Project 035 Airline Flight Data Examination to Improve Flight Performance Models

Georgia Institute of Technology, Delta Airlines, Landrum and Brown

Project Lead Investigator

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- P.I.(s): Professor John-Paul Clarke
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- Task(s):
    1. Airline Flight Data Examination to Improve Flight Performance Modeling

Project Funding Level

FAA: $150,001.00. Matching: $101,121.00 (Georgia Tech); $48,880.00 (Landrum and Brown); Data (Delta Air Lines).

Investigation Team

James Brooks (GT: Data Analysis); Karén Melikov (GT: Analysis Support); Jesse Miers (Delta Air Lines: Subject Matter Expert); Vince Mestre (Landrum and Brown: Subject Matter Expert).

Project Overview

Currently, when modeling either aircraft noise or emissions with the Integrated Noise Model (INM) or the Aviation Environment Design Tool (AEDT), there are errors associated with the methodology suggested for determining the aircraft gross takeoff weight and the inability to model reduced thrust/power departures. The goal of this project is to develop a functional relationship between stage/trip length and weight that can replace the existing guidance provided for weight estimation; and subsequently to determine the percentage of departures that use reduced thrust and the level of reduced thrust that is used when the takeoff weight is such that reduced thrust departures are possible.

Task 1 Airline Flight Data Examination to Improve Flight Performance Modeling

Georgia Tech

Objective(s)

Analyze aircraft departure operating data for two wide-body and two narrow body commercial aircraft to develop of a functional relationship between stage/trip length and weight that can replace the existing guidance provided for weight estimation; and determine the percentage of departures that use reduced thrust as well as the level of reduced thrust that is used.

Research Approach

The Air Transportation Laboratory (ATL) at the Georgia Institute of Technology has acquired a large database of aircraft departure operating data that provides aircraft specific takeoff power applied along with the gross weight of the aircraft, ambient temperature, and the origin and destination of the flight. We will use this data to develop a functional relationship between stage/trip length and weight that can replace the existing guidance provided for weight estimation; and subsequently to determine the percentage of departures that use reduced thrust and the level of reduced thrust that is used when the takeoff weight is such that reduced thrust departures are possible.

Takeoff Weight Determination

Although preliminary analysis has shown a strong functional relationship between aircraft weight and Great Circle Distance (GCD) flown there are known issues with using GCD for some specific airport pairs. An additional source of distance flown is the "planned distance" which is generated by the air carrier flight plan. Since the trip fuel that is loaded is determined for this planned distance, it is anticipated that the functional relationship will be stronger than the GCD methodology. With regard to modeler access to the planned distance, there are a number of websites that provide flight-tracking information and include the planned distance (i.e., Flightaware.com). The FAA/ATO also collects flight plan information daily. In addition, the air carrier supplying the reduced thrust data has also agreed to provide flight plan data to support this element of the research. The resulting functional relationship can then be decomposed into an aircraft specific "lookup" table in the AEDT using the flight distance just as currently done for the existing stage length versus weight relationship.

In the course of this research, we will:

1. Compare the functional relationship between great circle distance and planned distance to determine the best relationship.

2. Compare the aircraft weights generated with the existing AEDT methodology using the resulting relationship, and discuss the impact of the differences on the resulting aerodynamic vertical profile.

Reduced Thrust (Usage and Level)

The operational database described above is straightforward with respect to the aircraft/engine type and the takeoff weight and amount of reduced thrust used for the departure. While thousands of departures are contained in the database, the task to derive a relationship predicting the amount of reduced thrust for any departure of a specific aircraft/engine type is complicated by the way in which the carriers implement the use of reduced thrust.

The performance analysis to certify the maximum reduced thrust that can be used for a departure from a specific runway, at a specific airport, for existing temperature and wind conditions is mandated by the FAA certified Aircraft Flight Manual (AFM). The AFM requirements for performance analysis is the same for each air carrier. What varies within the various air carriers is the presentation of the allowable reduced thrust departure information to the flight crew. The variation is essentially due to the pilot community and their historical views of using something less than maximum thrust available for conducting the critical departure phase of the operation. Although the performance analysis is in compliance with the AFM just as the performance analysis of any departure, there are those in the pilot community that opt to use a reduced thrust that is less than the maximum reduced thrust certified to safely conduct the departure.

The flight crew is presented with takeoff performance information (by the air carrier) for each departure. Based on the agreed information format and the limitations, if any, on the amount of information that can be conveyed, a number of reduced thrust options can be presented. Even in situations where only one reduced thrust option is presented, this single option may be less than the maximum allowable reduced thrust (the existing case for some of the data contained in the ATL operational database).

As a result of the described pilot community reaction there exists a noticeable variation in reduced thrust applied for a given recorded takeoff weight, which complicates the task of developing a relationship describing the level of reduced thrust used. A number of statistical analyses can be performed and assessed with respect to defining the correct strategy for predicting the amount of reduced thrust applied as a function of variables that effect engine thrust. In each strategy, the implementation into the AEDT will be considered with regard to cost and complexity.

In the course of this research, we will:

1. Work closely with the airframe manufacturers to enable the development of the required reduced thrust coefficients.

2. Aircraft specific reduced thrust in both percentage of total departures and reduced thrust level. These percentages will be presented for the aggregate as well as by airport for those departures contained in the database.

3. Define a set of benchmark test cases that can be used to conduct a comparative noise contour analysis using various modeling approaches. The benchmark test cases will be comprised of:
   a. Three close-in and three distant departure procedures that best describe the air carriers departure procedure development with regard to AC 91-53A.
   b. Takeoff flap
   c. A range of weights and their associated percentage of reduced thrust
   d. The initiating or thrust cutback altitude.

   These test cases can be compared to:
   a. AEDT/INM - standard departure profiles
   b. AEDT/INM - user defined departure profiles (matching flight trajectory)
   c. AEDT/INM – simulated cutback

4. Dependent on the timing of the coefficient development, work with the A-21 PWT to compare the resulting reduced thrust modeling with the output of both ACRP 02-41 and ACRP 02-55.

5. Present comparison results to AEE/tool development team, COE ASCENT advisory board members and SAE A21.

6. If new coefficients are considered critical, develop a plan to obtain them for an expanded coverage of the AEDT aircraft fleet. Various aircraft performance tools will be considered (i.e. BCOP, PIANO, Suave, etc.)

Milestone(s)
Developed a functional relationship between the trip distance and the takeoff weight for one wide-body aircraft type.

Major Accomplishments
None

Publications
None

Outreach Efforts
ASCENT Advisory Board Meeting. SAE-A21 Committee.

Awards
None

Student Involvement
The graduate student will be cleaning and analyzing data under the supervision of the PI (John-Paul Clarke) and the lead analyst (Jim Brooks).

Plans for Next Period

Developed a functional relationship between the trip distance and the takeoff weight for one other wide-body aircraft type and two narrow-body aircraft. Begin development of the functional descriptors for the aircraft specific reduced thrust in both percentage of total departures and reduced thrust level