

Development of a Procedure for Impedance Education With the CDTR

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Acoustic Technical Working Group Meeting

Ohio Institute of Aerospace

April 29-30, 2010

Cleveland, Ohio

Outline

- Motivation
- Three procedures for determining impedance
- Impedance education procedure for GFIT
- Advantages of impedance education in CDTR
- New challenges introduced by CDTR
- An impedance education procedure for CDTR
- Results using synthesized data
- Conclusions
- Future Plans

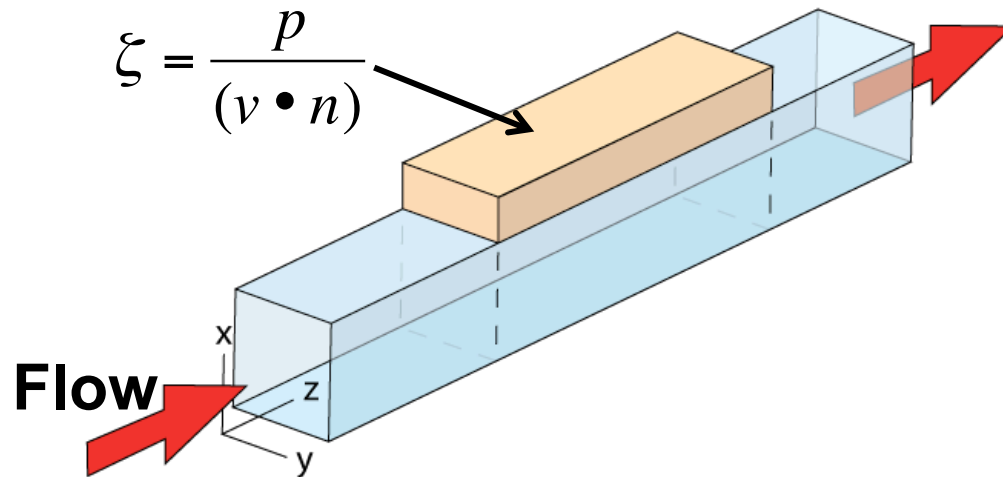
Motivation



Nacelle Liner with
impedance, ζ

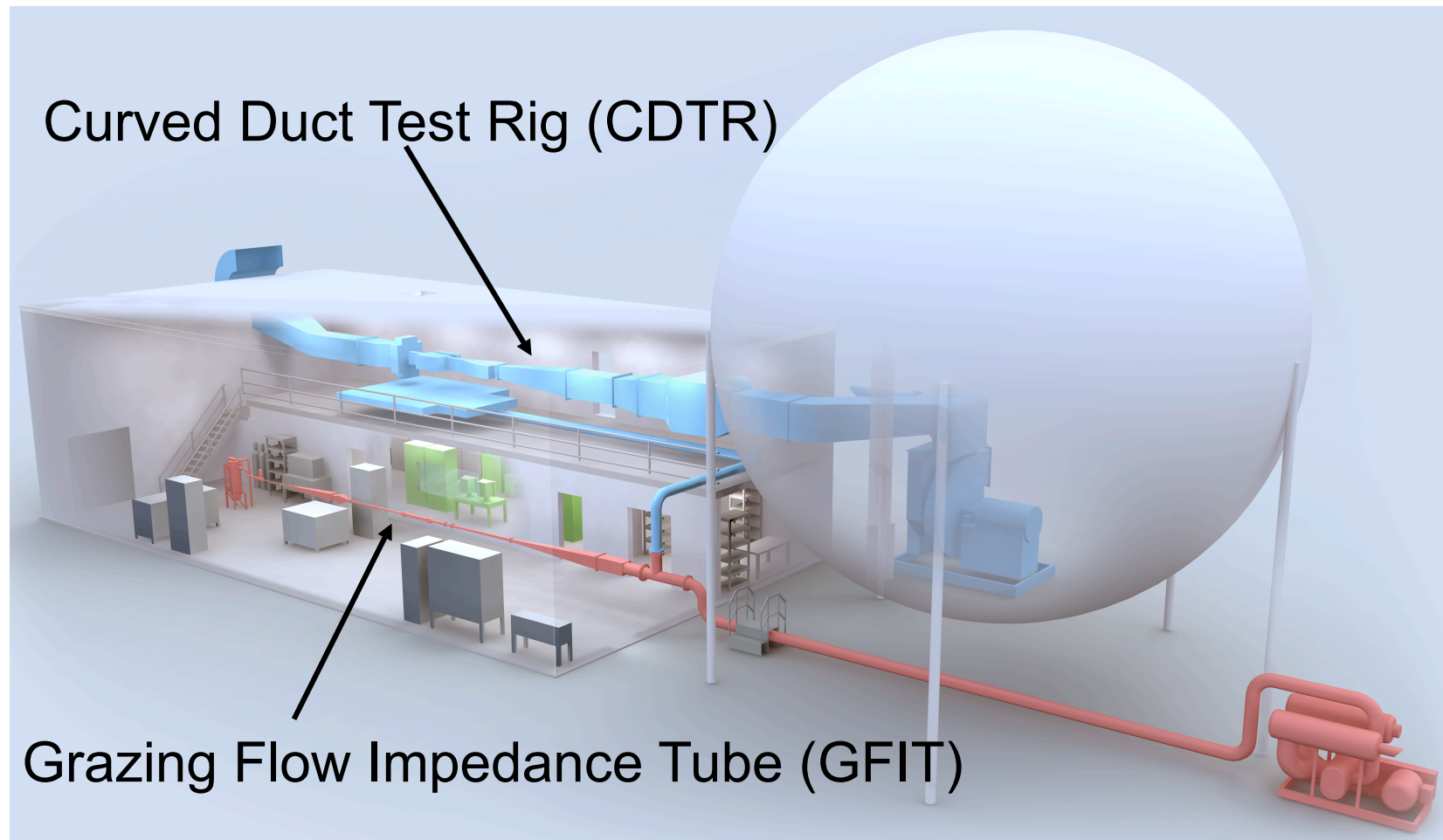
- Knowledge of **acoustic impedance critical** for low noise design
- Quantification of the **effects of grazing flow** remains a major problem

