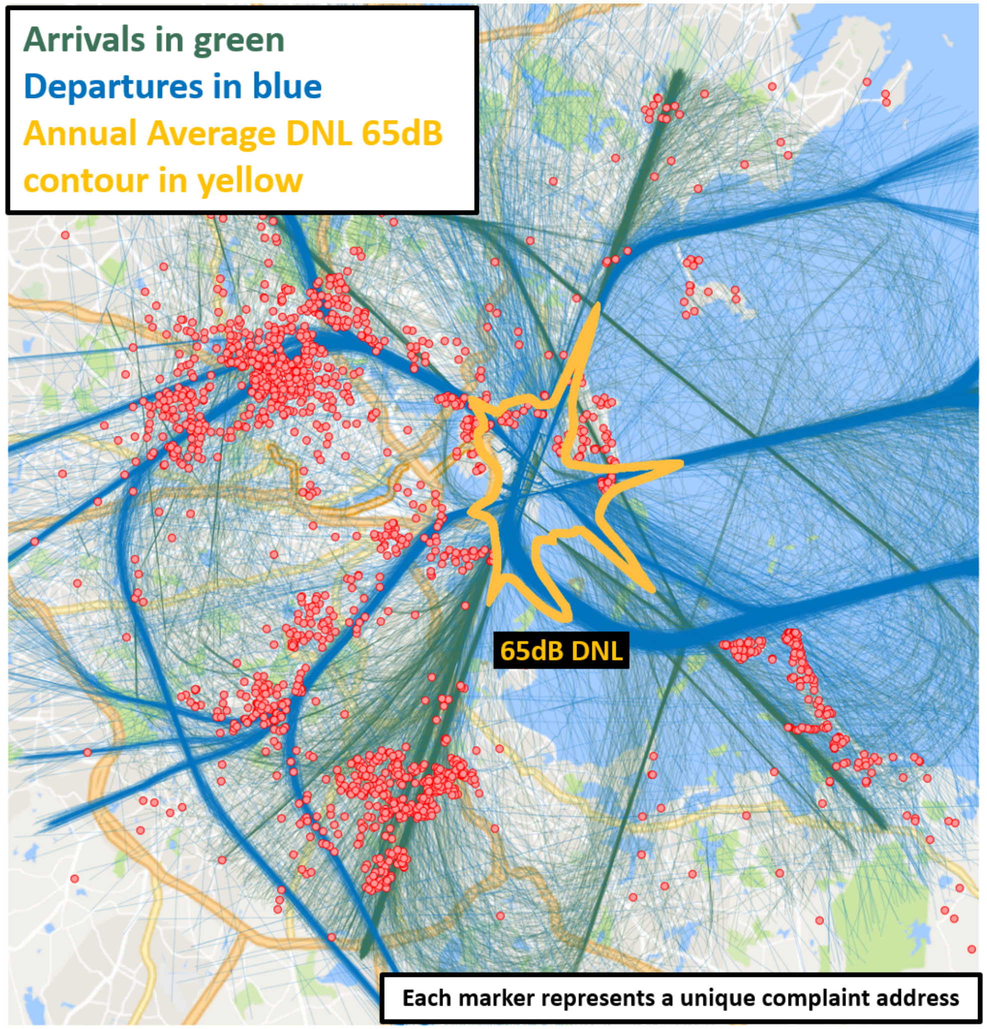


2017



Alternative Metrics to Capture RNAV Concentration Impacts

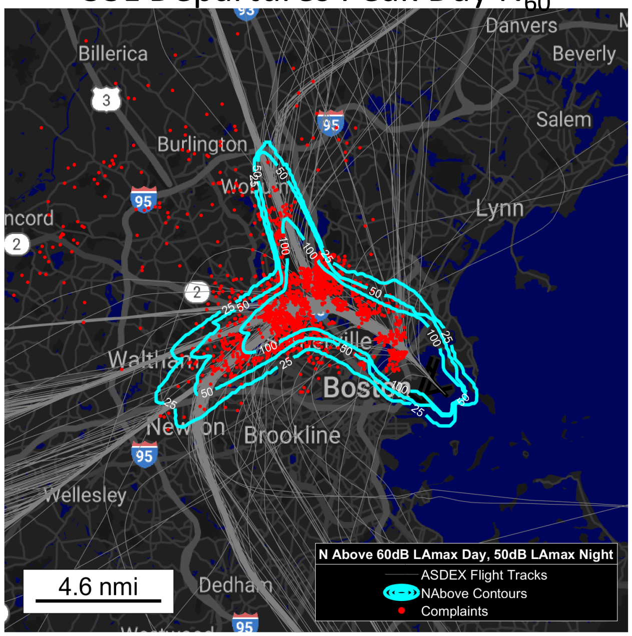
- RNAV concentration issue outside of Annual Average DNL 65dB contour
- Analysis performed by this research team at BOS, MSP, CLT, and LHR indicates that Peak Day 50 N_{60} represents the noise threshold for complaints



BOS N_{60} Count Thresholds

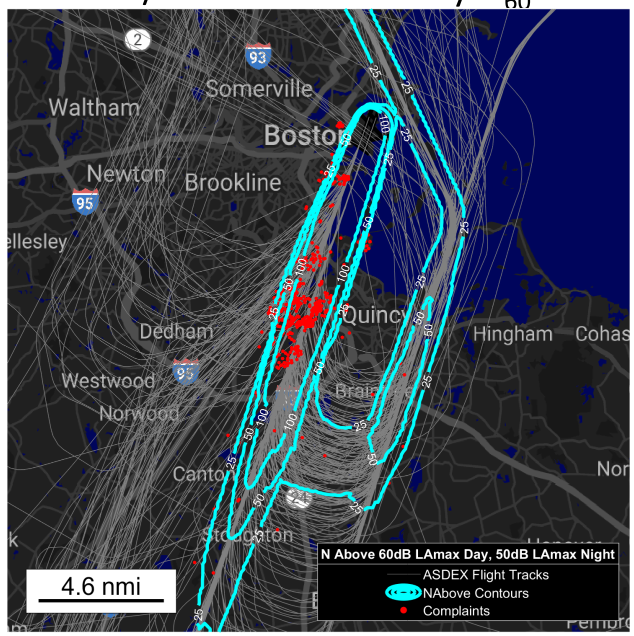
- 50 N_{60} on a peak day appears to capture complaint threshold in dispersion analysis

33L Departures Peak Day N_{60}



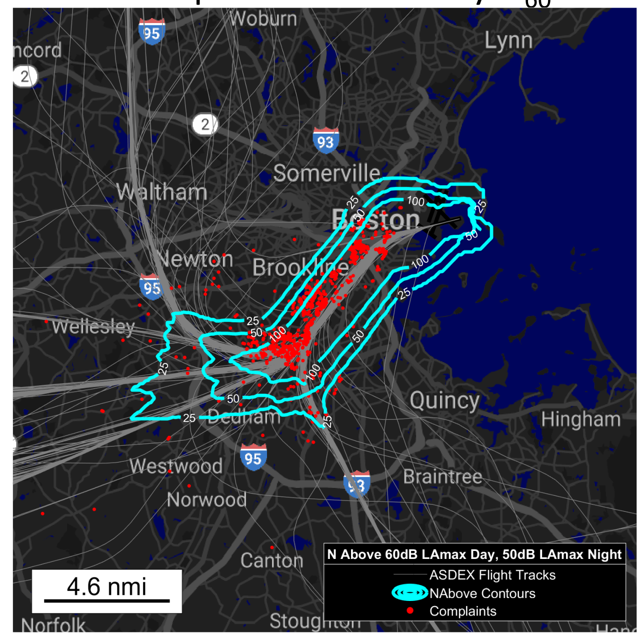
Peak Day N_{60}	Complaints Captured
25x	90.0%
50x	83.8%
100x	59.9%

4L/R Arrivals Peak Day N_{60}



Peak Day N_{60}	Complaints Captured
25x	91.3%
50x	81.3%
100x	70.6%

27 Departures Peak Day N_{60}



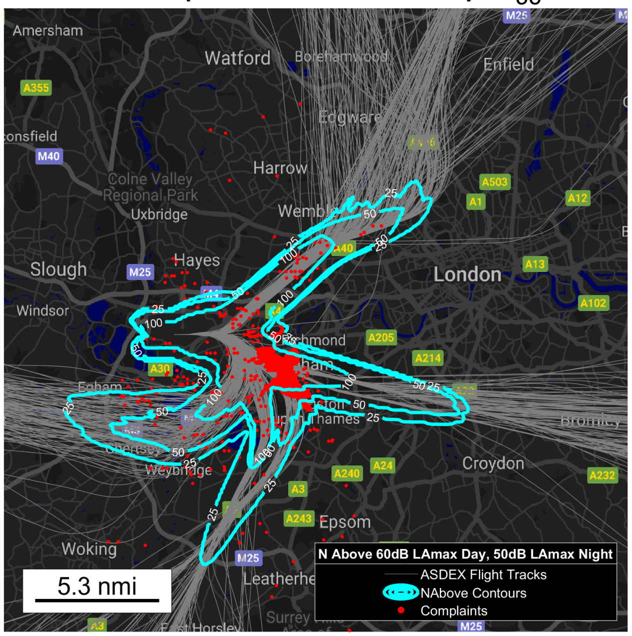
Peak Day N_{60}	Complaints Captured
25x	94.6%
50x	90.2%
100x	76.8%

2017 Data

LHR N_{60} Count Thresholds

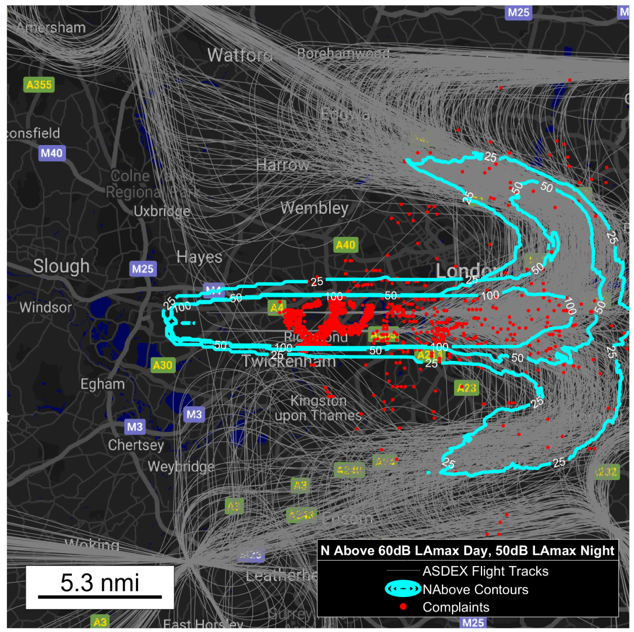
- 50 N_{60} on a peak day appears to capture complaint threshold in dispersion analysis

09 Departures Peak Day N_{60}



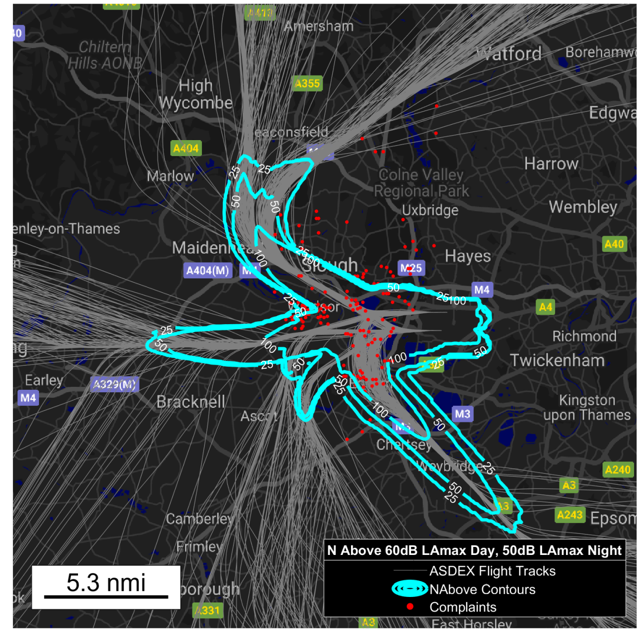
Peak Day N_{60}	Complaints Captured
25x	92.1%
50x	85.5%
100x	66.2%

27 Arrivals Peak Day N_{60}



Peak Day N_{60}	Complaints Captured
25x	89.6%
50x	80.9%
100x	75.6%

27 Departures Peak Day N_{60}



Peak Day N_{60}	Complaints Captured
25x	76.6%
50x	70.1%
100x	56.5%

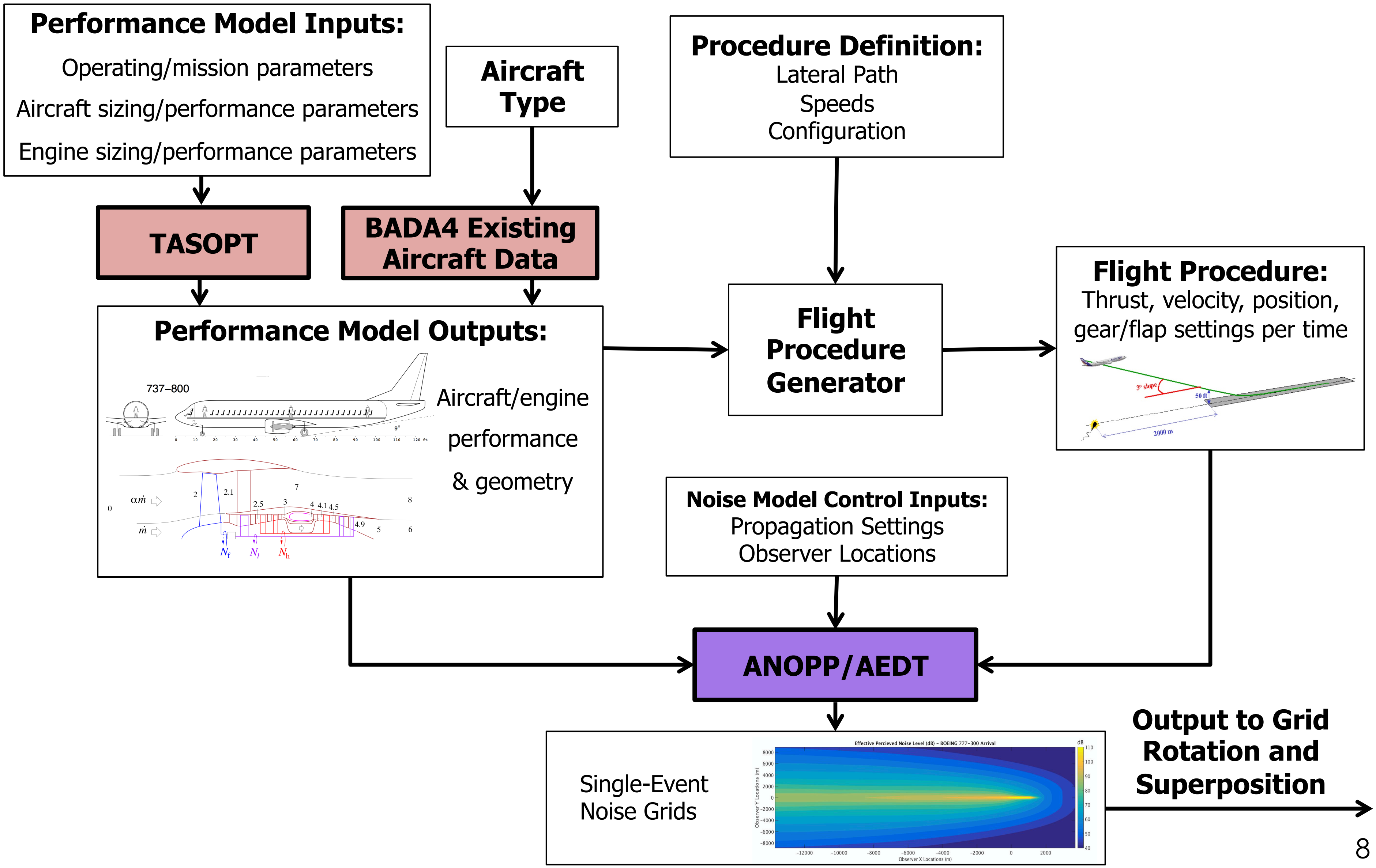
2017 Data

Massport/FAA MOU
MIT 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

Noise Modeling Framework

Developed under FAA ASCENT COE Project 23 https://ascent.aero/project/analytical-approach-for-quantifying-noise-from-advanced-operational-procedures/



