



Liner Technology Research Progress

Michael Jones
NASA Langley Research Center
Acoustics Technical Working Group Meeting
Hampton, VA
October 23 – 25, 2012

Outline



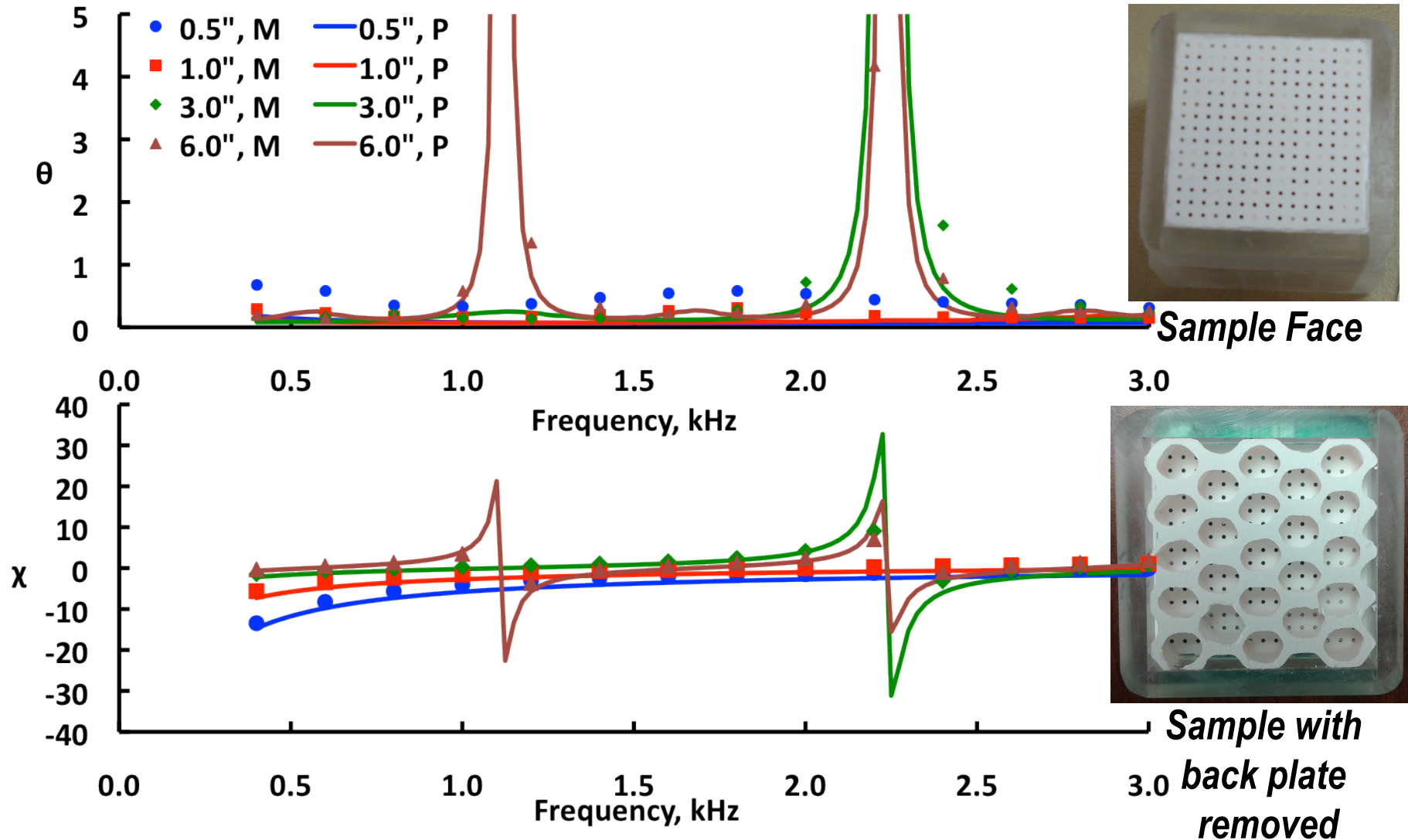
- Research Areas
 1. Liner Impedance Prediction
 2. Develop and Validate Propagation/Radiation Codes
 3. Evaluate Liner Acoustic Performance and Drag
 4. Liner Optimization Studies
- External Collaborations
- Research Team
- References

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CMC Core Liner (NIT: Predicted vs Measured)



Next: Test of variable-depth CMC liner in GFIT (Jones)



Liner Impedance Prediction

Other Key Activities

- Developed/validated enhanced MDOF impedance prediction model
- Initiated research in Metamaterials area

