FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Noise Power Distance Re-evaluation

Project 43

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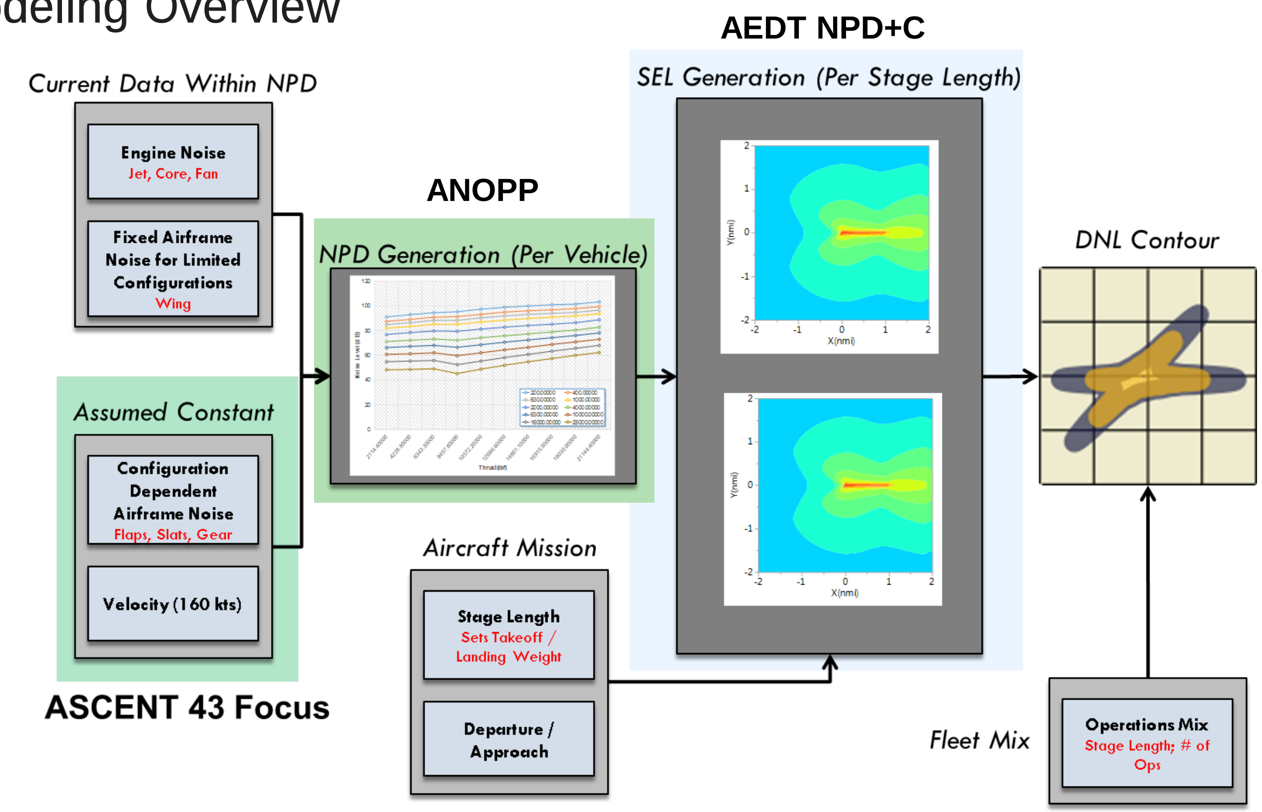
Project 43 Goals

- Motivation
  - NPD method within AEDT was developed decades ago with little flexibility to account for airframe noise and speed effects
  - Away from airports and for different flight segments, assumptions become less robust
- Project Impact
  - Enhance the accuracy of AEDT through improved aircraft source noise prediction and modeling
  - Needed to support the evaluation and development of aircraft flight procedures that could reduce community noise
  - Facilitate the implementation of NextGen through improved characterization of the noise benefits it would deliver
- Objectives
  - Study representative fleet mixes and aircraft types
  - Validation against available measurement data
  - Investigate a method to effectively represent the fleet
  - Maintain compatibility with existing NPD (integrated modeling) approach

ASCENT Project 43 Overview (Year 1)

