

# BADA 4 in AEDT 3a & Plans for AEDT4

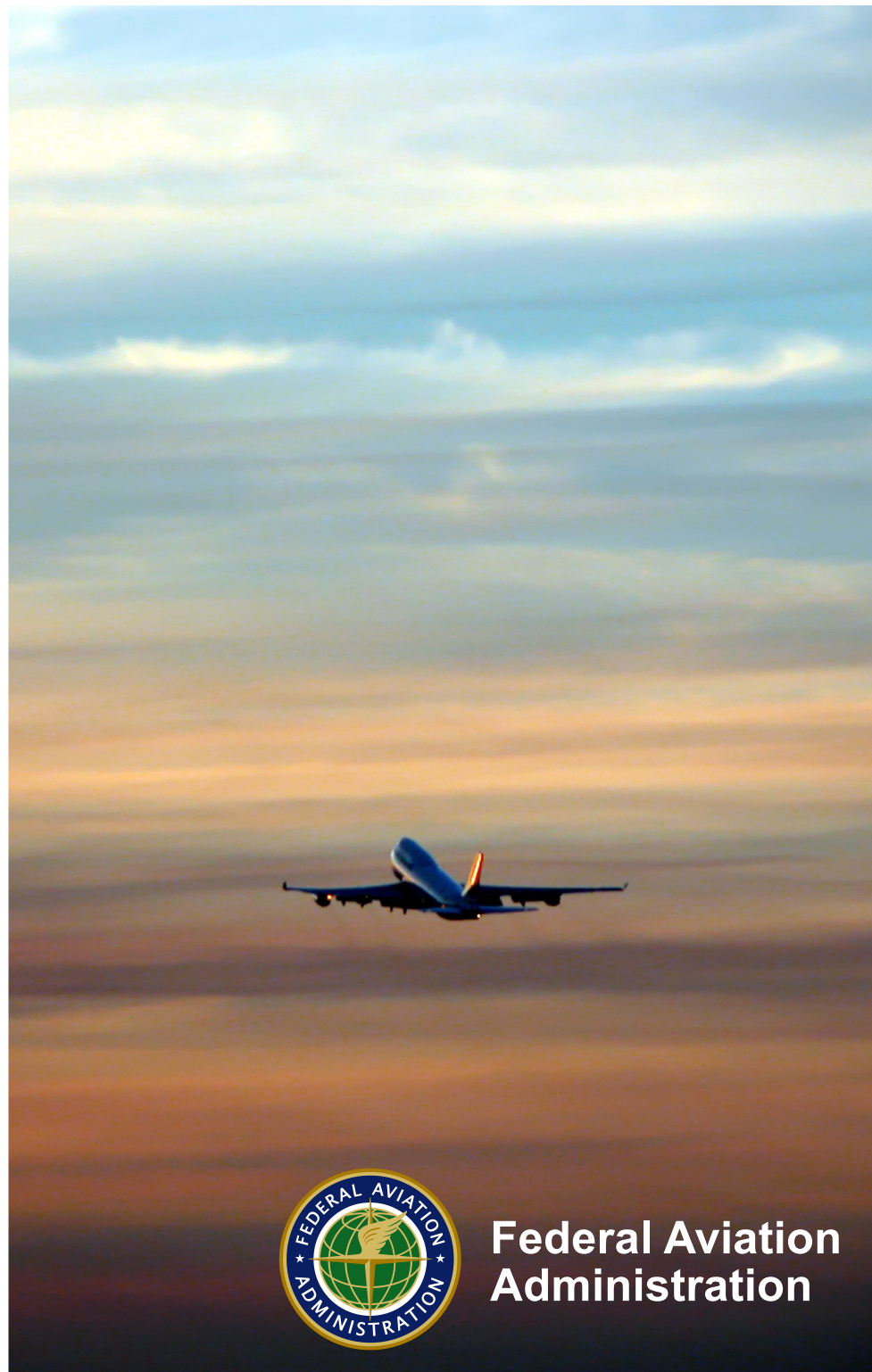
Presented to: ASCENT Advisory Committee

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Date: October 10, 2018



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# Outline

- **What is BADA 4?**
- **Why BADA 4 for AEDT?**
- **AEDT 3a Current Status**
- **AEDT Future Development**
  - AEDT 3 series
  - AEDT 4
  - ASCENT Support



