# Project 023 Analytical Approach for Quantifying Noise from Advanced Operational Procedures

## Massachusetts Institute of Technology

## Project Lead Investigator

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## University Participants

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- P.I.(s): R. John Hansman
- FAA Award Number: 13-C-AJFE-MIT, Amendment Nos. 008, 015, 022, and 031
- Period of Performance: Oct. 28, 2014 to Aug. 31, 2018
- Task(s):
    1. Evaluate the noise impacts of flight track concentration or dispersion associated with PBN arrival and departure procedures
    2. Identify the key constraints and opportunities for procedure design and implementation of noise-minimizing advanced operational procedures
    3. Develop concepts for arrival and departure procedures that consider noise impacts in addition to operational feasibility constraints
    4. Analyze location specific approach and departure design procedures in partnership with impacted industry stakeholders
    5. Develop and propose a demonstration plan for new procedure designs through modeling and/or flight testing

## Project Funding Level

Project Funding Level: $610,000 FAA funding and $610,000 matching funds. Sources of match are approximately $80,000 from MIT and $530,000 from Massachusetts Port Authority.

## Investigation Team

Prof R. John Hansman (PI)
Greg O'Neill (Post Doctoral Researcher)
Luke Jensen (Graduate Student)
Jacqueline Thomas (Graduate Student)
Alison Yu (Graduate Student)

# Project Overview

This project will evaluate the noise reduction potential from advanced operational procedures in the terminal (arrival and departure) phases of flight. The noise impact from these procedures is not well understood, or modeled in current environmental analysis tools, presenting an opportunity for further research to facilitate Air Traffic Management (ATM) system modernization. This project will leverage a noise analysis framework developed at MIT under ASCENT Project 23 to evaluate a variety of sample procedures. In conjunction, the project will contribute to the Memorandum of Understanding between the FAA and Massport to identify, analyze, and recommend procedure modifications at Boston Logan Airport.

# Task 1- Evaluate the Noise Impacts of Flight Track Concentration or Dispersion Associated with PBN Arrival and Departure Procedures

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## Objective(s

This task evaluates the impact of flight track concentration arising from Performance-Based Navigation (PBN) procedure implementation and the potential noise mitigation impact of track dispersion. The effects of track concentration due to PBN procedure implementation have not been fully explored. While the potential benefits of PBN for flight efficiency and predictability are well understood, the resulting environmental impact has caused increased community awareness and concern over the procedure design process. Current methods and noise metrics do not provide adequate information to inform the policy decisions relating to noise concentration or dispersion due to PBN implementation.

In this task, models were used to evaluate noise concentration scenarios using a variety of metrics and procedure design techniques. Noise data from Massport was used to support the simulation effort. The impact of track dispersion was compared to potential community noise reduction through noise-optimal RNP procedure designs that avoid noise-sensitive areas and use background noise masking where possible.

## Research Approach

- Evaluate the impact of noise dispersion directly through modeling of a dispersed set of flight tracks in AEDT
- Analyze population exposure impact using multiple metrics, including DNL and $N_{above}$
- Validate which metrics best capture the impacts of noise concentration and dispersion

## Major Accomplishments

- Determined best metrics for analyzing noise impacts due to dispersion by evaluating which metrics best capture at least 80% of noise complaints from multiple airports and runways.
- Completed dispersion modeling method for multiple flight tracks from a single centerline route.
- Modeled and evaluated the impacts of dispersion in for several departure and arrival scenario examples at Boston Logan using the identified metrics that best captured noise complaints.

# Task 2- Identify the Key Constraints and Opportunities for Procedure Design and Implementation of Noise-Minimizing Advanced Operational Procedures

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## Objective(s)

Arrival and departure procedure design is subject to physical, regulatory, and workload constraints. Procedures must be flyable by transport-category aircraft using normal, stabilized maneuvers and avionics. The procedures must comply with Terminal Instrument Procedures (TERPS) guidelines for obstacle clearance, climb gradients, and other limitations. The procedures must be chartable and work within the limitations of current Flight Management Systems. Advanced operational procedures must also be compatible with airport and air traffic control operations, avoiding workload saturation for air traffic controllers and pilots.

