UCI Aircraft Systems Laboratory

Aviation Noise & Emissions Symposium 2024

Approaches of Flight Procedure Noise Modeling of Commercial Aircraft

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24 Hours of Flights

The Commercial Aerospace Industry

- Efficient, reliable and safe air transport is vital to global economic growth
- This leads to growing demand for global connectivity

www.flightradar24.com

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Planning for Growth

- Many requirements to support continued growth of aviation, for example:
    - Partnerships
    - Improved access to airports
    - Innovative solutions to baggage and security processes, cargo handling, and other activities
    - Air traffic management reform to cut delays, costs
    - Accounting for growing effects of environmental impacts due to aviation
- New technologies are creating new possibilities in flight

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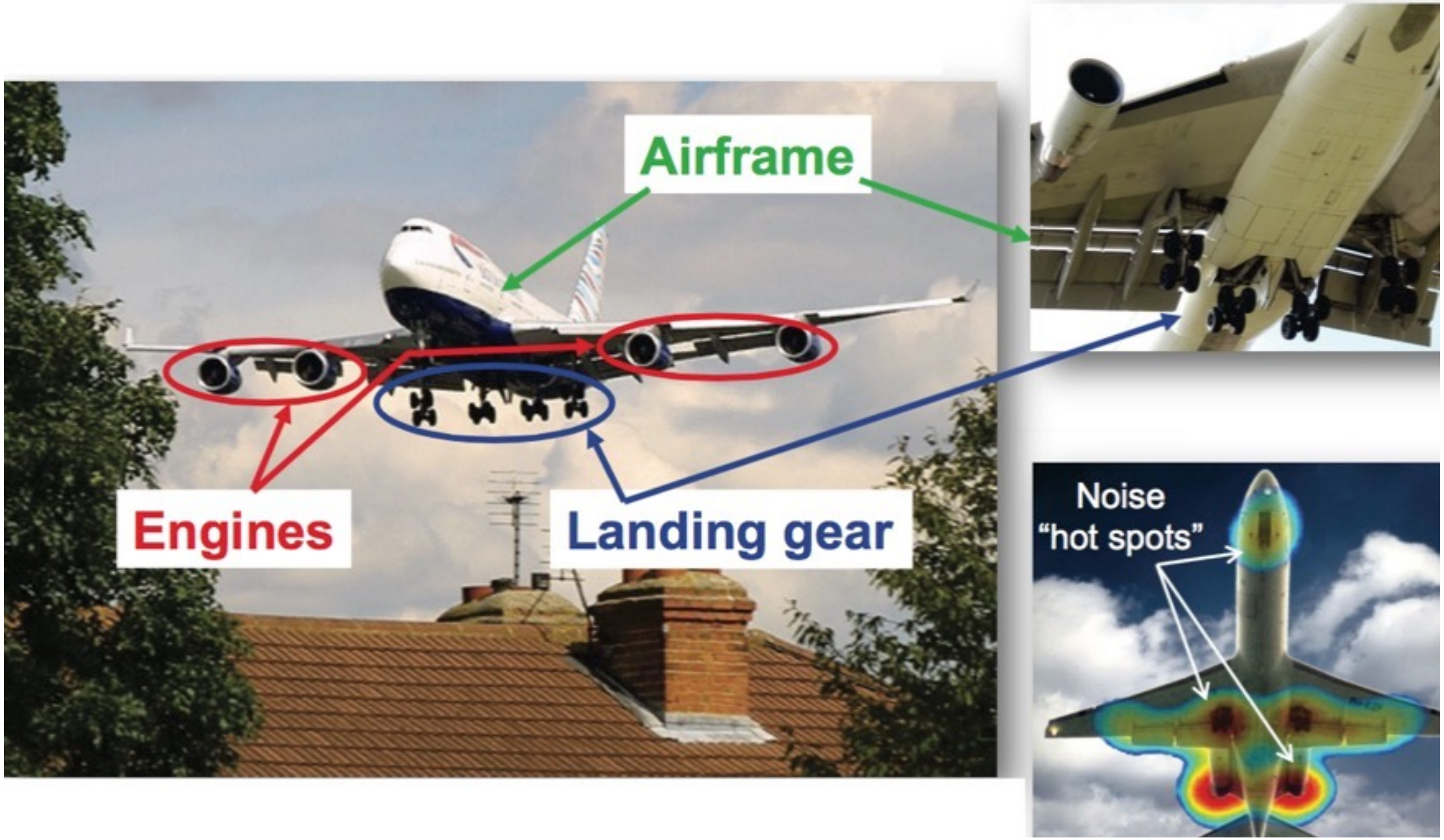
Challenges in ”Green” Aviation

- Aircraft Fuel Efficiency

- Aircraft Emissions

- Aircraft Noise

Aircraft Noise



Aircraft noise comes from many sources

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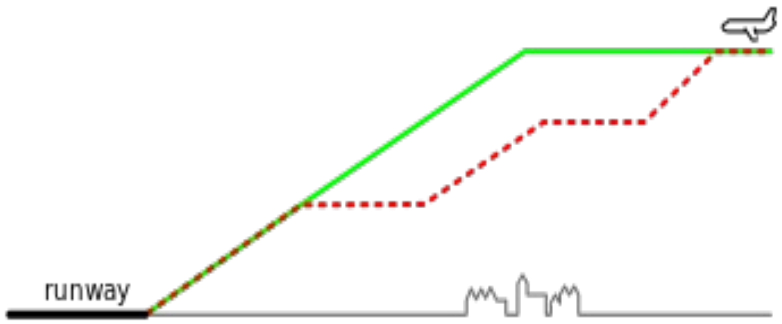
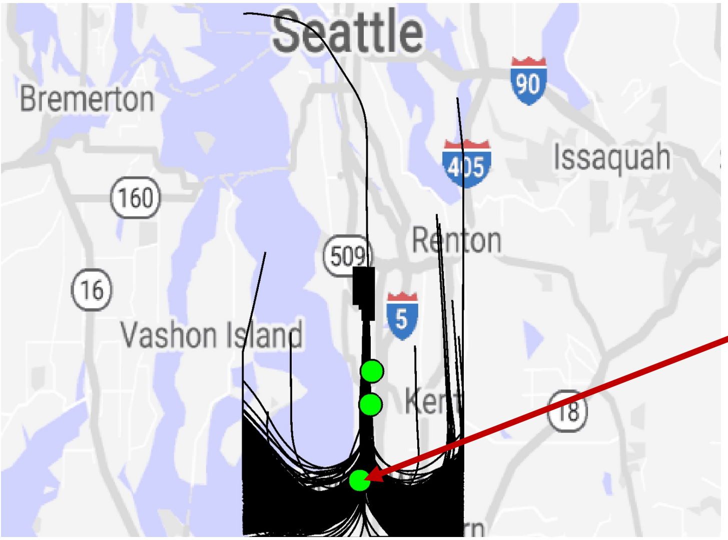
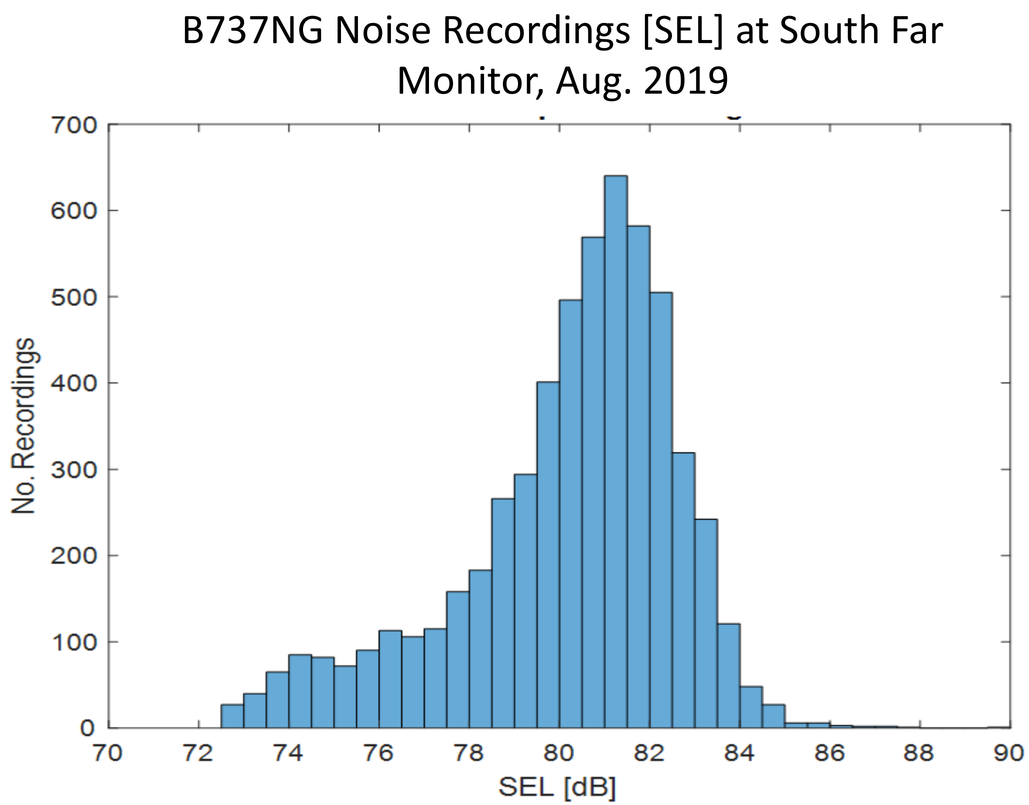
Aircraft Noise



