

Fuel consumption modeling in support of ATM environmental decision-making

paper #48

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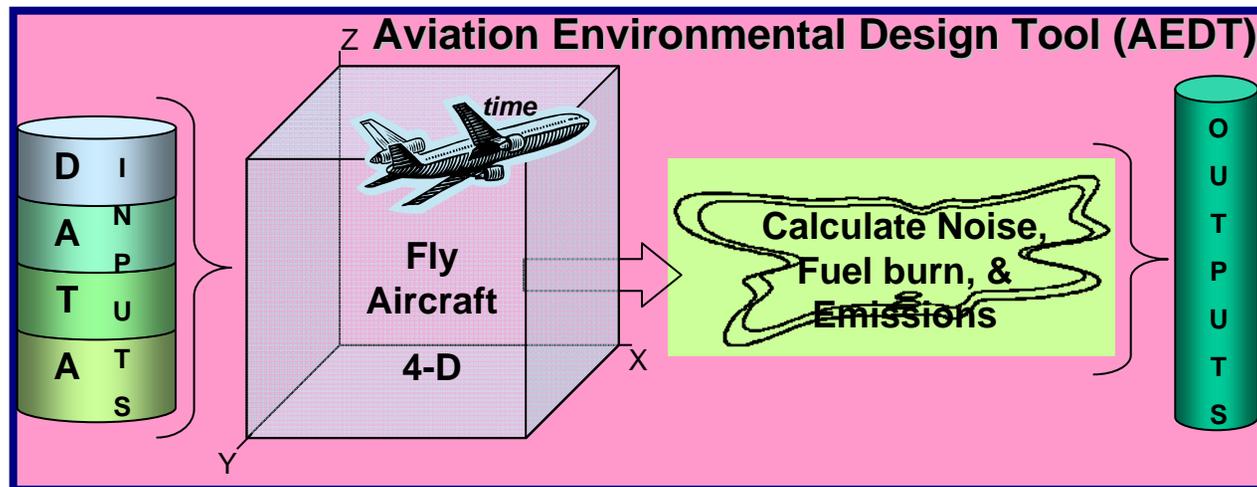


Federal Aviation
Administration



Motivation: FAA fuel consumption modeling

- FAA's Office of Environment & Energy is developing AEDT
 - Dynamically models aircraft in 4 dimensional space & time
 - Scalable from single flight → global analyses
 - Singular environmental policy and regulatory tool
 - Will handle inputs from radar and/or simulation tools
 - Capable of analyzing interdependencies of noise and emissions
 - **Aircraft performance and fuel burn calculations are critical to quantify environmental consequence**



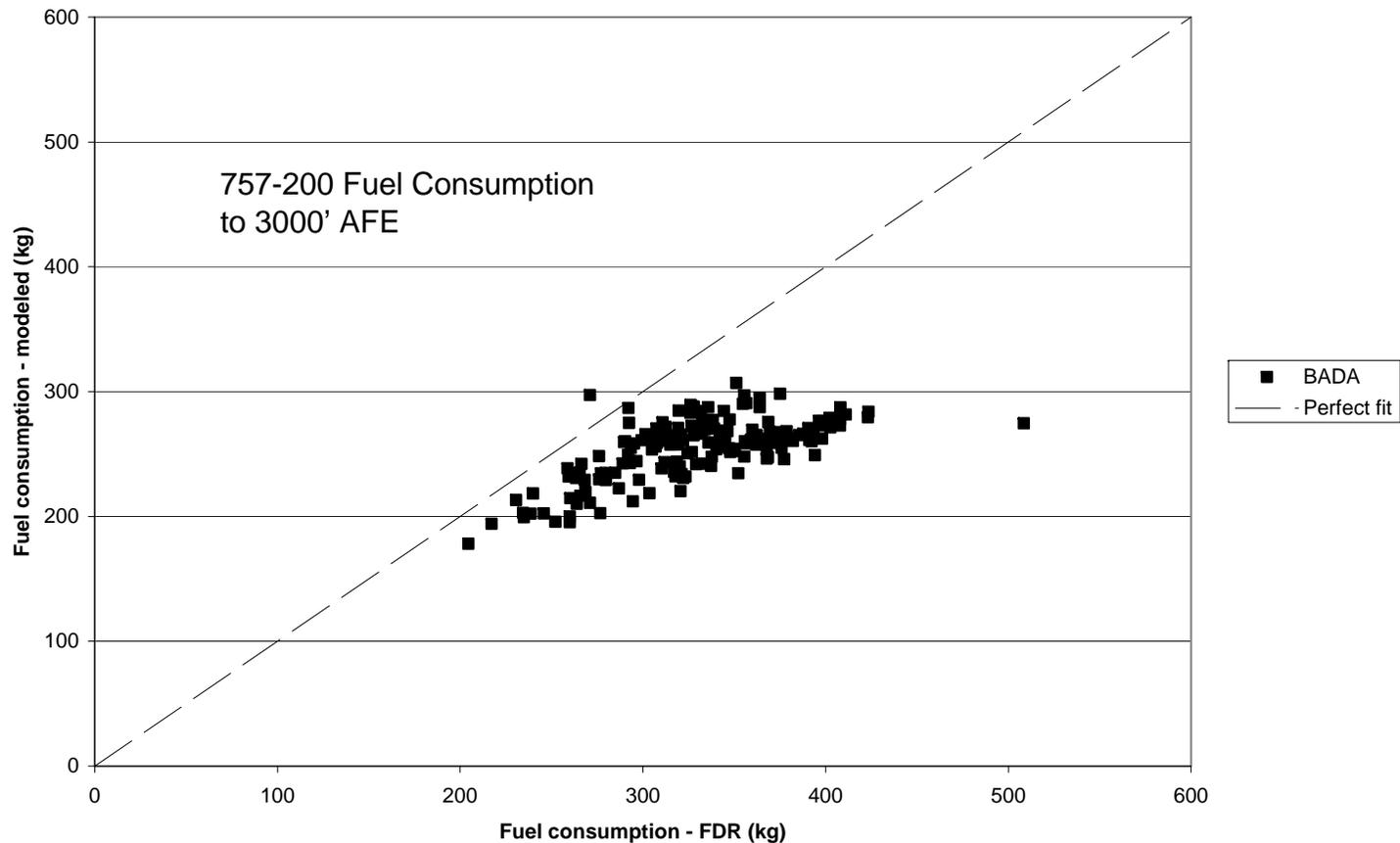
Background: FAA fuel consumption modeling

- Historically, we have used a combination of SAE-AIR-1845 thrust and EUROCONTROL's Base of Aircraft Data (BADA) Thrust Specific Fuel Consumption (TSFC) to predict fuel burn in the terminal area
- BADA is intended as an enroute Air Traffic Management tool