Impedance Prediction Methods

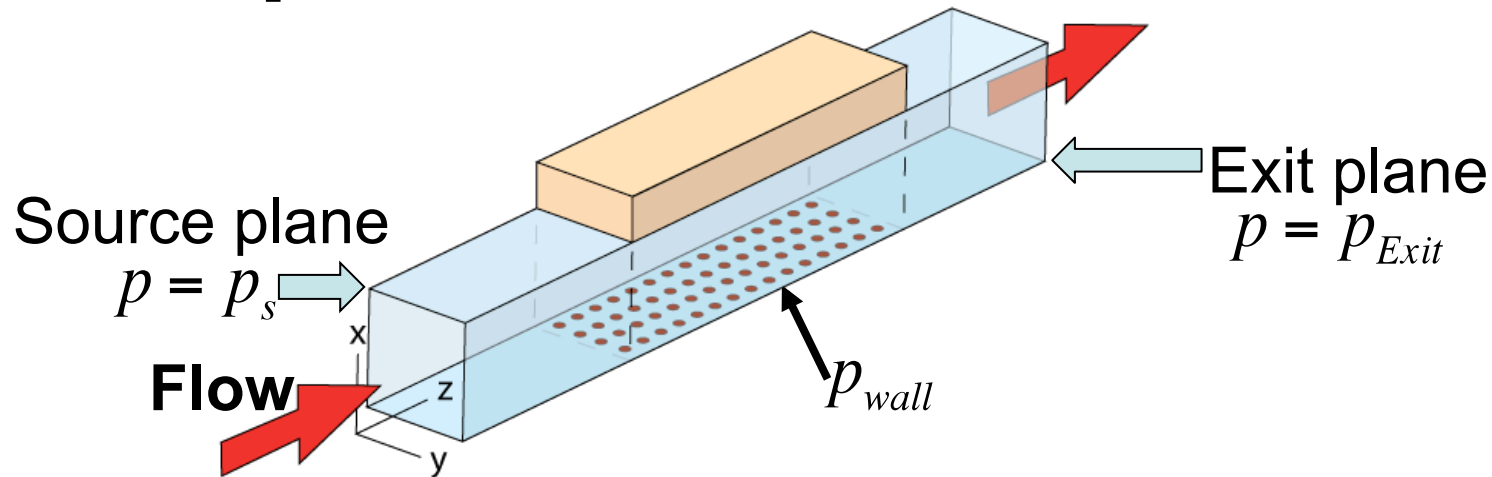


- Impedance prediction models (use the liner geometry and mean flow to predict ξ)
- Measurements (use a measurement of p and $v \cdot n$ to determine ξ)
- Impedance eduction (combine measurements and computation to determine ξ)

LaRC Liner Technology Facility



Impedance Education in GFIT

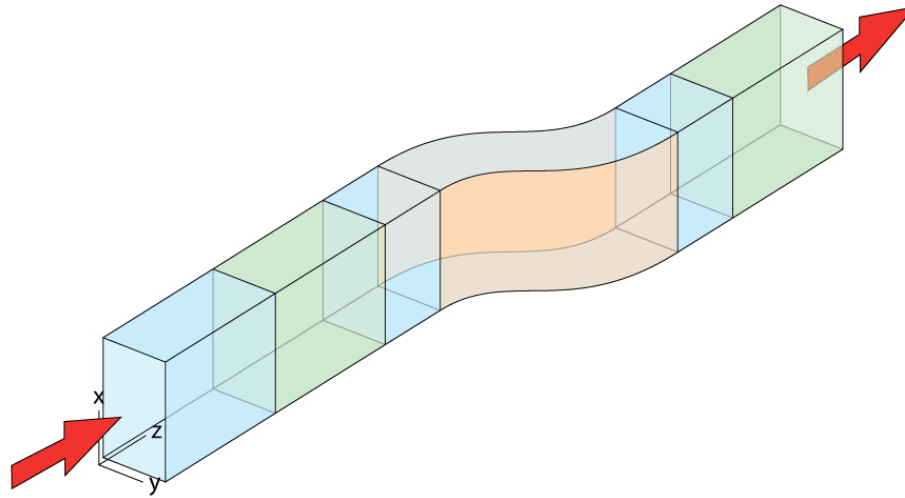


$$\frac{D^2 p}{Dt^2} - c^2 \nabla^2 p = 0; \text{ Source BC } \Rightarrow p = p_s; \text{ Exit BC } \Rightarrow p = p_{Exit};$$