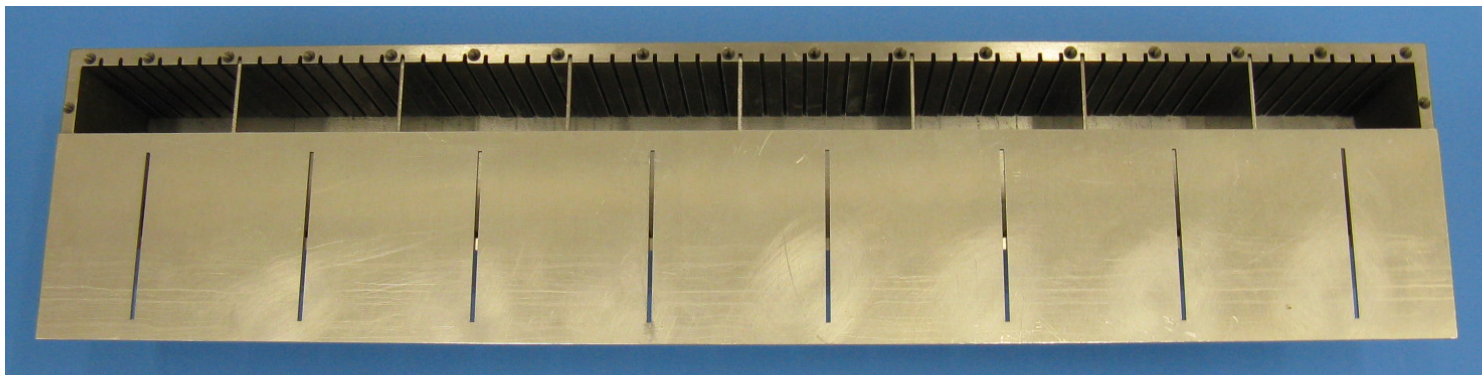
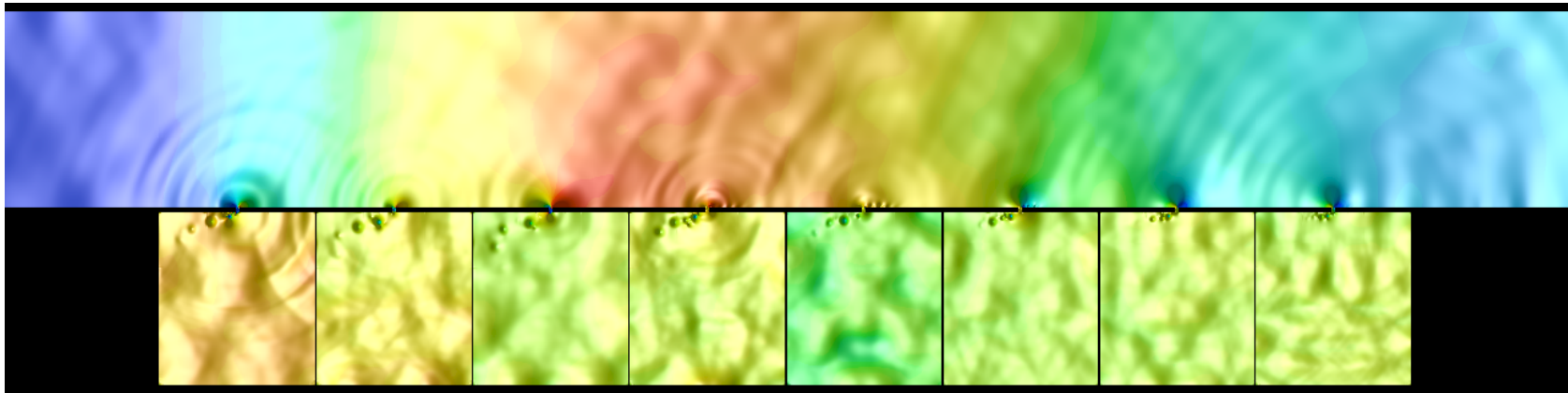
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DNS Simulation Validation

- Comparison of simulations (DNS) and measurements (GFIT) of 8-cell slit liner (AIAA-2013, Tam)



(Tam, Jones, Watson)

