Acoustic Liner Overview

Douglas M. Nark (for Liner Team)
NASA Langley Research Center, Hampton, VA

Acoustics Technical Working Group Meeting
Cleveland, OH
October 22-23, 2019

NASA LaRC Liner Physics Team

Aeroacoustics Branch:

Brown

Structural Acoustics Branch:

Galles, Howerton, Jones, Nark, Schiller

Computational Aerosciences Branch:

Watson (retired)

Fabrication Technology Development Branch:

Andrews

On-site contractor support:

Becker, Leath, Reid

Outline

- Research Areas
  - Liner Modeling and Concept Development
  - Propagation Codes and Data Analysis
  - Liner Drag
  - Novel Liner Concepts
- Acoustically Treated Bifurcation
  - Conventional Configuration
  - Slotted Core
- Additional Liner Concept Development
- External Collaborations
- References

Current Investigations

Liner Modeling and Concept Development

- Development of impedance eduction for multizone liners
- Development of improved perforate facesheet impedance model

Data Analysis

- Implementation of amplitude-compensated swept-sine measurements
- Investigation of flow direction effects on impedance eduction
- Updated CDTR data analysis routines for improved efficiency and accuracy
- Impedance eduction based on the Prony method controlled via a Python wrapper
- High Intensity Modal Impedance Tube (HIMIT) online within the next month

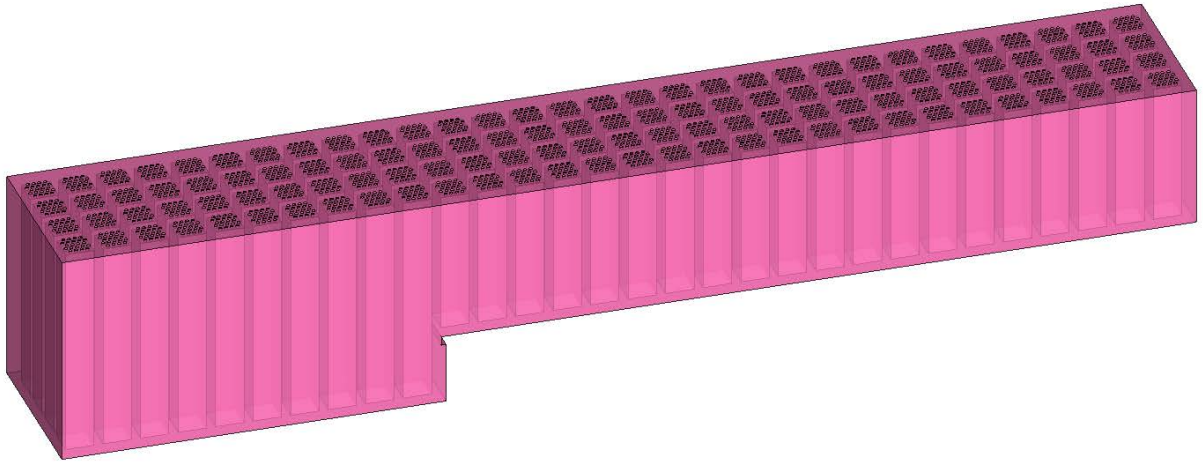
Current Investigations

Liner Drag

- Statistical methods to reduce liner drag measurement uncertainty (GFIT)
- Investigating commercial shear stress sensors (CDTR)

Novel Liner Concepts

- Multizone
- Multidegree of Freedom
- Shared port inlet
- Slotted core
- Variable-depth, bent chamber
- Metal foam with controllable variable density



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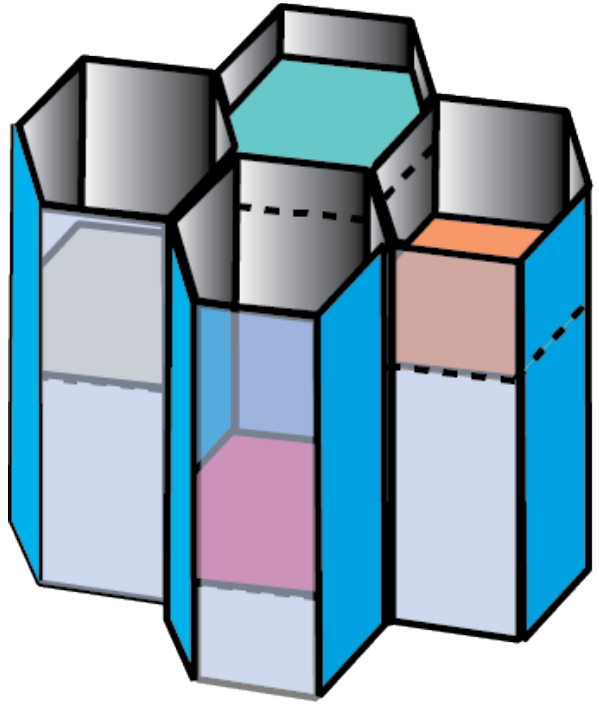

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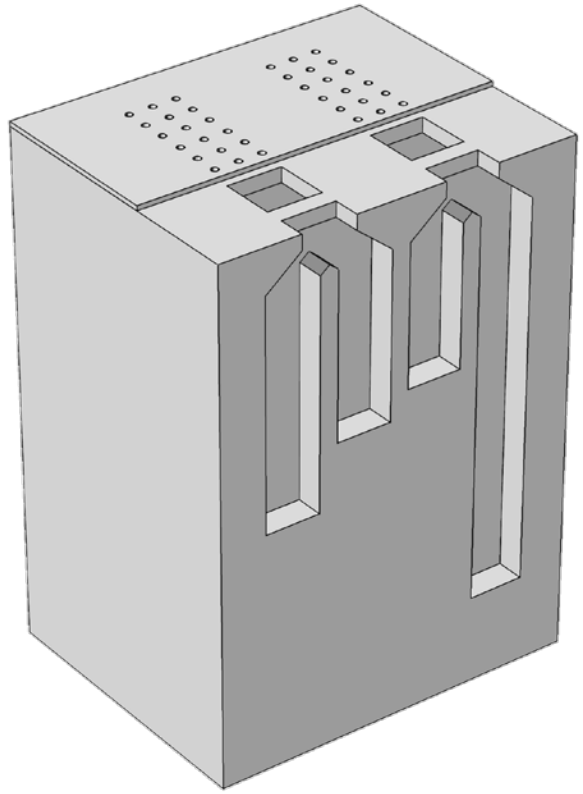

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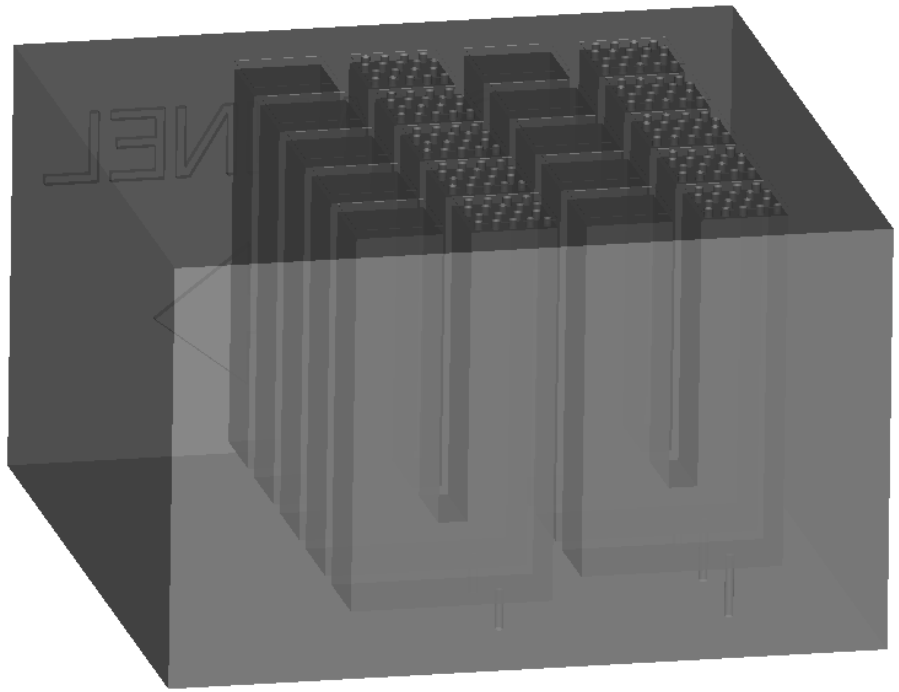