$$\text{Wall BC } \Rightarrow \nabla p \cdot n = ik \left(\frac{p}{\zeta} \right) + 2M \frac{\partial}{\partial z} \left(\frac{p}{\zeta} \right) + \frac{M^2}{ik} \frac{\partial^2}{\partial z^2} \left(\frac{p}{\zeta} \right)$$

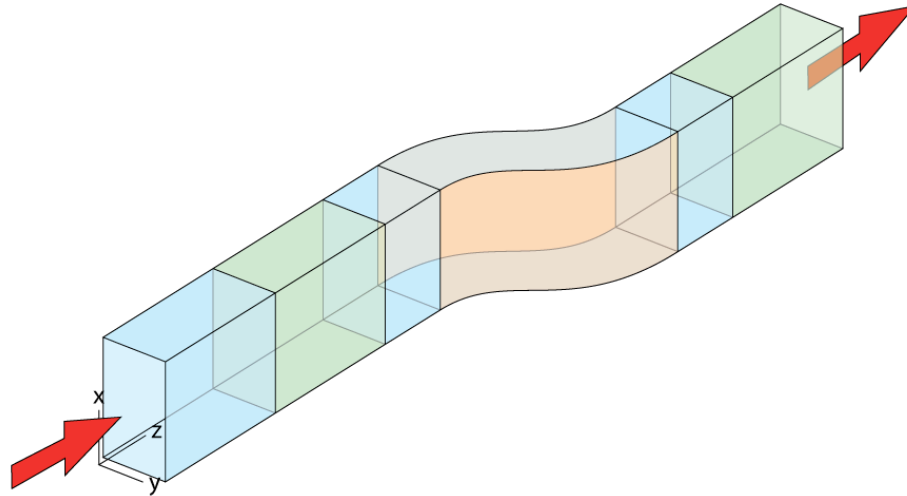
- Measure p_s , p_{exit} and p_{wall}
- Provide an initial estimate for the liner impedance, ζ
- Solve the above BVP to obtain estimates of p_{wall}
- Iterate on ζ until p_{wall} match the measurements