Community noise affected by flight procedure design





Significant variations in measured noise observable for similar aircraft

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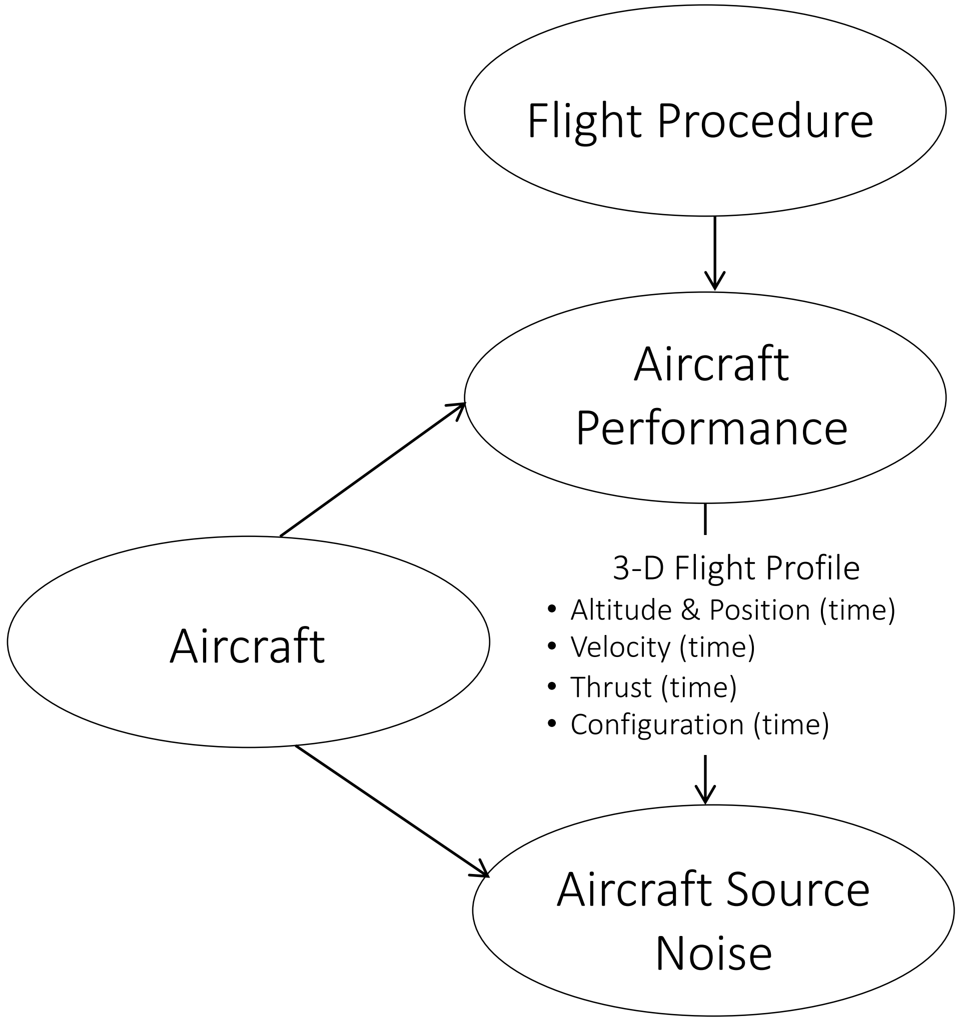
Full Flight Procedure Community Noise Analysis Requires System Approach

- Analysis of community noise due to aircraft on approach and departure requires requires an integrated system consisting of the aircraft and flight procedure
  - Flight procedures describe of how the aircraft will fly
  - The aircraft flies that procedure, its performance determines the 3-D flight profile
  - Aircraft source noise is dependent on the aircraft and the flight profile



