ASCENT FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Project 062 Noise Model Validation for AEDT

Georgia Institute of Technology
The Pennsylvania State University

Project Lead Investigators

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- FAA Award Number: 13-C-AJFE-GIT Amendments 61, 82, 106, 125, 144, 160, and 164
- Period of Performance: September 27, 2021, to September 30, 2025
- Task:
  1. Noise modeling in the Aviation Environmental Design Tool (AEDT) with automation (Georgia Tech)

The Pennsylvania State University (**Penn State**)

- P.I.: Prof. Victor Sparrow
- FAA Award Number: 13-C-AJFE-PSU, Amendments 59, 83, 89, 106, 114, and 122
- Period of Performance: October 1, 2021, to September 30, 2025
- Task:
  2. Assessing the use of high-fidelity meteorological data in AEDT noise calculations (Penn State)

Project Funding Level

The project is funded by the Federal Aviation Administration (FAA) at the following levels: Georgia Tech: $235,000; Penn State: $140,000. Cost-sharing funding is described below.

Georgia Tech has agreed to a total of $235,000 in matching funds. This total includes salaries for the project director, research engineers, and graduate research assistants, as well as computing, financial, and administrative support, including meeting arrangements. Georgia Tech has also agreed to provide tuition remission for the students, paid for by state funds.

For Penn State, Spire Global is providing cost-sharing funds in the form of meteorological data and research support. The point of contact for this cost-sharing is Ms. Ashley O'Neil (703-853-8468; ashley.oneill@spire.com). Metropolitan

Washington Airports Authority is providing sound level meter data from Dulles International Airport (IAD) as in-kind cost-sharing; the point of contact is Mr. Mike Jeck (703-417–1204; michael.jeck@mwaa.com). Raleigh-Durham International Airport is providing sound level meter data from Raleigh-Durham International Airport (RDU) airport as in-kind cost-sharing; the point of contact is Mr. John Wiatrak (919-840-7748; john.wiatrak@rdu.com). Additional in-kind cost-sharing is being provided by the Penn State College of Engineering to meet the required matching of $140,000.

Investigation Team

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- Prof. Dimitri N. Mavris, (P.I.)
- Dr. Michelle R. Kirby, (co-investigator)
- Dr. Mayank Bendarkar, (co-investigator)
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- Humfrey Kimanya, (graduate student)
- Sonal Mehta, (graduate student)

The Pennsylvania State University
- Prof. Victor Sparrow, (P.I.)
- Pierce Hart, (postdoctoral scholar)

Project Overview

The focus of this project is to assess the accuracy of the AEDT in estimating noise in the vicinity of airports as well as further afield. The foundation of AEDT noise modeling is based on the Integrated Noise Modeling (INM) tool, which has undergone several validation and verification efforts in the past, specifically at the Denver International Airport (DEN), and has shown continual improvements in the agreement between modeling predictions and measurement data. During the development of the AEDT, multiple algorithm updates have occurred. This project seeks to quantify the new noise modeling capabilities through comparison with field measurement data from DEN and other airport monitoring systems. The research team will develop a detailed model validation plan, review the plan with the FAA for concurrence, execute the plan, and make recommendations for future AEDT development. The research, once completed, is expected to provide a noise model validation benchmark that can be used not only to respond to questions regarding AEDT noise prediction accuracy, but also to allow the tool development team to prioritize further development of modeling features and enhancements. The research team will also collaborate with Penn State on the assessment of the noise propagation assumptions and the use of higher-fidelity weather data.

Task 1 - Noise Modeling in AEDT With Automation

Georgia Institute of Technology

Objective

The objective of this task is to provide information on noise modeling data sources, AEDT assumptions, and automation capabilities developed for the current work. Improvements made to the AEDT input processing pipeline are described in full. The results generated for the bulk flight operations modeled, along with particular or aggregate insights are discussed. Additionally, a validation study to confirm input parameters for AEDT version transition from AEDT 3e to 3g was completed.

Research Approach

The research approach used for the present year mimics last year's approach applied to newer datasets to increase the size of the validation study (Mavris & Sparrow, 2023). Some important aspects of it are repeated here for completeness. Readers interested in the details are directed at prior annual reports (Mavris & Sparrow, 2023). The present work focuses on updates made to the framework and results from the 2021 datasets at Minneapolis-Saint Paul International Airport (MSP) and Seattle-Tacoma International Airport (SEA) airports.

The two essential elements in this modeling are (1) the data sources used during modeling and (2) the modeling assumptions and alternatives available for each assumption. It is worth noting that an improvement was made to the AEDT input processing pipeline to eliminate AEDT flight modeling errors that were experienced in previous years.

Data Sources Used
The main datasets relevant to this work include the flight operations data, airport noise event data, airport noise time-history data, and Automated Surface Observing Systems (ASOS) weather data, and are described below:

1. ***Flight Operational Quality Assurance (FOQA)*** data are recorded by the airline operating the flight. FOQA systems record large amounts of data at one recording per second (i.e., 1 Hz). The important elements of FOQA data in this report relate to the detailed time history of parameters such as altitude, speed, thrust, weight, configuration (i.e., flaps and gear), and so on, for each flight modeled in the AEDT. These flights consist of the Boeing® 717-200, 737-800, 737-900, 757-200, 757-300, and 777-200ER/LR, Airbus® A319-100 and A320-200, and Airbus 220 airframes.

2. ***Airport noise event data*** contain the following key parameters: a noise monitor identification (ID), noise monitor locations, sound exposure level (SEL), and the maximum, A-weighted sound level (L_{max}) metrics of associated noise events, the time of the noise event, and the flight operation correlated to the noise event. The flight ID and the time of closest approach in the noise monitor data allow flights to be matched to the appropriate flight from FOQA data, thereby matching the aircraft configuration and the time of the noise event with the noise metric value. The locations of the noise monitors are used in flight modeling within the AEDT. The noise monitor data are used as a benchmark comparison for noise results calculated by the AEDT.

3. ***Airport noise time-history data*** contain A-weighted equivalent noise levels (LAeq) (dB) that is measured by different noise monitors situated close to runways. These data are processed using an in-house visualization tool that couples associated noise levels perceived by noise monitors with flight trajectory on an interactive map. Noise event identification is conducted and on the back end, appropriate formulae are used to calculate SEL, the maximum, and L_{max} noise metrics. The formulae consider the distance to closest approach, speed of sound, air density, noise-event intervals, among others.

4. ***ASOS weather data*** contain meteorological observations collected by automated stations for forecasting purposes. This study employs the 5-min interval ASOS weather data at specific airports, obtained from the Iowa Environment Mesonet dataset of Iowa State University. Key parameters utilized in this study include temperature, wind speed and direction, and precipitation type.

The framework for modeling and automation developed in this report is independent of the data source used and will need to be modified only to account for the availability of parameters if other data sources are used. In this report, data used are obtained from flight operations SEA for 2021 in addition to detailed noise history for the same.

Modeling Assumptions and AEDT Capabilities
AEDT offers its users multiple modeling options for critical assumptions of performance and noise of a flight operation. A matrix of alternatives for these settings is shown in Table 1 for completeness. Although there are many possible modeling combinations, this project explores only those that are compatible with arrival and departure operations. The assumptions, limitations and compatible options are noted in the discussion of individual modeling options in previous year’s annual reports.

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Table 1. Modeling Options on Aviation Environmental Design Tool (AEDT). ASOS: Automated Surface Observing Systems, FOQA: Flight Operational Quality Assurance, NPD: Noise Power Distance.

Assumption	AEDT Default	Option 2	Option 3	NPD: Option 4	Option 5
Procedure	Standard	FOQA	NADP1_1	NADP2_11	
Thrust	Full	FOQA	RT05	RT10	RT15
Weight	AEDT	FOQA	Alt Wt		
Ground Track	Airport Default	FOQA			
Weather	AEDT Standard	FOQA	ASOS	High Fidelity	
Surface	Soft	Hard			
Terrain	Flat	Actual			
Flaps	AEDT	FOQA			
Gear	AEDT	FOQA			
NPDs	AEDT	NPD+C			

AEDT Input Processing Improvements

This report utilizes an in-house procedure to convert real-world flight data in the form of FOQA into AEDT modeling inputs. These steps are developed to enhance quality of data and to reduce the high volume of bulk flight operations data prior to running on the AEDT (see Figure 1). These additional steps are an improvement to AEDT noise modeling methodology that was explained in former reports.