Initial Outreach (Partial List)

- Community
  - Community Meetings
  - Massport Community Advisory Committee
  - Public Officials
  - ASCENT (FAA Center of Excellence)
- FAA
  - ATO Air Traffic (HQ, TRACON, Tower, Center, Region)
  - AJV Flight Procedures
  - AFS Flight Standards
  - AEE Environment and Energy
- Airlines
  - Technical Pilot Group
  - A4A
- Manufacturers
  - Boeing

FAA 7100.41 Working Group

- Performance Based Navigation Implementation Process
- Purpose: To vet procedures with industry and facilities including airlines, ATC, and FAA
- Following FAA 7100.41 working group, procedures will be reviewed by flight standards

Lessons learned:

- Stakeholders may have flyability concerns despite a procedure design being within TERPS criteria
  - RNP SIDS are being further analyzed for situations where RNAV SIDS do not meet the desired objectives
- Designing RNAV and RNP procedures that are similar enough to be used simultaneously relieves ATC of workload burdens and allows for slight additional noise benefits in the RNP procedure

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Air Traffic Organization Policy

ORDER 7100.41

Effective Date:
April 3, 2014

SUBJ: Performance Based Navigation Implementation Process

This order provides a standardized five-phase implementation process related to Performance-Based Navigation (PBN) routes and procedures, referred to as the "Performance Based Navigation Implementation Process," which has been deemed compliant by the Office of Safety and meets the requirements set forth by the Federal Aviation Administration (FAA) Air Traffic Organization's (ATO) Safety Management System (SMS).

This order applies to the development and implementation of PBN procedures and routes; specifically, Area Navigation (RNAV)/Required Navigation Performance (RNP) Standard Instrument Departures (SID), RNAV/RNP Standard Terminal Arrivals (STAR), and RNP Authorization Required (AR) Standard Instrument Approach Procedures (SIAP), Q, Tango or "T," and TK (helicopter) Routes, and RNAV/RNP transitions to SIAPs.

Development and implementation of RNAV (GPS, GLS, LPV, etc.) and conventional (ILS, VOR, NDB, etc.) SIAPs, routes, position, and airspace modifications are not covered by this order. This order does not eliminate the SMS process required to decommission existing navigation stations.

This order is to be used in conjunction with and does not supersede other FAA orders and directives related to procedure development and implementation.

Elizabeth L. Ray
Vice President, Mission Support Services

2/7/14
Date Signed

https://www.faa.gov/documentLibrary/media/Order/FAA_JO_7100.41_Performance_Based_Navigation_Implementation_Process.pdf

Block 1 Examples:

Clear noise benefit, no equity issues, limited operational/technical barriers

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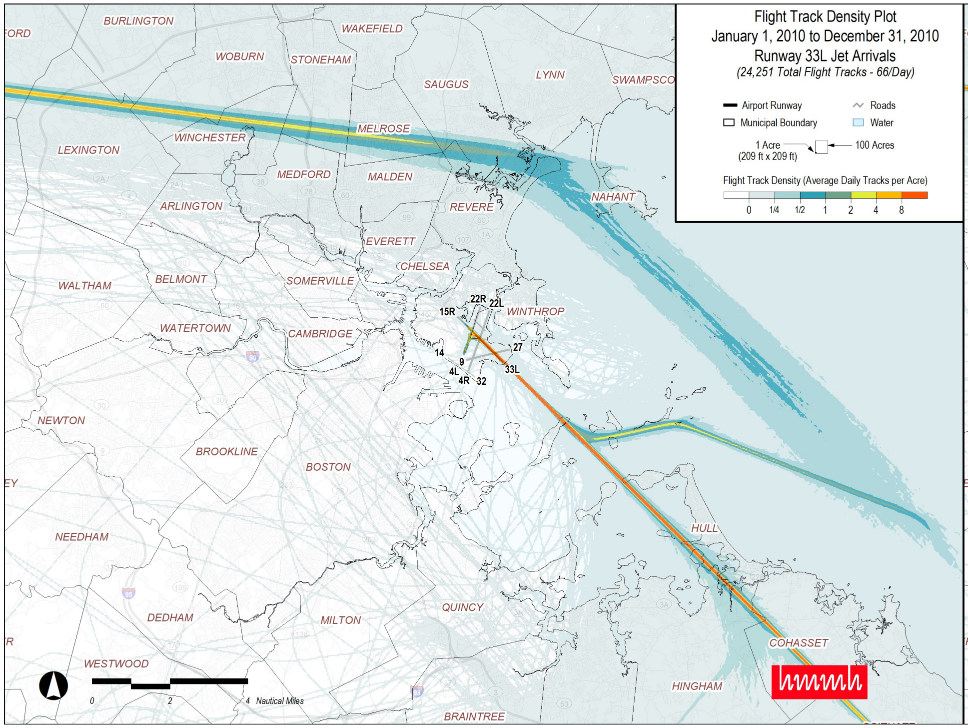
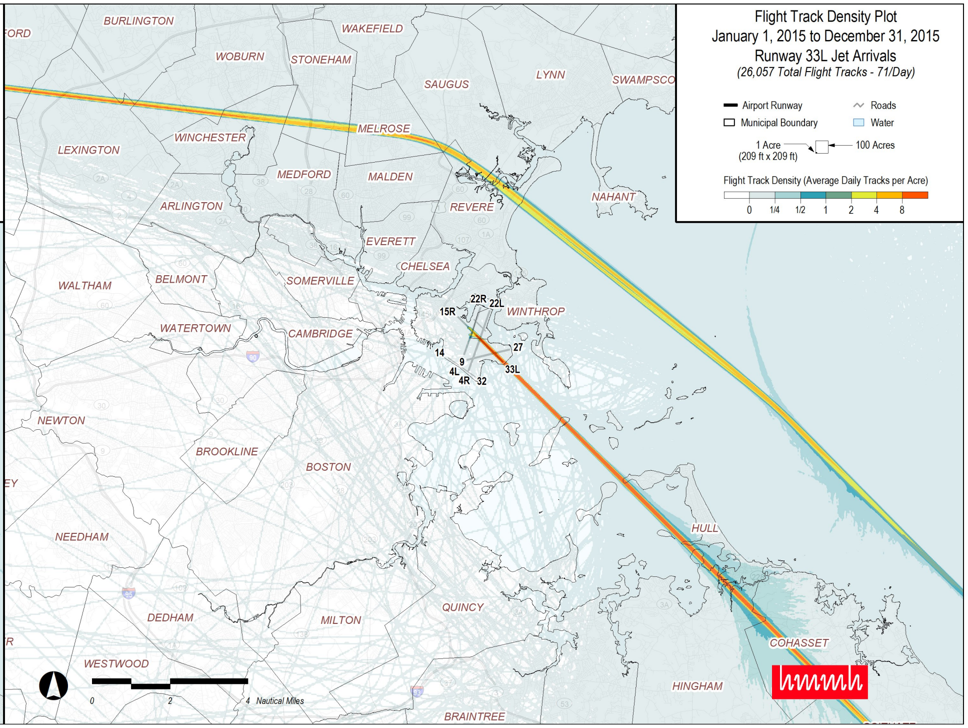
Block 1: Runway 33L
RNAV Approach and RNP Approach

Runway 33L Arrivals: 2010-2015

2010

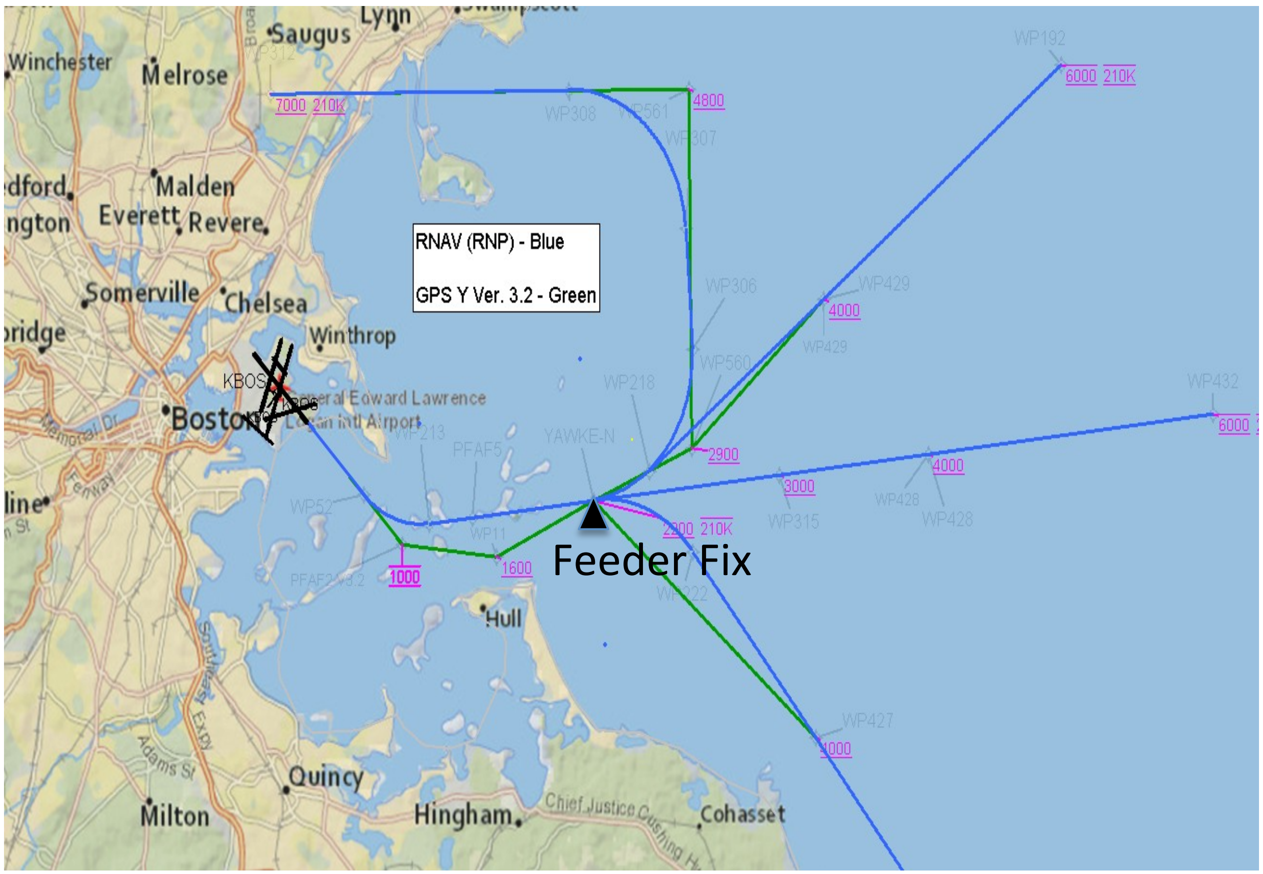


2015



33L RNAV and RNP Approach

- RNAV design criteria not able to fully meet noise objectives, so RNP designed to fully meet noise objectives
- RNAV and RNP designed similarly enough and with same feeder fix to allow for simultaneous use by ATC