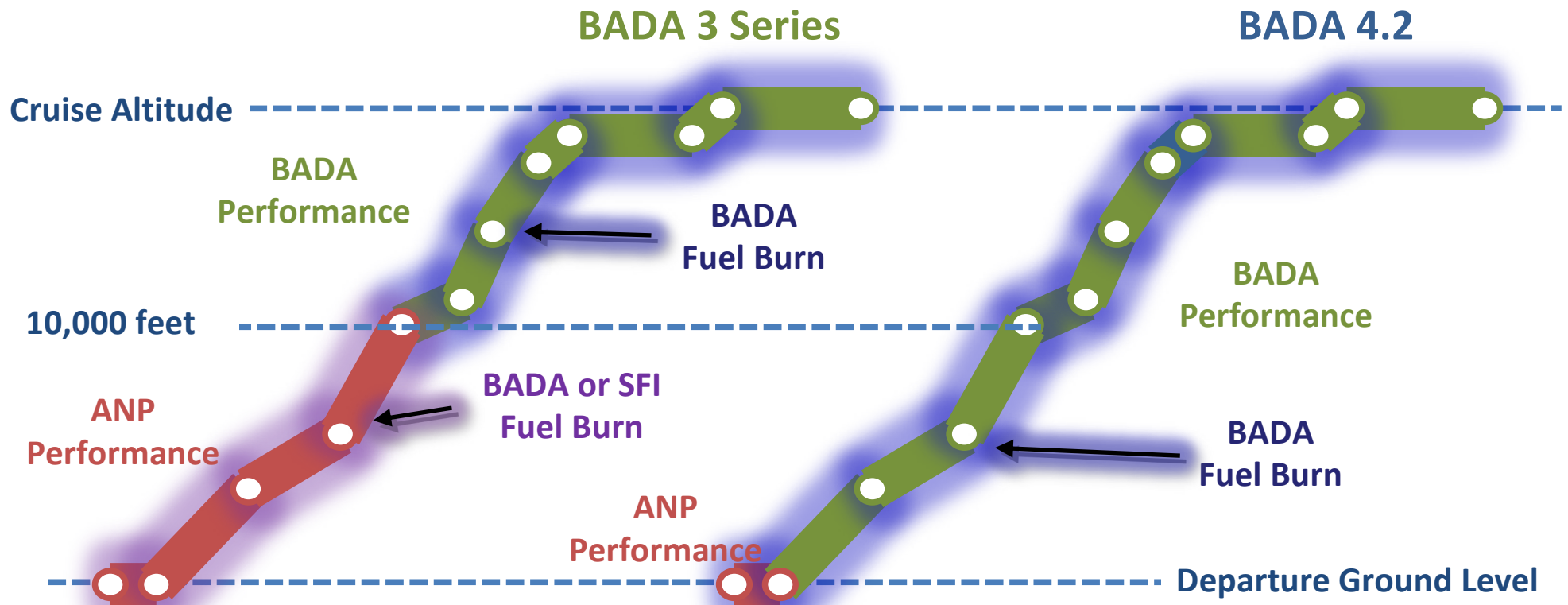
# Base of Aircraft Data (BADA)

- Database and methodology developed and maintained by EUROCONTROL with input from the aircraft/engine manufacturers
- Designed for simulation and prediction of aircraft trajectories
  - BADA can provide fuel burn but not noise or emissions
- Most current public version of BADA is 3 series (v13)
  - Intended for cruise; not accurate for terminal area
  - Public version of AEDT uses Aircraft Noise and Performance (ANP) and certification data for terminal area and BADA3 for cruise.
- Most current version of BADA is 4 series (v2)
  - High fidelity aircraft model (thrust, lift, drag)
  - Includes terminal area data (excluding ground roll)
  - More accurate than ANP in terminal area
  - Currently not publicly available (AEDT use only approved for CAEP and NextGen analyses)



# Incorporating BADA4 within AEDT

- Update performance module to BADA 4.2
  - Represents most accurate dataset
  - Replaces ANP data up to ground roll



