A Dielectric Elastomer Acoustic Liner

Chelsea Dodge; Dr. Yang Zhang; Dr. Louis Cattafesta

FAMU-FSU College of Engineering

Acoustic Liners in Aircraft Engines

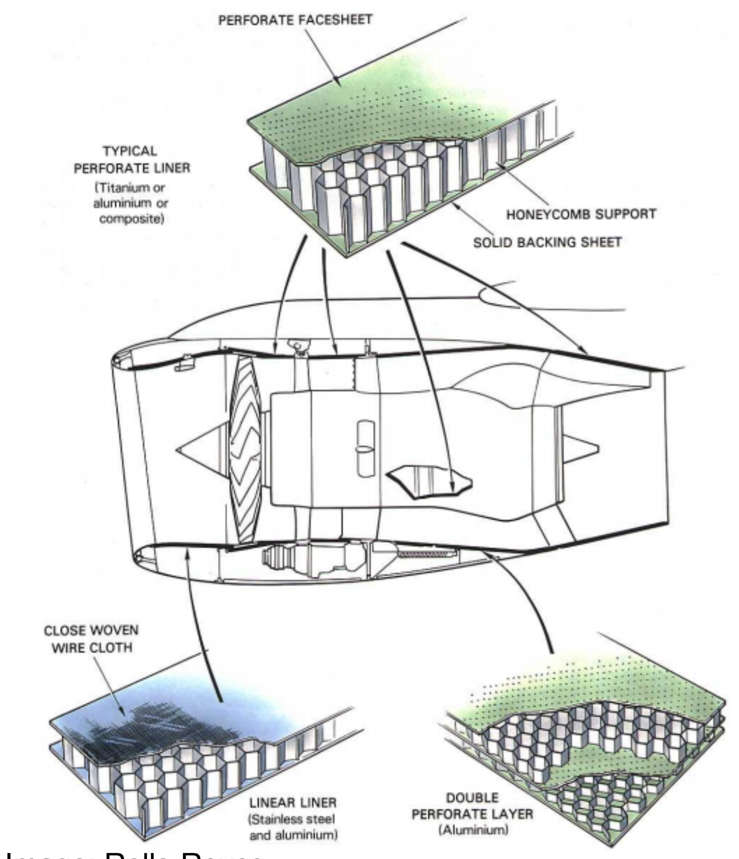
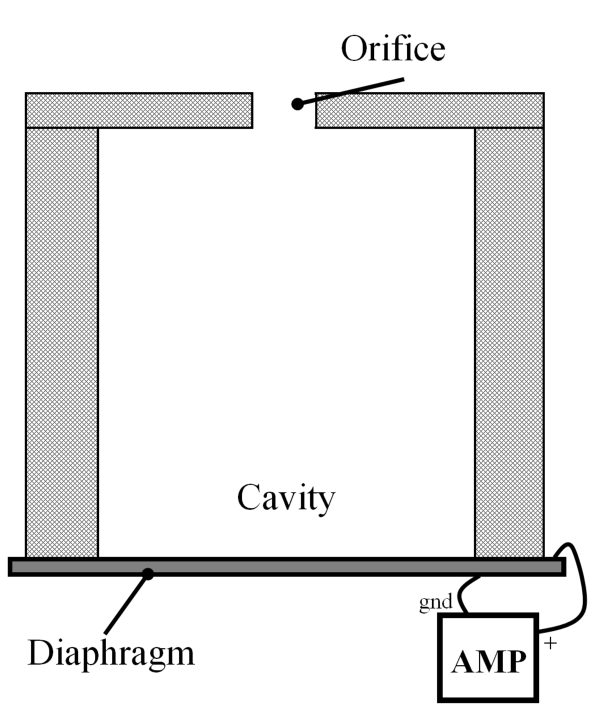