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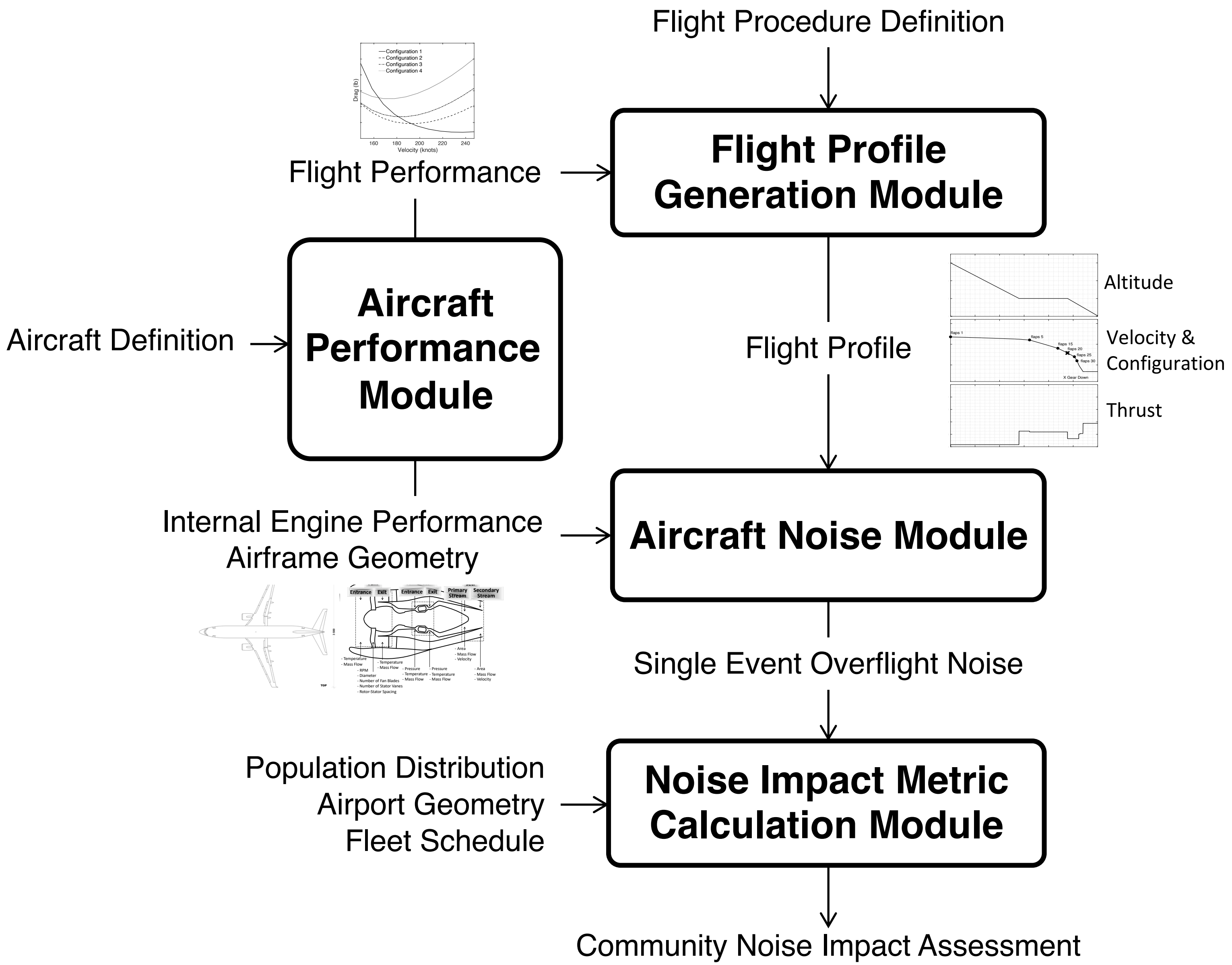
Framework for Analyzing Aircraft Community Noise Impacts of Advanced Operational Procedures



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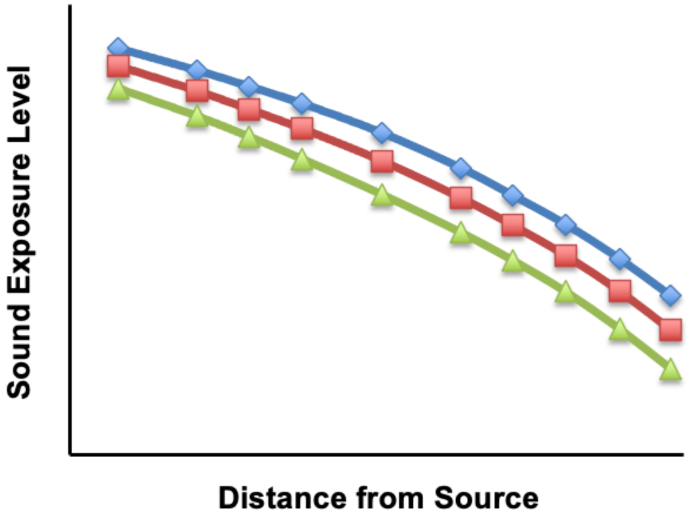
Aircraft Noise Modeling Methods

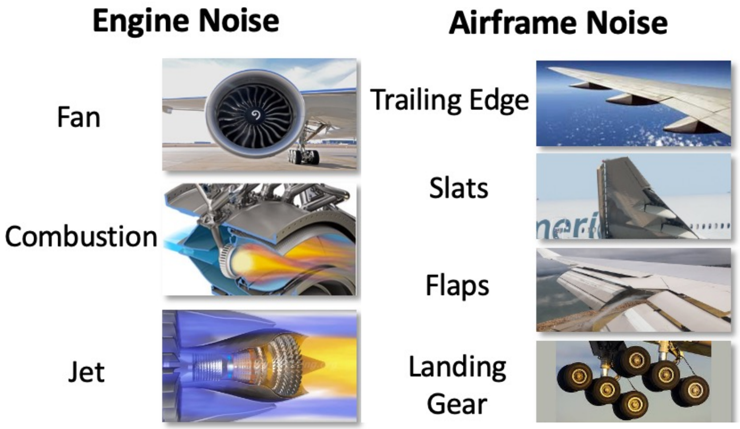
Noise-Power-Distance Models

- Noise interpolated from data tables
- Useful for simulating many approach and departure events and lateral procedure adjustments



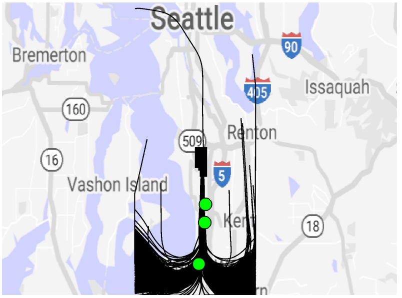
Noise Source Component Models

- Models describe functional relationships between noise components & aircraft
- Enable analysis of detailed flight procedures, inputs extensive

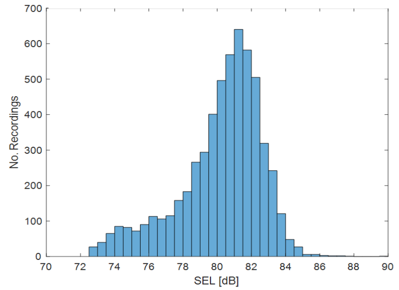


Data Mining Derived Models

- Models associating surveillance data, weather, and airport noise recordings
- Depends on availability of data

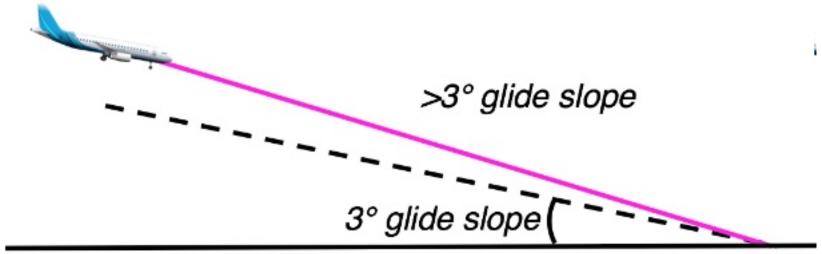


B737NG Noise Recordings [SEL] at South Far Monitor, Aug. 2019



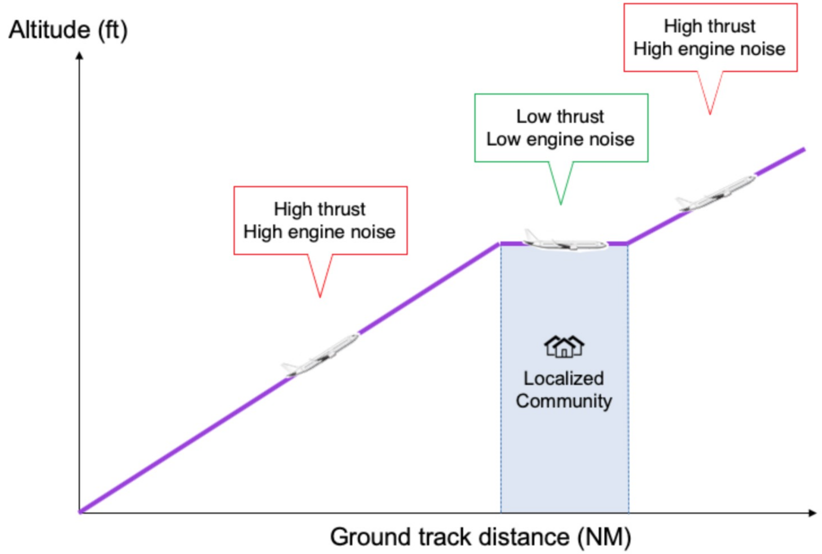
Example Advanced Operational Approach and Departure Procedures Examined with Framework