This task involved evaluating the key constraints impacting advanced operational procedures and opportunities to improve noise performance, identifying those that may impact design and implementation. This process involved collaboration with pilots, air traffic controllers, procedure designers, and community members. The task also considered current research and evidence on physical, psychological and social impacts of aircraft noise as well as emerging issues such as community perceptions of equity and the impact of overflight frequency on noise perception.

### Research Approach

- Meet with key stakeholders in the implementation pathway to understand procedure development processes, timeline, and constraints.
- Research documentation on regulations and operational standards influencing new flight procedure development.
- Consult with stakeholders during candidate advanced operational procedure development to identify potential implementation obstacles.

### Major Accomplishments

- Met with airport operators and airline technical pilots to discuss potential concepts for advanced operational procedures.
- Conducted follow-up meetings with ATC, Massport, FAA representatives, communities, and airline technical pilots to discuss initial procedure concepts.

## Task 3- Develop Concepts for Arrival and Departure Procedures that Consider Noise Impacts in Addition to Operational Feasibility Constraints

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### Objective(s)

This task applied the findings from Task 2 to identify a set of generic constraints and procedures for designing feasible and flyable advanced operational procedures to minimize noise perception as measured by traditional metrics (e.g. 65 dB DNL) and alternate metrics that address noise concentration concerns introduced by PBN procedures and emerging equity issues. Given an understanding of technology capabilities and operational constraints, this task developed potential operational concepts and identified potential implementation pathways for both specific locations and generalizable operational concepts. Some of the approaches considered were;

- Lateral Track Management Approaches (e.g. Dispersion, Parallel Offsets, Equivalent Lateral Spacing Operations, Multiple Transition Points, Vectoring, High Background Noise Tracks, Critical Point Avoidance Tracks, etc.)
- Vertical/Speed Thrust Approaches (e.g. Thrust Tailoring, Steep Approaches, Delayed Deceleration Approaches, etc.)

In addition, procedures were identified and categorized for the noise reduction effort at Boston Logan Airport. These included “Block 1” procedures, which were characterized by clear predicted noise benefits, limited operational/technical barriers and a lack of equity issues, and “Block 2” procedures, which exhibited greater complexity due to potential operational and technical barriers as well as equity issues (defined as noise redistribution between communities).

### Research Approach

- Use feedback from Task 2 to identify procedures with noise reduction potential
- Model procedures using AEDT and ANOPP for generic runways to evaluate noise impacts for candidate procedures on a single event and/or integrated basis
- Determine noise impacts based on multiple metrics that are location-agnostic (i.e. contour area) as well as location-specific (i.e. population exposure at specific runways)

### Major Accomplishments

- Developed a set of generic approach and departure modifications using PBN and other techniques to take advantage of noise benefits from advanced procedures

- Identified key constraints for lateral, vertical, and speed profile redesign based on ATC operational guidelines and FAA procedure design criteria
- Modeled and showed the impacts of candidate vertical/speed thrust approaches that were within FAA procedure design criteria
- Identified and made recommendations for Block 1 procedures for assessment by the FAA for implementation at Boston Logan Airport
- Identified candidate Block 2 procedures for noise reduction at Boston Logan Airport

## Task 4- Analyze Location Specific Approach and Departure Design Procedures in Partnership with Impacted Industry Stakeholders

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### Objective(s)

Advanced operational procedures may be particularly applicable for specific airports based on local geography, population density, operational characteristics, fleet mix, and local support for procedure modernization (among other factors). Specific procedures will be evaluated at a series of representative airports around the U.S. It is anticipated that this task will involve collaboration with multiple airports and air carriers on potential opportunities at locations which would benefit from advanced PBN procedures.

For the Boston Logan Airport noise reduction project, this task also involves collaboration with the FAA 7100.41 PBN working group, which is the initial operation evaluation group for new procedure design concepts.