Propagation/Radiation Codes



Other Key Activities

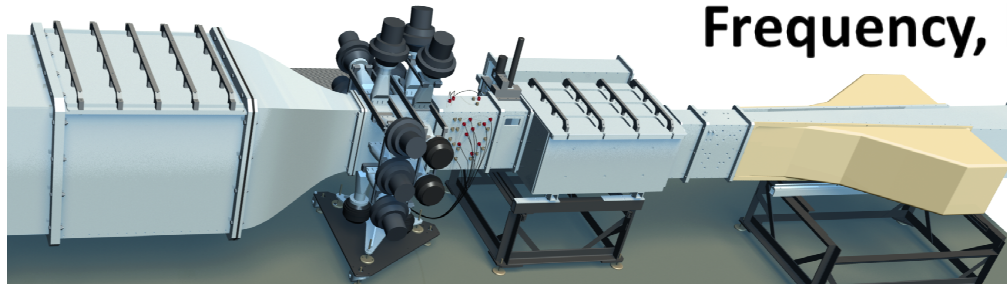
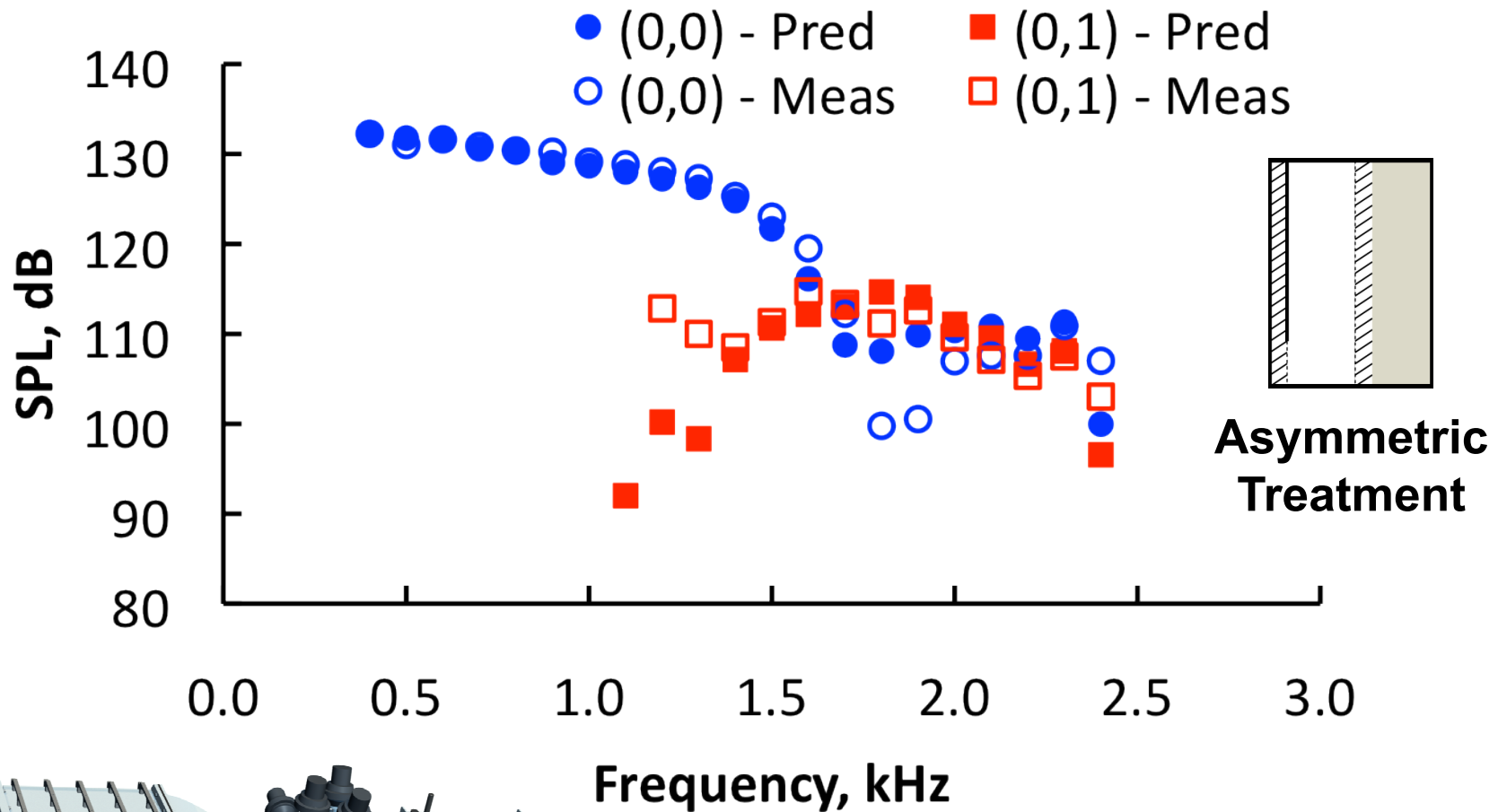
- Coupled CHQ3D and CDL duct propagation codes into single computational framework (multi-fidelity code)
 - Validate via comparisons with ANCF test data
 - Compare with ONERA predictions
 - Use for active liner analysis
 - Biologically inspired approach
 - Control impedance via cell-to-cell communication
- Implementing Linearized Navier-Stokes for propagation within liner & duct