## Notes:

1. ANP = Aircraft Noise and Performance
2. SFI = Senzig, Fleming, Iovinelli Method

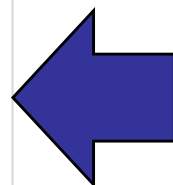
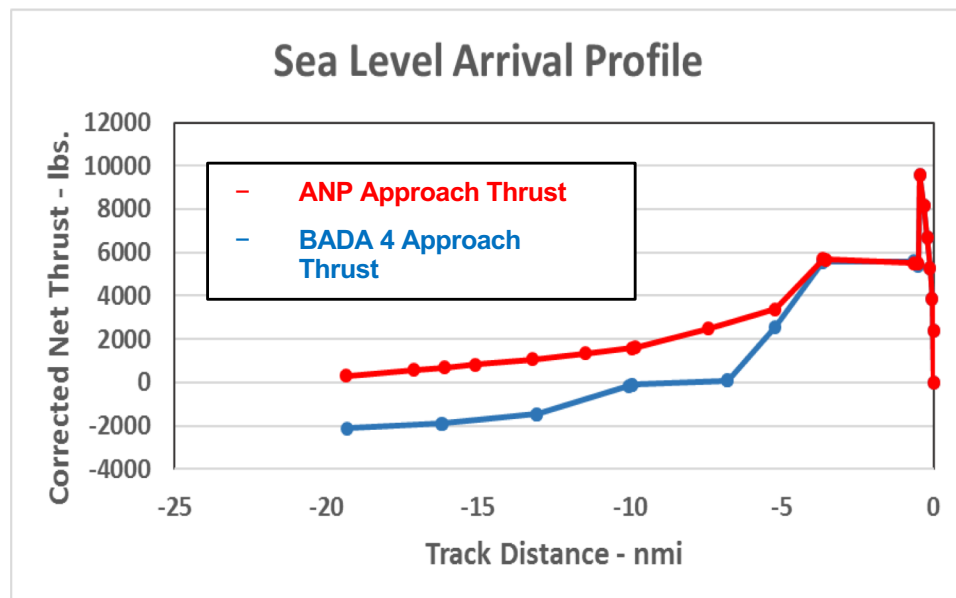
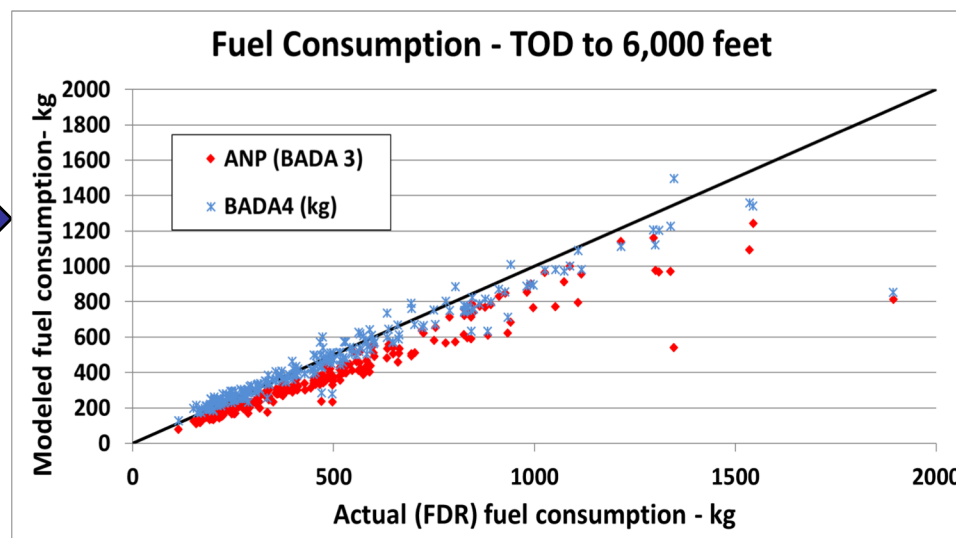
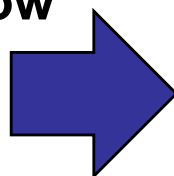


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# Improved Performance Model

- **BADA 4 improves accuracy of fuel burn calculation below cruise.**
  - Necessary for NextGen procedure benefits analysis

