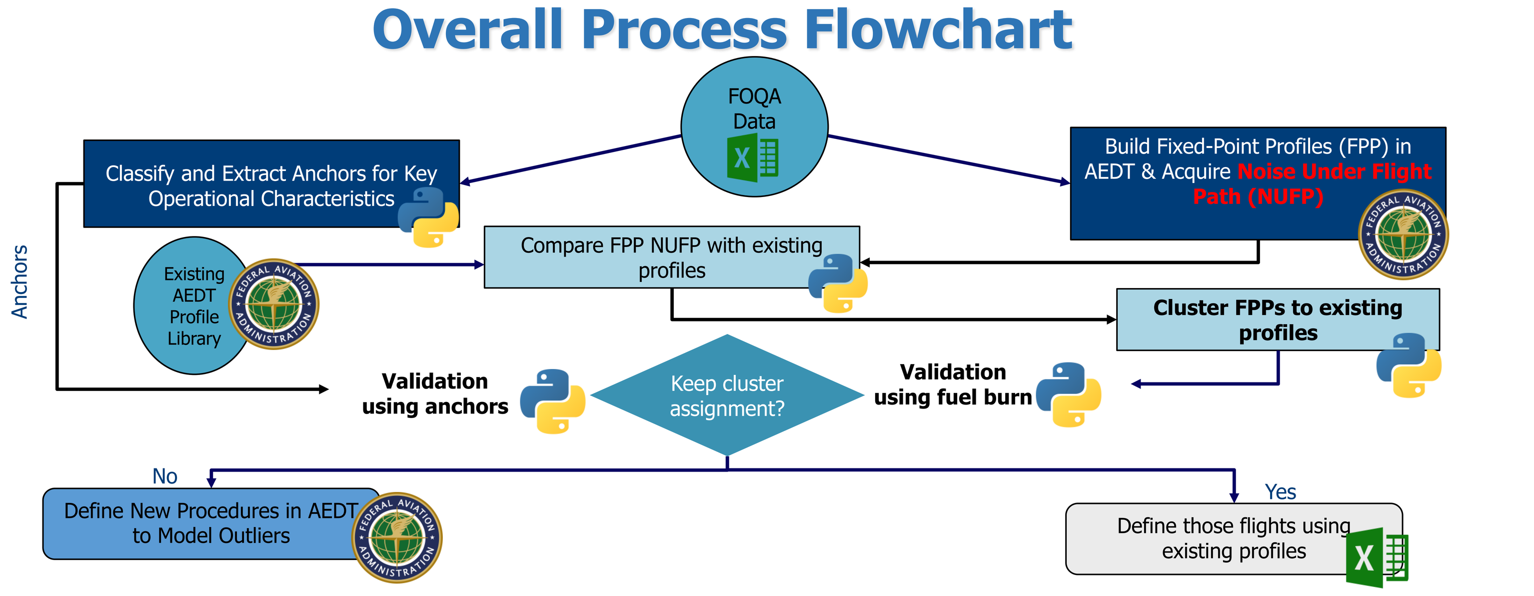
Project 54
AEDT APM Evaluation and Development Support