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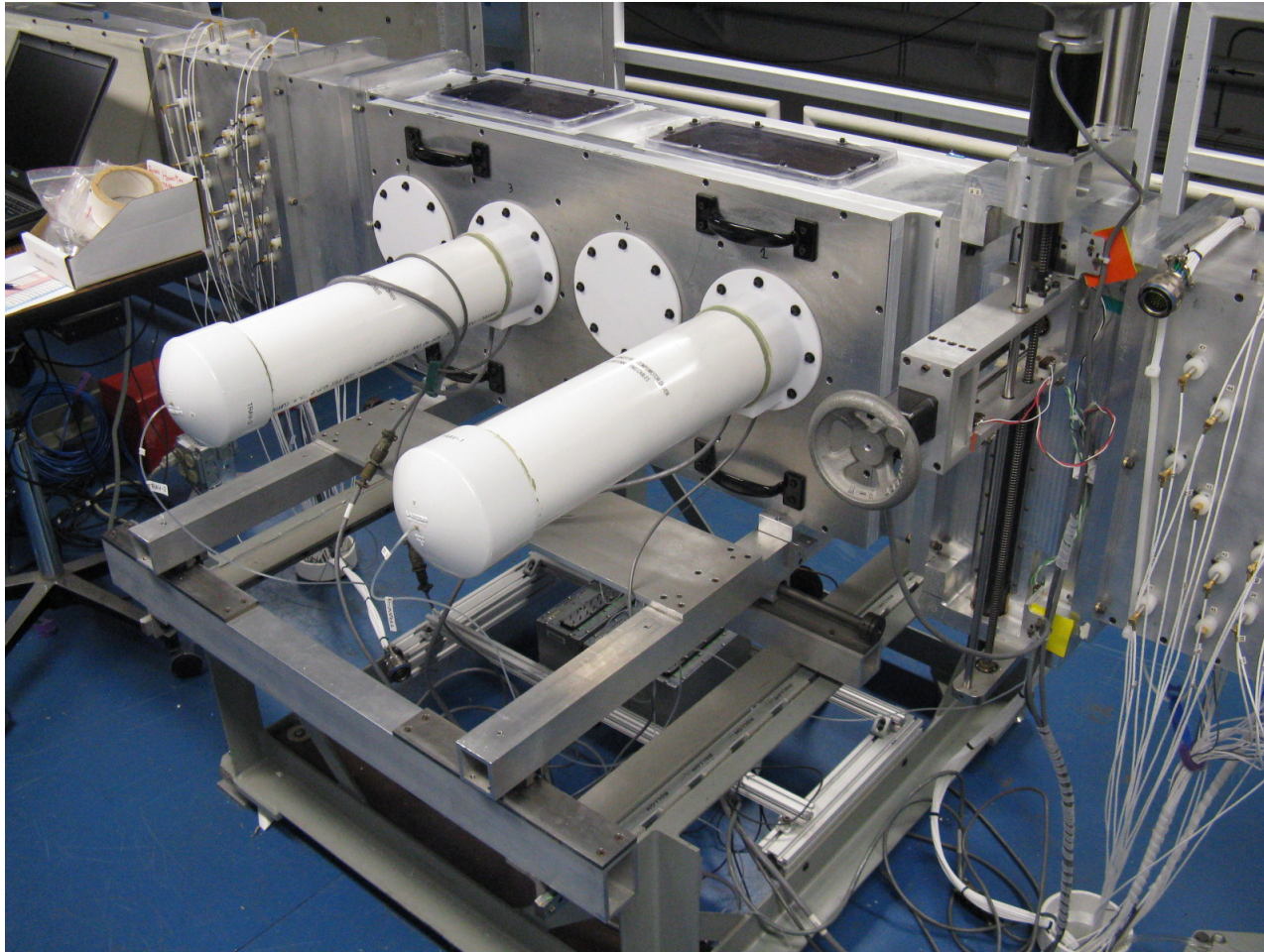
Mode Scattering (Predicted vs Measured)