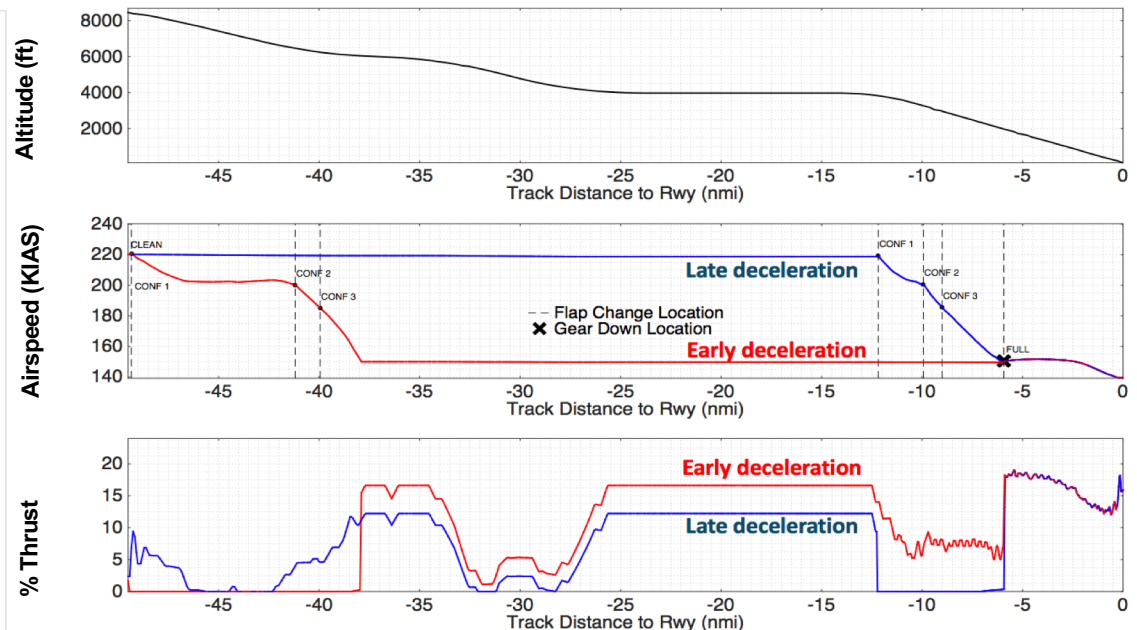
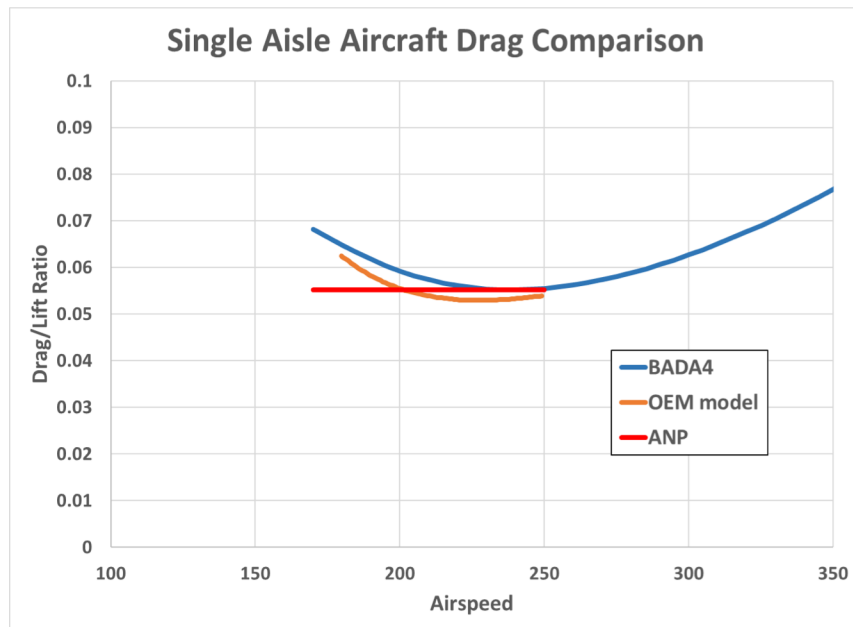


- **BADA 4 improves fidelity on approach modeling producing more accurate thrust levels compared to ANP model.**



# Higher Fidelity Modeling

- Higher fidelity BADA 4 performance data will allow for more detailed procedure modeling
  - Captures configuration and speed changes of advanced operational procedures



# AEDT Status

- **AEDT 3a release planned for 4<sup>th</sup> Quarter 2018**
- **Aircraft performance modeling update**
  - BADA4 implementation provides more accurate and unified modeling of aircraft performance for both terminal area and cruise operations
  - Improved aircraft takeoff weight and takeoff thrust modeling to better represent flight operations
  - Guidance document for reduced thrust and alternate weight modeling
- **nvPM methods for CAEP analysis**
- **Fleet database updates**
  - Gulfstream G650; Boeing 737- MAX8; Boeing 737-800 Approach
- **Windows 10 compatibility**

