Project 023(A) Analytical Approach for Quantifying Noise from Advanced Operational Procedures

Massachusetts Institute of Technology

Project Lead Investigator

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- FAA Award Number: 13-C-AJFE-MIT, Amendment Nos. 008 and 015
- Period of Performance: Nov. 1, 2014 to Aug. 31, 2016
- Task(s):
    1. Development of one or more procedures for calculating the source generation and propagation of aerodynamic noise in the terminal environment
    2. Identify requirements for aircraft performance modeling during advanced operational procedures
    3. Apply a modified noise assessment technique to one or more sample advanced operational procedures
    4. Identify modeling improvements of existing tools required to represent noise impacts of advanced operating procedures

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- P.I.(s): Phillip Morris
- FAA Award Number: 13-C-AJFE-PSU, Amendment Nos. 009 and 018
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- Task(s):
    5. Identify improvements required to noise source models and implement and assess new prediction formulas
    6. Extend existing noise source models to account for changes in aircraft noise due to changes in aircraft configurations
    7. Continue evaluation of candidate metrics in addition to DNL and assess the importance of the need for such metrics

Project Funding Level

MIT
$110,000 FAA funding and $110,000 matching funds. Source of match is $110,000 from Massachusetts Port Authority.

PSU
$176,711 FAA funding and $176,711 matching funds. Source of match is $176,711 from Massachusetts Port Authority

Investigation Team

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Project Overview

The objective of the research is to continue development of an analytical approach for evaluating the noise impacts of advanced operating procedures. Older generations of jet engines produced significantly more noise than current-generation products. The assumption that jet noise dominates aerodynamic sources may have been reasonable in previous environmental impact studies. However, for new advanced approach and departure procedures, aerodynamic noise reduction may contribute strongly to environmental benefits. For example, in a delayed deceleration approach (DDA), deployment of landing gear and high-lift devices can be delayed until later stages in an approach, reducing aerodynamic noise. This effect is not captured using current noise-power-distance (NPD) noise calculation tools now in common use throughout the aerospace industry. This illustrates a gap in noise analysis capability for advanced operational procedures.

Task Progress and Plans

Task 1: Development of one or more procedures for calculating the source generation and propagation of aerodynamic noise in the terminal environment

Task 1 will involve a continued review of the physics driving aerodynamic noise generation from advanced procedures (including speed adjustments, thrust adjustments and timing of high-lift device and/or landing gear deployment). The objective of the task is to guide improvements to current noise analysis techniques incorporating aerodynamic effects. This may take the form of enhanced NPD reference data or direct estimation of noise from a physics-based model such as ANOPP. Calibration of the noise model will be aided by a variety of data sources and analytical techniques. Operational overflight noise data provided by Massport will be used to help calibrate and refine the model. The data will be correlated with high-resolution PDARS radar track records and NOAA weather models to provide a large set of flyover noise events and the corresponding flight conditions. If needed, this calibration method will be supplemented with other noise data (through FAA-AEE, Volpe, and/or aircraft manufacturers).

Task 2: Identify requirements for aircraft performance modeling during advanced operational procedures

Task 2 will evaluation options for higher-fidelity performance calculation and simulation for advanced operating procedures. Thrust level, flap setting, and landing gear configuration all have an impact on noise levels and performance capabilities. During the first phase of this research, it was evident that accurate modeling of flight dynamics and performance are vital to generate high-fidelity noise models. This is true for analysis using either NPD-based approaches or higher-fidelity models. Therefore, this phase of the research will include more detailed analysis of performance characteristics and resulting impact on procedural noise.

Task 3: Apply a modified noise assessment technique to one or more sample advanced operational procedures

Task 3 will incorporate the results of Tasks 1-2 to illustrate potential noise analysis improvements for advanced approach and departure procedures. The sample approach or departure procedure(s) will be used to demonstrate noise analysis capability improvements from Task 3 relative to existing AEDT/INM methods. Data from Massport will be used to help define utility as well as operational and noise issues for candidate procedures and to provide calibration baselines. The dataset, consisting of single-event overflight noise signatures at specific locations surrounding Boston Logan International Airport, includes a wide variety of flight operating conditions. This baseline dataset will be explored as a potential validation source for the noise model at different real-world operating points.

Modifications to account for alternate aircraft configurations will then be applied to demonstrate the potential for parametric analysis of advanced approach and departure procedures. The larger applicability and development requirements for such methods will be discussed.

Task 4: Identify modeling improvements of existing tools required to represent noise impacts of advanced operating procedures

Task 4 will use the results from Tasks 1-3 to determine necessary modeling improvements to capture the impact of advanced operating procedures. These changes may include noise source and propagation methods, aircraft performance model refinement, or both. The methods implemented in the sample problem from Task 3 will be described in terms such that outside tool developers could incorporate similar changes as needed.

Task 5: Identify improvements required to noise source models and implement and assess new prediction formulas
The theory that underlies ANOPP dates from the 1970's and is crude at best. In particular, the models for airframe noise are based on a very simplified representation of the noise generation mechanisms and scaling. In addition, the prediction procedures have been calibrated based on conventional aircraft component geometries. The extent to which these simplifications affect the evaluation of the noise impacts of advanced operational procedures remains unknown. In recognition of these deficiencies NASA introduced a new noise prediction program concept called ANOPP2. This revised approach is based heavily on computational fluid dynamics with the associated computational costs. So the revised concept is not yet applicable to noise impact studies. In this task, based on the shortcomings in noise prediction models identified in the first phase of the project, revised noise source models will continue to be developed. It is not proposed to modify ANOPP but to develop noise source models with higher fidelity to replace key airframe noise elements in the present predictions.

Task 6: Extend existing noise source models to account for changes in aircraft noise due to changes in aircraft configurations
This task will identify noise source characteristics that would be affected by interaction effects or unconventional aircraft configurations. This could have a significant effect on the noise radiation. Examples would be shielding and reflection effects. To make such models computationally viable for operational procedure assessment they will be based on reduced order models. For example, at the lowest level of fidelity, line-of-sight models could be used for shielding effects. At a higher level of fidelity, analytic solutions for refraction effects could be included. The extent to which these effects have a noticeable effect on the noise metrics will be evaluated by comparisons with predictions omitting these installation effects as well as comparisons with measurements where available.

Task 7: Continue evaluation of candidate metrics in addition to DNL and assess the importance of the need for such metrics
The DNL metric represents the current industry standard. It remains to be determined if this metric is the most appropriate one to assess the noise impact of advanced operational procedures. Based on the final results of the first phase of the project, continued assessment of alternative noise metrics will continue. These metrics will be evaluated on the basis of the noise prediction models and flight procedures developed in the other tasks.

Major Accomplishments
Have developed and demonstrated TASOPT and ANOPP connection and modeled several aircraft types with good agreement with certification data. Have demonstrated the tool on representative departure (cut back) procedures and approach (Delayed Deceleration Procedures).

Publications
None

Outreach Efforts
Several briefings on FAA Tools Team meeting

Awards
None

Student Involvement
Graduate students have been involved in all aspects of this research and have been the key implementers.