ASCENT Project 59A/E

Jet Noise Modeling To Support Low Noise Supersonic Aircraft Technology Development.

Georgia Institute of Technology & Penn State University

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Cost Share Partner: Georgia Institute of Technology & Penn State University

Objective:

To develop and assess computational tools to simulate the flow and noise of Civil Supersonic Aircraft engines.

To assess the impact of noise reduction methods on the overall engine performance

Project Benefits:

The developed tools will enable airframe and engine manufacturers to assess the noise impacts of engine design changes and to determine if particular designs will meet current or anticipated noise certification requirements

Research Approach:

Perform steady and unsteady numerical simulations of the internal and external flow from dual-stream, subsonic and supersonic jet nozzles using a commercial CFD application

Predict the radiated noise using an acoustic analogy and compare with experimental measurements

Select operating conditions for initial experimental geometry. (Project 59B).

Assemble zeroth-order methods for predicting supersonic inlet performance.

Determine installed thrust loss by jet noise reducing nozzles and find inlet designs that overcome this.

Major Accomplishments (to date):

Grids generated and boundary conditions specified for the Georgia Tech nozzles (Project 59B)

Reynolds-averaged Navier-Stokes solutions performed

Initial zeroth-order supersonic inlet performance and structural analysis complete for 2D inlets.

Future Work / Schedule

Improve grids for Large Eddy Simulation (LES) of jet exhaust flow and use Ffowcs Williams & Hawkings acoustic analogy to predict radiated noise (3/22)

Dual-stream nozzle noise predictions (7/22)

Convert inlet analysis into design environment, including axisymmetric configurations (1/22)

Incorporate sizing and installation performance (7/22)

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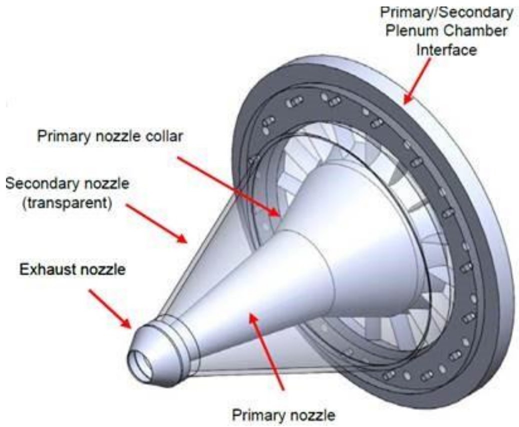
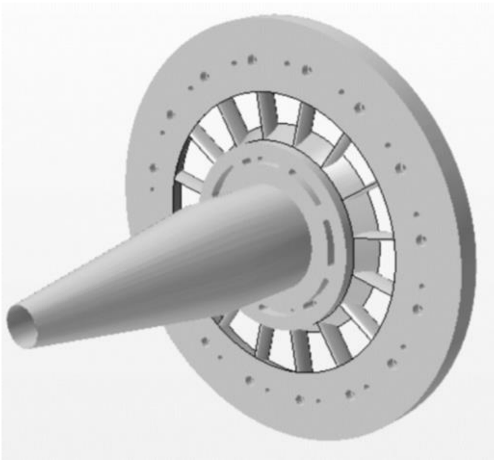
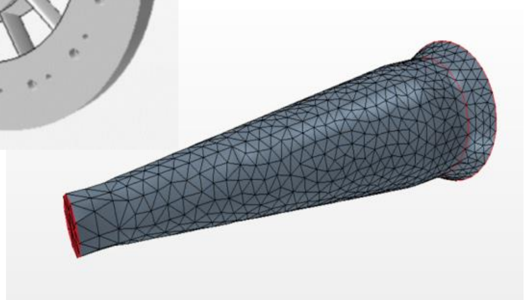
Preliminary Simulations