**AIAA-2012-2245
& AIAA-2013
(Gerhold)**

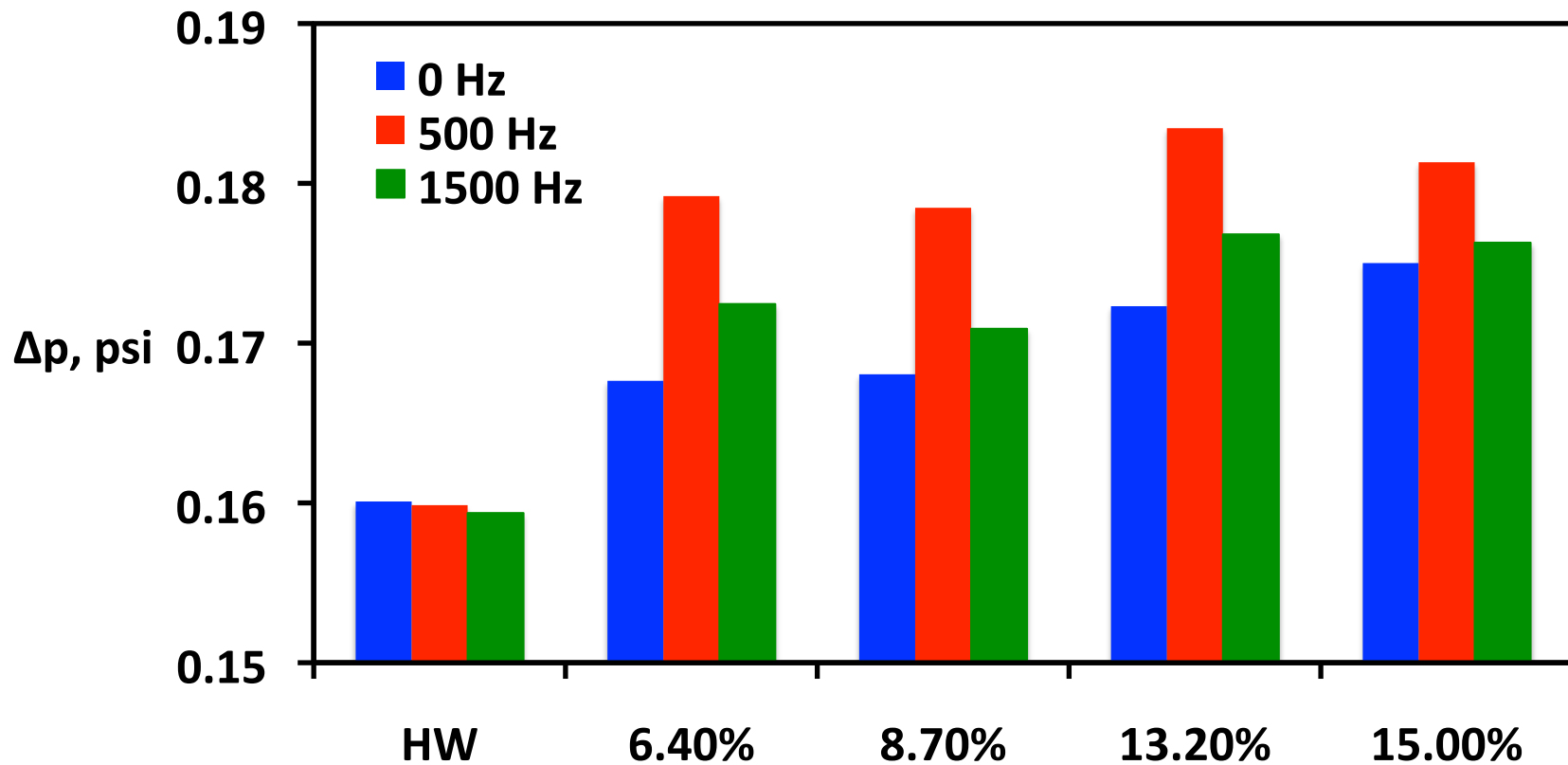
Liner Drag (CDTR Measurement Method)

- Implemented two traverse probe systems to measure boundary layer profiles directly over liner



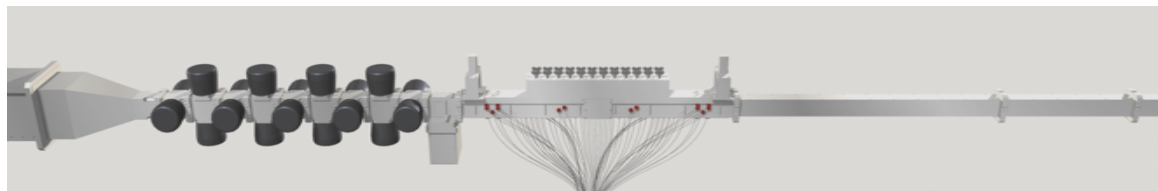
(Gerhold, Howerton, Brown)

Liner Drag (GFIT tests)



Implemented approach for quick evaluation of relative drag

(Jones, Howerton)