FAA 7100.41 TARGETS file

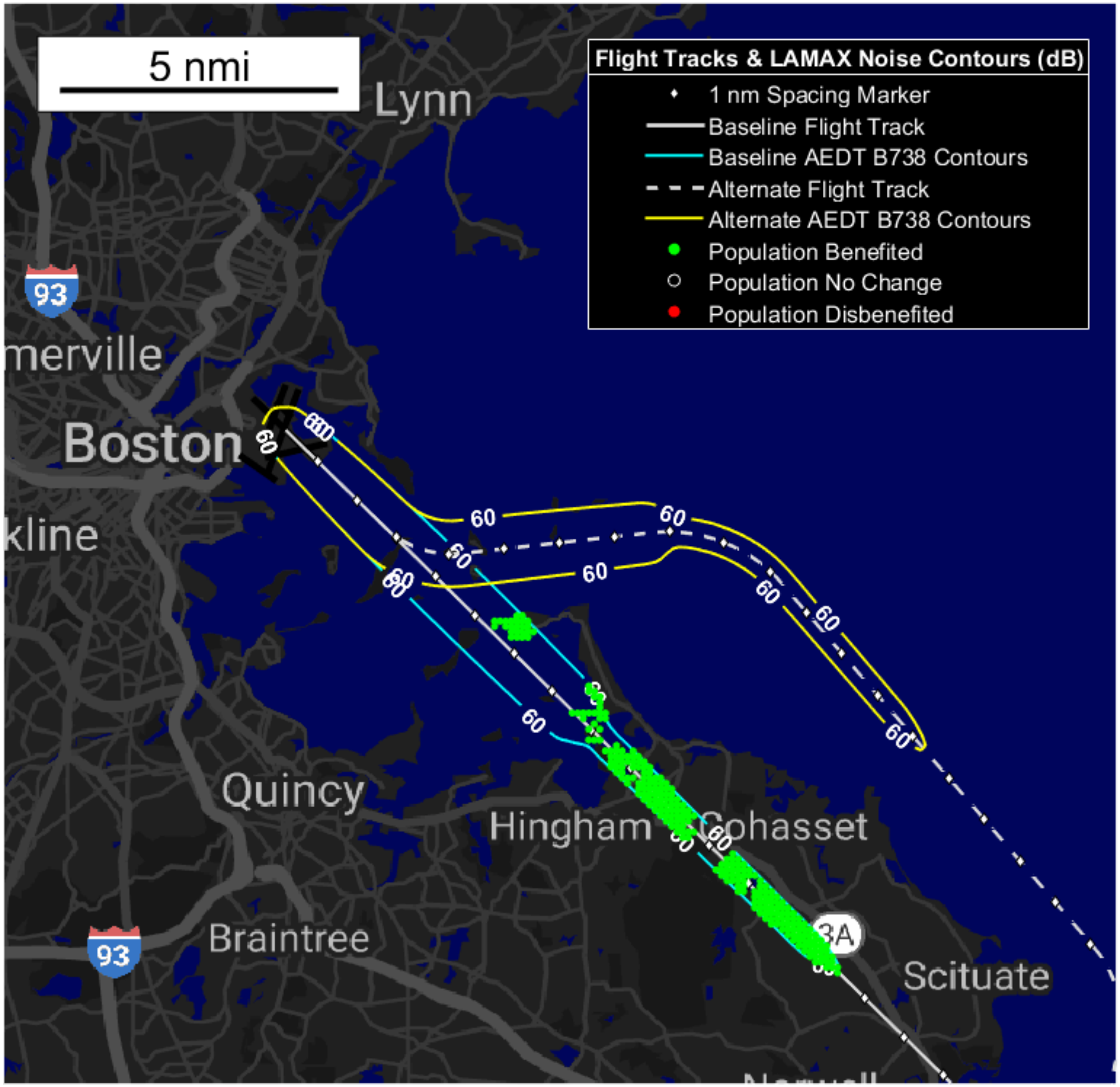
RNAV Approach in green

RNP Approach in blue

1-A1a 33L RNP Approach FAA 7100.41 Group Final

Status: Procedure design supported by FAA 7100.41 Group

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



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

	60dB
Straight In	2,954
RNP	0
Difference (Straight In–RNP)	2,954

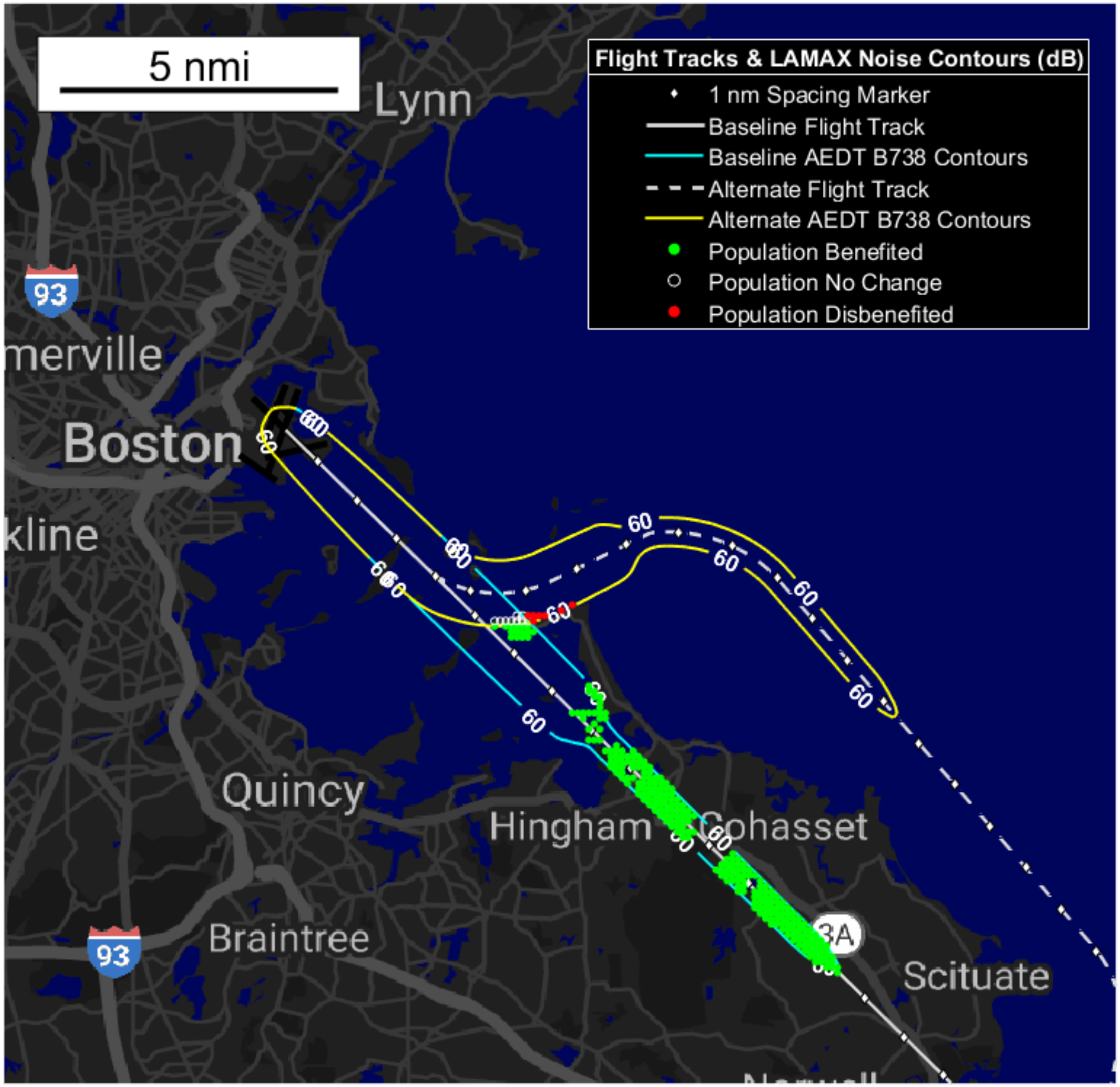
Implement an overwater RNP approach procedure to Runway 33L that follows the ground track of the jetBlue RNAV Visual procedure as closely as possible.

1-A1b: RNAV Visual procedures are distributed through the Lead Carrier who developed the procedure

1-A1a 33L RNAV GPS Approach FAA 7100.41 Group Final

Status: Procedure design supported by FAA 7100.41 Group

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



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

	60dB
Straight In	2,954
.41 RNAV GPS	396
Difference (Straight In– .41 RNAV GPS)	2,558

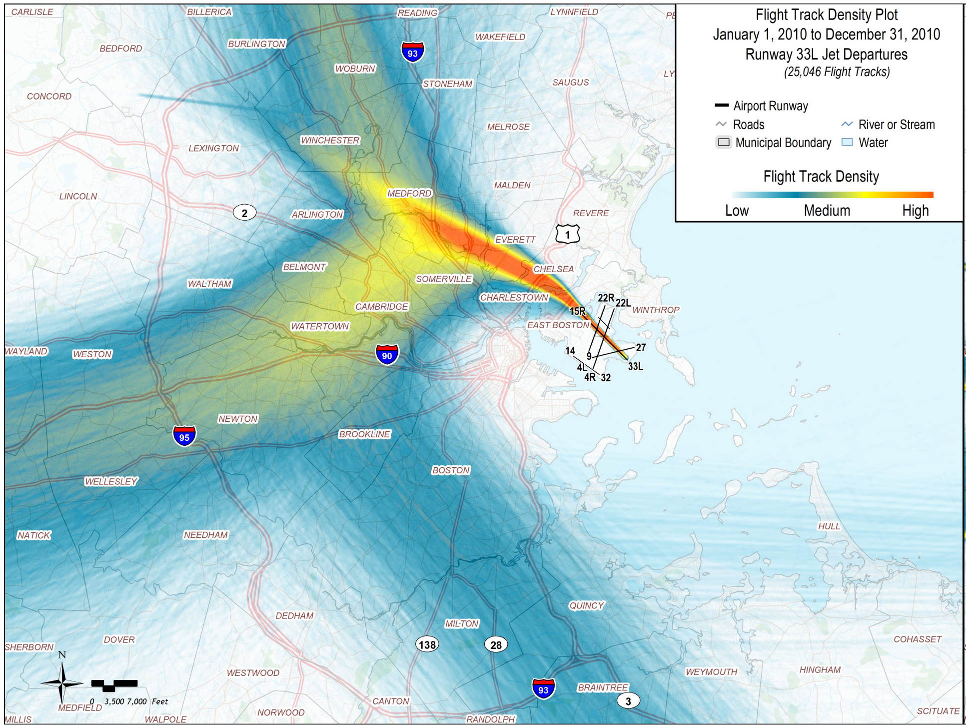
Implement an overwater RNAV approach procedure to Runway 33L that follows the ground track of the jetBlue RNAV Visual procedure as closely as possible.

Block 1: Reduced Speed Departures (1-D1)

