A device that can be used to attenuate noise generated in an engine nacelle of an aircraft is an acoustic liner. A conventional single degree of freedom (SDOF) acoustic liner is comprised of a perforated face sheet, honeycomb cells, and a rigid backing. The SDOF liners attenuation characteristics is a function of its dimensions and the fluid properties of the medium. In other words, the device is passive and provides a constant impedance boundary condition on the nacelle walls. However, noise generated by an aircraft is a function of the phase of flight it is in. To maximize attenuation over the entire duration of the flight, it would be advantageous if the liner could change its attenuation capabilities based on the flight phase.

This dissertation presents the development of a dielectric elastomer acoustic liner (DEAL), a device which can modify its acoustic properties. The DEAL is comprised of a standard SDOF liner with it's cavity depth split by a compliant dielectric elastomer (DE). A dielectric elastomer is a smart material capable of changing shape. When a DE is maintained in tension and subjected to an electric field, it can produce large strains resulting in a decrease in stiffness and resonance frequency. When a DE is coupled with an acoustic liner, actuating the DE effectively modifies the resonance frequency of the entire liner. The design of a DEAL would be aided with a model to choose the best dimensions and DE material properties.

A lumped element model (LEM) of a dielectric elastomer is verified and validated. We assume the elastomer behaves as a membrane because it is very thin and cannot support a bending moment. Therefore, we derive the LEM from the damped wave equation. We validate the model by experimentally measuring the normal velocity on the membrane surface using a laser doppler vibrometer while subjecting the membrane to a low frequency, sinusoidal pressure loading. The results prove the membrane assumption is accurate because the mode shape derived aligns with the mode shape measured. Using the relationship between pressure loading and volume displacement as a function of static deflection, the LEM was created. The resonance frequency is a function of material properties, dimensions and stress where the stress is a function of the applied voltage. Decrease of the membrane resonance when subjected to an electric field is measured and compared to predictions, with a maximum difference of 2.3\% at 5 kV. The results validate the LEM of the dielectric elastomer membrane, allowing integration into an acoustic liner to predict the acoustic impedance of a DEAL.

The modeling, design, and optimization of a DEAL is then performed. A lumped element model of an embedded dielectric elastomer acoustic liner is derived and validated in a normal incidence impedance tube and is subsequently used to optimize its performance. The optimization cost functions include (1) maximization of the absorption coefficient over a targeted frequency range, 400 – 1600 Hz and (2) maximization of the change in the liner’s fundamental resonance frequency when the membrane is activated. Excellent agreement between measured and predicted absorption is observed. Tuning of the resonant frequency requires us to numerically solve for resonance using the imaginary part of the impedance, since a clean expression for resonance could not be derived due to coupling between the acoustics of the liner and the vibrations of the DE membrane. Nonetheless, resonant frequency shifts predicted with the lumped element model compare favorably to those measured with the activated liner sample, with a shift of over 200 Hz.