**Notes:**

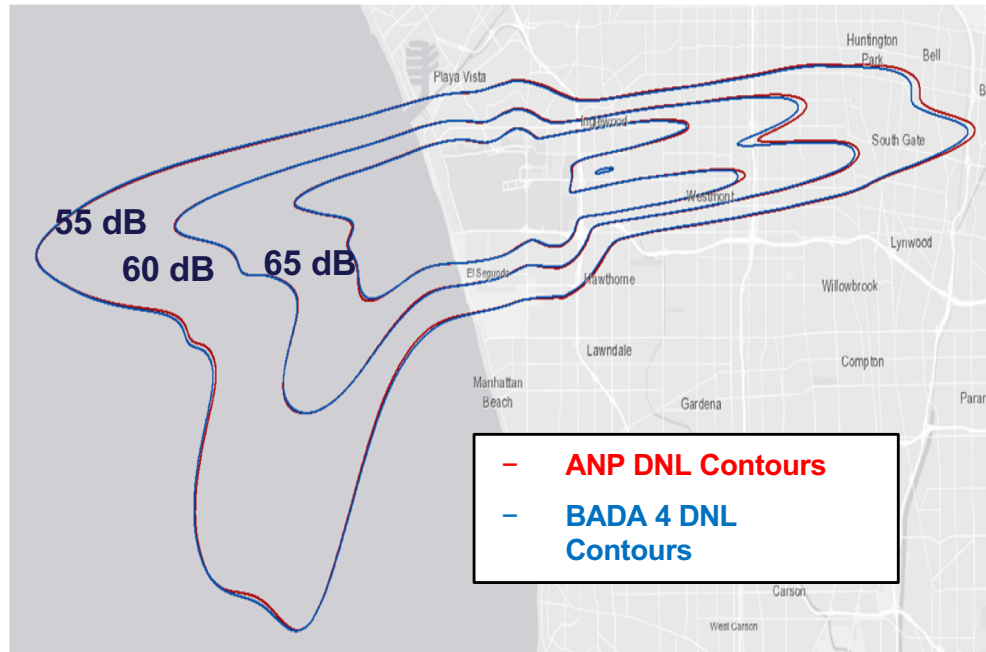
1. nvPM = Non-Volatile Particular Matter
2. CAEP = International Civil Aviation Organization (ICAO) Committee on Environmental Protection



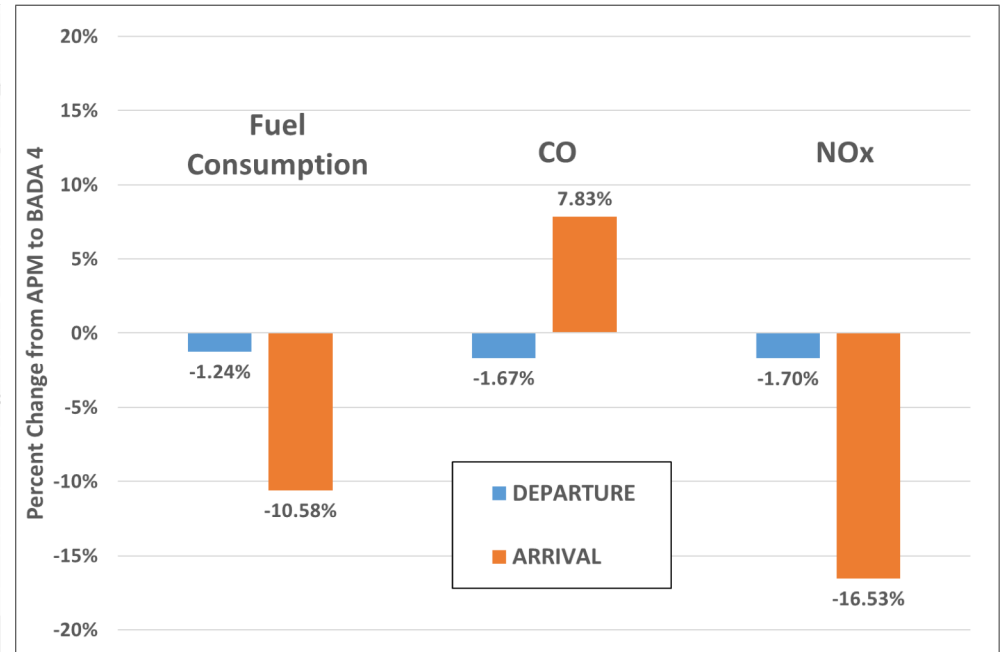
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# BADA 4 Airport Level Results

- **BADA 4 performance has small effect on noise**
  - DNL noise contours roughly 2% smaller with BADA 4 on average

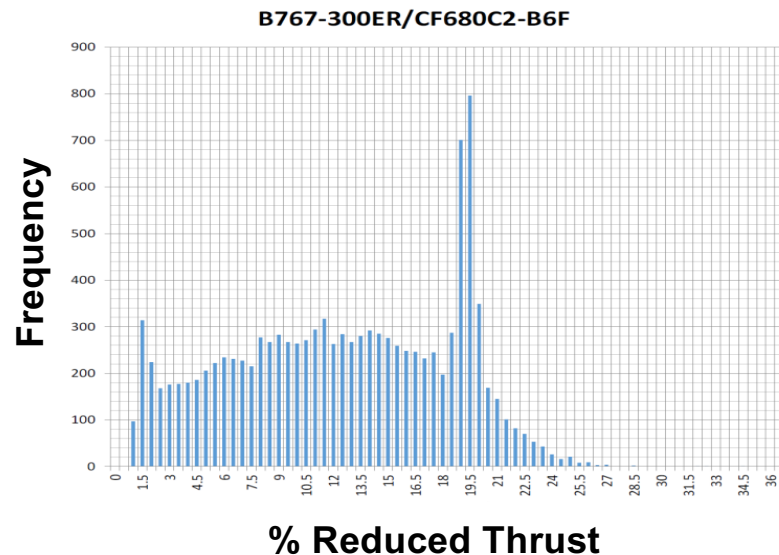


- **BADA 4 performance effect on fuel burn varies by fleet mix**
  - Total (departure and arrival) fuel burn below 10K feet roughly  $\pm 5\%$  change with BADA 4

