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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- PI: R. John Hansman
- FAA Award Number: 13-C-AJFE-MIT, Amendment Nos. 008, 015, 022, 031, 046, and 051
- Period of Performance: October 1, 2020 to September 30, 2021
- Tasks:
    1. Evaluate the noise impacts of flight track concentration or dispersion associated with performance-based navigation (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 affected industry stakeholders.

Project Funding Level

FAA provided $860,000 in funding, and matching funds totaling $860,000 were provided by the Massachusetts Institute of Technology (MIT) (approximately $80,000) and the Massachusetts Port Authority (Massport) (approximately $780,000).

Investigation Team

- Professor R. John Hansman (PI)
- Sandro Salgueiro (graduate student)
- Clement Li (graduate student)
- Ara Mahseredjian (graduate student)
- Kevin Zimmer (graduate student)

Project Overview

This project is evaluating 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. The project leverages a noise analysis framework developed at MIT under ASCENT Project 23 to evaluate a variety of sample procedures. In conjunction, the project is contributing to the memorandum of understanding between the FAA and Massport to identify, analyze, and recommend procedure modifications at Boston Logan International Airport (hereafter, Boston Logan).

Task 1 - Evaluate the Noise Impacts of Flight Track Concentration or Dispersion Associated with Performance-Based Navigation (PBN) Arrival and Departure Procedures

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Objectives

This task evaluates the impact of flight track concentration arising from 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. Although 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 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 were used to support the simulation effort. The impact of track dispersion was compared with potential community noise reduction through noise-optimal required navigation performance 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 the Aviation Environmental Design Tool (AEDT).
- Analyze population exposure impact using multiple metrics, including day-night average sound level (DNL) and N_{above}.
- Validate which metrics best capture the impacts of noise concentration and dispersion.

Major Accomplishments

- Created new visualization methods to allow communities to more easily understand the impact of flight procedure changes at different scales.
- Evaluated noise complaints at Boston Logan and began development of method to correlate them with specific overflights, allowing a data-driven review of annoyance criteria.
- Published the final Block 2 Report for the Boston Logan project, containing a series of low-noise procedure recommendations based on the analysis of flight tracks and complaints from both before and after the implementation of area navigation (RNAV).

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

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Objectives

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 affecting advanced operational procedures and opportunities to improve noise performance, identifying those that may affect design and implementation. This process involved collaboration with pilots, air traffic controllers (ATC), 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 effect 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

- Finalized the design of proposed Boston Block 2 procedures and held meetings with operational stakeholders (ATC, pilots, FAA safety staff) to conduct preliminary assessments of feasibility. All proposed procedures for runways 22L/R, 27, and 33L have passed these preliminary checks.
- Identified categories of constraints (1) flight standards design criteria, (2) ATC rules and procedures, (3) aircraft limitations and standard operator practices—and recorded lessons learned in satisfying constraints in these three key areas.
- Shared key lessons learned regarding flight procedure constraints at the Fall 2021 ASCENT meeting.

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

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Objectives

This task applied the findings from task 2 to identify a set of generic flyable advanced operational procedures to minimize noise perception as measured by traditional metrics (e.g., 65 dB DNL) and alternative metrics that address noise concentration concerns introduced by PBN procedures and emerging equity issues. Given an understanding of technology capabilities and operational constraints, in this task we 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, and critical point avoidance tracks)
- Vertical/speed thrust approaches (e.g., thrust tailoring, steep approaches, and delayed deceleration approaches).

In addition, procedures were identified and categorized for the noise reduction effort at Boston Logan. 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 the Aircraft Noise Prediction Program (ANOPP) for generic runways to evaluate noise impacts for candidate procedures on a single-event 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

- Investigated a *thrust cutback* concept for departure procedures, in which aircraft momentarily reduce engine thrust by flying a procedural level segment on departure, therefore also reducing engine noise.
- Published an academic paper at the 2021 AIAA SciTech conference on the thrust cutback concept, titled "Operational Noise Abatement through Control of Climb Profile on Departure."

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

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Objectives

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 were evaluated for Boston Logan through a project with Massport. This task involved collaborating with airport stakeholders, air carriers, and local air traffic controllers on potential opportunities for developing lower-noise procedures for Boston Logan.

Research Approach

- Identify opportunities for procedural noise abatement through the evaluation of current flight trajectories, local noise complaint data, and community input.
- Develop new alternative procedures and modify existing procedures that both show potential for noise reduction and meet procedure implementation constraints.
- Work closely and communicate with affected 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

- Held regular meetings with airport and operational stakeholders to assess preliminary feasibility of procedures developed specifically for Boston Logan.
- Published the final Block 2 Report for the Boston Logan project, containing a series of low-noise procedure recommendations based on the analysis of flight tracks and community input.
- Continued regular meetings and collaboration with Massport and its Community Advisory Committee, ensuring that communities have the data needed to decide on what procedures to support.

Publications

- "Block 1 Procedure Recommendations for Logan Airport Community Noise Reduction," 2017. Link: http://hdl.handle.net/1721.1/114038
- Thomas, J; Hansman, J. "Framework for Analyzing Aircraft Community Noise Impacts of Advanced Operational Flight Procedures," *Journal of Aircraft*, Volume 6, Issue 4, 2019. https://doi.org/10.2514/1.C035100

- Thomas, J., Yu, A., Li, C., Toscano, P., and Hansman, R.J. "Advanced Operational Procedure Design Concepts for Noise Abatement" *In Thirteenth USA/Europe Air Traffic Management Research and Development Seminar*, Vienna, 2019.
- Yu, A., and Hansman, R.J. "Approach for Representing the Aircraft Noise Impacts of Concentrated Flight Tracks" *AIAA Aviation Forum 2019*, Dallas Texas, 2019.
- Salgueiro, S., Thomas, J., Li, C., and Hansman, R.J. "Operational Noise Abatement through Control of Climb Profile on Departure" *AIAA SciTech Forum 2021*.

Outreach Efforts

- September 27, 2017: Poster to ASCENT Advisory Board
- December 5, 2017: Call with Boeing to discuss procedure noise impact validity
- March 16, 2018: Discussion with Minneapolis-St. Paul (MSP) Airport about metrics
- April 4, 2018: Poster to ASCENT Advisory Board
- May 7, 2018: Presentation to FAA 7100.41 PBN Working Group
- June 24, 2018: Discussion with air traffic controllers about dispersion concepts
- July 23, 2018: Briefing to FAA Joint University Program research update meeting
- October 9, 2018: Poster to ASCENT Advisory Board
- November 8, 2018: Presentation to Airline Industry Consortium
- March 3, 2019: Presentation to the Aviation Noise and Emissions Symposium
- October 15, 2019: Presentation to the ASCENT Advisory Board
- November 12, 2019: Presentation to Airline Industry Consortium
- May 21, 2020: Meeting with operational stakeholders from FAA 7100.41 process to discuss Block 2 concepts
- September 23, 2021: Public hearing to present Block 2 procedure recommendations for Boston Logan
- 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 and ASCENT Advisory Board member

Awards

2018 Dept of Transportation/FAA COE Outstanding Student of the Year Award to Jacqueline Thomas.
2021 Massachusetts Port Authority Logan Stars Award to the MIT International Center for Air Transportation research group.

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 focus on the documentation of lessons learned from the Boston Logan project, during which several low-noise flight procedures were developed with considerable input from operational and community stakeholders. Based on findings from this step, areas of opportunity for future work will be considered in coordination with the Project Managers.