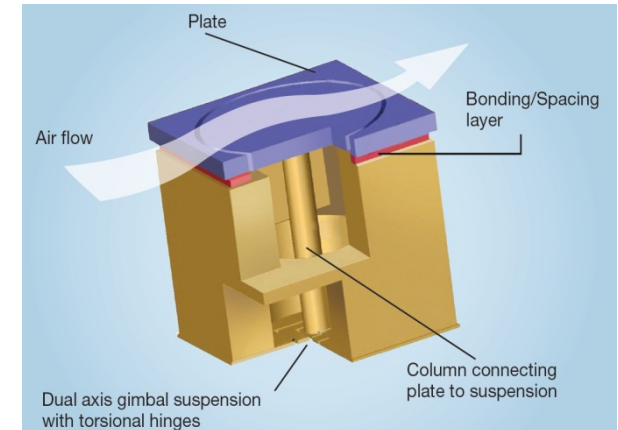
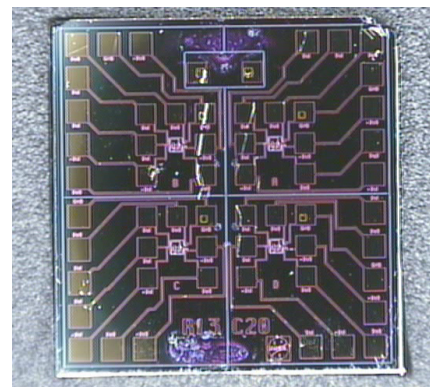
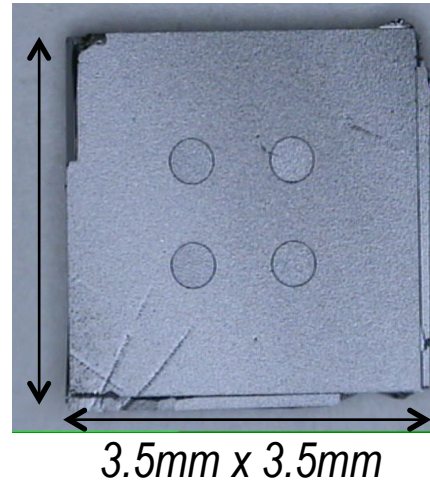
Shear Stress Sensors



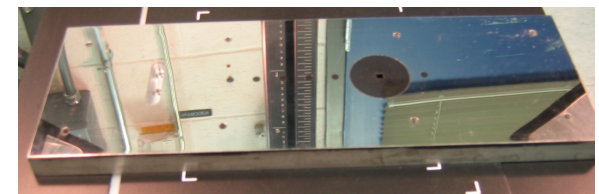
*NASA two component sensor: single device concept
and front and back view of die with four devices*



*Commercially available shear
stress measurement system*



*Top of flow channel used for
sensor characterization*



(Scott, Adcock)

Evaluate Aeroacoustic Performance of Liners



Other Key Activities

- Upgraded CDTR
 - Instrument lid for impedance eduction
 - Increase # microphones
 - Implement control system to increase max freq to ~3 kHz
- Implemented impedance eduction methods based on Prony and Mode-Matching equations
(*Watson presentation*)
- Univ of Florida shear stress sensor test in CDTR
(*Sheplak presentation*)

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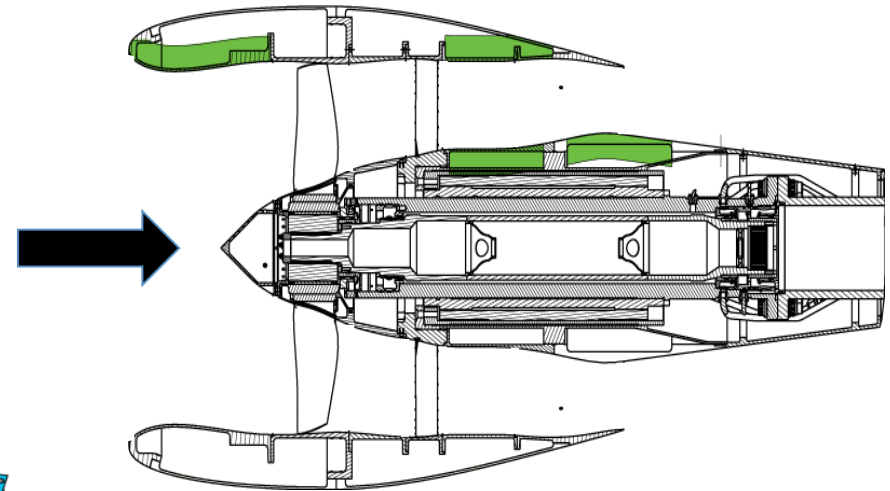
Liner Optimization Studies