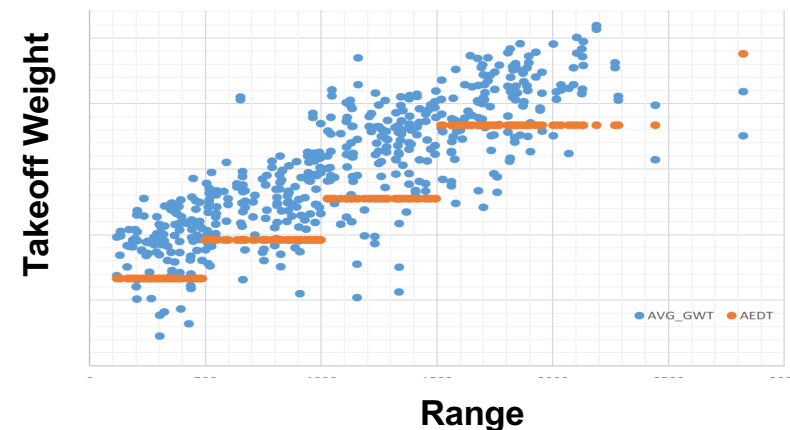


# Aircraft Takeoff Weight and Thrust

- Aircraft takeoff weight and thrust are critical parameters in environmental modeling.
- Accurate estimate of the parameters has been historically challenging.
- Limited data available and assumptions:
  - Payload load factor at 65%
  - Standard departure profiles assumes maximum thrust at takeoff
- Research: analyzed airline data and recommended options for improvement
  - ASCENT 35/45
  - Other related projects

