ASCENT Project 59D

Physics-based Analysis and Modeling for Supersonic Aircraft Exhaust Noise

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Cost Share Partner: TBA

Objective:

In collaboration with ASCENT partners in Project 59, develop multi-fidelity physics-based analyses for supersonic aircraft exhaust noise.

The main goals are to develop improved jet noise prediction methods and better understand the uncertainty associated with the noise predictions, for a range of engine cycle parameters and operating conditions relevant for commercial supersonic aircraft.

Project Benefits:

Aircraft and engine companies, and organizations such as NASA, FAA, and DoD R&T community would also benefit from the improved methods and tools. Ultimately, supersonic jet noise tools with predictive capabilities can be used to design better noise mitigation systems and to provide estimates of noise for certification studies.

Research Approach:

- In consultation with Project 59 and other project partners in ASCENT define the plans for high-fidelity simulations and jet noise modeling.
- Develop and validate high-fidelity jet noise predictions for baseline configurations
- Develop and validate RANS-based jet noise predictions for baseline configurations
- Develop and validate high-fidelity jet noise predictions for configurations with noise mitigation concepts
- Develop and validate RANS jet noise predictions for configurations with noise mitigation concepts

Major Accomplishments (to date):

Preliminary LES of primary nozzle and primary+secondary buried nozzle (GaTech geometry)

Development and validation of far-field noise propagation model (Adjoint-Green's function)

Future Work / Schedule:

Noise prediction for selected cases from GaTech baseline experiments using LES (Year 2)
Development and validation of RANS based approach
Noise source model improvements (Year 3)
Noise predictions for noise mitigation concepts (Year 3)

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Introduction

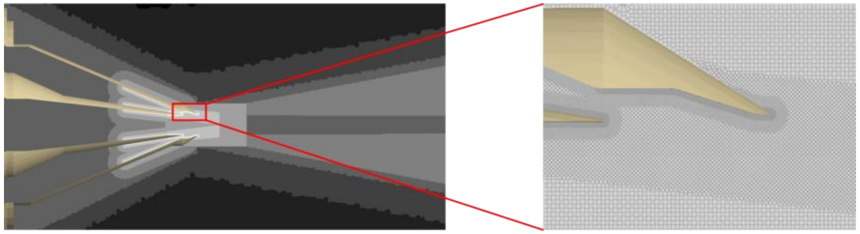
Develop multi-fidelity approach for jet noise prediction and mitigation with focus on configurations and operating points relevant for supersonic civilian aircraft

LES (high-fidelity) and RANS + noise source models

- Georgia Tech coannular nozzles
  - Primary and primary+secondary nozzle configurations
  - Goal: to supplement experimental datasets with high fidelity and RANS
  - Effect of variable length mixer ducts on acoustic modes
  - Flow conditions for preliminary simulations:
    - NPR1 = 1.691
    - NPR2 = 1.387
    - NTR1 = NTR2 = 0.82
    - Exit Re = 1E6
- In future extend to noise mitigation concepts being evaluated by NASA

LES Cases (thus far)

- Simulations based on CharLES (from Cascade Technologies)
- Bres et al (2018, *JFM*) have demonstrated sub-dB accuracy for noise predictions with CharLES

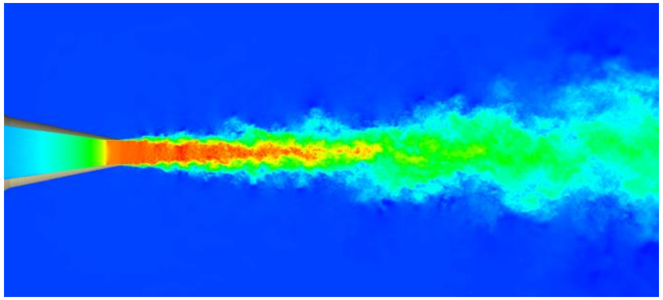


* These are low-resolution meshes used for preliminary calculations. We plan to further increase the resolution near the nozzle wall and exit.