Image: Rolls-Royce

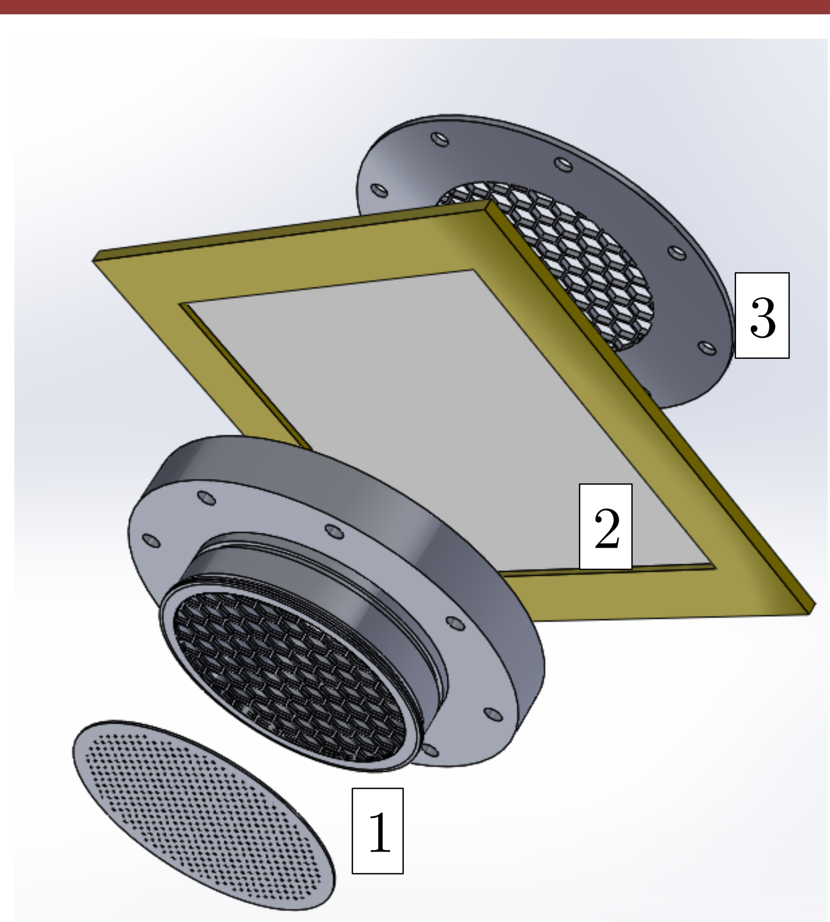
Aircraft engines have different blade passage frequencies and noise characteristics distinct to phase of flight. Acoustic panels line the walls of aircraft engine ducts to suppress tones in flight. Past acoustic liner technologies are designed to be passive and can only attenuate a limited frequency range of approximately one octave[2].

Project Summary



To suppress a range of blade passage frequencies, passive liner technology is transformed to have an adaptive design. Replacement of one of the standard rigid walls with a voltage tunable compliant diaphragm yields an adaptable target frequency for different flight conditions. To close the loop, the diaphragm can passively generate electrical charge for energy reclamation.