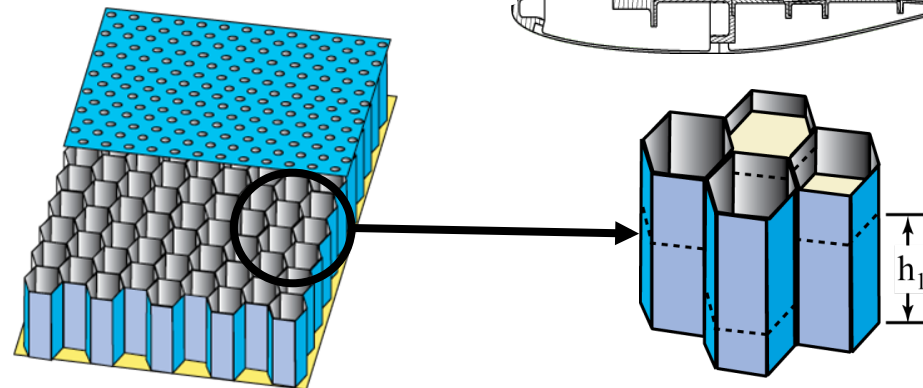
CDUCT-LaRC Acoustic Propagation/Radiation

NASA/GE Source Diagnostic Test (SDT) Fan

- Mean Flow: 1D Mach-Area
- Acoustic Source: All cut-on modes
 - Random Amplitude/Phase
 - Example: At Approach Mach number:
 - **35 modes** at 2863 Hz (BPF @ Approach)
 - **231 modes** for 9282 Hz (2BPF @ T/O)
- Acoustic Treatment: Locally Reacting