### Research Approach

- Coordinate with a specific airport operator to evaluate procedure design opportunities with noise reduction potential
- Work closely and communicate with impacted stakeholders throughout the procedure evaluation, design, and analysis process to ensure that key constraints and objectives are appropriate for the selected location on a procedure-by-procedure basis

### Major Accomplishments

- Continued regular meetings and collaboration with Massport to finalize Block 1 procedure recommendations and to develop Block 2 arrival and departure procedures for analysis at Boston Logan Airport
- Performed detailed noise analysis for Block 1 and preliminary Block 2 arrival and departure procedure concepts that addressed community concerns, including population impact estimation based on 2010 census data and re-gridding methodology developed for this research
- Assisted with community outreach meetings about noise in the Boston area
- Presented at and collaborated with stakeholders during the FAA 7100.41 PBN working group meeting for evaluation of the Block 1 procedure concepts at Boston Logan Airport
- Modeled and assessed the noise impacts of adjusted Block 1 procedures that satisfied lateral position criteria as identified by the FAA 7100.41PBN working group meeting

## Task 5- Develop and Propose a Demonstration Plan for New Procedure Designs Through Modeling and/or Flight Testing

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### Objective(s)

The noise impact of advanced operating procedures must be validated in terms of operational acceptability (crew workload, safety, precision, controller workload, etc.) and noise impact. This task involved the generation of a testing plan for high value candidate advanced operational procedures developed in Task 4. Test plans considered included flight simulator studies, noise modeling, initial discussions of flight testing, and noise monitoring plans for newly-implemented procedures.

## Research Approach

- Document procedure recommendations thoroughly and unambiguously so that simulator or flight trials are possible
- Meet with airline technical pilots and representatives from aircraft manufacturers to discuss operational constraints and test opportunities
- Develop test plans and protocols for potential flight trials
- Develop test plans and protocols for potential noise measurement campaigns
    - Specific flight test locations
    - Operational field measurements

## Major Accomplishments

- Coordinated with airlines, Massport, and a major aircraft manufacturer to discuss objectives and potential strategies for possible noise measurement campaigns for reduced-speed departure procedures
- Published Block 1 procedure recommendations for specific flight procedures at Boston Logan that could be implemented for noise reduction as a result of feedback from several stakeholders

## Publications

- "Block 1 Procedure Recommendations for Logan Airport Community Noise Reduction," 2017. Link: http://hdl.handle.net/1721.1/114038
- "Framework for Analyzing Aircraft Community Noise Impacts of Advanced Operational Flight Procedures," *Submitted for Review, Journal of Aircraft*, 2018.

## Outreach Efforts

9/27/2017: Poster to ASCENT Advisory Board
12/05/2017: Call with Boeing to Discuss Procedure Noise Impact Validity
03/16/2018: Discussion with MSP Airport About Metrics
4/04/2018: Poster to ASCENT Advisory Board
05/07/2018: Presentation to FAA 7100.41 PBN Working Group
06/24/2018: Discussion with Air Traffic Controllers about Dispersion Concepts
7/23/2018: Briefing to FAA Joint University Program research update meeting
10/09/2018: Poster to ASCENT Advisory Board
11/08/2018: Presentation to Airline Industry Consortium
Numerous community meetings
Numerous briefings to politicians representing Eastern Massachusetts (local, state, and federal)
Briefing to FAA Management Advisory Council
In-person outreach and collaboration with Massport, operator of Boston Logan Airport and ASCENT Advisory Board member

## Awards

None

## Student Involvement

Graduate students have been involved in all aspects of this research in terms of analysis, documentation, and presentation.

## Plans for Next Period

The next phase of this project will involve continued outreach to stakeholders impacted by implementation of advanced operational procedures, including airlines, airports, air traffic controllers, the FAA, and communities. Specific procedures that have significant operational or equity challenges such as steep approaches, delayed gear approaches, and flight track dispersion will continue to be evaluated in a generic sense as well as at specific airports of interest, including Boston Logan Airport and any other locations agreed upon by the project team and FAA program managers. For the Boston Logan Airport noise reduction project, this will also include the finalization and publication of Block 2 procedure concepts. This procedure evaluation process is expected to inform recommendations to airport operators, airlines, and the FAA to develop noise-mitigating advanced operational procedures at specified locations in the NAS.