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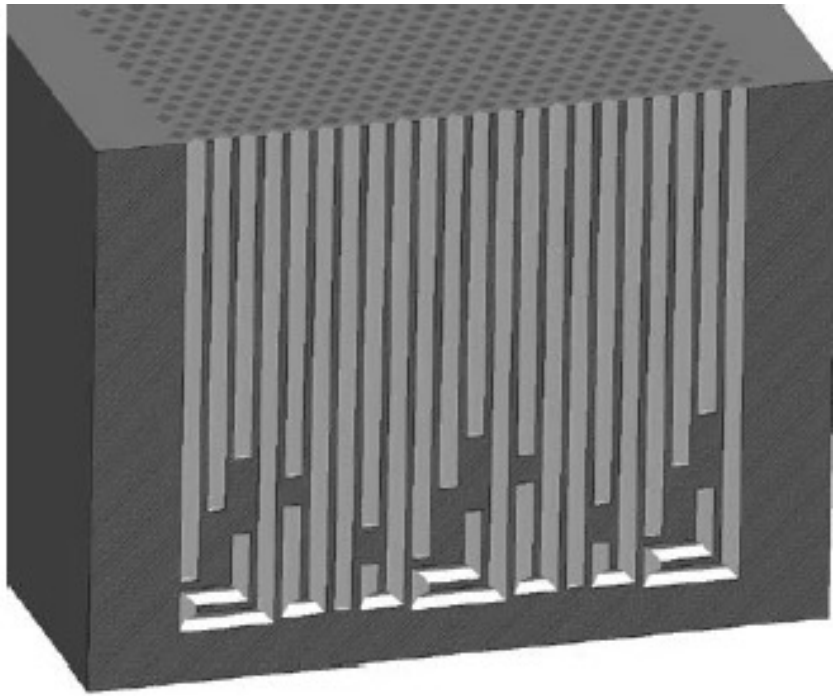

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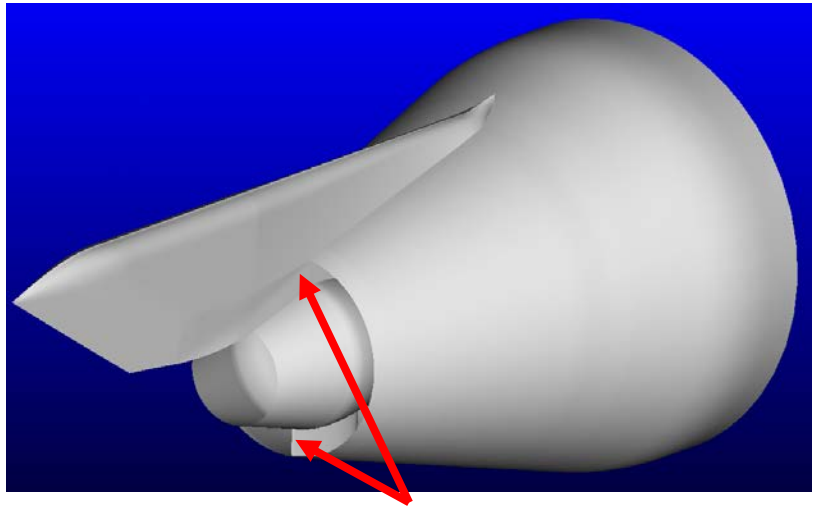
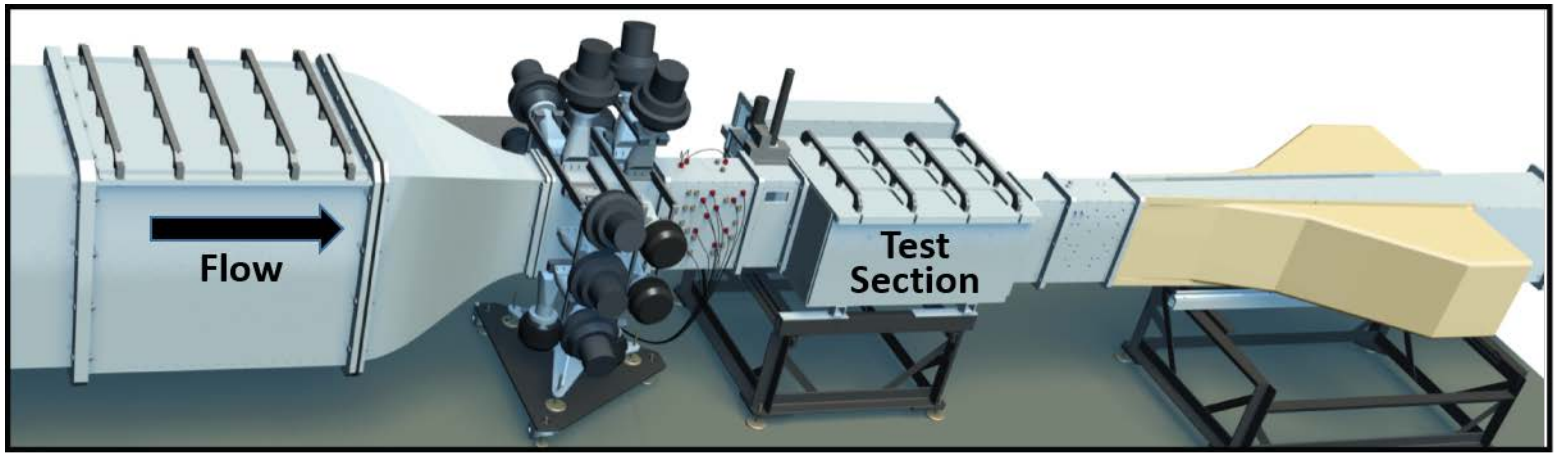
Acoustically Treated Bifurcations

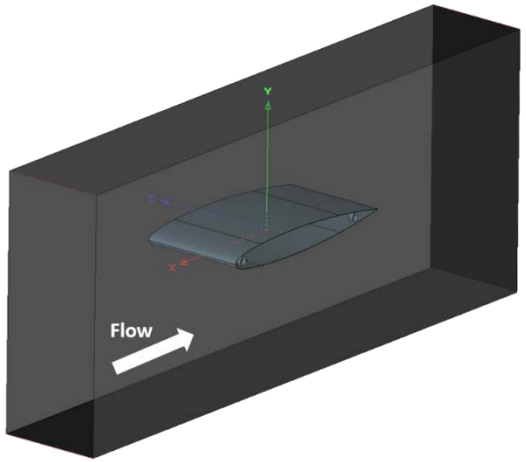


Bypass duct bifurcations



Curved Duct Test Rig (CDTR)

