ASCENT Project 54

AEDT Evaluation and Development Support

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Cost Share Partner: Delta Air Lines

Objective:

- Provide data and methods to continue to improve the aircraft weight, takeoff thrust, and departure and arrival procedure modeling capabilities within AEDT
- Utilize real-world flight data to improve departure, full flight, and arrival modeling
- Conduct system evaluation of AEDT features

Project Benefits:

- The main benefit of this research is to address the gaps in AEDT related to departure profiles that are outdated and arrival procedures that might not reflect current airport operations.
- Improve AEDT's environmental impact assessment, i.e., noise, fuel burn, emissions and air quality impacts.

Research Approach:

- Perform comparisons between thousands of real flights against the outputs of AEDT's performance models for arrival, departure, and enroute phases to obtain statistics about the overall agreement with existing AEDT definitions
- Model noise abatement departure procedures (NADP) in AEDT and compare against real-world data to quantify differences
- Perform system testing and evaluation of AEDT features to identify discrepancies, quantify differences, and document possible improvements for future efforts

Major Accomplishments (to date):

- Compared AEDT profiles with real-world operations for arrival and departure procedures to identify key differences
- Implemented method for full flight modeling using airline data for comparison against AEDT
- Performed system testing on various AEDT features and made recommendations

Future Work / Schedule:

- Implement clustering on level-off data to identify representative arrival operations
- Complete comparison of full-flight modeling in AEDT with real-world flight operations

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Outline

ASCENT 54 project is comprised of two main parts:

ASCENT 54

Aircraft Performance Modeling (Prior A45)

- The primary impact of this task is to improve the accuracy of AEDT so its environmental modeling can better represent real aircraft operations
- The improvements to AEDT will support airport noise compatibility programs and planning with more accurate results to better inform federal financial support of those programs
- This task addresses improvements and comparisons to real-world operations for arrival, departure, and full-flight modeling options in AEDT

Uncertainty Quantification (Prior A36)

- Perform system testing to evaluate the accuracy, functionality, and capabilities of AEDT and support the future development process
- Identify gaps in the tool's functionality and areas for further research and development

Departure Modeling

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<u>Objective:</u> Determine how representative NADP profiles are to real world procedures by comparing real-world trajectories to procedural profiles modeled in AEDT

Profiles Modeled and Compared					
Aircraft	**Profiles**	**Weight**	**Thrust**	**SL**	**Airport**
B737, B738, B739, A319, A320, A321, B752, B712	STANDARD NADP 1-1 NADP 2-11	ALTERNATE WEIGHT	• MAX • RT15	All SL	KLAX, KORD, KDFW, KLAS, KJFK, KLGA, KDCA, KSNA, KSFO, KATL, KSLC, KDEN

Comparison Metric

1,612,917 flights

Real-World Trajectories

NADP Trajectories

2,880 profiles

MPE: Mean Percentage Error
(+ if AEDT is higher)

$$MPE = \frac{100\%}{n}\sum_{i=0}^{n}\frac{x_{AEDT,i} - x_{Real,i}}{\frac{1}{2}(x_{AEDT,i} + x_{Real,i})}$$

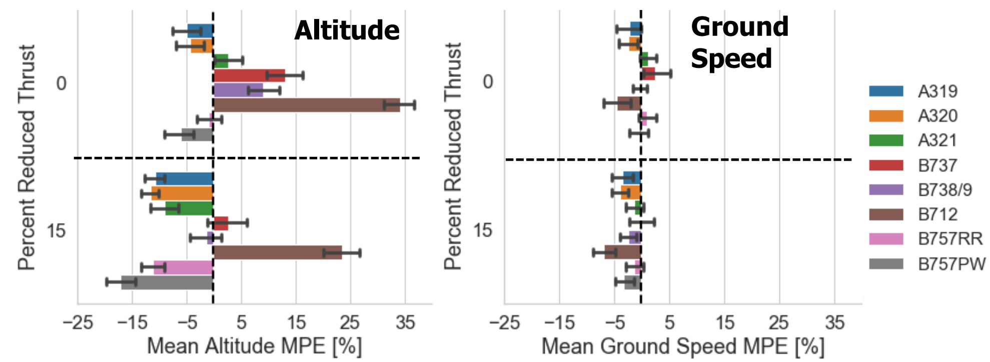
Percentage relative difference computed per data point pair along ground track distance and averaged over the trajectory

