ASCENT Project 63

Parametric Noise Modeling For Boundary Layer Ingesting Propulsors

Georgia Tech

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Cost Share Partner: Georgia Tech

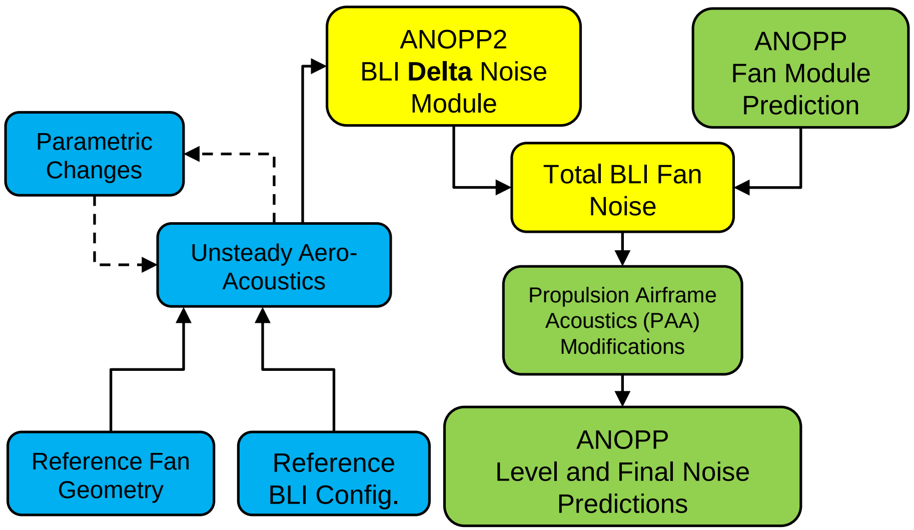
Objective:

To identify, develop, and validate a parametric fan noise module for a generic BLI propulsor based on the specifics of a configuration and design

Project Benefits:

- New capability for design engineers to determine the noise impact of new concepts
- Perform trades of fuel burn benefit versus noise at the conceptual level
- Reduce overall community noise by improving the accuracy of noise predictions for future advanced concepts
- Allowing vehicle designers to find the best opportunity for BLI technologies that offer fuel burn and noise benefits simultaneously

Research Approach: Quasi-Empirical



Major Accomplishments (to date):

- Validation of fan noise module with NASA ANOPP and experimental data.
- Successful Creation of CFD meshes for Unsteady CAA with baseline SDT geometry
- Integrated Geometry Design and Testing in STAR-CCM steady RANS for Tail Cone Thruster

Future Work / Schedule:

- Finalize design work for the 4 remaining parametric BLI geometries
- Validation of CAA results for the SDT fan
- Mesh and generate CAA results for each BLI case

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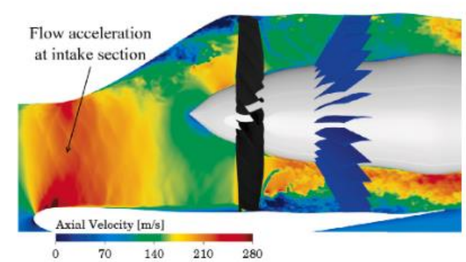
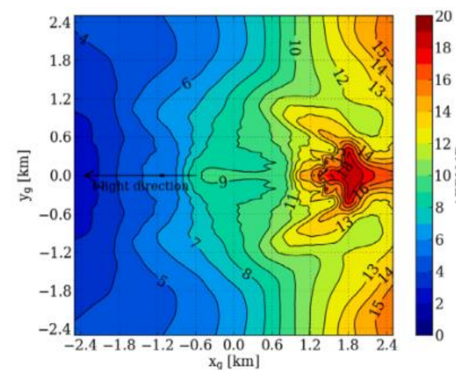
Project Motivation and Objectives

- Boundary Layer Ingestion (BLI) Concepts to **Reduce Fuel Burn**:
  - Ingest part of the boundary layer into the propulsor to improve propulsive efficiency
  - Creates distortion at the fan face
  - Problematic for operability and performance
  - **But what about the noise impact?**

- Distortion has an impact on noise:
  - Experiments have shown impact of inlet turbulence ingestion and aerodynamic distortion on noise
  - Broadband and tonal impact
  - Variability in directivity



- Some BLI noise modeling attempts have been made:
  - NASA Study Based on **Analogous Empirical Data**:
    - Clark, I. A., et al, "Aircraft System Noise Assessment of the NASA D8 Subsonic Transport Concept"
    - Found **16 dB impact** for ND8 configuration
  - TU Delft study looked at the NOVA BLI Configuration using high fidelity CAA
    - Qingqing Ye, Francesco Avallone, Daniele Ragni, Damiano Casalino, "Numerical analysis of fan noise for the NOVA boundary-layer ingestion configuration"
    - +10 EPNdB impact of BLI