- Approach procedures:
  - Continuous Descent Approach
  - Steeper Approach
  - Delayed Deceleration Approach



Example: Steeper Approach Concept, Adjustment to Thrust and Altitude

- Departure procedures:
  - Departure Thrust Cutback
  - Noise Abatement Departure Procedure 1 & 2
  - Lateral Adjustments



Example: Thrust Cutback on Departure Concept, Adjustment to Thrust and Altitude

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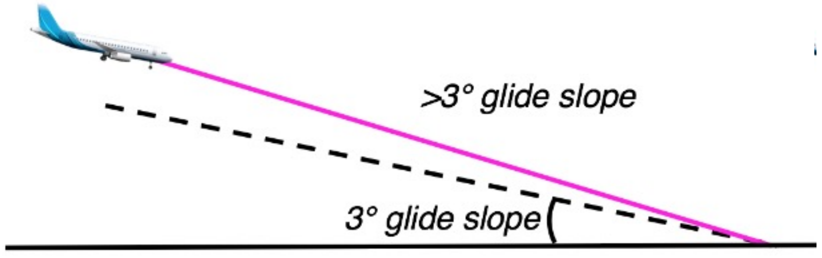

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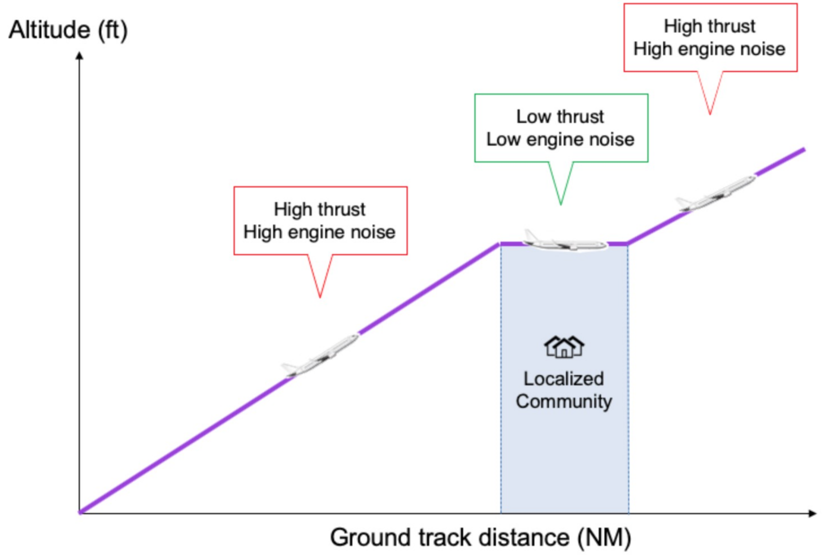


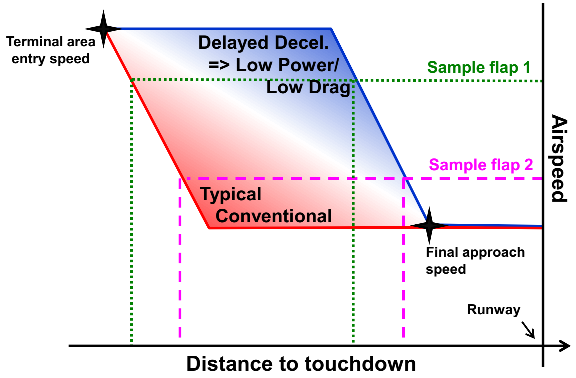
Example: Thrust Cutback on Departure Concept, Adjustment to Thrust and Altitude

The Delayed Deceleration Approach Concept

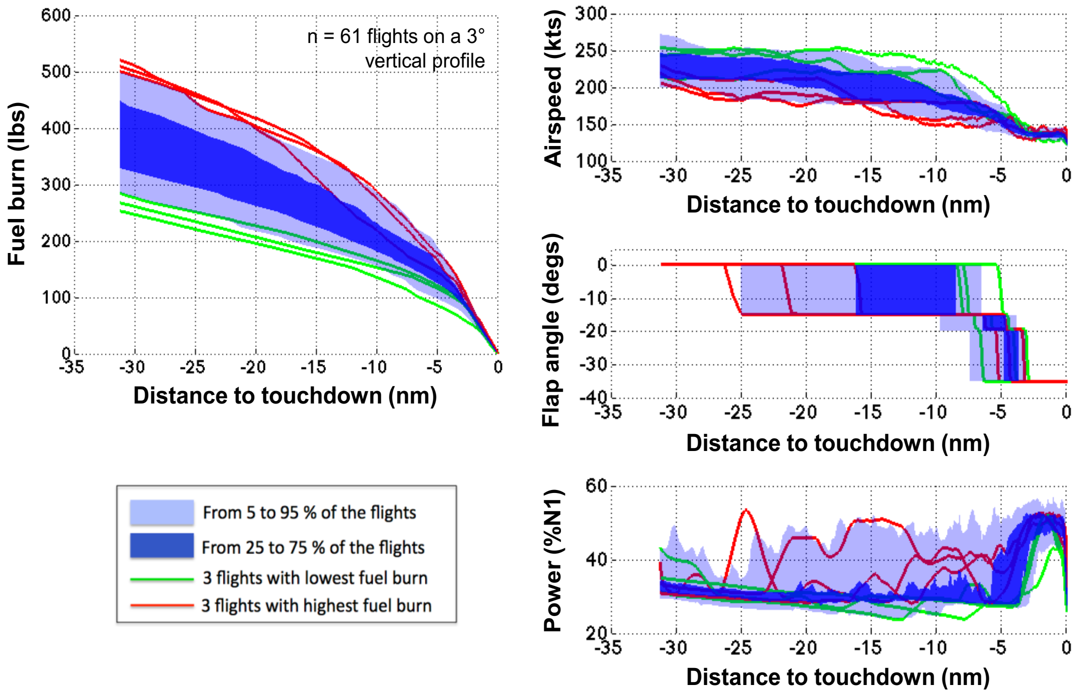
Delayed Deceleration Approaches (DDAs)

- Initial flap speed velocity held as long as possible during approach to lower drag and thrust requirements
  - Shown to yield fuel burn reductions
- Need source noise modeling to determine overall noise impact:
  - Lower thrust levels reduce engine noise
  - Delaying flap/slat deployment reduces flap/slat noise
  - Higher velocities increase airframe noise

