Massport Community Advisory Committee
One Broadway, 14th Floor
Cambridge, MA 02142

May 26, 2020

(VIA ELECTRONIC MAIL)
Massport CAC Members

RE: RNAV Study Block 2 Runway 33L Departures Updated Analysis

Dear Massport CAC Members:

On May 15, 2020, Dr. John Hansman provided a regional briefing to Massport CAC representatives whose communities are included in the 33L Departures Block 2 analysis. Attached you will find the slides presented by Dr. Hansman at that meeting. We anticipate that FAA staff will brief the full Massport CAC on this topic at our June meeting as part of their RNAV Study update.

This briefing was the first of a series of briefings we expect to hold as we bring the RNAV Study to conclusion. Dr. Hansman has offered to provide a one-time briefing for each group of communities impacted by the options analyzed by MIT. Much like this 33L Departures briefing, these upcoming regional briefings will allow communities to focus solely on the options that impact them, and to receive answers to questions directly from Dr. Hansman. MIT's presentations at the Massport CAC General Meetings are intended to provide an overview and status update of the entire RNAV study, rather than the in-depth review these regional briefings offer.

We will work with Massport and MIT to facilitate upcoming regional briefings for the remaining options being evaluated in Block 2 of the RNAV Study.

Let me know if you have any questions.

Sincerely,

Matthew A. Romero
Massport CAC Executive Director

Enc: MIT Runway 33L Departure Update Presentation

cc: (via electronic mail)
David Carlon, MCAC Chairman
Flavio Leo, Massport Director of Aviation Planning and Strategy
Anthony Gallagher, Massport Community Relations
Colleen D'Alessandro, ANE-1, FAA New England Regional Administrator

MIT
International Center for
Air Transportation

RWY 33L Departure Update

May 13, 2020

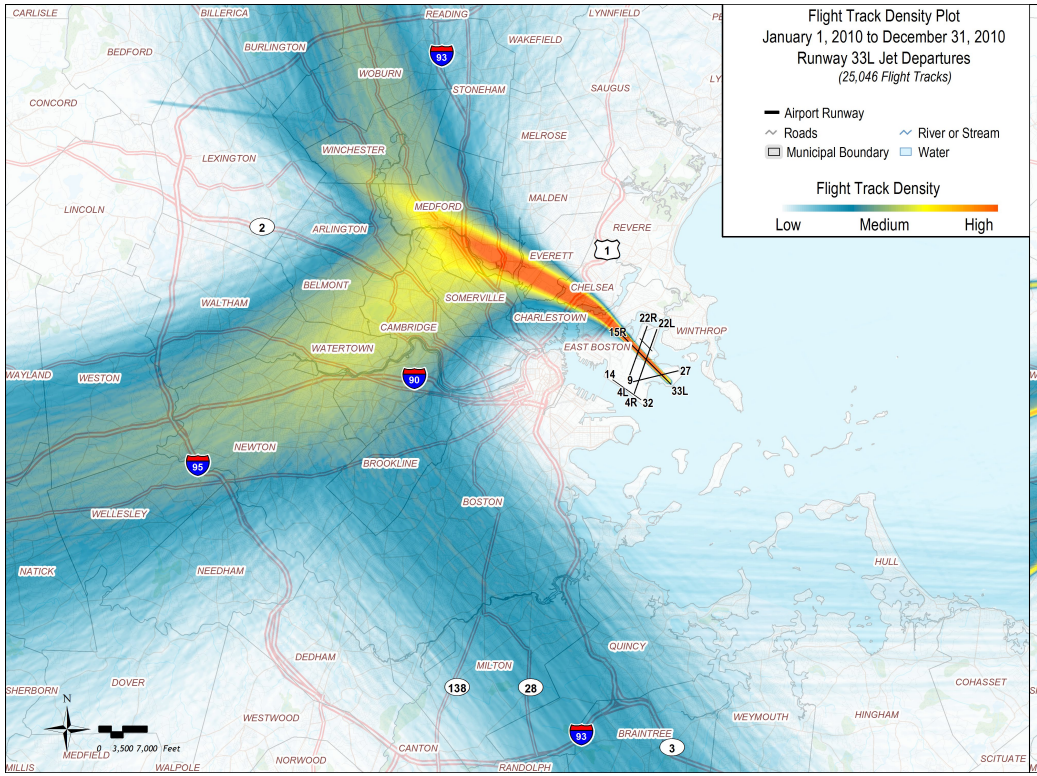
R. John Hansman

rjhans@mit.edu

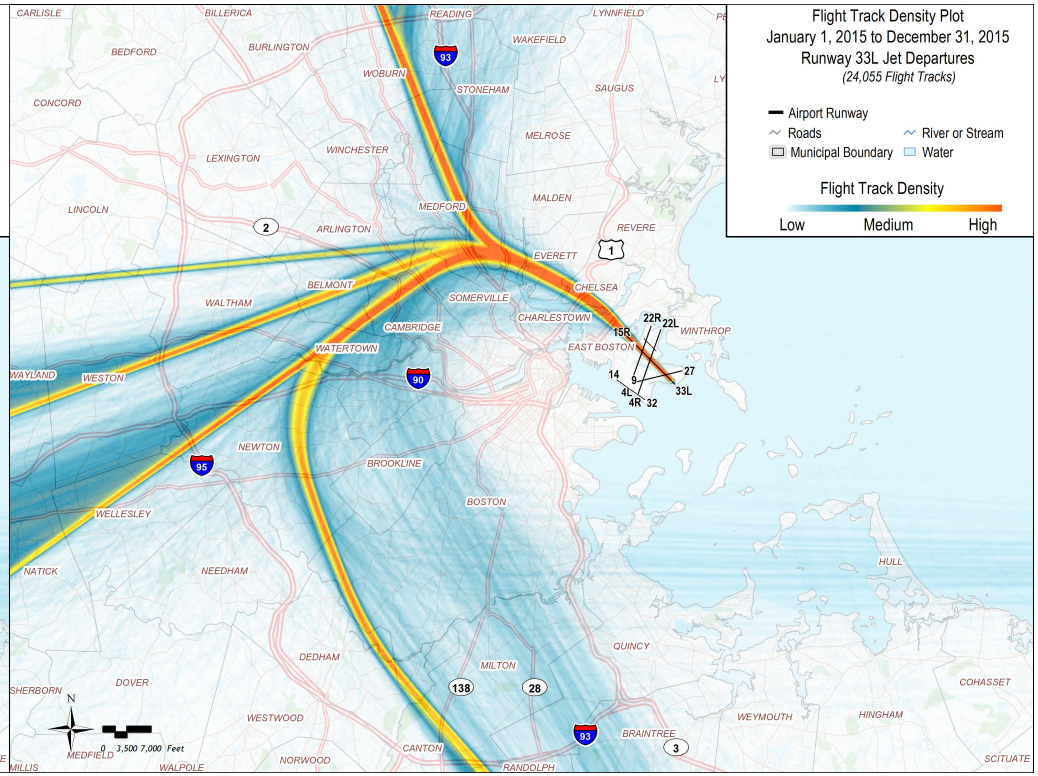
Technical support from MIT ICAT students,
HMMH, and Massport

Runway 33L Departures: 2010-2015

2010



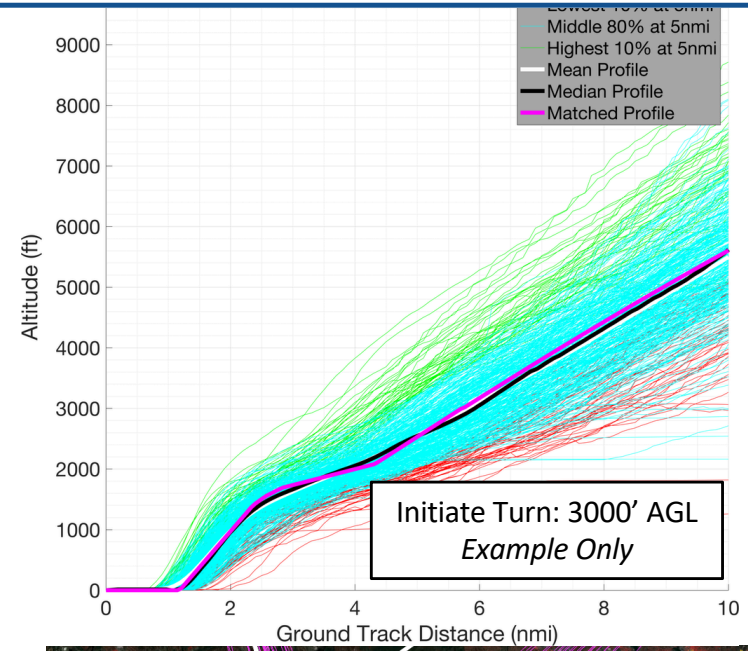
2015

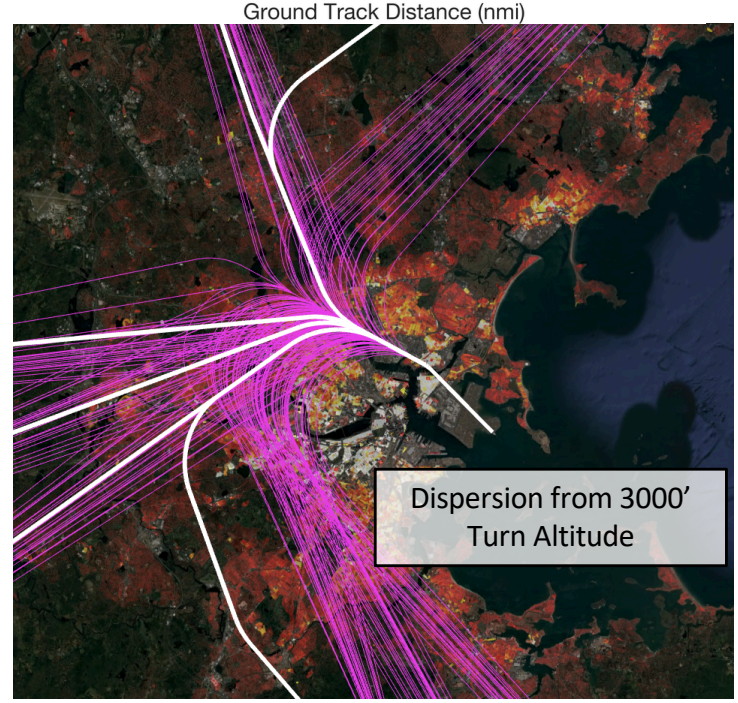


33L Departures Dispersion Analysis

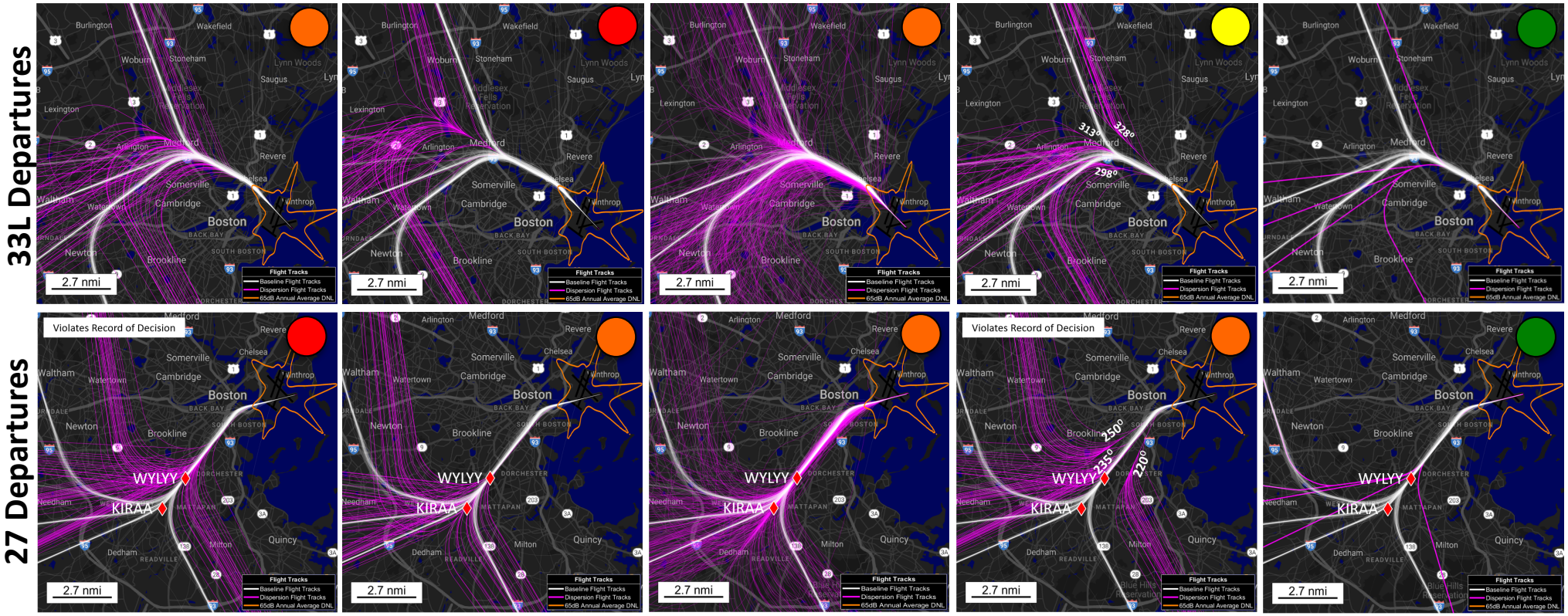
Dispersion Concepts

- 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
  - 15^0 divergent headings then direct routing to transition waypoint upon reaching 3000ft
- RNAV Waypoint Relocation
  - Moving the waypoint at which the RNAV tracks branch off could allow for population exposure reduction





Original Dispersion Concepts



Altitude-Based 3000ft | Altitude-Based 4000ft | Controller-Based | Divergent Headings | RNAV Waypoint Relocation

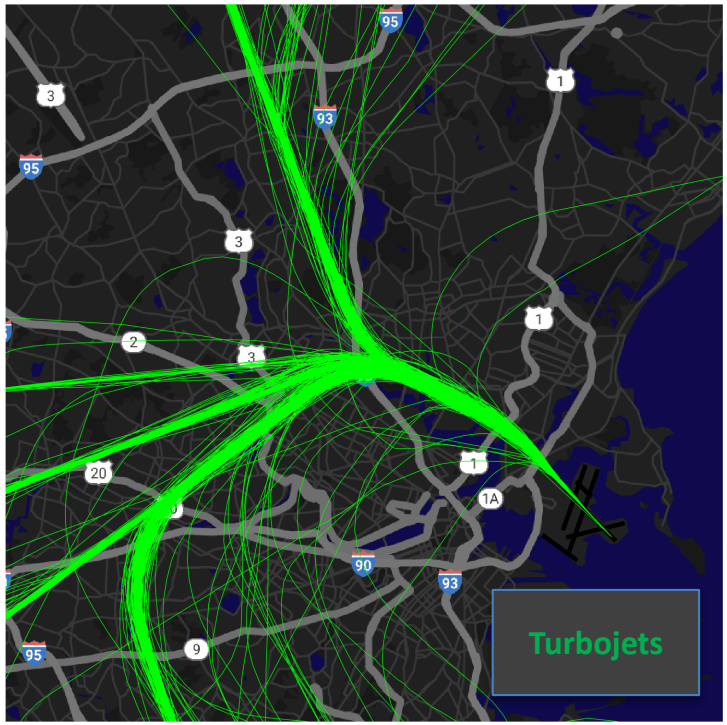
Preliminary examples for consideration only. May be modified or eliminated.

Noise Analysis Baselines

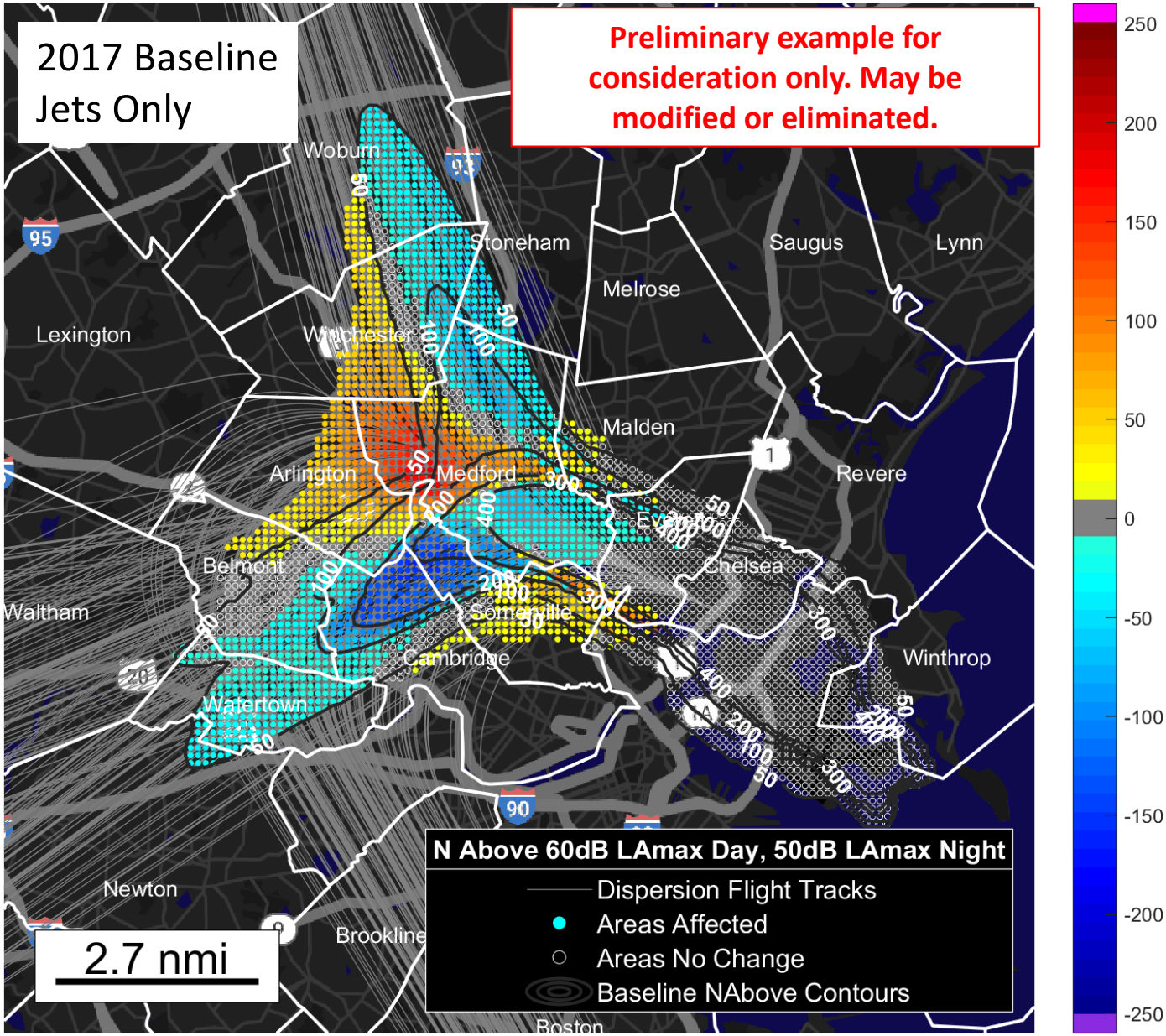
- 2017 Peak Day Baseline corrected to remove turboprops which do not fly the RNAV procedures
- 2010 Peak Day Baseline analysis conducted at community request (not presented here)
- Updated results sent to communities through Rep. Hecht Oct 22, 2019

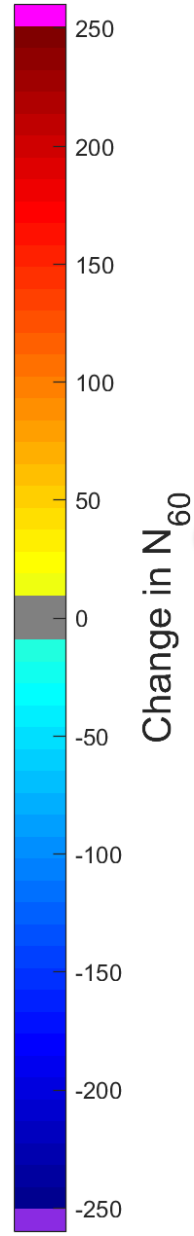
2017 Baseline with Turboprops

2017 Baseline without Turboprops



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





Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	340,974
Baseline - Dispersion	-5,151