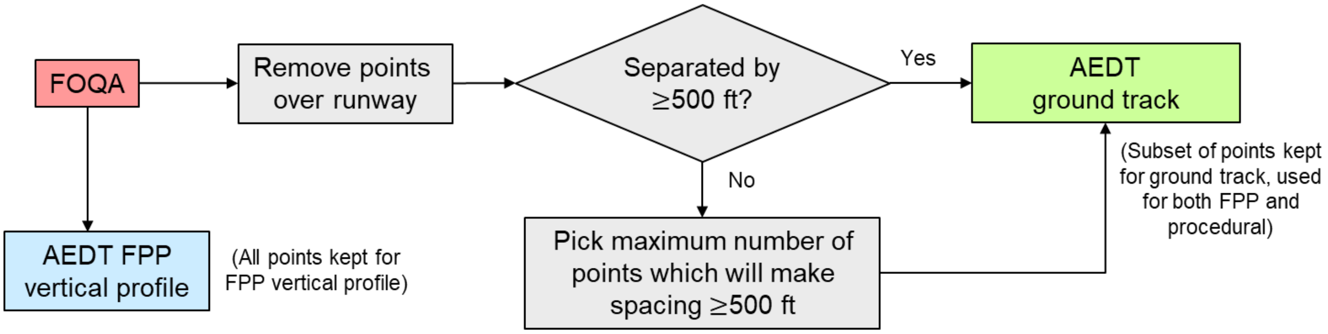


Figure 1. Aviation Environmental Design Tool (AEDT) Input Processing Pipeline.

In modeling ground tracks, the AEDT discards the first track point for departures and the last track point for arrivals, and numerical issues can arise if adjacent points are too closely spaced (e.g., bank-angle errors). Therefore, FOQA ground tracks must be pre-processed to avoid these issues while preserving the shape of the lateral profile. The input processing pipeline shown in Figure 1 performs this task. Track filtering distinguishes between “over-runway’” and “air”’ points using a 500-ft lateral offset threshold. An example of this filtering for 2021 departures at SEA is shown in Figure 2.

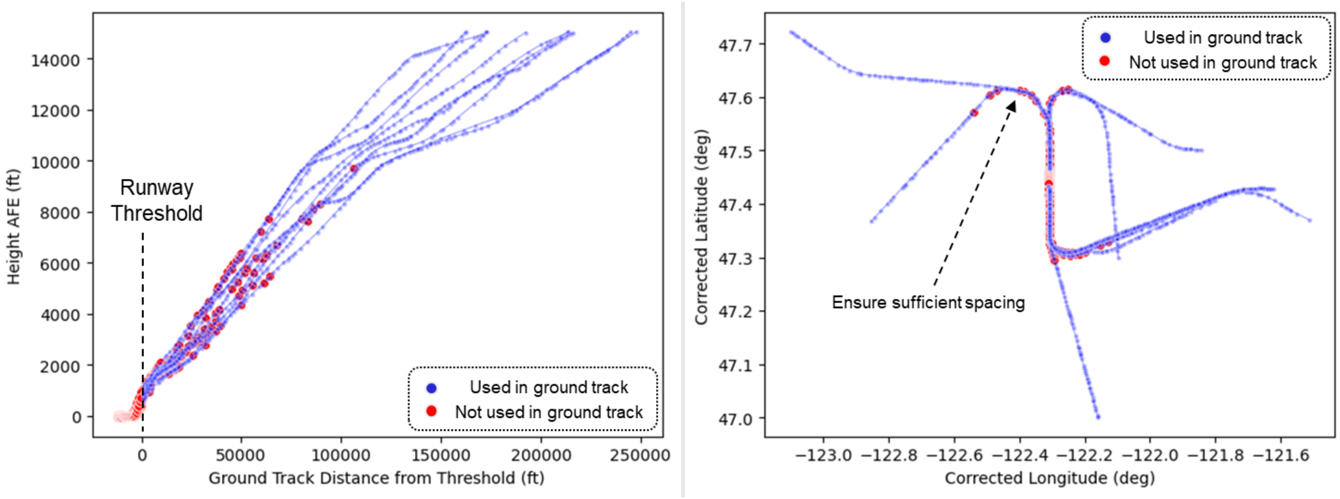


Figure 2. Example visualization for ground track filtering (SEA 2021 Departures). AFE: Above Field Elevation.

Raw FOQA data consist of points of elevation up to 15,000-ft above field elevation, recorded at 1 Hz. Such a high sampling rate is memory-intensive and impractical for modeling in the AEDT. As a result, an opportunity to reduce the number of datapoints for air segment and retain the shapes of trajectory and parameters of interest was found. An iterative end-point fit algorithm "Ramer-Douglas-Peucker" (RDP) (Douglas, Ramer) was modified and utilized in this procedure. The fundamental one-dimensional (1D) RDP algorithm (Figure 3 [left]) starts with just the end points of a trajectory, and forms piece-wise linear segments and recursively adds points from original trajectory until $d_{max} < \varepsilon$. The modification to the 1D trajectory RDP algorithm was made to use Euclidean distance to find d_{max} for N-D since raw FOQA data have at least 30 parameters. A select N target of parameters (Table 2) was identified and then normalized before computing the Euclidean distance between the piece-wise linear segments and the full data. It is noteworthy that applying the modified algorithm with all FOQA parameters would result in most points being kept which defeats the intention.

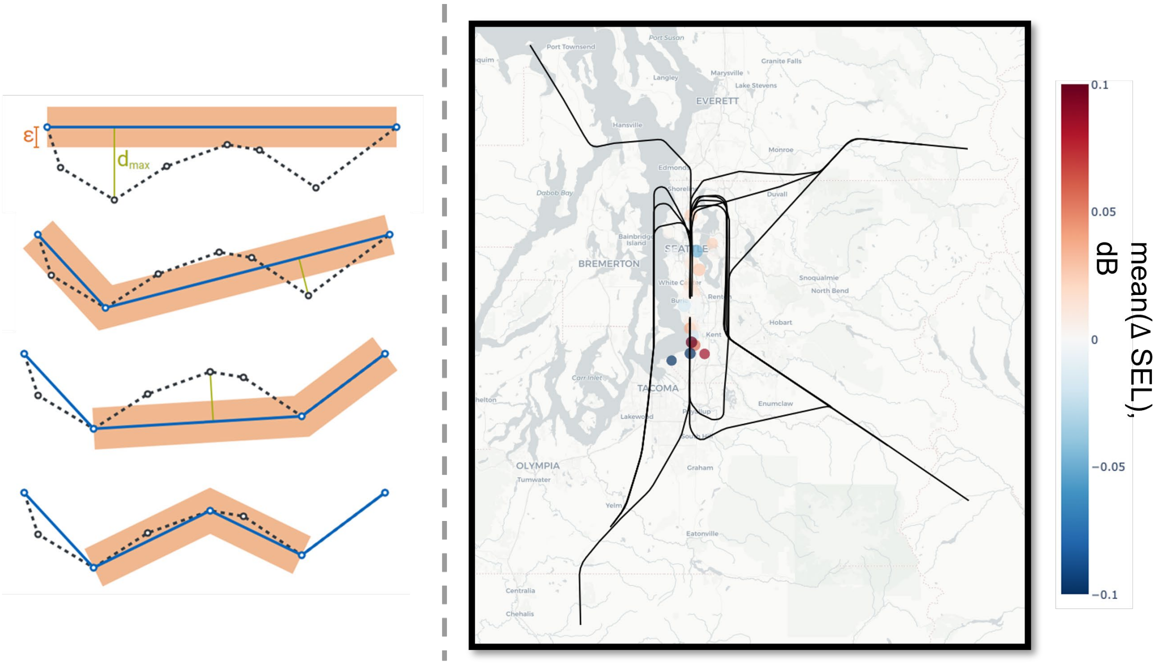


Figure 3. Ramer-Douglas-Peucker (RDP) algorithm (left) and down-sampled flights SEA 2021 arrivals (right).

Table 2. Target parameters for FOQA downsampling.

Corrected Latitude	Corrected Longitude	Ground Speed
Calibrated Airspeed	MSL Altitude	Corrected Thrust
Vertical Speed	Flap Position	Landing Gear Position

After down-sampling FOQA data, a sampling rate retaining about 45% of the total points on average for arriving flights contained enough flight information when modeled on AEDT. Figure 3 (right) shows that the difference in AEDT noise levels computed are within 0.1 dB compared to the Fixed-Point Profile (FPP) from raw FOQA data for a randomly selected set of flights at the noise receptors of SEA in 2021. This project utilizes down-sampled FOQA data as FPP and used as inputs in the AEDT.