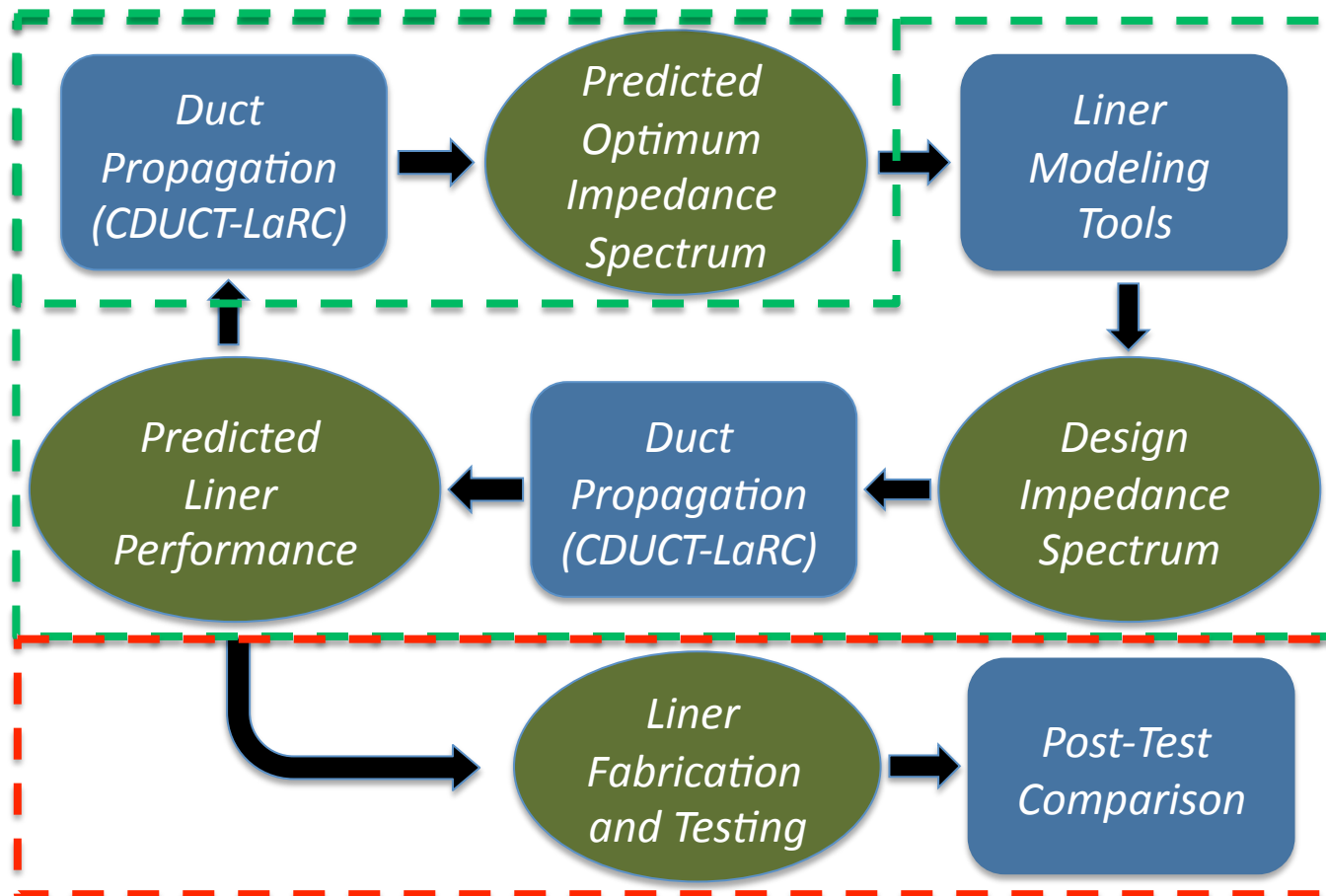
Liner Design



Establish process to design/evaluate novel broadband liner concepts



Liner Optimization Studies



**AIAA-2012-2195
(Nark)**

- Used SDT geometry to establish approach
- Used process to establish Fixed Wing Project interim goals
- Planned usage: ANCF tests (2012 & 2013), P&W GTF fan rig test (2014)



External Collaborations

- GRC Acoustics Branch
- Space Act Agreements: Boeing, Goodrich, Hexcel
- International Agreement: ONERA
- NRA
 - University of Florida (shear stress sensors)
 - Old Dominion University (acoustic scattering)
- SBIR Phase II:
 - Cornerstone Research Group/University of Cincinnati (drainage slot effects)
- Seedling Fund Activities
 - Johns Hopkins University (adaptive liner back plate)
 - GRC (multi-functional low pressure turbine)



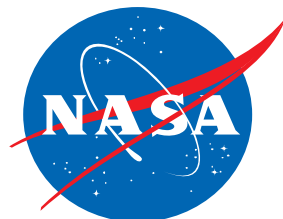
Research Team

- LaRC Branches
 - Structural Acoustics
 - Aeroacoustics
 - Computational Aerosciences
 - Supersonic/Hypersonic Testing
 - Electromagnetics and Sensors
 - Advanced Sensing and Optical Measurements
 - Flow Physics and Control
- Northrop Grumman Corporation



References

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2. M. Jones, B. Howerton, E. Ayle: "Evaluation of parallel-element, variable-impedance, broadband acoustic liner concepts," AIAA-2012-2194, June 2012.
3. B. Howerton, M. Jones, J. Buckley: "Development and validation of an interactive liner design and impedance modeling tool," AIAA-2012-2197, June 2012.
4. W. Watson, M. Jones: "Investigation of a modified Ingard-Myers boundary condition for use in impedance eduction," AIAA-2012-2199, June 2012.
5. D. Nark, M. Jones: "Broadband liner optimization for the source diagnostic test fan," AIAA-2012-2195, June 2012.
6. C. Gerhold, M. Brown, M. Jones, B. Howerton: "Configuration effects on liner performance," AIAA-2012-2245, June 2012.
7. M. Brown, M. Jones, W. Watson: "Uncertainty analysis of the grazing flow impedance tube," AIAA-2012-2296, June 2012.



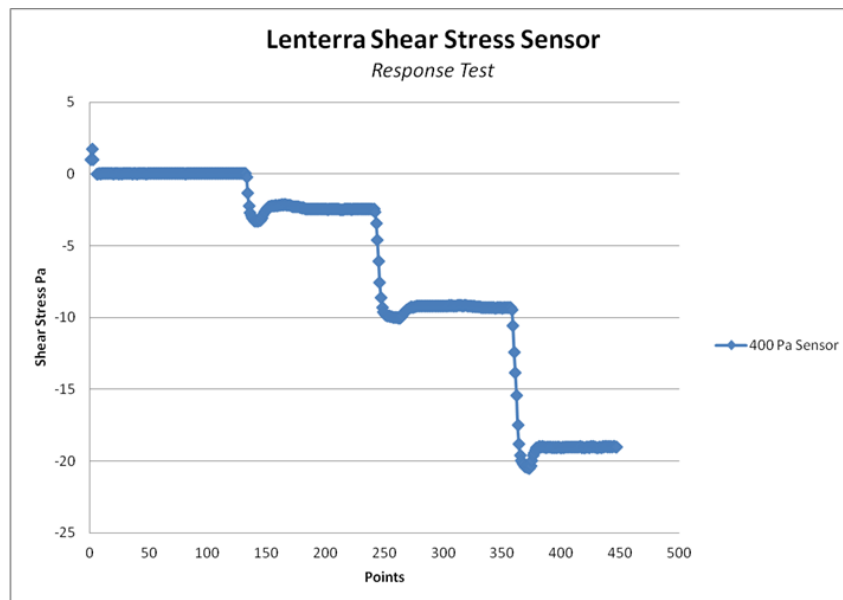
Backup Slide



Shear Stress Sensor Testing in Flow Channel to Support Liner Drag Studies



400 Pascal commercial shear stress sensor time series versus calculated shear stress in flow channel



Langley two component shear stress sensor output versus calculated shear stress in flow channel