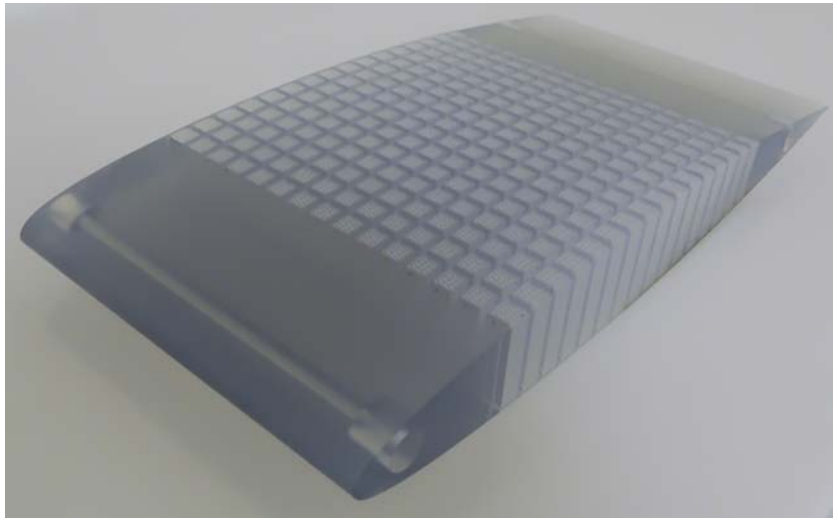
- Test Section: 6” x 15”
- M = 0.0, 0.25, 0.45
- Frequencies: [400:3000:200] Hz



Fundamental study of the effects of bifurcation treatment on simulated aft fan noise

Acoustically Treated Bifurcations

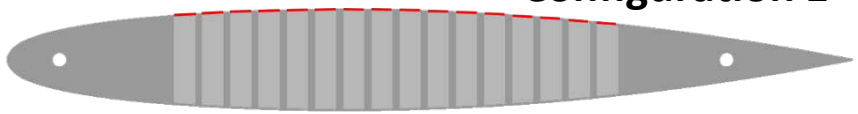
CDTR test samples
Profile: NACA0012-64



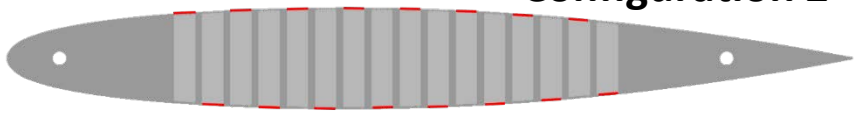
0.4” x 0.4” cells

- **15 Spanwise**
- **16 Chordwise**

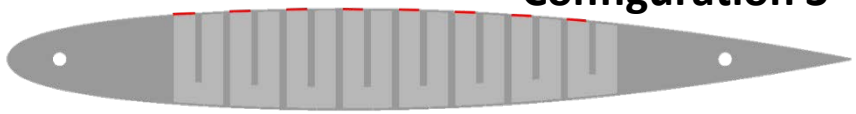
Configuration 1



Configuration 2



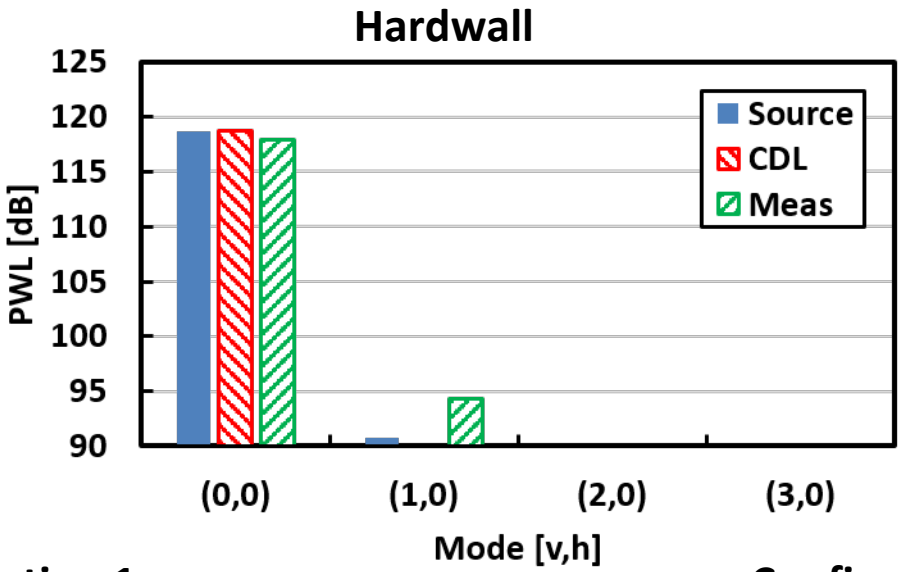
Configuration 3

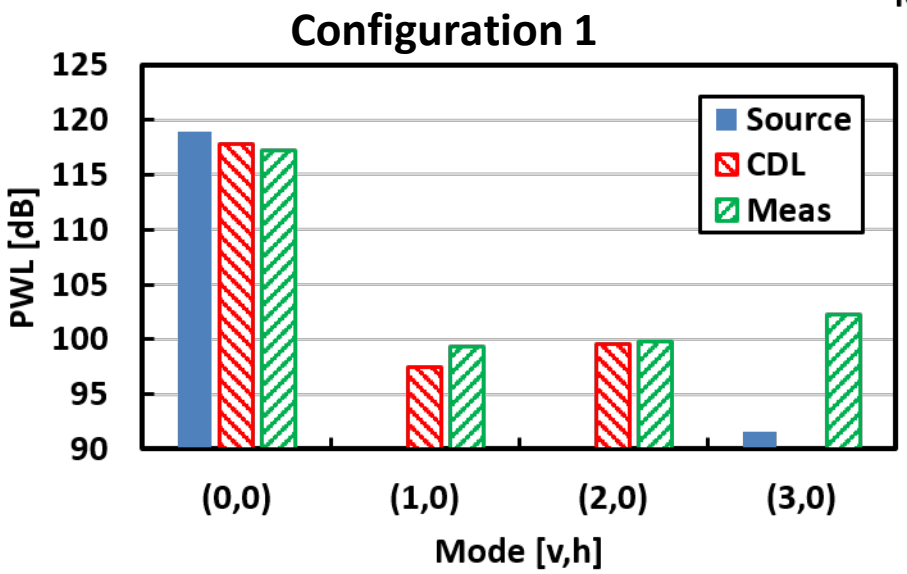


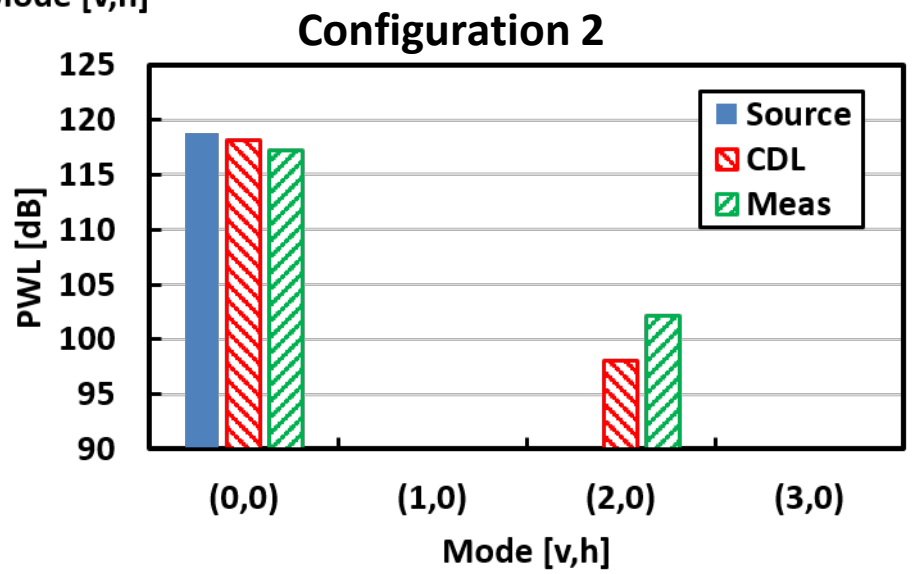
Configuration 4

Acoustically Treated Bifurcations: Slotted Core (CDTR)

