Project 011(A) Development of Rapid Fleet-Wide Environmental Assessment Capability Using a Response Surface Modeling Approach

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Project Lead Investigator

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- Period of Performance: Aug. 18, 2014 to Aug. 31, 2018 (year 4 as NCE)
- Task(s):
  1. Extend And Enhance Modeling Framework
  2. Extend Fleet Gauge Sample Problem To System Level
  3. Develop Multi-stakeholder Valuation Methods To Enable Comparison And Decisions About Preferred Strategies In The Environmental Output Space
  4. Apply Fast Modeling Framework To Additional Sample Problem

Project Funding Level

$670,000 FAA funding and $670,000 matching funds. Sources of match are approximately $232,500 from MIT and $437,500 from Massachusetts Port Authority.

Investigation Team

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Project Overview

The objective of the research is to continue development of an analytical framework for evaluating the environmental impact of air transportation and to use that framework on a variety of sample policy and operational problems. This framework will use fast models for aircraft-level performance, noise, and emissions, enabling broad scenario explorations and parametric analyses in environmental studies. Phase I of this research (2014-2015) consisted of general analysis framework development, sample problem selection, and surrogate model development. Phase II of this research (2015-

2016) aimed to continue model development while demonstrating the capability of the modeling approach on a specific multi-dimensional sample problem involving fleet gauge modification. Phase III of this research (2016-2017) aimed to increase the ability to evaluate local noise impacts at the system level and develop additional multi-objective sample problems to demonstrate the flexibility and extensibility of the rapid environmental analysis framework. This phase refined the relationship between local and system-level impacts arising from specific advanced operational procedures and aircraft fleet evolution.

Task 1- Extend and Enhance Modeling Framework

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Objective(s)

The modeling framework for rapid environmental impact assessment has been developed to include local and system wide impacts for noise, emissions, and fuel consumption at specific locations based on representative or generic airports. The first two years of this research highlighted the challenge of systematically evaluating local impacts (e.g. noise and LTO emissions) which depend on location-specific elements such as procedure design, fleet mix, population density, etc. with global factors such as emissions and fuel consumption.

This task aimed to develop techniques that can capture key environmental characteristics at a system level that incorporates location-specific characteristics. In order to rapidly analyze individual airport performance, it is necessary to have a generic representation of the operating patterns and flight trajectories. This task leverages work that has been done on statistical clustering methods to identify common operations at individual airports, simplified generic profile definitions for some airports, and detailed procedure modeling for certain classes of advanced operational procedures.

Research Approach

- Expand the modeling framework and architecture developed in the initial phases of the research to add greater detail on modules and interfaces to enable implementation of specific sample problems.
- Locate and incorporate data sources for procedure definition, fleet mix, and timetable to enable rapid system-level analysis without requiring extensive manual intervention on an airport-by-airport basis.

Major Accomplishments

- Modeling framework applied for system-wide analysis of all runway ends for OEP-35 airports
- Modeling framework now integrates AEDT emissions results into analysis
- Modeling framework allows for rapid analysis of multiple flight procedures, and varying metrics are considered to communicate integrated noise exposure

Task 2- Extend Fleet Gauge Sample Problem to System Level

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Objective(s)

In Year 2 of this effort, an initial fleet gauge sample problem was evaluated. The objective of this sample problem was to calculate the environmental impact of a 10% upgauge at a single example airport (DCA) using the 2015 operational fleet model. The aggregate noise, emissions, fuel consumption and NOx impacts were calculated, along with potential effects on passenger throughput. In Year 3, this sample problem will be expanded to a broader system level using the results of Task 1, specifically incorporating local noise analysis at the OEP 35 airports. This allowed for continued development and refinement of the modeling framework, allowing for policy valuation and comparison across multiple stakeholders and impact scales.

Research Approach

- Develop modeling capability at a specific airport (DCA) that is representative of the types of results desired for each airport in a broader system-level analysis.
- Extend the modeling capability developed for the specific airport to a small subset of the NAS to evaluate potential data and analysis implementation challenges.

- Extent modeling capability to full airport sample set of interest (initially the OEP 35 airports).