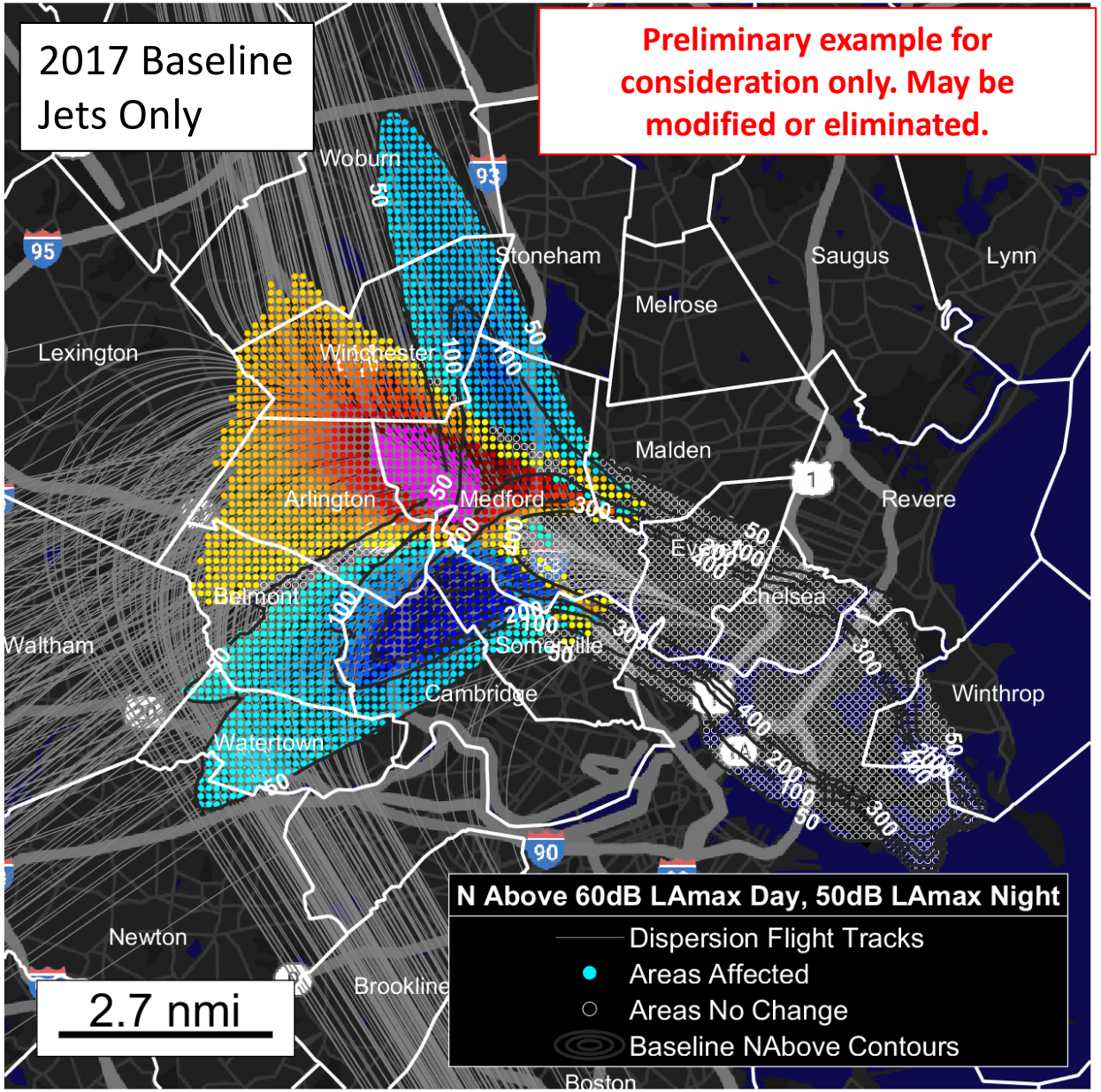
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

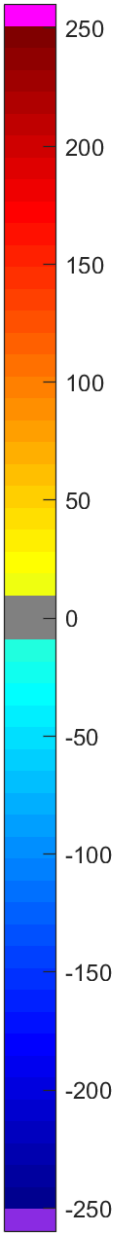
Controller concerns about variability in flight path length

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

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

33L Departures Altitude-Based Dispersion at 4000ft Change in N_{60} Compared to 2017





Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	281,319
Baseline - Dispersion	54,504

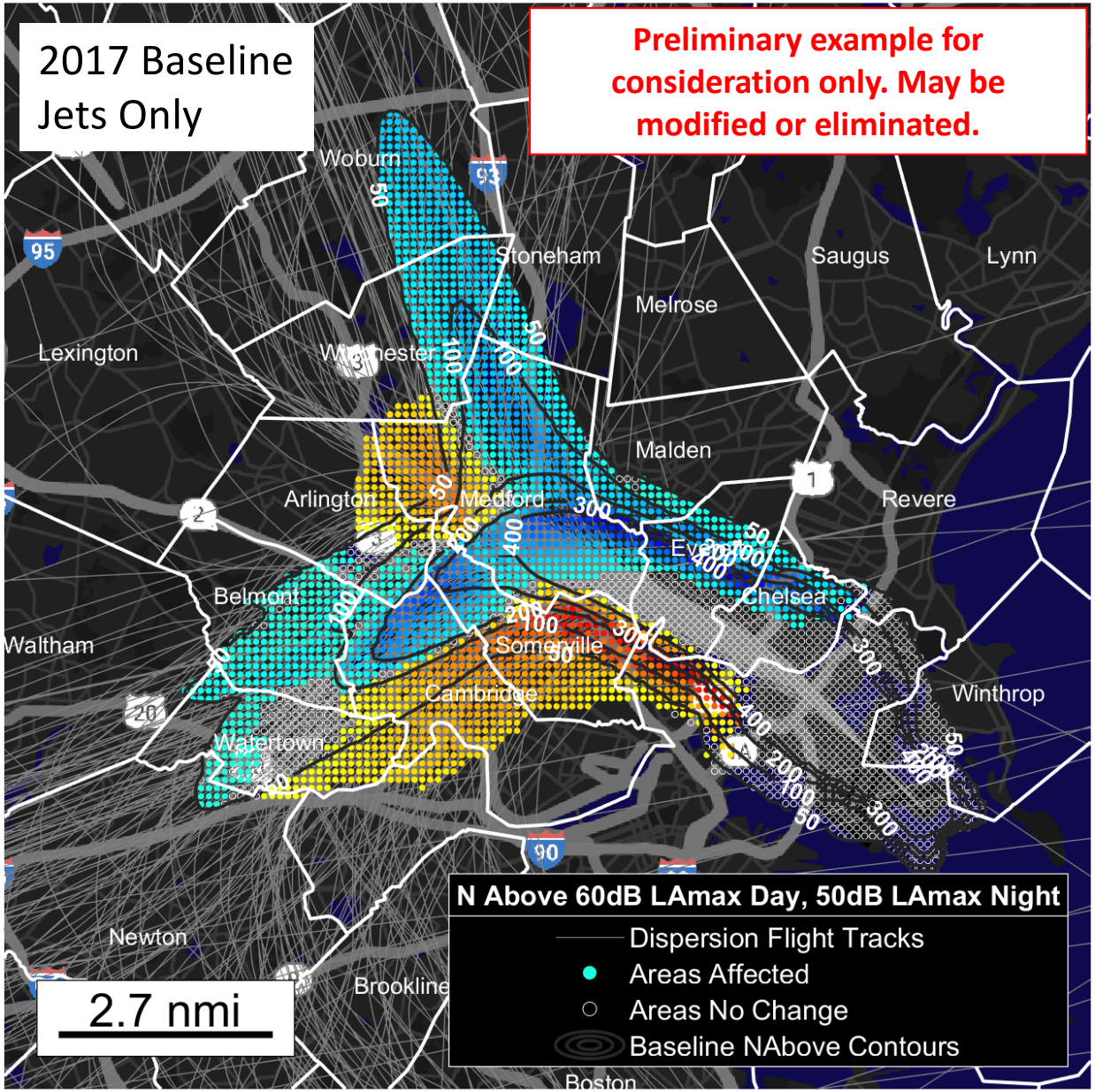
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

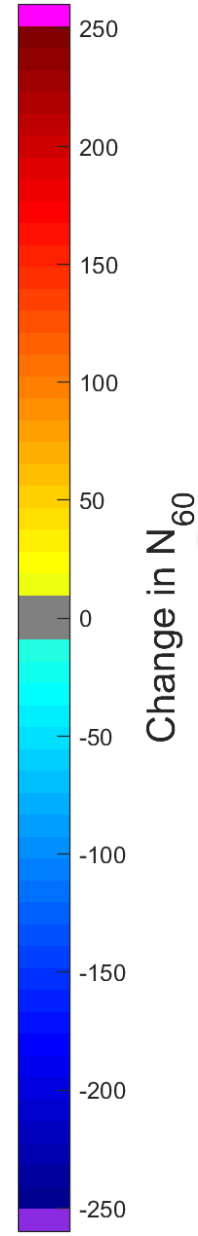
- Controller concerns about variability in flight path length
- Conflicts with airspace at Hanscom Airport

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

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

33L Departures Controller-Based Dispersion Change in N_{60} Compared to 2017





Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	356,864
Baseline - Dispersion	-21,041

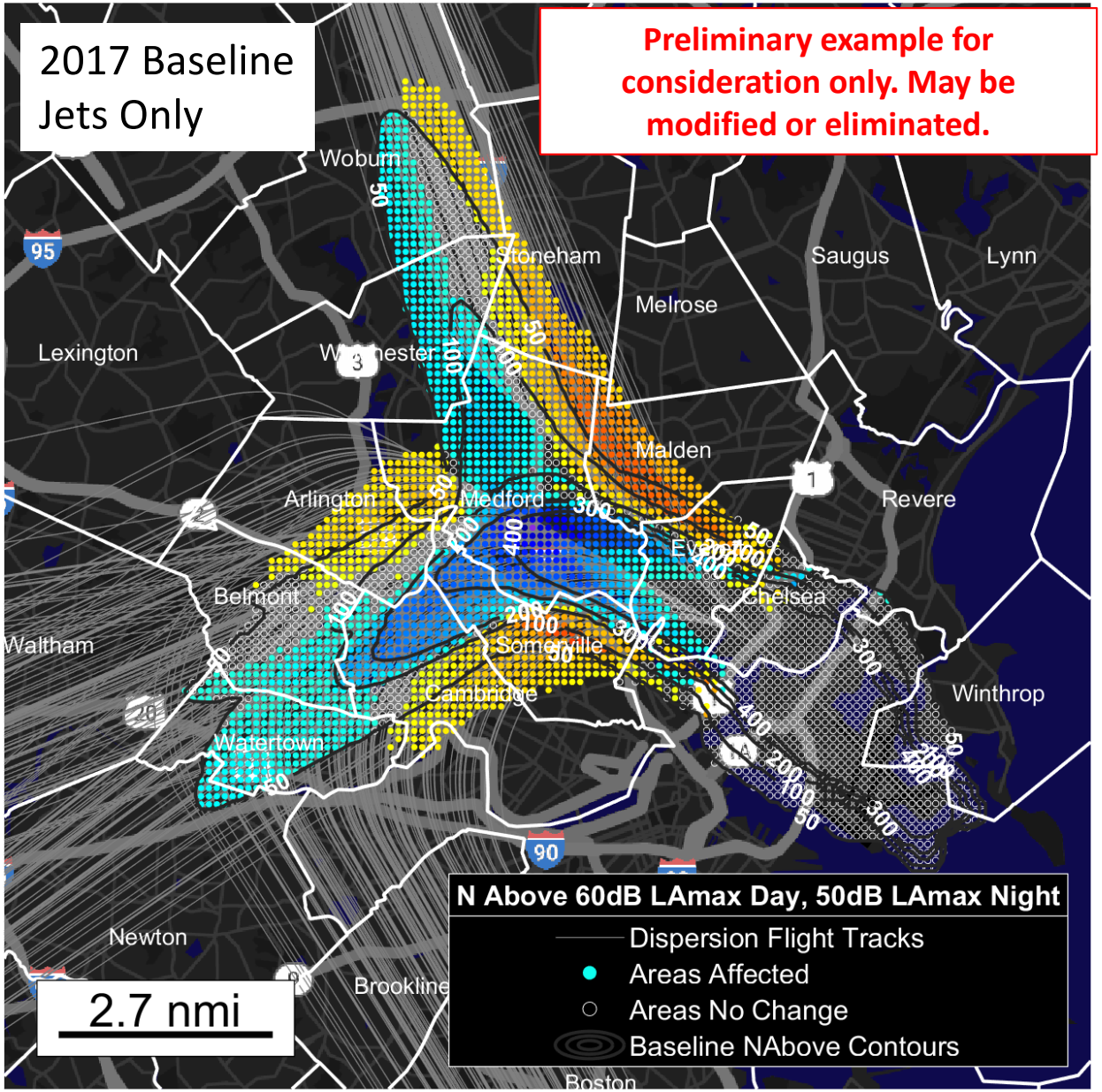
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

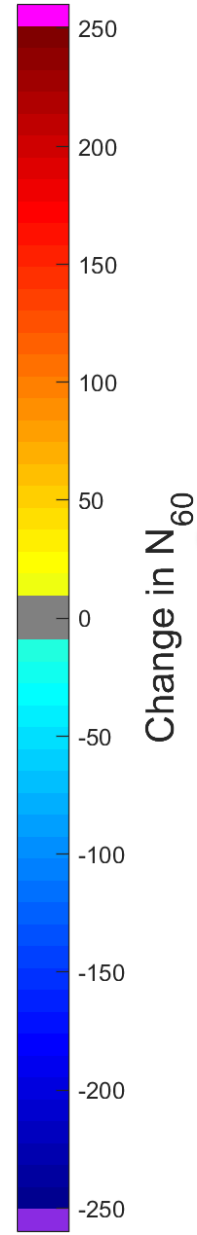
Controller concerns about variability in flight path length

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

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

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





Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	363,759
Baseline - Dispersion	-27,936

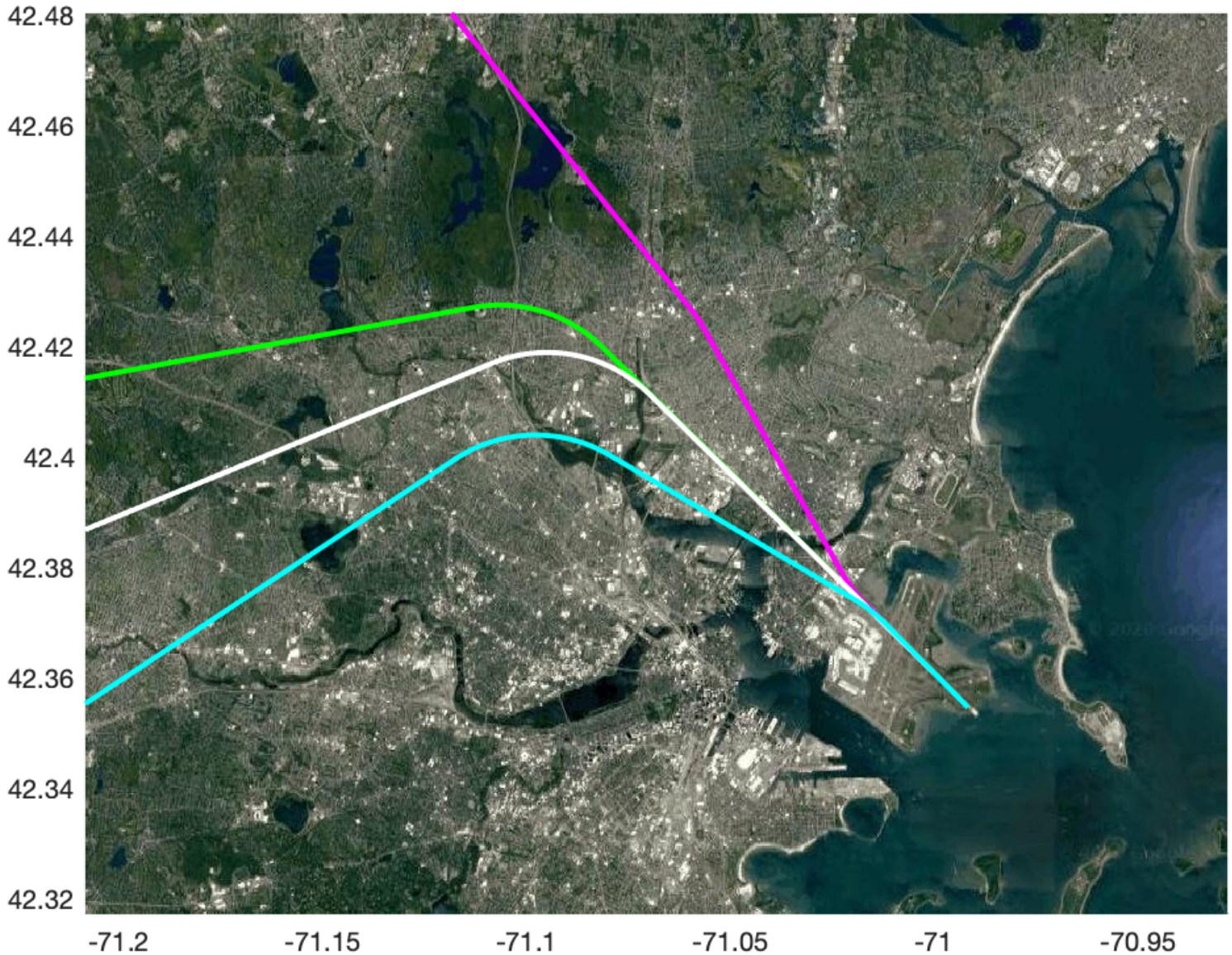
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