Georgia Tech Aerospace Systems Design Laboratory

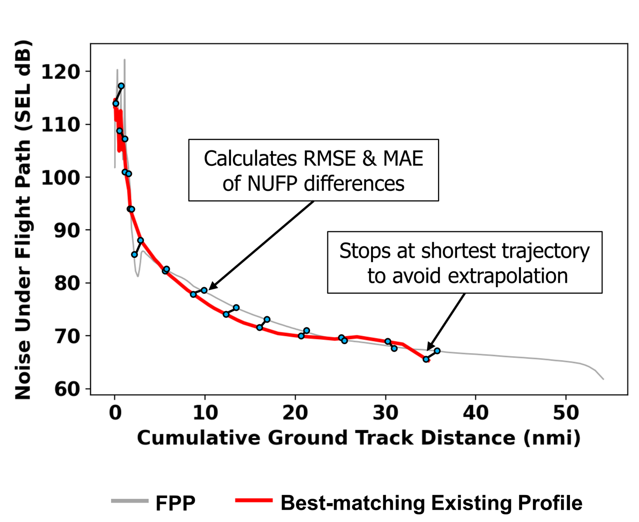
Task 1 – Departure Modeling

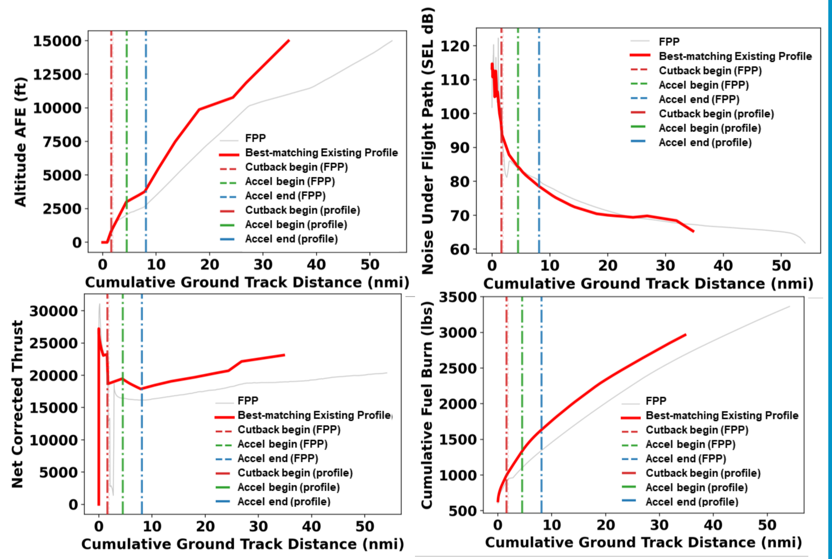
Objective: Utilize FOQA data to improve existing AEDT profile library via comparison, clustering, and validation to ultimately decide whether to create new profiles based on outlier information

Overall Process Flowchart



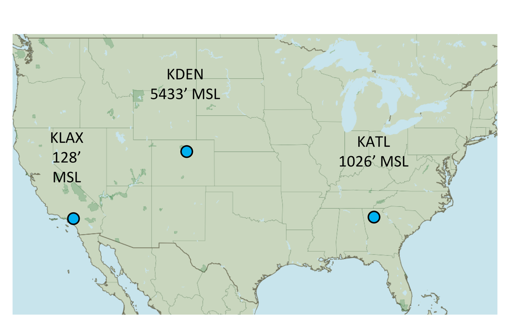
- Extracted SEL NUFP from FOQA/existing profile library and interpolated onto a common ground track distance grid for comparison
- Calculated RMSE+MAE score between existing profiles and each FPP; best-matching profile chosen by lowest score
- Validated cluster similarity by checking thrust cutback and acceleration anchors, ensuring aligned locations and fuel burn within anchor windows

