Project 023 Analytical Approach for Quantifying Noise from Advanced Operational Procedures

Massachusetts Institute of Technology

Project Lead Investigator

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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

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Project Overview

The objective of this research activity is to evaluate the noise reduction potential from advanced operational procedures in the arrival and departure phases of flight. In particular, the project is intended to address the need and opportunity for noise-driven PBN procedure design utilizing the enhanced flexibility and precision of RNP. Advanced operational procedures change noise exposure near airports in two respects. First, flight track alterations (terminal-area route

changes, concentration, or dispersion) can impact the noise experienced by specific observers or neighborhoods near airports. Second, the source noise generated by engines and aerodynamics are impacted by aircraft speed, thrust, and configuration. Therefore, arrival and departure procedures that impact these variables also impact noise generation. The combined noise impact from these two effects are not well understood or modeled in current environmental analysis tools, presenting an opportunity for further research to facilitate ATM system modernization. This phase of research leverages the analytical tools and approaches developed in prior phases of this project to evaluate noise impacts of variable aircraft speeds and configurations.

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 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 Nabove
- Develop alternative rapid dispersion modeling method to reduce computational burden for evaluating operational strategies that impact flight track density

Major Accomplishments

- Developed methodology for rapid dispersion modeling as an alternative to exhaustive flight-by-flight analysis in AEDT/ANOPP.
- Completed development of numerical method for dispersion modeling using a single centerline route rather than individually modeling a representative set of dispersed routes

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
- Identified strong speed dependence on airframe noise that is not captured by NPD-based methods.

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 which 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.)

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

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 US. 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.

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

- Established regular meeting and collaboration schedule with Massport and developed an initial set of arrival and departure procedures for analysis at Boston Logan Airport
- Contributed to a joint effort Memorandum of Understanding between the FAA and Massport to identify, analyze, and recommend procedure modifications at Boston Logan Airport
- Performed detailed noise analysis for preliminary arrival and departure procedure concepts, 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

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 airline technical pilots from a major US airline to plan and fly a set of simulator trials of candidate procedures in a Level-D Boeing 767 simulator
- 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

Publications

"Delayed Deceleration Approach Noise Assessment," *16th AIAA Aviation Technology, Integration, and Operations Conference*, 2016. DOI: 10.2514/6.2016-3907

"Investigation of Aircraft Approach and Departure Velocity Profiles on Community Noise," *23rd AIAA/CEAS Aeroacoustics Conference*, 2017. DOI: 10.2514/6.2017-3188

"Analytical Approach for Quantifying Noise from Advanced Operational Procedures," *12th USA/Europe Air Traffic Management Research and Development Seminar*, 2017.
http://www.atmseminarus.org/seminarContent/seminar12/papers/12th_ATM_RD_Seminar_paper_135.pdf

Outreach Efforts

1/25/2017: Briefing to FAA Joint University Program research update meeting
4/17/2017: Joint briefing to FAA and MITRE to discuss tool development pathway
4/18/2017: Briefing to ASCENT Advisory Board
6/5/2017: Presentation at AIAA Aviation Conference in Denver, CO.
6/29/2017: Presentation at Eurocontrol/FAA ATM R&D Seminar in Seattle, WA.
7/10/2017: Briefing and simulator testing session with a major US-based airline
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
In-person outreach and collaboration with Volpe noise tool development team

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 extensive outreach to stakeholders impacted by implementation of advanced operational procedures, including airlines, airports, air traffic controllers, the FAA, and communities. Specific procedures will be evaluated for noise impacts, including a detailed analysis of operational barriers to entry and pathways to implementation for high-benefit options. Procedures will 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. 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.