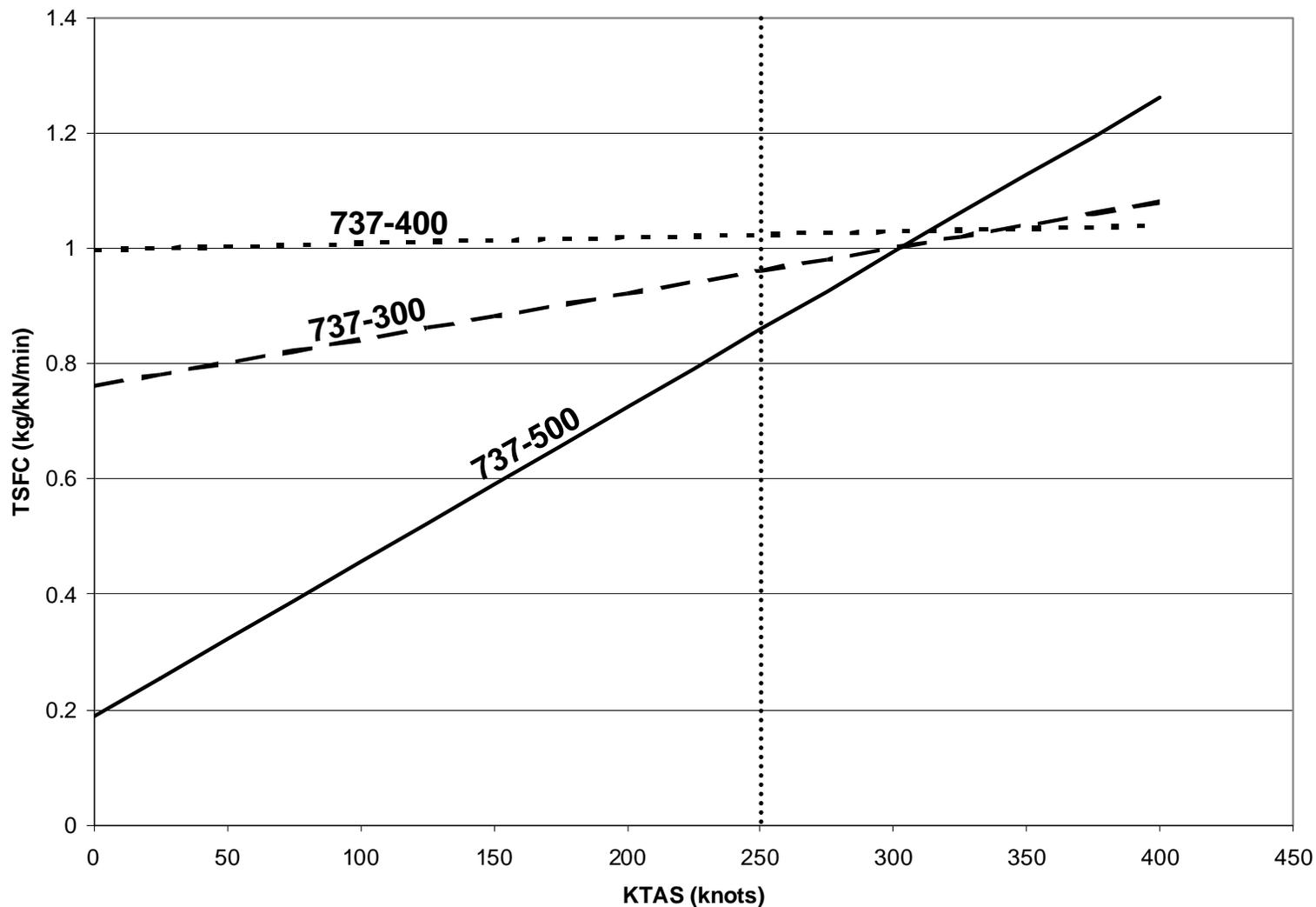
Example of fuel consumption under-prediction

- Flight Data Recorder (FDR) analyses showed that the **SAE/BADA method** did not accurately model terminal area fuel burn for some aircraft
- Incorrect fuel consumption leads to incorrect emission calculations and potentially ill-informed policy decisions