Geometry	M_{j1}	M_{j2}	Mesh Size*
Primary	0.5	N/A	25M
Primary	0.9	N/A	27M
Primary + 0.7'' Mixer Duct + Secondary	0.9	0.7	16M
Primary + Mixer Duct + Secondary	Planned		

$M_j = 0.9$

More quantitative flow data will be updated

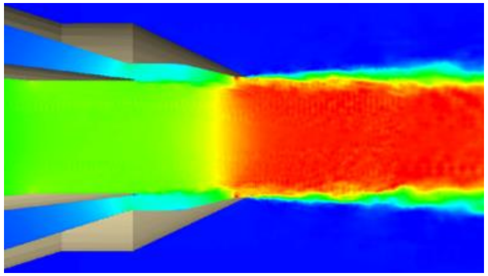


We plan to compare
- velocity (mean, rms)
- near- and far-field acoustics

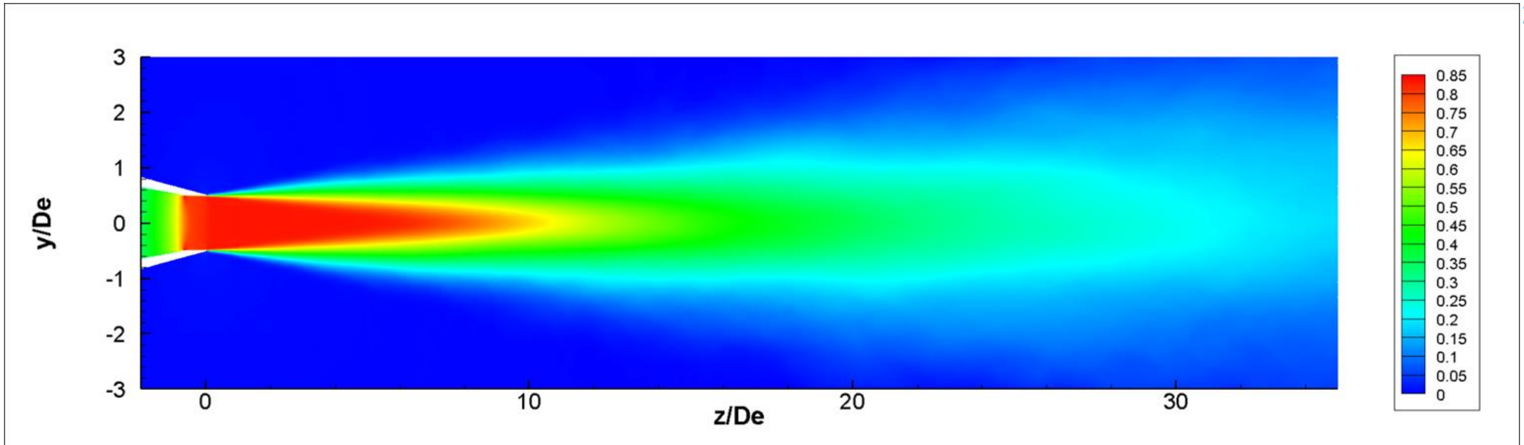
with experiments and relevant literature