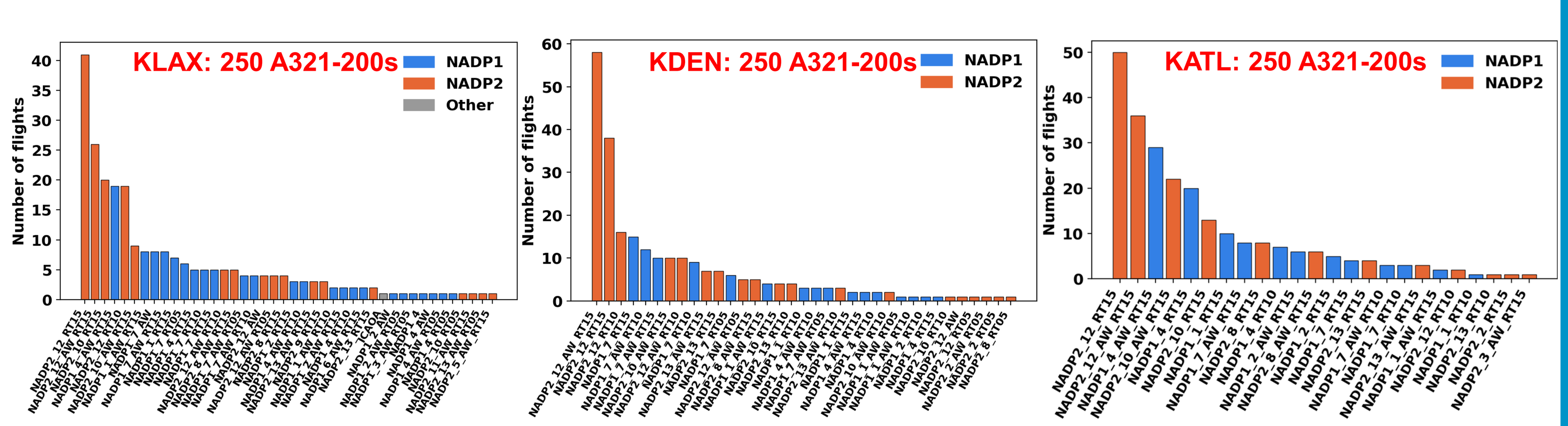




Research Findings

- NADP2_12 with RT15 dominates at all airports; RT10 and RT05 are rare (*Note: the NADP2_12 profile is defined in the reference: Lim et al. "Improved Noise Abatement Departure Procedure Modeling for Aviation Environmental Impact Assessment," AIAA 2020-1730. AIAA Scitech 2020 Forum. January 2020.)*
- Cluster distributions differ: KATL has fewer small clusters, KLAX has more NADP1 clusters (but still more flights matched to NADP 2), and KDEN shows longest tail of small clusters

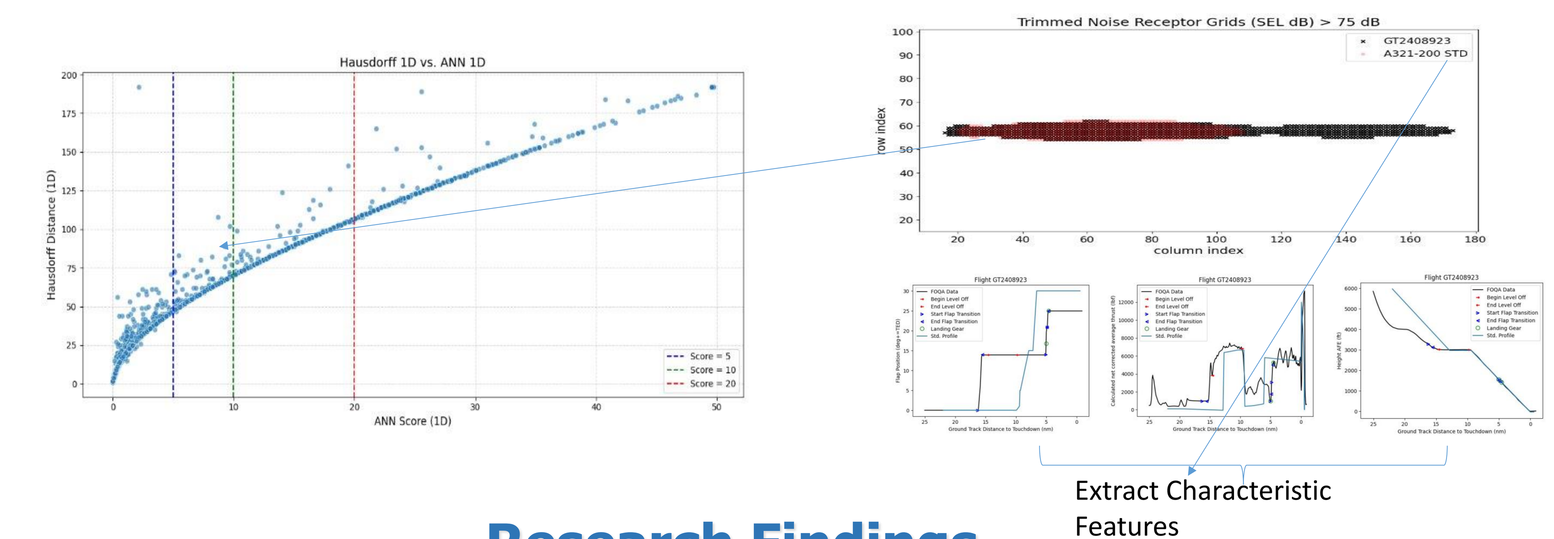




Next steps: Determine and analyze outliers based on cluster validation
Expand clustering analysis to other airframes and non-U.S. airports

Task 2 – Arrival Modeling

Objective: Investigate the noise modeling accuracy of the AEDT standard profile by performing an analysis of FOQA-data arrivals as fixed-point profiles in AEDT. Compare their performance metrics and noise outputs against the AEDT standard arrival profile and identify key characteristics to model new step-wise thrust, speed and altitude inputs for proposed alternative AEDT standard arrival procedures.