Advantages of Impedance Education in CDTR vs GFIT



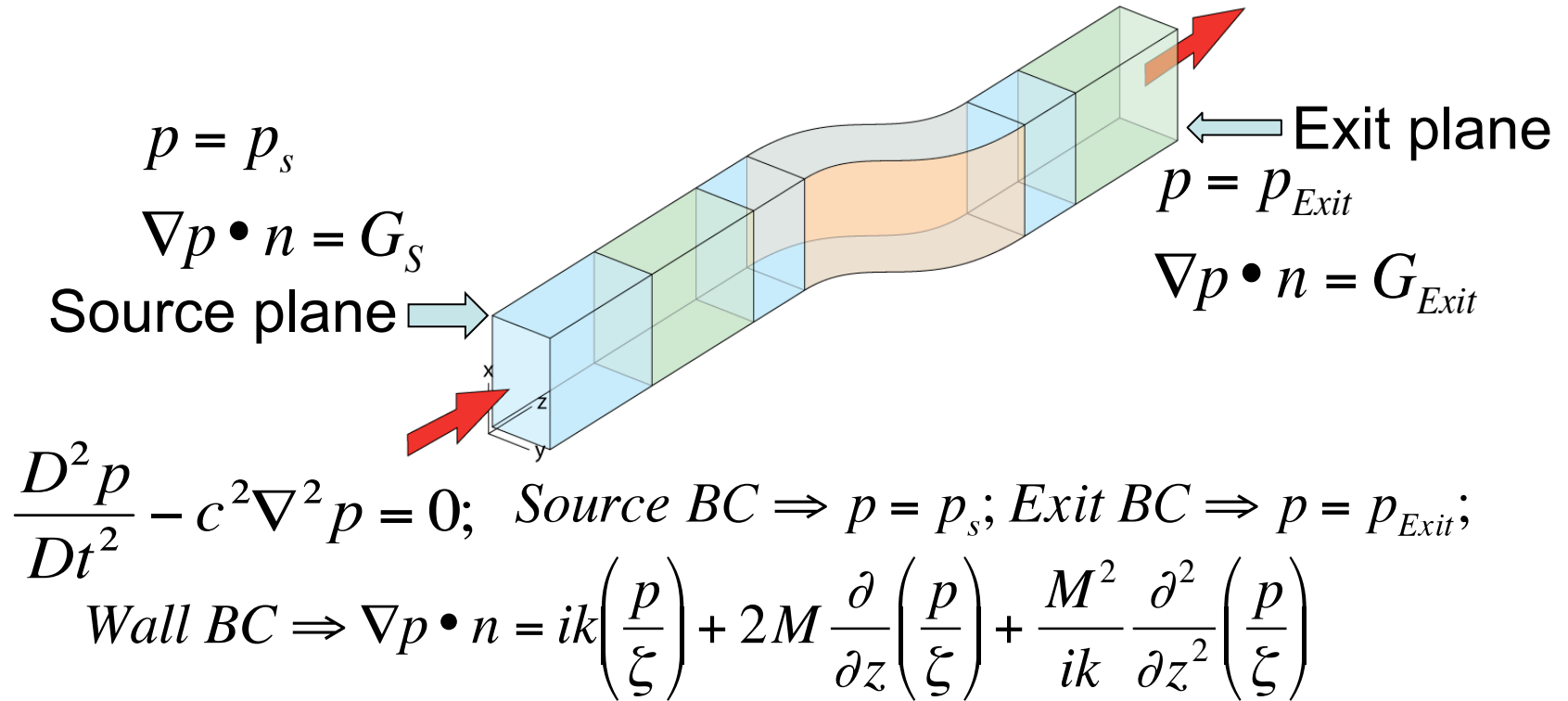
- More realistic mean flow profiles
- The effects of wall curvature are evaluated
- Test liners are closer to full scale
- Multiple test liners on opposite walls
- Control over source modal content