Conventional Approach vs. DDA

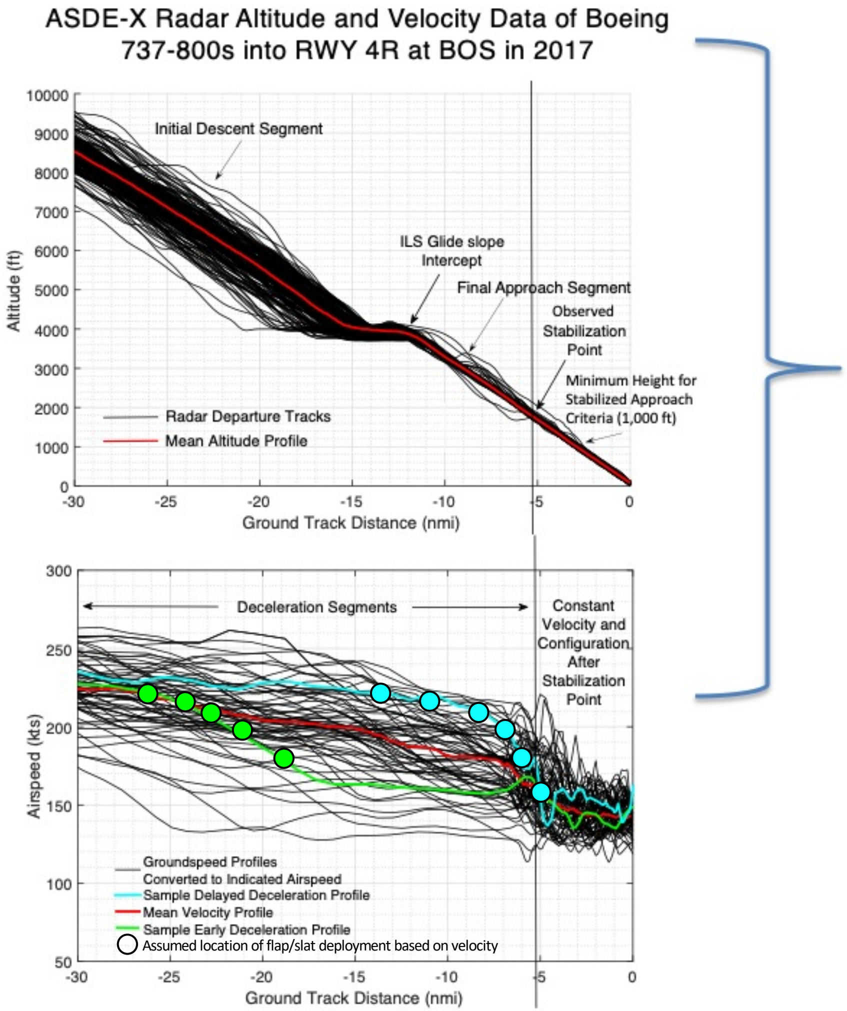


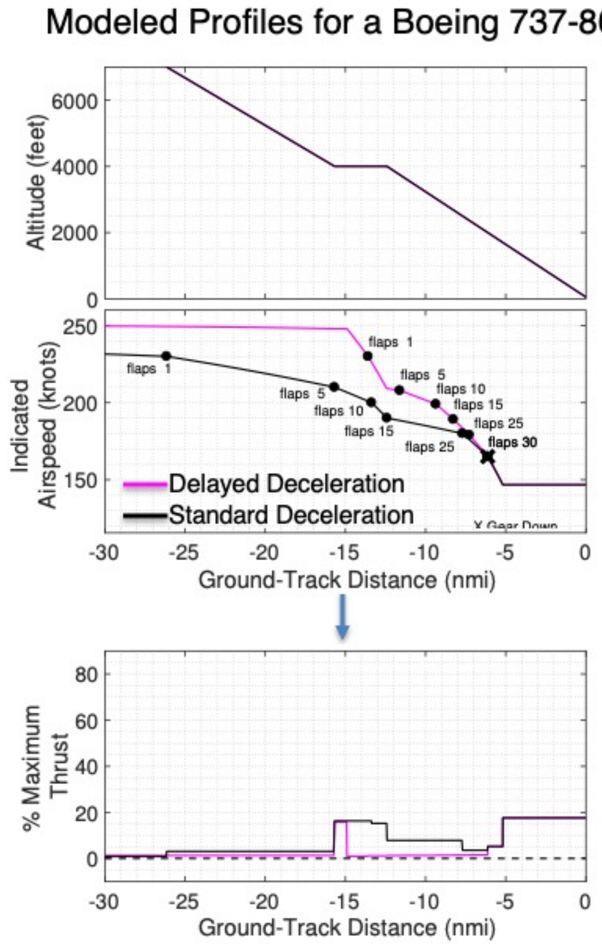
European A320 Flight Data Recorder Analysis (similar for B757 & B777)



Flight Profile Generation

Radar-Based Approach and DDA Examples, B737-800





- Flap, slat deployment assumed to occur at 10 knots below max safety speeds for each configuration
- Must decelerate early enough to assure stable approach criteria

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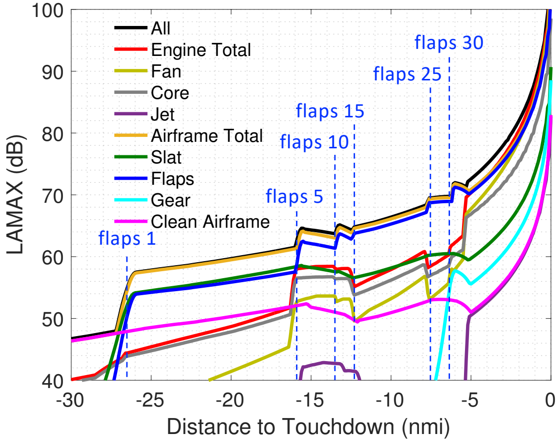
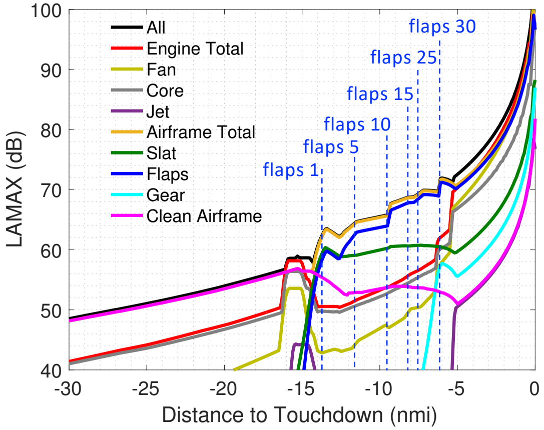
Noise Benefit of Delayed Deceleration Approaches
Overall Noise Reduced by Delaying Flap/Slat Deployment

$L_{A,MAX}$ Under the Flight Track for Boeing 737-800s

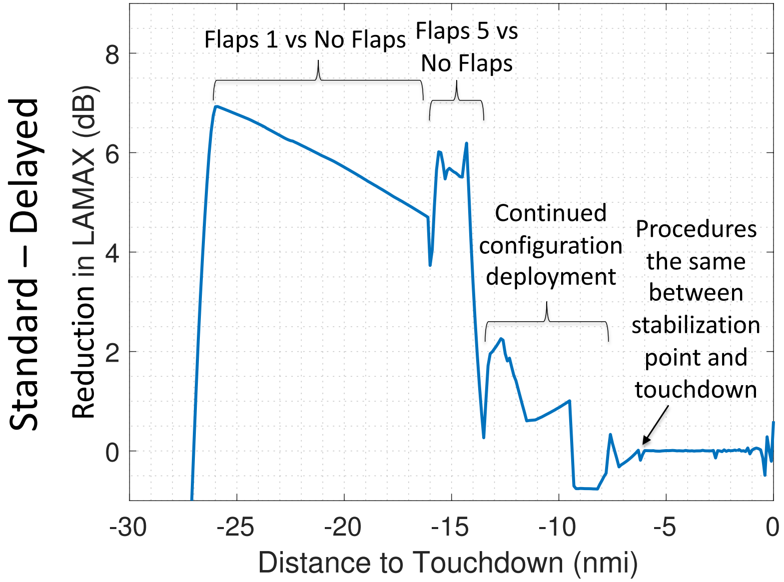
Standard Deceleration



Delayed Deceleration



Noise Impact Comparisons



- Modeled with component based noise modeling approach
- Reduce noise by delaying deceleration and thus extension of flaps and slats