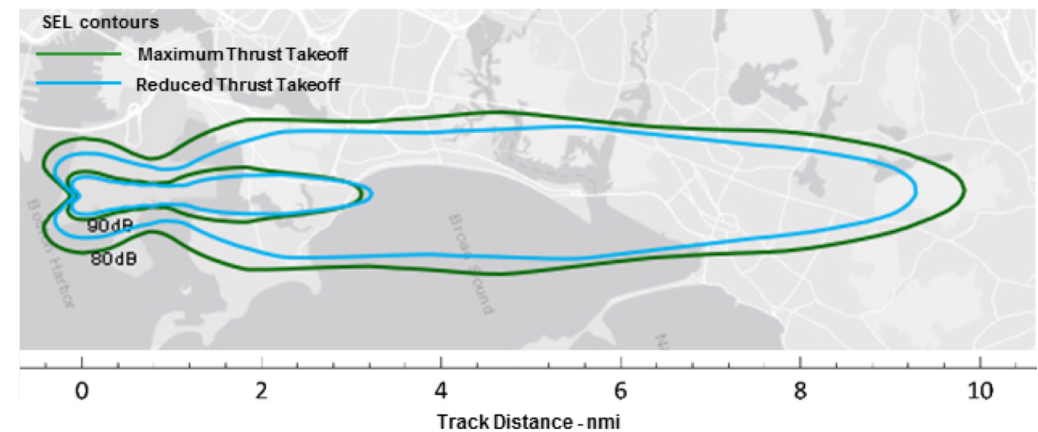
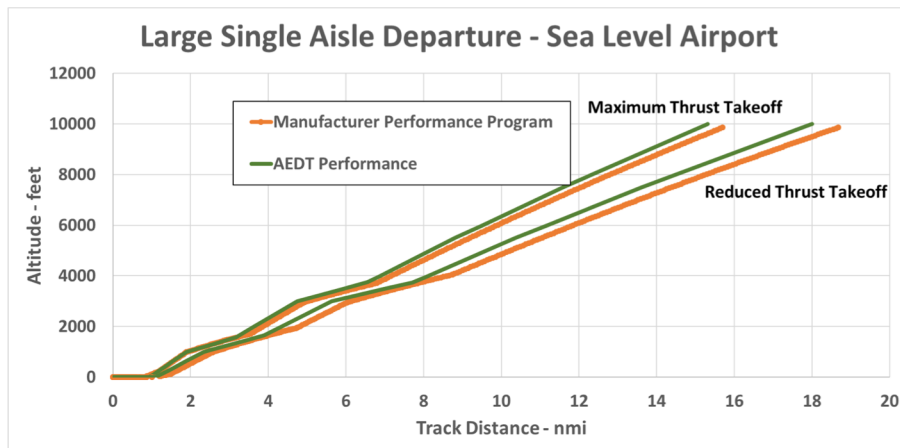
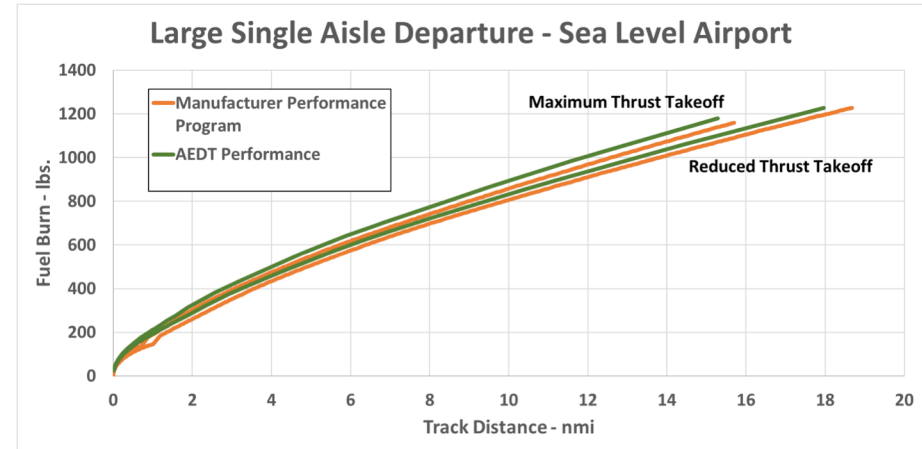
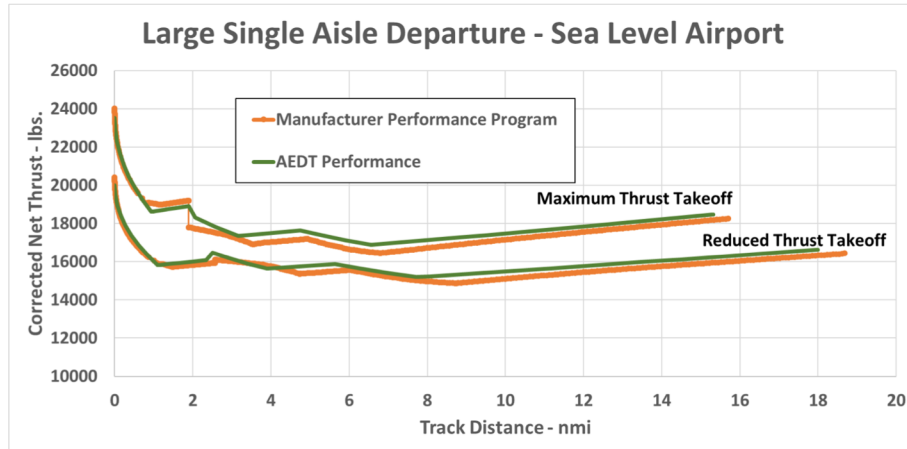


B737-800 AEDT2d Modeled versus Actual Takeoff Weight





# Reduced Thrust Takeoff Example



# AEDT 3x Development Goals

- **Further improve the tool's efficiency and user workflow**
  - Apply lessons learned from user feedback and improved technologies
- **Expand and refine ground operations modeling capabilities**
  - Implement latest Taxi operations research
- **Improve terminal area noise modeling for airports near water**
  - Implement latest noise propagation research
- **Improve helicopter noise modeling**
  - Expand helicopter noise database
  - Improve helicopter procedure modeling
- **Enhance air quality modeling**
  - Provide EPA screening options for 1-hour NO<sub>2</sub> modeling
  - Improve characterization of aircraft exhaust emissions



# AEDT 4 Development Goals

- **Higher fidelity noise characterization**
  - Improve accuracy of noise modelling at lower DNL (where many communities have recently expressed concerns)
  - Support design of innovative operational procedure concepts that could reduce noise while maintaining safety and efficiency
- **Incorporate improved version of EPA's AERMOD for local-scale airport air quality modeling**
  - Improvements critical for environmental compliance thereby avoiding delays in project milestones and schedule
- **Include capabilities to model supersonic aircraft performance in cruise**
  - Complete supersonic modeling capability to cover full gate-to-gate operation
- **Environmental analysis of commercial space operations**