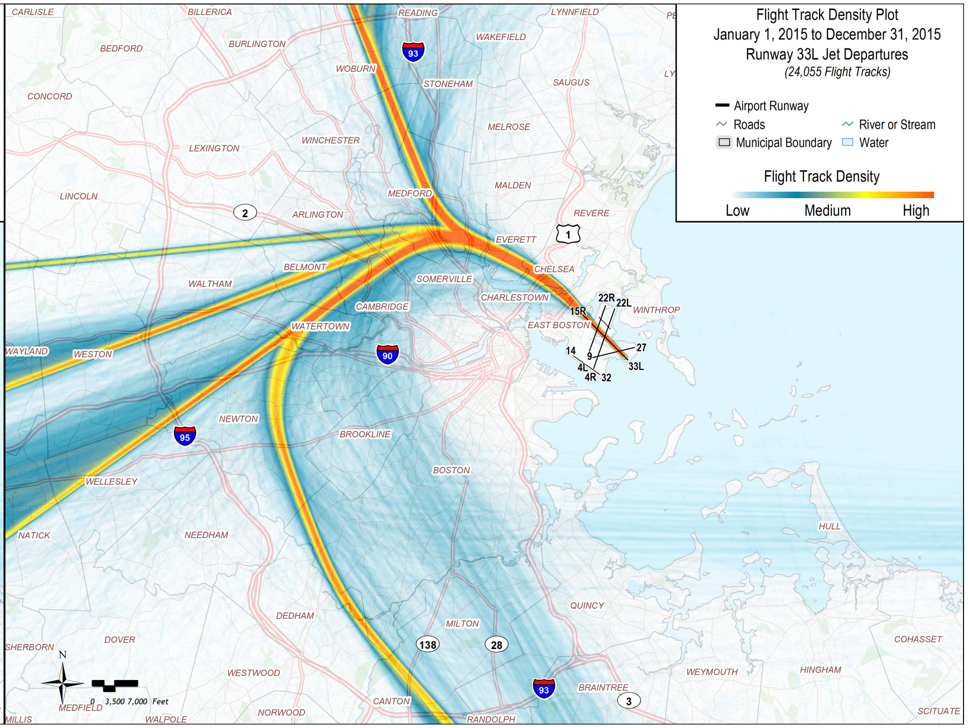
MIT ICAT

Runway 33L Departures: 2010-2015

2010

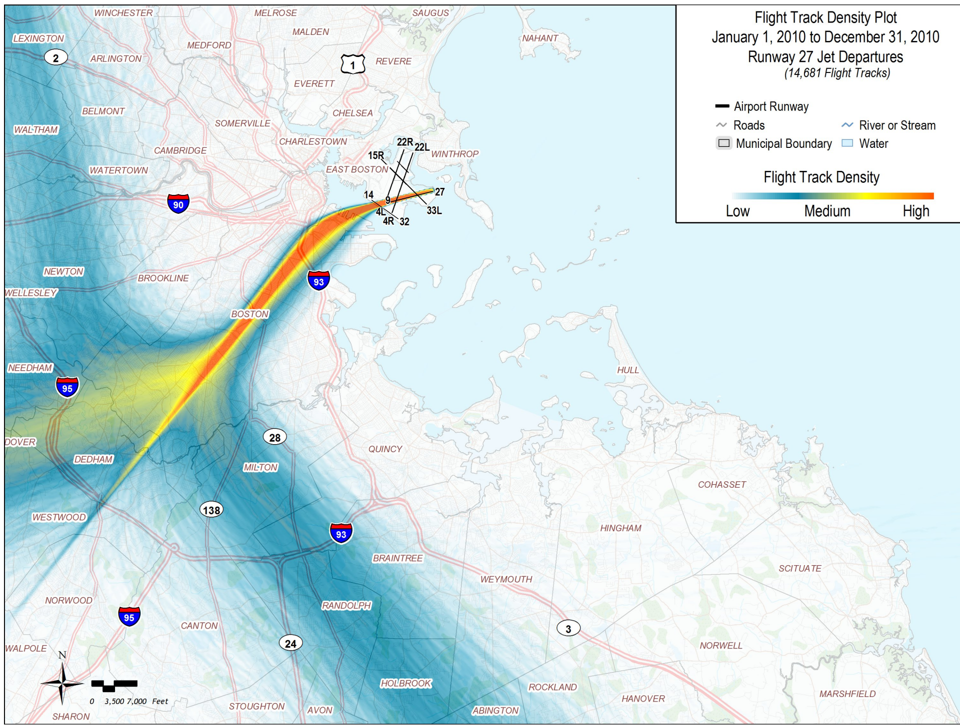


2015

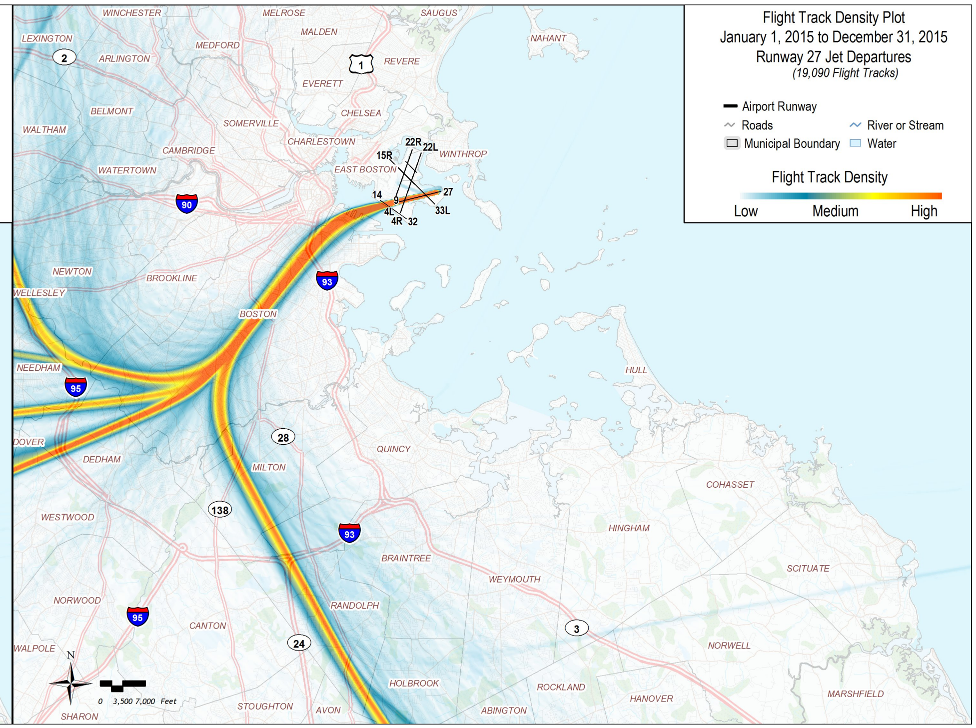


Runway 27 Departures: 2010-2015

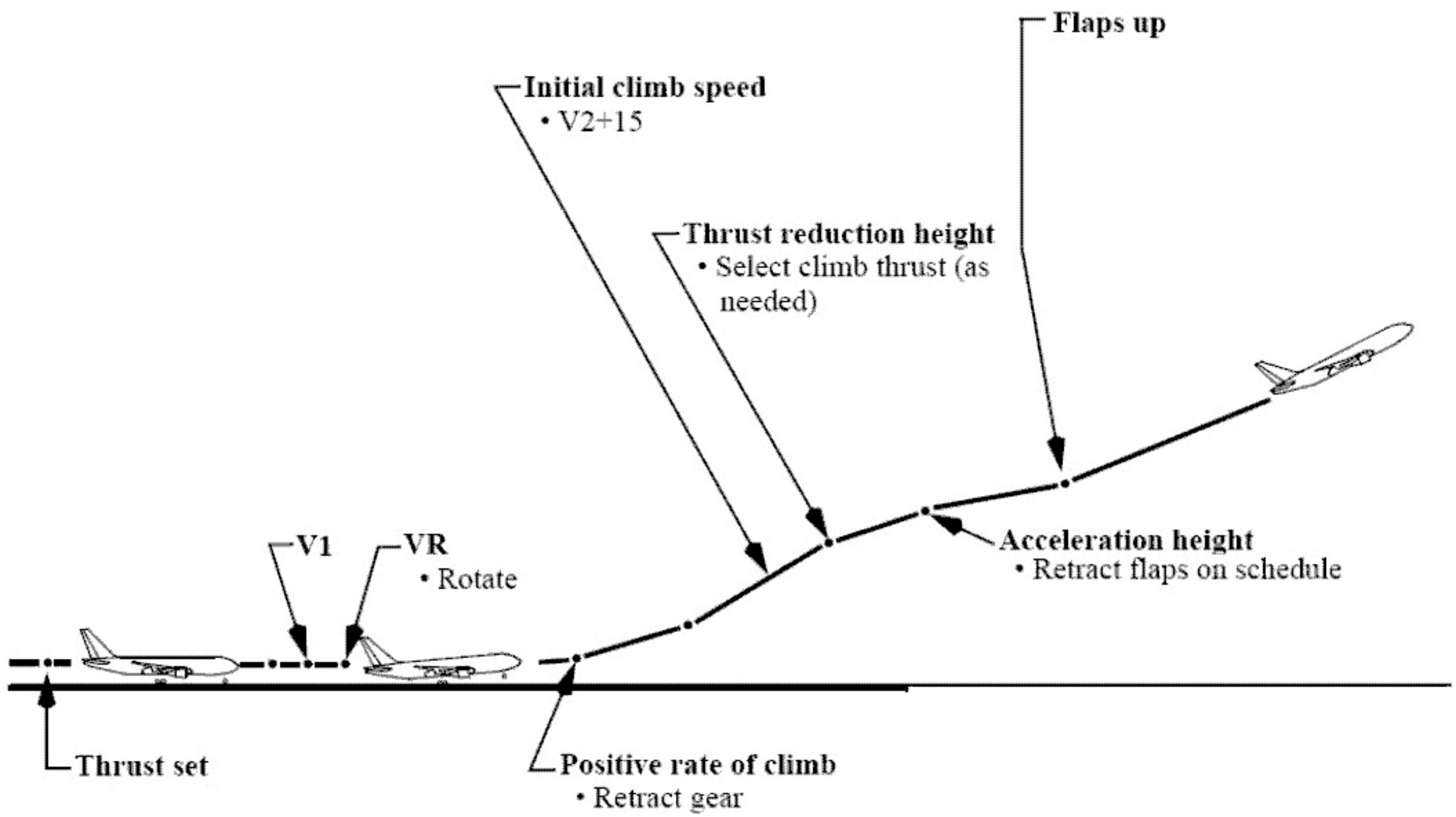
2010



2015



1-D1 Reduced Speed Departures

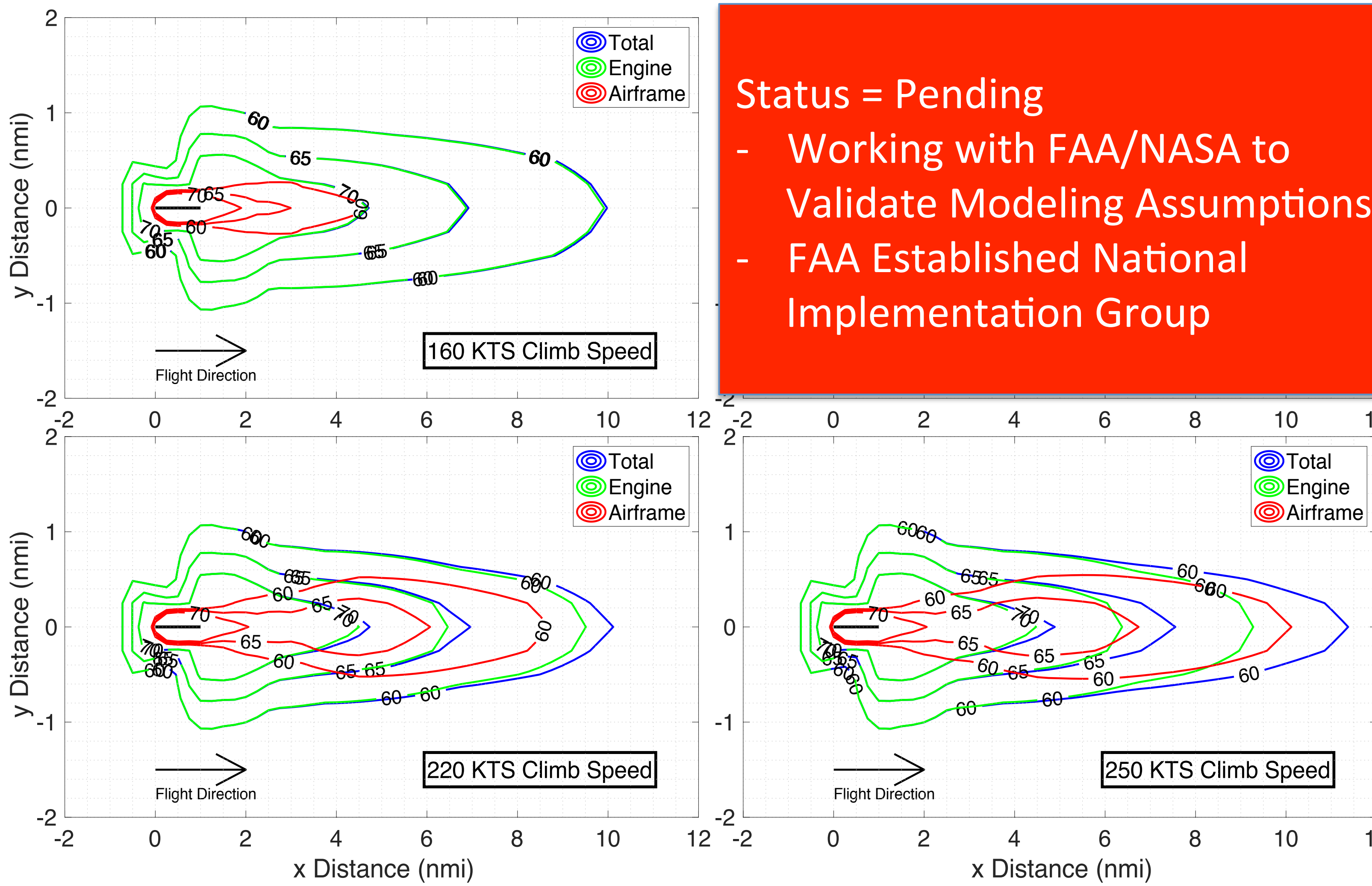


- **Baseline**: Typical profile includes thrust reduction at 1,000' AGL followed by an **acceleration to 250 kt climb speed** & **flap retraction**
- **Reduced Speed Departure**: thrust reduction at 1,000' AGL followed by an **acceleration to 220 kt climb speed or minimum clean airspeed to 10,000 ft**

Impact of Climb Speed

Matching Airframe to Engine Noise Level Minimizes Total

Boeing 737-800 Departure LAMAX Contours with Variations in Climb Speed



Status = Pending

- Working with FAA/NASA to Validate Modeling Assumptions
- FAA Established National Implementation Group

Aerodynamic noise sensitive to "Wing Cleanliness" coefficient in ANOPP

Currently resolving with NASA & exploring clean airframe flight test validation opportunities

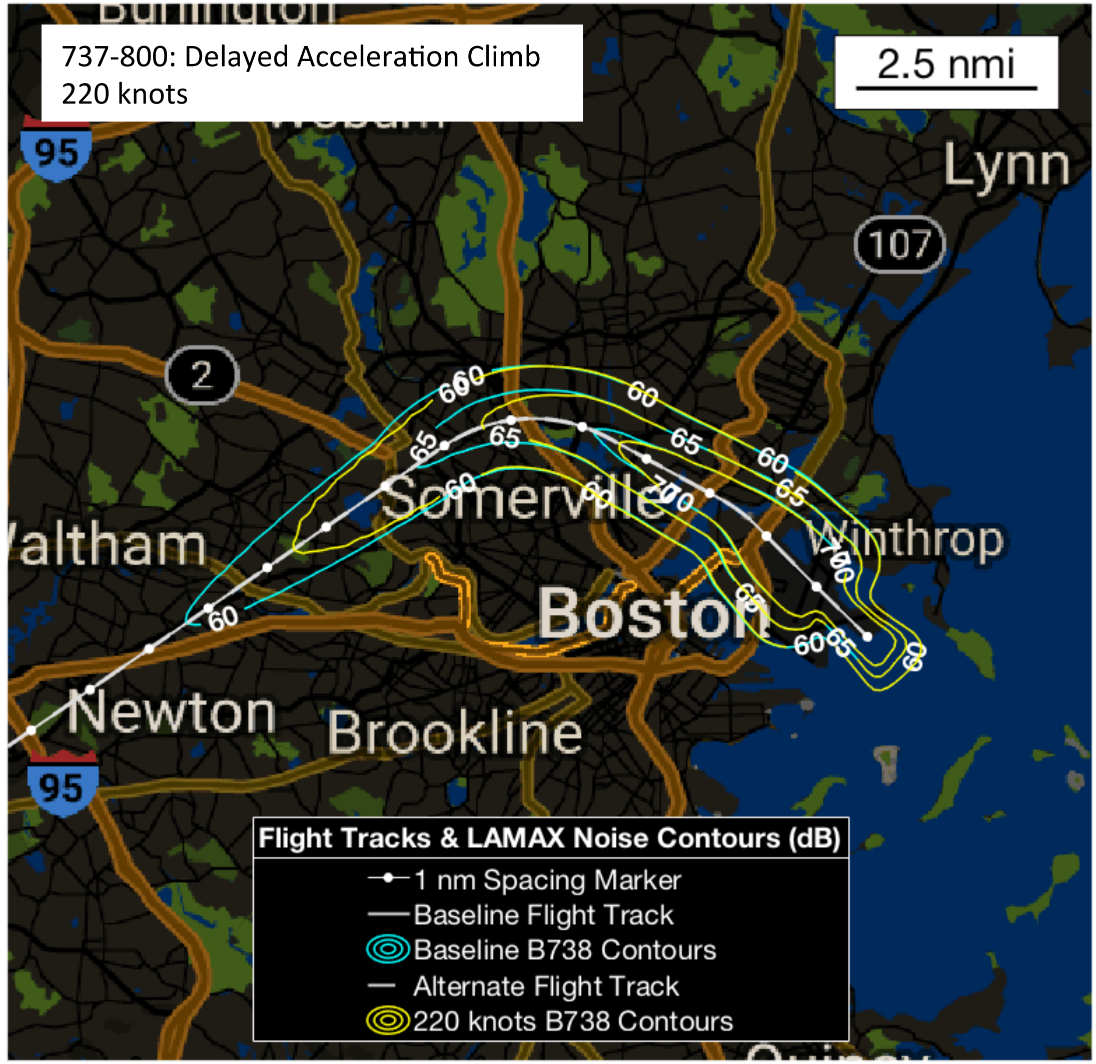
1-D1 Reduced Speed Departures

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

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

	60dB
Baseline	187,106
Reduced Speed Departure	162,558
Baseline – Alternate	24,548

Analysis assumes higher airframe noise assumption
Working with FAA/NASA to Validate Modeling Assumptions



1-D1 Reduced Speed Departures

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

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

	60dB
Baseline	178,973
Reduced Speed Departure	169,397
Baseline – Alternate	9,576

Analysis assumes higher airframe noise assumption
Working with FAA/NASA to Validate Modeling Assumptions

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Block 2 Examples:

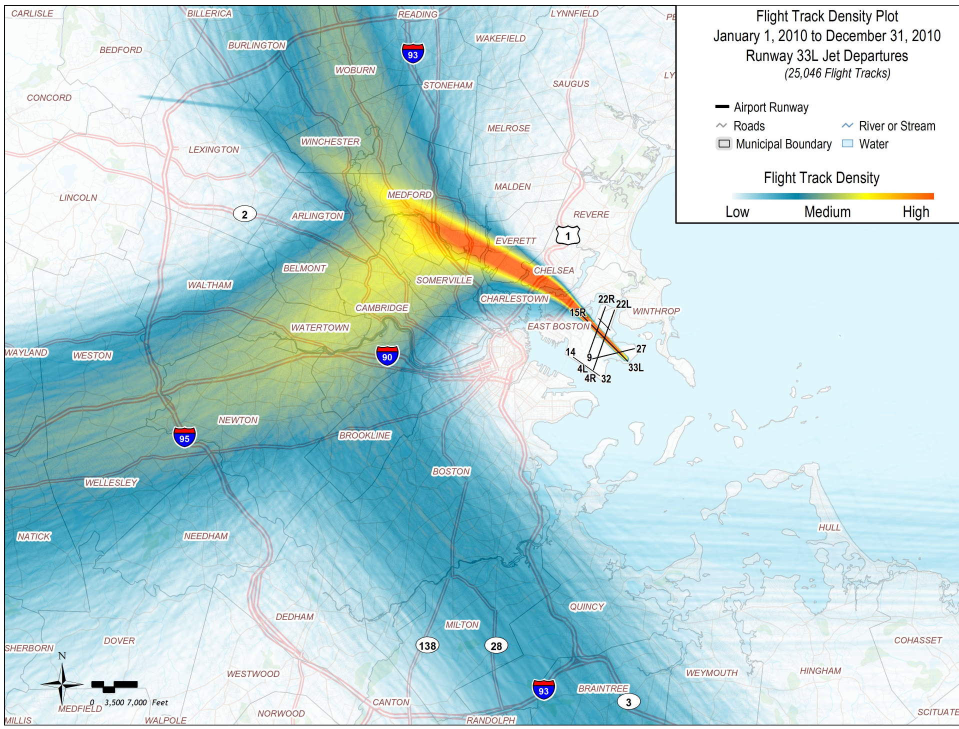
More complex due to potential operational/technical barriers or equity issues