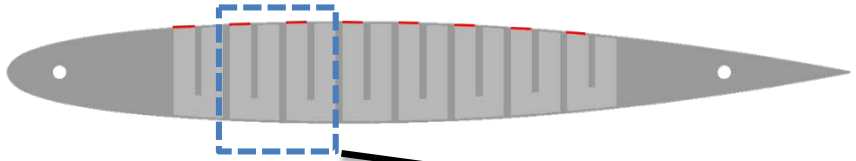
Plane Wave Source: f = 1600 Hz, M = 0.25



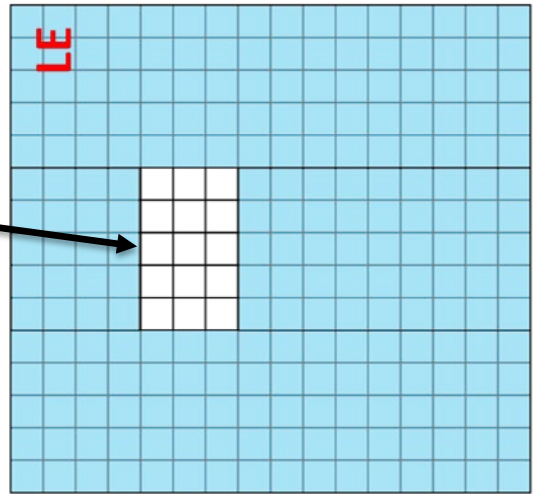


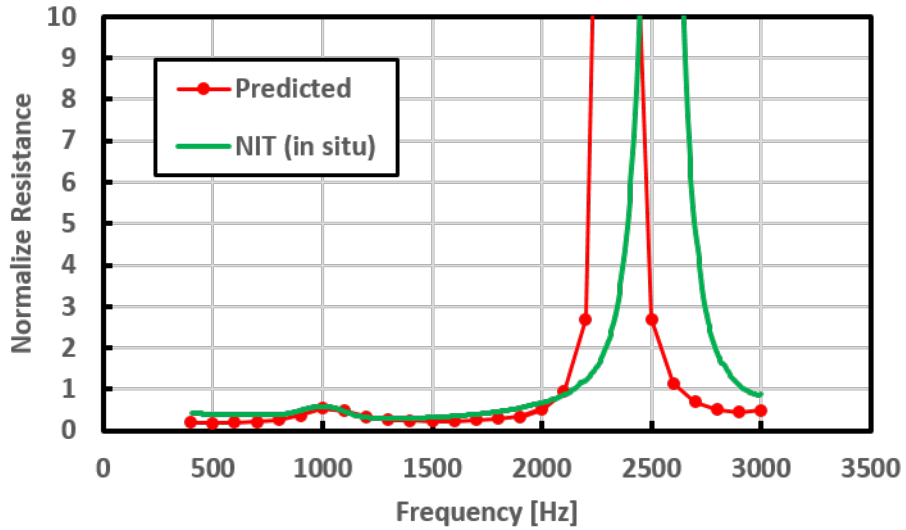


Configuration 3: Slotted Core (NIT)

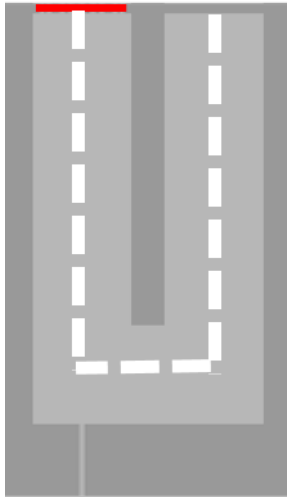


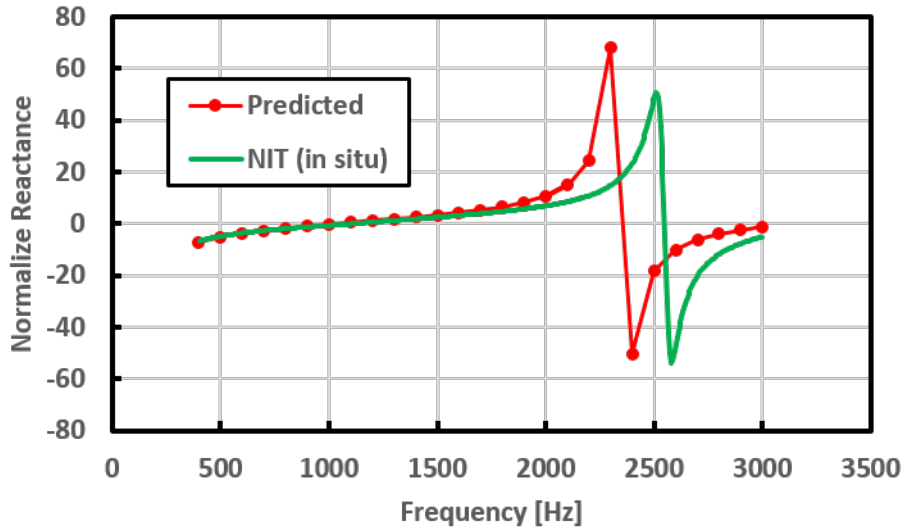
NIT (In situ)





- Centerline length of slotted core used to define ‘depth’
- Frequency of antiresonance under-predicted
- Possibly effect of sample curvature





