



Project 082(B) Integrated Noise and CO₂ Standard Setting Analysis

Massachusetts Institute of Technology

Project Lead Investigator

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University Participants

Massachusetts Institute of Technology (MIT)

- P.I.: Dr. Raymond L. Speth
- FAA Award Number: 13-C-AJFE-MIT, Amendment Nos. 095, 102, 115, 119, 133, and 143
- Period of Performance: June 14, 2022, to August 31, 2027 (with the exception of funding and cost-sharing information, this report covers the period from October 1, 2024, to September 30, 2025)
- Tasks:
 1. Engagement in CAEP policy revisions
 2. Development of an aircraft conceptual design tool for policy analysis
 3. Aircraft design and impacts studies

Project Funding Level

ASCENT Project 082(B) has received \$1,400,000 Federal Aviation Administration (FAA) funding and \$1,400,000 matching funds. Sources of matching funds are approximately \$185,200 from MIT, plus third-party in-kind contributions of \$274,000 from Savion Aerospace Corp., and \$532,000 from NuFuels, LLC, and \$408,800 from Earth Force Technologies.

Investigation Team

Dr. Raymond L. Speth (P.I.), Tasks 1, 2, & 3
Dr. Prakash Prashanth (co-investigator), Tasks 2 & 3
Dr. Jayant Sabnis (co-investigator), Task 1
Jonas J. Gonzalez (PhD student), Tasks 1 & 2
Aditeya Shukla (PhD student), Tasks 2 & 3

Project Overview

To evaluate the economic reasonableness of proposed aircraft environmental standards, the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP) requires tools for assessing the impacts of technologies and design changes intended to control aircraft noise and emissions, and for evaluating the costs of implementing such changes to aircraft and engine designs. Existing methods used to support decision-making in previous CAEP stringencies do not represent modern aircraft and propulsion designs and technologies. The goal of this project is to develop new tools that address the shortcomings of the previous methods, in support of CAEP/13 and CAEP/14 stringency analyses.



Task 1 – Engagement in CAEP Policy Revisions

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Objective

A primary contribution of this project is continued support of the United States Research Team (USRT) for CAEP and its constituent Working Groups (WG). This support includes technical review, studies, and proposals that inform the WG's stringency analyses, and is intended to provide accurate assessments of commercial aviation's technological capability for rulemaking. This reporting period spanned the conclusion of CAEP/13 (Integrated Dual Stringency [IDS] of noise and fuel burn) and the initiation of CAEP/14 (nitrogen oxide stringency).

Research Approach

The inputs provided to the stringency analysis are intended to modify its technology and policy assumptions. These inputs include examination of existing aircraft technology, presentation of historical trends, and technical analyses of aircraft and engines. Specific to this reporting period, proposals were put forth for (i) the stringency analysis's analytical space and limit line options as follows from extensive analysis of the Engine and Emissions Data Bank and (ii) the types of anticipated technology responses as follows from an engine cycle design demonstration highlighting the sensitivity of emissions of nitrogen oxides (NO_x) to engine pressure ratio (OPR).

Milestones

- CAEP/13 Conclusion
 - Contributed to and reviewed the IDS final report. The decisions from the CAEP/13 meeting will be reflected in updates to ICAO Annex 16, Volumes I and III.
- CAEP/14 Initiation
 - Prepared proposals to be presented at the WG3/3 meeting advocating for (1) analyzing a broad analytical space that enables reduced OPR-scaling in the limit lines, and (2) flexibility in the technology assumptions for OPR of engines designed in response to new emissions limits. These proposals would enable a robust reflection of the capabilities of current and near-future engine technologies.

Publications

None.

Outreach Efforts

- Presented the analyses to the US CAEP participants and WG members to collect feedback during regular teleconferences.
- Submitted analysis proposals for consideration and adoption during quarterly in-person WG3 meetings.

Awards

None.

Student Involvement

MIT Graduate student, Jonas J. Gonzalez, conducted and presented part of the analyses presented in this work to CAEP WGs.

Plans for Next Period

- Apply lessons learned and methods developed during the CAEP/13 stringency process to contribute to emissions standards being updated during CAEP/14.
- Develop additional analyses as input to the technology response process.



Task 2 – Development of an Aircraft Conceptual Design Tool for Policy Analysis

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Objective

The goal of this task is to enhance the capability of our Julia¹-based aircraft conceptual design software, Transport Aircraft System Optimization in Julia (TASOPT.jl), to incorporate new disciplines and components, including noise analysis and optimization. The objective is to use this tool to estimate the sensitivities of design changes to the engine, structures, and aerodynamics on metrics of performance, such as fuel burn, emission of NO_x, and certification noise.

Research Approach

Development of TASOPT.jl during the reporting period centered around two thrusts: (i) component model enhancement and (ii) enhancing user-accessibility and transparency. While the former supports enhanced fidelity and expanded applicability, the latter focus is essential for the long-term development of TASOPT.jl and its future use in CAEP.

