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
  - Takeoff thrust
  - Departure flight procedures

Practical Outcomes

- Short term
  - Assessment of current modeling assumptions within the APM
  - Identify modeling gaps to real world flight
  - Identify necessary flight data and analyze
  - Sensitivity investigation of modeling assumptions
- Long term
  - Recommendations for new algorithm to mimic real world takeoff performance
  - Documentation of sensitivity analysis and implications of modifications to the APM

Task Plan/Schedule

- Task 1: Literature review - completed
- Task 2: Statistical Analysis of Flight Data - ongoing
- Task 3: Development of Aircraft State Estimators - ongoing
- Task 4: Develop APM Enhancement Recommendations – in refinement based on identification of new data
- Task 5: Implementation – in progress

Approach

- Take a partial derivative approach to understand the impact of each APM takeoff assumption
- Utilize High Fidelity Validation Data (HFVD) to validate new departure procedures within AEDT
- Identify possible implementation options along with level of effort and data requirements

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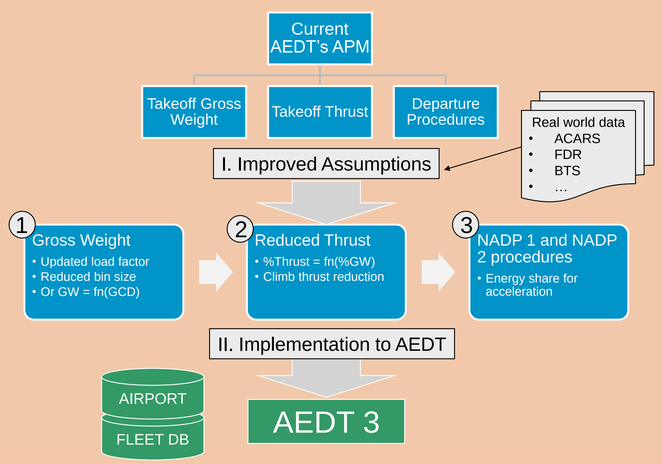
Partial Derivative Approach to the APM

- Step 1: Baseline AEDT Standard departure procedures to determine current contour area, fuel burn, and NOx
- Step 2: Project 35 weight with baseline AEDT Standard departure procedures; Sensitivity to TO weight assumption
- Step 3: AEDT weight with reduced thrust AEDT Standard departure procedures; Sensitivity to TO thrust assumption
- Step 4: Project 35 weight with reduced thrust AEDT Standard departure procedures; Sensitivity to TO thrust and weight assumption
- Step 5: AEDT assumed weight and full thrust NADP 1 & 2 procedures; Sensitivity to takeoff procedure at AEDT weight assumption
- Step 6: Project 35 weight and full thrust NADP 1 & 2 procedures; Sensitivity to takeoff procedure and correct TO weight from P35
- Step 7: AEDT assumed weight and reduced thrust NADP 1 & 2 procedures; Sensitivity to takeoff procedure and reduced thrust at AEDT weight assumption
- Step 8: Project 35 weight and reduced thrust NADP 1 & 2 procedures; Sensitivity to TO procedure, TO thrust, and correct TO weight from P35

Initial Recommendations

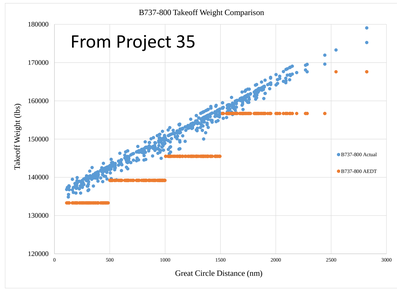
AEDT APM Assumption	AEDT vs Reality (What's the problem?)	Importance (Does it matter?)	Changes to AEDT (How?)	Potential Data Source (By how much?)
Weight	•AEDT uses Stage Length (SL) bins •AEDT tends to underestimate GW by ~%5 for low SLs •AEDT may overestimate GW for high SLs	•Medium (-5 to +10%) difference in noise contour areas •NOx and FB	•Update the load factor (LF) assumption for each bin AND/OR •Reduce the bin size OR •Use a continuous function	•IATA (GW) •BTS (Payload) •CAEP (LF) •SAPOE •Users
Departure Thrust	•AEDT uses 100% thrust •Airlines uses reduced takeoff thrust when possible (~95% of the time) •Typically limited at 25% reduction •About 15% reduction on average, but can be as low as 40%	•High (Up to 40+%) difference in noise contour areas •NOx and FB	•Change the thrust coefficients E for takeoff and climb in the THRUST_JET table •Change all Acceleration segments into Percent Acceleration segments in the PROCEDURES table	•IATA •FLYAPG.com •Project 35 •Volpe •Physics based calculations •TTREAT •Users
Departure Procedure	•Most aircraft in AEDT have STANDARD, ICAO-A, and B Procedures •Airlines use NADP1 and 2 Procedures	•Medium (1~10%) difference in noise contour areas •NOx and FB	•Rename the ICAO-A and B procedures to NADP1 and 2 •Adjust the segment steps	•IATA •ICAO PAN-OPS •ICAO 2007 NADP Survey