Example of why BADA has trouble at low speeds

BADA 737-500/-300/-400 TSFC curves

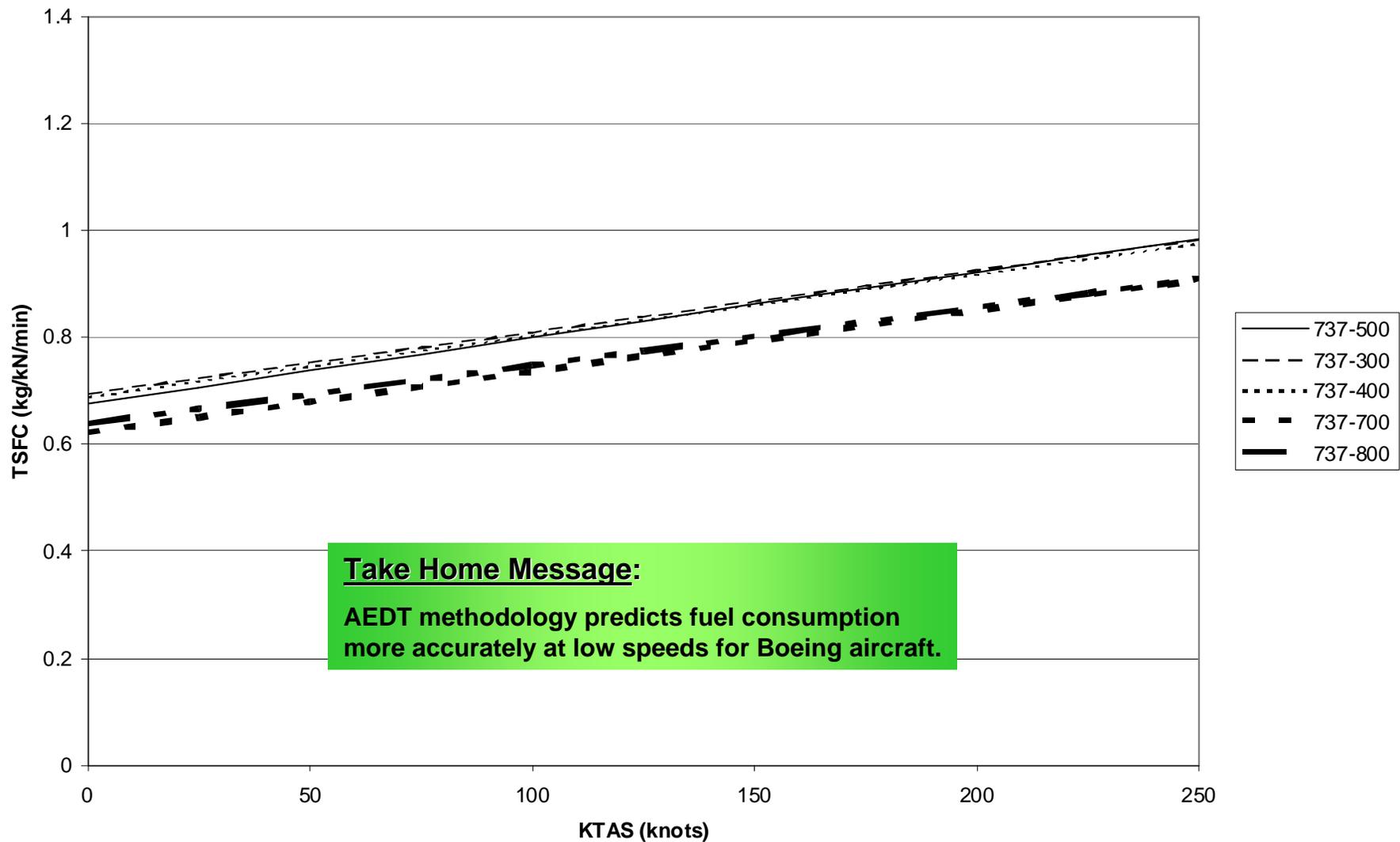


AEDT Fuel Burn Modeling Improvement

- In agreement with Boeing – FAA obtained the Boeing Climb-Out Program (BCOP) software
 - BCOP yields improved low speed performance and fuel burn predictions
- Results: More accurate empirical models for arrivals and departures.



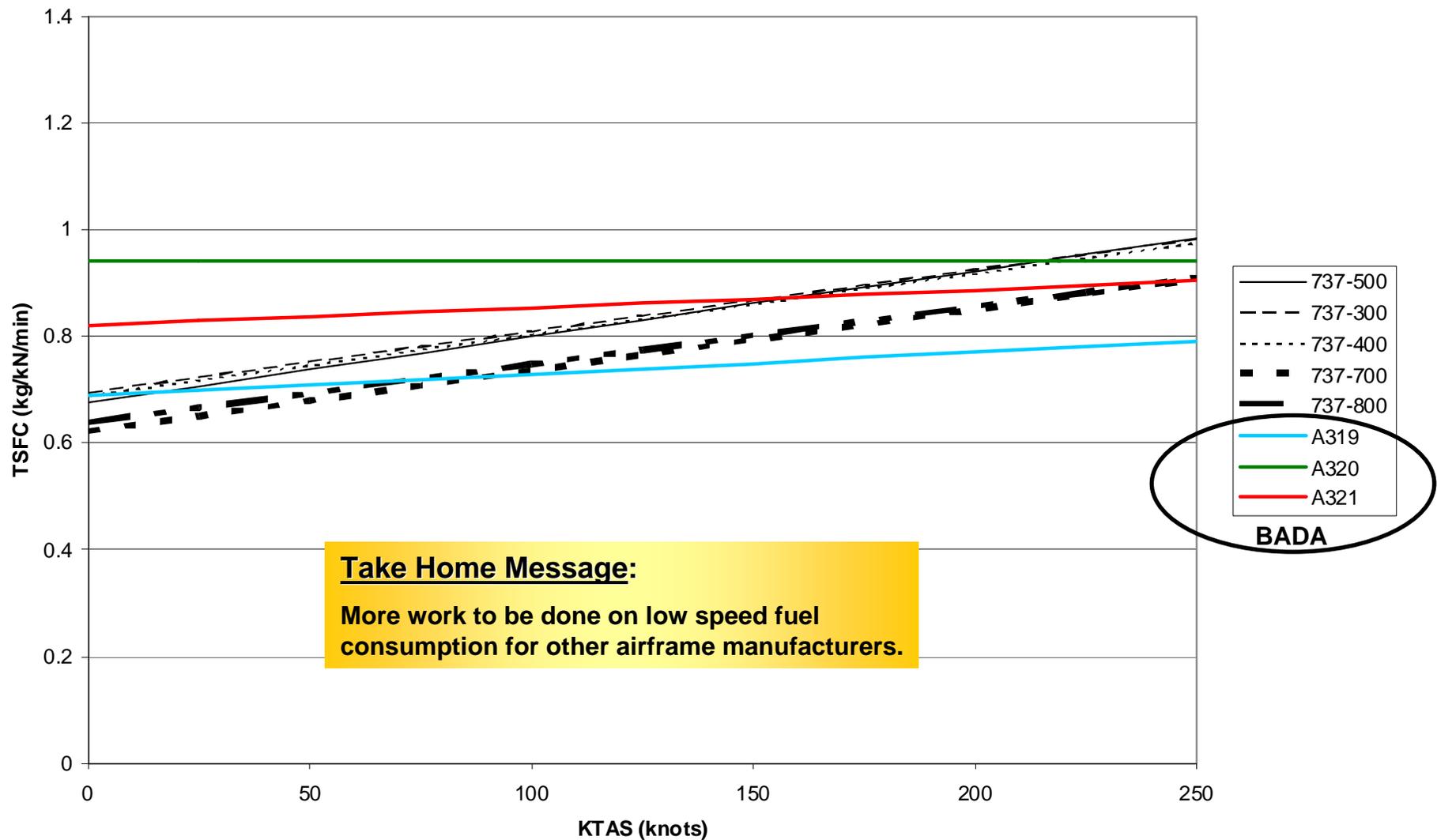
New AEDT Fuel Burn Methodology – 737 family



Take Home Message:

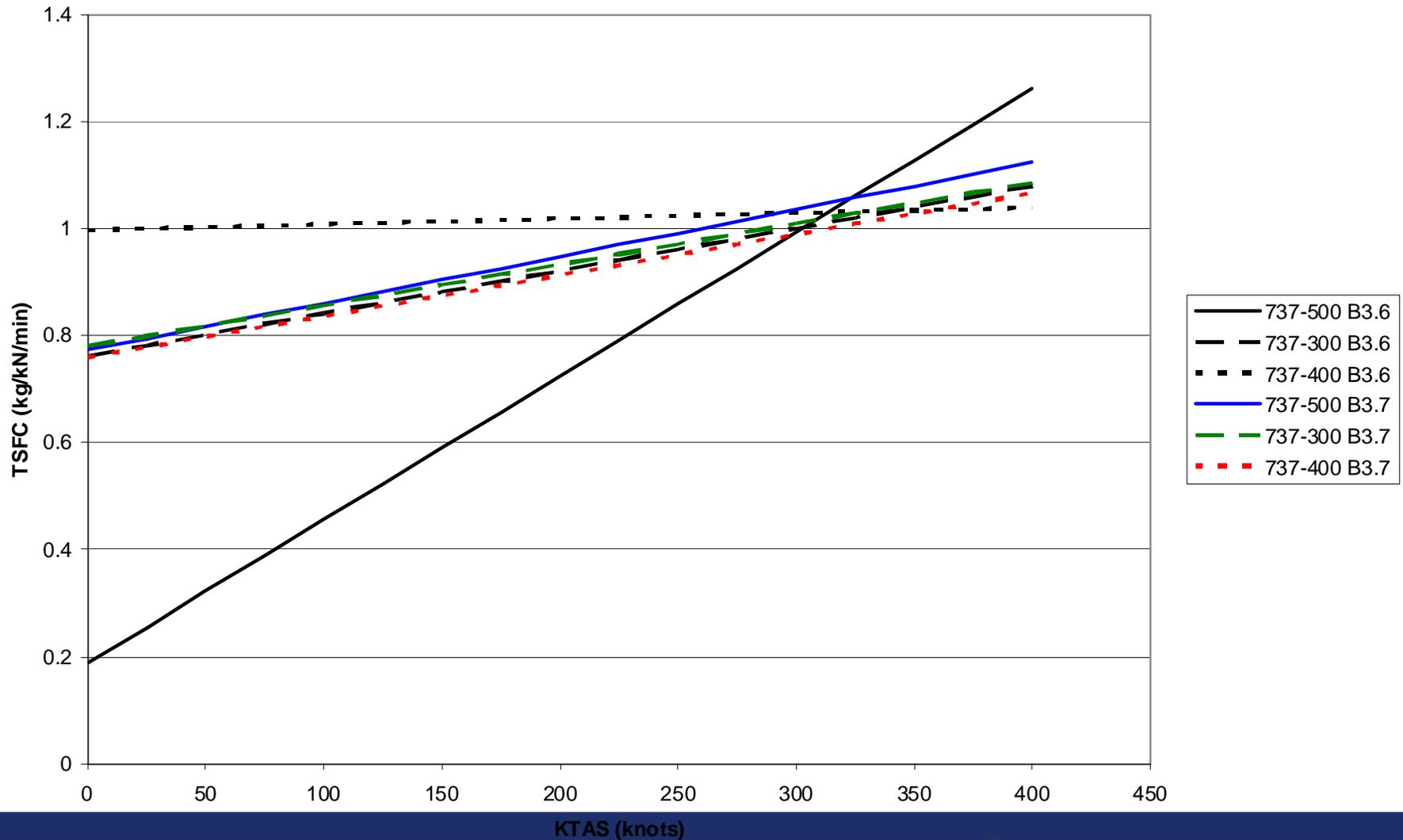
AEDT methodology predicts fuel consumption more accurately at low speeds for Boeing aircraft.