Major Accomplishments

- Noise analysis for all runway ends at OEP-35 airports considers set of possible flight procedures within RNAV and RNP criteria and not only straight in and straight out procedures.
- Noise analysis applied to all runway ends at OEP-35 airports in order to determine noise-minimum flight procedures within RNAV and RNP criteria.
- Noise metric analysis considered at multiple airports within US and internationally.

Task 3- Develop Multi-stakeholder Valuation Methods to Enable Comparison and Decisions About Preferred Strategies in the Environmental Output Space

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Objective(s)

Environmental impacts from air transportation activities are felt across multiple stakeholders, geographic scales, and timescales. As a result, different stakeholders have different priorities and perceived valuations of possible policies and procedures. The focus of the first two years in this research effort was to generate system outputs in terms of raw environmental metrics (for noise, emissions, fuel burn, etc.). These metrics do not translate directly to a stakeholder preference structure or an improved understanding of community welfare on local and system wide scales. In this phase of the research effort, multi-stakeholder valuation methods were investigated with specific emphasis placed on an evaluation of different noise metrics to capture annoyance beyond traditional "significant" noise level definitions.

Research Approach

- Evaluate methods and metrics for assessing impact from environmental variables, particularly noise.
- Analyze and compare results using the rapid system-level analysis framework using appropriate metrics of choice.

Major Accomplishments

- Integrated AEDT fuel emissions calculations into system model for analyzing environmental impact
- Results reported in terms of noise analysis and emissions analysis
- Further development of noise metrics for population impact analysis with DNL as well as supplemental metrics for analysis such as N_{Above}.
- Initial complaint analysis for correlation of complaints and integrated noise metrics, including DNL and N_{Above}. Complaint analysis conducted at multiple airports including BOS and MSP.
- Developed methods for rapid population impact analysis of flight procedures such as dispersed flight tracks using integrated exposure metrics including DNL and N_{Above}.

Task 4- Apply Fast Modeling Framework to Additional Sample Problem

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Objective(s)

In this task, the fast modeling architecture for local and system wide environmental analysis was applied to an additional sample problem to evaluate system-level applications for location-specific procedural changes. The objective of this task was to exercise modeling capabilities with scenarios that are relevant for multiple stakeholders, including local communities, operators, airports, and regulators.

Research Approach

- Identify methods to model flight operations in the vicinity of airports using representative trajectories based on historical radar data and published procedures

- Integrate schedule, fleet, and runway utilization data from external sources to allow calculation of noise contours at airports of interest
- Analyze noise impacts at a system level that would arise from implementing a specific advanced operational procedure of interest, or modifying procedure design criteria for specific types of PBN procedures.

Major Accomplishments

- Developed method for generating set of possible flight procedures based on RNAV and RNP procedure design criteria
- Developed method for rapidly applying noise contour analysis to tens of thousands of possible flight procedures
- Applied rapid noise analysis framework to RNAV and RNP procedures in order to determine noise-minimum procedure for each runway procedure at all OEP-35 airports

Publications

- Jensen, L., "Data-Driven Flight Procedure Simulation and Noise Analysis in a Large-Scale Air Transportation System," *MIT ICAT*, 2018. http://hdl.handle.net/1721.1/116741

Outreach Efforts

02/26/2018: Briefing to Aviation Noise Symposium
04/03/2018: Briefing to ASCENT Advisory Board
04/19/2018: Briefing to FAA Joint University Program research update meeting
06/15/2018: Collaboration with NASA discussion
07/12/2018: Collaboration with MSP airport discussion
07/23/2018: Briefing to FAA Joint University Program research update meeting
10/09/2018: Briefing to ASCENT Advisory Board
10/22/2018: Briefing to FAA Joint University Program research update meeting
11/08/2018: Briefing to Airline Industry Consortium
In-person outreach and collaboration with TASOPT aircraft performance model development team at MIT.
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 further analysis of metrics to best communicate noise results for multi-stakeholder situations. The noise analysis framework will be applied to further examples in analyzing potential concepts for flight procedures including dispersed flight tracks. The framework will be applied at a system-level, analyzing not only a single flight procedure but rather a set of flight procedures and the impacts to the communities.