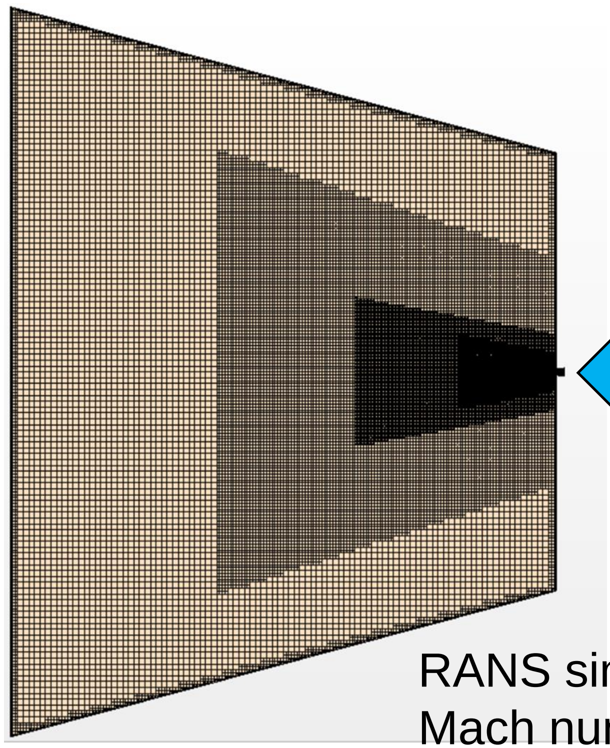
CAD model of Georgia Tech dual flow nozzle