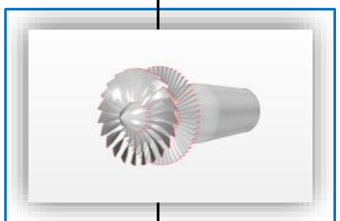


<u>Project Purpose:</u> To identify, develop, and validate a parametric fan noise module for a generic BLI propulsor based on the specifics of a configuration and design

Project Technical Approach

SDT Fan Inputs → NPSS Performance Model → ANOPP Inputs → ANOPP Noise Model Calibration

Geometry Preparation in SolidWorks → SDT Mesh → STARC-CCM CFD/CAA → Noise Prediction → CAA and ANOPP Calibration



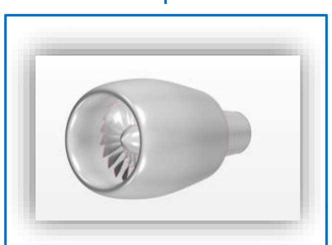
Reference configuration:

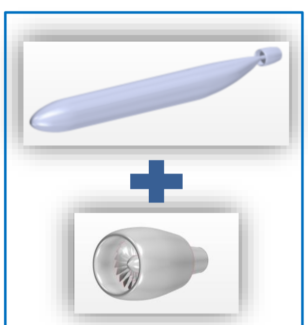
- STARC-ABL aircraft
- SDT Fan Geometry (Similar to TUD study)

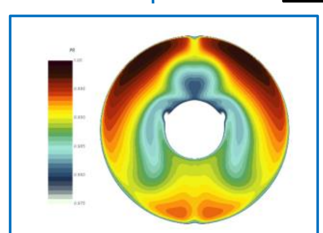
Project has two key paths:

- SDT Fan Noise Performance Modeling and Calibration (top)
- BLI Design and Parametric Noise Impact Generation (bottom)

Scale SDT-A to Clean Fan → Integration STARC-ABL & SDT-A → Design Changes and RANS studies → Baseline BLI Geometry → CFD/CAA







Parametric Changes

ANOPP2 BLI **Delta** Noise Module

Technical Approach: Proposed Analysis Cases

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Case Number	Operating Condition	Engine Percent Power	Fan Diameter	Configuration
1	Takeoff	100%	SDT	No Distortion / Clean Inlet
2	Flyover / Cutback	87.5%	SDT	No Distortion / Clean Inlet
3	Approach	61.7%	SDT	No Distortion / Clean Inlet
4	Takeoff	100%	Baseline	Baseline Fuselage Length
5	Flyover / Cutback	64.8%	Baseline	Baseline Fuselage Length
6	Approach	20.3%	Baseline	Baseline Fuselage Length
7	Takeoff	100%	Baseline + 25%	Baseline Fuselage Length
8	Flyover / Cutback	64.8%	Baseline + 25%	Baseline Fuselage Length
9	Approach	20.3%	Baseline + 25%	Baseline Fuselage Length
10	Takeoff	100%	Baseline - 25%	Baseline Fuselage Length
11	Flyover / Cutback	64.8%	Baseline - 25%	Baseline Fuselage Length
12	Approach	20.3%	Baseline - 25%	Baseline Fuselage Length
13	Takeoff	100%	Baseline	Extended Fuselage Length
14	Flyover / Cutback	64.8%	Baseline	Extended Fuselage Length
15	Approach	20.3%	Baseline	Extended Fuselage Length
16	Takeoff	100%	Baseline + 25%	Extended Fuselage Length
21	Approach	20.3%	Baseline - 25%	Extended Fuselage Length

Limited set of cases to capture **both BLI and Fan Diam without interaction effects**

Takeoff
Mach Number: 0.24
Altitude: 1000 ft
Angle of Attack: 8.5 deg

Flyover / Cutback
Mach Number: 0.25
Altitude: 2000 ft
Angle of Attack: 4.5 deg

Approach
Mach Number: 0.20
Altitude: 400 ft
Angle of Attack: 6.5 deg

Geometry:
Full set: 7 Geometries x 3 Cases Each: 21 Cases
Min set: 5 geometries x 3 Cases Each: 21
3 Geometry designs completed and tested
1 Geometry completed and tested for CAA