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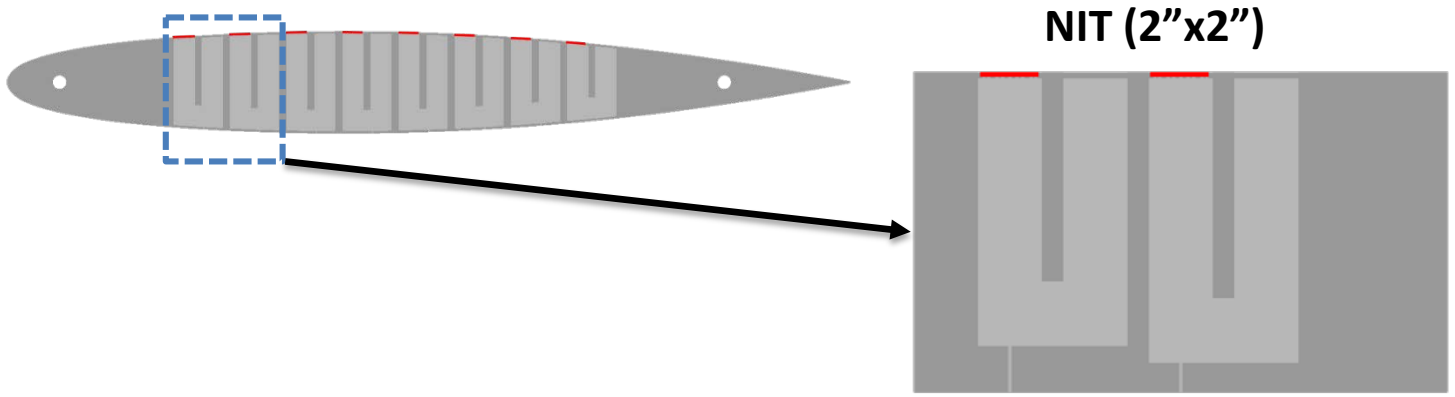
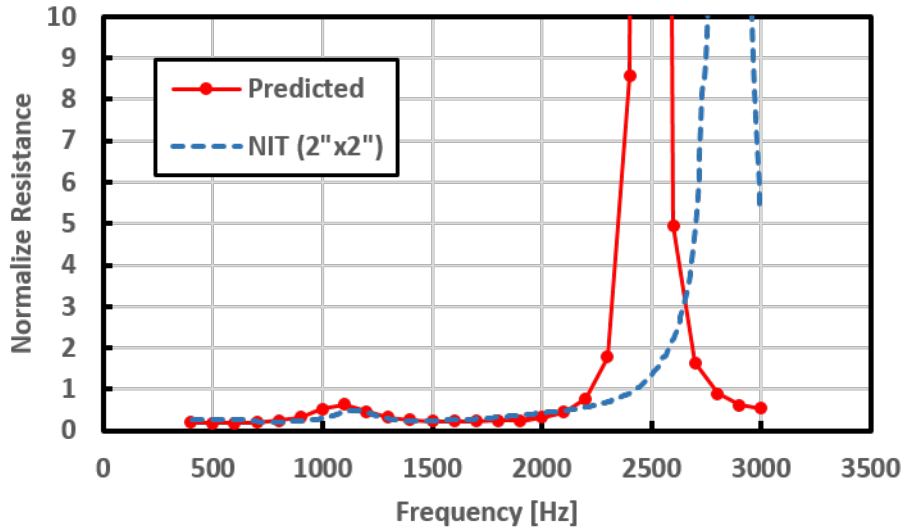
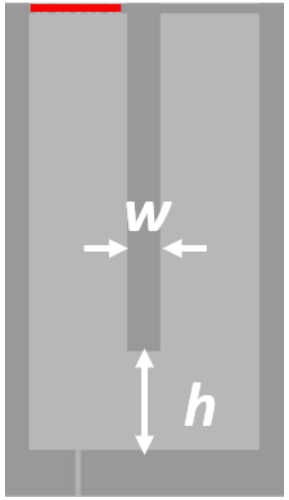
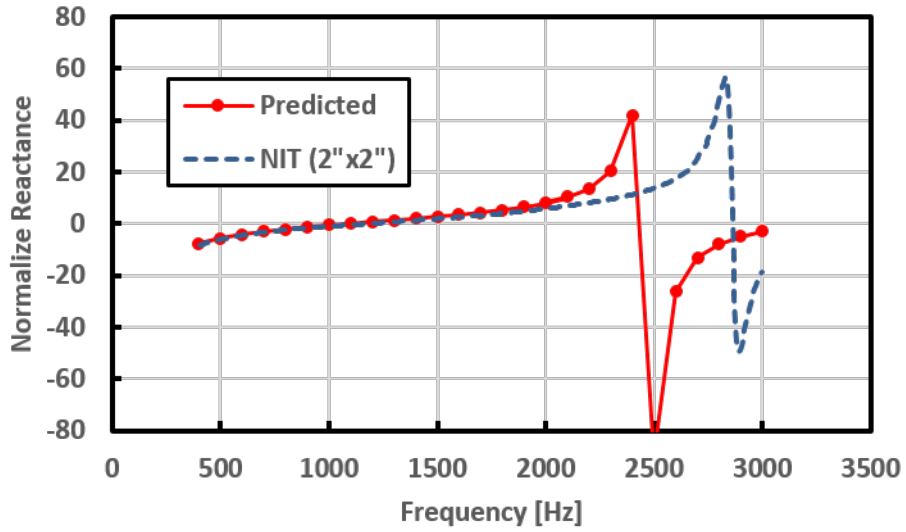