Divergent headings help to maintain aircraft separation criteria

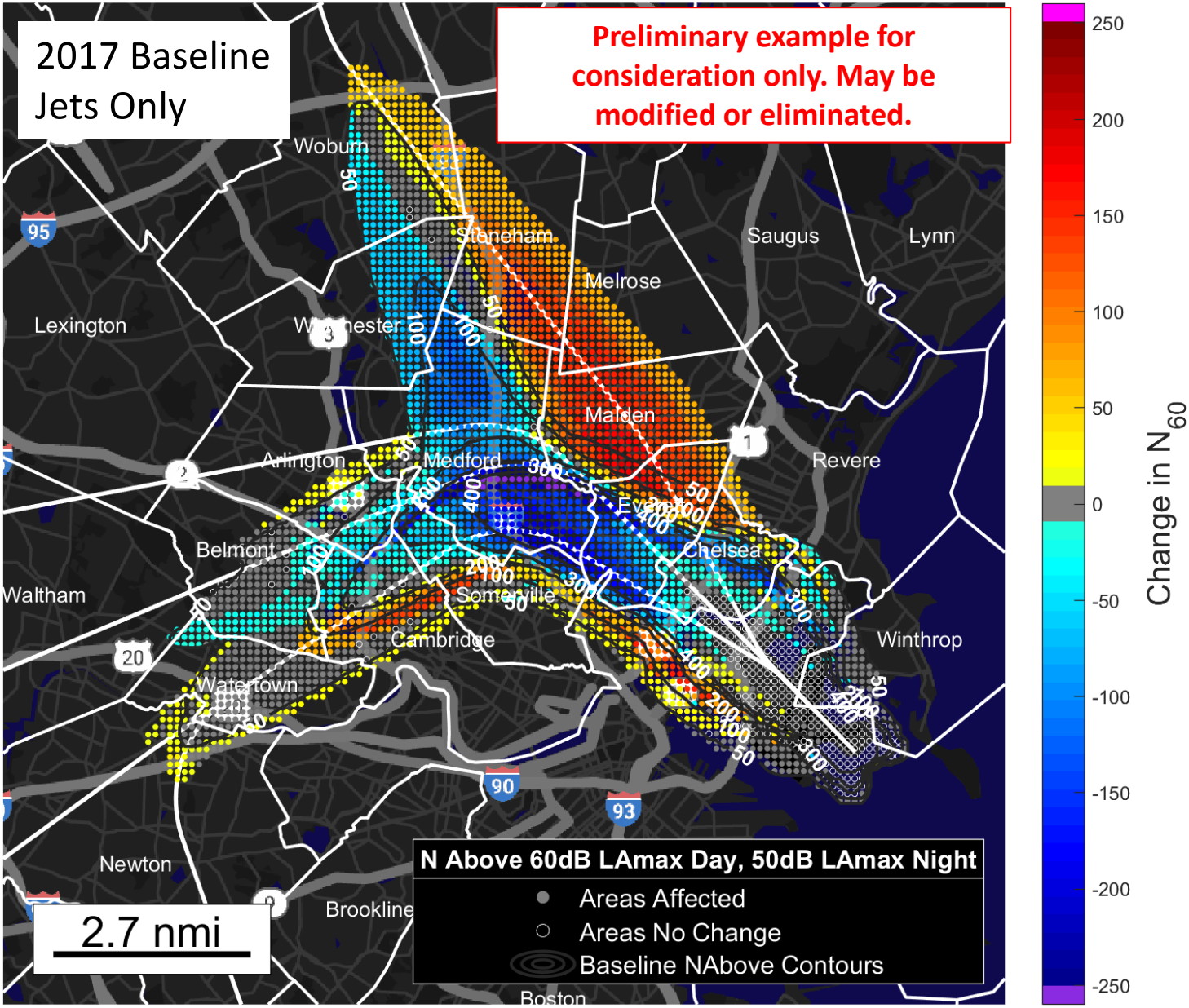
Analysis based on peak day operations; only includes 33L departures

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

Alternative Divergent Heading Concept Off Runway



Divergent Headings Off Runway
Change in N_{60} Compared to 2017



Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	412,782
Baseline - Dispersion	-76,959

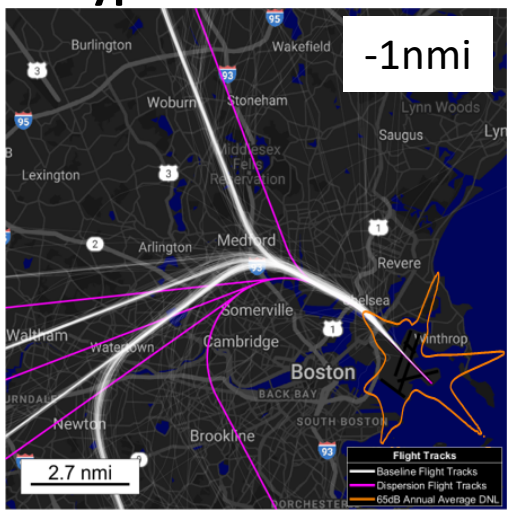
- Divergent headings help to maintain aircraft separation criteria

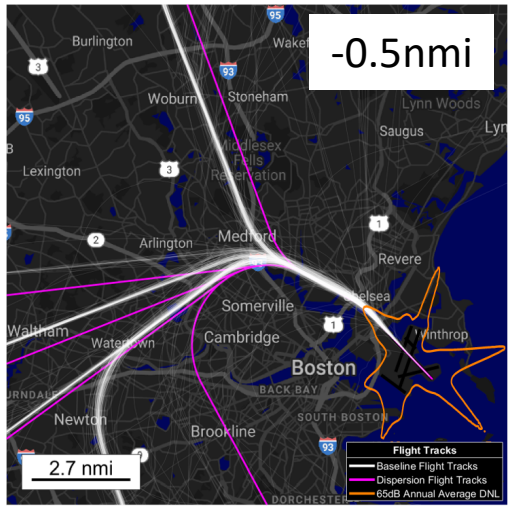
Analysis based on peak day operations; only includes 33L departures

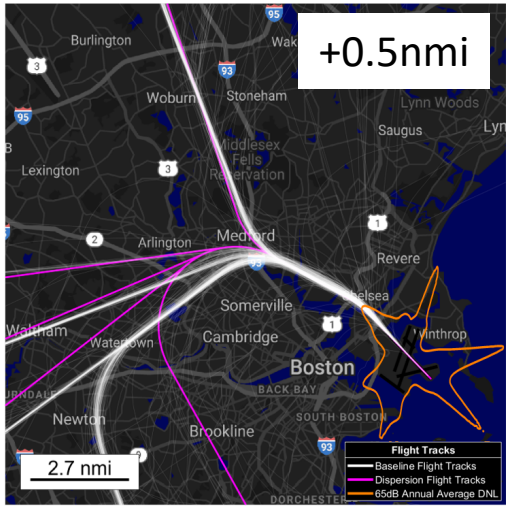
N_{60} Thresholds:
60dB $L_{A,max}$ Day, 50dB $L_{A,max}$ Night

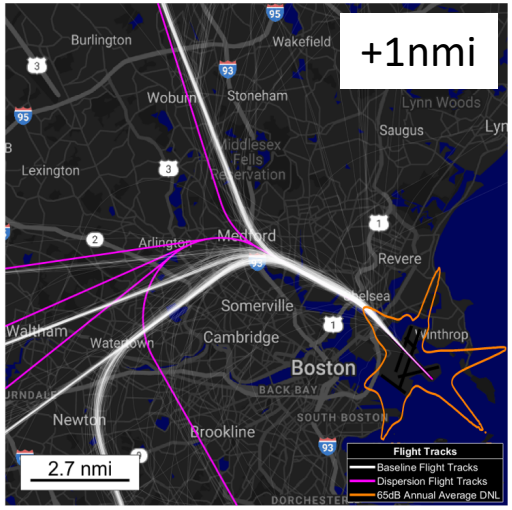
33L Departures RNAV Waypoint Relocation

Waypoint moved:



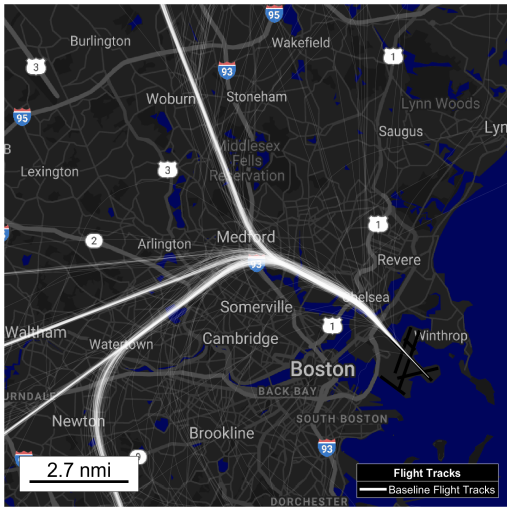






50 N_{60} Population Exposure Change (Baseline – Alternate):

-1nmi	-0.5nmi	+0.5nmi	+1nmi
-9,545	11,062	32,999	41,404

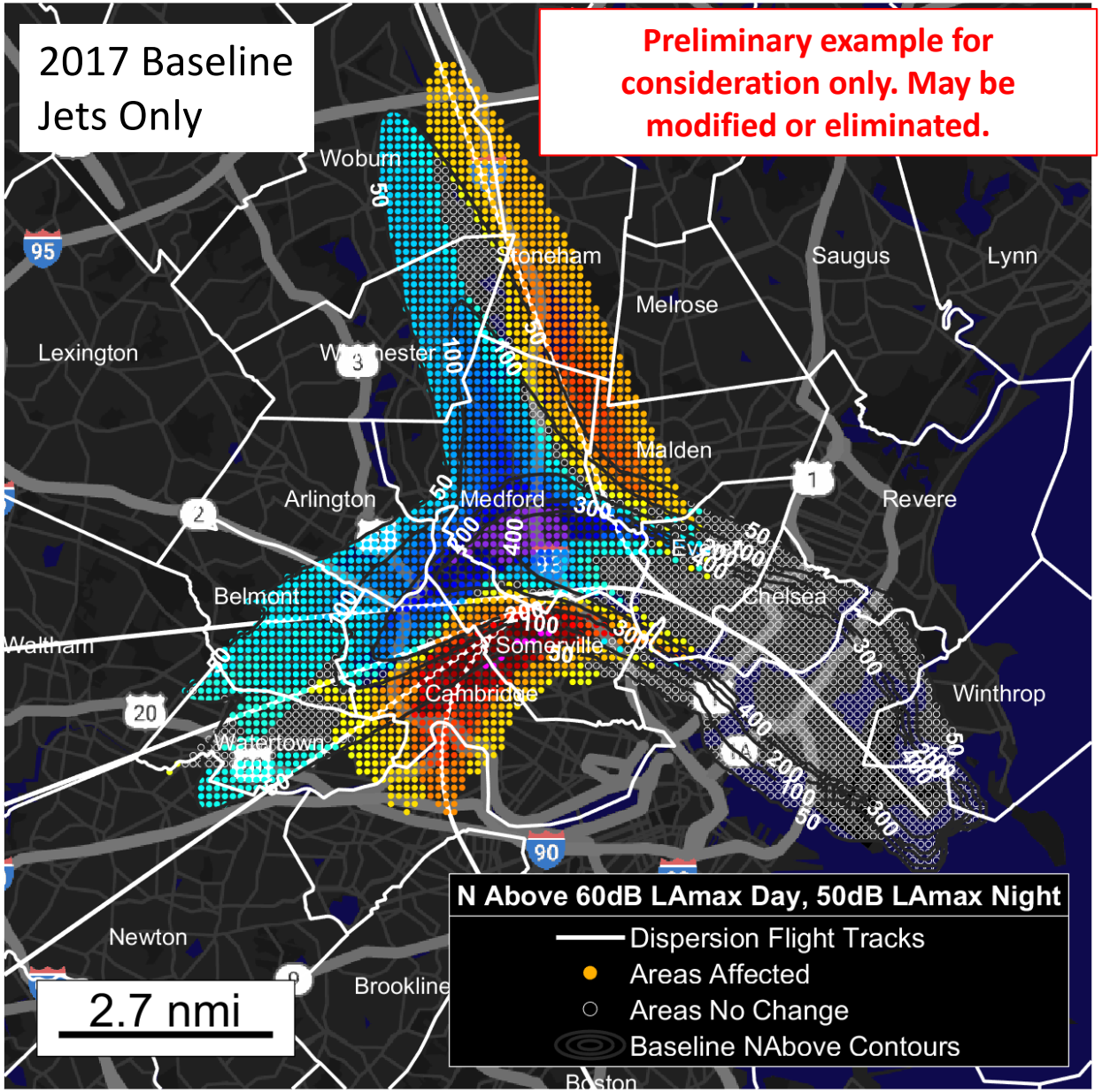


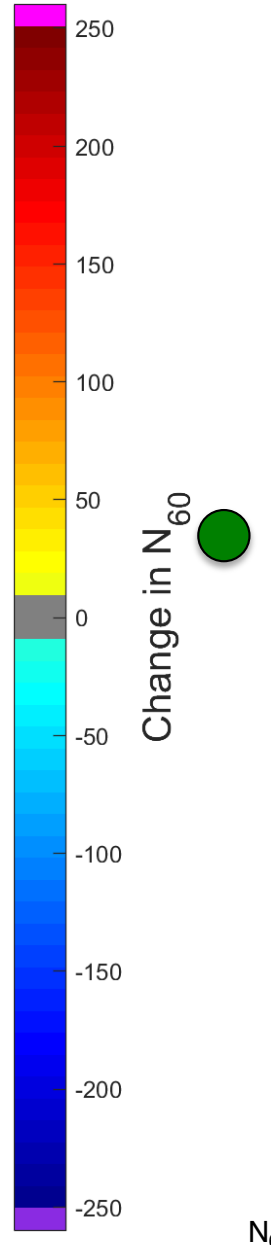
RNAV N_{60} Population Exposure:
335,823

Modification to existing RNAV procedure

Preliminary example for consideration only. May be modified or eliminated.

33L Departures RNAV Waypoint Relocation -1nmi
Change in N_{60} Compared to 2017





Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	345,368
Baseline - Dispersion	-9,545

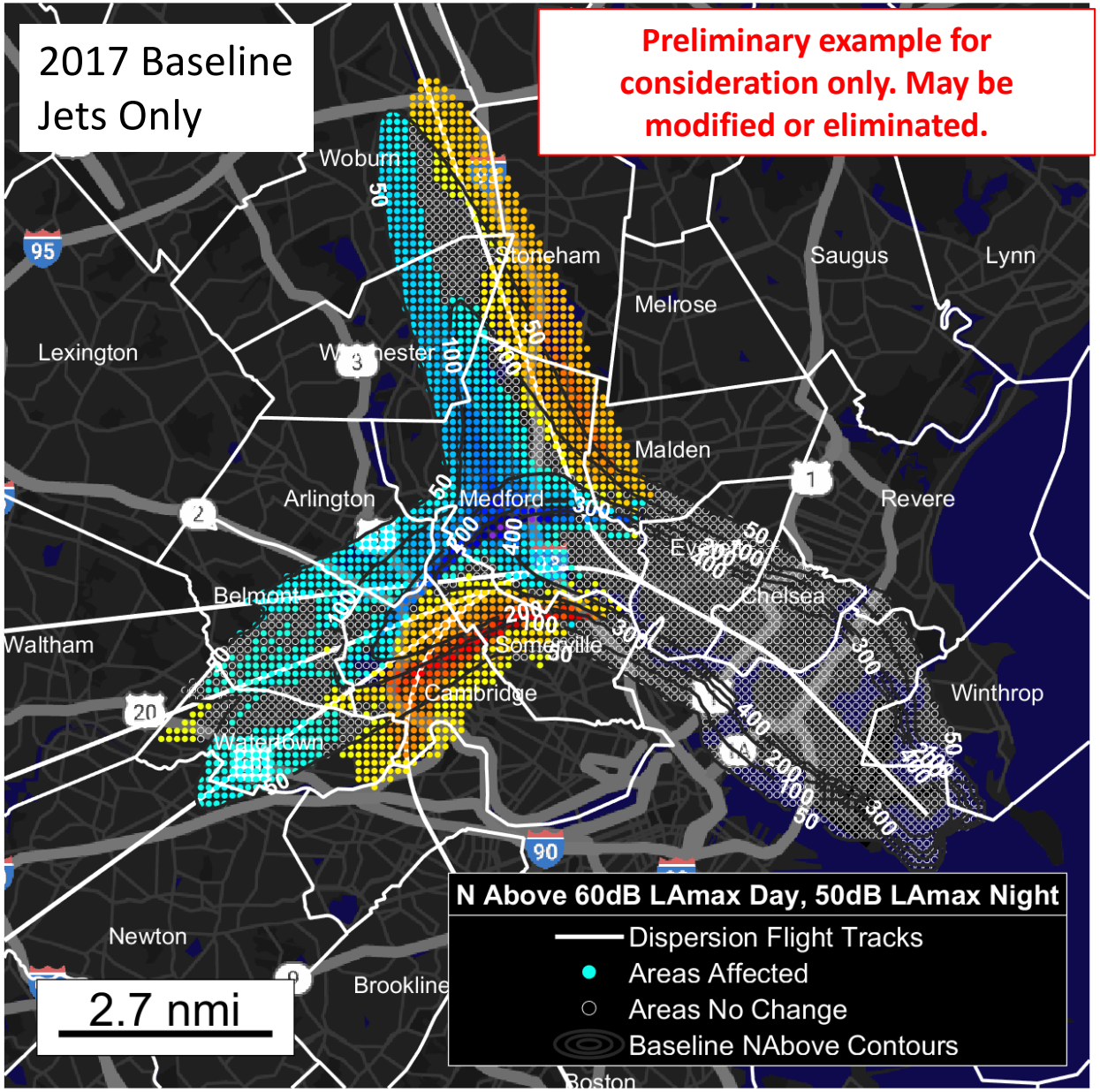
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

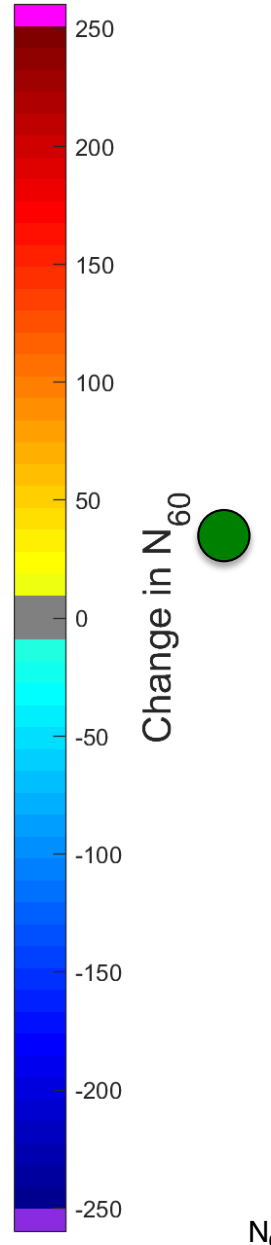
Modification to existing RNAV procedure

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

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

33L Departures RNAV Waypoint Relocation -0.5nmi
Change in N_{60} Compared to 2017





Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	324,761
Baseline - Dispersion	11,062

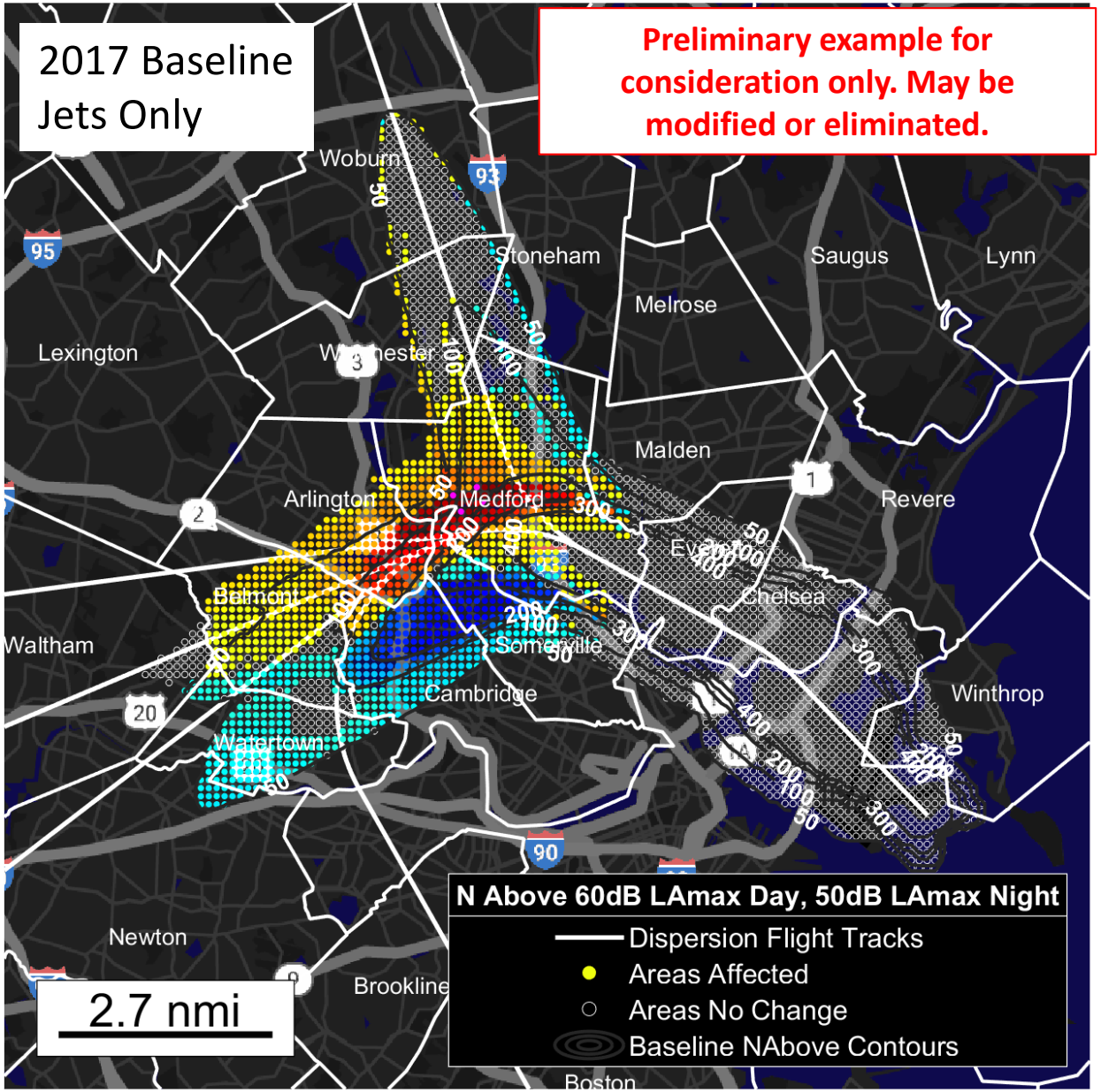
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