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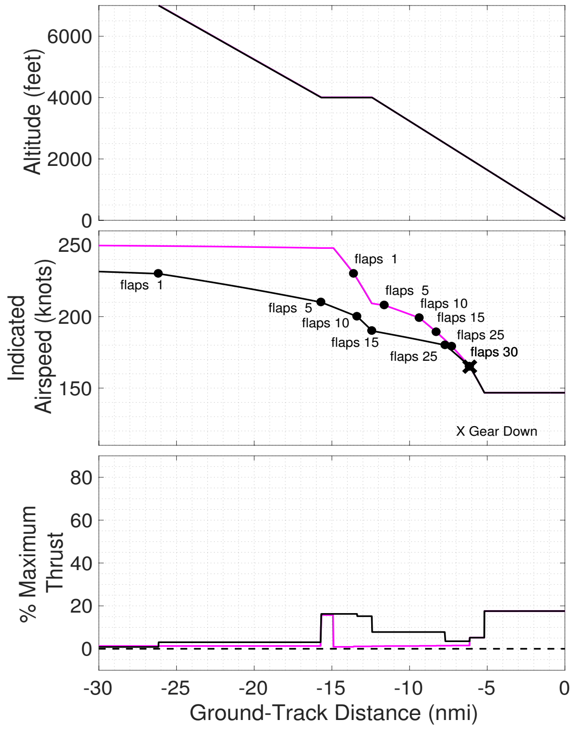
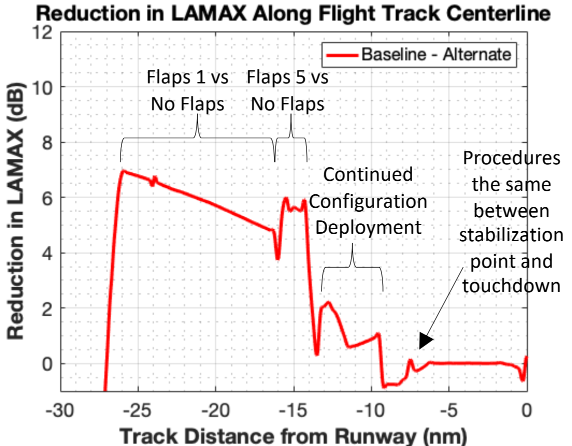
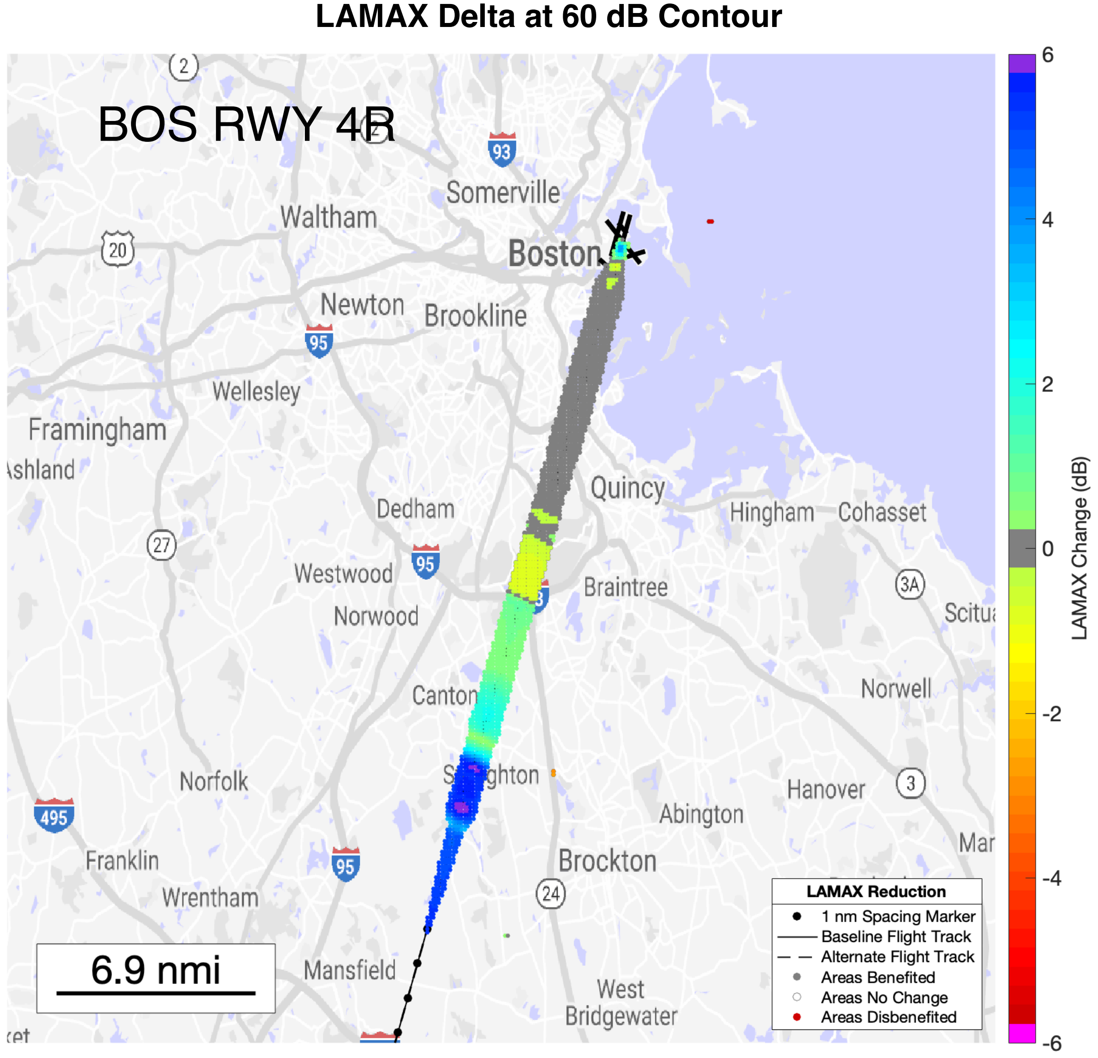
Example Noise Benefit: DDA vs Standard Approach for Boeing 737-800