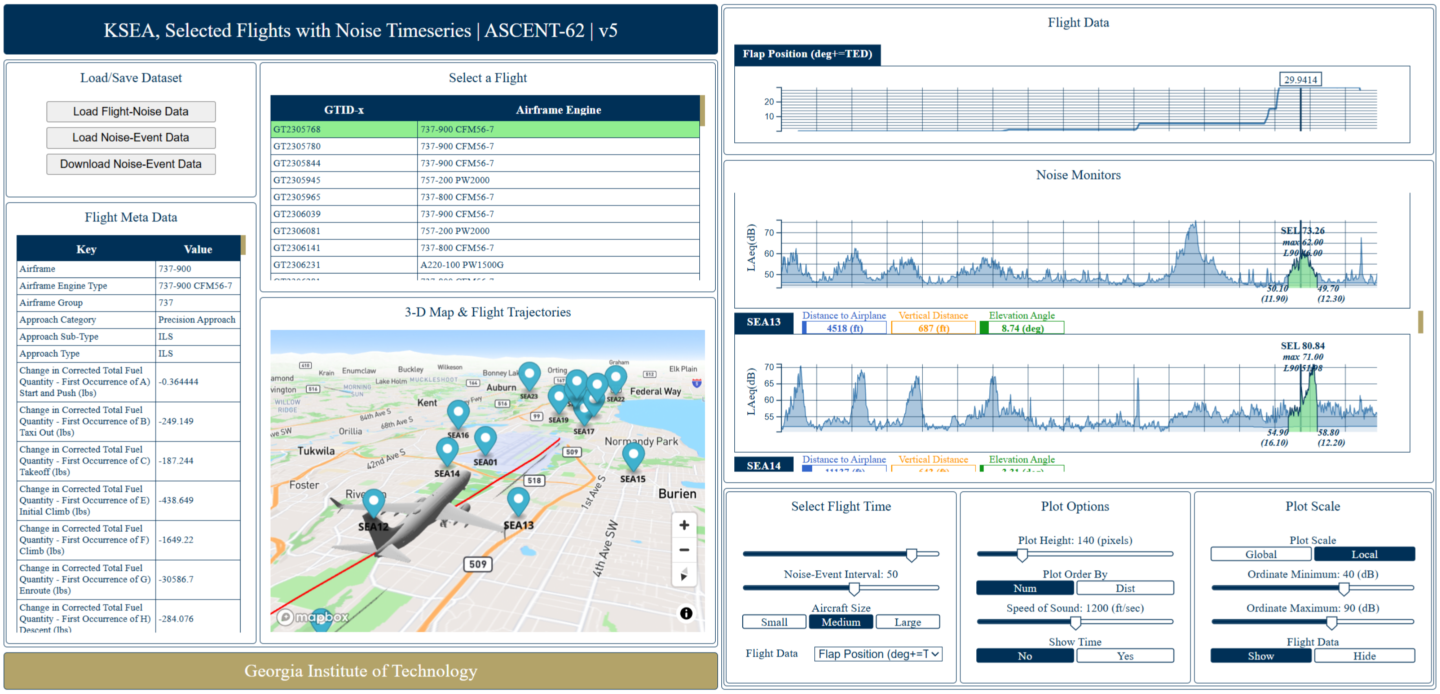
To manage the large number of flight modeling combinations efficiently, an automation process consisting of pre-AEDT and post-AEDT stages is utilized. This stage is fully described in earlier reports as the procedure was not altered.

SEA 2021 – Validation of Aggregate Flight Modeling Results against Airport Noise History Data

Dashboard Development

The development of the dashboard was driven by the critical need to generate ground-truth noise measurement data by correlating flight trajectories with noise measurement time series. Because matching a specific portion of a flight trajectory to a segment of a noise time series is often characterized as an art rather than an exact science, the primary objective was to create an efficient, human-in-loop tool. This application allows analysts to identify and validate source flight and noise events segment pairs with high precision, bridging the gap between raw data collection and verified analysis.

The interface, shown in Figure 4, is designed to guide the user through a logical sequence of operations, beginning with the selection of a specific flight from monthly collections of arrival or departure flight data. Upon selection, the dashboard populates a flight metadata display with FOQA details. Central to the visualization is a three-dimensional (3D) map that renders the terrain, airport runway layout, the specific trajectory curve of the selected flight, and the locations of noise monitoring stations. A time selector serves as the synchronization mechanism; as the user adjusts the time of flight, the aircraft's position on the 3D map updates immediately, simultaneously indicating the potential noise event interval across the time series plots of all monitoring stations. To facilitate detailed analysis, the dashboard presents noise time series data from all monitoring stations as time-vs-LAeq (dB) plots within the relevant flight window. These acoustic plots are juxtaposed with flight time series data, allowing the user to overlay selected FOQA metrics – such as aircraft flap position, airspeeds, or thrust – against the noise profile to investigate correlations. The user is provided with various controls to fine-tune the analysis, including settings for the noise event interval, the speed of sound used for propagation calculations, and variables for plot sizing. The core methodology for data association involves a systematic visual matching process. After the dashboard renders the 3D trajectory and corresponding noise time series for a finite pre-arrival or post-departure window, the user utilizes the time selector to identify a matching "peak" in a monitor's noise time series that aligns with a specific moment in the flight. The system dynamically calculates the distance and elevation angle between the aircraft and the station to help the user determine the relevancy of the candidate event. Once a match is confirmed, the user selects by clicking it, which automatically registers a comprehensive data row containing the flight and monitor IDs, start and end times, acoustic metrics such as SEL and L_{max}, and relative geometric or distance values.



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Select a Flight

GTID-x	Airframe Engine
GT2305768	737-900 CFM56-7
GT2305780	737-900 CFM56-7
GT2305844	737-900 CFM56-7
GT2305945	757-200 PW2000
GT2305965	737-800 CFM56-7
GT2306039	737-900 CFM56-7
GT2306081	757-200 PW2000
GT2306141	737-800 CFM56-7
GT2306231	A220-100 PW1500G

Flight Meta Data

Key	Value
Airframe	737-900
Airframe Engine Type	737-900 CFM56-7
Airframe Group	737
Approach Category	Precision Approach
Approach Sub-Type	ILS
Approach Type	ILS
Change in Corrected Total Fuel Quantity - First Occurrence of A) Start and Push (lbs)	-0.364444
Change in Corrected Total Fuel Quantity - First Occurrence of B) Taxi Out (lbs)	-249.149
Change in Corrected Total Fuel Quantity - First Occurrence of C) Takeoff (lbs)	-187.244
Change in Corrected Total Fuel Quantity - First Occurrence of E) Initial Climb (lbs)	-438.649
Change in Corrected Total Fuel Quantity - First Occurrence of F) Climb (lbs)	-1649.22
Change in Corrected Total Fuel Quantity - First Occurrence of G) Enroute (lbs)	-30586.7
Change in Corrected Total Fuel Quantity - First Occurrence of H) Descent (lbs)	-284.076

SEA13: Distance to Airplane 4518 (ft); Vertical Distance 687 (ft); Elevation Angle 8.74 (deg)

Noise-Event Interval: 50
Aircraft Size: Medium
Flight Data: Flap Position (deg+=T
Plot Height: 140 (pixels)
Plot Order By: Num
Speed of Sound: 1200 (ft/sec)
Show Time: No
Plot Scale: Local
Ordinate Minimum: 40 (dB)
Ordinate Maximum: 90 (dB)
Flight Data: Show

Figure 4. Interactive dashboard (v5) to capture sound exposure level (SEL) and maximum, A-weighted sound level (L_{max}) from Seattle-Tacoma International Airport (SEA) noise time history data.

Technically, the dashboard is constructed as a standalone web application utilizing a standard JavaScript® and HTML framework. The implementation relies on a suite of specialized open-source libraries to handle the complex visualizations. D3.js is employed for all two-dimensional (2D) plotting of signal and flight data, while Mapbox® is utilized for the 3D geographic information system application programming interface to render terrain and base maps. Finally, Three.js handles the rendering of the aircraft models and the 3D flight trajectory visualization within the geospatial environment.

Methodology

The detailed methodology for comparing SEA 2021 aggregate flight modeling results in the AEDT against events capture using airport noise history data is summarized in Figure 5 below. We start by using FOQA data to model flight operations

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in AEDT as described in the above subsection. After generating AEDT predictions, the next step is to utilize the noise history measurement data to calculate real-word noise metrics for validation. For SEA, the noise history data for calendar year 2021 obtained include detailed noise history in terms of noise levels LAeq (dB) that is measured by different noise monitors situated close to runways. These data are processed using an in-house visualization tool (shown in Figure 4 above) that couples associated noise levels measured by noise monitors with flight trajectory on an interactive map. This is described in detail in the above subsection on dashboard development. Using this, noise event identification is conducted. The formulae consider the distance to closest approach, speed of sound, air density, noise-event intervals, among others. All noise events with wind speeds greater than 10 knots, non-zero precipitation, elevation angles less than 20° will be discarded for the same reason stated under MSP 2021 results.