BADA A320 family vs. AEDT 737 family

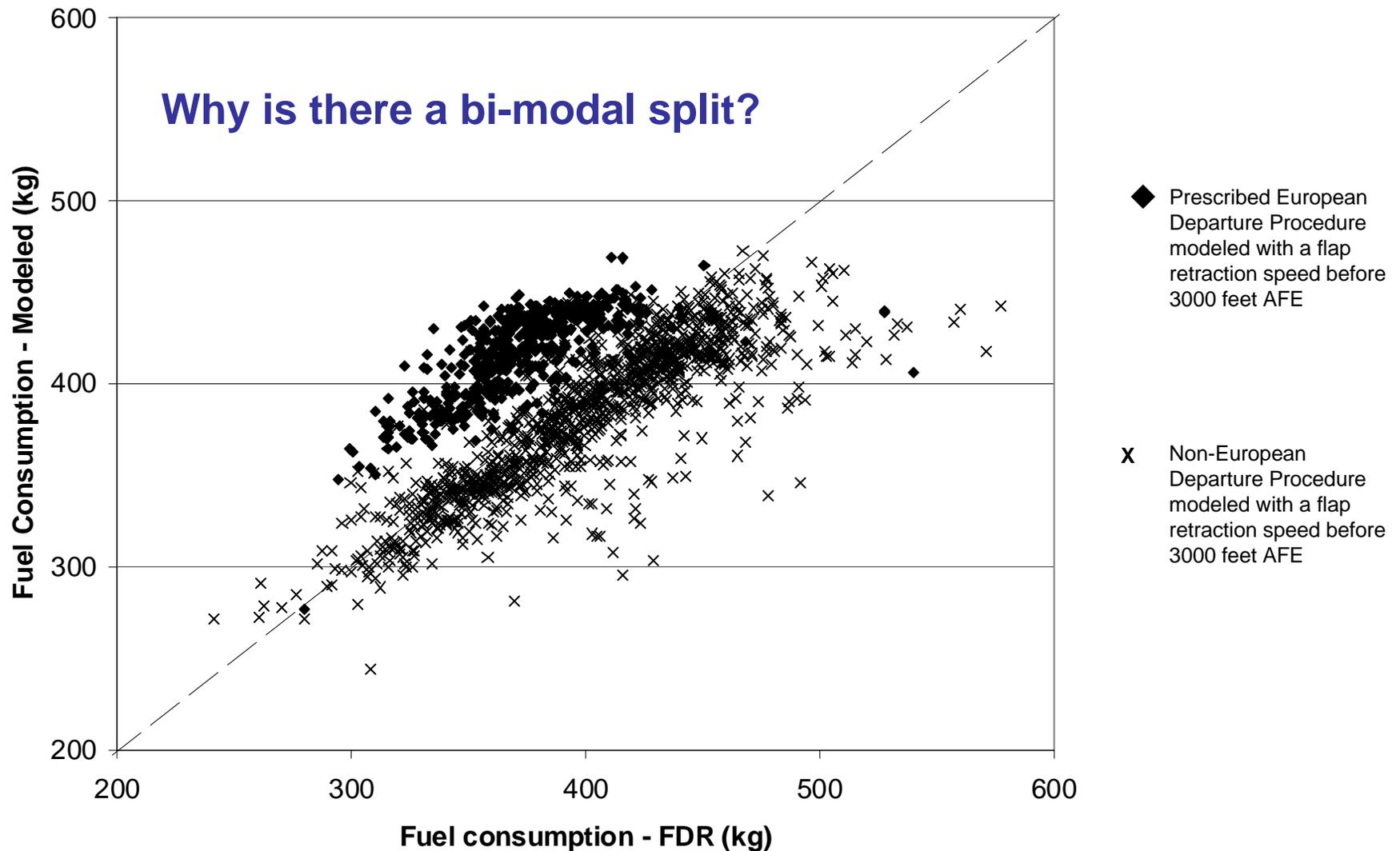


BADA 3.7 may be a significant improvement at low speeds

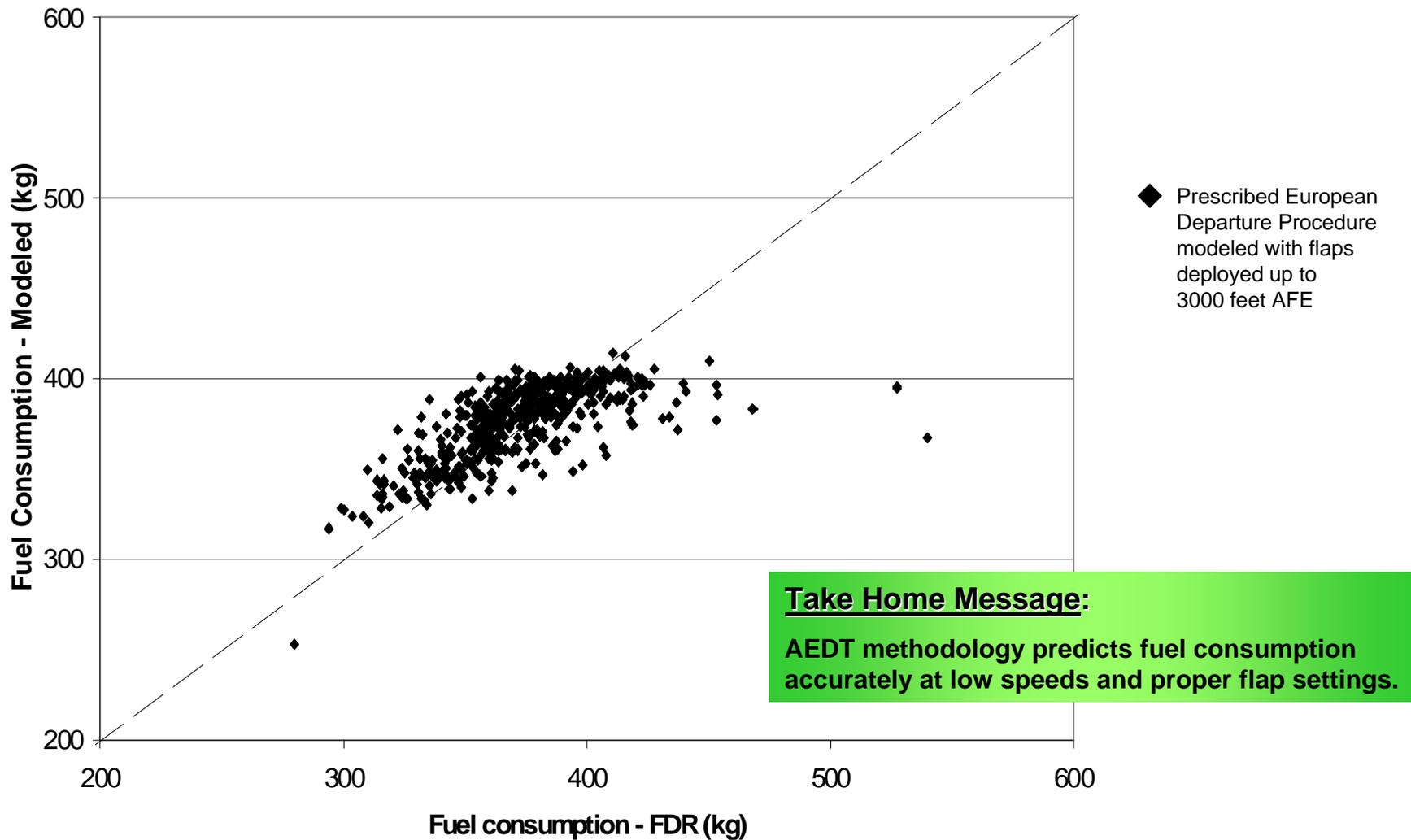
BADA 737-500/-300/-400 TSFC curves



How well does our tool work? Another B757 example...



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Tailored Arrival Demo – Sept 2008, Miami Int’l Airport



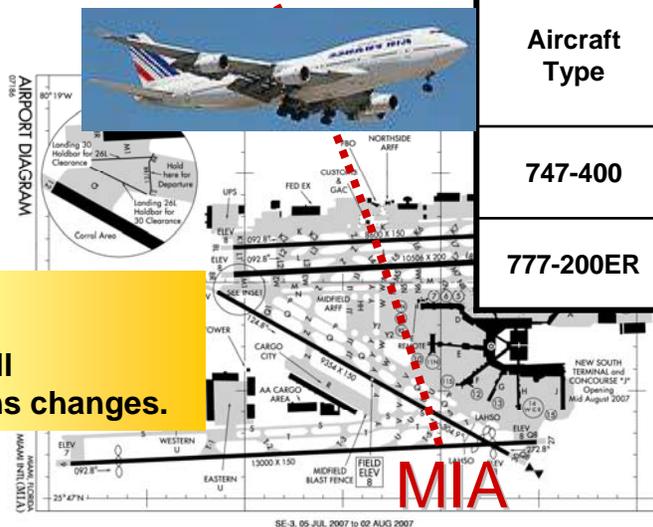
B777-200ER

“Modeled versus Measured”

Tailored Arrival Flight	Fuel Burn FDR (kg)	Fuel Burn AEDT (kg)	Difference (kg)	Difference (%)
1	3112	2942	-170	-5.5%
2	3278	3367	+89	+2.7%
3	3029	3063	+34	+1.1%



“Modeled Operational Differences”



Aircraft Type	Standard Arrival (kg)	Tailored Arrival (kg)	Difference (kg)	Difference (%)
747-400	4080	3930	-150	-3.7%
777-200ER	3141	3003	-138	-4.4%

Take Home Message:
The model can capture small differences due to operations changes.



Summary

- The FAA's Office of Environment and Energy has a process in place to generate airplane fuel burn data from manufacturers' performance tools
- Fuel consumption data from these airplane performance tools-derived methods match the FDR fuel consumption data in the terminal area within 5%
- We have added the new fuel burn data for the current generation of Boeing airplanes into new environmental models – AEDT
- These improved tools enable improved studies which involve trades between noise, emissions, and fuel burn



Next Steps

- Expand the new terminal fuel burn methods to other manufacturers – Airbus, Bombardier, etc.
- Examine how to model fuel consumption of turboprop aircraft
- Test limits of new method



Comments and Questions...