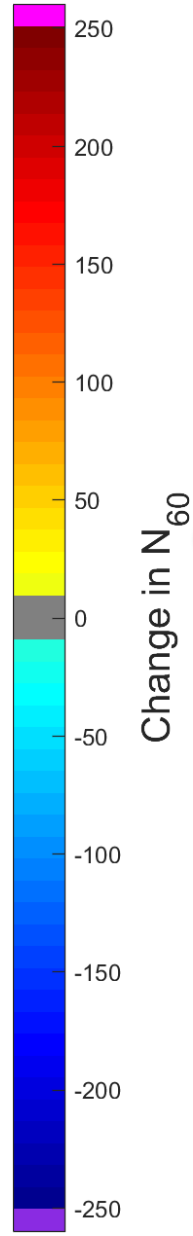
Modification to existing RNAV procedure

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

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

33L Departures RNAV Waypoint Relocation +0.5nmi
Change in N_{60} Compared to 2017





Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	302,824
Baseline - Dispersion	32,999

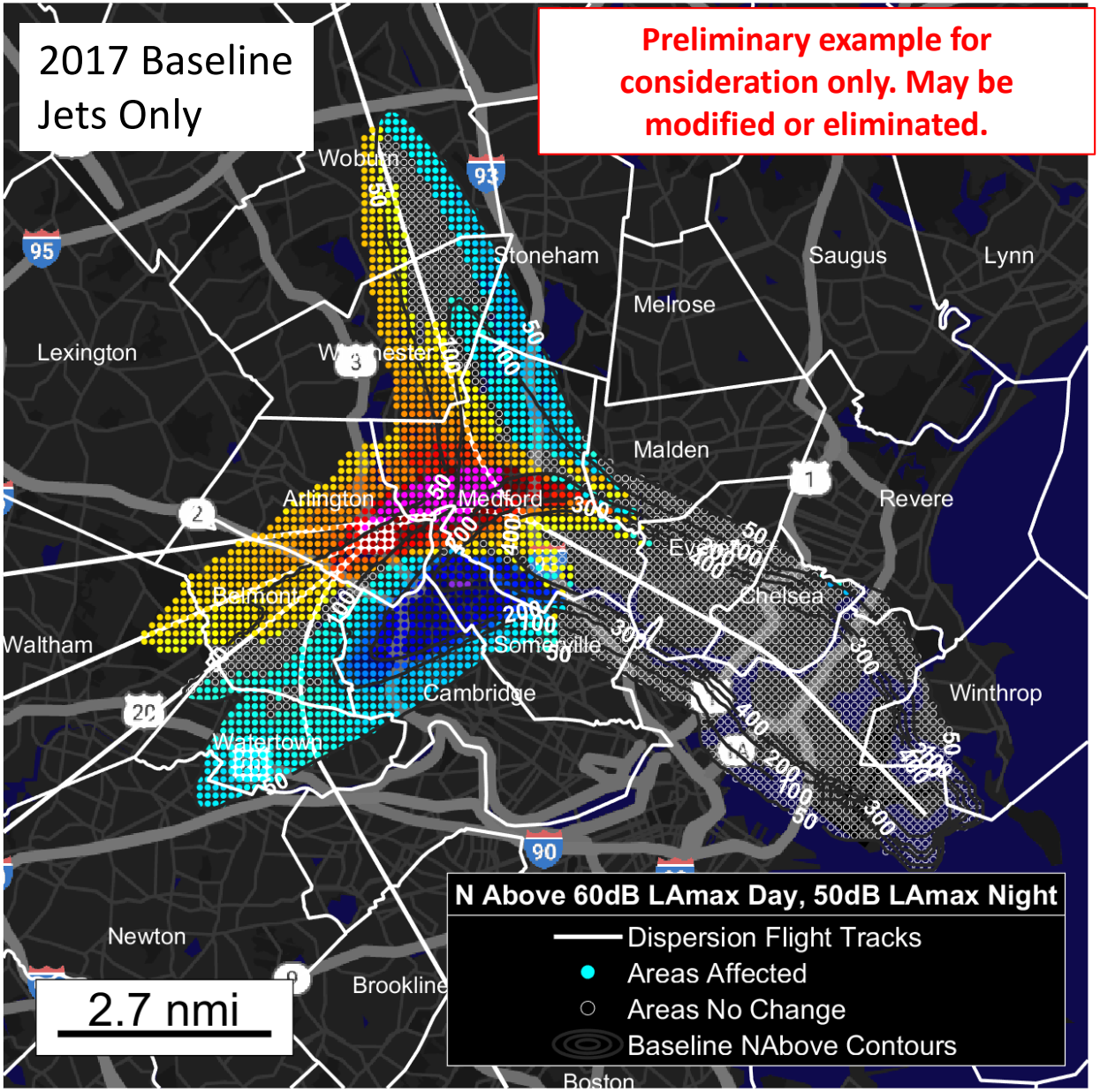
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

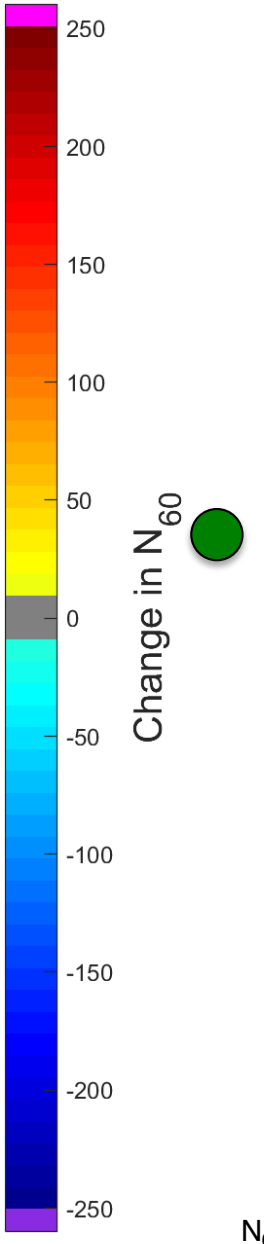
Modification to existing RNAV procedure

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

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

33L Departures RNAV Waypoint Relocation +1nmi
Change in N_{60} Compared to 2017





Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	294,419
Baseline - Dispersion	41,404

Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

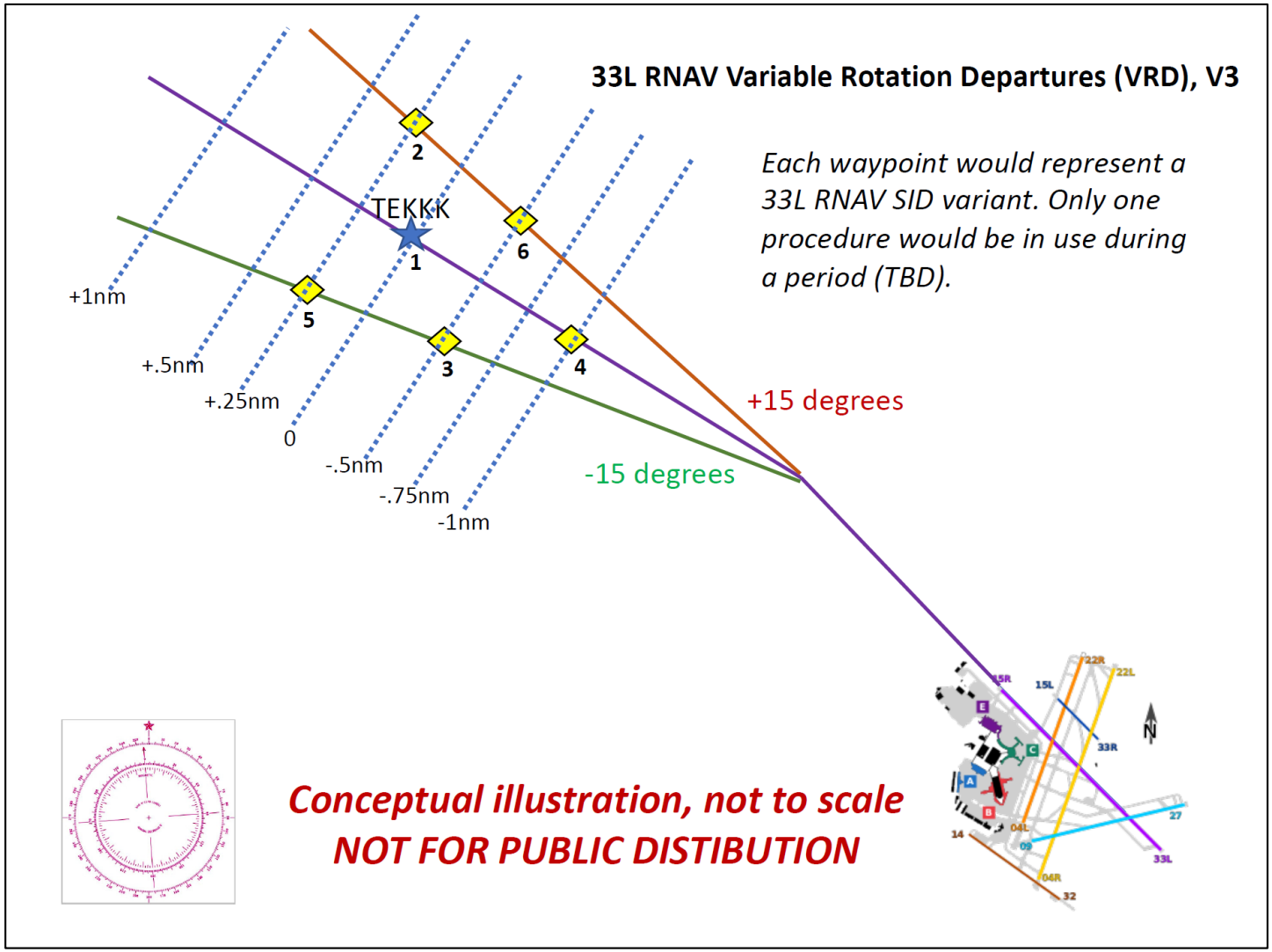
Modification to existing RNAV procedure

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

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

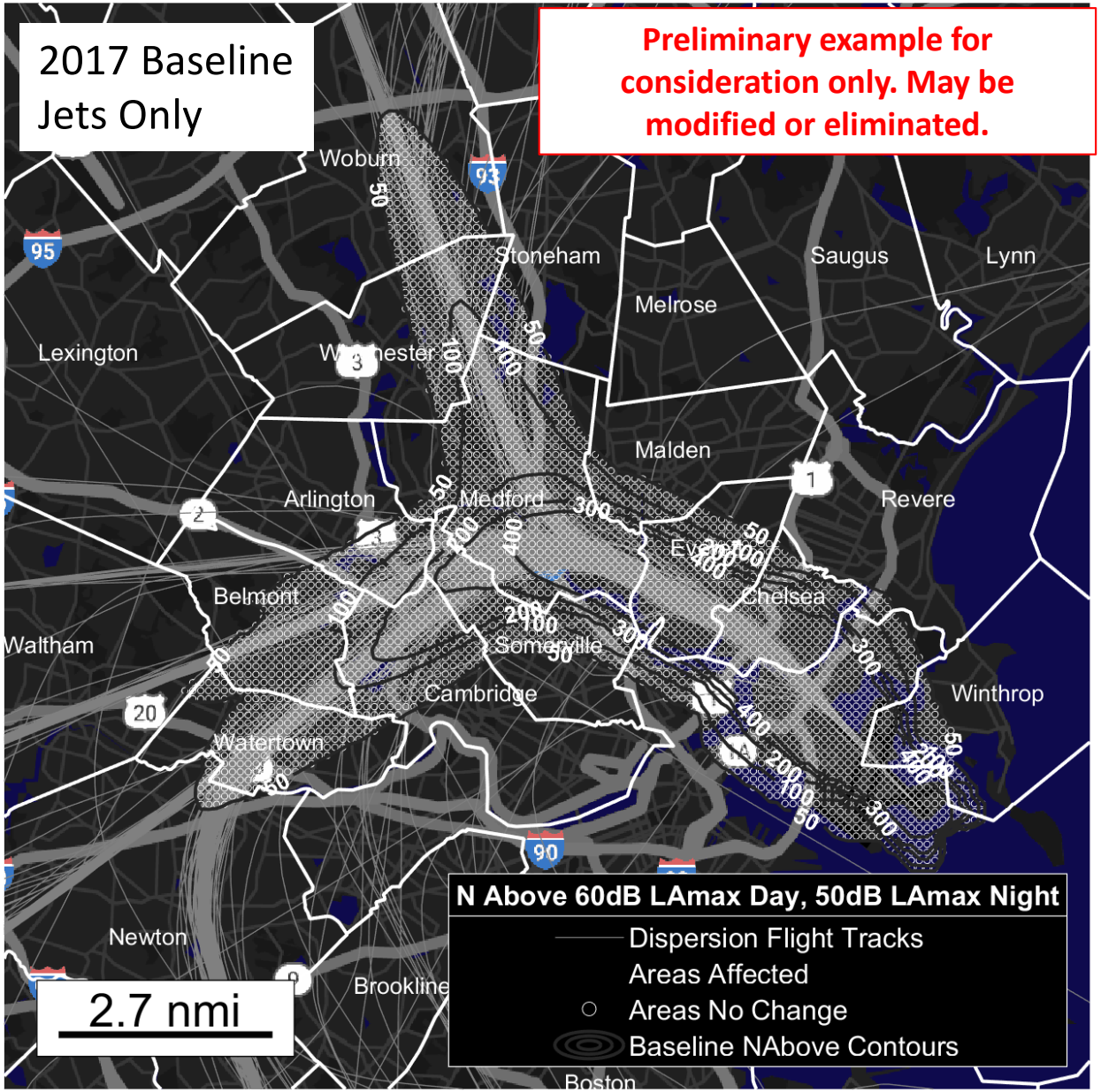
Community Dispersion Suggestion Variable Rotation Departures (VRD)

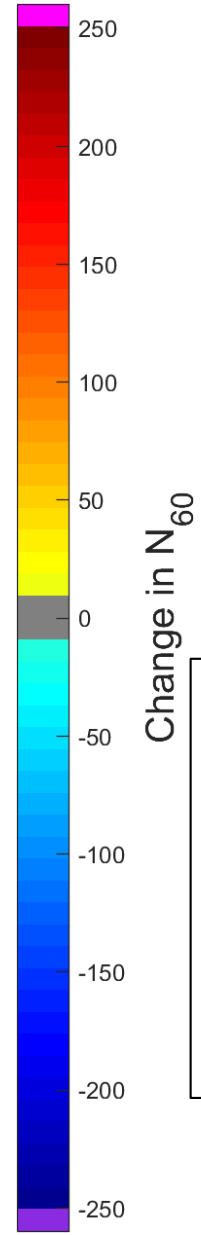
Analysis done on full peak day of operation using a single waypoint
Other rotations possible.



- Complex procedures for ATC and Pilots
- Requires numerous procedures in the Flight Management System
- Rotating between waypoints from day to day does not take advantage of the separation requirements satisfied by divergent headings

33L Departures VRD Waypoint #1 Change in N_{60} Compared to 2017

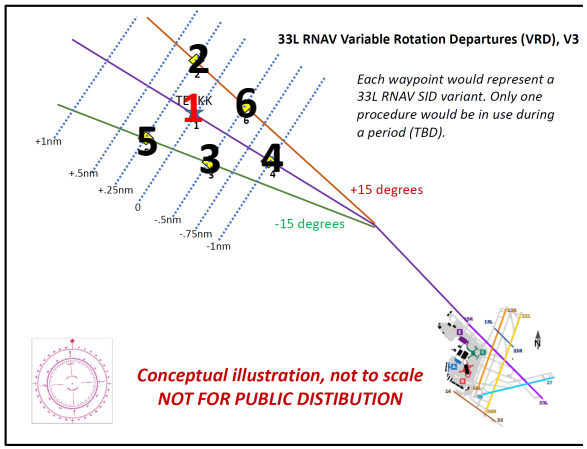




Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	335,823
Baseline - Dispersion	0

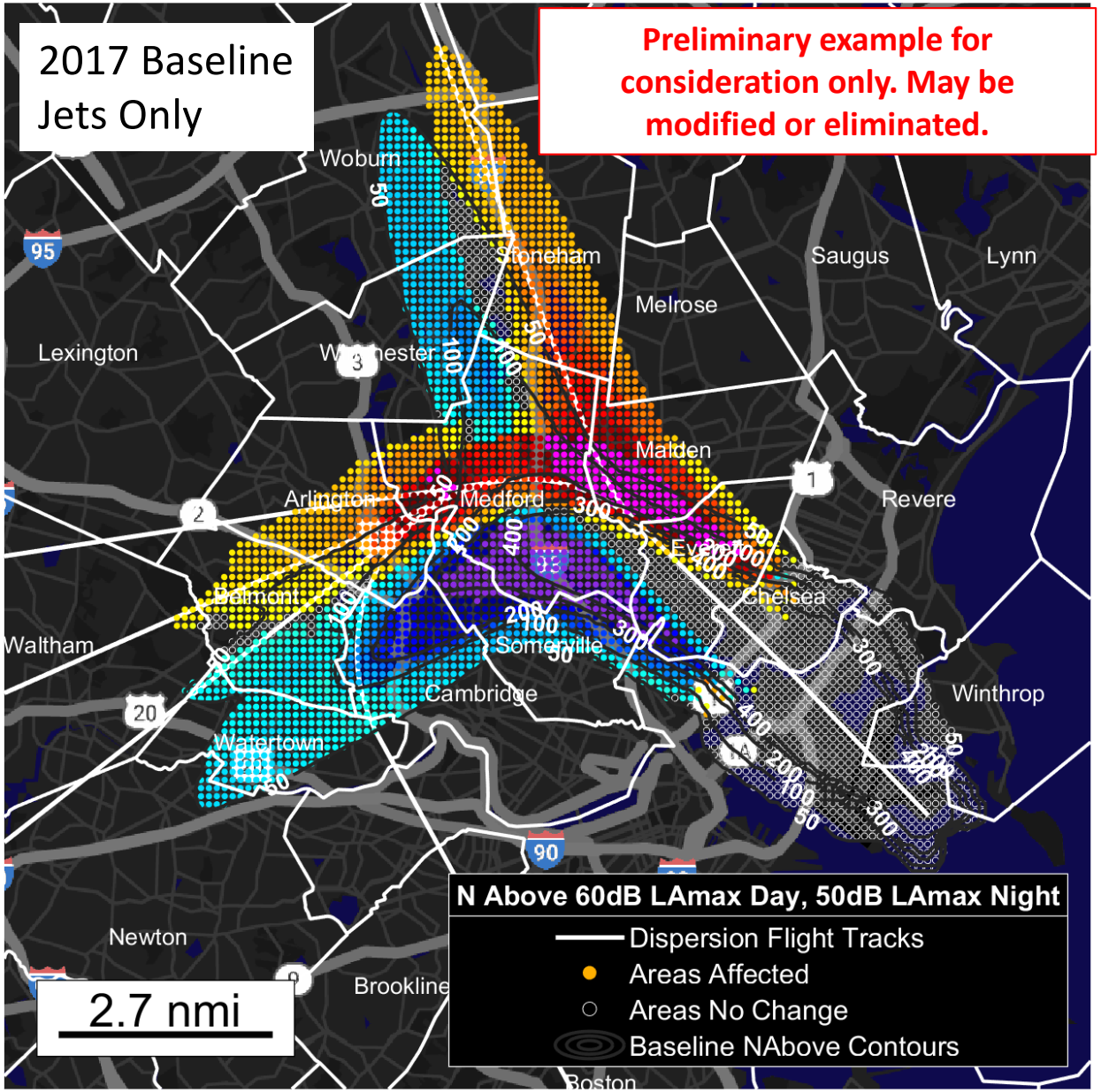
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