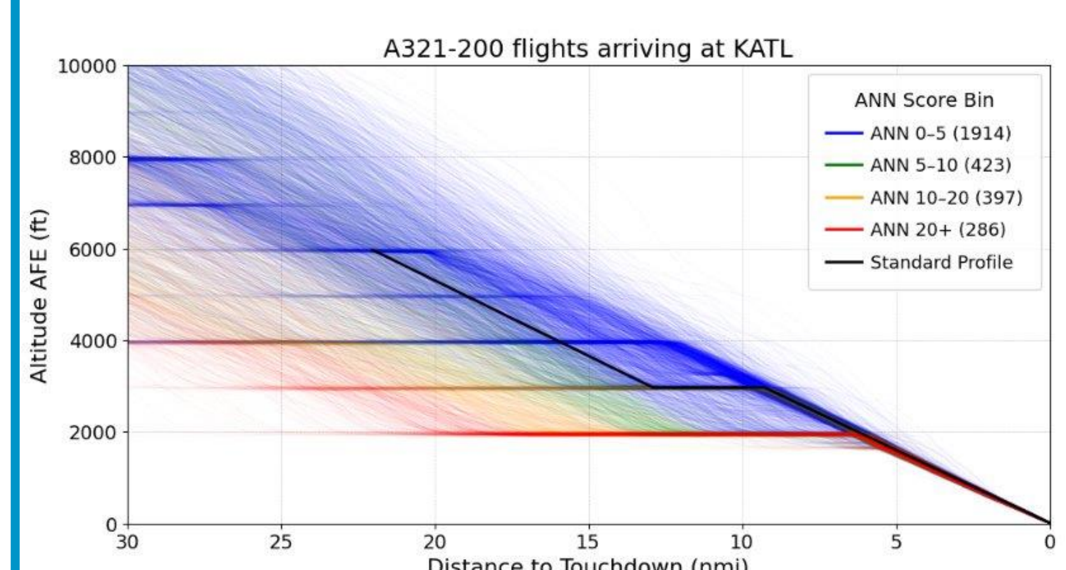
Research Findings

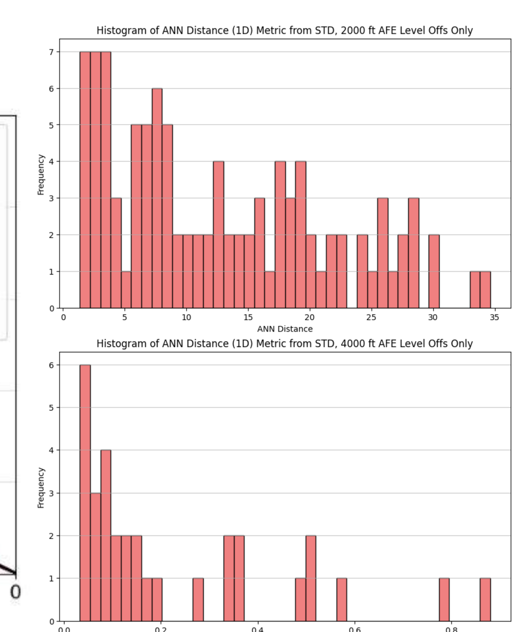
Methodology: Used Average Nearest Neighbor (ANN) along Ground Track as final metric to compare SEL contours

- Hausdorff, Intersection over Union, and ANN over 2D contour and 1D contour roughly equivalent metrics of similarity
- 75 dB SEL threshold for contours chosen as minimum level for significant noise

Verifying and Visualization of Results:

- Plotted gradient-key results of ANN scores overlapped with trajectories to find patterns
- Filtered and performed data analysis to confirm feature-related noise differences, and plotted contour maps of high ANN scores as a reference for future matching with new AEDT profiles





Findings: Current standard profile often *underpredicts* SEL >75dB noise, noise signature most resembles a CDA. Poor ANN scores correlated to level-offs at 2000 or 3000 ft AFE, as well as longer level-offs with early flap deployment and decreased airspeed.