- Objectives
  - Understand the sensitivity of including aircraft configuration changes and reference speed in NPDs on resulting noise contours for 50 – 400 PAX
  - Provide physics-based recommendations on format of NPD + Configuration (NPD+C) curves for use in AEDT
  - Maintain compatibility as much as possible with existing NPD approach

- NPD Modeling Overview



Summary of Key Findings (Year 1)

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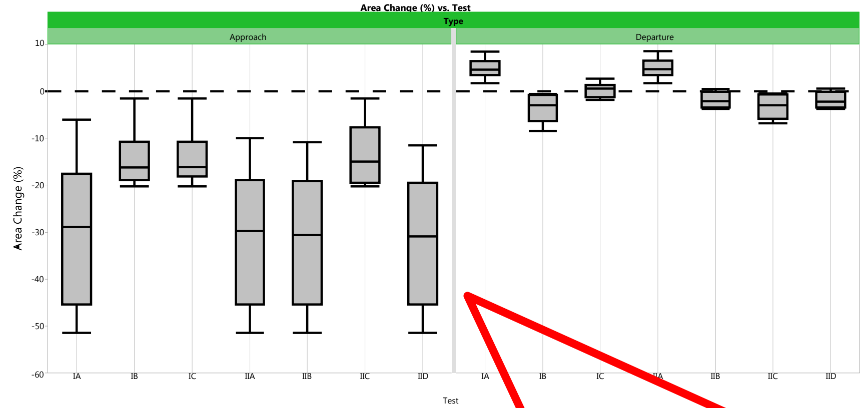
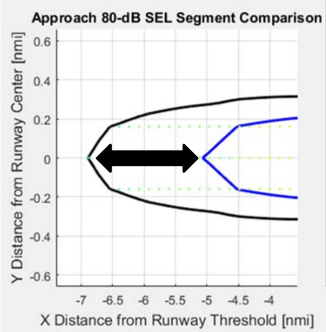
- Examined six aircraft classes ranging from regional jet to large wide-body
- Found effect of flight velocity on source noise to be main source of difference
- Flap noise secondary contributor
- Major differences occur during approach
  - Engine noise near maximum power dominates during departure



SEL Contour Area Variation for Approach and Departure



Grouping	Study	Parameters
Baseline	0	Baseline NPD
Main Effects	I.A	Include only speed
	I.B	Include only flaps/slats
	I.C	Include only gear
Cross Terms	II.A	Speed + Gear
	II.B	Speed + Flaps
	II.C	Gear + Flaps
	II.D	Speed + Gear + Flaps

Year 2 Project Goals

- Goal
  – Provide a method for expanding and implementing NPD+Cs into AEDT
- Project Impact
  – Previous year study was performed using existing detailed analysis models (ANOPP2)
  – Not practical to create detailed ANOPP2 models for every AEDT database vehicle
  – Develop a method to facilitate implementation correction functions to database NPD+Cs
- Objectives
  – Quantify sensitivity of corrections to aircraft configuration as well as aircraft and engine design inputs
  – Understand the sensitivity of configuration and design inputs in order to develop correction factors
  – Study sensitivities to various noise sources
  – Develop correction functions for NPD+Cs
  – Validate correction functions with ANOPP2 or data (if available)

Various Options and approaches

Integration Approach	By	Benefits	Challenges
Multiconfiguration NPDs (working w. mfgrs)	Euro-Ctrl	• From manufacturers. • Considered to be well validated.	• Only limited models so far. • Challenges to cover fleet, esp. with out of production a/c models
NPD+C directly from ANOPP	GT tried this	• The process is easy to understand • Consistent method for generating NPD+C	• Complex input parameters and delicate balance of the parameters • Validation is still needed • Large model library required
NPD+C via correction functions based on ANOPP	GT (Proposed approach – year 2)	• Able to create NPD+C sets from simpler inputs (available within AEDT). • No need to create ANOPP models for each a/c type.	• Need to consider wide condition ranges/rank orders • Validation of NPD+Cs • Industry buy-in