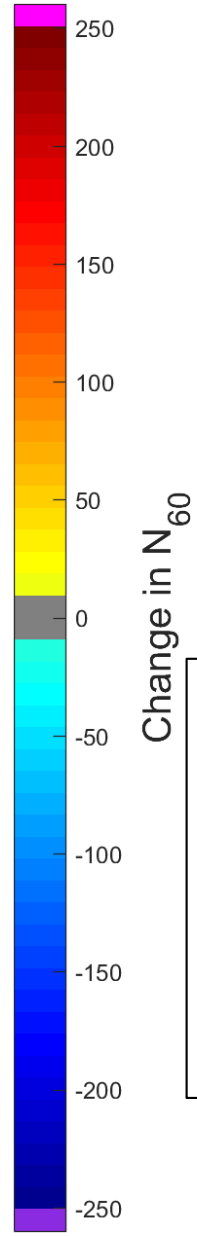


Analysis based on peak day operations; only includes 33L departures

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

33L Departures VRD Waypoint #2 Change in N_{60} Compared to 2017

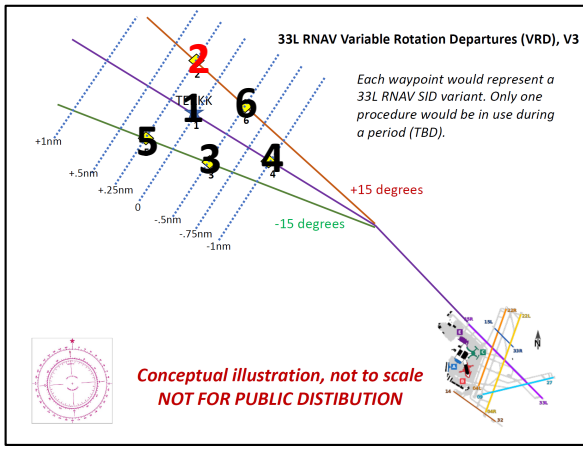




Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	269,491
Baseline - Dispersion	66,332

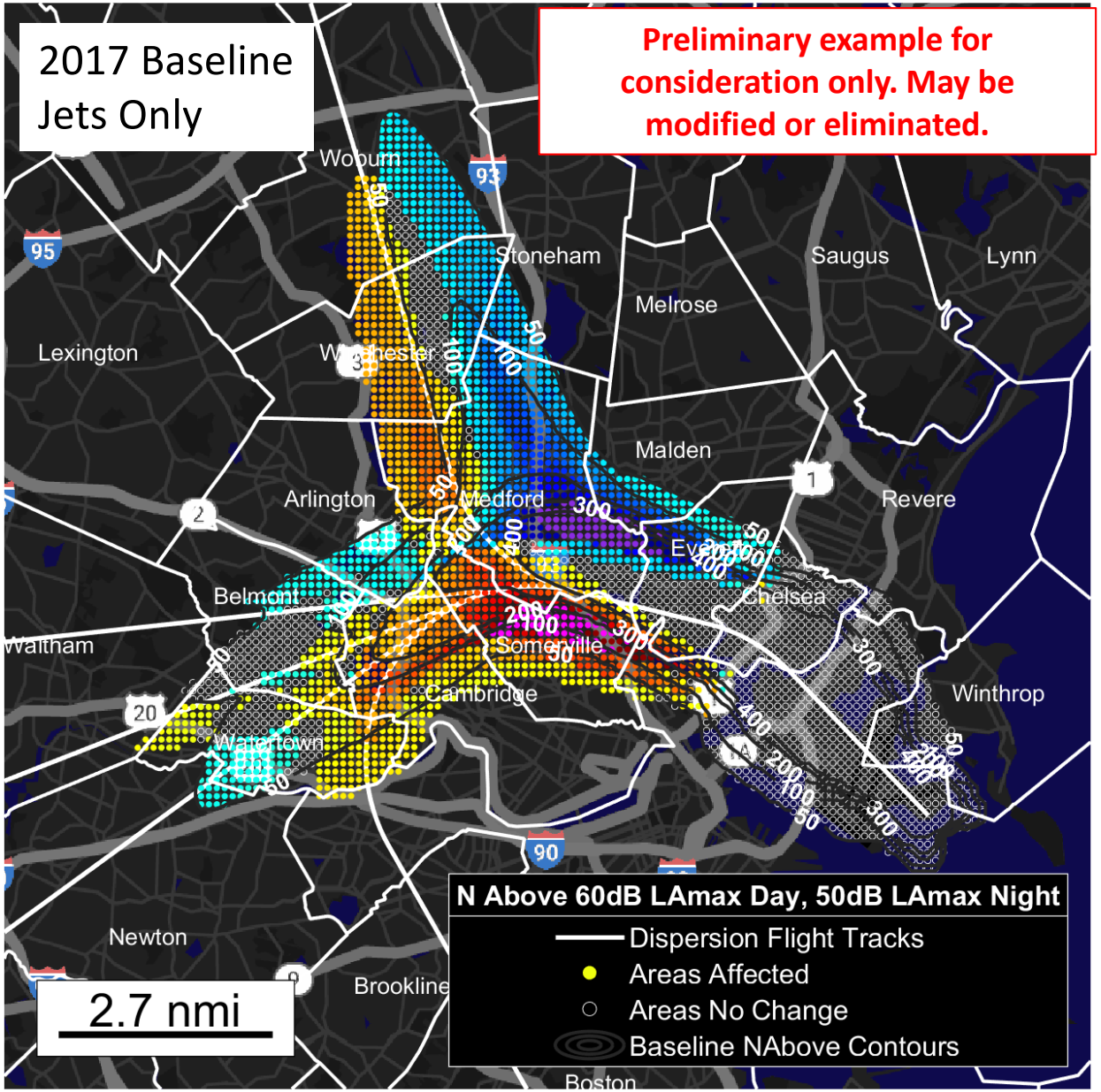
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

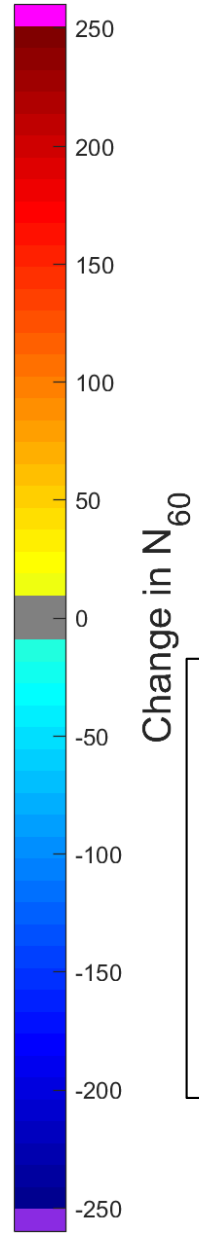


Analysis based on peak day operations; only includes 33L departures

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

33L Departures VRD Waypoint #3 Change in N_{60} Compared to 2017

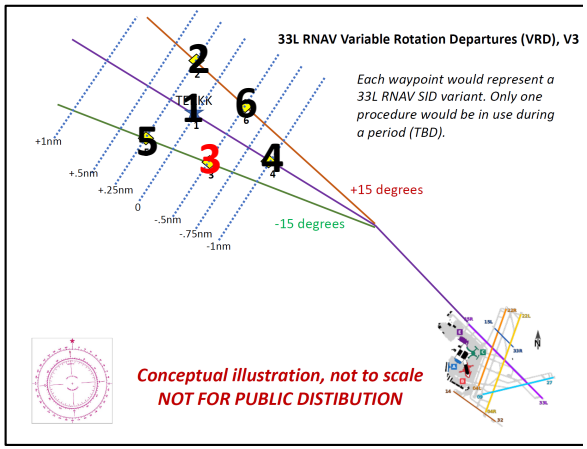




Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	334,570
Baseline - Dispersion	1,253

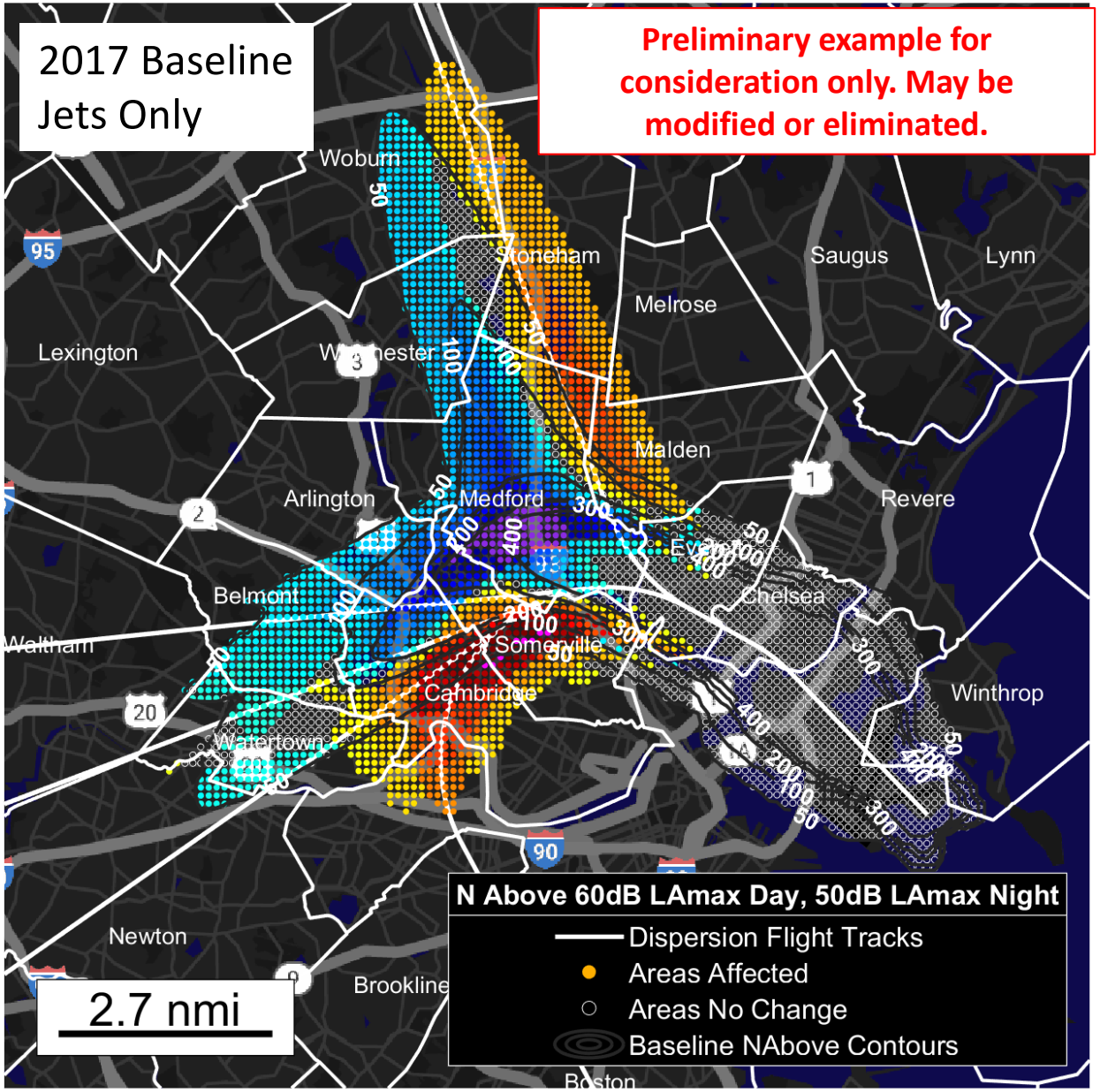
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

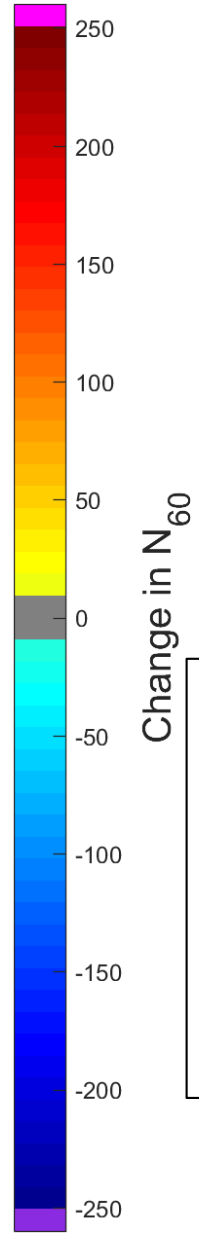


Analysis based on peak day operations; only includes 33L departures

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

33L Departures VRD Waypoint #4 Change in N_{60} Compared to 2017

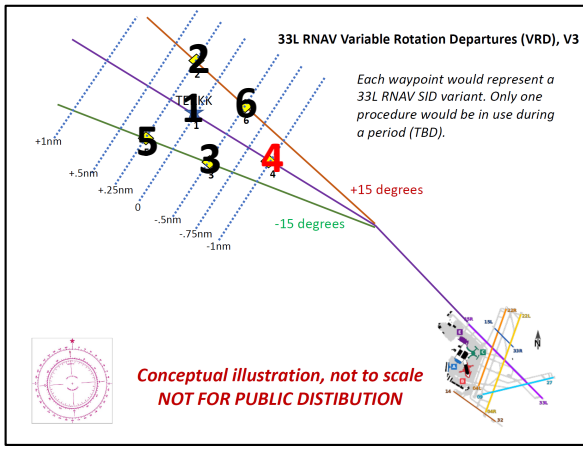




Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	345,368
Baseline - Dispersion	-9,545

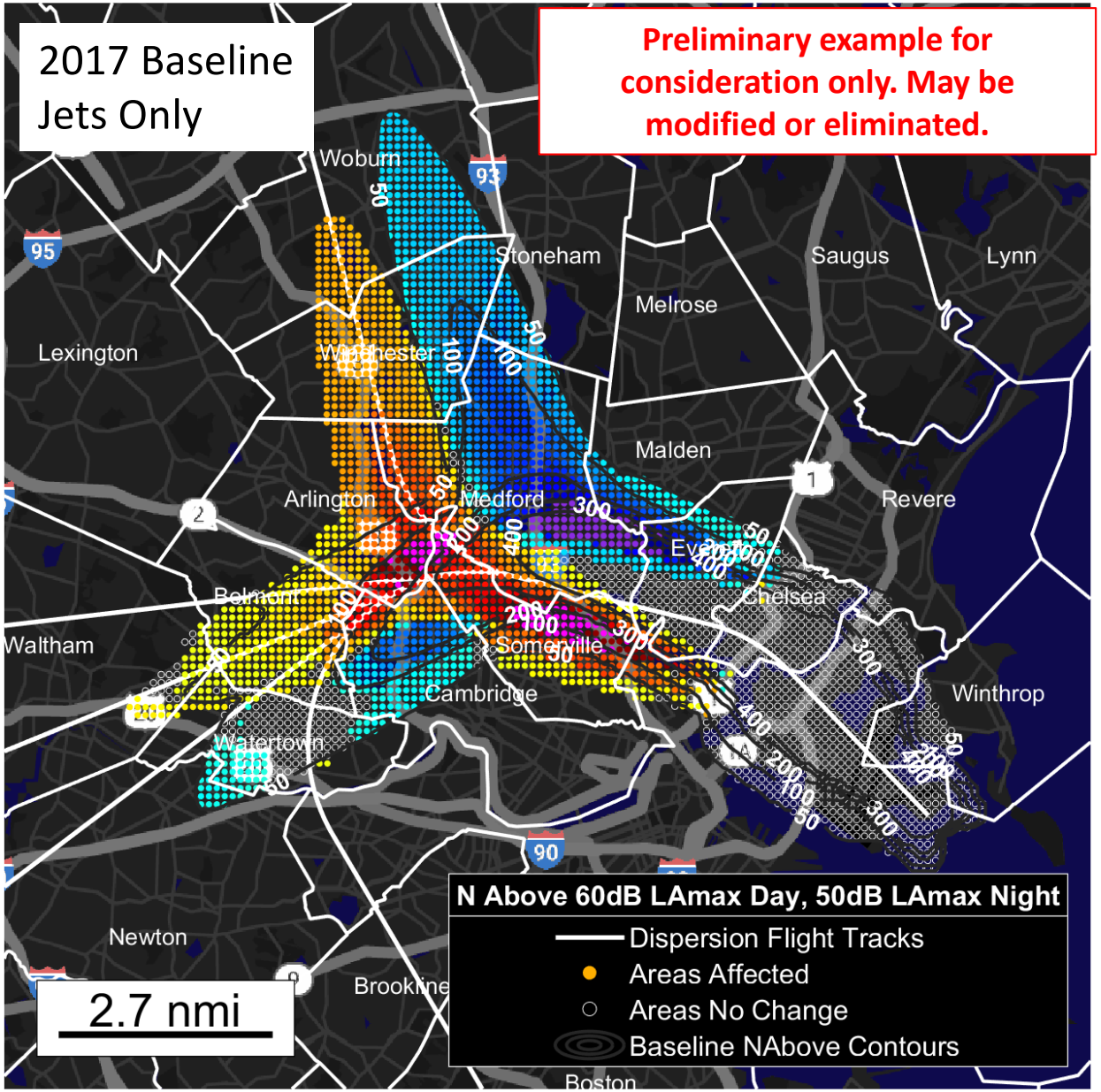
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

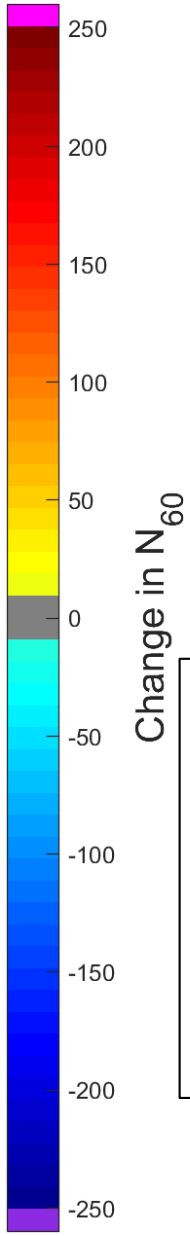


Analysis based on peak day operations; only includes 33L departures

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

33L Departures VRD Waypoint #5 Change in N_{60} Compared to 2017

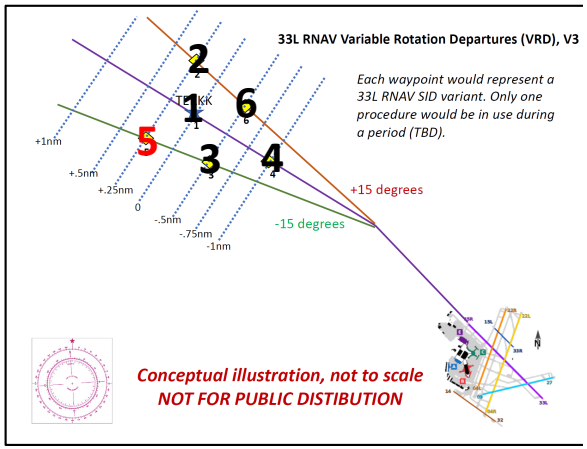




Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	321,688
Baseline - Dispersion	14,135

