Project 45
Takeoff/Climb Analysis to Support AEDT APM Development

Motivation and Objectives

- Accurate modeling of performance is a key factor in estimating noise, emissions and fuel burn
- Various assumptions are made for aircraft performance modeling (APM) within the AEDT:
  - Aircraft takeoff weight, and thrust
  - Departure & Arrival flight procedures
  - Noise Power Distance tables (NPD)

Practical Outcomes

Short term
- Assessment of impact of current modeling assumptions within the APM and within NPDs
- Sensitivity investigation of modeling assumptions
- Modeling of real-world flight data in AEDT for validation

Long term
- Recommendations for implementation of new noise abatement departure procedures (NADPs)
- Recommendations for implementation of new arrival profiles
- Sensitivity analysis and quantified implications of assumptions within AEDT to environmental modeling results

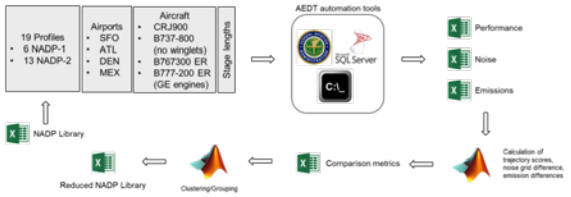
Task Plan

- Task 1: NADP Library grouping and down-selection
- Task 2: NextGen Arrival profile modeling
- Task 3: Integrated Impact Assessment

Task 1 – NADP Library

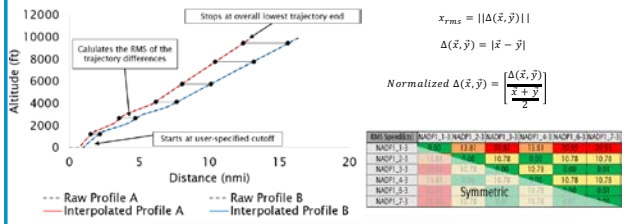
Objective: Given library of NADP profile definitions, select a subset which retains variability within profiles while reducing number of options for implementation into AEDT

Process Flowchart



Quantifying NADP Profile Differences

- NADP profile differences quantified by calculating pairwise RMS metrics from trajectory, emissions, fuel burn, and noise data
- Seeking to reduce profile count while maintaining integrity of NADP library



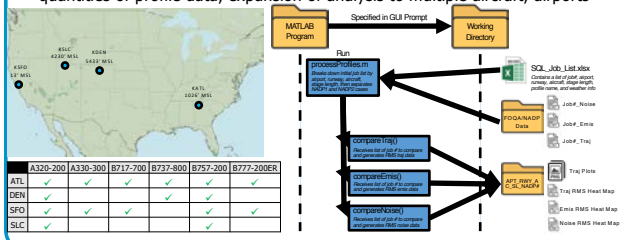
$$x_{rms} = ||\Delta(\vec{x},\vec{y})||$$

$$\Delta(\vec{x},\vec{y}) = |\vec{x} - \vec{y}|$$

$$Normalized\ \Delta(\vec{x},\vec{y}) = \left|\frac{\Delta(\vec{x},\vec{y})}{\frac{\vec{x}+\vec{y}}{2}}\right|$$

Preparation for Clustering

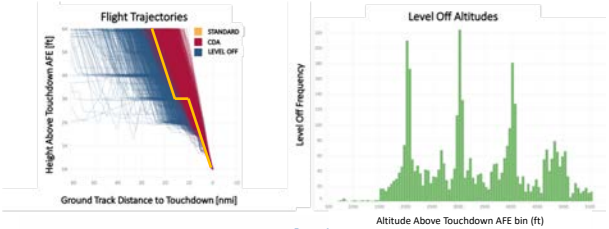
- Midpoint normalization method allows for cross-comparison of metrics
- Next step – Development of post-processing architecture to handle mass quantities of profile data, expansion of analysis to multiple aircraft, airports



	A320-200	A330-300	B717-700	B737-800	B757-200	B777-200ER
ATL	✓	✓	✓	✓	✓	✓
DEN	✓			✓	✓	
SFO	✓	✓	✓		✓	✓
SLC	✓				✓	

Task 2 – Arrival Profile Modelling

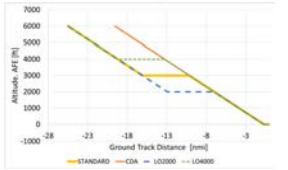
Objective: Investigate the common trajectories taken by multiple aircraft types by performing a statistical analysis of FOQA data taken from one airline and threaded track data taken from multiple airlines. As a result of this investigation, propose arrival procedures, define them in AEDT and observe a noise and/or emission difference from the current trajectory defined within AEDT.