Use LES data for lower fidelity noise models

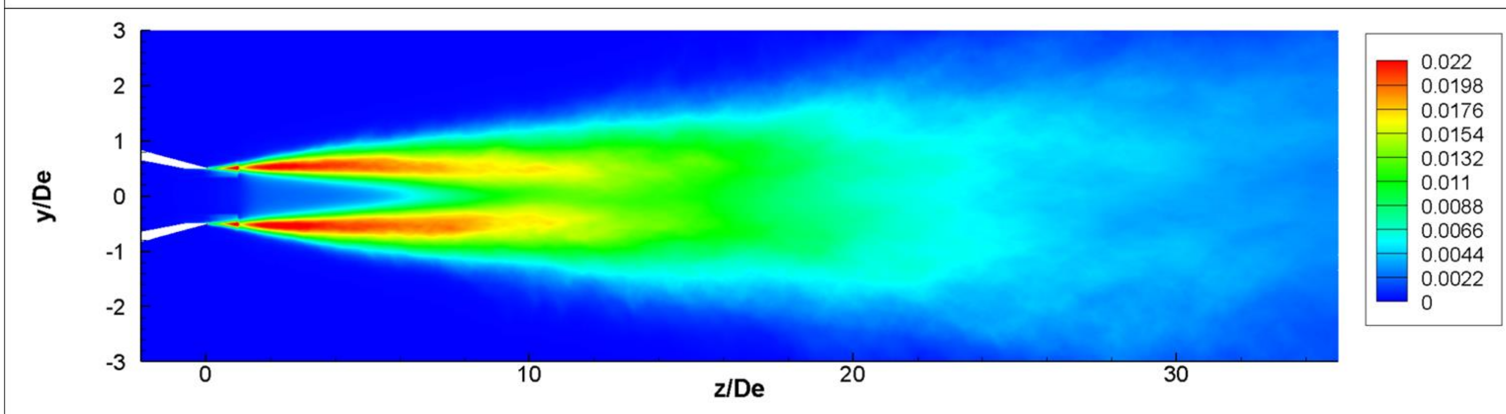
$M_{j1} = 0.9$
$M_{j2} = 0.7$



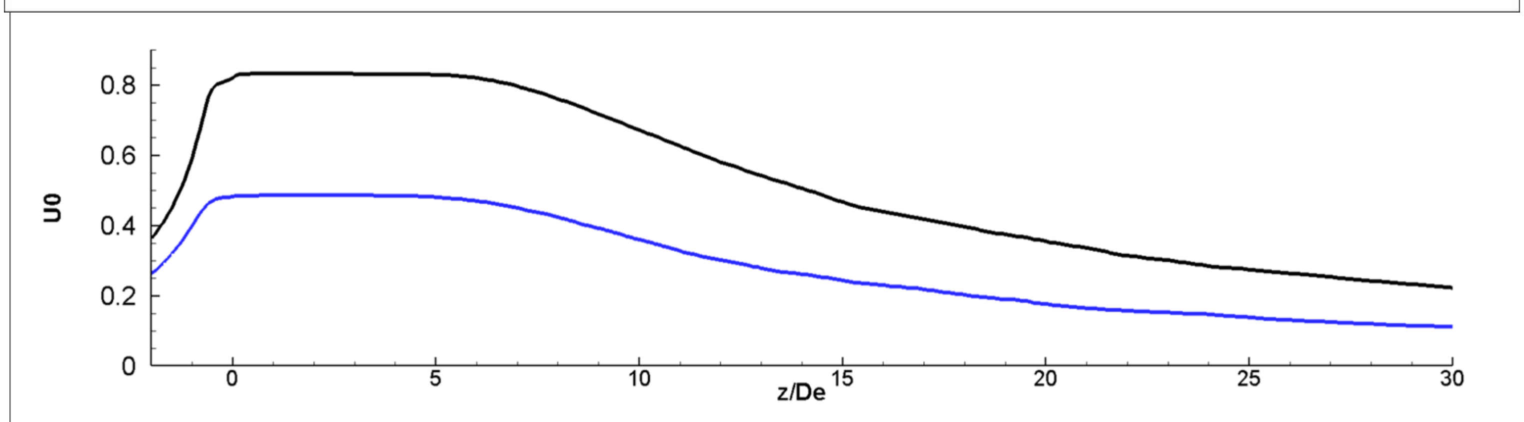
LES Case: Mj = 0.9



mean streamwise velocity

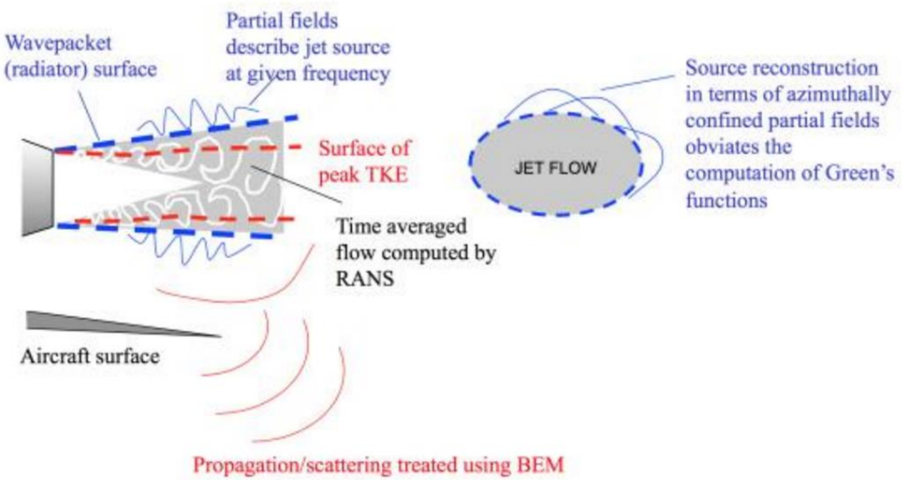


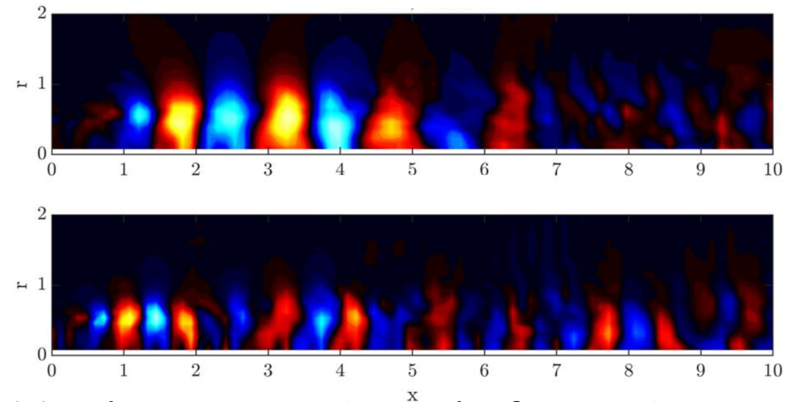
mean TKE



Mean velocity along lip line and centerline

Jet noise analysis