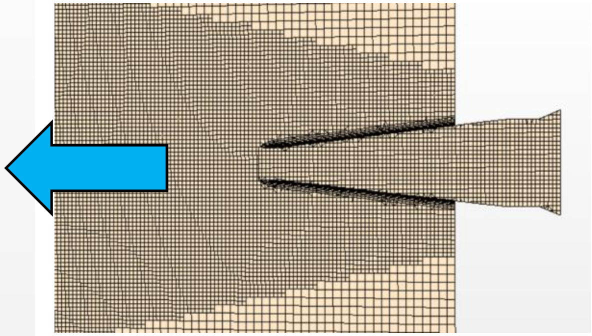
Inner nozzle alone



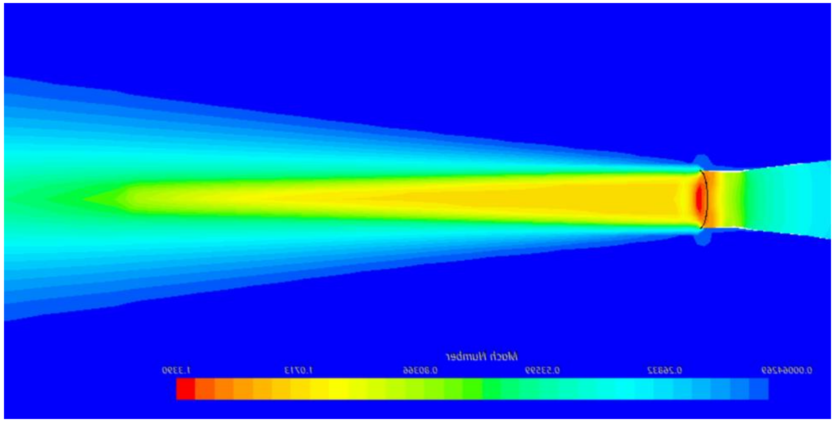




Unstructured grid generation: STAR-CCM+



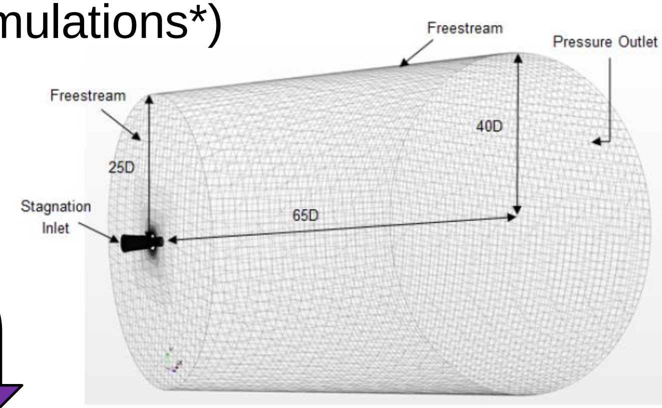
RANS simulation, Mach number contours



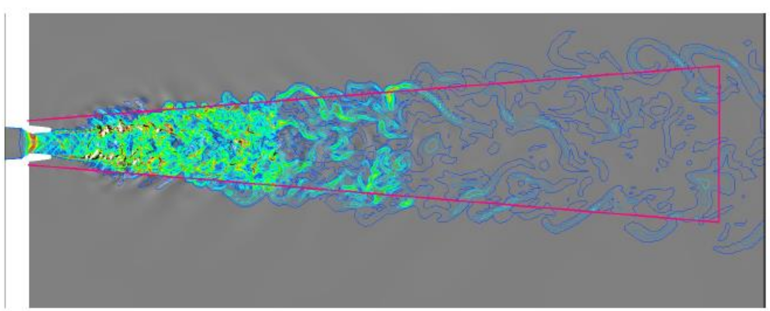
Simulations – Next Steps

a) Primary nozzle, b) Dual flow nozzle c) Nozzles with duct

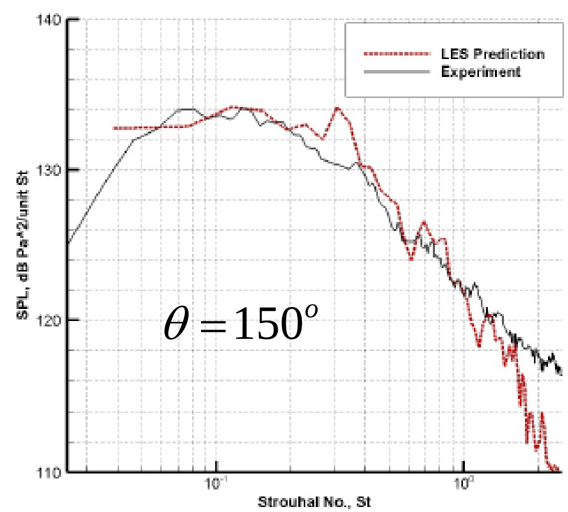
(Examples from previous simulations*)