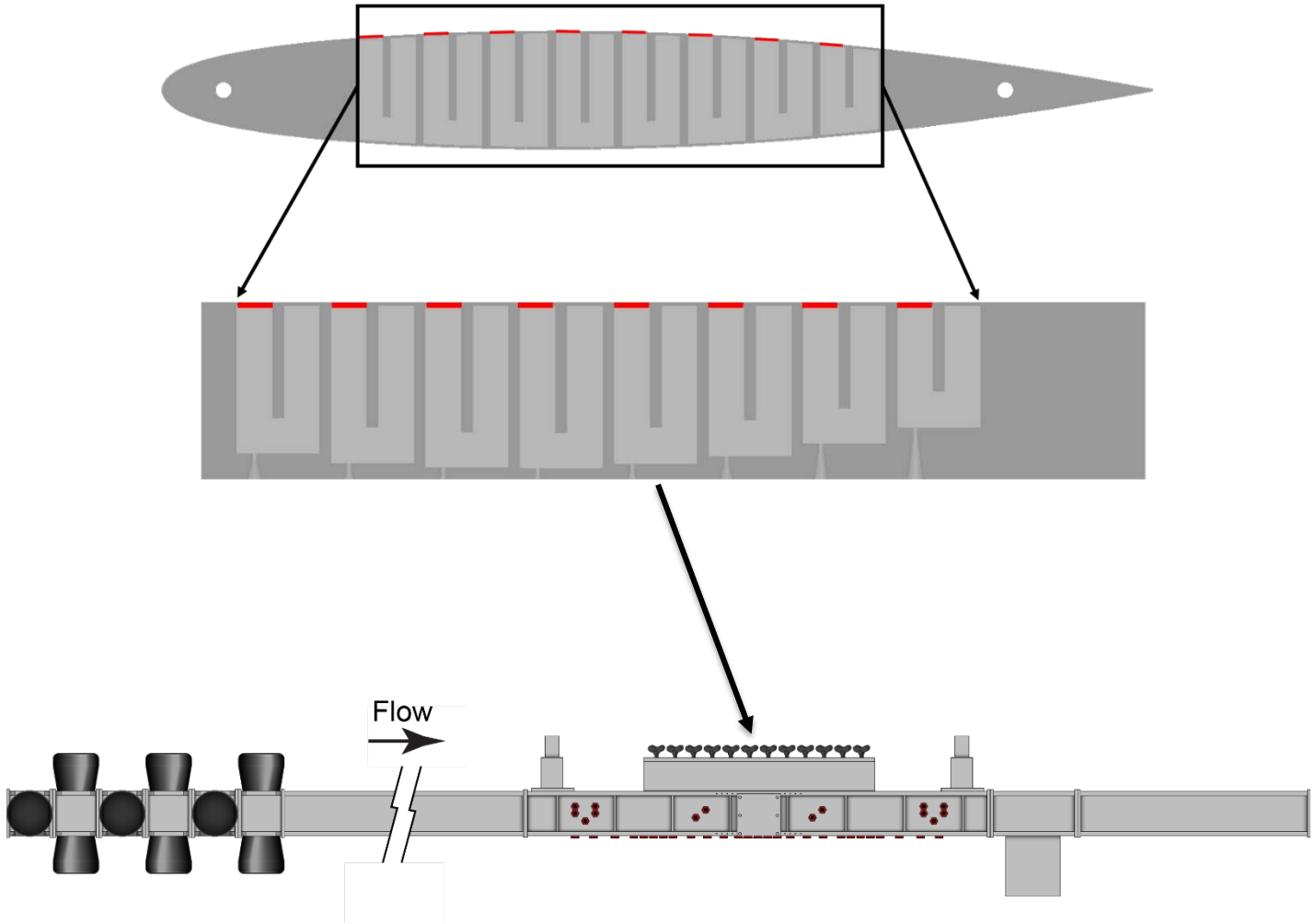


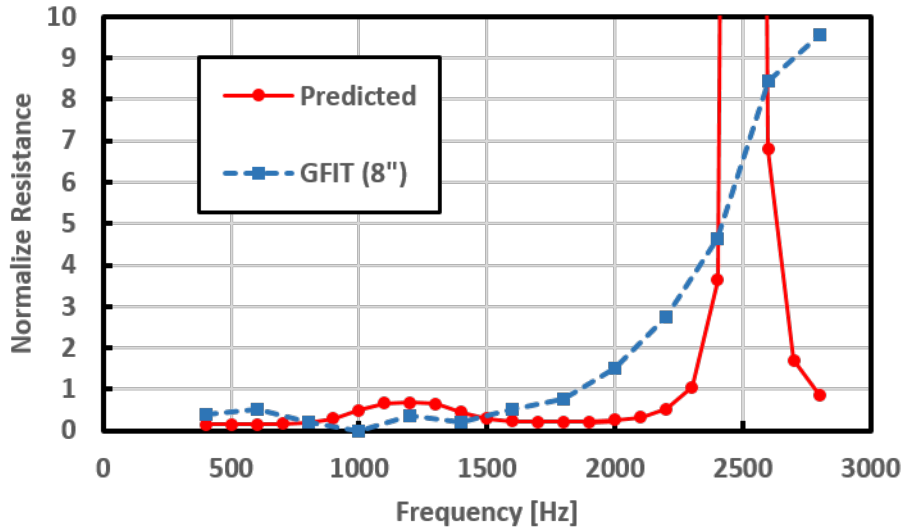
- Flat sample upper surface
- Frequency of antiresonance again under-predicted
- Seek updated estimate for “effective” cell depth

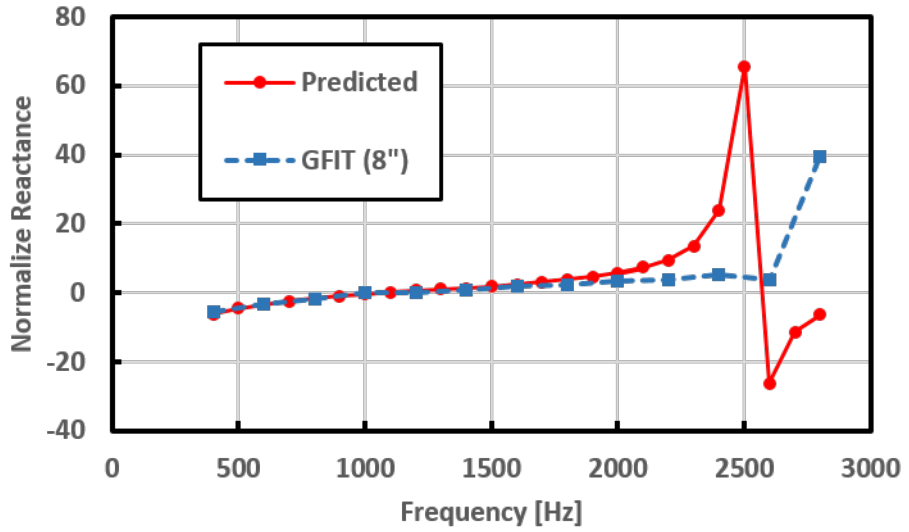




Acoustically Treated Bifurcations: Slotted Core (GFIT)



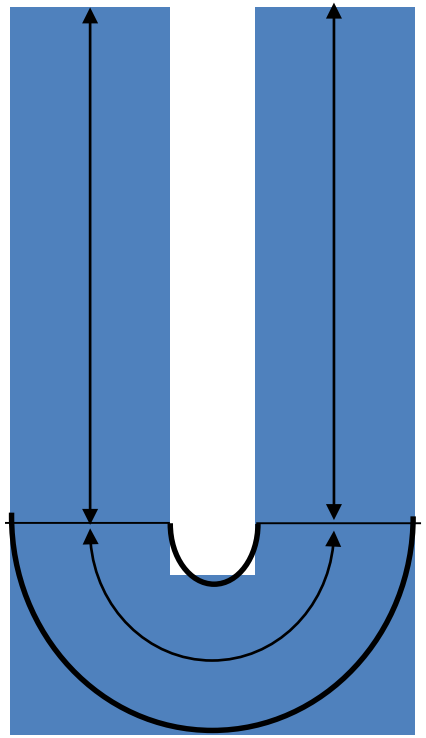


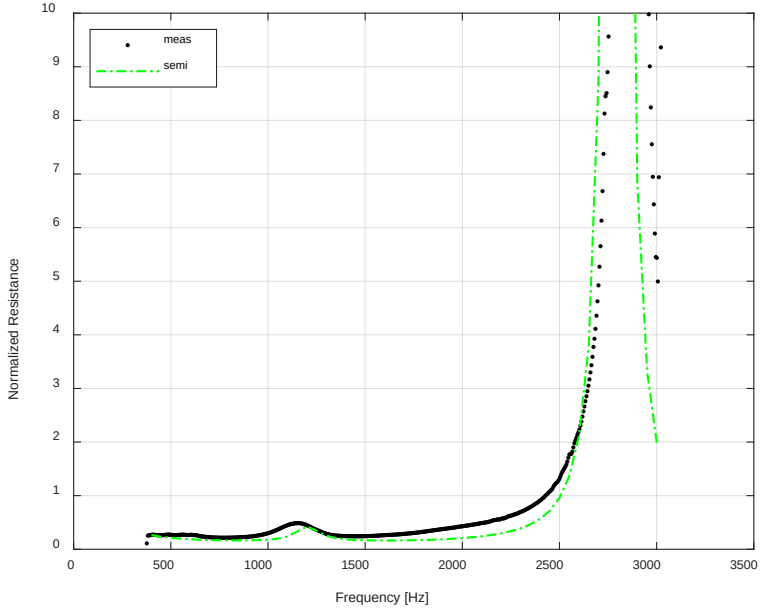


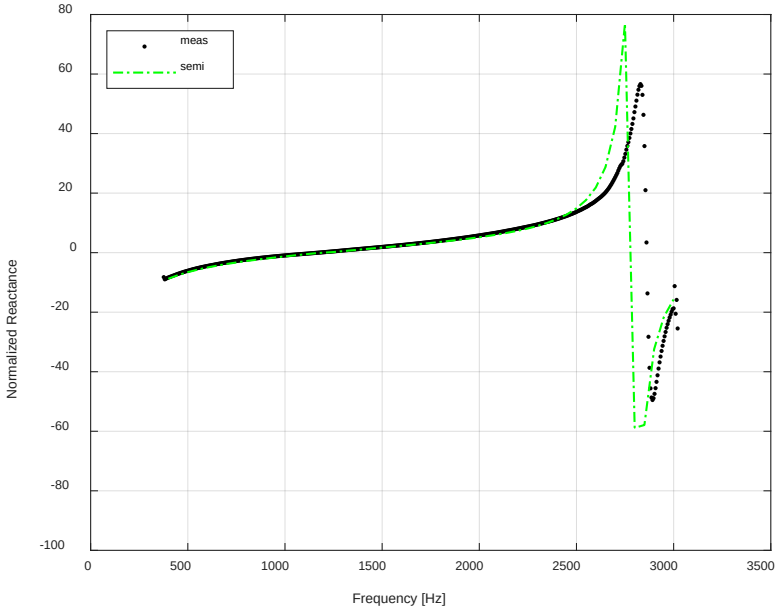
Acoustically Treated Bifurcations: Slotted Core