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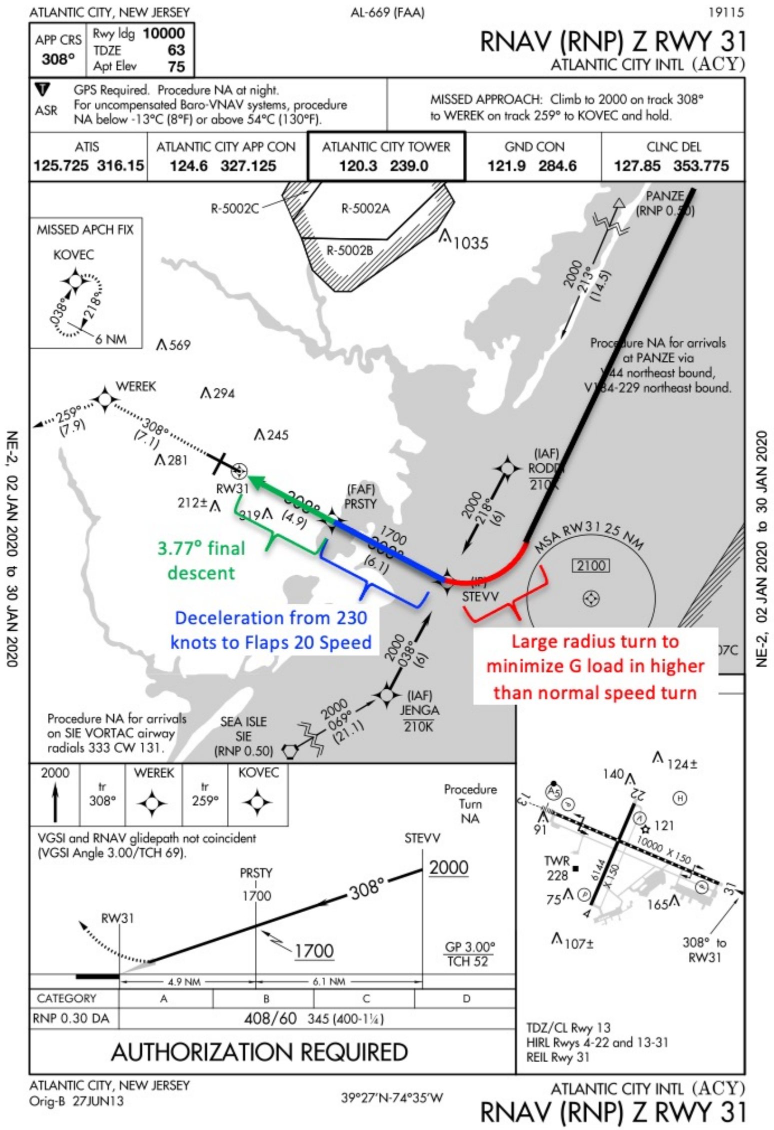
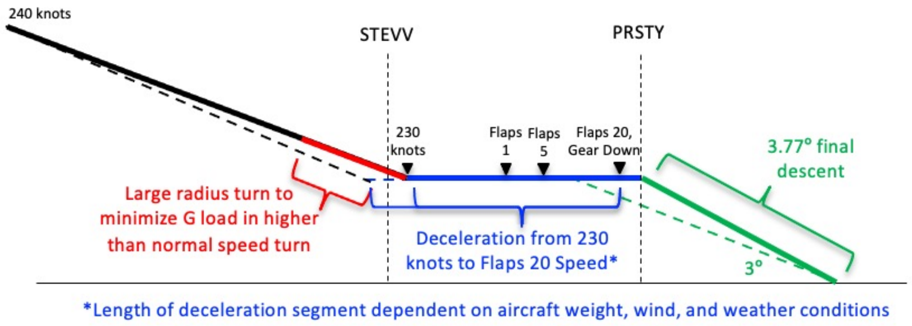
Target of Opportunity: Flight Demonstration
DDA Added to Planned 3.77° Steeper Approach Demonstration





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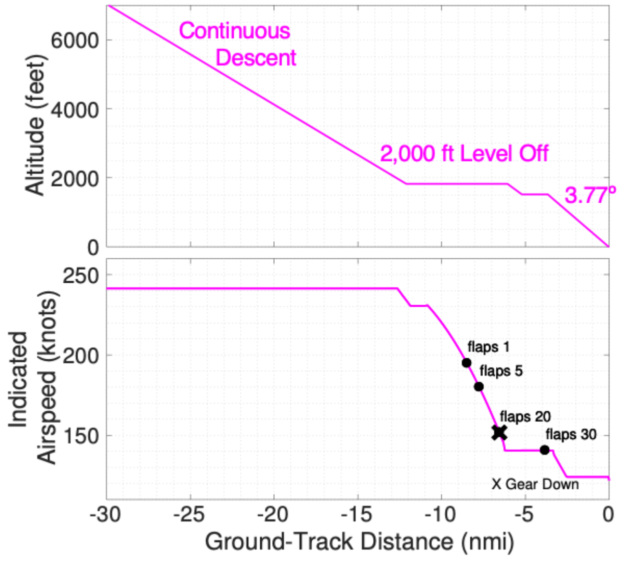
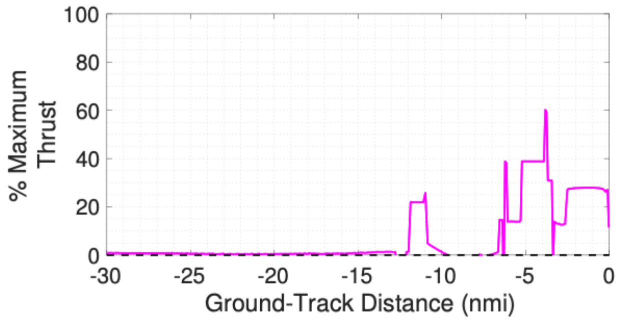
Flight Demonstration Modeled Result

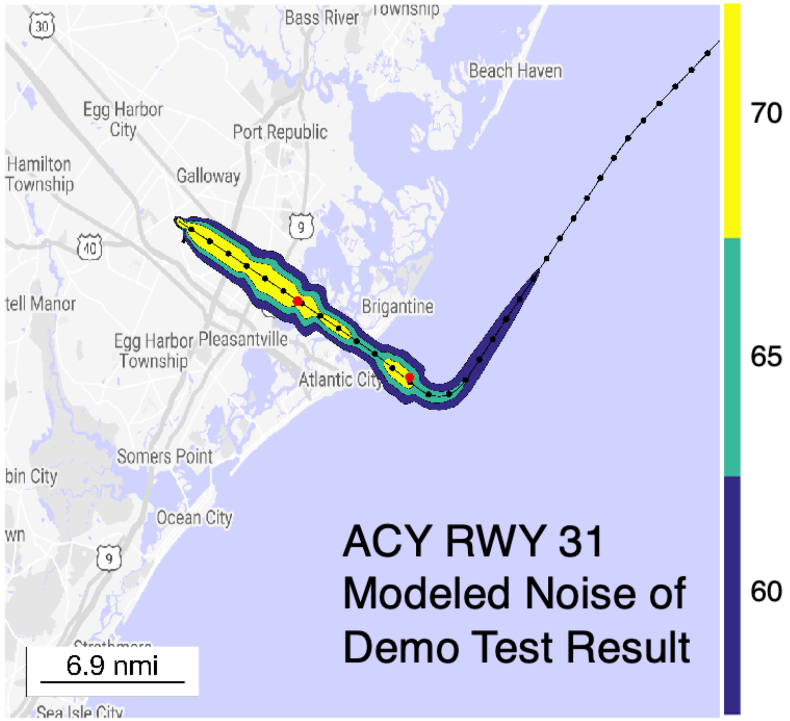
Flight Altitude and Velocity Radar Data*