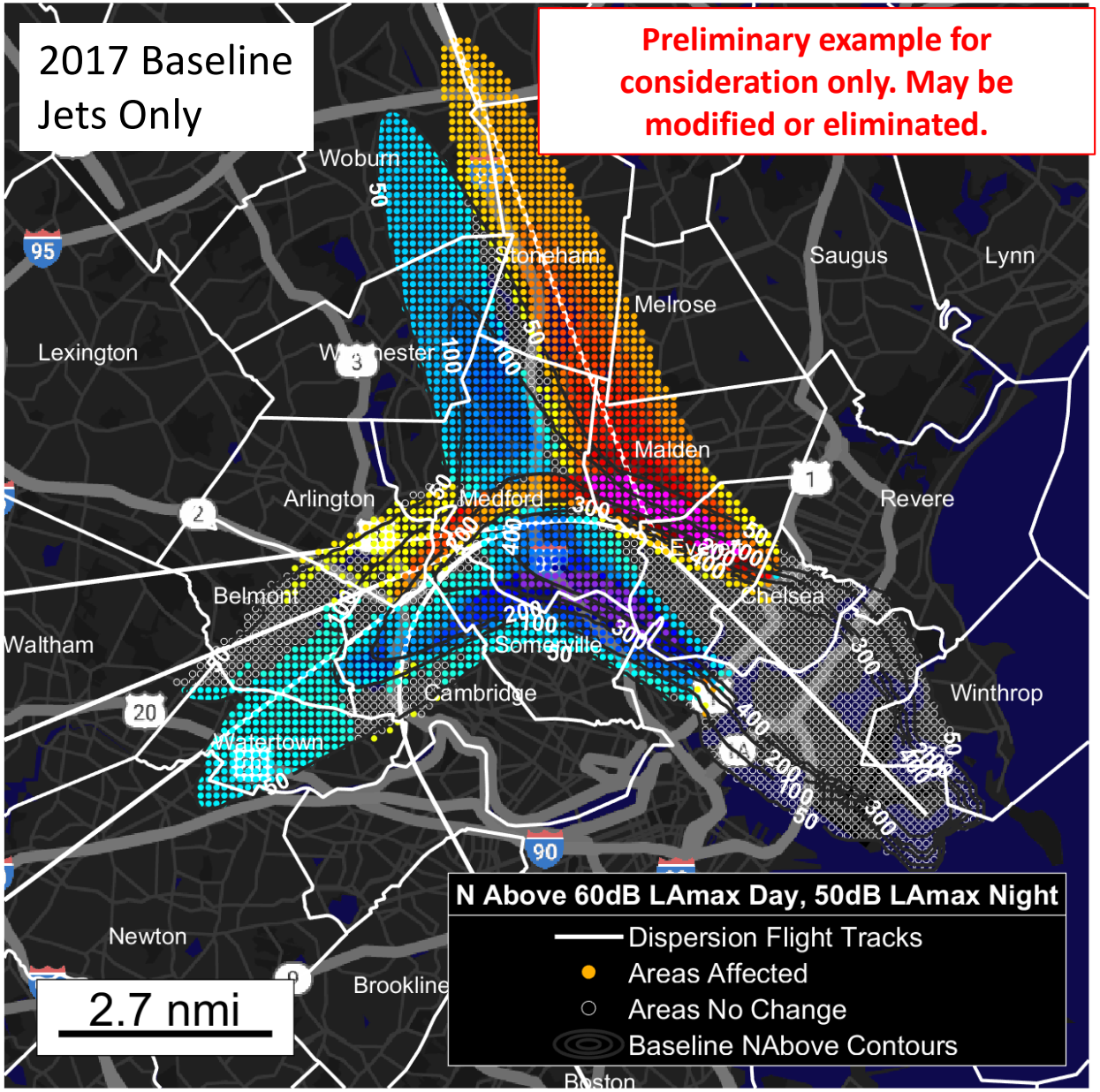
Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed

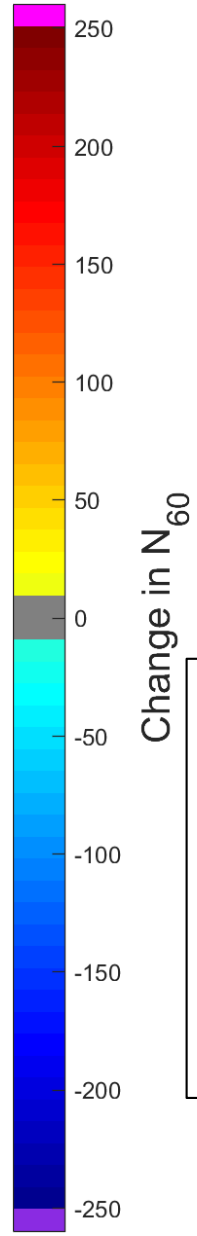


Analysis based on peak day operations; only includes 33L departures

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

33L Departures VRD Waypoint #6 Change in N_{60} Compared to 2017

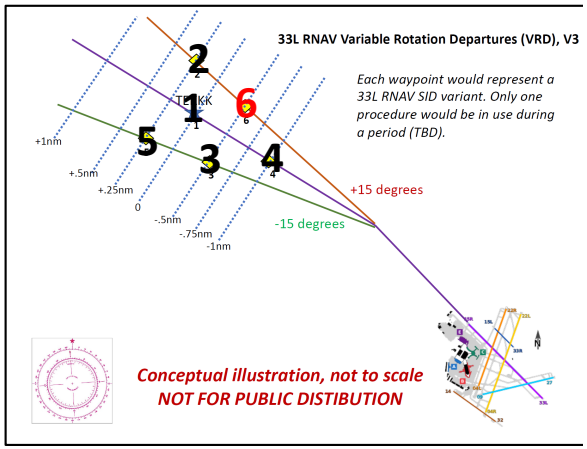




Population Exposure

N_{60}	50x
Baseline 2017	335,823
Dispersion	319,040
Baseline - Dispersion	16,783

Analysis updated Oct. 17 2019 to remove Turboprops and refine lateral tracks
Modeling/Discretization effects near airport removed



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

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

Community Questions

Variable Rotation Departures (VRD):

- "What is the capability of the cockpit FMS's to handle a greater number of RNAV variants as described in the VRD option?"
- "What is the ability of ATC to manage 4-6 variants?"
- "Are there operational or technical obstacles that we should know about?"

Departure with Diverging Headings:

- "How are flights allocated to branches (north, west, south)?"
- "Do you envision branch distribution to be tracked by ATC and somehow equalized?"
- "How does distribution change based on volume/time-of-day?"

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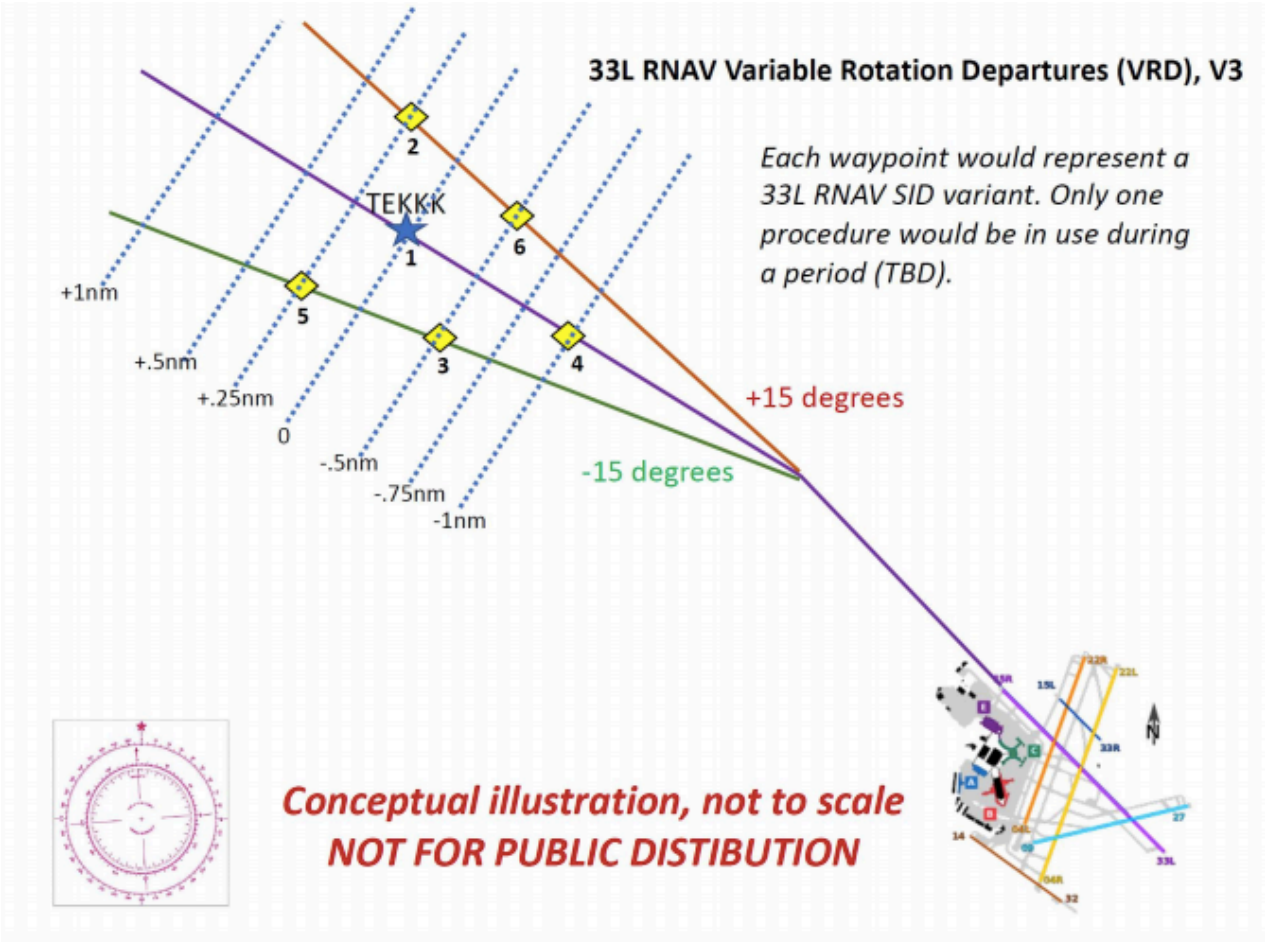
Departure with Diverging Headings:

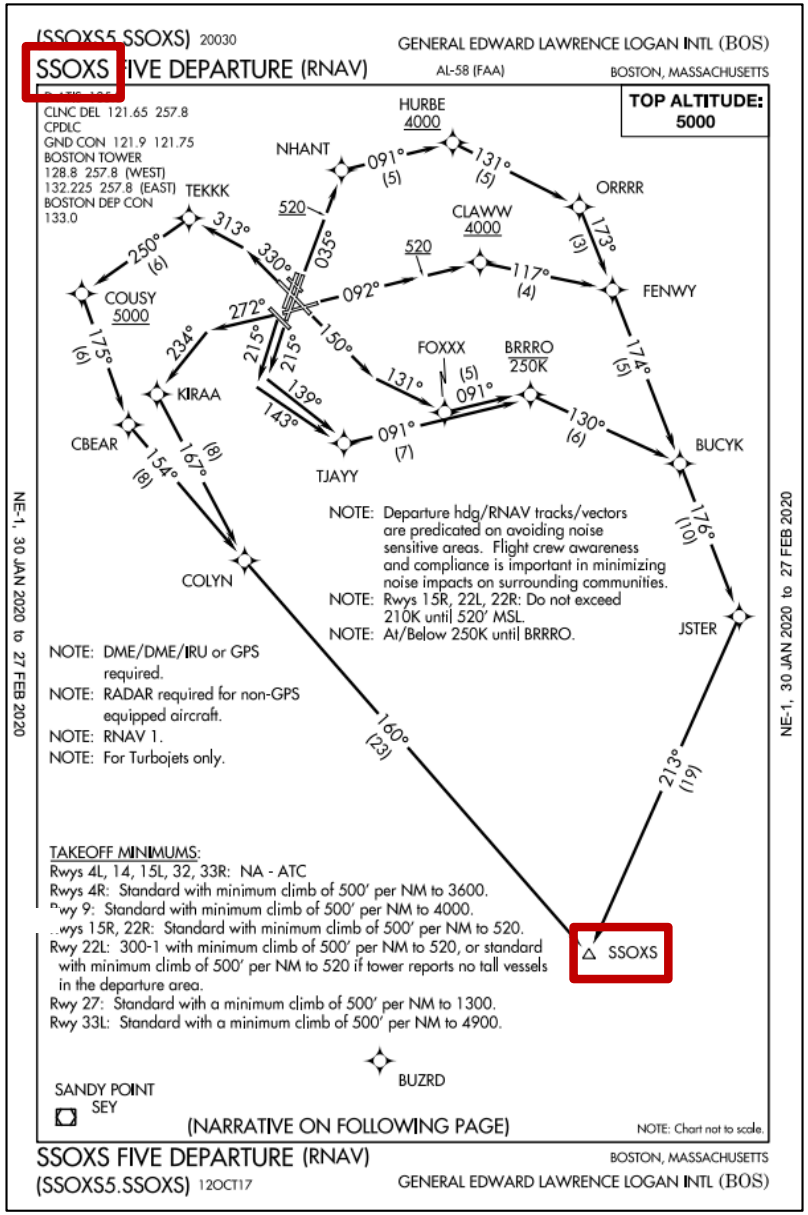
- "How are flights allocated to branches (north, west, south)?"
- "Do you envision branch distribution to be tracked by ATC and somehow equalized?"
- "How does distribution change based on volume/time-of-day?"

Community-suggested Variable Rotation Departures (VRD)



- Presents SID naming issues.
- Would require up to 48 procedures (40 new) (6 “TEKKK” locations x 8 existing RNAV end fixes).

RNAV Procedure Naming Convention Is Major Operational Barrier to VRD



RNAV procedures named after **enroute fix** where procedure ends

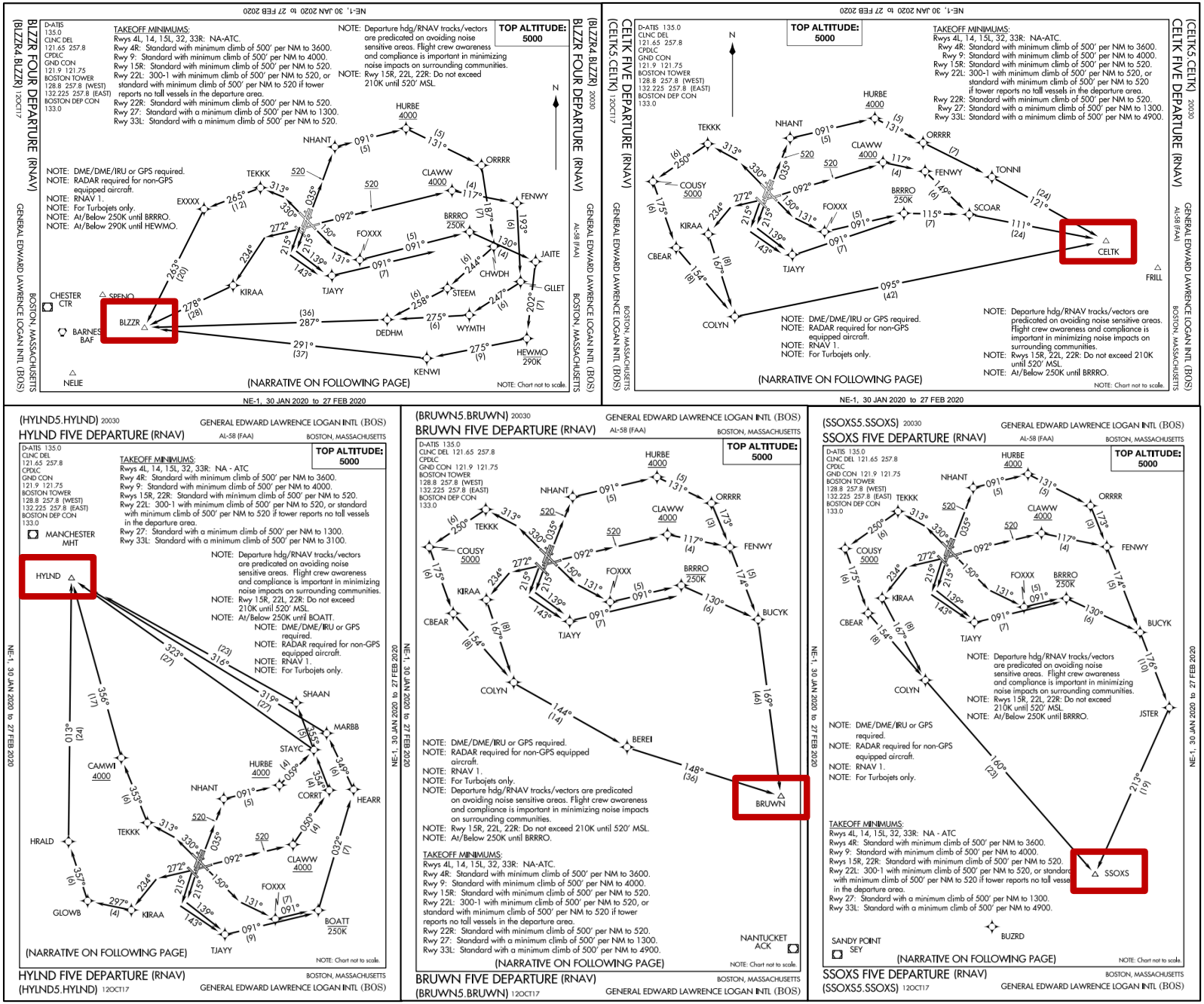
FAA Order 8260.46G 3-1-2(d)

"DPs designed using conventional, RNAV, or required navigation performance (RNP) guidance ***must be named to correspond with the enroute fix/NAVAID name where the DP ends****."*

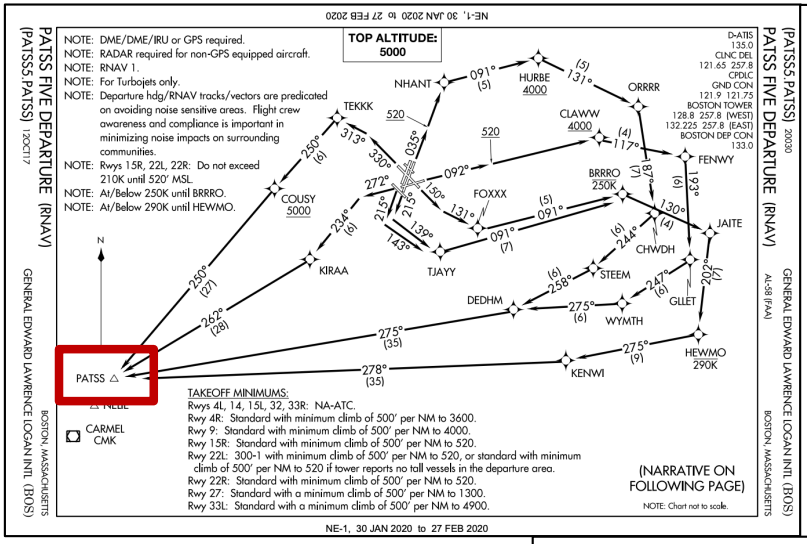
Implications for

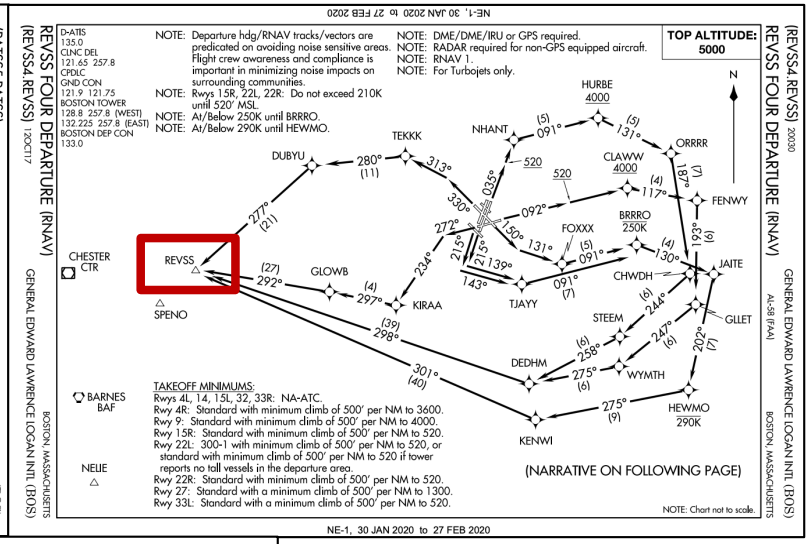
- FMS Memory (Requires 48 Separate Procedures)
- ATC Handoff Procedures (new waypoints)
  - New Waypoints
  - Letters of Agreement
  - Airspace and ATC Automation
  - Potential for Errors