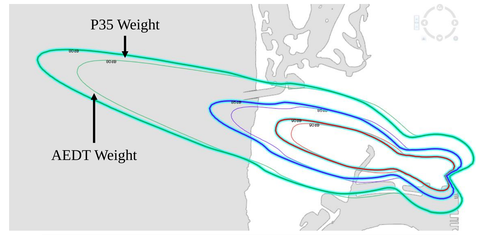
Initial Implementation Plan



Sensitivity to Takeoff Weight

- AEDT assumes takeoff weights in bins, which tends to under predict actual takeoff weight per Project 35

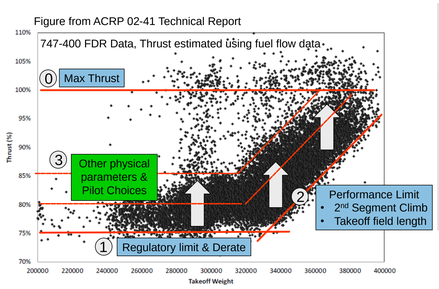


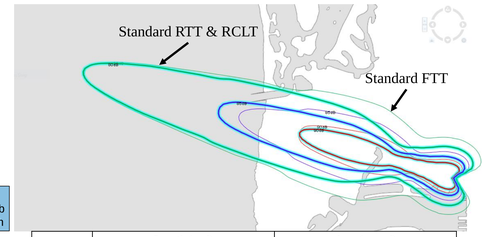


	Length (nmi)			Area (sq nmi)		
SEL dB	Standard FT (AEDT Weight)	Standard FT (P35 Weight)	Diff	Standard FT (AEDT Weight)	Standard FT (P35 Weight)	Diff
80	18.2	20.0	8.9%	11.1	12.2	8.8%
85	10.8	11.7	7.9%	4.2	4.5	7.4%
90	7.6	8.3	8.0%	1.9	2.0	7.0%

Sensitivity to Takeoff Thrust

- AEDT assumes a full power takeoff thrust.
- Most aircraft takeoff with ~15% or more reduced thrust

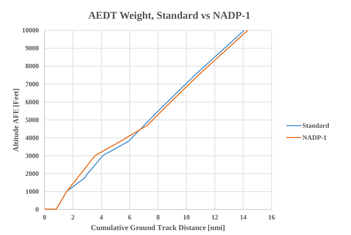


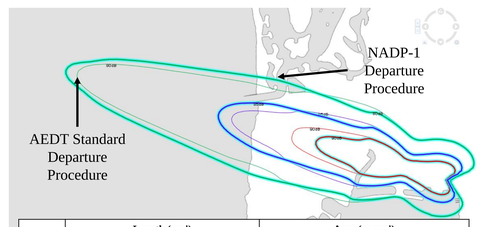


	Length (nmi)			Area (sq nmi)		
SEL dB	Standard FTT (AEDT Weight)	Standard RTT (AEDT Weight)	Diff	Standard FTT (AEDT Weight)	Standard RTT (AEDT Weight)	Diff
80	18.2	17.6	-3.5%	11.1	8.7	-27.7%
85	10.8	11.2	3.5%	4.2	3.4	-23.6%
90	7.6	7.2	-5.6%	1.9	1.2	-53.9%

Sensitivity to Takeoff Procedure

FAA AC 91-53A and ICAO PANS OPS Chapter 3 Volume II recommend that all carriers adopt no more than two procedures for each aircraft type; one for noise abatement of communities close to the airport (NADP-1) and one for noise abatement of communities far from the airport (NADP-2) - Neither of these departure procedures are currently in AEDT

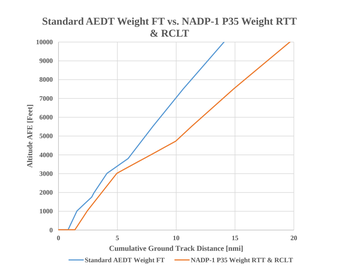


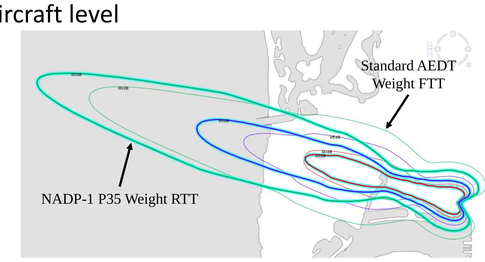


	Length (nmi)			Area (sq nmi)		
SEL dB	Standard FT (AEDT Weight)	NADP-1 FT (AEDT Weight)	Diff	Standard FT (AEDT Weight)	NADP-1 FT (AEDT Weight)	Diff
80	18.2	18.7	2.5%	11.1	12.1	7.9%
85	10.8	11.4	5.2%	4.2	4.4	5.1%
90	7.6	6.6	-15.8%	1.9	1.4	-32.3%

Sensitivity to All Assumptions

- Adjusting all of the takeoff assumptions has a significant impact on the departure noise contour at the aircraft level





	Length (nmi)			Area (sq nmi)		
SEL dB	Standard FTT (AEDT Weight)	NADP-1 RTT (P35 Weight)	Diff	Standard FTT (AEDT Weight)	NADP-1 RTT (P35 Weight)	Diff
80	18.2	19.7	7.8%	11.1	10.3	-7.6%
85	10.8	12.2	12.1%	4.2	3.6	-15.8%
90	7.6	7.2	-5.9%	1.9	1.1	-64.4%