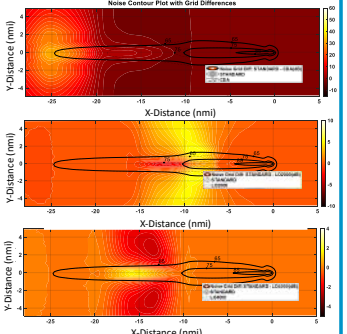
Research Findings

Flights are divided into two types of approaches:
- Constant Descent Approaches with glide slope angles of roughly 3 degrees
- Level off Approaches which contain 1 or multiple level segments occurring at 2000 ft, 3000 ft, or 4000 ft for all airframes and all airports

Proposed implementation in AEDT:
- Add procedures to represent flights with a level off at 2000 ft, 4000ft and one Constant Descent Approach to more properly represent day to day operations



Noise Level [dB]	Profile	Area Change	Width Change	Length Change
65	CDA	-17.06%	2.80%	-23.54%
	LO2000	-8.16%	-11.99%	0.07%
	LO4000	1.52%	-0.27%	-0.05%
75	CDA	9.75%	-0.02%	9.63%
	LO2000	-0.71%	-2.86%	33.26%
	LO4000	1.52%	-0.27%	-0.05%
85	CDA	-0.06%	0.00%	-0.03%
	LO2000	0.21%	0.00%	0.44%
	LO4000	-0.01%	0.00%	0.00%



Findings: Largest changes in noise are found before final approach as all profiles overlap during the last 7 nmi of their procedures, with CDA having the most change

Next Steps: Investigate thrust changes between profiles and the behavior of these noise differences at a higher altitude airport (DEN) and provide final recommendations

Task 3 – Integrated Impact Assessment

Assess the total impact of proposed improvement in accuracy in modeling assumptions from thrust, weight, procedures, and noise-power-distance (NPD) curves in AEDT vs. real world settings. The final comparisons will be among standard baseline AEDT modeling assumptions, improved AEDT modeling assumptions (based on real-world data), and actual real-world noise contours.

1 Process FOQA Data
- Obtain FOQA data
- Extract relevant phases and parameters

2 Determine Departure Modes
- Visualize distributions of parameters during departure
- Perform statistical analysis on FOQA data to obtain parameter setting modes during various segments of departure

3 Generate New NPDs
- Use ANOPP to generate NPDs for the departure modes generated from step 2
- Add resulting multiple NPDs to AEDT FLEET DB for each mode

4 Create Fixed Point Profiles
- Create fixed point departure profiles in AEDT for each procedure, based on departure modes
- Generate AEDT noise metric results using the Fixed Point Profile with mode-based NPDs

5 Perform Integrated Assessment
- Calculate departure noise contour based on integrated effect of updated thrust, weight, NPD curves, procedures and compare to real-world data (obtained from SFO noise monitoring partner)

Complete *In progress*

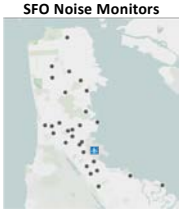
FOQA Data Usage

- FOQA data will be used:
  - To evaluate the current NADP library generated by this project
  - As a basis for comparing current AEDT departure assumptions to real-world operations
- Visualization dashboard created to analyze FOQA parameter distributions to determine common departure modes of aircraft for NPD generation
- Cases are set up in AEDT to test the impact of various assumptions (input variables) on SEL noise contours
- SEL noise measurements will be compared to actual readings from various noise monitors around SFO
- A series of FOQA flights will also be modelled in AEDT using fixed-point profiles and mode-based NPD lookup to compare the AEDT noise results to real-world noise results

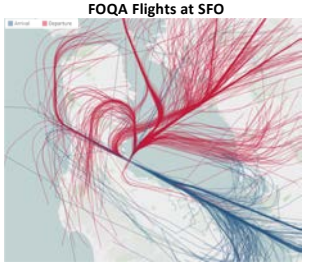
Input Variables for Cases

Departure Procedure	Standard NADP 1 NADP 2 FOQA
Thrust	Standard thrust 5% reduced thrust 10% reduced thrust 15% reduced thrust FOQA thrust
Weight	AEDT weight Alternative weight FOQA weight
Track	Straight AEDT track FOQA custom track
NPD	Baseline NPD ANOPP NPD+C
Weather	Standard day FOQA

SFO Noise Monitors



FOQA Flights at SFO



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