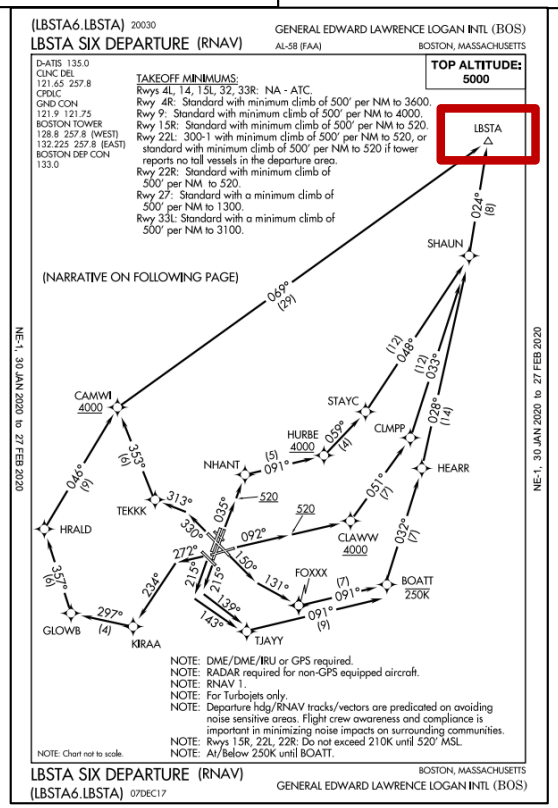
BOS Existing RNAV Departures (1/2)



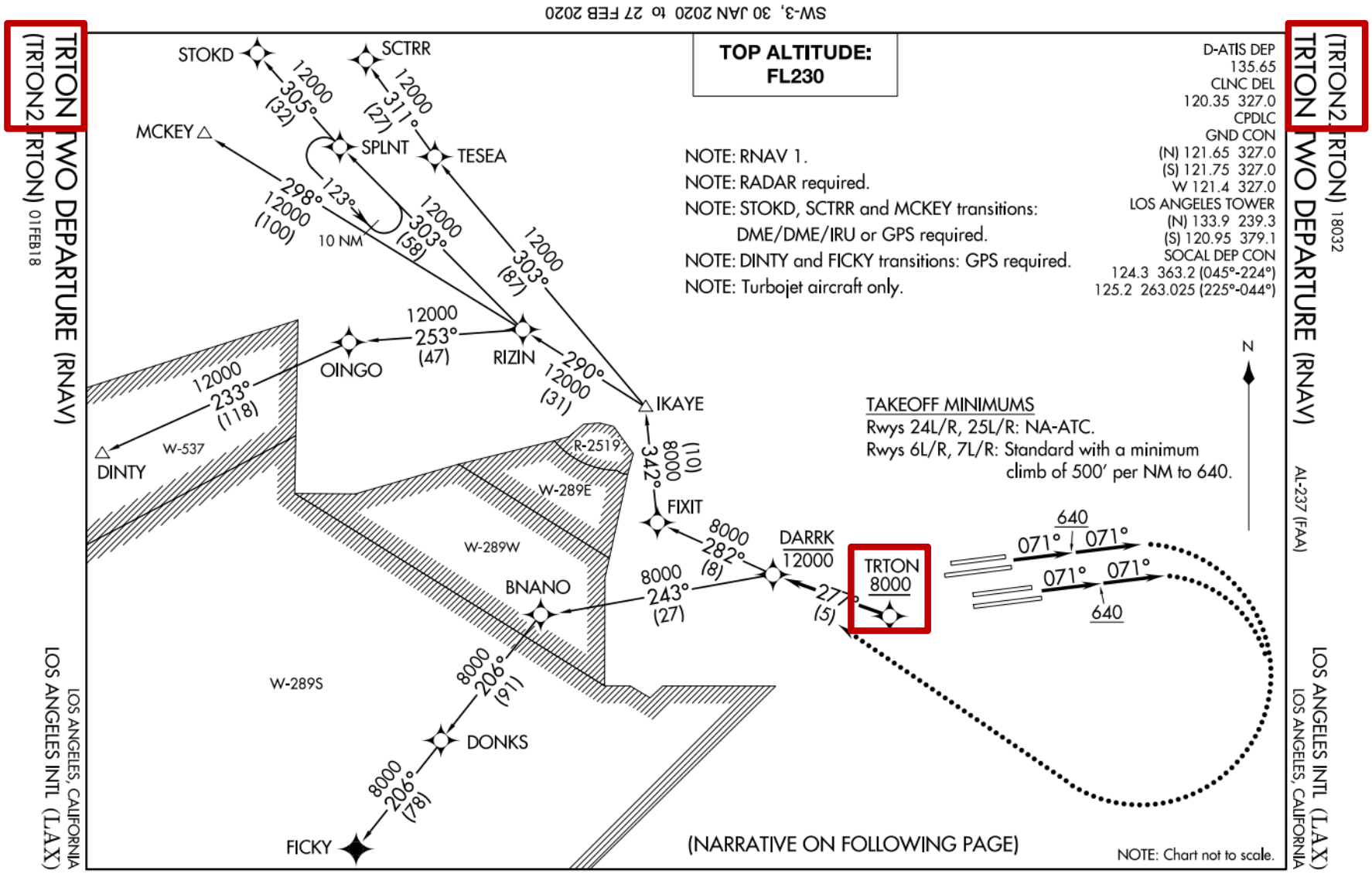
BOS Existing RNAV Departures (2/2)



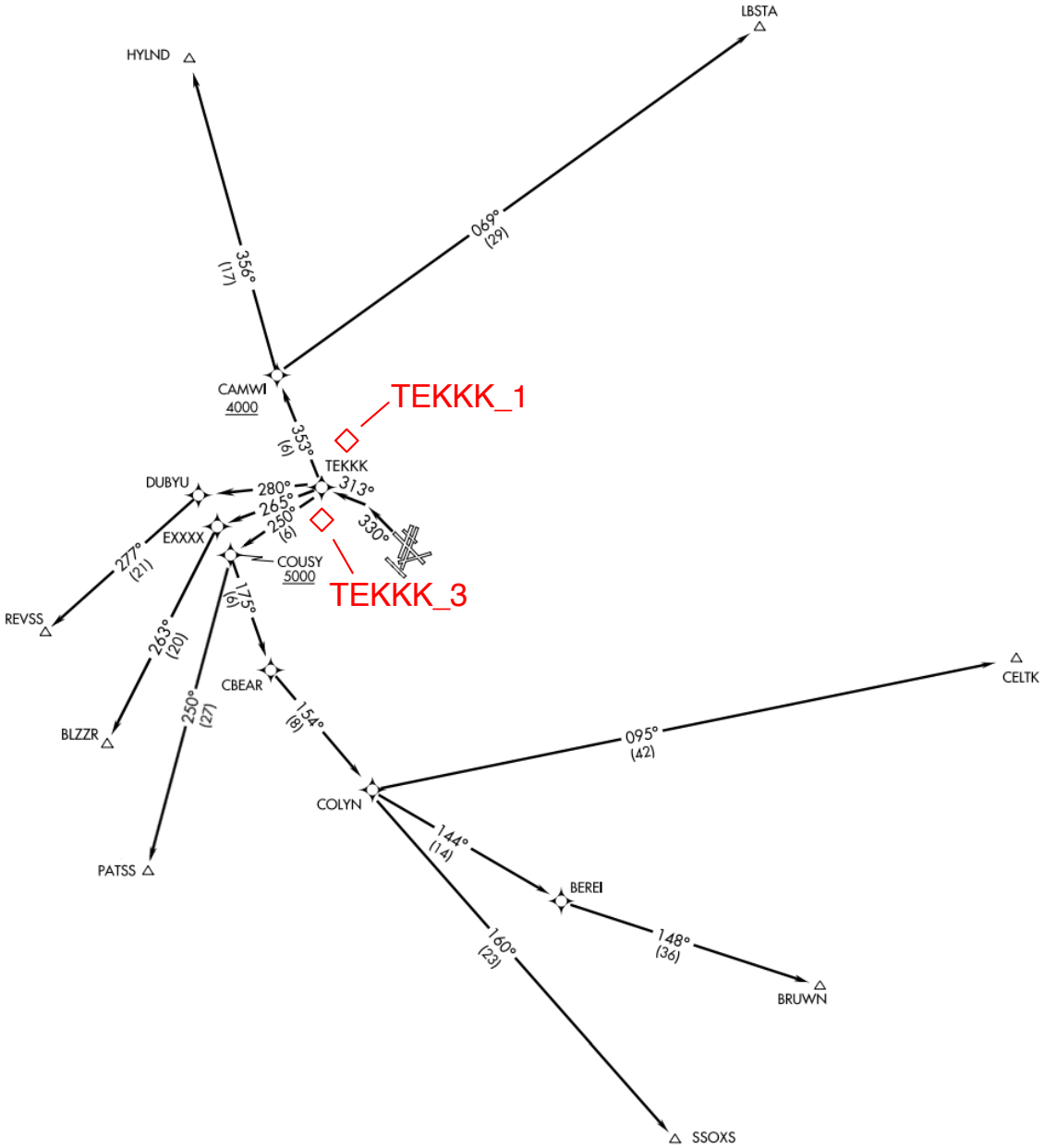




RNAV SID with Transitions Charting
LAX Example



Diverging Headings
RNAV SIDs with transitions (33 only)



- Requires multiple RWY 33-only RNAV SIDs with shifted initial waypoints (e.g., TEKKK_1, TEKKK_2, TEKKK_3

Implementation Issues

- Not consistent with BOS SID Charting
- Procedure complexity
- Concern regarding potential operational errors or ATC incidents
- Likely requires 3-6 additional SIDs

Issues Identified with VRD Concept

1. Requires 48 separate procedures
2. Limited memory in aircraft Flight Management Systems (FMS).
3. New exit waypoints (42) would be required due to SID naming conventions.
    1. New Letters of Agreement (LoA) must be developed if new exit waypoints are used.
    2. Modifications to ATC software (ERAM) required to handle new waypoints.

Community Questions

Variable Rotation Departures (VRD):

- "What is the capability of the cockpit FMS's to handle a greater number of RNAV variants as described in the VRD option?"
  - *Major issue due to 48 SIDs required*
  - *Probably not feasible*
- "What is the ability of ATC to manage 4-6 variants?"
  - *Would require major restructuring of LOAs and Waypoints*
  - *Concern regarding air traffic incidents*
- "Are there operational or technical obstacles that we should know about?"
  - *Discussed in prior slides*

Charting Implications for Other Dispersion Concepts

- Waypoint Relocation
  - No Charting issues
  - May require airspace changes
- Controller Based Dispersion
  - Can be implemented by current Logan 2 (non RNAV) departure
  - Controller workload concerns
- Divergent Heading Departures
  - Can be implemented by enroute fix
  - Branch distribution not flexible
    - Determined by enroute fix (i.e. Destination)

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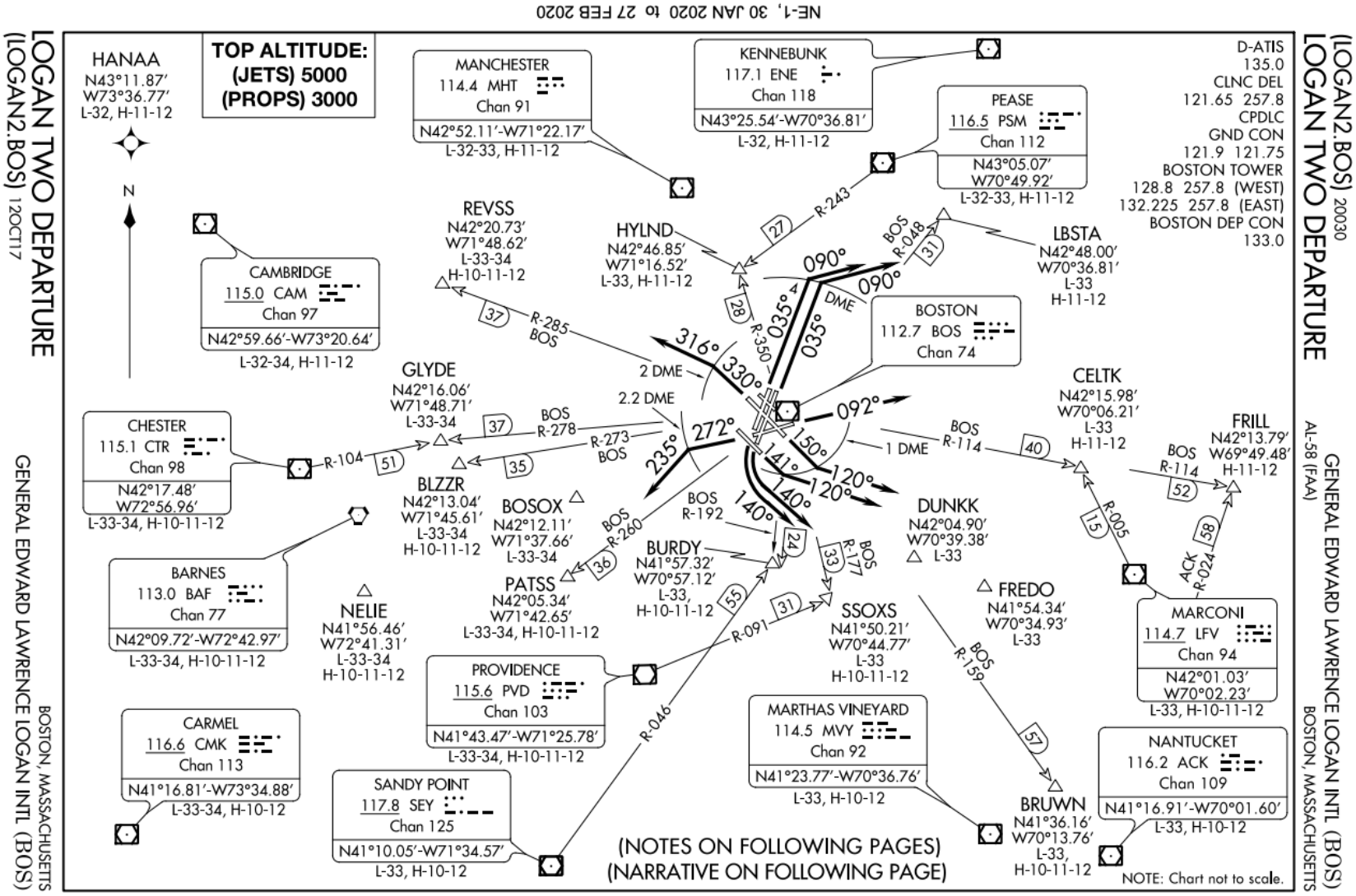
Controller Based Dispersion

Use existing LOGAN TWO?



NE-1, 30 JAN 2020 to 27 FEB 2020

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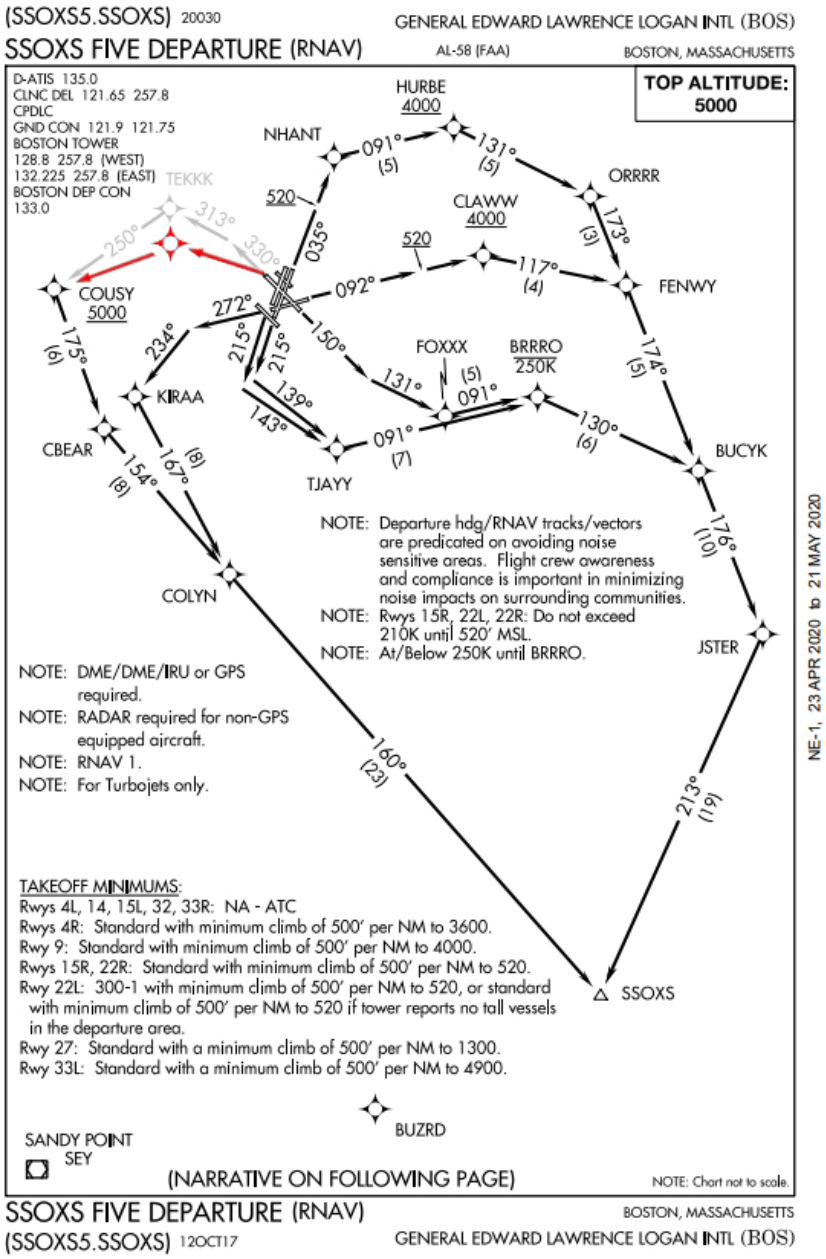
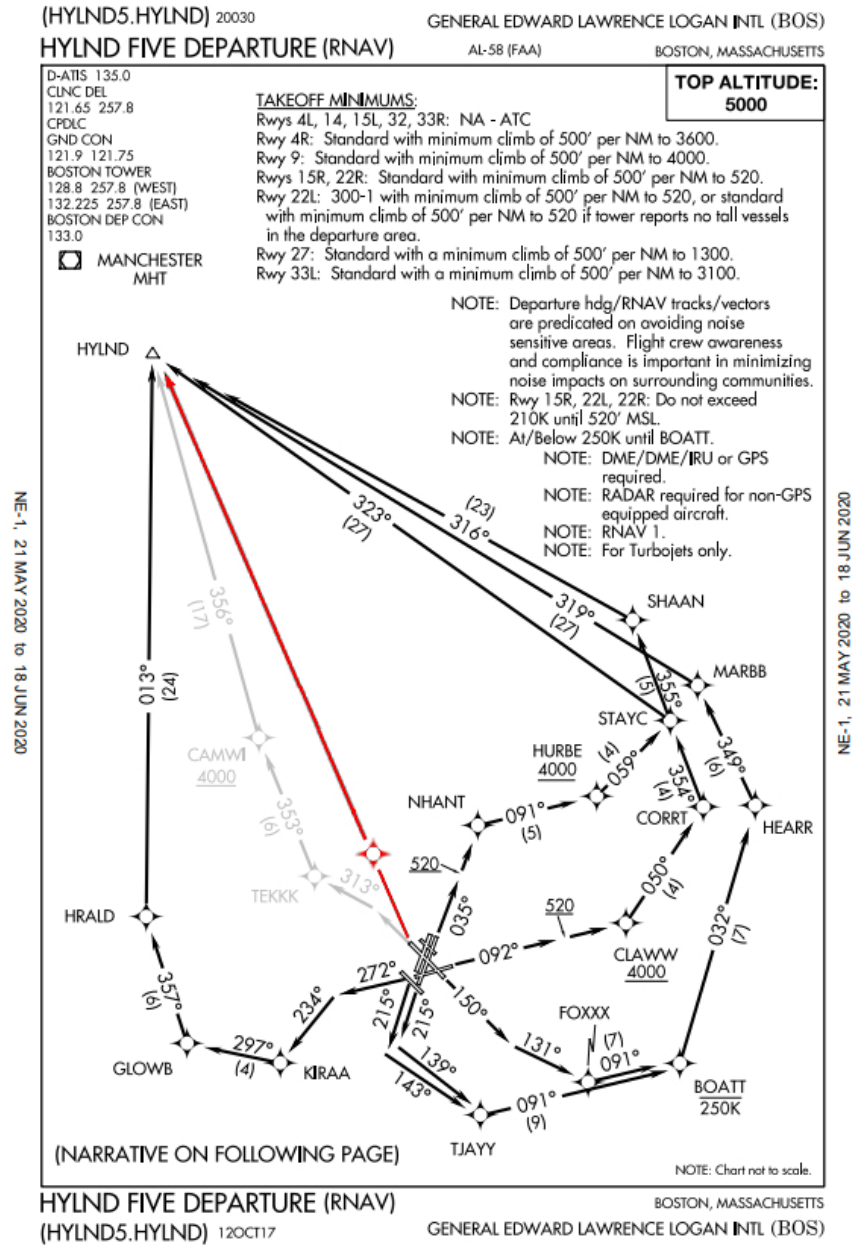
Diverging Headings Procedures Charted by Enroute Fix