Updated Liner Model

- Seek semiempirical model for use in liner optimization
- Model with equivalent curved resonator (ref: Cummings)
- “Effective” cell depth based on mean radius of curved portion (shorter than previous estimate)
- Slotted core NIT results provide insights to antiresonance behavior

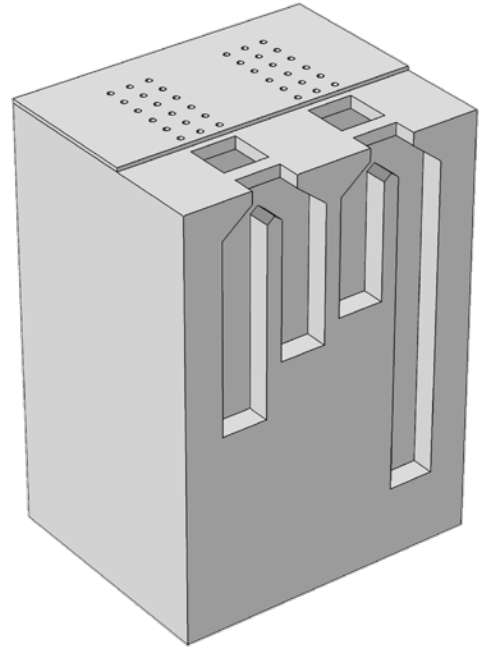


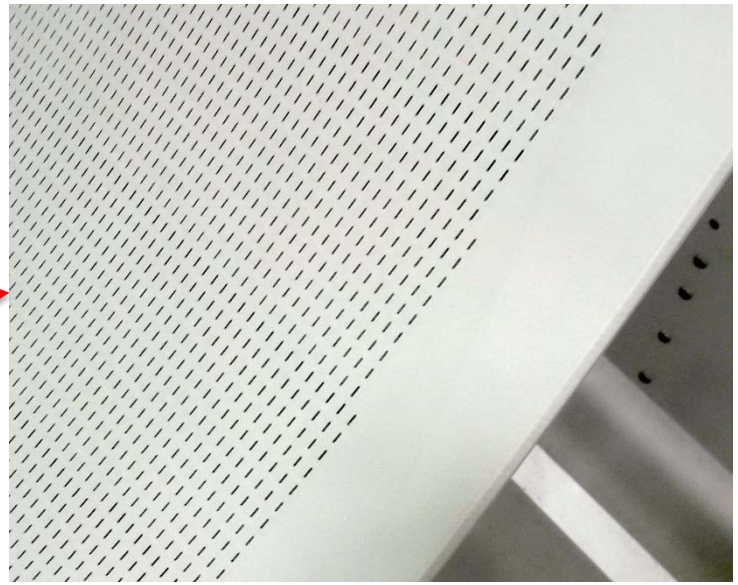




Additional Liner Concept Development

- **Low-drag concepts**
  - **Alternative facesheet designs (slotted facesheet: B737 MAX flight test)**
  - **Reduced POA (shared port)**
- **Investigating statistical methods to reduce liner drag measurement uncertainty in GFIT**
- **Shear stress sensor testing in CDTR**

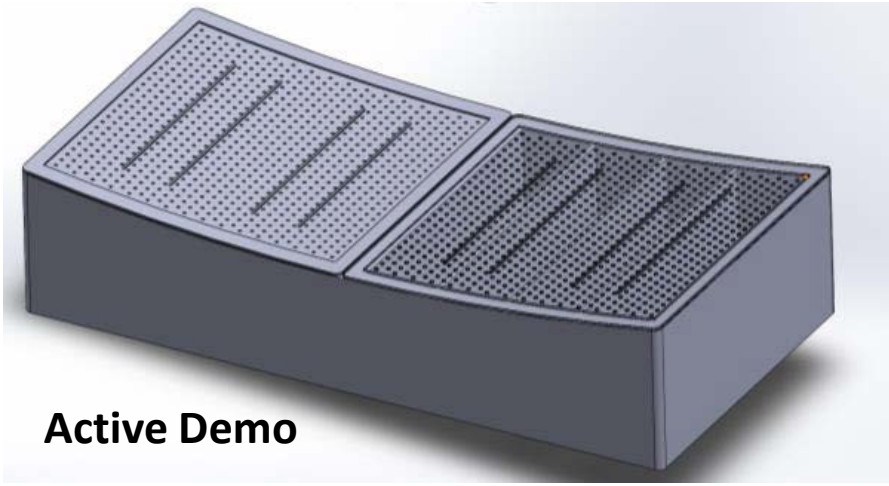




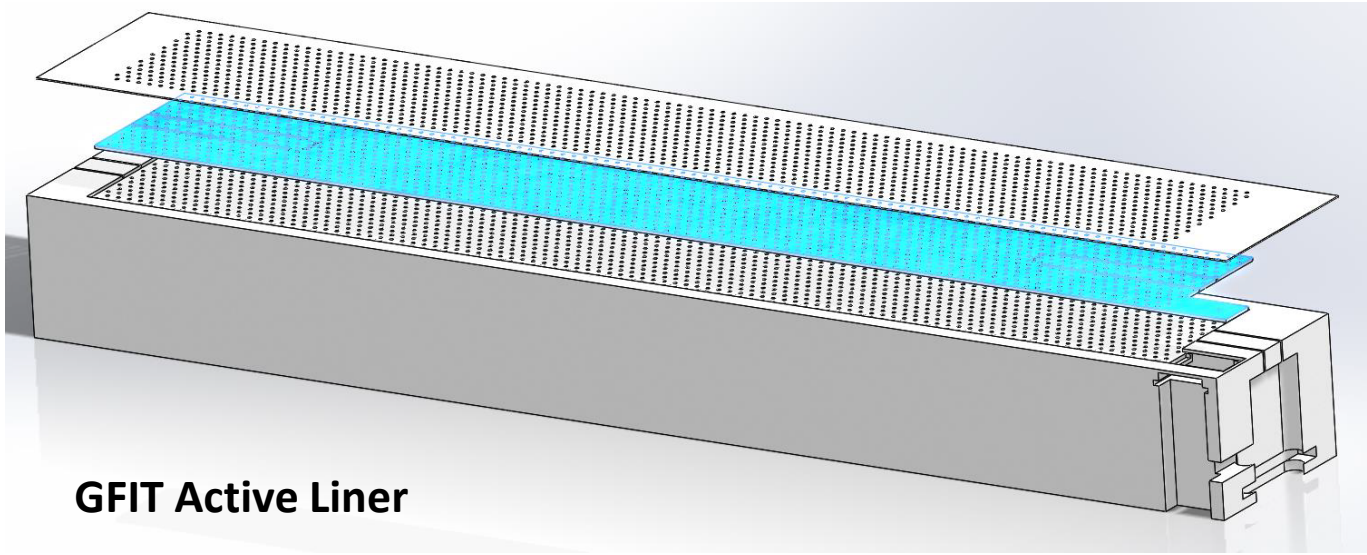
Additional Liner Concept Development

Active Liner (NRA: Boeing/FSU)