The two datasets are combined for further analysis. Some events were solely found in noise history analysis and were excluded from further study since the purpose of this analysis is to validate AEDT predictions. For events predicted in AEDT that were not recorded in the noise history analysis, the dashboard is reinvestigated to capture these noise events. This round of reinvestigation makes the approach robust to human errors, ensuring AEDT validation for all events predicted.

The final identified noise events are then used to calculate the ΔSEL between the two datasets. At this stage, any events with $\Delta SEL \geq 10\,\mathrm{dB}$ are identified as outliers for the dataset and investigated for trends that might be causing high prediction errors. For the remaining dataset, trends are investigated to estimate prediction errors by modeling approach in AEDT, operation type, elevation angles, and aircraft type. Overall, this work is aimed at (1) assessing the accuracy of AEDT predictions for different modeling assumptions, against detailed noise history data, and (2) identifying outliers and any systematic biases in the matching between AEDT predictions and detailed noise-history data.

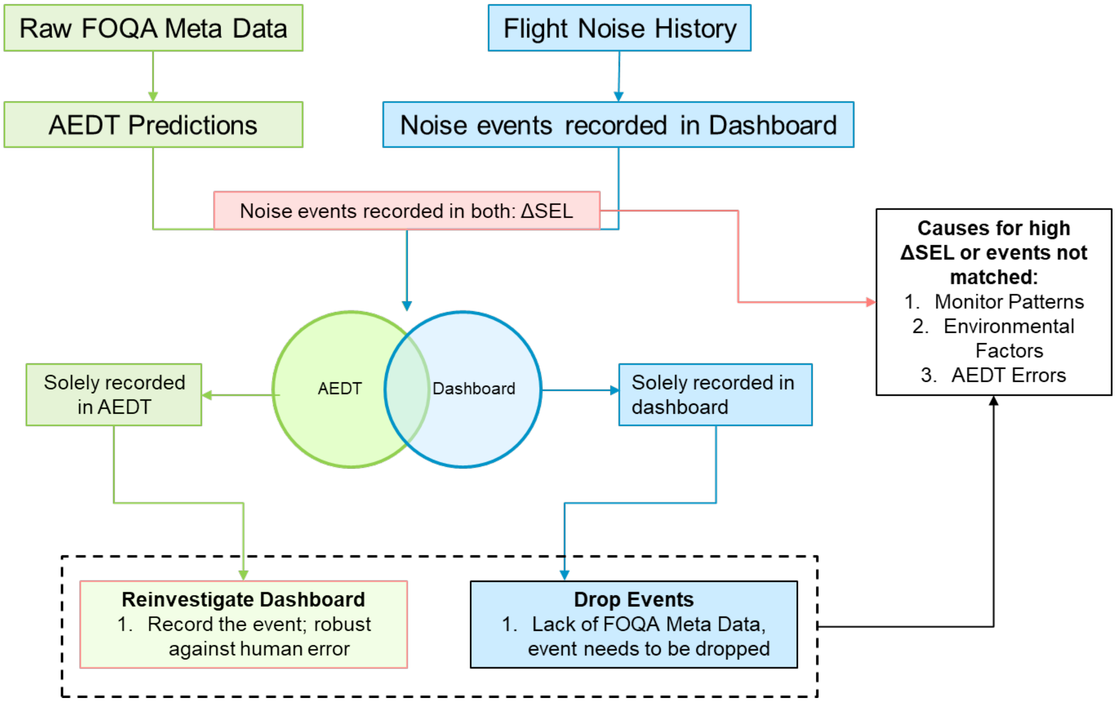


Figure 5. Methodology for comparing SEA 2021 aggregated flight modeling results in AEDT against airport noise history data.

Results

Using the methodology described above for which the results were also presented, flight and noise event data from both the AEDT predictions and measured noise histories were systematically processed and filtered to ensure data integrity. A total of 9,866 noise events were initially captured across both datasets. Of these, 3,882 events were excluded due to missing

AEDT predictions or FOQA metadata, and an additional 2,735 events were removed after applying standard quality filters, such as wind speed, precipitation, and elevation angle thresholds described above. Events with extreme discrepancies (Δ SEL ≥ |10| dB) accounted for 20 instances and were classified as outliers. After all filtering and validation steps, a total of 3,249 high-quality noise events were retained for SEA 2021, and a noise prediction error analysis was conducted.

Results for noise prediction error (ΔSEL) are shown, and the noise modeling accuracy is studied in different modeling options that are available in AEDT. ΔSEL levels are defined as $SEL_{predicted} - SEL_{measured}$, where $SEL_{predicted}$ corresponds to AEDT predictions, and $SEL_{measured}$ corresponds to SEL calculated from the events captured in the noise-history dashboard. This offers more statistical insights into all noise computations. Of all AEDT modeling options, this report presents aggregate results that are categorized in terms of AEDT modeling profiles, elevation angles, and AEDT modeling airframes. Box plots were selected to explain all ΔSEL values. The distance between the whiskers on the plots indicate the interquartile range (IQR) with the upper whisker representing the 75th percentile while the lower one representing the 25th percentile. The maximum of the box is 1.5*IQR above 75th percentile and vice versa for minimum of the box. Ideally, the median of zero with a small spread (±3 dB) indicates that AEDT predictions are accurate with real-world data. It is important to note that the outliers were deliberately retained for the plots to permit examination of the complete distribution prior to outlier filtering in order to identify trends, if any, emerge in the outlier distribution.

Figure 6 compares ΔSEL levels that are compared for two different modeling approaches in the AEDT, Standard and FOQA. Standard profiles are generic, pre-defined flight trajectories provided within the AEDT based on assumed or average operational parameters. FOQA profiles by contrast are data driven and generated from actual flight operation data, thus reflecting real world performance. Overall, both FOQA and standard profiles show good agreement with measured noise history data, with median prediction errors lying within ±2 dB for both arrivals and departures. FOQA-based predictions exhibit slightly reduced bias and variability compared to standard profiles, suggesting that incorporating real flight performance data enhances model accuracy. Negative ΔSEL values indicate cases where the AEDT underpredicted measured noise levels, which is observed more in the case of arrival operations.

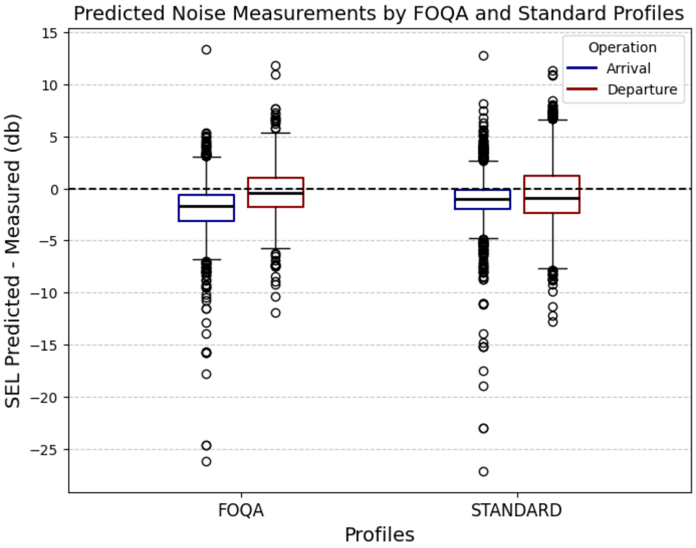


Figure 6. ΔSEL trends by profile type.

Figure 7 compares ΔSEL levels, defined as $SEL_{predicted} - SEL_{measured}$, where $SEL_{predicted}$ corresponds to AEDT predictions, and $SEL_{measured}$ corresponds to SEL calculated from the events captured in the noise-history dashboard. ΔSEL levels are compared for two different modeling approaches in AEDT: Standard and FOQA, and clubbed by elevation angles. The results show systematic dependence of ΔSEL predictions on elevation angles. For elevation angles below 20°, both FOQA and standard profiles exhibit greater variability and underprediction of measured noise, for both arrivals and departures. These low-elevation events typically correspond to monitors located close to runways, where elevated background noise, ground reflections, and operational variability can distort measurements. Consequently, such low-angle events were excluded from further analyses. For elevation angles ≥20°, prediction accuracy improves substantially, with median ΔSEL values generally within ±1 dB for both profile and operation types. This consistency indicates that after excluding near-runway monitors, AEDT predictions using FOQA and standard profiles perform within reasonable bounds of accuracy in estimating overall noise exposure.