New model capabilities include support for interpolated compressor maps, a simplistic specific-fuel-consumption-based engine model, ducted fan modelling (for electrified propulsion architectures), and landing gear geometry modelling. To enable integration with the Python Noise Assessment (pyNA) model, aerodynamic performance models are being extended and validated to cover landing-takeoff operations (LTO) in with higher fidelity. A review of the “basket” of relevant technology insertions to be modelled was also initiated to guide this thrust in the future.

Documentation was written about the new capabilities as part of the accessibility thrust. Beyond this, user-friendly data structures were introduced and integrated through the codebase, along with developer-friendly interfaces that simplify the integration of novel component models. Additional enhancements include miscellaneous documentation updates and expansions, new user-facing functions for common analyses (e.g., payload-range), plotting utilities, and various bug patches.

Milestones

A paper describing TASOPT.jl was accepted to the *Journal of Open Source Software (JOSS)*.

Publications

Prashanth, P., Gomez-Vega, N., He, S., Shukla, A., Gonzalez, J. J., Bobadilla, D. S., Lee, K., Ranjan, P., Zahid, S. S., Abel, J., Drela, M., & Speth, R. (2025). TASOPT.jl: A Julia package for conceptual commercial transport aircraft design. *Journal of Open Source Software*, 10(113), 8521. <https://doi.org/10.21105/joss.08521>

Outreach Efforts

Continued publication of updates to TASOPT.jl on GitHub (github.com/MIT-LAE/TASOPT.jl).

Awards

None.

Student Involvement

MIT graduate students, Jonas J. Gonzalez and Aditeya Shukla, were engaged in code development and documentation.

Plans for Next Period

- Continue to expand TASOPT.jl functionality and documentation toward its application as a transparent source of data in the CAEP tech response process. Development focus is pulled toward engine modelling and NO_x by the current CAEP cycle. Noise prediction also continues to be a development target, though it awaits integration of aerodynamic performance modelling for LTO operations.

¹ Julia is a high-performance, open-source, general purpose programming language designed for scientific computing, machine learning, and data mining.



- Benchmark the included baseline models against trusted performance data of existing aircraft of varying sizes. This will all for the accuracy of the current models to be characterized, and a metric to be established for further model improvement.

Task 3 – Aircraft Design and Impacts Studies

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Objectives

The objectives of this task are to (1) analyze the environmental impact of near-future technology insertions across three aircraft subsystems: propulsion, structures, and aerodynamics, (2) quantify the climate and air quality impacts resulting from purely fuel efficiency driven design and optimization, and (3) assess and compare results across three aircraft categories—narrow body, wide body, and regional jet—to understand technology effects across different baseline aircraft and operational profiles.

Research Approach

- Defined technology insertion scenarios across propulsion (engine upgrades), structures (advanced materials for primary structures), and aerodynamics (drag reduction improvements) for each aircraft category.
- Developed integrated assessment framework to insert technology, design and optimize aircraft and then evaluate multiple environmental impact pathways from emissions such as carbon dioxide (CO₂), NO_x, sulfur oxides (SO_x), etc.
- Used monetization of environmental impacts to estimate present day values of future environmental damages and compare climate impacts, air quality impacts, and economic trade-offs between different technologies.

Milestones

- Established that fuel efficiency improvements alone do not serve as a reliable proxy for overall environmental impact reduction, revealing important trade-offs between climate and air quality effects.
- Quantified that engine upgrades, while improving fuel efficiency through higher pressure ratios, generally increase NO_x emissions and negatively affect air quality unless paired with other technologies that provide substantial fuel burn reductions.
- Demonstrated that structural material improvements offer environmental benefits comparable to engine upgrades on a net present value basis, with reduced operating weight leading to decreased fuel consumption and lower NO_x emissions across all aircraft categories.

Publications

Shukla, A., Prashanth, P., & Speth, R. L. (2025, July). Impact of Efficiency-Driven Aircraft Technology Improvements on Climate and Air Quality (AIAA 2025-3502). *AIAA AVIATION FORUM AND ASCEND 2025*.
<https://doi.org/10.2514/6.2025-3502>

Outreach Efforts

Presented at the AIAA AVIATION Conference in Las Vegas, Nevada in July 2025 during the technical session “Aircraft Operational and System Studies.”

Awards

None.

Student Involvement

This work was primarily conducted by MIT graduate student Aditeya Shukla.

Plans for Next Period

Expand on the existing work, which is based on optimizing aircraft for minimum mission fuel consumption, to consider alternative optimization targets that include environmental impacts. Analysis of these results will help to understand design decisions and policies that can lead to reduced environmental impacts while avoiding significant fuel consumption and cost trade-offs.