Altitude & Ground Speed Differences

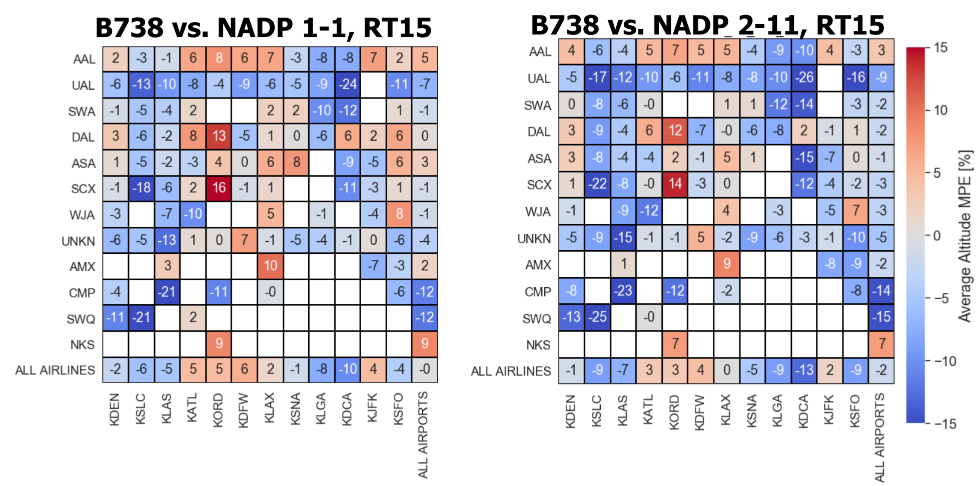
Insights:
- By Aircraft
- By Airport
- By Airline
- By Profile

- Most narrow-body aircraft show good overall similarity
- B737/B738/B739 commonly utilize 15% reduced thrust
- Adjustments to A319/A320 high temperature thrust coefficients may improve results at high altitude airports
- B712 NADP profiles require acceleration adjustment
- Analysis on-going for wide-body aircraft

