Project 023 Analytical Approach for Quantifying Noise from Advanced Operational Procedures

Massachusetts Institute of Technology

Project Lead Investigator

R. John Hansman
T. Wilson Professor of Aeronautics & Astronautics
Department of Aeronautics & Astronautics
Massachusetts Institute of Technology
Room 33-303
77 Massachusetts Ave
Cambridge, MA 02139
617-253-2271
rjhans@mit.edu

University Participants

Massachusetts Institute of Technology

- PI: R. John Hansman
- FAA Award Number: 13-C-AJFE-MIT, Amendment Nos. 008, 015, 022, 031, 046, and 051
- Period of Performance: October 28, 2014, to March 28, 2020
- Task(s):
    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

$860,000 in FAA funding and $860,000 matching funds. Sources of match are approximately $80,000 from Massachusetts Institute of Technology (MIT) and $780,000 from Massachusetts Port Authority (Massport).

Investigation Team

- Professor R. John Hansman (PI)
- Jacqueline Thomas (graduate student)
- Clement Li (graduate student)
- Sandro Salgueiro (graduate student)
- Rachel Price (graduate student)
- Annick Dewald (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 Performance-Based Navigation (PBN) Arrival and Departure Procedures

Massachusetts Institute of Technology

Objective(s)

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

- 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 for several departure and arrival scenario examples at Boston Logan Airport using the identified metrics that best captured noise complaints
- Determined the impacts of dispersion concepts recommended by communities after demonstration of initial dispersion concepts
- Refined modeling methods to more accurately model which aircraft realistically fly which tracks based on performance in dispersion simulations

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

Massachusetts Institute of Technology

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 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

- 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
- When preparing for phase two of the project, used lessons learned from Block 1 FAA 7100.41 PBN meeting in Block 2 procedure design, incorporating feedback from airline procedure designers

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

Massachusetts Institute of Technology

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 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, critical point avoidance tracks)
- Vertical/speed thrust approaches (e.g., thrust tailoring, steep approaches, delayed deceleration approaches)

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 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

- 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 Affected Industry Stakeholders

Massachusetts Institute of Technology

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 United States. It is anticipated that this task will involve collaboration with multiple airports and air carriers on potential opportunities at locations that 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 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

- 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 regridding 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
- Reconsidered select Block 1 procedures not accepted by FAA 7100.41 PBN working group and revised proposed procedures based on feedback to be recommended in Block 2

- Modeled noise impacts of Block 1 procedures re-recommended for Block 2

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.

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
- 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

2018 Dept of Transportation/FAA COE Outstanding Student of the Year Award to Jacqueline Thomas

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 affected by implementation of advanced operational procedures, including airlines, airports, ATC, the FAA, and communities. The next phase will include finalization of Block 2 procedures for recommendation. Operational challenges of specific noise reduction procedures, such as the delayed deceleration approach and dispersion concepts, will be identified. 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 National Airspace System.