Experimental Setup

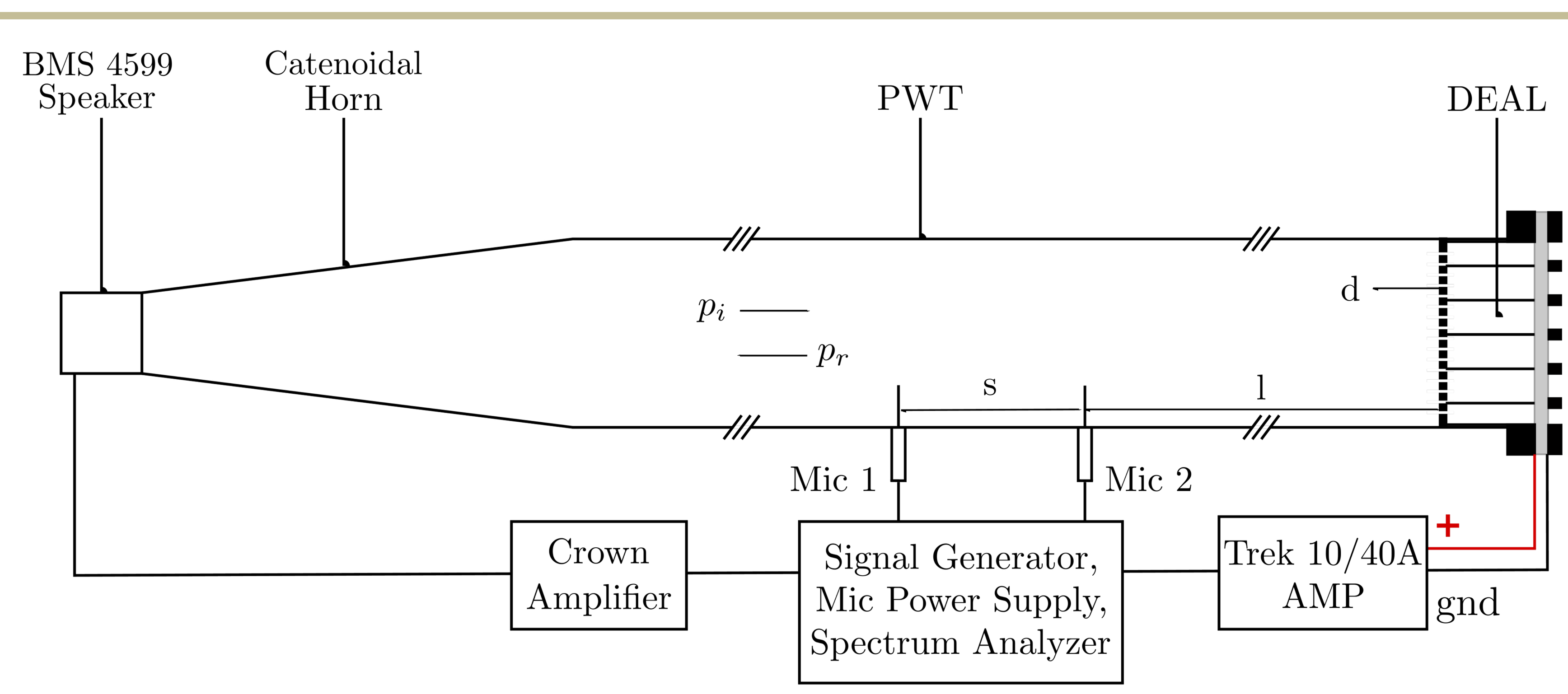


Dielectric elastomer acoustic liner (DEAL) test specimen:

1. Standard acoustic liner with no backplate
2. Diaphragm backplate: an electroactive polymer
3. Honeycomb backplate to secure diaphragm