Challenges Introduced by CDTR



- The wall opposite the test liner contains another liner and cannot be populated with microphones
- Where will impedance education data be obtained
- The curved portion of duct introduces 3-D effects

Impedance Education in CDTR

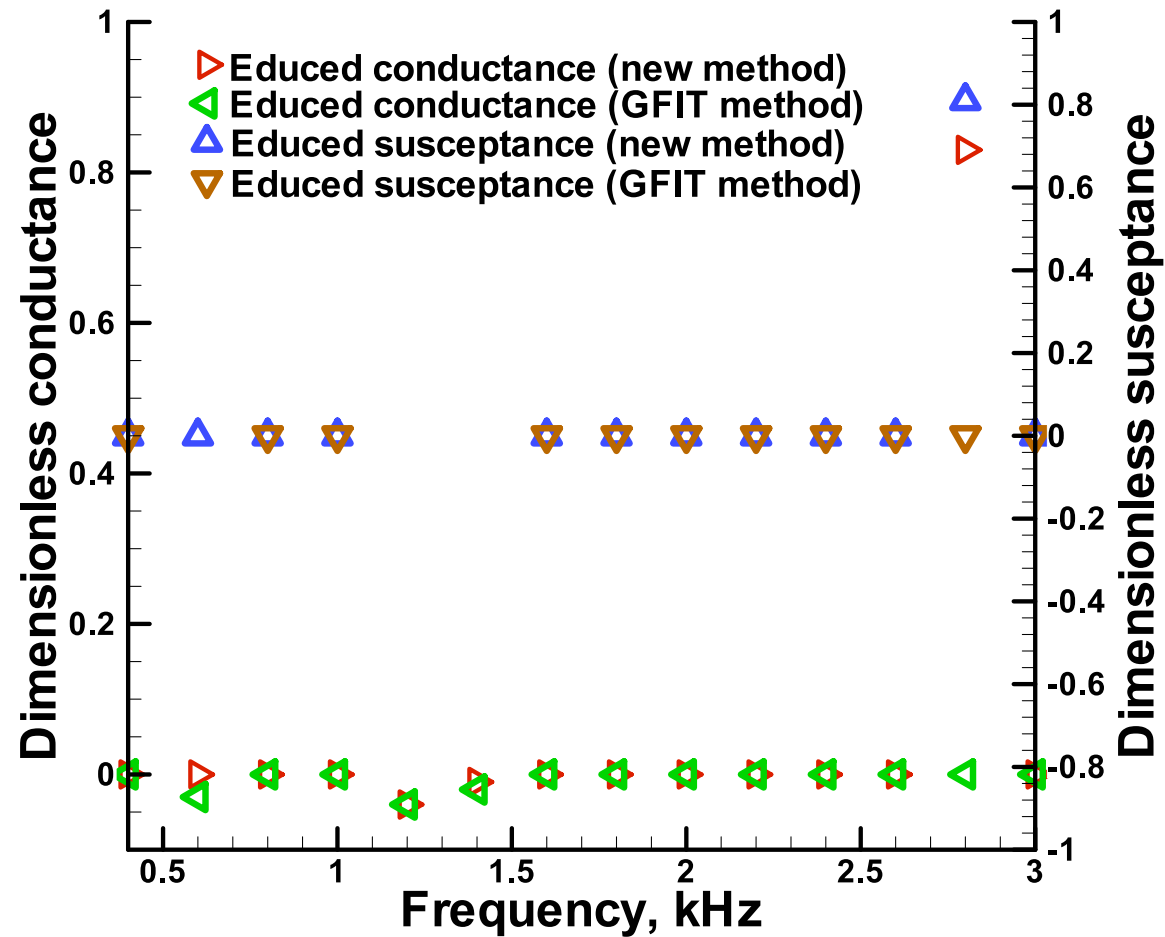


- Measure p_s, p_{Exit}, G_s and G_{Exit}
- Provide an initial estimate for the liner impedance, ζ
- Solve the above BVP to obtain estimates of G_s, G_{Exit}
- Iterate on ζ until G_s and G_{Exit} match the measurements

