Project 59E

Moderate Fidelity Simulations for Efficient Modeling of Supersonic Aircraft Noise

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Cost Share Partner: 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

Major Accomplishments (to date):

Generated grid for RANS simulations of inner nozzle geometry provided by Georgia Tech

Performed RANS simulations using STARCCM+ with boundary conditions for Georgia Tech experiments & additional validation cases

Built LES grid for inner nozzle & performed preliminary LES simulation

Future Work / Schedule:

Complete LES simulations of inner nozzle

Use Ffowcs Williams & Hawkings acoustic analogy to predict radiated noise

Generate grid for dual-stream nozzle RANS simulations

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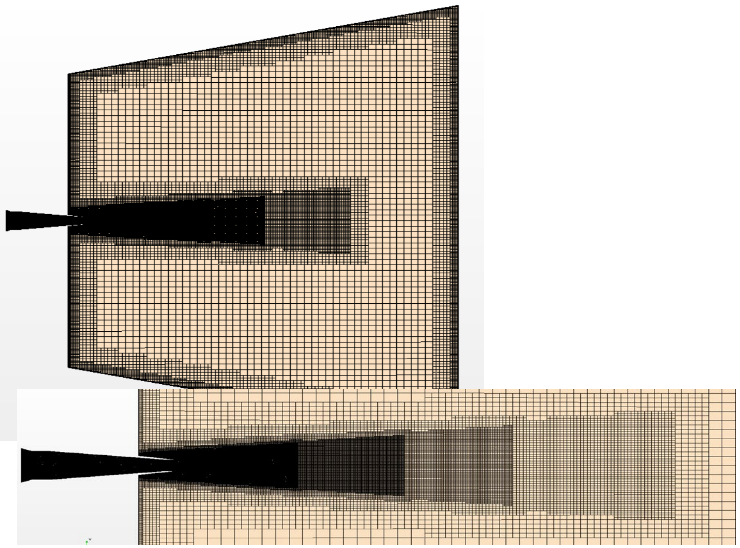
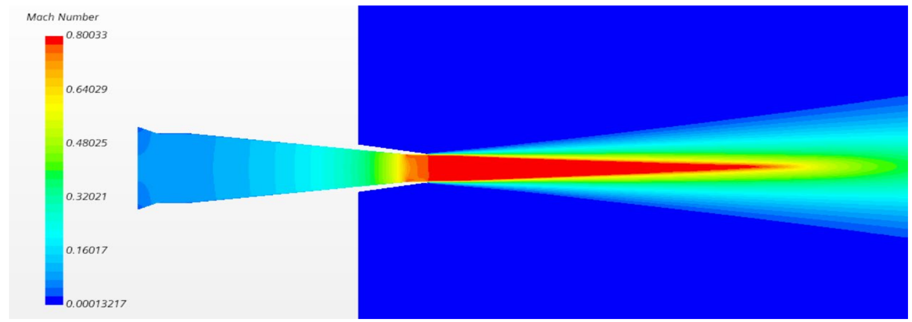
RANS Simulations



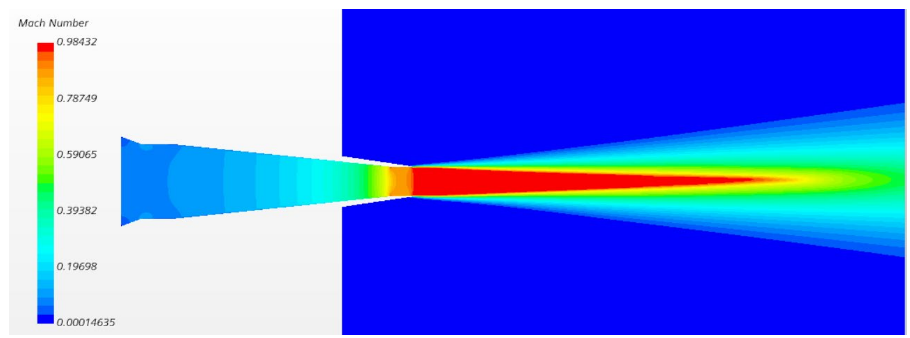
RANS Grid: 13,799,046 cells

Given Conditions (GA Tech)

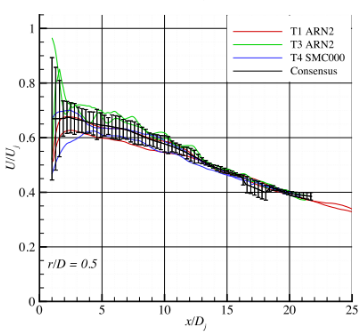


NPR = 1.57 M_j=0.8
TTR = 0.984 D_j=1.6”

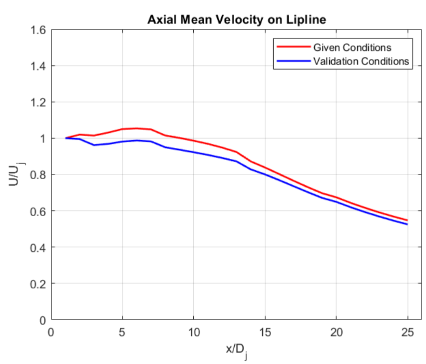
Validation Conditions (Bridges & Wernet 2010)