1) Develop external grid for LES



2) Perform LES and extract data on FWH surface

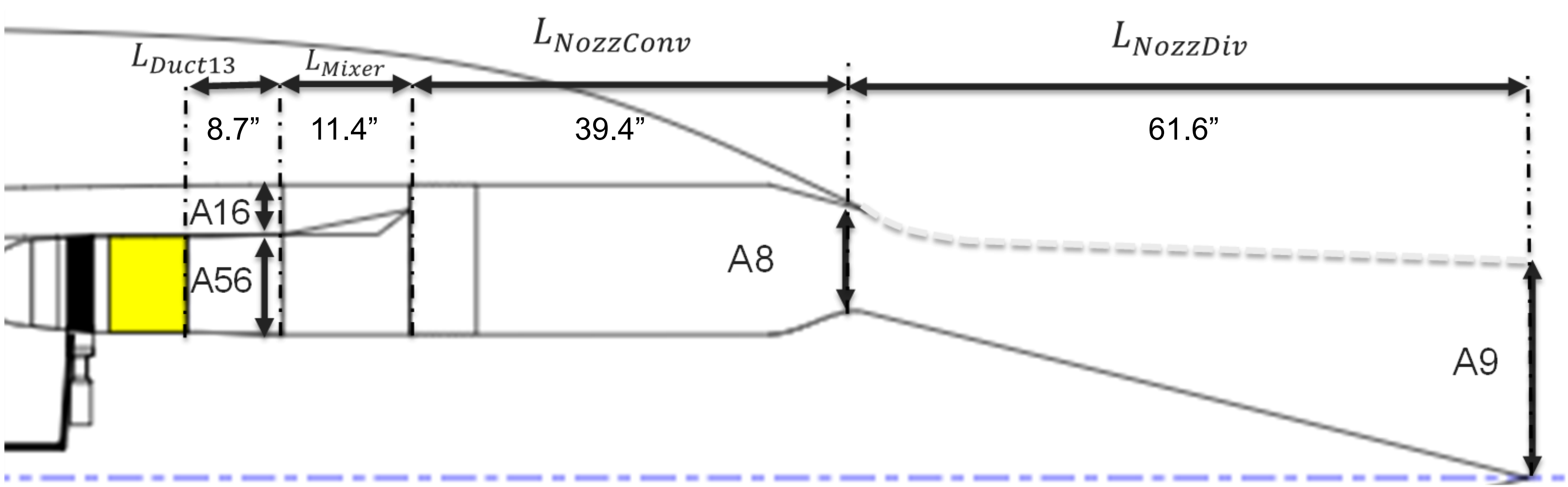


3) Predict far-field noise spectra

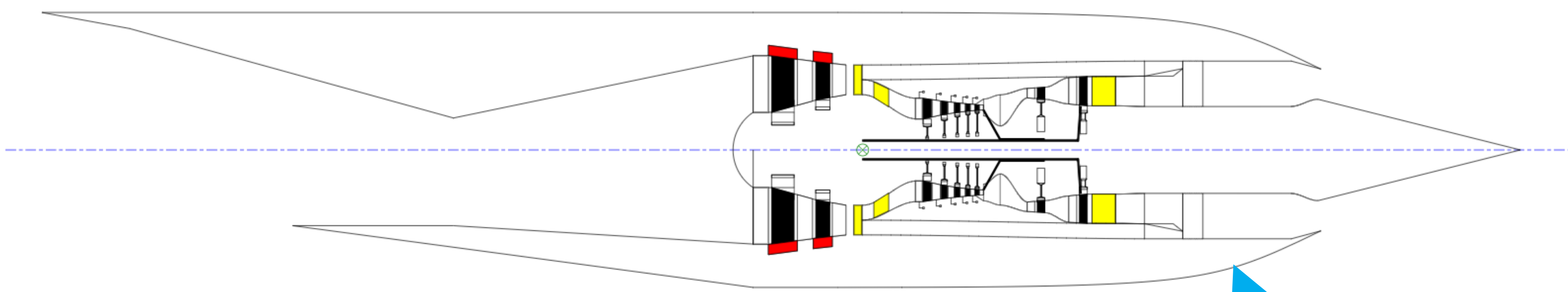
* C. Prasad, Ph.D. thesis, PSU (2019)

Nozzle Operating Conditions (59B)

Cycle Parameter @ TO, ISA+18F, 10% Derate	**Range** STCA – Medium SST **(v11.5)**		
BPR	3.23 – 1.393		
FPR	1.83 – 2.392		
NPR	1.81 – 2.152		
Extraction Ratio	1.1386 – 1.069		
Station	Area $[in^2]$ STCA – Medium SST	Mach STCA – Medium SST	Tt $[°R]$ STCA – Medium SST
16 (Mixer secondary in)	697.6 - 678.4	0.526 - 0.5147	658.85 - 715.51
5.6 (Mixer primary in)	625.5 - 987.8	0.298 - 0.417	1593.55 - 1728.2
6 (Mixer out)	1323.2 - 1666.2	0.428 - 0.481	895.32 - 1165.65
7 (Nozzle in)	1323.2 - 1666.2	0.428 – 0.494	895.32 - 1165.65
8 (Nozzle throat)	877.7 - 1158.2	0.963 – 1.000	895.32 - 1165.65
9 (Nozzle out)	877.7 - 1175.6	0.963 – 1.11	895.32 - 1165.65



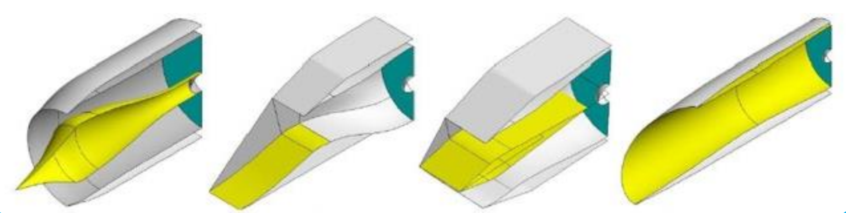
Zeroth-order Inlet Analysis

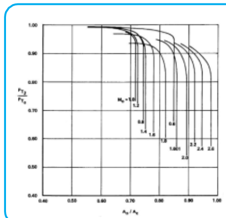


Noise Reducing Nozzle Technology
Has traditionally negatively impacted thrust production.

Inlet Designs
May be improved to recover these thrust losses.

Engine System Level Integration
Enables the determination of installed performance and the potential for offsetting nozzle related thrust loss.





Zeroth-order Inlet Design Tool
Allows us to rapidly explore the design space of alternatives regarding on-design and off-design performance.