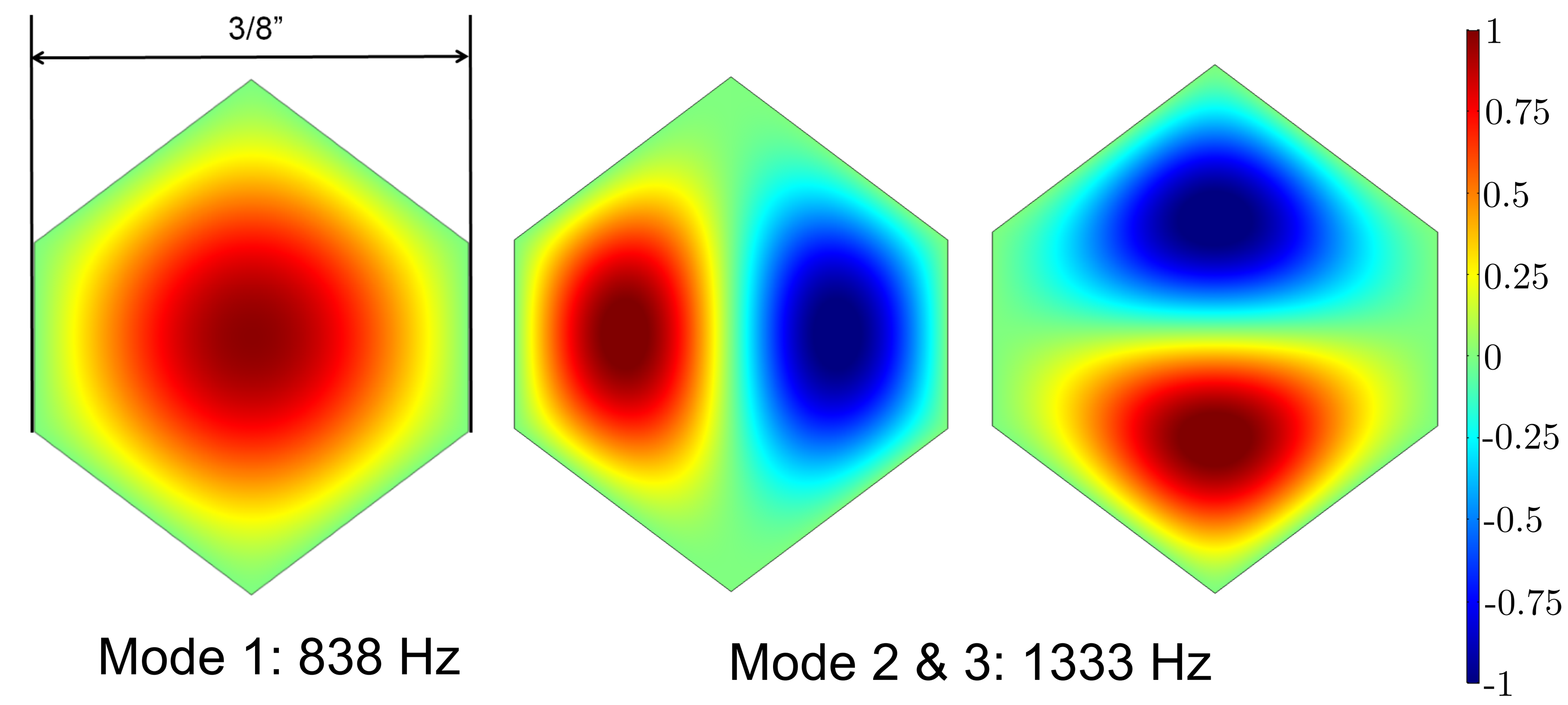
The assembled specimen is inserted into the impedance tube as pictured below.

Normal incidence impedance tube measurements determine the absorption characteristics of the acoustic liner. Displacement measurements of the diaphragm give insight into the motion of the diaphragm induced by the compliance change.



Compliant Diaphragm Modeling

Resonant frequency model[3] of diaphragm is used to predict the optimal material properties that yield the most frequency tuning. The first three resonant frequency mode shapes are pictured.