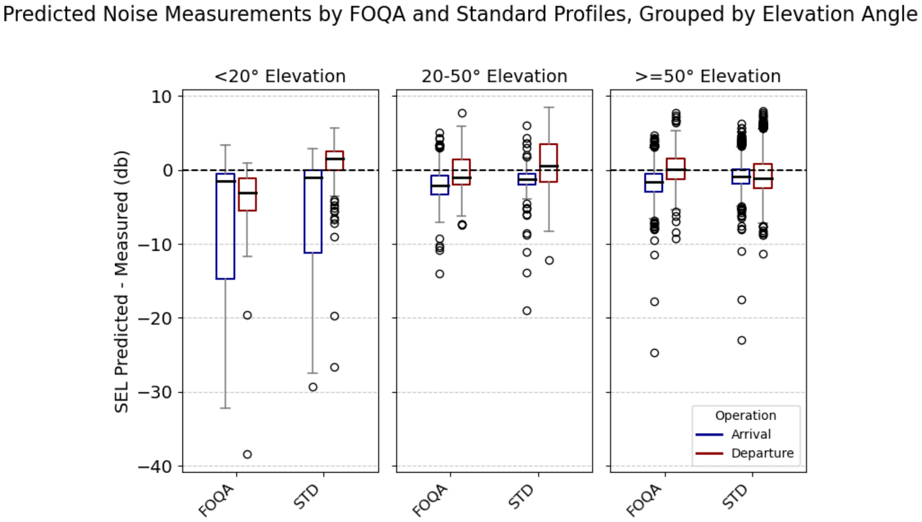


Figure 7. ΔSEL Trends by Elevation Angle.

Figure 8 compares ΔSEL levels, defined as $SEL_{predicted} - SEL_{measured}$, where $SEL_{predicted}$ corresponds to AEDT predictions, and $SEL_{measured}$ corresponds to SEL calculated from the events captured in the noise-history dashboard. ΔSEL levels are compared for two different modeling approaches in the AEDT, Standard and FOQA, and grouped by aircraft type. Results show aircraft specific trends in prediction accuracy. A320 exhibits underprediction for departure operations, which is consistent with the results obtained from MSP 2021 modeling in a similar result in the previous year. The A220, which is modeled in the AEDT using the B737 Aircraft Noise and Performance (ANP) database entry due to the absence of dedicated ANP data, tends to overpredict noise levels. This likely reflects differences in airframe and engine characteristics between the two types. In contrast, B737 predictions, which use their native ANP data, show close agreement with measurements for both arrivals and departures. The B757 demonstrates good agreement when FOQA-based trajectories are used but exhibits noticeable underprediction under the standard profile configuration. Overall, these results highlight that AEDT prediction accuracy depends both on the fidelity of the underlying ANP data and on whether actual (FOQA-derived) or generic (standard) flight profiles are used.

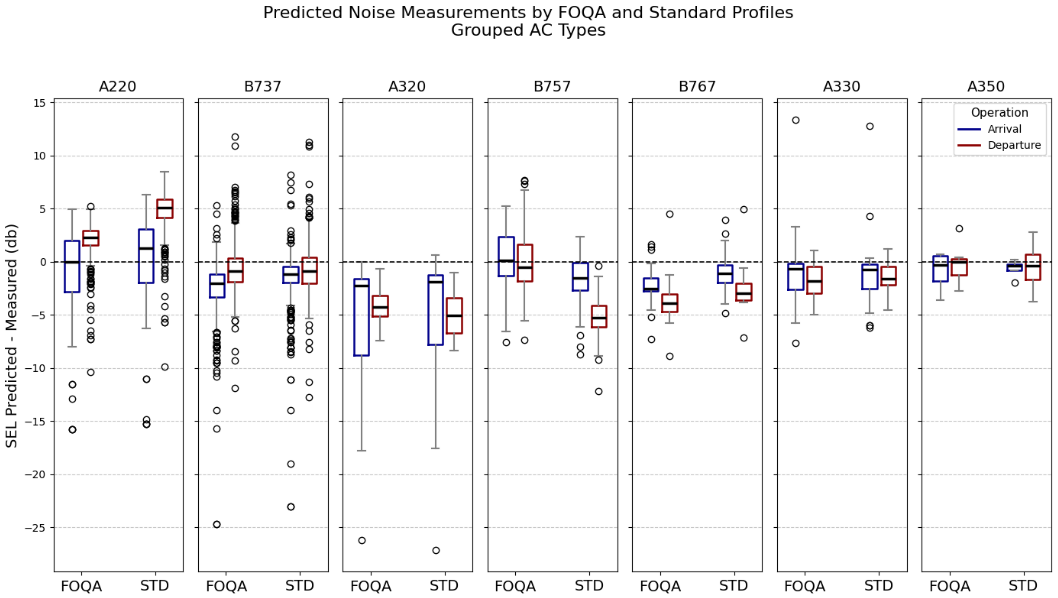
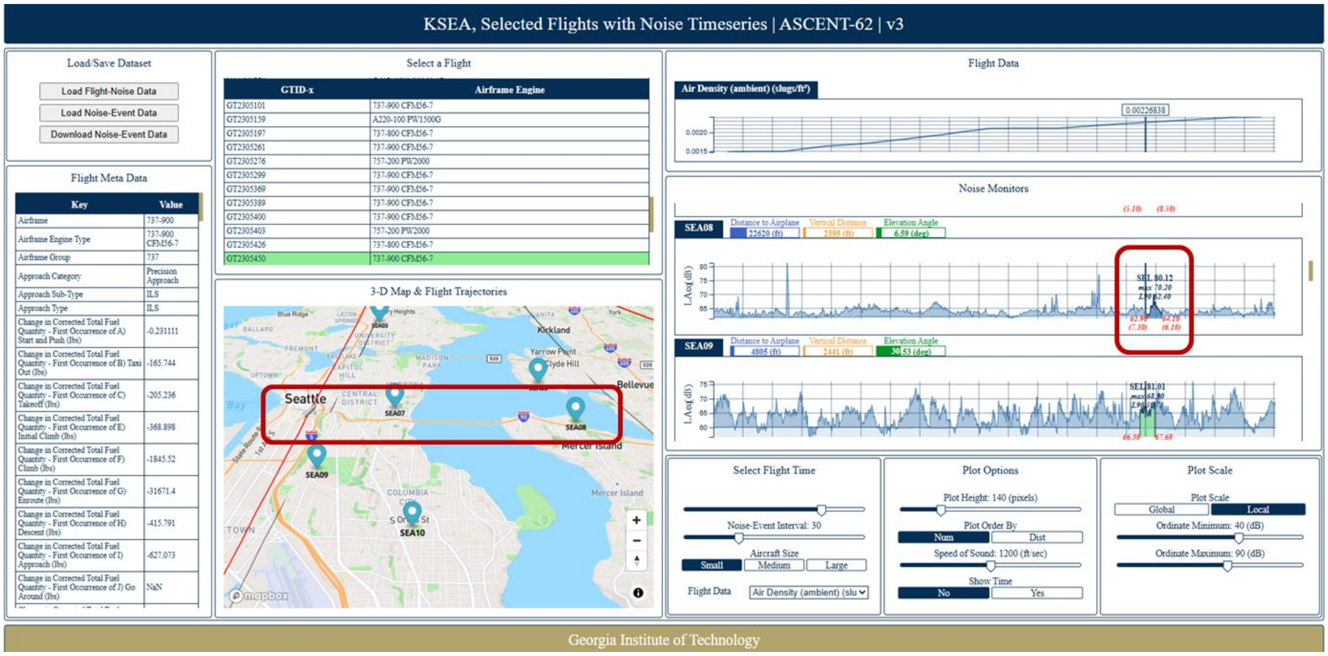


Figure 8. ΔSEL Trends by Airframe.

Figure 9 shows one example of an outlier (defined as ΔSEL ≥ |10|) in this validation study. As shown in this figure, the selected noise event does not exhibit the typical signature of an aircraft-related noise event but was nonetheless captured in AEDT predictions. This occurs because AEDT models the total noise contribution from aircraft overflight rather than filtering only for distinct, high-amplitude noise events. In this instance, a large slant distance between the aircraft and noise monitor resulted in a significant underprediction, with a ΔSEL of -17.97 dB. Across the full dataset of 3,449 matched noise events with filters applied, 20 such outliers were identified. Possible explanations include noise monitors positioned in areas with persistently high ambient noise, environmental conditions affecting measurement accuracy, or other untraceable anomalies. Despite thorough review, no consistent trend or operational pattern was observed among these outliers, indicating that these discrepancies are more likely due to random measurement variability than to systematic AEDT modeling bias.