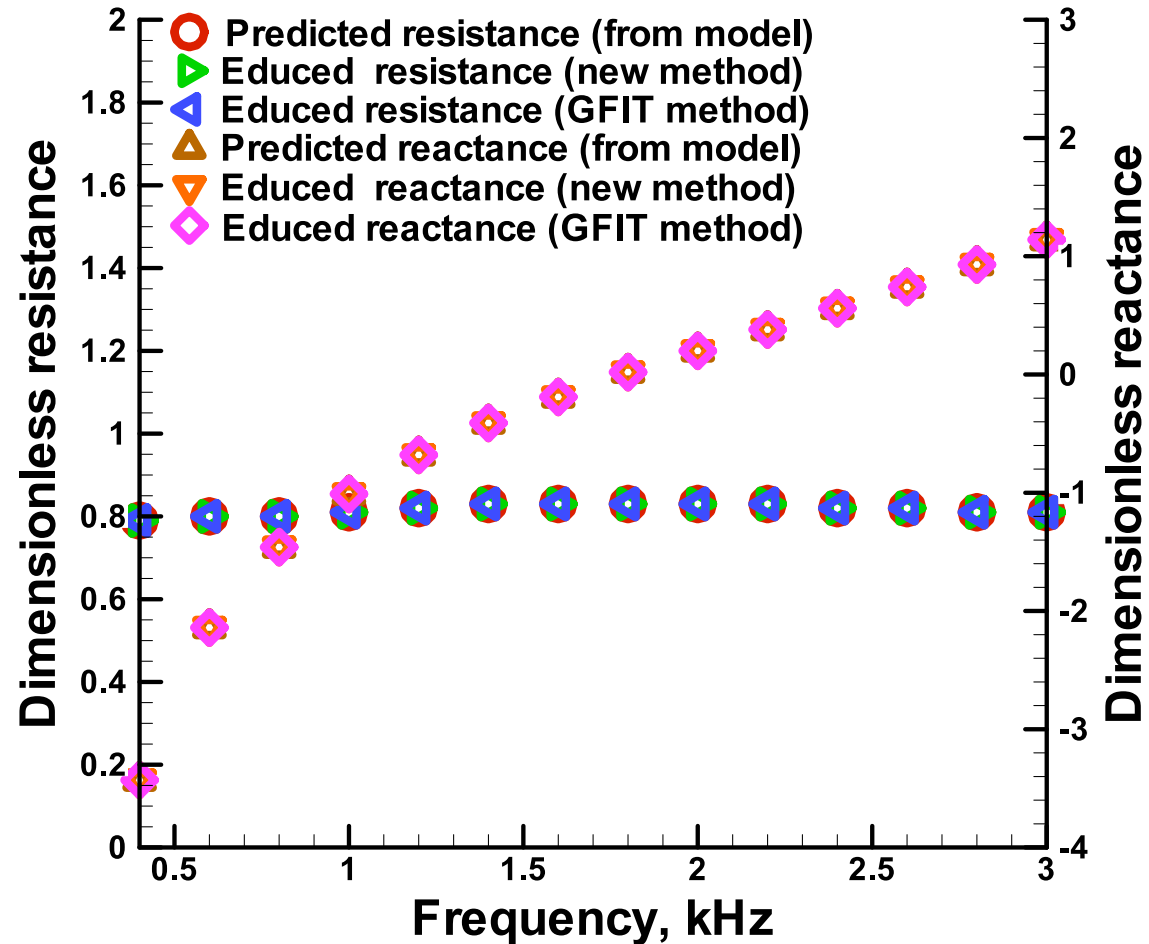
Test Samples and Education Data

- The new impedance education model is tested on two liners; (1) a rigid wall insert, and (2) a conventional liner
- The impedance of the conventional liner is obtained from an impedance prediction model for three centerline Mach numbers (Mach 0.0, Mach 0.3, and Mach 0.5)
- The data for the impedance education is then synthesized using a finite element duct propagation code
- The impedance education code (that uses an optimizer to iterate on impedance) is run to educate the impedance
- The educated impedance is expected to match that from the impedance prediction model