Next Steps: Vary individual STD profile parameters (e.g., level-off AFE, thrust), while keeping all other values fixed and recompute ANN (and ΔSEL) vs. baseline; provide best performing new profiles as final recommendations

Task 3 – En Route Modeling

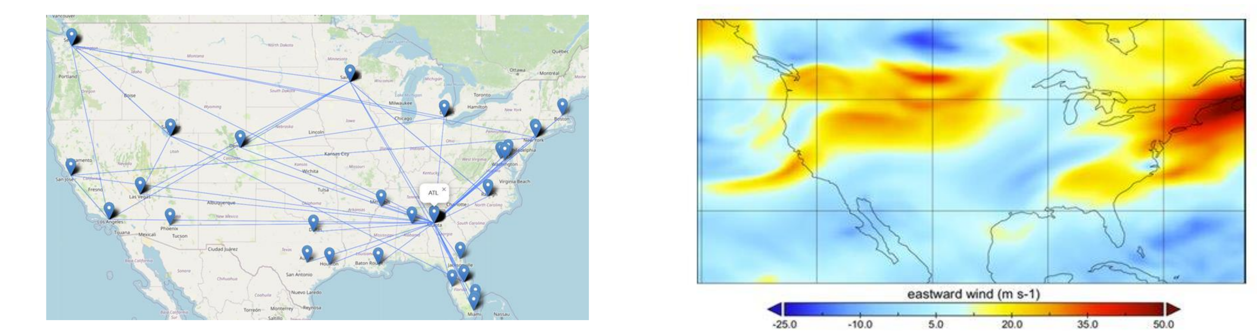
Fuel Burn Prediction

Objective

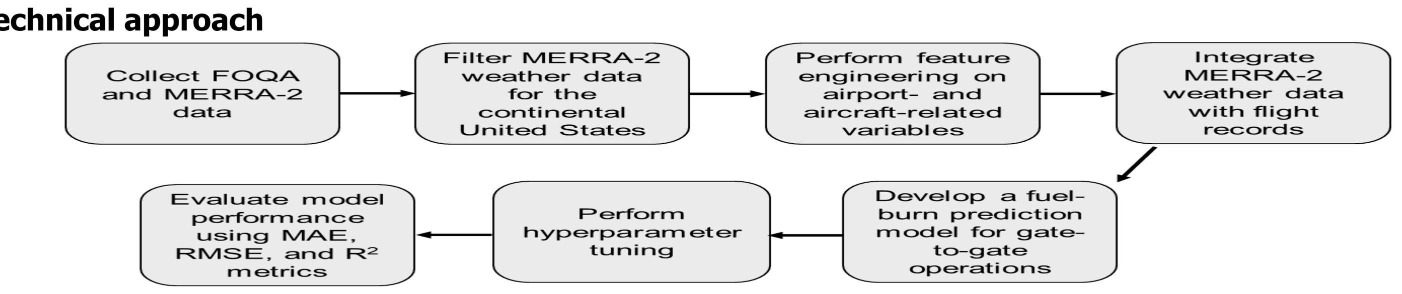
- Develop machine learning models to predict aviation fuel burn for gate-to-gate operations using limited and easily available inputs from real-world flight data

Source of data

- Flight Operations Quality Assurance (FOQA) data for flight information and Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2) data for weather
- Dataset included 11,500 flights for 86 city-pairs across 16 airframe types



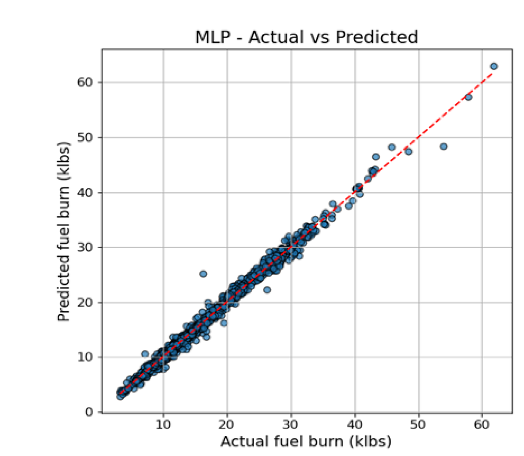
Technical approach



Results and Findings

Metric	Decision Tree	Random Forest	MLP
MAE	0.729	0.496	0.453
MSE	1.792	0.969	0.463
RMSE	1.320	0.969	0.680
R^2	0.973	0.986	0.992