Highest energy SPOD modes for St=0.2, 0.4; WMLES jet Mj = 0.9 (EU Project G4H test case)

RANS (time avg)

LES (time varying)

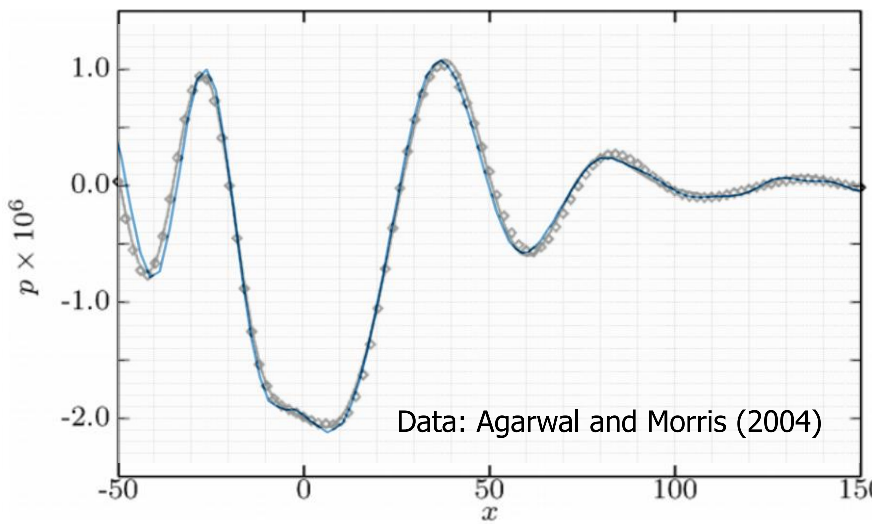
Resolvent analysis

SPOD analysis

Partial fields (large scale structures)

Far field (adjoint Green's)

Fine scale (Tam/Auriault)



Adjoint Green's function validation case. 2D parallel shear flow with immersed monopole Gaussian source - acoustic pressure along y=15.

Questions and feedback