Block 2: Runway 33L and 27 Departures – Re-Introduce Dispersion

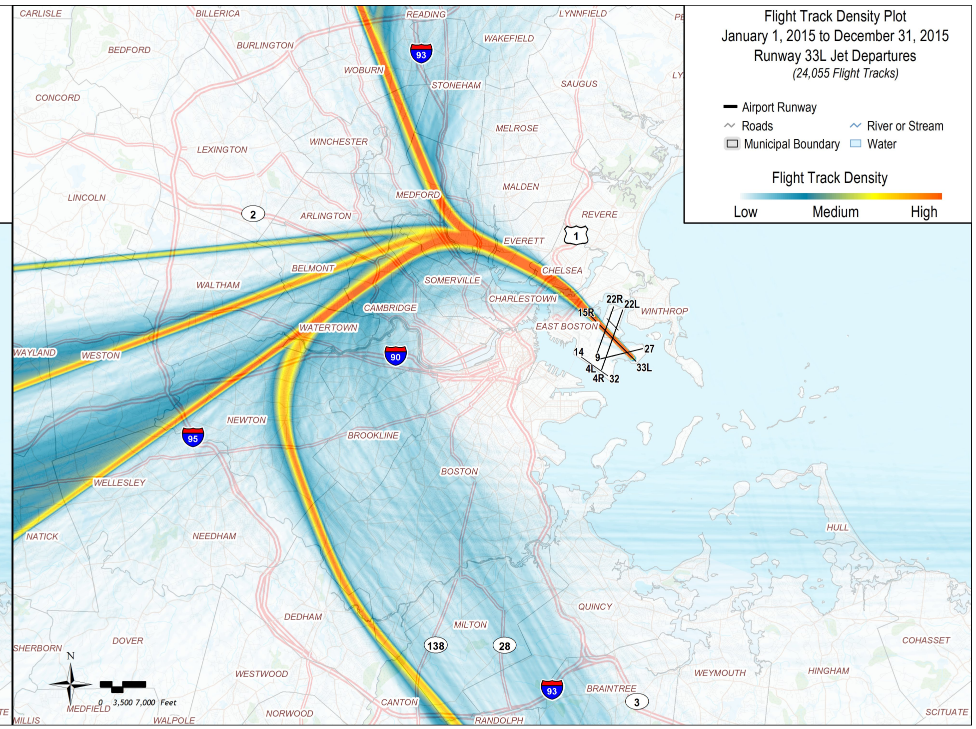
Runway 33L Departures: 2010-2015

Using Open SIDs or Flexible SIDs to Re-introduce Dispersion

2010



2015

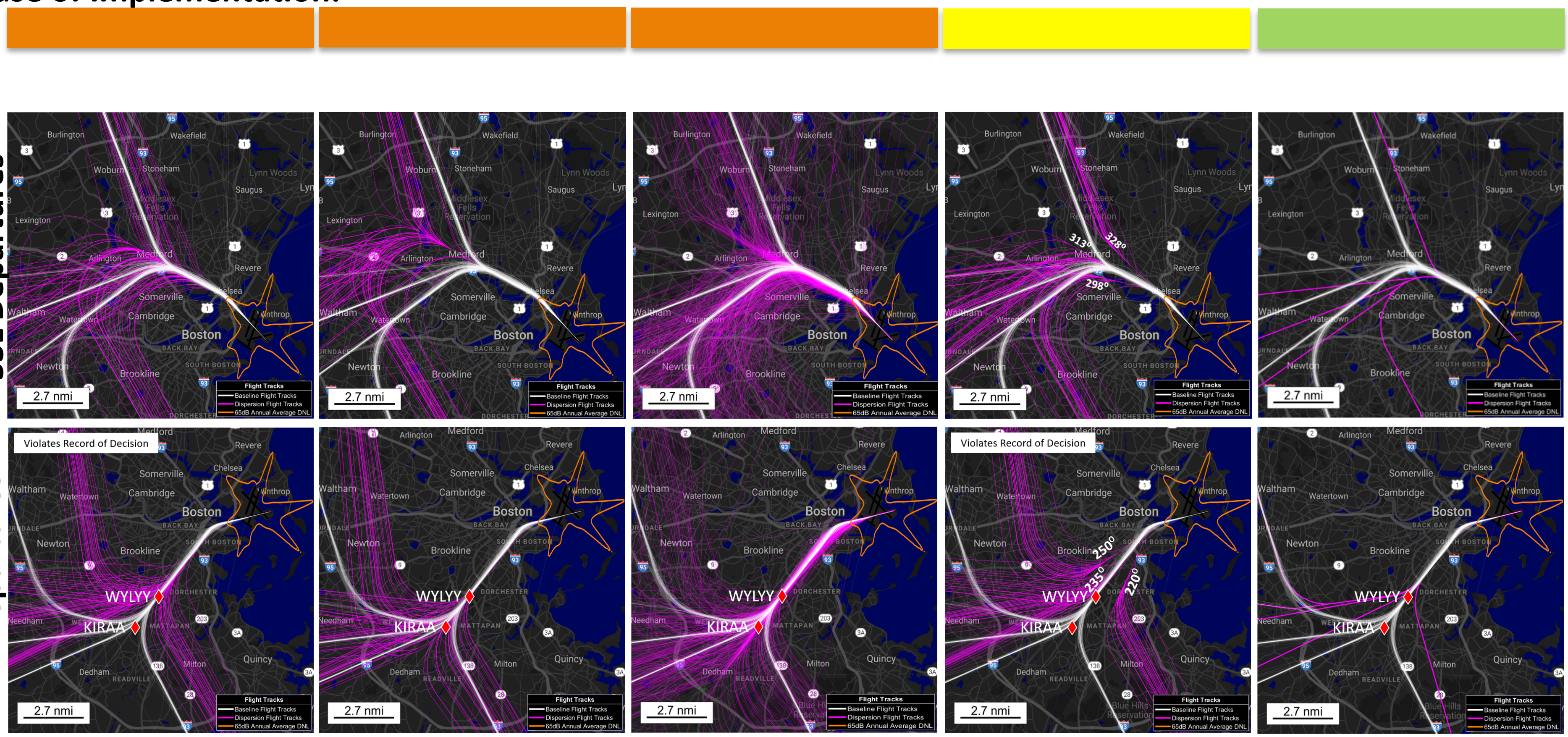


Dispersion Concepts

Ease of Implementation:

33L Departures

27 Departures



Altitude-Based 3000ft

Altitude-Based 4000ft

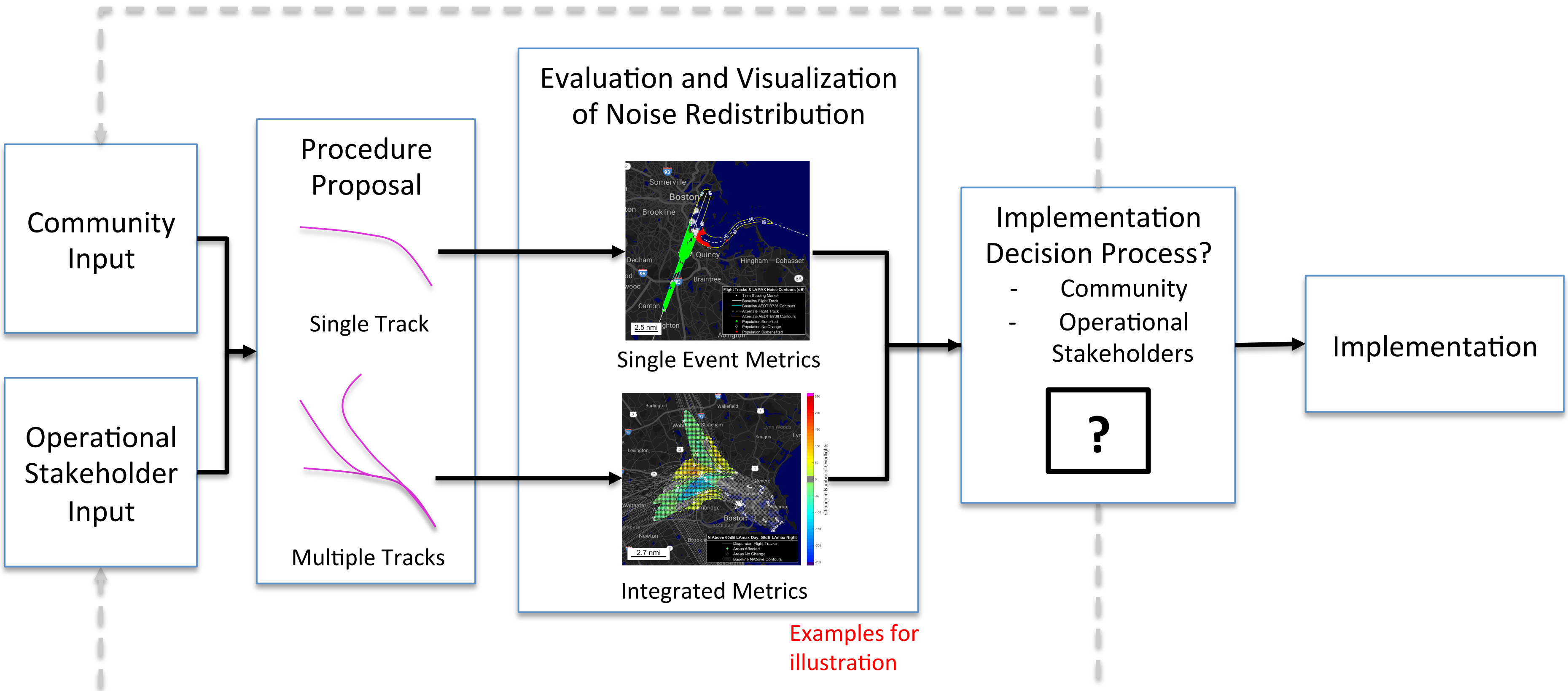
Controller-Based

Divergent Headings

RNAV Waypoint Relocation

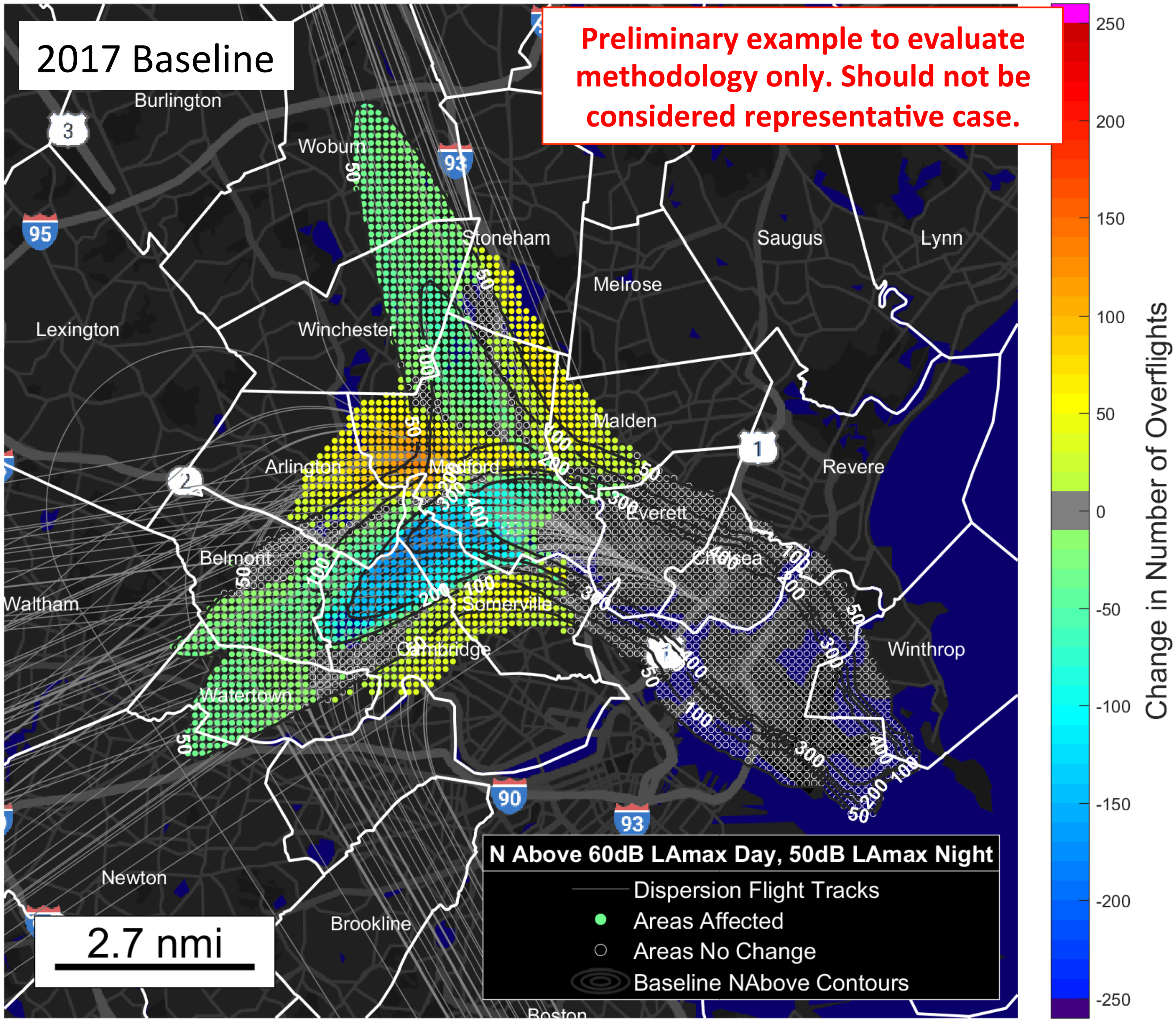
Preliminary examples to evaluate methodology only. Should not be considered representative case.