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Load/Save Dataset

Flight Meta Data

Key	Value
Airframe	737-900
Airframe Engine Type	737-900 CFM56-7
Airframe Group	737
Approach Category	Precision Approach
Approach Sub-Type	ILS
Approach Type	ILS
Change in Corrected Total Fuel Quantity - First Occurrence of A) Start and Push (lbs)	-0.231111
Change in Corrected Total Fuel Quantity - First Occurrence of B) Taxi Out (lbs)	-165.744
Change in Corrected Total Fuel Quantity - First Occurrence of C) Takeoff (lbs)	-205.236
Change in Corrected Total Fuel Quantity - First Occurrence of E) Initial Climb (lbs)	-368.898
Change in Corrected Total Fuel Quantity - First Occurrence of F) Climb (lbs)	-1845.52
Change in Corrected Total Fuel Quantity - First Occurrence of G) Enroute (lbs)	-31671.4
Change in Corrected Total Fuel Quantity - First Occurrence of H) Descent (lbs)	-415.791
Change in Corrected Total Fuel Quantity - First Occurrence of I) Approach (lbs)	-627.073
Change in Corrected Total Fuel Quantity - First Occurrence of J) Go Around (lbs)	NaN

Select a Flight

GTID-x	Airframe Engine
GT2305101	737-900 CFM56-7
GT2305159	A220-100 PW1500G
GT2305197	737-800 CFM56-7
GT2305261	737-900 CFM56-7
GT2305276	757-200 PW2000
GT2305299	737-900 CFM56-7
GT2305369	737-900 CFM56-7
GT2305389	737-900 CFM56-7
GT2305400	737-900 CFM56-7
GT2305403	757-200 PW2000
GT2305426	737-800 CFM56-7
GT2305450	737-900 CFM56-7

3-D Map & Flight Trajectories

Flight Data

Air Density (ambient) (slugs/ft³)

Noise Monitors

SEA08 Distance to Airplane: 22620 (ft); Vertical Distance: 2595 (ft); Elevation Angle: 6.59 (deg)

SEA09 Distance to Airplane: 4805 (ft); Vertical Distance: 2441 (ft); Elevation Angle: 30.53 (deg)

Select Flight Time

Noise-Event Interval: 30

Aircraft Size: Small

Flight Data: Air Density (ambient) (slu

Plot Options

Plot Height: 140 (pixels)

Plot Order By: Num

Speed of Sound: 1200 (ft/sec)

Show Time: No

Plot Scale

Plot Scale: Local

Ordinate Minimum: 40 (dB)

Ordinate Maximum: 90 (dB)

Georgia Institute of Technology

Figure 9. Visualization showing example outlier noise event.

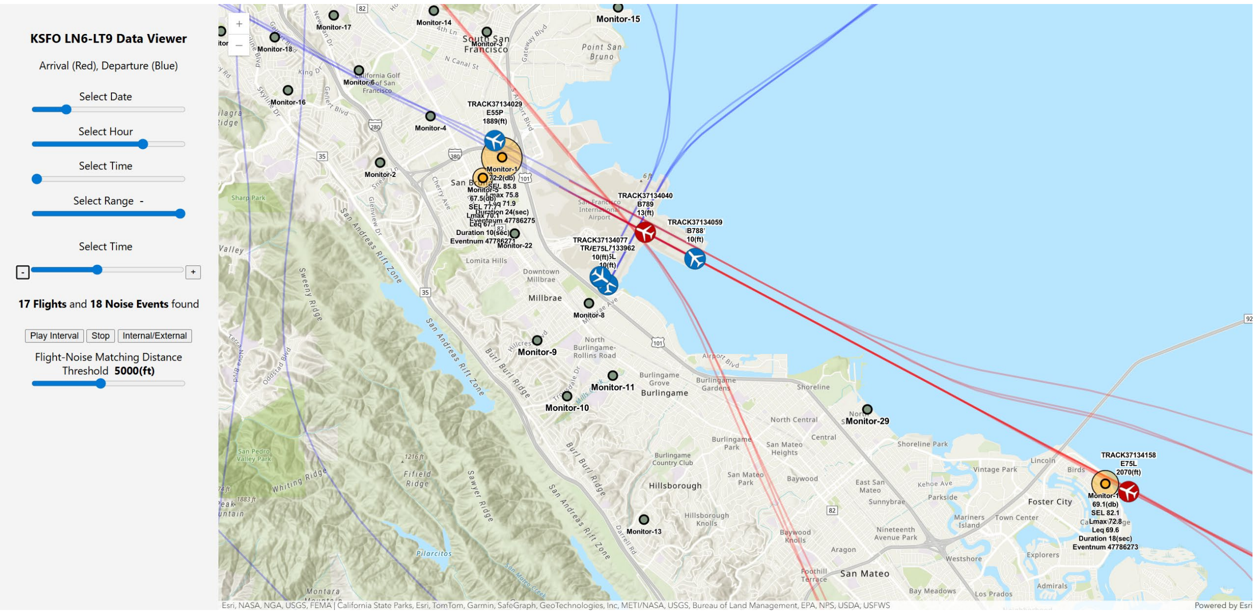
SFO 2021 – Validation of Aggregate Flight Modeling Results against Airport Noise History Data

Data Processing

To support the validation of flight modeling results against historical data, specific datasets collected within the San Francisco International Airport (SFO) airspace during 2021 were targeted for incorporation. These datasets are comprised of LT6 files, which serve as collections of flight tracking data, and LN6 files, which contain pre-selected noise events described by relatively short time series histories and event-wise statistics. The data items and formats for these files are detailed in the ANOMS_8_LT6 Rosetta Stone documentation. Because these files constitute a novel form of flight and noise records when they are compared to the previous analyses, new data processing routines were required to correlate them effectively. However, the sheer volume of data spanning the entire year – including approximately 761,000 noise events and 3.8 million flight tracking points for arrivals and departures (to/from SFO) – rendered the exclusive use of the previously developed human-in-the-loop dashboard infeasible for pairing tasks.

In pursuit of a fully autonomous and quantitatively accurate matching process, a qualitative pilot matching workflow was developed this year, supported by necessary data processing routines and visual aids (as shown in Figure 10). One challenge was the requirement to juxtapose candidate noise events, which exhibit both statistical characteristics and time series history, directly onto the geospatial map alongside flight trajectory data. To facilitate this, the system moved away from conventional time series plots in favor of a station-centric pulsing visualization. This design choice enables an intuitive visual correlation between the aircraft's position and the variation of noise measurements across all monitoring stations, effectively replicating the visualization of seismic events or vibrations over a geographic area, but with the aircraft acting as a moving source.

The resulting dashboard successfully enables a comprehensive understanding of the relationship between the moving noise source (aircraft), derived from LT6 aircraft tracking positions, and candidate noise bursts identified in time-bounded LN6 noise time series, The interface, shown below, visualizes the matching process where arrival and departure tracks (red and blue lines) are correlated with station data. The established workflow now prioritizes performing automatic parings first, followed by validity spot checks using this dashboard to confirm the results for flight modeling analysis.



KSFO LN6-LT9 Data Viewer

Arrival (Red), Departure (Blue)

Select Date

Select Hour

Select Time

Select Range -

Select Time

17 Flights and 18 Noise Events found

Flight-Noise Matching Distance Threshold 5000(ft)

Figure 10. San Francisco International Airport (SFO) LN6-LT6 Data Viewer in action. Orange circles are paired noise bursts to closest aircraft.

AEDT 3e – 3g Transition and Verification

The AEDT version used in this research was initially 3e, released on May 9, 2022, and later upgraded to version 3g, released on August 24, 2024, for all subsequent analyses. It was important to confirm that all modeled flights in the year 2023 produced consistent results between the two versions since they used identical noise calculations. To ensure consistency between the two versions, a small verification study was conducted by randomly selecting flights—such as a 2023 departure from KRDU using the MODIFIED_AW_RT15 profile—and modeling them in both AEDT 3e and 3g with identical inputs. As expected, this produced matching results once settings were aligned (see Table 3).