NPR = 1.861 M_j=0.985
TTR = 0.835 D_j=1.6”

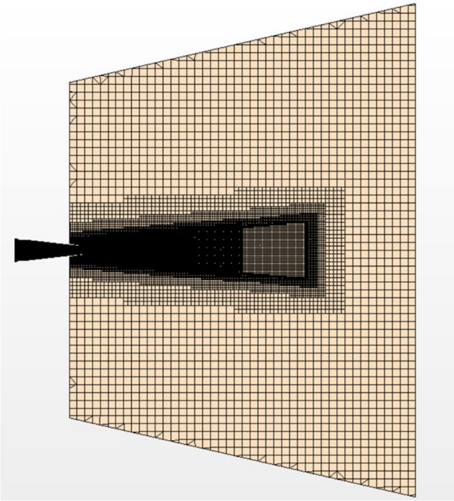


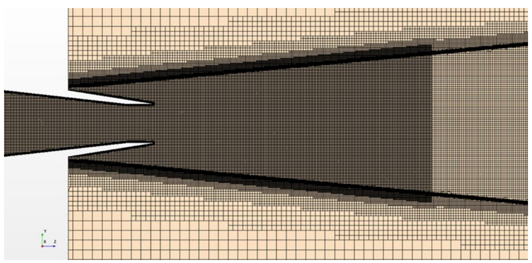
Bridges & Wernet (2010)



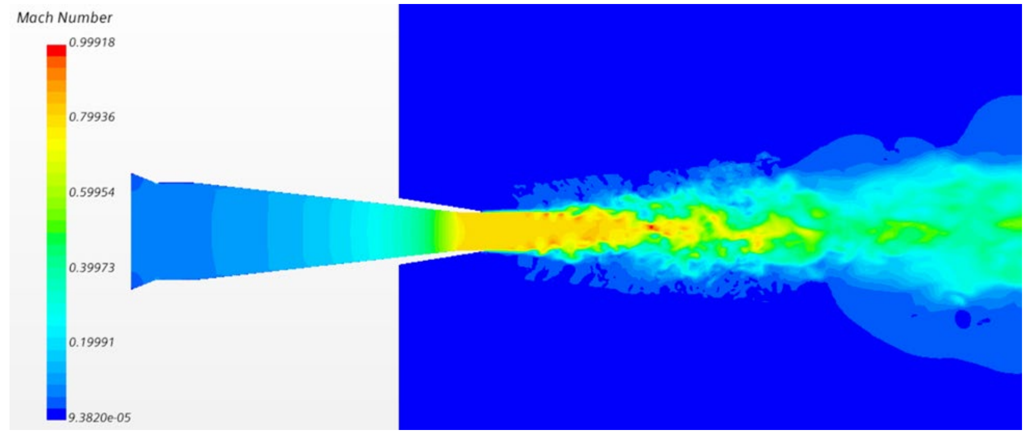
Validation cases (flow field)

Preliminary LES



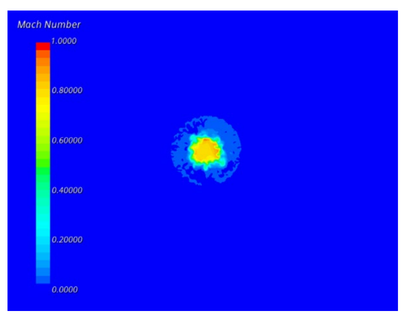


LES Grid: 20,779,237 cells

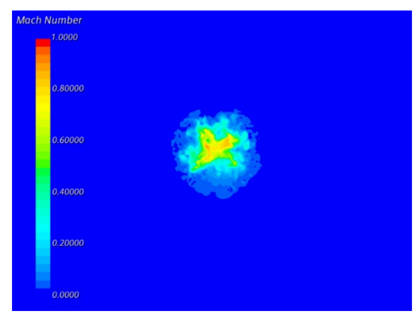


NPR = 1.57 M_j=0.8

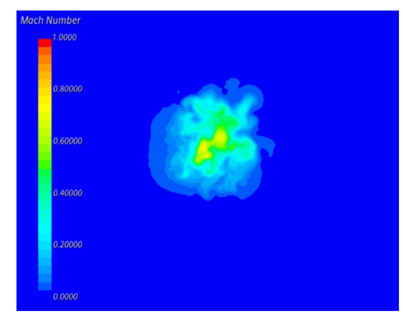
TTR = 1.0 D_j=1.6”



x/d=2



x/d=4



x/d=8

Findings/Next Steps

- Inner nozzle flow field shows good agreement with experimental data
- Continue flow and noise simulations for simplified nozzle geometries
  - Complete LES for inner nozzle
    - Compare flow predictions with simulations based on imposed RANS flow profile at the nozzle exit
  - Implement Ffowcs Williams & Hawkings (FWH) surface data extraction methodology
  - Calculate far field noise and compare with experiments
  - Generate grid and obtain RANS solution for flow of the dual stream nozzle
  - Perform LES simulations for dual stream nozzle
  - Use FWH analogy to predict far field noise for dual stream nozzle and compare with measurements