Overall Results



By Airline/Airport



NADP 1-1 generally more representative for narrow-body aircraft

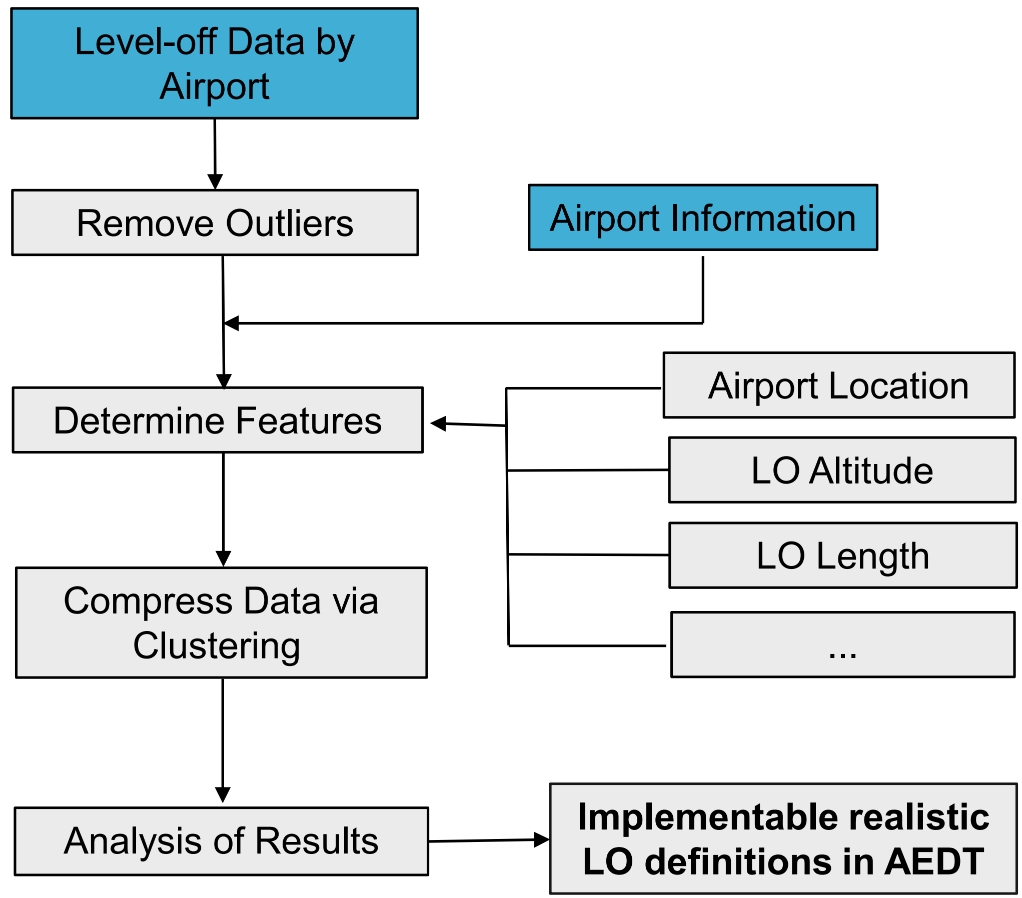
Arrival Modeling

Objective: Use Machine Learning (ML) to consolidate level-off (LO) arrival data into implementable recommendations for AEDT in order to improve arrival modeling.

Method:

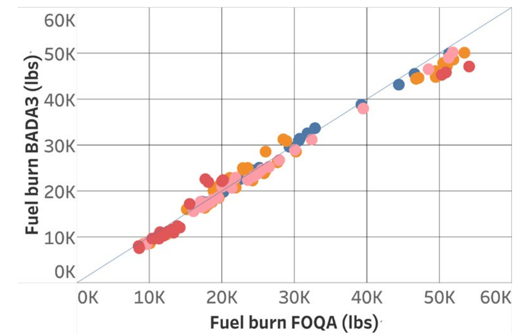
- ❑ Investigate potential clustering methods and their benefits and limitations, such as:
  - ❑ K-Means, K-Medoid, Agglomerative Clustering etc.
- ❑ Devise a ML algorithm that can be used to consolidate level off (LO) data, including features such as
  - ❑ Level-off length
  - ❑ Level-off height
  - ❑ Airport altitude, etc.
- ❑ Using obtained level-off data, create a test data set and implement each clustering method in the ML algorithm
- ❑ Evaluate performance using a set of quantitative scoring methods
- ❑ Provide recommendations on potential modifications to arrival profiles in AEDT based on clustering results

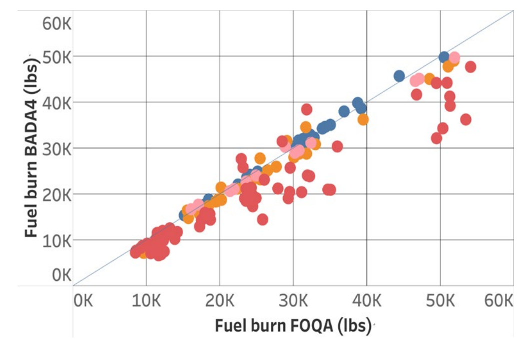
Approach:



Full Flight Modeling

- **Objective**: Conduct full flight modeling within AEDT without the use of sensor paths in order to investigate the accuracy of performance modeling in AEDT compared to actual airline flight data, where all states of the aircraft are known including thrust, weight and fuel flow.
- **Steps and Outcomes**:
  - Compare the AEDT performance results against the core path input from clustering results
    - Minimal impact on the analysis of altitude, ground speed, and time profile when data is downsampled
  - Cumulative fuel burn comparison between FOQA data and AEDT modeling options (BADA3 / BADA4)
    - BADA3 has been validated to be reasonable for the aircraft that can compare the total fuel burn using FOQA data
    - Using the MERRA-2 weather data significantly reduced the cumulative fuel burn difference between FOQA data and AEDT modeling
    - The amount of fuel required from FOQA data may vary substantially depending on factors such as engine degradation and the status of engine maintenance
    - Exceptional cases are identified in calculating the instantaneous fuel burn calculation using BADA4 and high-resolution data input
  - Additional city pairs representing high-density markets are being investigated: ATL – MSP, ATL – LGA, JFK, EWR, ATL – SEA, MSP – SEA





- **AEDT % error < 3%**
- **3% < AEDT % error <= 5%**
- **5% < AEDT % error <= 10%**
- **10% < AEDT % error**

The preliminary findings presented will be further investigated by modeling additional flights in the identified city pairs

System Evaluation on AEDT Features

- Performed system testing to support the implementation of various features introduced in AEDT 3 versions
  - Ground Track viewing and editing functionalities have been improved
  - Helicopter operations now include detailed logs consistent with INM legacy format
  - Modeling of emissions from stationary sources has been revised
  - AERMOD implementation has been greatly sped up
- Bugs encountered during testing were communicated to the Development team
- Working on a comprehensive UQ Report to inform AEDT users of new features and changes in AEDT 3, and their effects on environmental metrics

Thank you. Questions?

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