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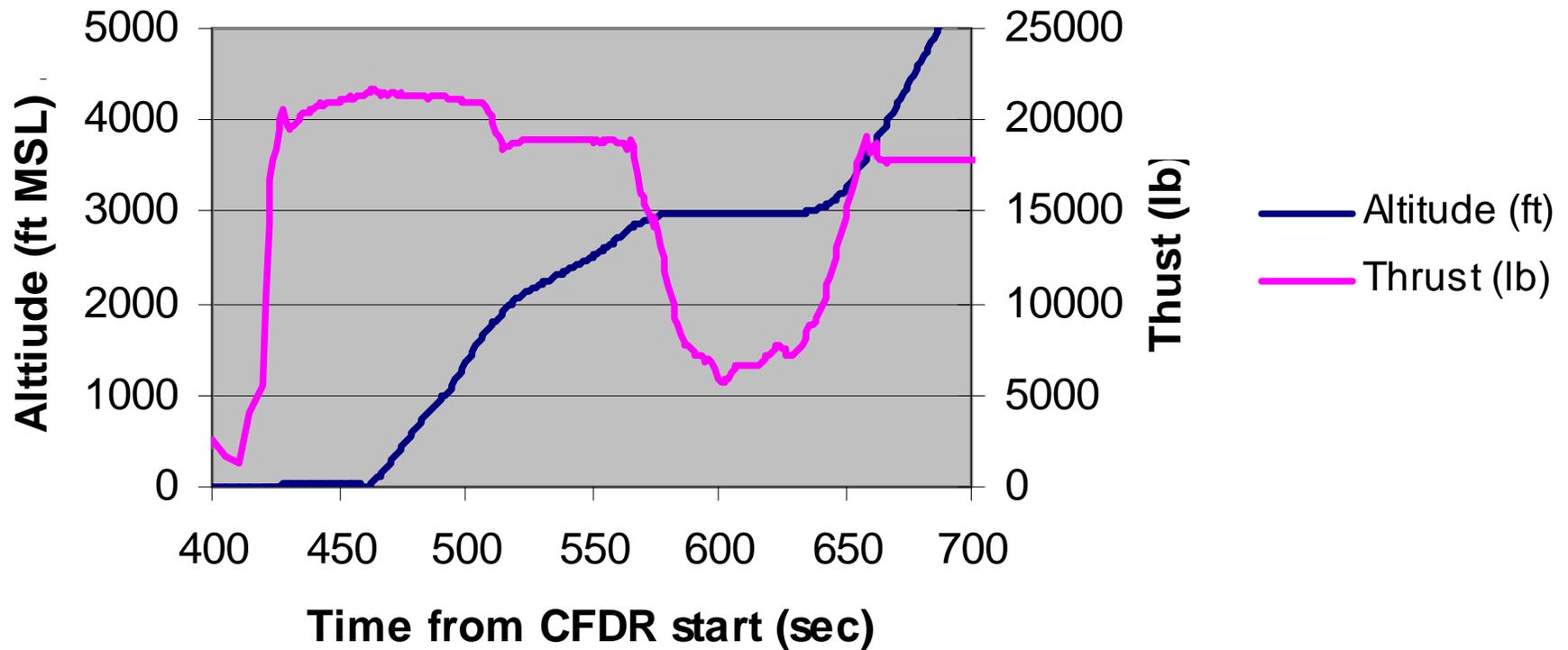
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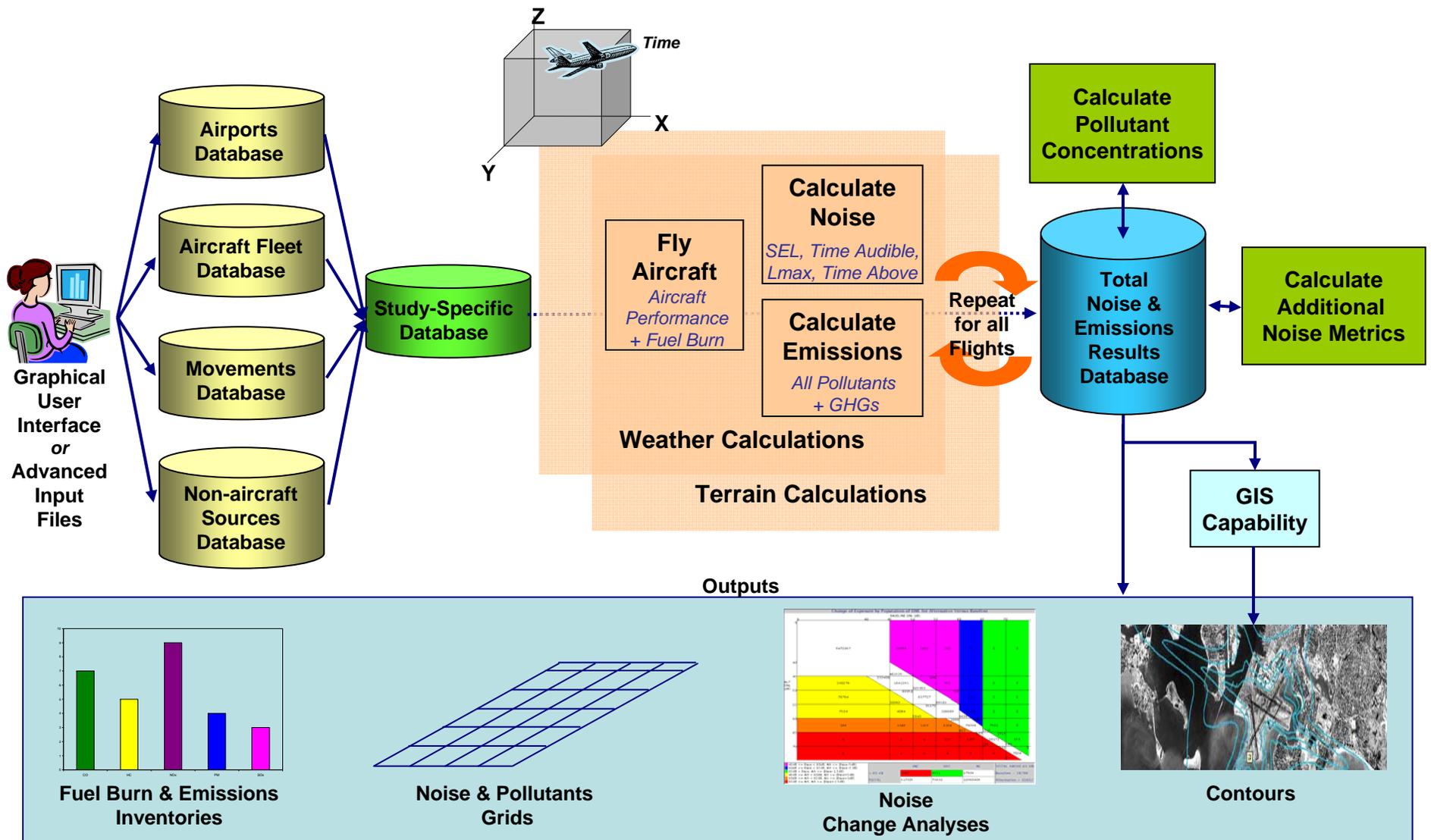
Back-up slides