Mode 1: 838 Hz   Mode 2 & 3: 1333 Hz

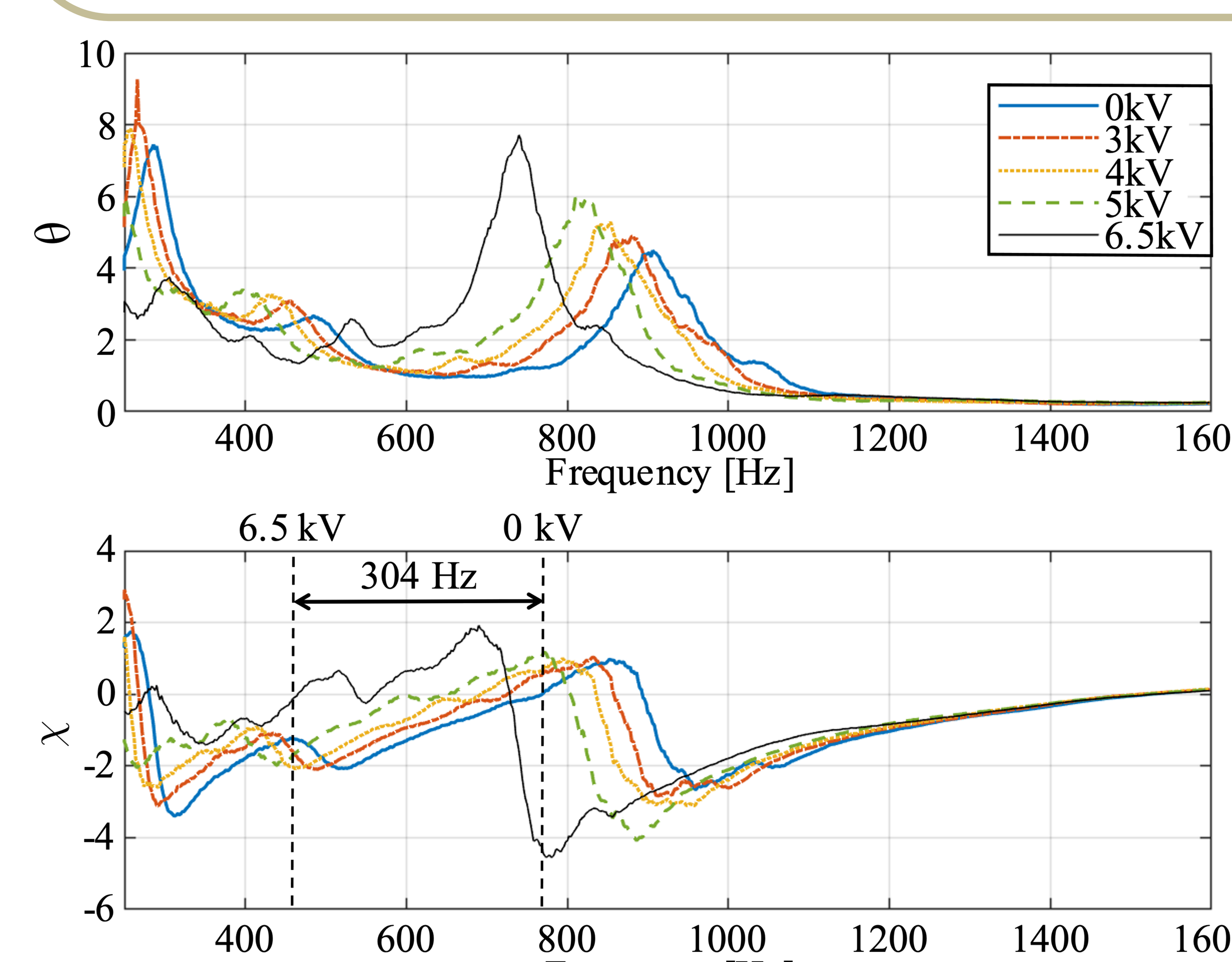
Frequency Tuning

Normalized specific acoustic impedance pictured

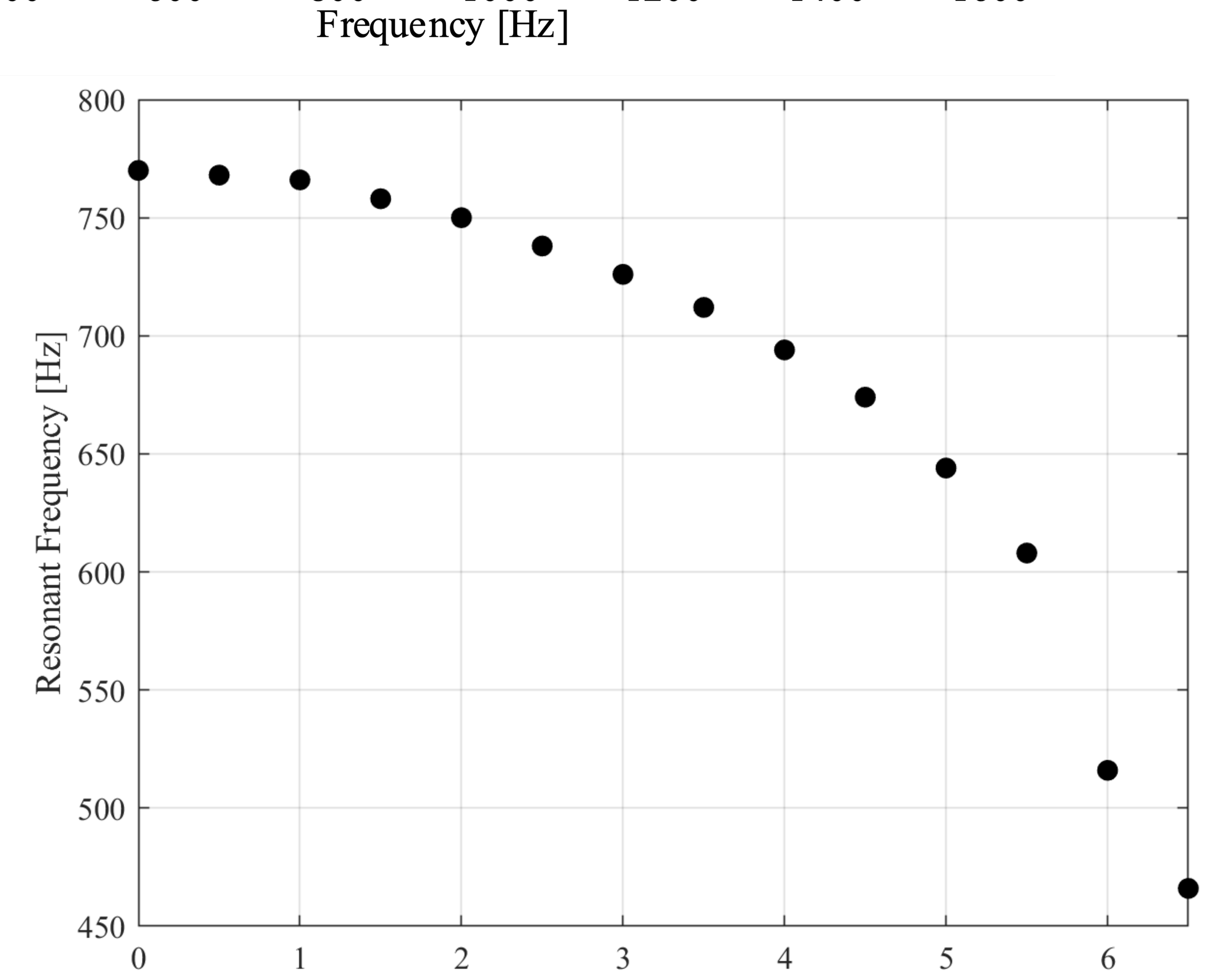
- Resonance, or targeted, frequency tuning of approximately 40%
- Resonant frequency decreases with voltage
- Resistance is higher than standard acoustic liner

Resonant frequency vs. applied voltage across diaphragm pictured

- Decrease in resonance more extreme at larger voltages



Voltage (kV)	Resonance (Hz)
0	770
0.5	768
1	766
1.5	758
2	750
2.5	738
3	726
3.5	712
4	694
4.5	674
5	644
5.5	608
6	516
6.5	466



References

[1] Rolls-Royce, "The Jet Engine", 1996
[2] Motsinger, R. E., and Kraft, R. E., Aeroacoustics of Flight Vehicles: Theory and Practice, Volume 2: Noise Control, 2nded.,Acoustical Society of America, New York, 1995, Chap. 14.
[3] Hays M. R., Hart A., Guettler A., Ukeiley L., Oates W. S., "Fluid-structural dynamic characterization of an electroactive membrane wing," Journal of Intelligent Material Systems and Structures. Vol. 24, No. 7, pp. 1510–1522, 2016.

Acknowledgements

Financial support for this project was provided by the Boeing Company (Contract No: 1340697), monitored by Jordan Kreitzman. I would like to thank Brian Howerton and Mike Jones for their advice and guidance on the project.