During this verification, an initial discrepancy in noise results (Table 4) was traced to differences in the default decade-average Integrated Surface Database (ISD) weather databases used by each version: AEDT 3e relies on 2015–2024 data, while AEDT 3g uses 2014–2023 data (Table 3). Because the test flight operated in 2023, both weather datasets were technically appropriate but still yielded slightly different noise predictions due to the role of weather in AEDT's calculations, underscoring the importance of updating the AEDT 3g database to incorporate the most recent available weather data.

Table 3. Default decade average weather data for the AEDT versions on 28016001 – Raleigh-Durham Intl (KRDU).

Parameter	AEDT 3e	AEDT 3g
Decade average period	2015–2024	2014–2023
Temperature (°F)	61.3	61.64
Pressure (millibars)	1002.22	1002.14
Sea level pressure (mb)	1018.14	1018.05
Relative humidity (%)	68.87	68.36
Dew point (°F)	50.98	51.1
Wind speed (knots)	5.08	5.15

Table 4. Noise level discrepancies at Raleigh-Durham International Airport (RDU) receptors due to weather data differences.

			Exposure (SEL)			Maximum (LAMAX)	
Receptor ID	Receptor Name	AEDT 3e	AEDT 3g	Difference (3g-3e) dB	AEDT 3e	AEDT 3g	Difference (3g-3e) dB
1	KRDU_1	88.83	88.81	-0.02	79.45	79.43	-0.02
2	KRDU_2	82.93	92.91	-0.02	71.27	71.24	-0.03
3	KRDU_3	78.98	78.96	-0.02	67.77	67.75	-0.02
4	KRDU_4	60.66	60.62	-0.04	46.79	46.75	-0.04
5	KRDU_5	58.78	58.73	-0.05	44.83	44.79	-0.04
6	KRDU_6	61.23	61.19	-0.04	47.37	47.32	-0.05

Milestones

None.

Major Accomplishments

- Completed successful implementation of the AEDT automation pipeline for (a) modeling real-world flights in various settings and (b) extracting and visualizing results from noise modeling efforts.
- Successfully analyzed over 9800 noise events at SEA in 2021to generate validation results. Excluded noise events with wind speeds >10 knots, non-zero precipitation, elevation angles less than 20° and slant distances >7,000 ft to ensure high quality of results.
- Presented SEA and MSP 2021 (from previous year) results at 2025 ASCENT spring meeting.
- Completed AEDT modeling of 2023 flights at the following airports: SEA, MSP, SFO, IAD, and RDU. Further analysis of noise validation is in progress pending noise data from the airports.
- Coordinated with the Penn State team to provide AEDT performance data required for tasks relevant to high-fidelity weather modeling.
- Developed an interactive human-in-loop dashboard to process detailed airport noise-history data for SEA 2021. Events identified from this dashboard are used to validate SEA 2021 AEDT predictions.
- Developed an interactive automated dashboard for SFO 2021 events. Events identified from this dashboard will be used in upcoming efforts to validate SFO 2021 AEDT predictions.

Publications

Willitt, A., Bendarkar, M. V., Bhanpato, J., Kirby, M., Abelezele, S., & Mavris, D. N. (2024, January). Preliminary AEDT noise model validation using real-world data (AIAA 2024-2107). *AIAA SCITECH 2024 Forum*. https://doi.org/10.2514/6.2024-2107

Outreach Efforts

Held currently monthly (previously biweekly) calls with the FAA, the Volpe Center, and Airborne Tactical Advantage Company (ATAC) and participated in biennial ASCENT meetings.

Awards

None.

Student Involvement

Sonal Mehta and Humfrey Kimanya, students at Georga Tech, worked on noise modeling for 2021 and 2023 SEA, MSP, SFO, IAD and RDU, and data processing for 2021 SEA and MSP datasets that were modeled in the previous year.

Plans for Next Period

- Provide insights into the statistical significance of results at various noise monitoring stations at SFO, IAD, and RDU, for the years 2021 and 2023.

- Further develop the interactive dashboard containing the modeling results with all different settings combined for performing trade-off studies.
- Collaborate with Penn State to complete analysis of the impact of high-fidelity weather on noise predictions and measurement.

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Task 2 - Assessing the Use of High-fidelity Meteorological Data in AEDT Noise Calculations

The Pennsylvania State University

Objective

As an exploratory step, Penn State is investigating the possibility of incorporating high-fidelity meteorological data in AEDT noise calculations without modifying the noise model in the AEDT. The ultimate goal is to suggest enhancements to the AEDT that will enhance the predictive capability of AEDT's noise calculations with respect to real-world measurement data.

Research Approach

Penn State's overall approach was described in the 2024 annual report.

Application of Physics-based Noise Calculations to RDU

As mentioned in last year's ASCENT Project 062 annual report, Penn State has begun working with RDU. This is because RDU has a significant interest in sustainability practices, and they also have noise monitors. The monitors, at the time of this study, were located toward the ends of a singular main runway (see Figure 11).

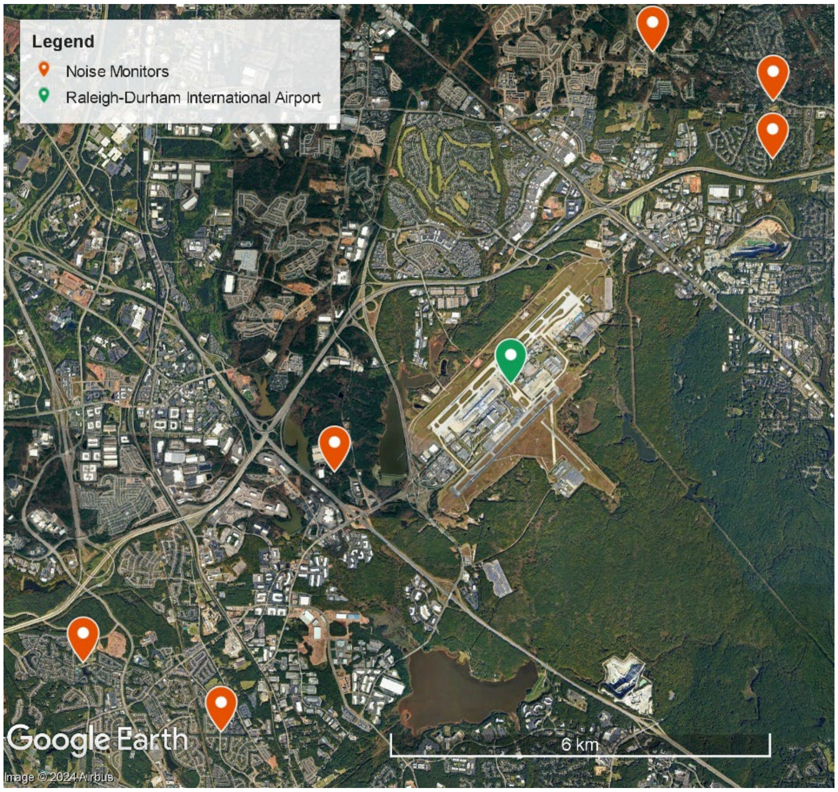

Figure 11. Locations of noise monitors around Raleigh-Durham International Airport.

Further, RDU is not near any large bodies of water, and this contrasts previously studied airports such as SFO. A long-term question is whether the presence of such large bodies of water can affect the accuracy of noise calculations, either with the AEDT or Penn State's physics-based ray-tracing noise calculation methodologies. It is hoped that by comparing across several airports that the question can be answered.

As a first go at analyzing the noise around RDU, noise monitor information was obtained from their noise office, and flight tracking data were obtained from an airline partner of Georgia Tech. Georgia Tech was able to sufficiently scrub the data of identifiers so that it could be analyzed at Penn State, and Penn State thanks Georgia Tech for making this flight data available for this research.

As an initial exploration of the dataset, Penn State obtained the microphone data from January 2021. Correspondingly, the Penn State team received weather data and data for ten flights and AEDT outputs from Georgia Tech for the same time period. Seven of the flights were from 737-800 aircraft, and these flights have been analyzed.

One of the early flights in January 2021, a departure, is GT2300164. The flight is shown in Figure 12, where the upward triangle is RDU, and the circle symbols t_1, t_2, and t_3 show the location of the aircraft at 1, 2, and 3 minutes after departure, respectively.