- Actively modulate impedance – variable hole size for drag reduction in cruise
- Active Demo: Incorporate curvature representative of aircraft system
- GFIT Active Liner: Acoustic test in representative environment (Mach 0.5, 140 to 150 dB)



Active Demo

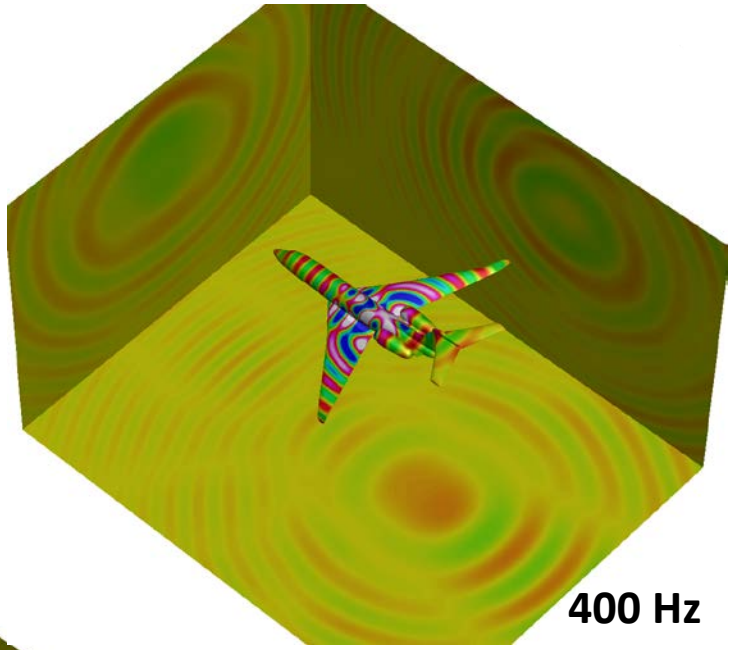


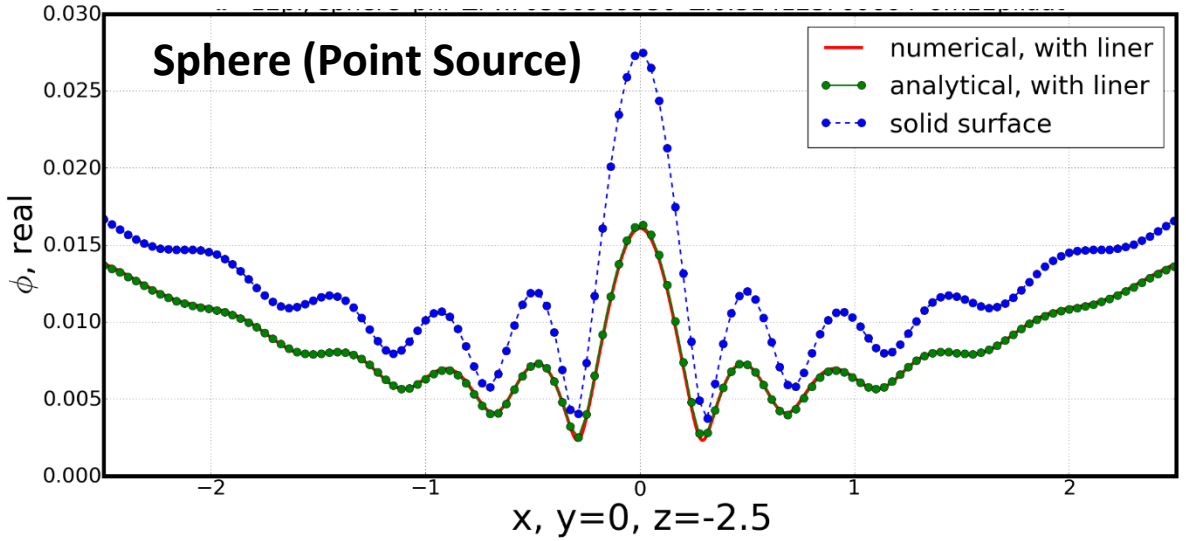
GFIT Active Liner

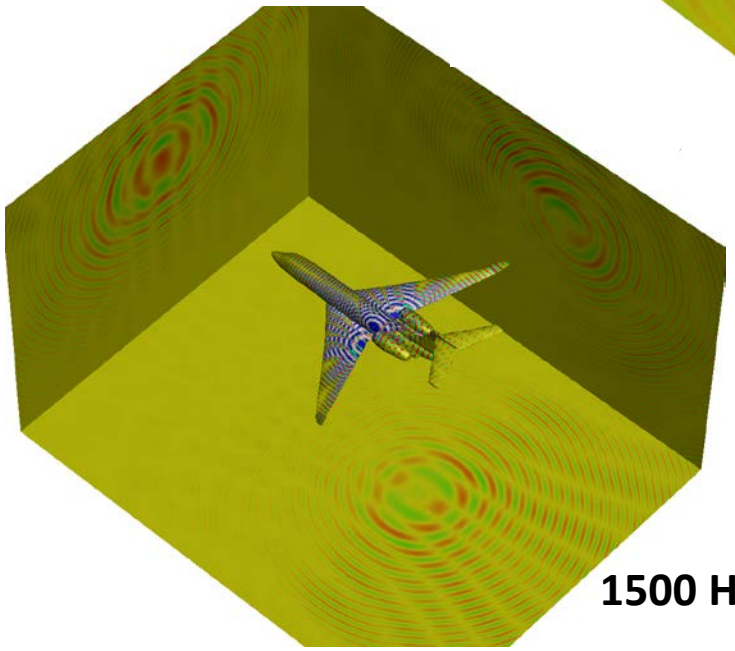
Additional Liner Concept Development

External liner evaluation

- Time-domain (Time Domain Fast Acoustic Scattering Toolkit: TDFAST) and frequency-domain (Fast Scattering Code: FSC)
- Validation via comparison with analytic solution and measured results (QFF, LSAWT)
- Full-scale predictions to assess external liner impact







External Collaborations

- NRA – Adaptive Liner (Boeing/FSU)
- International Agreement (ONERA) – Impedance BC investigation
- NASA/ONERA IA: Dr. Frank Simon (ONERA) has begun a one-year sabbatical at NASA LaRC. Collaboration regarding liner analysis and novel liner concepts has begun.
- International Forum for Aviation Research (IFAR): Special session at AIAA 2019 Aeroacoustics Conference regarding measurement methods, 3D propagation code evaluation, and multizone impedance eduction
- ODU (NIA) – Implementing acoustic liners into scattering calculations
- Vold LLC – Implement swept sine source for GFIT

<u>Space Act Agreements</u>

- Boeing – GFIT tests of novel liners
- GE Aviation – Conducting GFIT tests with Phase 2 samples
- Hexcel – Evaluate embedded mesh-cap and slotted-core liner concepts
- UTAS – GFIT tests of novel liners
- WSU – Investigation of metallic foams

References

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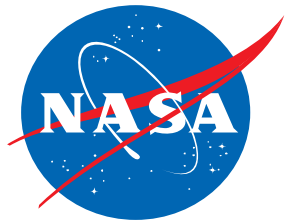

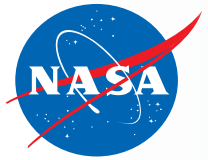

Backup Slides

Acknowledgements

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