Flight 119033, example of ATC hold

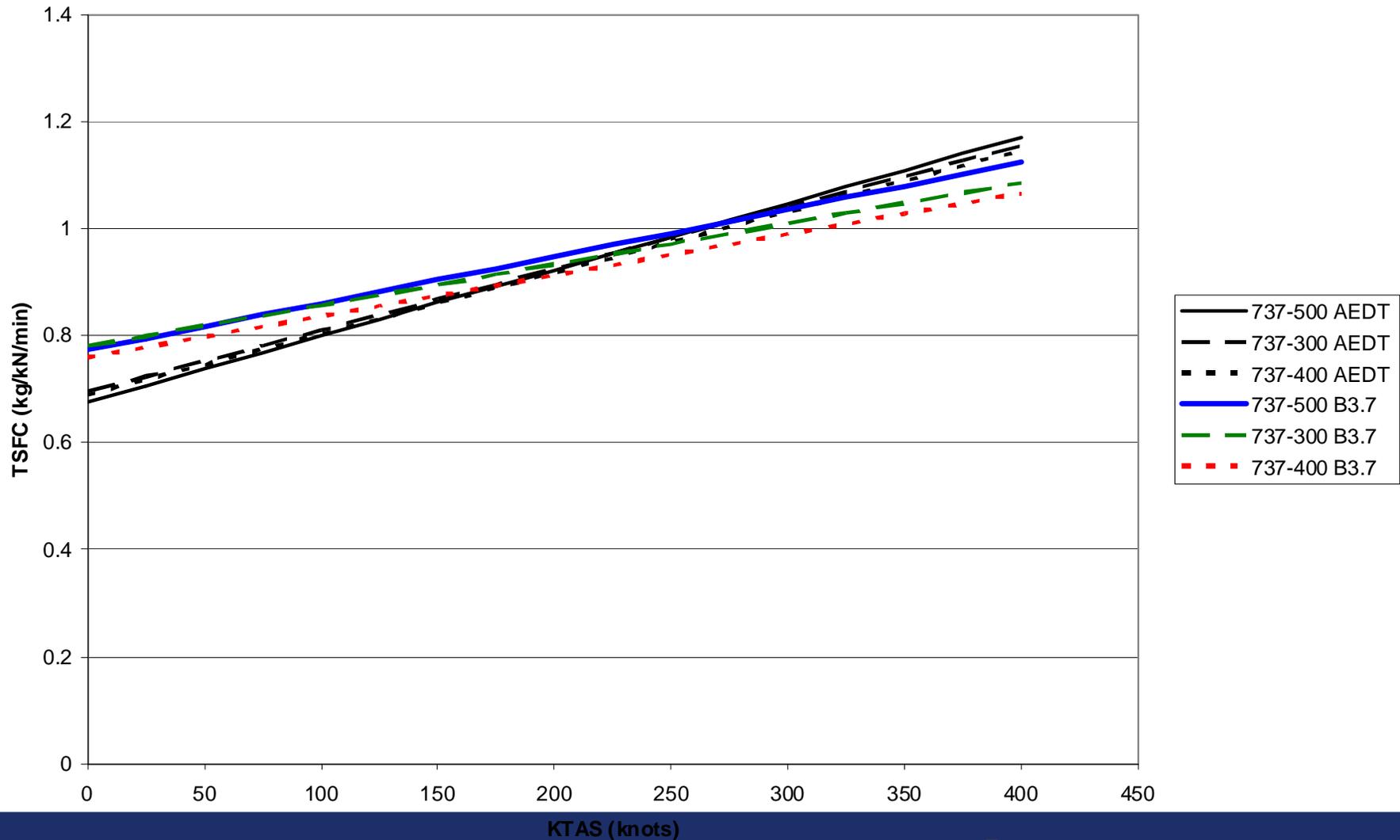


AEDT Overview

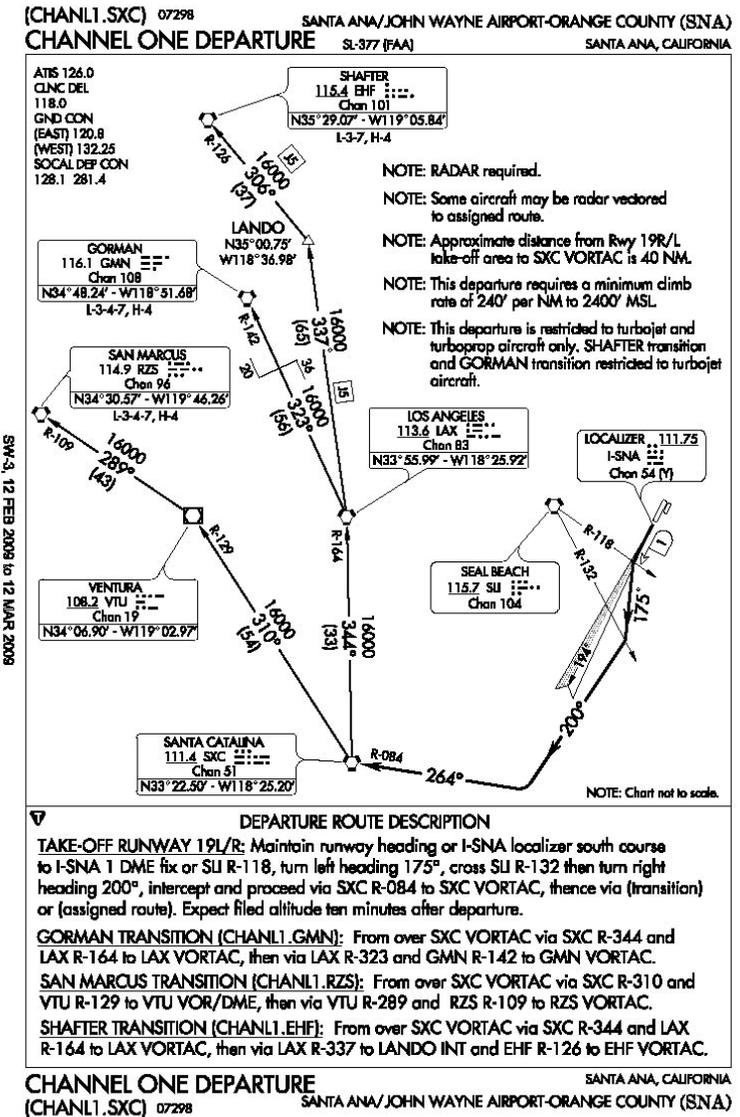


BADA 3.7 and AEDT differences are much less

AEDT, BADA 3.7 737-500/-300/-400 TSFC curves



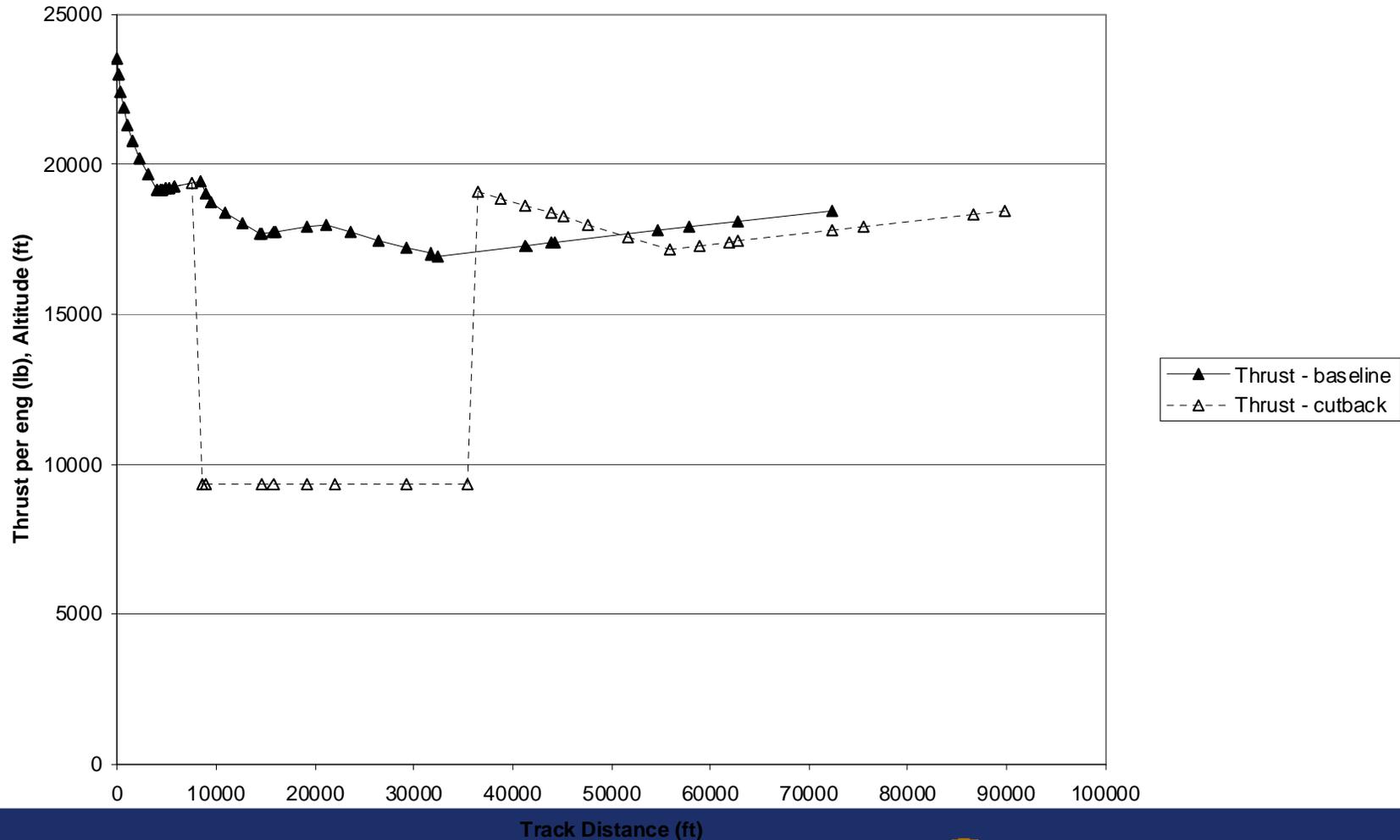
Modeling single operations – SNA Example



Modeling single operations – SNA

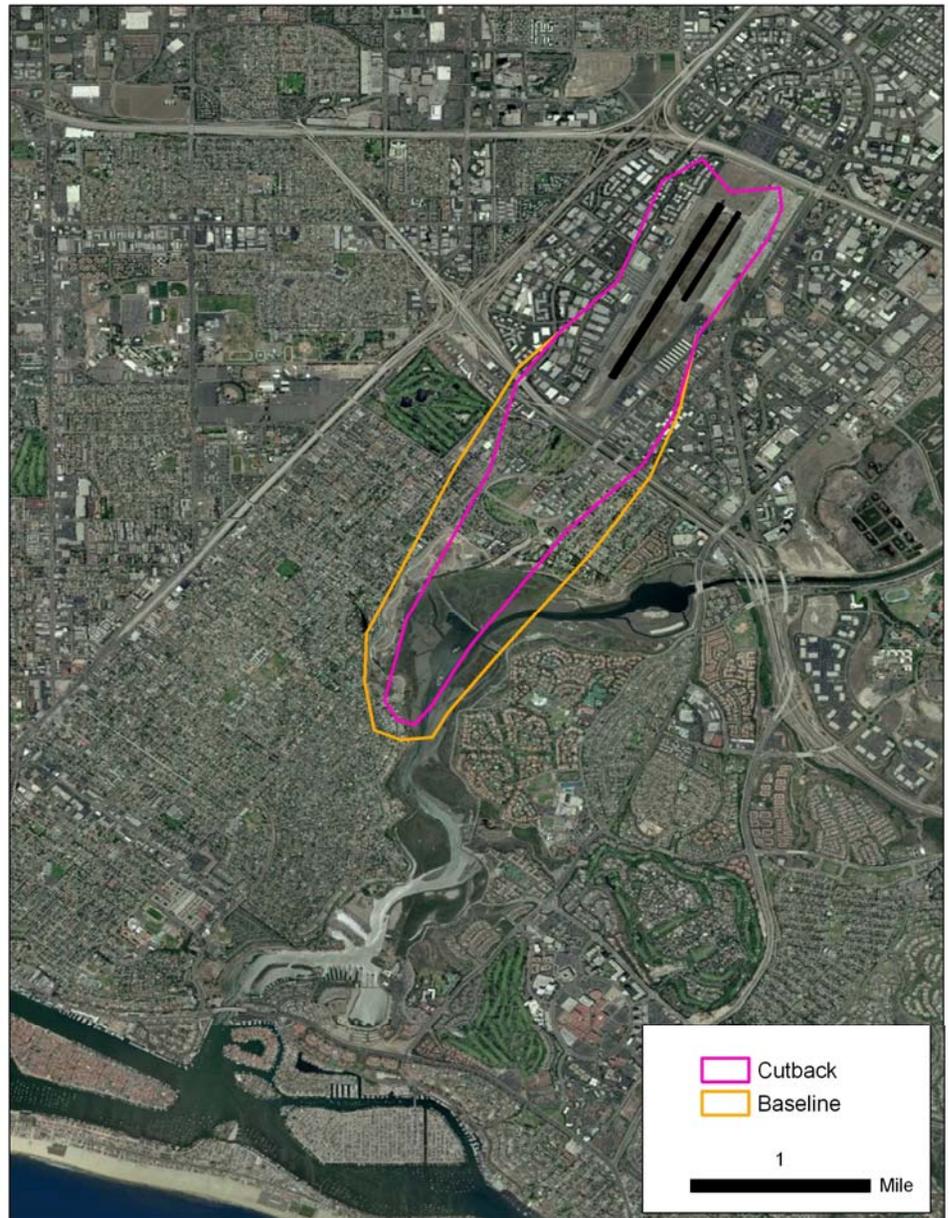
Example

737-700 departure SNA



Modeling single operations – SNA

Example, 85 dB SEL noise contour



Modeling single operations – SNA Example

- Tabular comparison of noise, fuel and emissions for

altitude	op type	Distance (ft)	Fuel (kg)	CO2 (kg)	CO (kg)	NOx (kg)
3000'	Baseline	21050	244.4	771.2	0.129	5.8
	Cutback	35500	283.3	893.9	0.192	5.6
10000'	Baseline	72272	475.6	1501	0.261	11.4
	Cutback	89870	544.6	1718	0.341	11.9