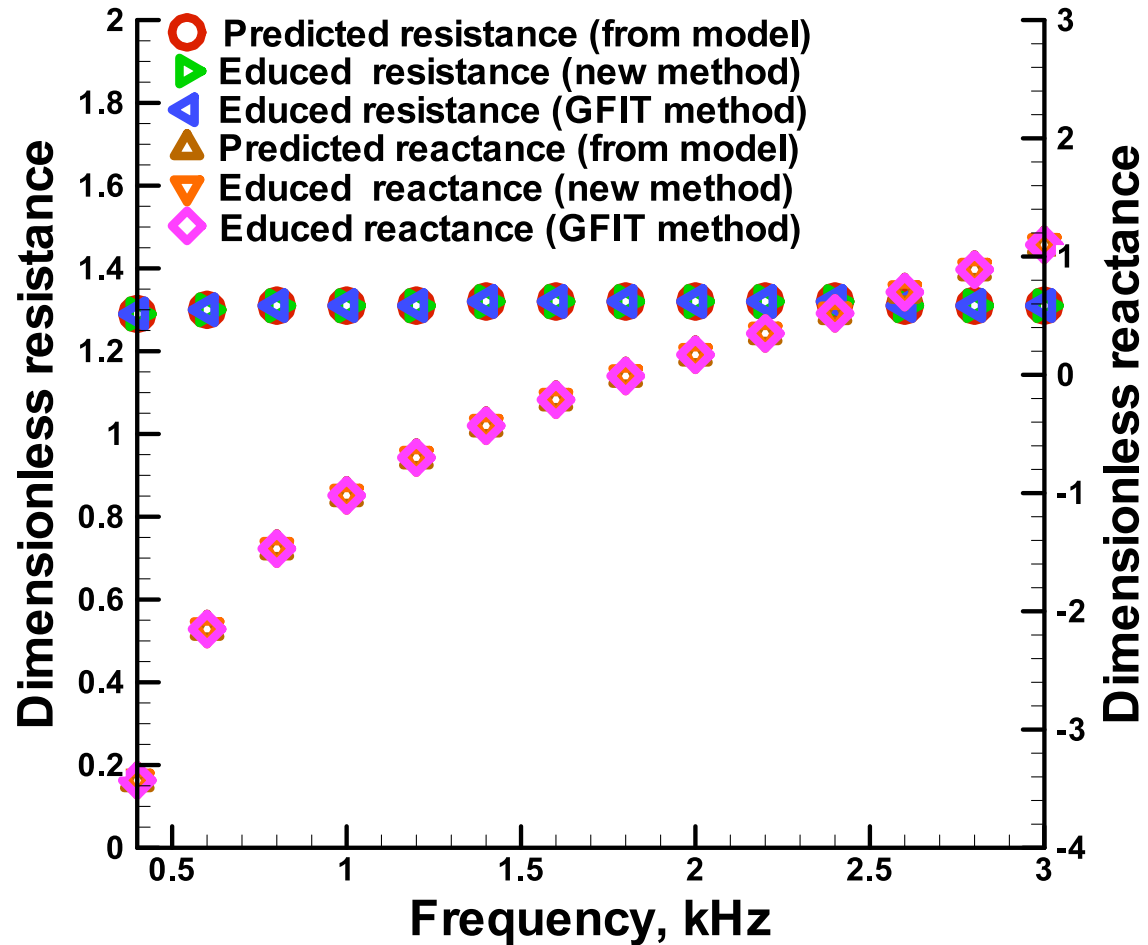
Hardwall (Mach 0.0)



Conventional Liner (Mach 0.3)



Conventional Liner (Mach 0.5)



Conclusions

- A new impedance eduction technique **that is void of microphones in the liner test section** has been developed
- The new impedance eduction technique is **ideally suited for curved ducts**
- When used with synthesized data, the new technique is **as robust as the one requiring the use of wall mounted microphones** in the liner test section

Future Plans

- Validate the new approach using measured data from GFIT and CDTR
- Introduce curved elements and shear flow into the prediction model
- Develop a parallel 3-D equation solver for the duct propagation model