Need for Community Decision Process for Procedures with Noise Redistribution



Developing Methods to Communicate the Results of Procedure Changes

33L Departures Altitude-Based Dispersion at 3000ft Change in N_{60} Compared to 2017



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

Population Exposure

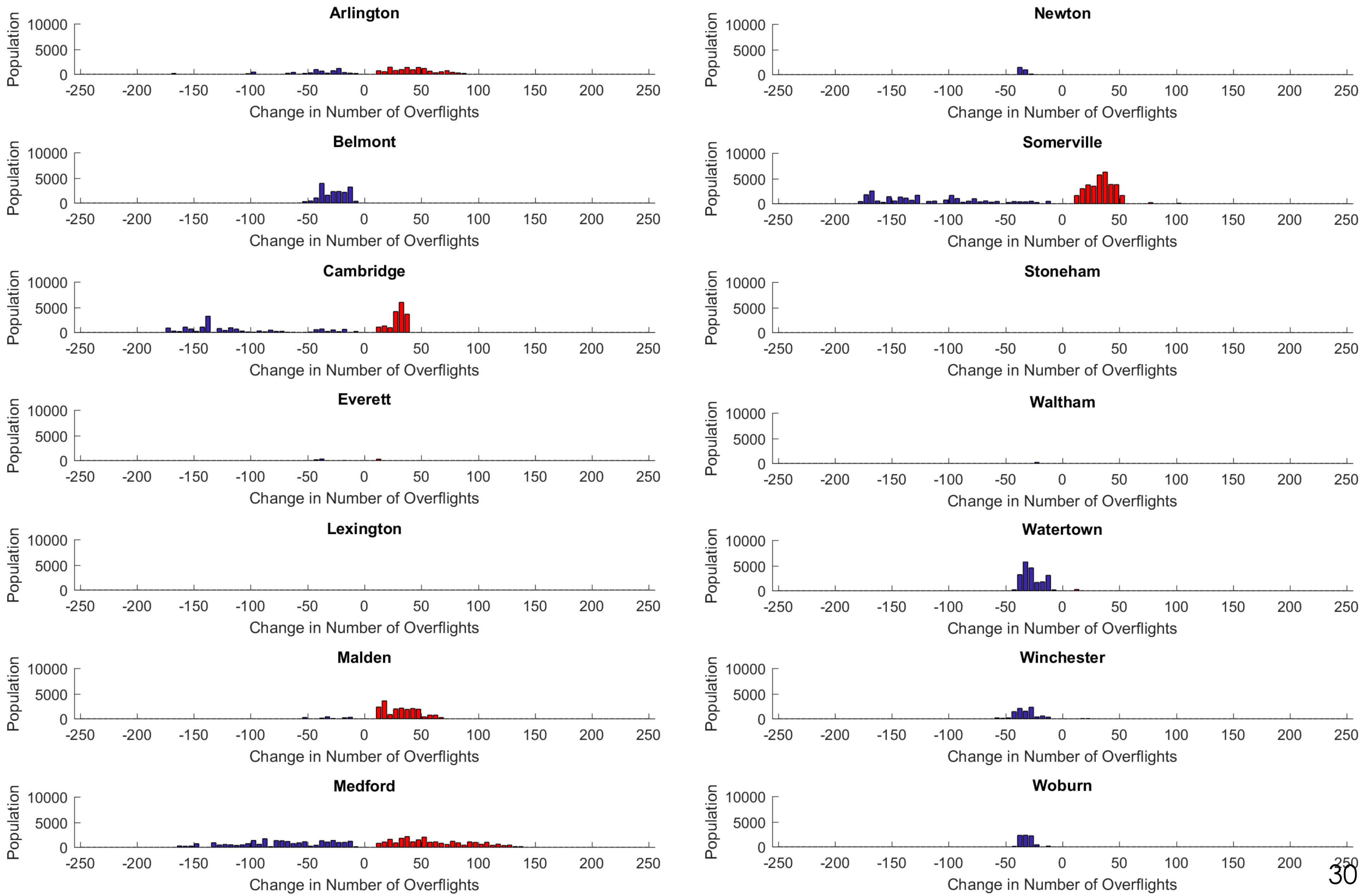
N_{60}	50x
Baseline 2017	336,643
Dispersion	342,387
Baseline - Dispersion	-5,744

Analysis updated Dec 4 2018 to correct for discretization differences

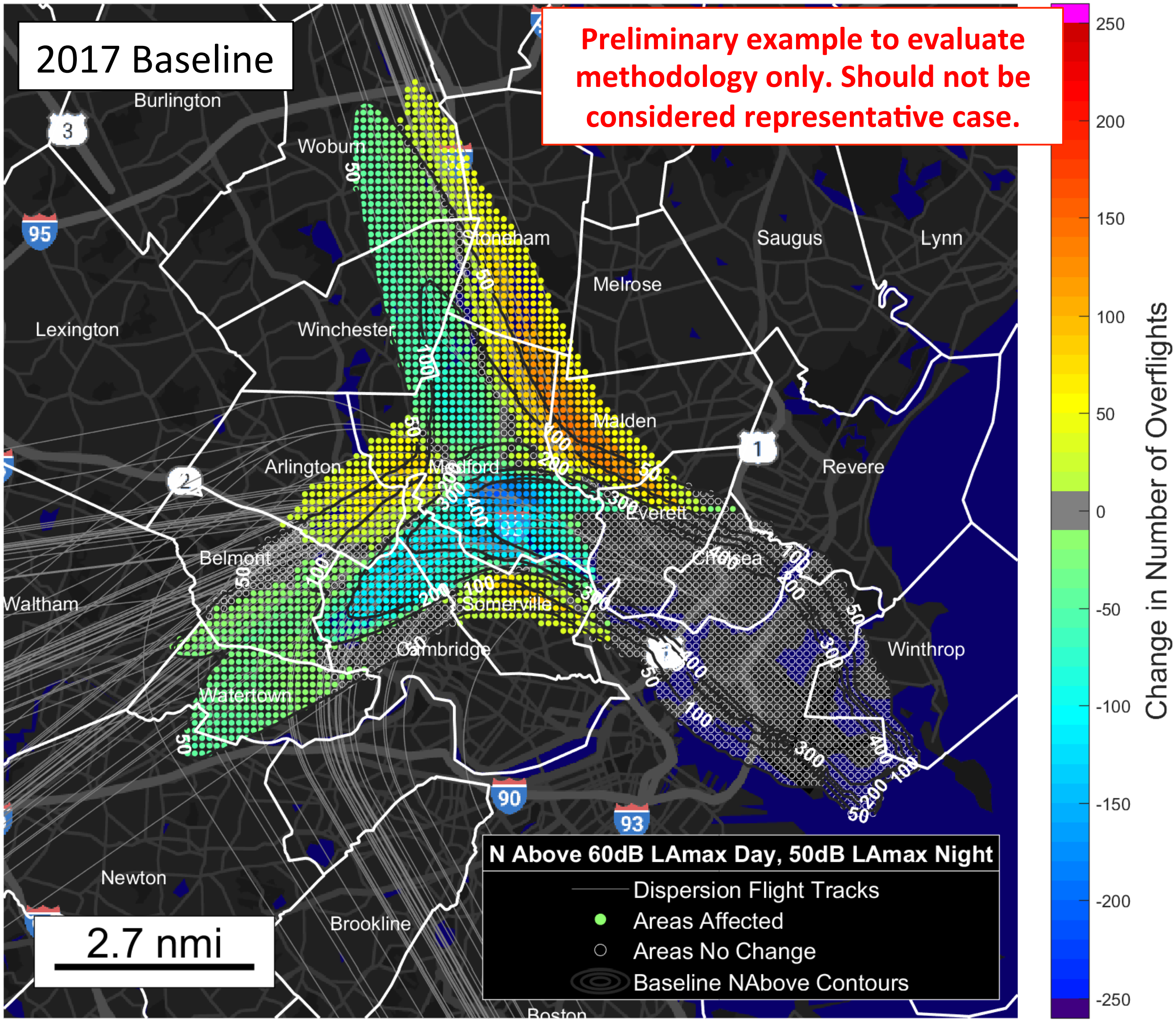
Change In N_{60}	Population
+200x	0
+100x	3,870
+50x	22,300
-50x	51,577
-100x	31,561
-200x	0

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

33L Departures Altitude-Based Dispersion at 3000ft
Change in N_{60} Compared to 2017



33L Departures Divergent Headings Dispersion Change in N_{60} Compared to 2017



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

Population Exposure

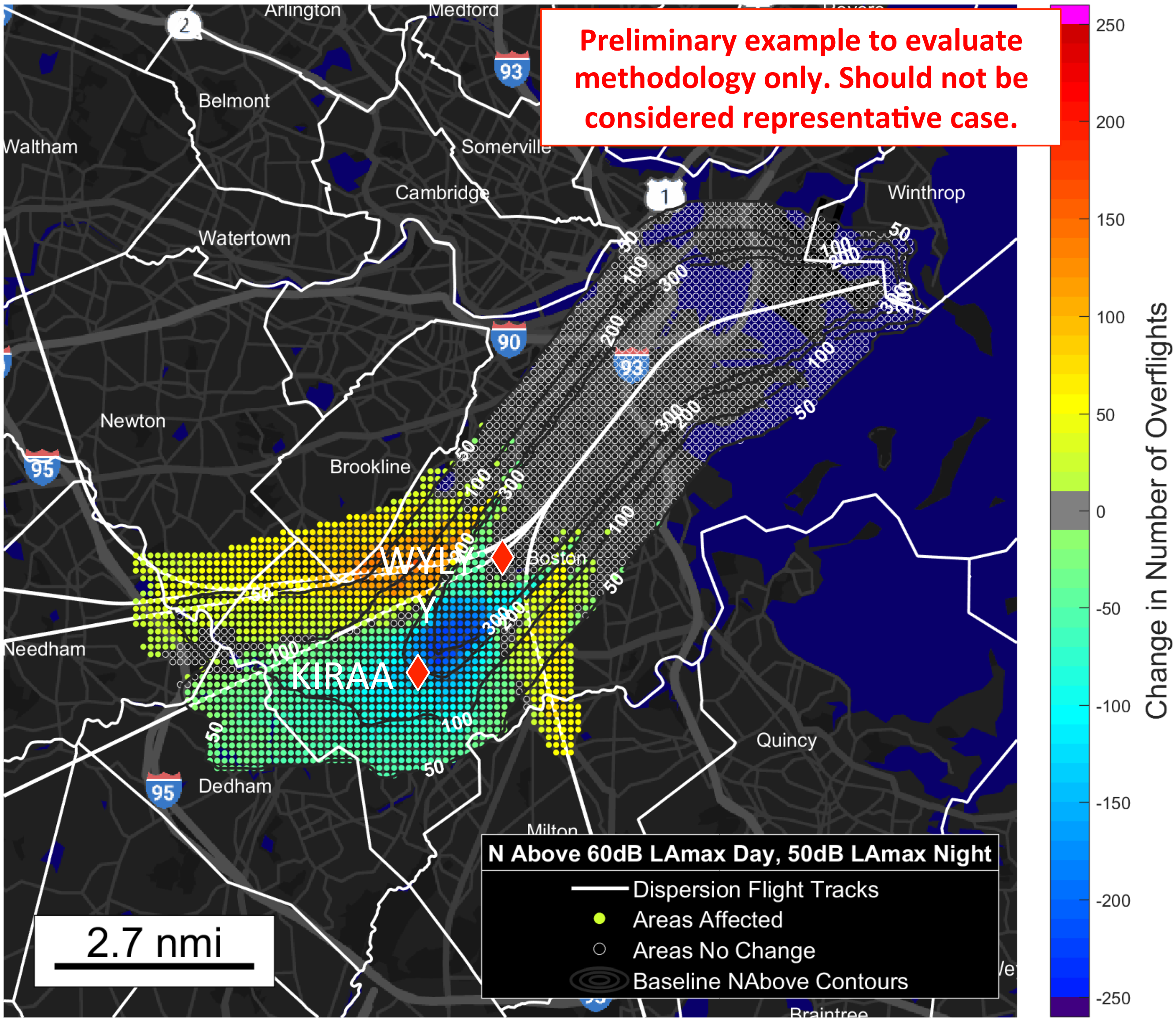
N_{60}	50x
Baseline 2017	336,643
Dispersion	334,305
Baseline - Dispersion	2,338

Analysis updated Dec 4 2018 to correct for discretization differences

Change In N_{60}	Population
+200x	0
+100x	13,651
+50x	47,885
-50x	62,772
-100x	31,545
-200x	0

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

27 Departures RNAV Waypoint Relocation
Change in N_{60} Compared to 2017



Analysis based on peak day operations; only includes 27 departures

Population Exposure

N_{60}	50x
Baseline 2017	407,357
Dispersion	388,449
Baseline - Dispersion	18,908

Analysis updated Dec 4 2018 to correct for discretization differences

Change In N_{60}	Population
+200x	0
+100x	5,105
+50x	30,578
-50x	49,067
-100x	20,423
-200x	4,415

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

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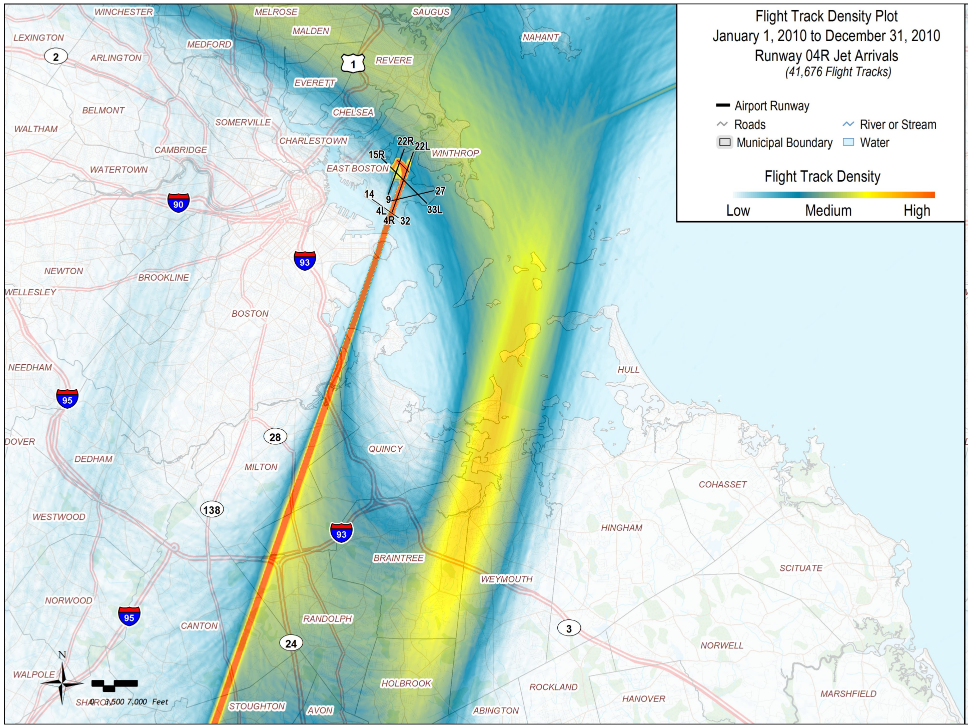
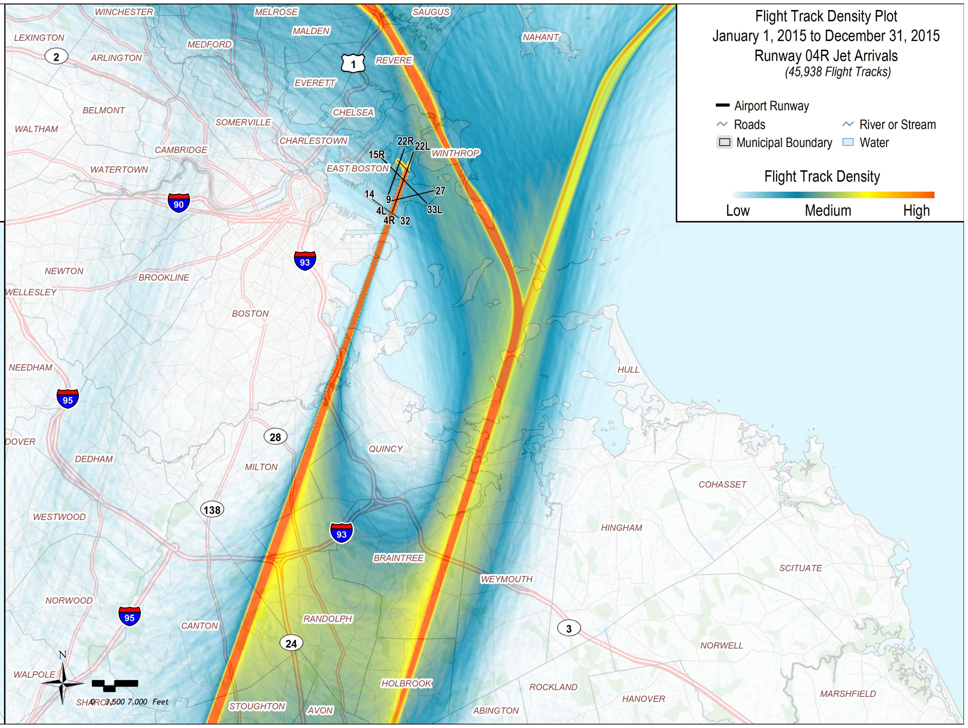
Block 2: Runway 4 Arrivals
Delayed Deceleration Approaches