Motivates Simpler Implementation Approach – Focus of year 2

ANOPP2 Input Simplifications

AEDT database information

BPR
OPR
Thrust

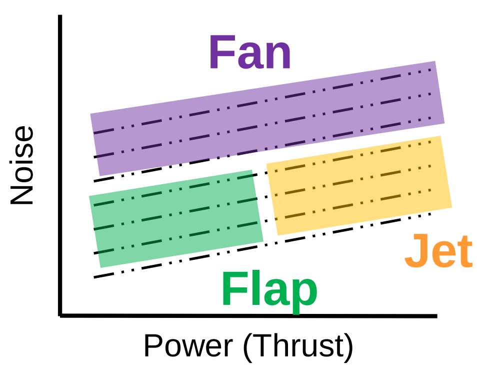
ANOPP2 Empirical Equation Inputs

$f_b = blade\ passage\ frequency, Hz$
$m = mass\ flow\ rate\ lb/sec$
$m_o = reference\ flow\ rate\ 1lb/sec$
$M_{TR} = tip\ relative\ Mach$
$RSS = rotor\ stator\ spacing\ divided\ by\ fan\ blade\ chord$
$\Delta T = total\ temperature\ rise\ across\ the\ fan$
$\Delta T_o = total\ temperature\ rise\ across\ the\ fan$
$\theta = angle\ from\ inlet\ axis$

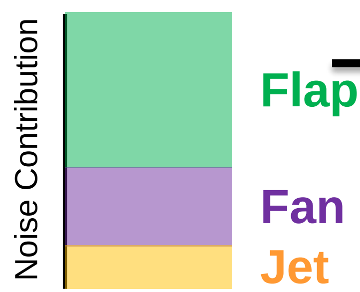
ANOPP2 Outputs

SEL
- Broadband source noise strength
- Broadband source noise directivity
- Broadband source noise directivity

A method for developing a correction function without using ANOPP2 Empirical equation inputs is being investigated
By using the computations that ANOPP2 does within the program, a correction function can be created based off of parameters available within AEDT



For Each Source -> Identify Physical Drivers



Predictor	L_4000 Contribution	Portion		Rank
Flap Deflection Angle	3.41832	0.2456		1
Flap Chord	1.88482	0.1354		2
Vehicle Weight	1.48983	0.1070		3
Flap Span	1.42878	0.1026		4
Wing Span	1.35327	0.0972		5
Flap Chord 2	1.31586	0.0945		6
Flight Velocity	1.30251	0.0936		7
Flap Span 2	1.03451	0.0743		8
Wing Area	0.69249	0.0497		9
THR_SET	0.00000	0.0000		10

Upcoming Validation Work

- Task 1: Investigate Impact of Frequency Content on Standard NPD
- Task 2: Investigate Impact of Frequency Content on NPD+C
- Task 3: Validate NPD+C Approach Using BANOERAC Data
- Task 4: Validate NPD+C Approach Using Vancouver Airport (YVR) Data

Validation Approach

Two Datasets – Collaborate with Penn State

Dataset	Flights	Aircraft / Engine State	Noise Directivity	Propagation Information	Noise At Receiver
BANOERAC	Many Enroute / Some Climb/descent	*	May contain shock-cell noise	Limited weather	4" and ground mics
YVR Data	Typical A/C mix, terminal area ops	*	*	Limited weather	Noise monitor terminals

- No direct information. But can be derived from careful processing and analysis of trajectory data using AEDT and EDS (FLOPS / NPSS)
- Exact process depends on dataset content

Validation Collaboration and work

BANOERAC

- Run AEDT in sensor path mode to match dataset
- Use EDS to compare NPD vs. NPD+C for selected vehicles
- Support PSU with ANOPP models of selected vehicles

YVR Data

- Run AEDT following ground tracks and sensor path tracks; use 3a options for weight/thrust
- Run EDS model for selected aircraft
- Compare NPD and NPD+C vs. data

Next Steps

We have been waiting for FY18 research funding to start the future work

- Complete correction function approach
- Gain agreement to access BANOERAC and YVR data
- Begin analysis of above datasets

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Participants

- GT Research Staff:
  - Holger Pfaender, Michelle Kirby, Yongchang Li, Don Lim
- GT Students:
  - Sara Huelsman, Arturo Santa-Ruiz, Edan Baltman