Modeled Thrust



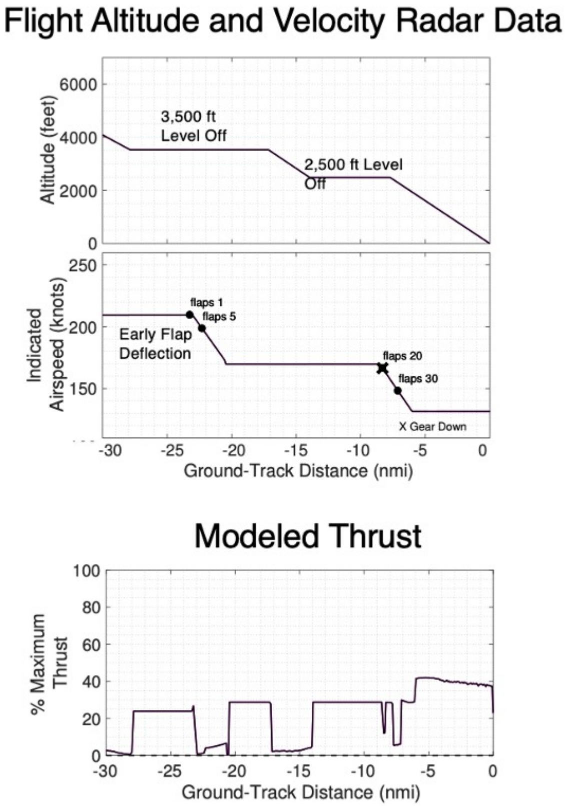
LAMAX (dB)

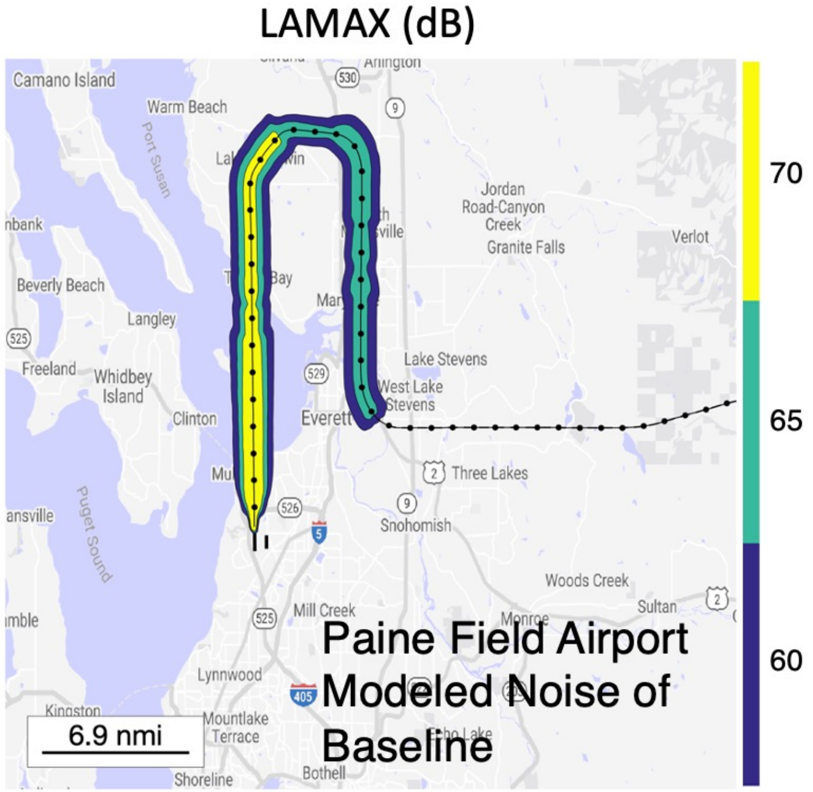


*Altitude, Track, and Velocity Radar Data Obtainable from Flight Aware

Flight Demonstration Modeled Result

- Baseline flight procedures into Seattle airports for comparison to demo test modeled results
  - Baseline: Early deceleration & flap deflection, standard glideslope:





*Altitude, Track, and Velocity Radar Data Obtainable from Flight Aware

Future Work

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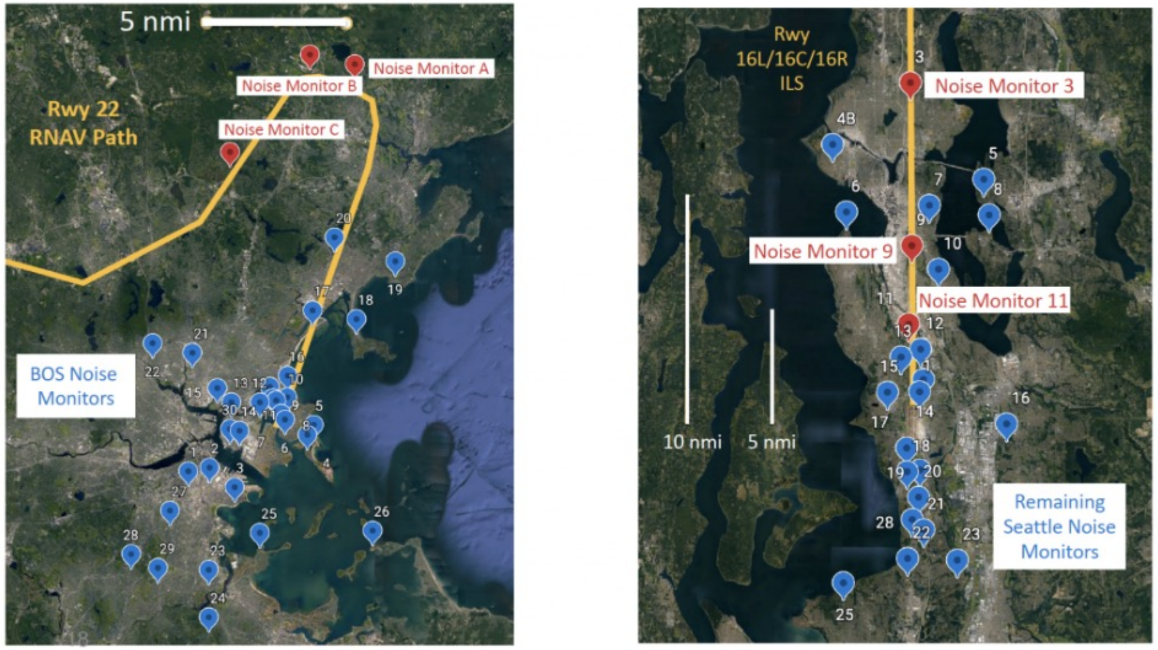
Data Modeling Approaches

- Goal to utilize empirical noise data to develop data-based validation of existing noise models and noise mitigation potential of advanced operational flight procedures
- Depends on data availability



Example Noise Monitor Networks at BOS (RNAV 22L) and SEA (SEA ILS 16L/16C/16R)

Observed Data			Modeled Parameters
Noise Data	**Aircraft Data**	**Environmental Data**	**Aircraft Performance**
SEL at Monitor Locations	Aircraft Type	Relative Humidity	Takeoff Weight
	Aircraft Operator	Northward Wind	Aircraft Configuration
	Altitude	Eastward Wind	Takeoff Thrust
	Lateral Position	Temperature	
	Groundspeed		
	Flight Path Angle		

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Integrated Advanced Air Mobility (AAM) Operations/Noise Analysis

- Various AAM configurations proposed in industry
- Noise assumed to be a critical aspect of these new AAM configurations
- Community noise impact will be a function of configuration and how vehicles are operated
- Desirable to update noise modeling tools to enable analysis of AAM vehicles and operations

Source: SMG Consulting

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Conclusion

- Framework developed to model community noise contours propagated over various types of approach and departure procedures and for different types of commercial aircraft using different noise modeling approaches
- From these results, more types of procedures could be analyzed to minimize community noise exposure over modified departures and arrivals with new emerging vehicle technologies, and availability of data can help to improve modeling methods