Runway 4R Arrivals: 2010-2015

2010



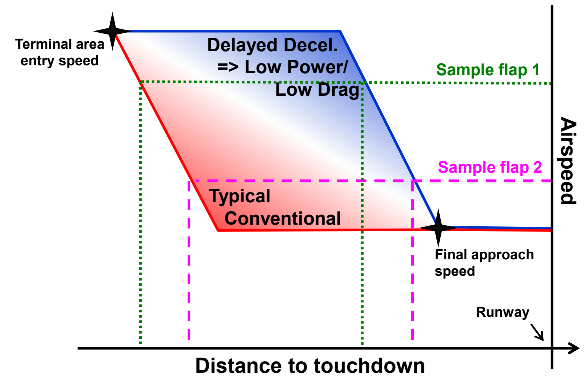
2015



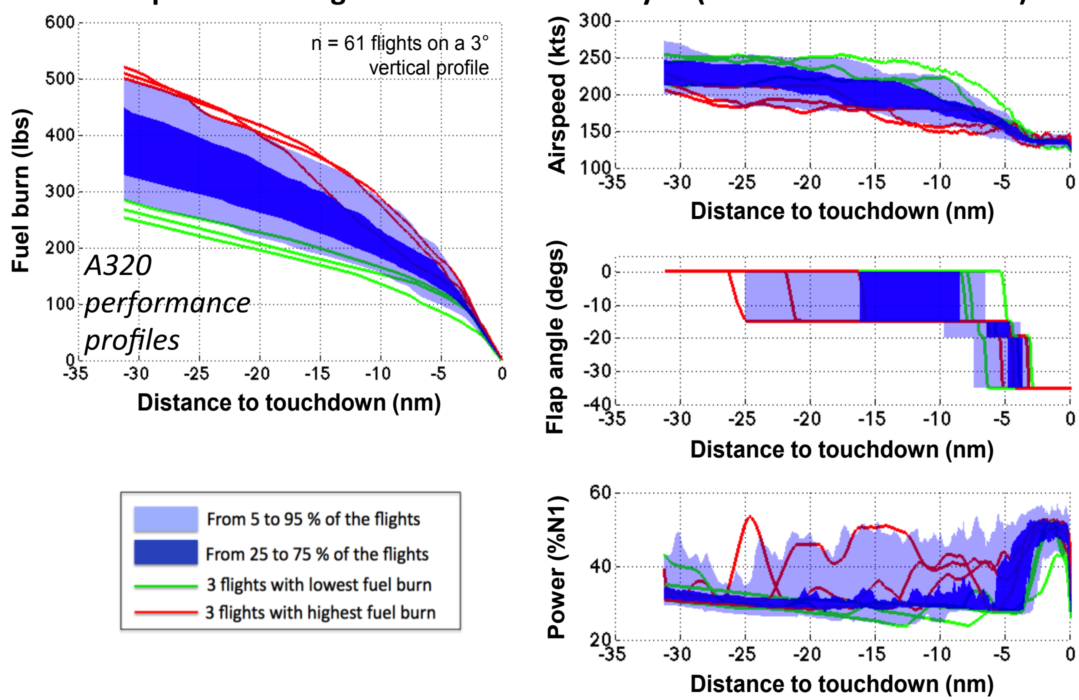
Delayed Deceleration Approaches (DDAs)

- In conventional approaches, aircraft decelerate early in the approach
- DDAs provide potential for fuel burn & noise reduction[1]
- In DDAs, initial flap speed velocity held as long as possible during approach to lower drag and thrust requirements
  - Lower thrust levels reduce engine noise
  - Higher velocities increase airframe noise

Conventional Approach vs. DDA[1]

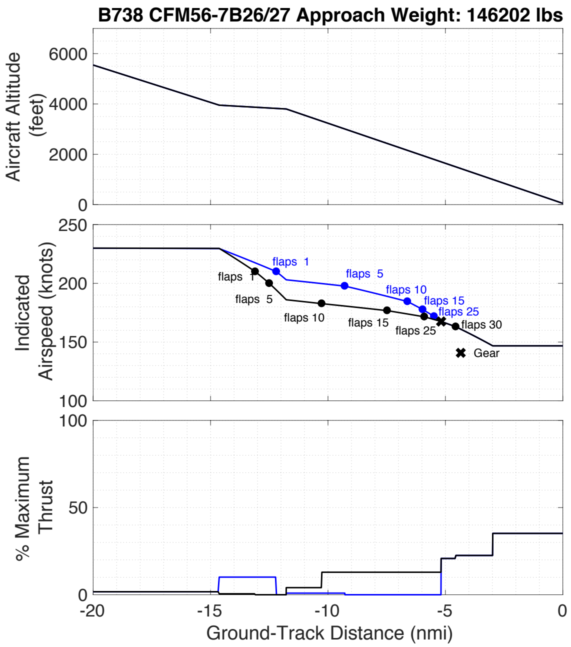


European A320 Flight Data Recorder Analysis (similar for B757 & B777)[2]

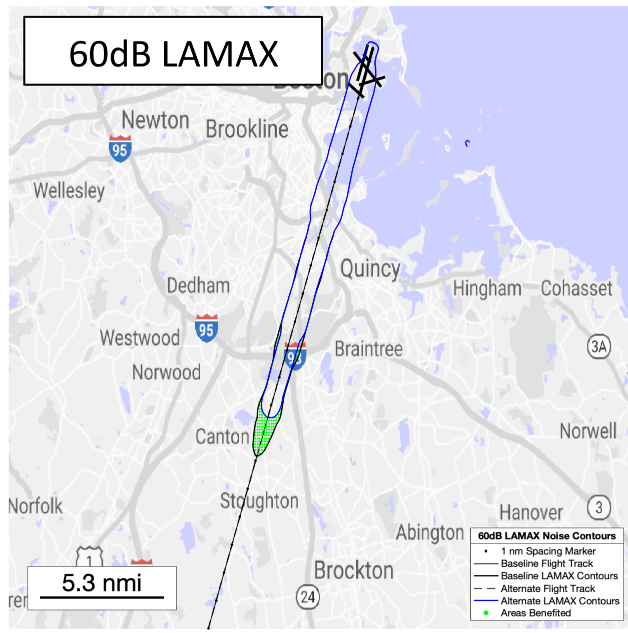


[1] Dumont, J., et al. (2012)
[2] Dumont, J., et al. (2011)

Standard Approach vs DDA
4000 ft Level Off, B738 (Boeing/Guo Flaps Method)

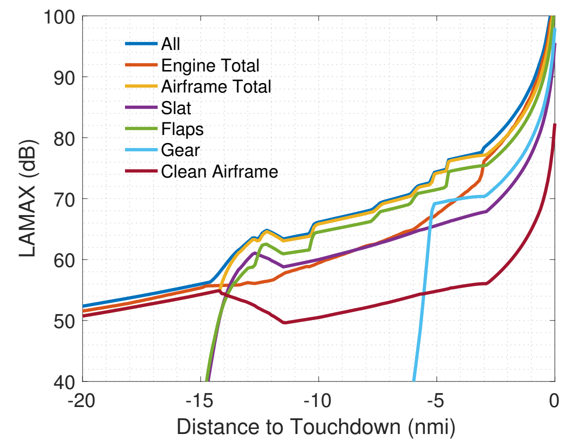


60 dB Contour Comparison

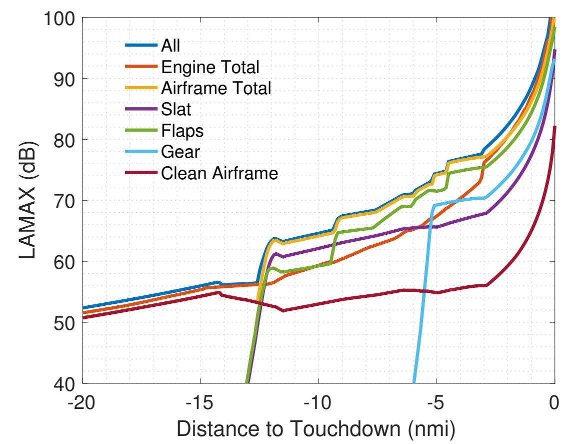


Under Flight Track

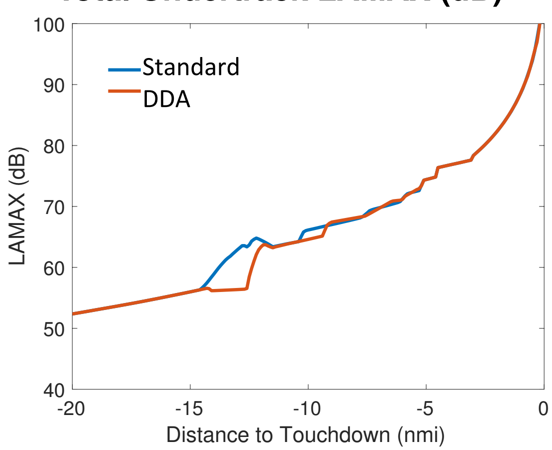
Standard:



DDA:



Total Undertrack LAMAX (dB)



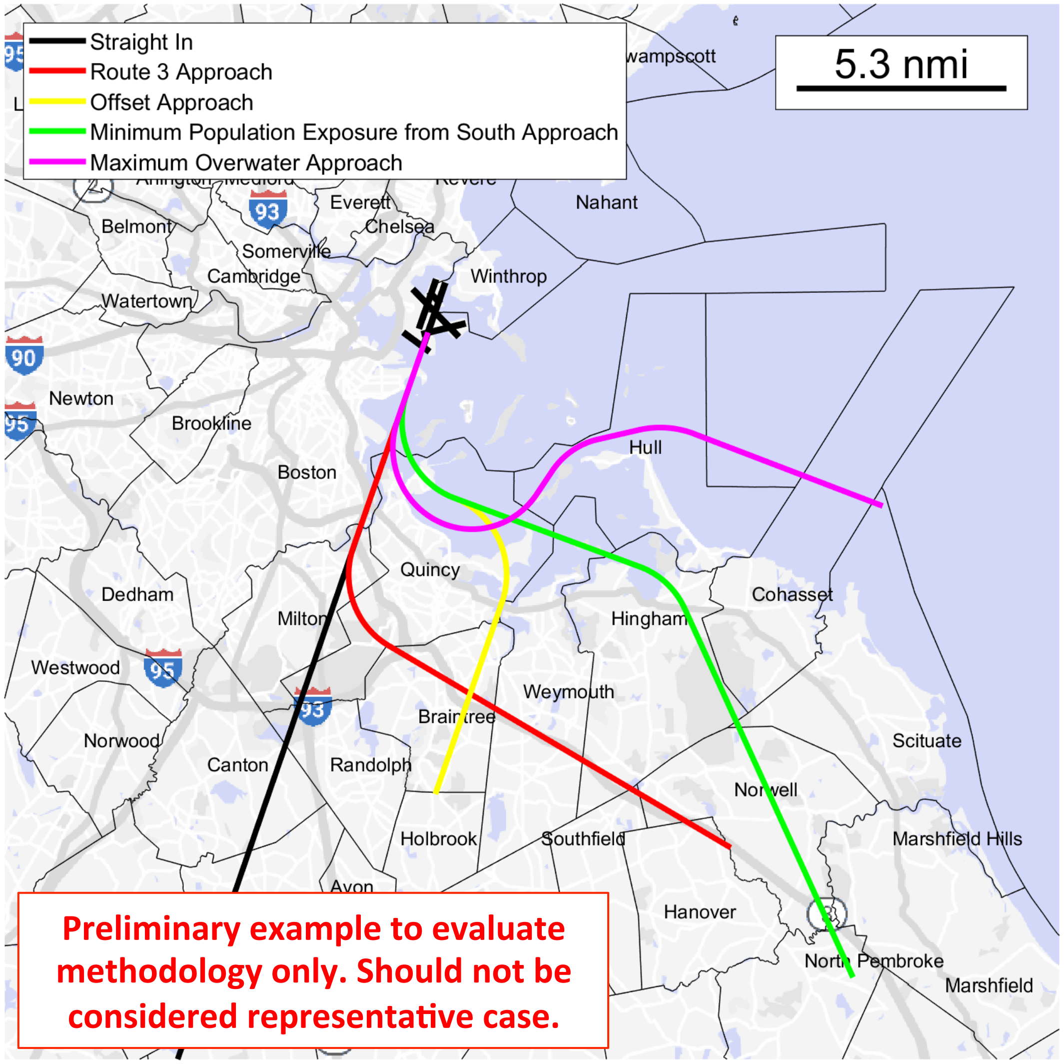
Population Exposure

$L_{A,max}$	60 dB	65 dB	70 dB
Standard	36,139	16,310	4,131
DDA	35,085	16,242	4,131
Difference	1,054	68	0