- Predictions were made with an average error of 500 lbs
- Expand to larger dataset with more city pairs and increase proportion of twin-aisle flight



Clustered Core Path Analysis

Objective: Analyze accuracy of AEDT performance models by employing a trajectory-based clustering algorithm to find 'core paths' for city pairs and comparing real-world flight data with modeled core path flight results. The goal is to leverage large-scale datasets such as the NAS database to provide recommendations for future tool improvements.

1 Extract FOQA Flights

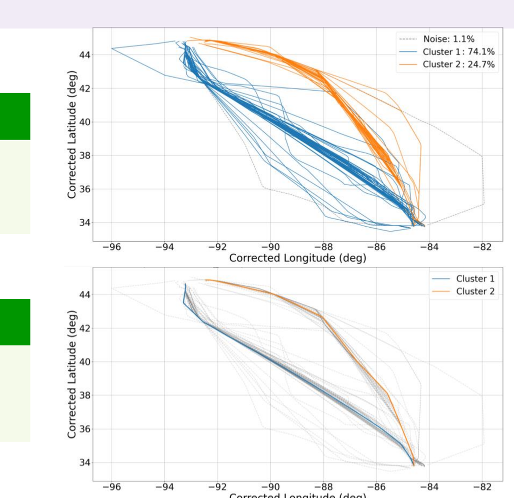
- Obtain FOQA CY2023 data for flights
- City pairs chosen based on flight frequency

2 Clustering of Flights

- Use DBSCAN algorithm with Dynamic Time-Warping (DTW)
- Cluster flights based on relative 2D distance between flight trajectories

3 Identify Core Paths for each cluster

- Define core path as median trajectory of flights in each cluster
- Some city pairs have multiple clusters, resulting in multiple core paths



4 Import into AEDT using Sensor Path Import Tool and SQL scripts

- Load all required airports (based on input file)
- Create an operation for each flight, and multiple annualizations for different cases (performance model used, weather data type)
- Create a metric result for each annualization

Run Fuel Burn Study in AEDT

5 Analyze Results

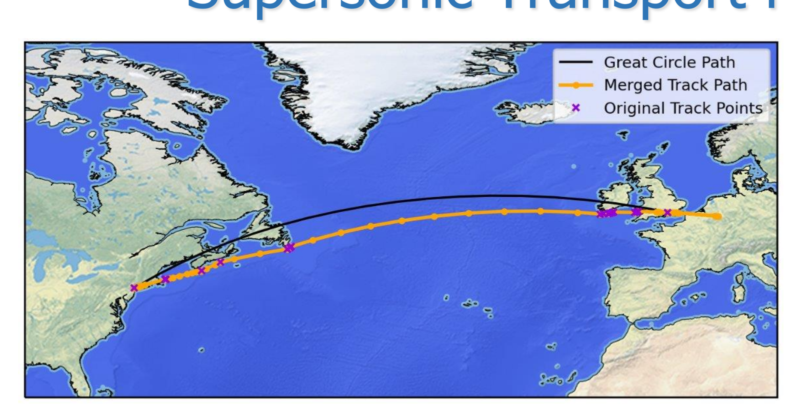
- SQL + Python based script to export results for all cases
- Post processing in Python to make necessary plots and enable proper comparison of results (Altitude, True Air Speed, Net Thrust, Fuel Flow, Cumulative Fuel Burn)

Findings: AEDT models flights with reasonable accuracy (errors <10%) using FOQA-derived sensor path information, especially when using BADA-4 performance model. Current AEDT SPI implementation is unable to accurately model high-fidelity, high-volume data; reduction in data fidelity required to complete modeling.

Task 4 – System Testing and Evaluation

Supersonic Transport Modeling

Objective: Support the development of AEDT 4 and future versions with verification and validation of new methods and functionalities.



Tested the performance modeling and fuel burn calculations across multiple O-D flight paths

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