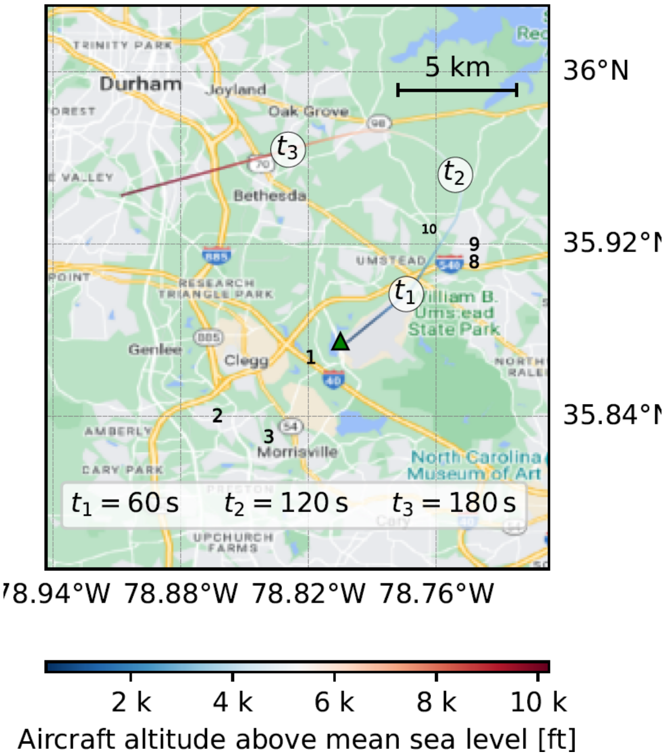

Figure 12. Departure of flight GT2300164 from Raleigh-Durham International Airport.

The weather on a notional day of flight GT2300164 varied considerably from the annual average weather assumed by the AEDT. These weather data are shown in Figure 13, and one can see this is a colder and dryer day than would be assumed in AEDT's annual average (shown with the red dashed lines). The AEDT does not include wind information in its noise calculation, so we will not include it in our physics-based calculations.

Table 5 shows the noise calculation results comparing the AEDT using its annual average atmosphere with the Penn State physics-based ray-tracing approach using an atmosphere with an average of the weather profiles on the day of GT2300164's departure. The in-house ray tracing assumes no refraction but does include altitude-dependent temperature and humidity, as an average over the weather at different times during a notional day of flight GT2300164. In this case, the LAmax (maximum, A-weighted sound level) values are quite close, and the SEL values vary only by about 1.5 dB. This is decent agreement between AEDT and the Penn State calculations, given all the uncertainties, particularly our not knowing the exact time of the flight.

Now we turn to a different case, a similar departure later in the month of January 2021, flight GT2301209, when the weather was particularly cold and dry in that portion of the month. Similar data processing shows AEDT and Penn State noise calculations are much further apart, for both SEL and LAmax, on the order of 2 to 3 dB. In this case for flight GT2301209, the AEDT is overpredicting the noise levels in comparison to the physics-based approach.

Hence, during this project period shortened by funding delays, we have shown that there are noise calculation differences between the AEDT's approach and the Penn State physics-based straight ray tracing approach at the RDU airport. Sometimes SEL and LAmax metrics agree within a dB and other times they do not. This merits further research, and the Penn State team looks forward to analyzing both the RDU data in more detail and similar data from additional airports in the near future. It would also be helpful if such datasets contain a reasonable number of flights somewhat uniformly spread throughout the months of the year. This would make seasonal comparisons possible, such as comparing summer versus winter. Obtaining such results will allow us to provide FAA information that potentially could lead to impactful improvements in AEDT noise predictions.

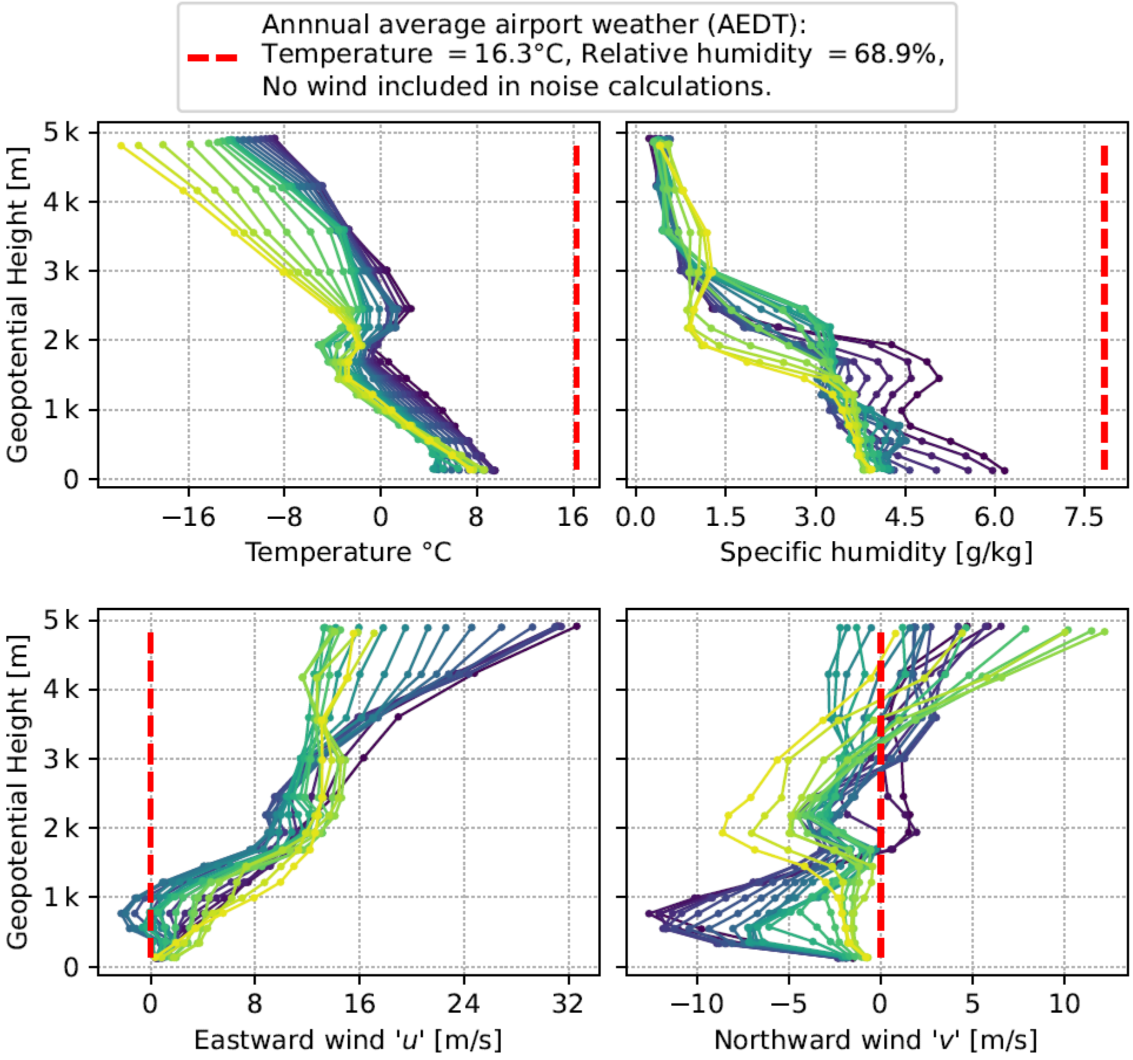

Figure 13. Weather data on the notional day of flight GT2300164 from Raleigh-Durham International Airport.

Table 5. Computed noise levels given by AEDT and Penn State's physics-based codes for flight GT2300164.

Sensor	AEDT		Ray Tracinig (Homo)	
	SEL	LAMAX	SEL	LAMAX
8	79.06	65.76	80.18	65.58
9	80.76	68.68	82.09	68.57
10	84.11	72.49	85.14	72.35

Milestones

None.

Major Accomplishments

None.

Publications

None.

Outreach Efforts

- Attended biweekly calls with the FAA and Georgia Tech.
- Participated in semiannual ASCENT meetings.

Awards

None.

Student Involvement

Harshal Patankar, a graduate student at Penn State, recently completed his Ph.D. work based on the ASCENT Project 040 research. ASCENT Project 040 was the predecessor to ASCENT Project 062. The in-house ray tracing approaches applied here were developed by Patankar. Pierce Hart, a post-doctoral scholar at Penn State, did all the heavy lifting during the current project period utilizing the Patankar codes and generating the results shown in this report.

Plans for Next Period

- Continue the analysis of RDU airport and expand such noise calculation comparisons to additional airports based on the availability of funding.

Special Acknowledgments

The contributions to ASCENT Project 062 by industrial partners Spire Global, Metropolitan Washington Airports Authority, and RDU were incredibly important for this project. Our research team gratefully acknowledges their essential and exemplary support to the Penn State research efforts described here.

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