Results and Accomplishments to Date

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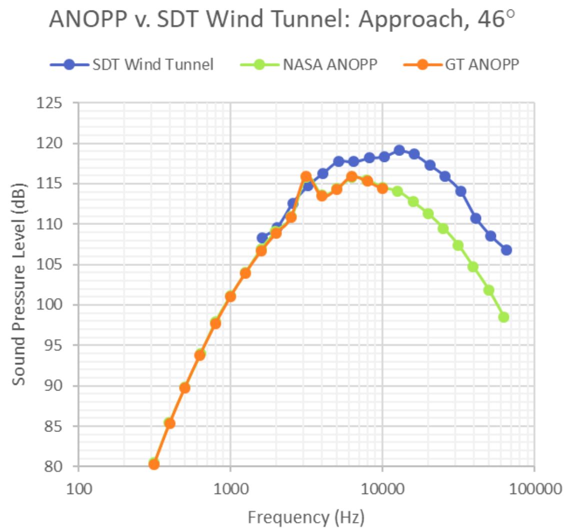
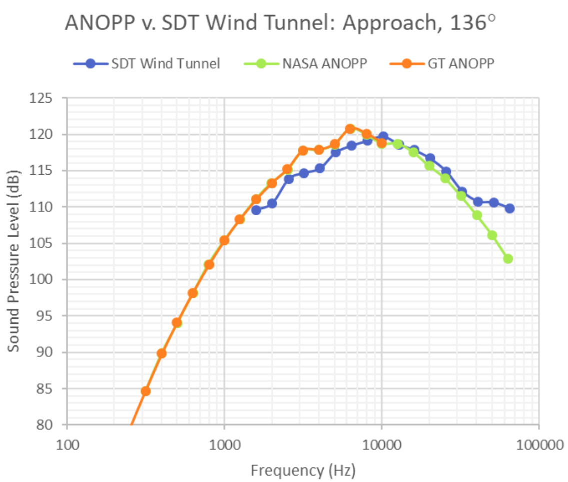
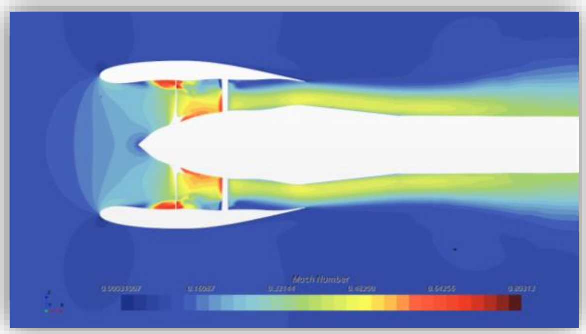
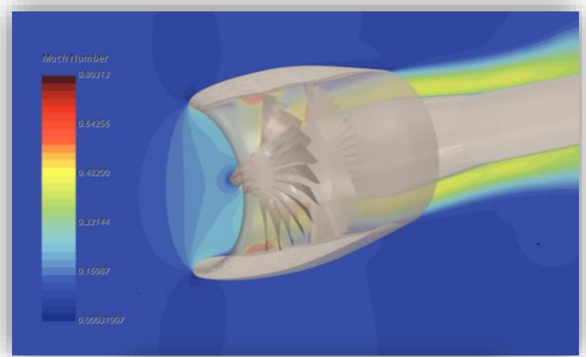
Accomplishment #1:
Validation of fan noise module with NASA ANOPP and experimental data.

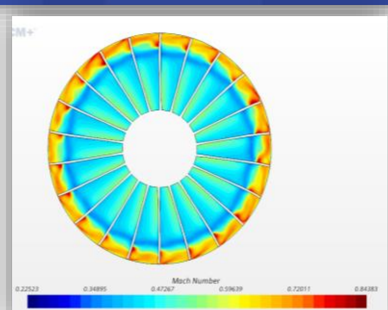




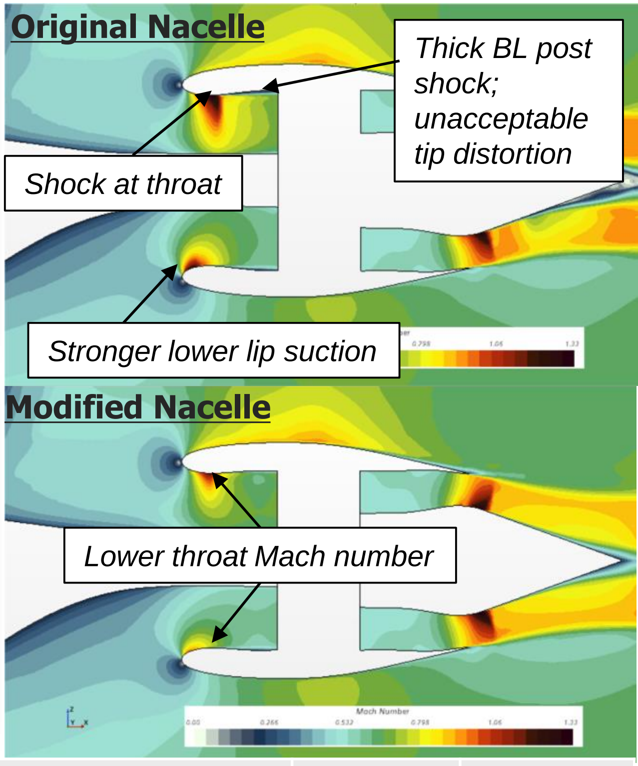
Accomplishment #2:
Successful Creation of CFD meshes for Unsteady CAA with baseline SDT geometry







Accomplishment #3:
Integrated Geometry Design and Testing in STAR-CCM steady RANS for Tail Cone Thruster



Approximate Values	Original Nacelle	Modified Nacelle
Peak upper throat Mach number	1.27	1.14
Peak lower throat Mach number	1.18	0.90