Community Questions

Departure with Diverging Headings:

- "How are flights allocated to branches (north, west, south)?"
  - *Allocation would be by enroute fix due to charting issue*
- "Do you envision branch distribution to be tracked by ATC and somehow equalized?"
  - *Allocation would be by enroute fix*
- "How does distribution change based on volume/time-of-day?"
  - *Based on carrier schedules*

Discussion

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

Performance Model Inputs:
Operating/mission parameters
Aircraft sizing/performance parameters
Engine sizing/performance parameters

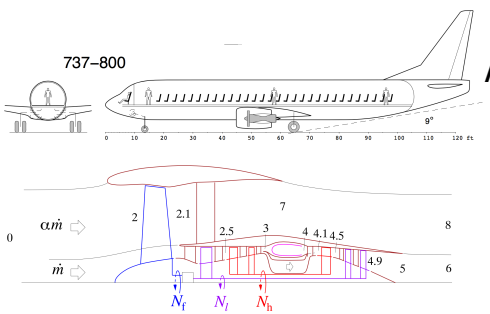
Aircraft Type

Procedure Definition:
Lateral Path
Speeds
Configuration

TASOPT

BADA4 Existing Aircraft Data

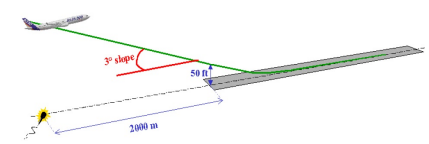
Performance Model Outputs:



Aircraft/engine performance & geometry

Flight Procedure Generator

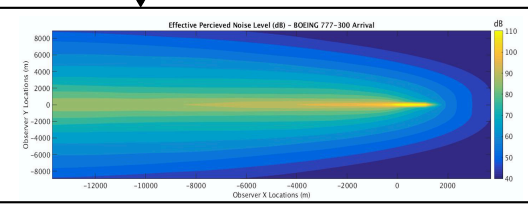
Flight Procedure:
Thrust, velocity, position, gear/flap settings per time



Noise Model Control Inputs:
Propagation Settings
Observer Locations

ANOPP/AEDT

Single-Event Noise Grids

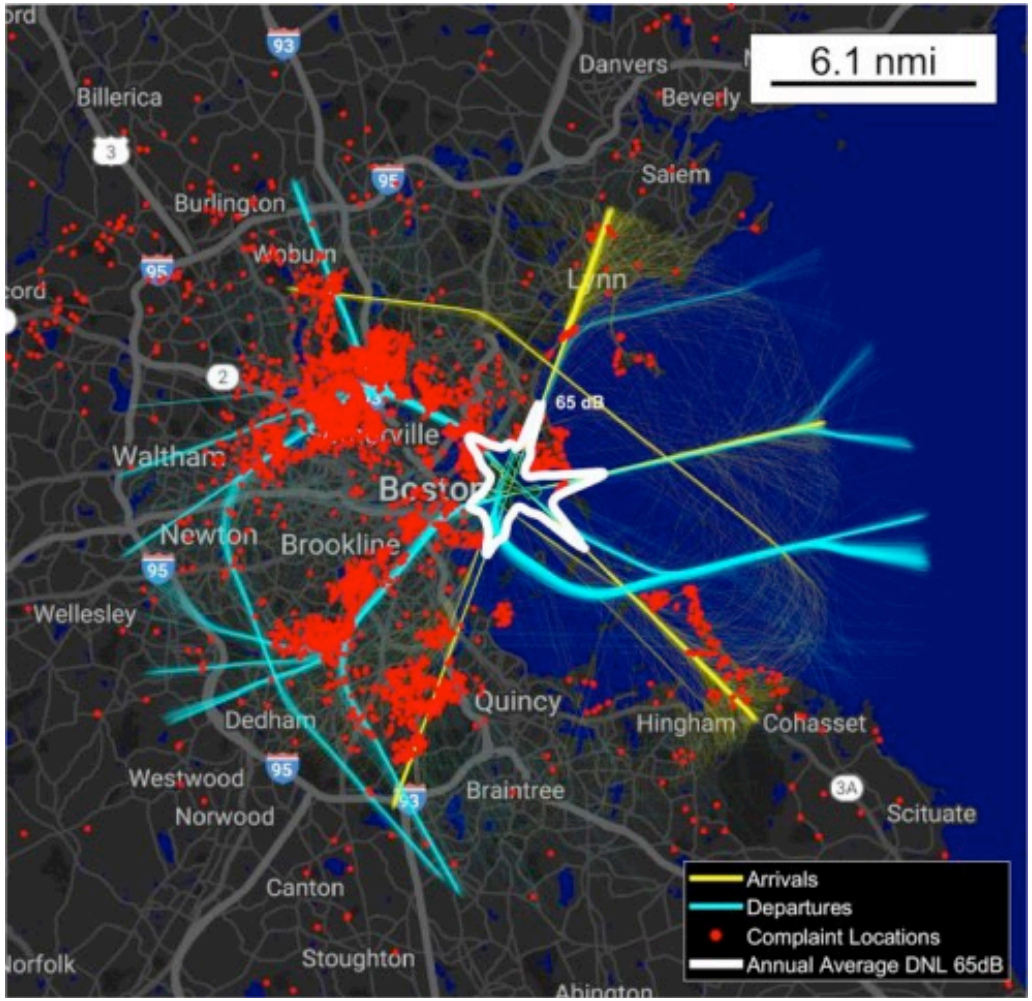


Output to Grid Rotation and Superposition

Alternative Metrics to Capture RNAV Concentration Impacts

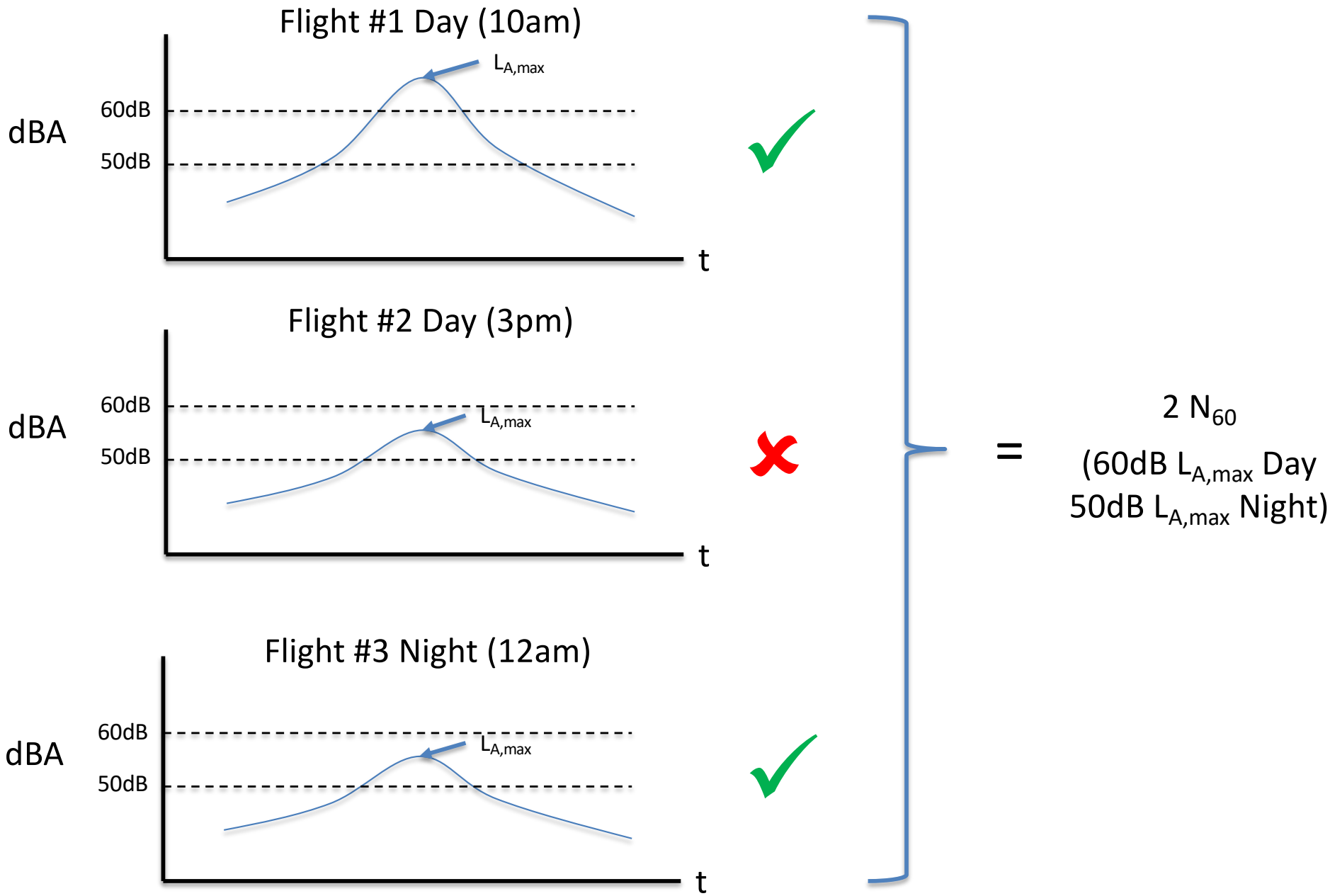
- RNAV concentration issue outside of Annual Average DNL 65dB contour
- Complaints frequently cite repetitive overfights as a concern
- Evaluated number of overflights above a threshold level on a peak day of runway use as an alternative metric at BOS, LHR, CLT, MSP

2017



Alternate Metric

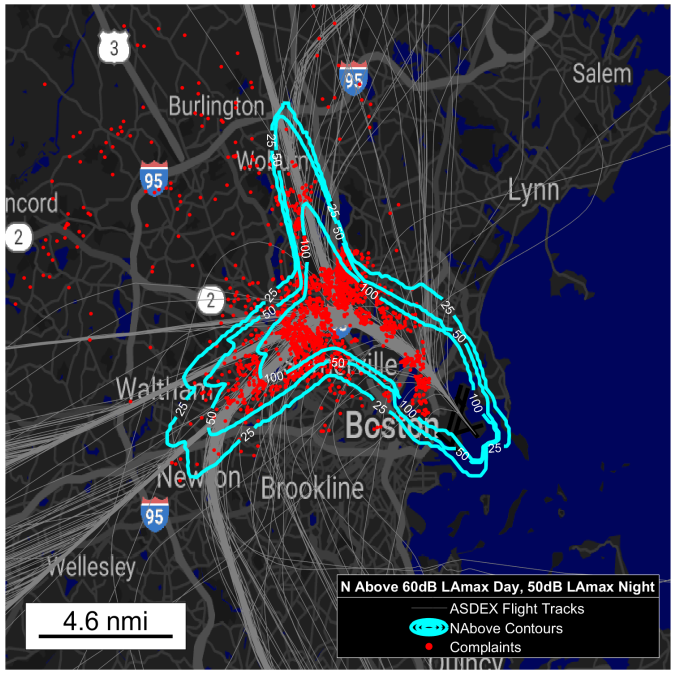
N_{60} Number of Overflight Events (60dB Day, 50 dB Night)



BOS N_{60} Count Thresholds

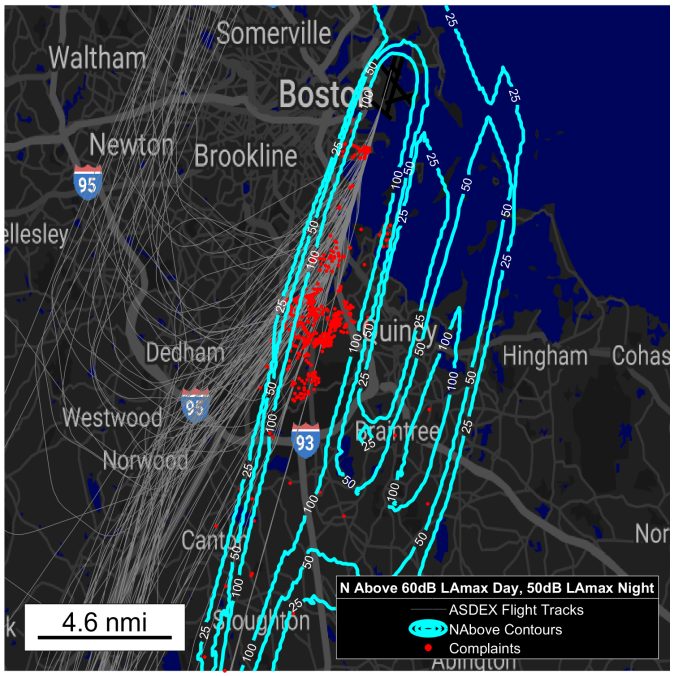
- N_{60} on a peak day with 50 overflights appears to capture complaint threshold in dispersion analysis

33L Departures Peak Day N_{60}



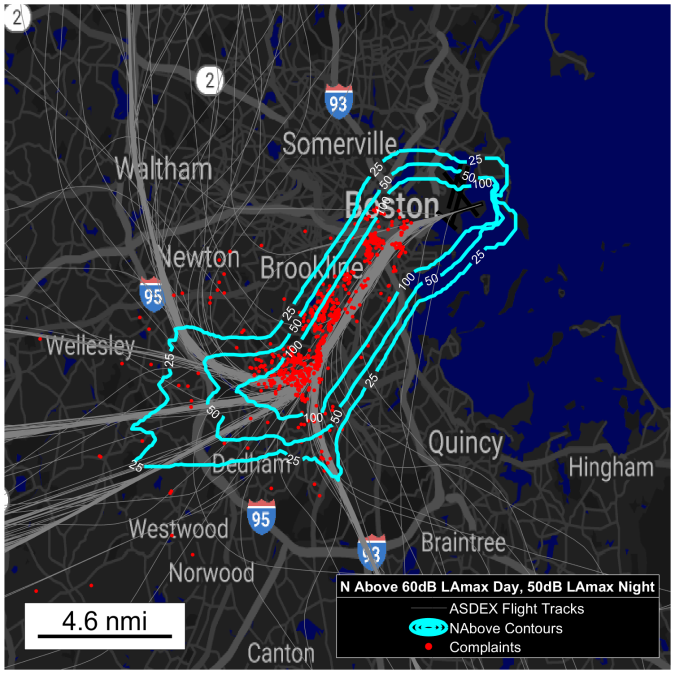
Peak Day N_{60}	Complaints Captured
25x	87.3%
50x	80.9%
100x	59.4%

4L/R Arrivals Peak Day N_{60}



Peak Day N_{60}	Complaints Captured
25x	97.7%
50x	94.7%
100x	81.0%

27 Departures Peak Day N_{60}

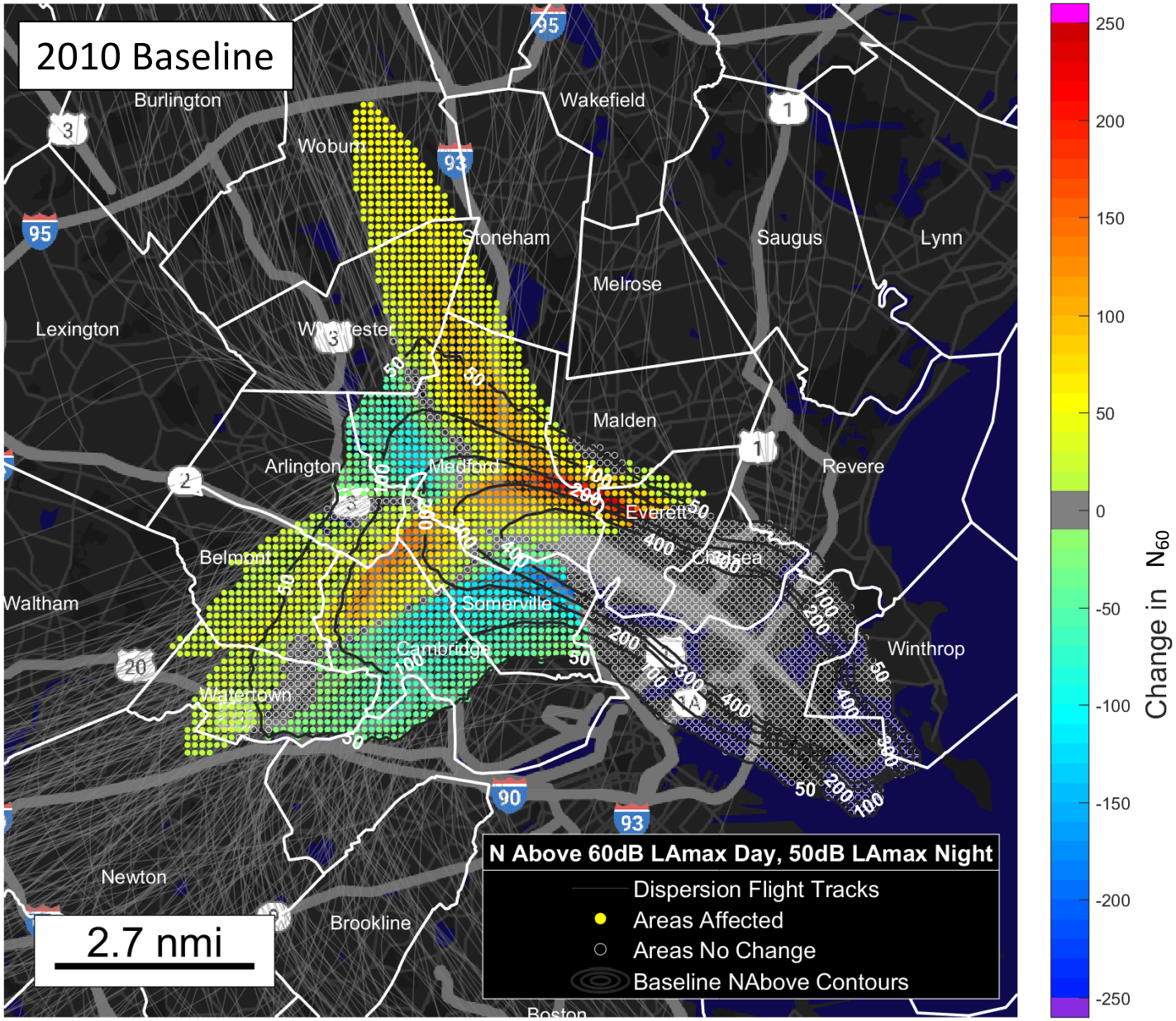


Peak Day N_{60}	Complaints Captured
25x	95.4%
50x	92.1%
100x	78.8%

2017 Data

Effect of RNAV Concentration on 33L Departures

2010 to 2017



Population Exposure

N_{60}	50x
Dispersion	356,960
RNAV	344,244
RNAV Benefit	12,716

Analysis updated Dec 4 2018 to correct for discretization differences

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

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