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

Block 2: Runway 4R RNP Approach

Initial Examples of 4R RNP Approaches

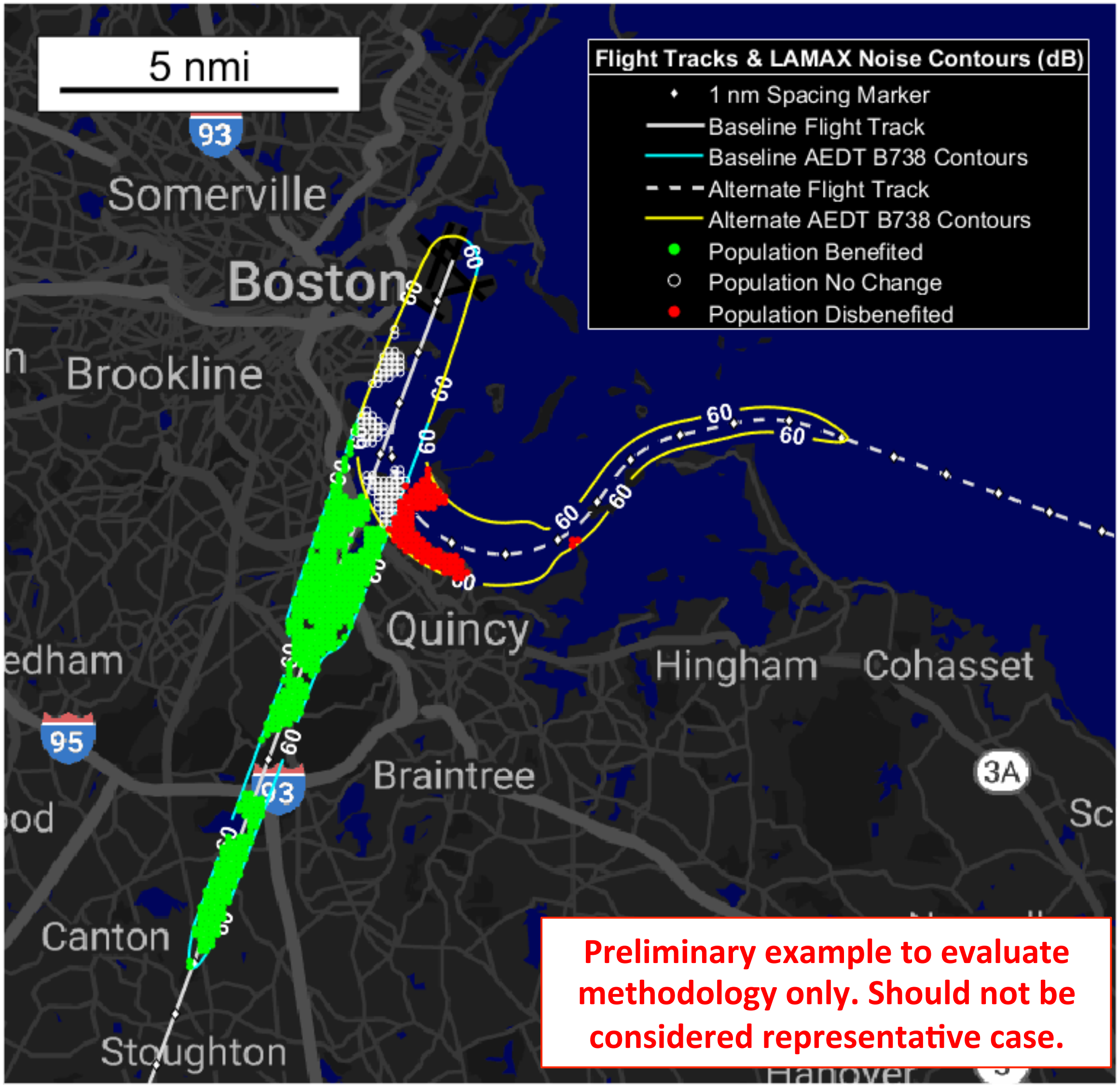


- Initial examples of possible approaches to 4R with flexibility of RNP technology

- RNP technology allows approach to be kept overwater near final approach

4R Arrival RNP – Maximum Overwater

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

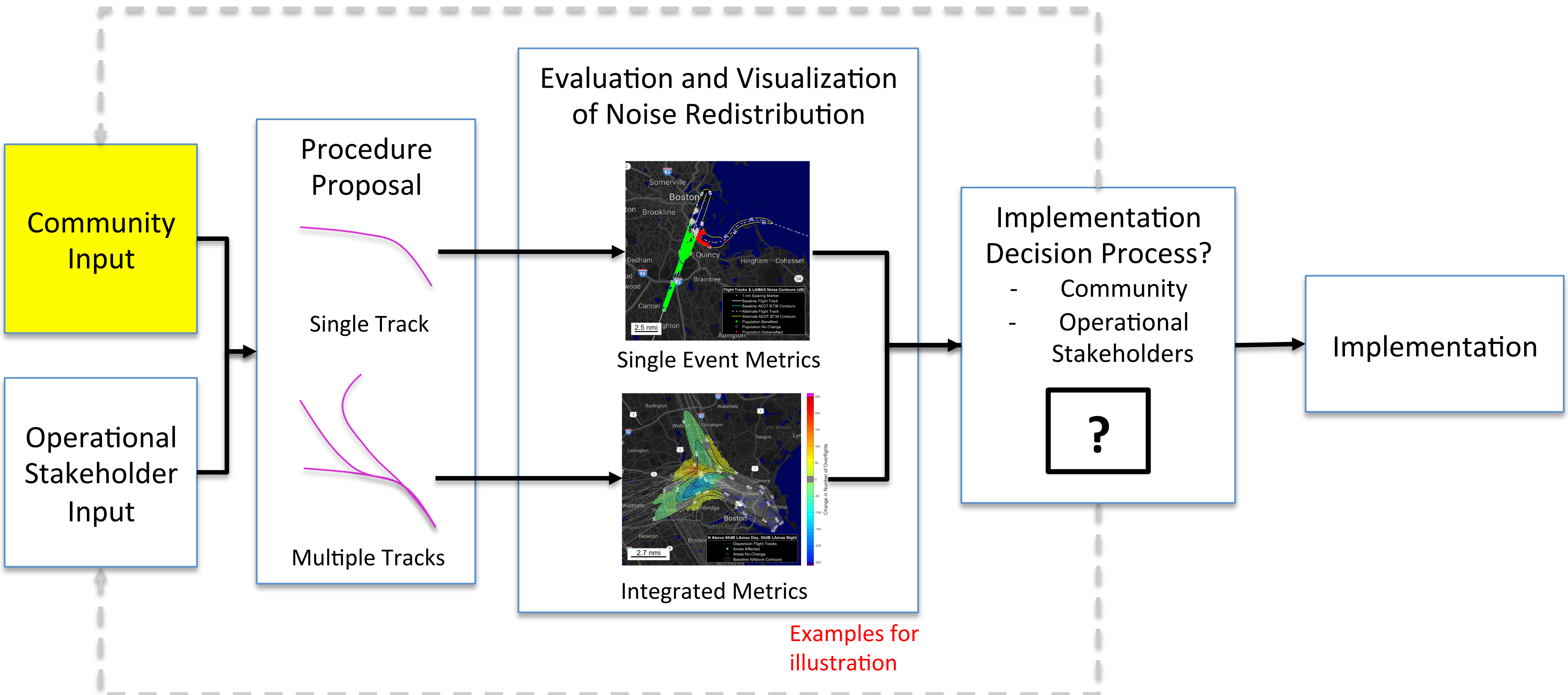


B737-800
Population Exposure ($L_{A,MAX}$)

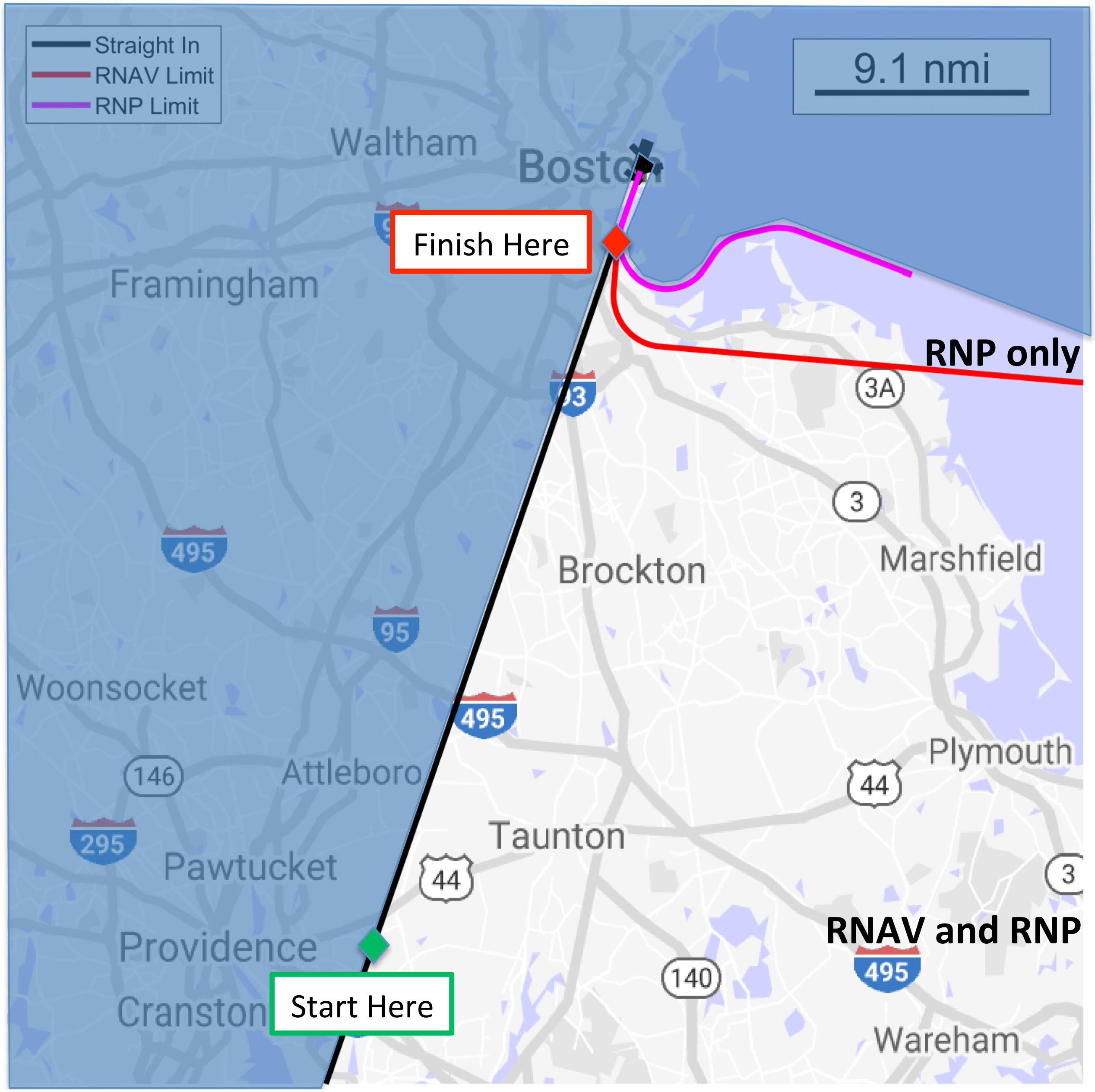
	60dB
Straight In	32,144
RNP	20,754
Difference (Straight In – RNP)	11,390

Different routes for 4R arrivals still under analysis

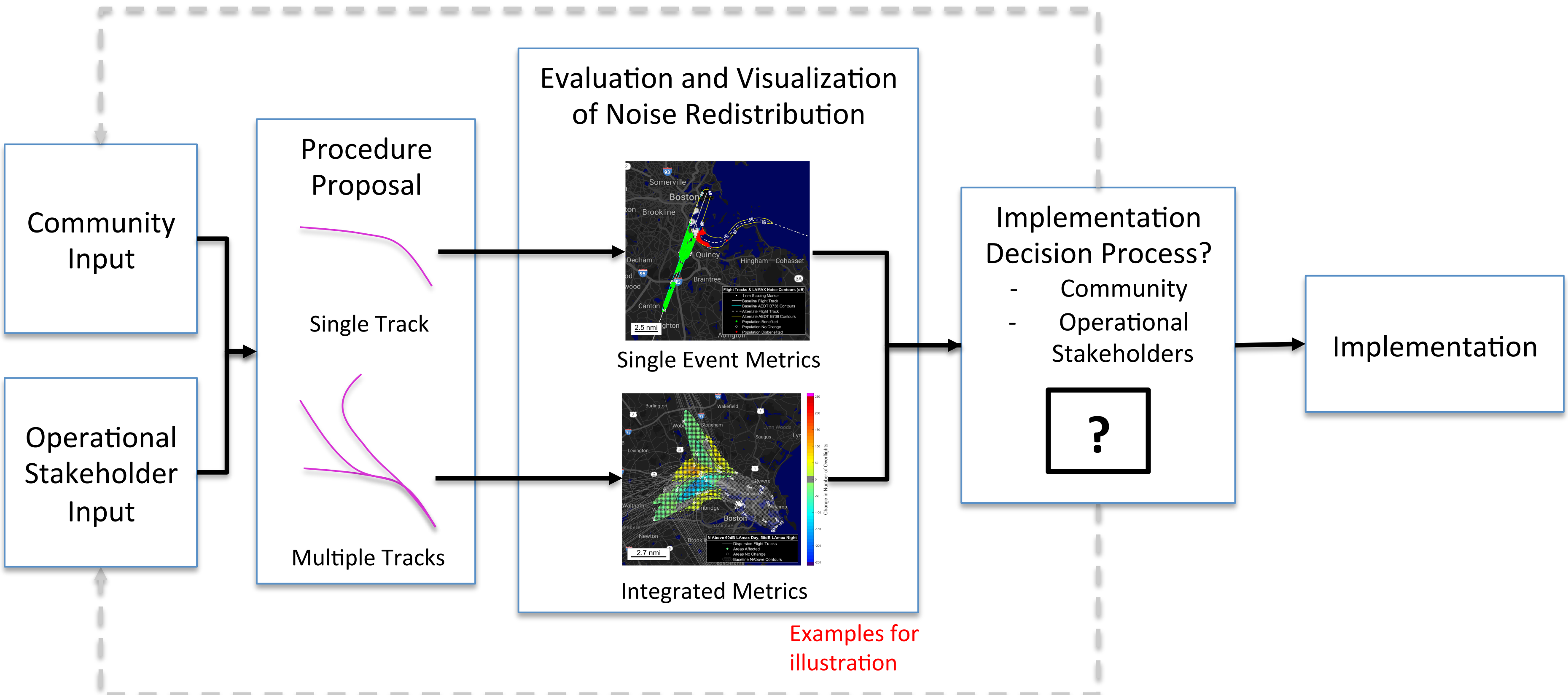
Mechanisms for Community Input Procedures with Noise Redistribution



RNAV and RNP Design Space



Need for Community Decision Process for Procedures with Noise Redistribution



Discussion