# ASCENT Projects Supporting AEDT Development

- **ASCENT 9 GIS-based Noise Estimation Tool (TBD)**
  - Update AEDT GIS engine to improve efficiency and lower development costs
- **ASCENT 10 Aircraft Technology Modeling and Assessment**
  - Enable modeling of supersonic aircraft in AEDT
- **ASCENT 19 Development of Aviation AQ Tool for Airport-Specific Impact Assessment: AQ Modeling**
  - Enhance air quality modeling in AEDT
- **ASCENT 23 Noise from Advanced Operational Procedures**
  - Account for airframe noise in AEDT noise model
- **ASCENT 36 Parametric Uncertainty Assessment for AEDT**
  - Provide uncertainty evaluation of the AEDT to inform future development
- **ASCENT 38 Rotorcraft Noise Abatement Procedures Development**
  - Develop noise abatement modeling capability in AEDT



# ASCENT Projects Supporting AEDT Development

- **ASCENT 40 Quantifying Uncertainties in Predicting Aircraft Noise in Real-world Situations**
  - Support development of AEDT enhanced aircraft noise model
- **ASCENT 43 Noise Power Distance Re-Evaluation**
  - Develop higher fidelity aircraft noise characterization
- **ASCENT 44 Aircraft Noise Abatement Procedure Modeling and Validation**
  - Support validation of AEDT aircraft noise model
- **ASCENT 45 Takeoff/Climb Analysis to Support AEDT APM Development**
  - Develop reduced thrust takeoff capability in AEDT
- **ASCENT 46 Surface Analysis to Support AEDT APM Development**
  - Support development of taxiway noise and emissions modeling in AEDT





# AEDT Future Development Goals

ACRP 02-27 Aircraft Taxi Noise Database  
 ACRP 02-52 Noise Modeling of Mixed Ground Surfaces  
 ACRP 02-55 Enhanced AEDT Modeling of Aircraft Arrival and Departure Profiles  
 Volpe helicopter polar sphere research  
 ASCENT 19 Development of Aviation AQ Tool for Airport-Specific Impact Assessment: AQ Modeling  
 ASCENT 36 Parametric Uncertainty Assessment for AEDT  
 ASCENT 38 Rotorcraft Noise Abatement Procedures Development  
 ASCENT 45 Takeoff/Climb Analysis to Support AEDT APM Development  
 ASCENT 46 Surface Analysis to Support AEDT APM Development

ACRP 02-66 Commercial Space Operations Noise and Sonic Boom Modeling and Analysis  
 ACRP 02-79 Aircraft Noise with Terrain and Manmade Structures  
 ACRP 02-81 Commercial Space Operations Noise and Sonic Boom Measurements  
 ACRP 02-85 Commercial Space Vehicle Emissions Modeling  
 ASCENT 9 GIS-based Noise Estimation Tool  
 ASCENT 10 Aircraft Technology Modeling and Assessment  
 ASCENT 19 - Development of Aviation AQ Tool for Airport-Specific Impact Assessment: AQ Modeling  
 ASCENT 23 Noise from Advanced Operational Procedures  
 ASCENT 36 Parametric Uncertainty Assessment for AEDT  
 ASCENT 40 Quantifying Uncertainties in Predicting Aircraft Noise in Real-world Situations  
 ASCENT 43 Noise Power Distance Re-Evaluation (Research)  
 ASCENT 44 Aircraft Noise Abatement Procedure Modeling and Validation



- Infrastructure and usability updates to improve efficiency and workflow
- Software maintenance updates
- Updates to add new airplane and helicopter models to the noise and performance database
- Enhance enroute performance calculations
- Potential enhancements of reduced thrust and takeoff weight implementation
- Enhance noise modeling for airports near water
- Taxiway Modeling (Noise and Emissions)
- Helicopter noise modeling improvements
- Air quality modeling enhancements

- Higher fidelity aircraft noise characterization
- Update GIS engine to reduce development costs
- Supersonic airplane performance (gate to gate)
- Modeling noise with Terrain and Manmade Structures
- Commercial Space
- New Air Quality model

**AEDT 3x – Release AEDT updates biannually**

**AEDT 4a**

**AEDT 4x – Release updates biannually**



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# Summary

- **AEDT 3a will introduce two new features to its users**
  - An improved performance model that results in more accurate fuel burn and emissions estimates below cruise, and;
  - Reduced Thrust Takeoff and Alternative Weight procedures that offer greater flexibility in modeling aircraft departures
- **ASCENT research:**
  - Supported reduced thrust and alternative weight implementation
  - Provided critical V&V of BADA 4 implementation
- **ASCENT will continue to support near term (AEDT 3x) and future (AEDT 4) development. ASCENT projects include:**
  - Helicopter noise modeling
  - Taxi modeling
  - High fidelity noise characterization
  - Supersonic aircraft modeling
  - Air quality modeling

