8-2012

Overview of Beranek & Work's 1949 Paper on "Sound Transmission through Multiple Structures Containing Flexible Blankets"

Ryan Schultz
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Old Meets New:

An Overview of Beranek & Work's 1949 Paper "Sound Transmission through Multiple Structures Containing Flexible Blankets"

Ryan Schultz
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20 August 2012

Introduction

1. Motivations
2. Describe the structure & the individual elements
3. Present TL predictions for single elements & multi-layered systems and show effect of varying key parameters
4. Discuss measurement method, significance of the work and conclusions

Why?

Predict Barrier Performance

- TL of a structure consisting of several acoustic elements

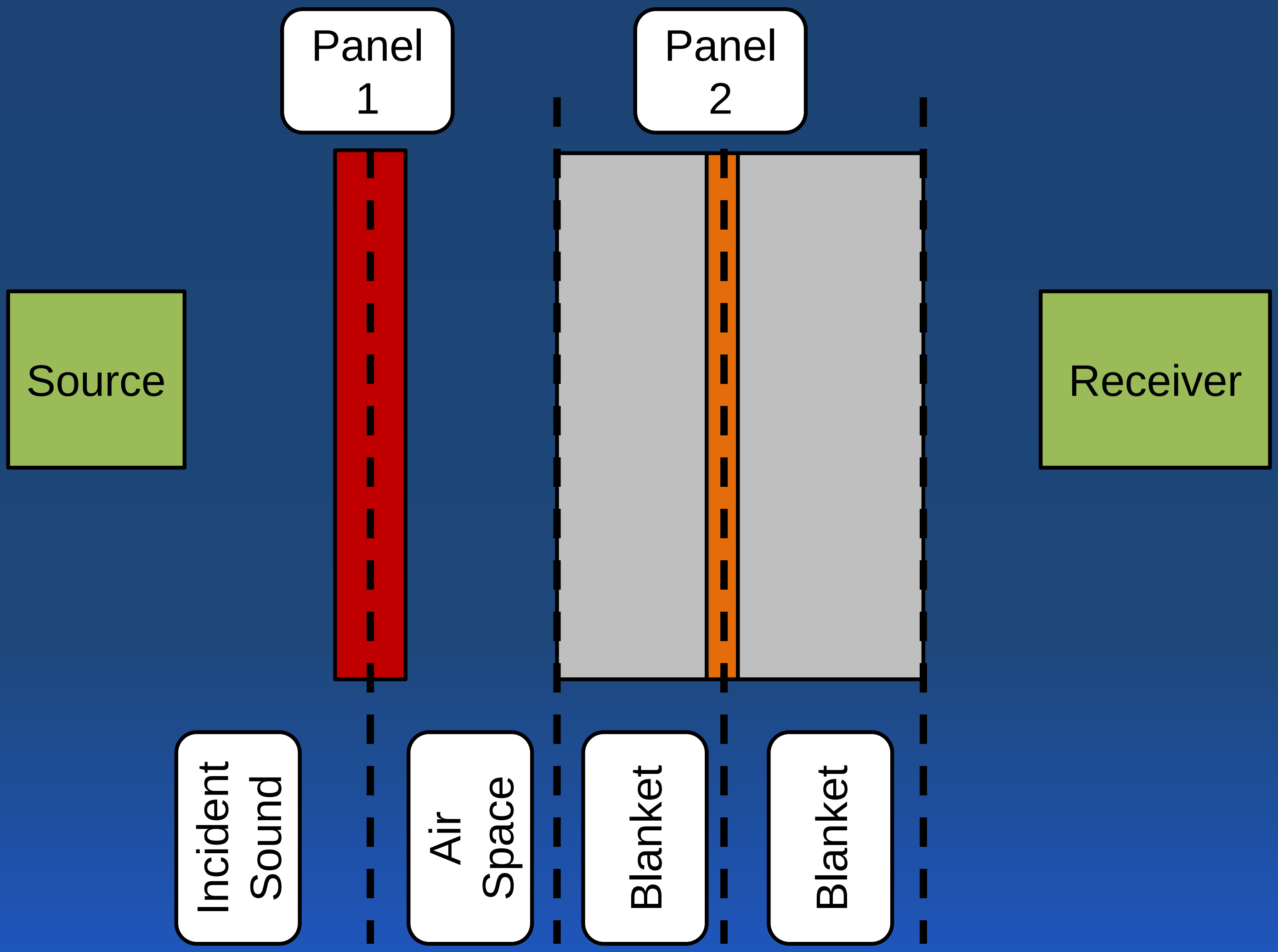
Smarter Design Choices

- Which elements matter most?
- Does the order of elements matter?
- How do I best utilize cost, weight, & space budgets?

Better Designs

- Lighter
- More Economical
- Higher Performance

Structure Description



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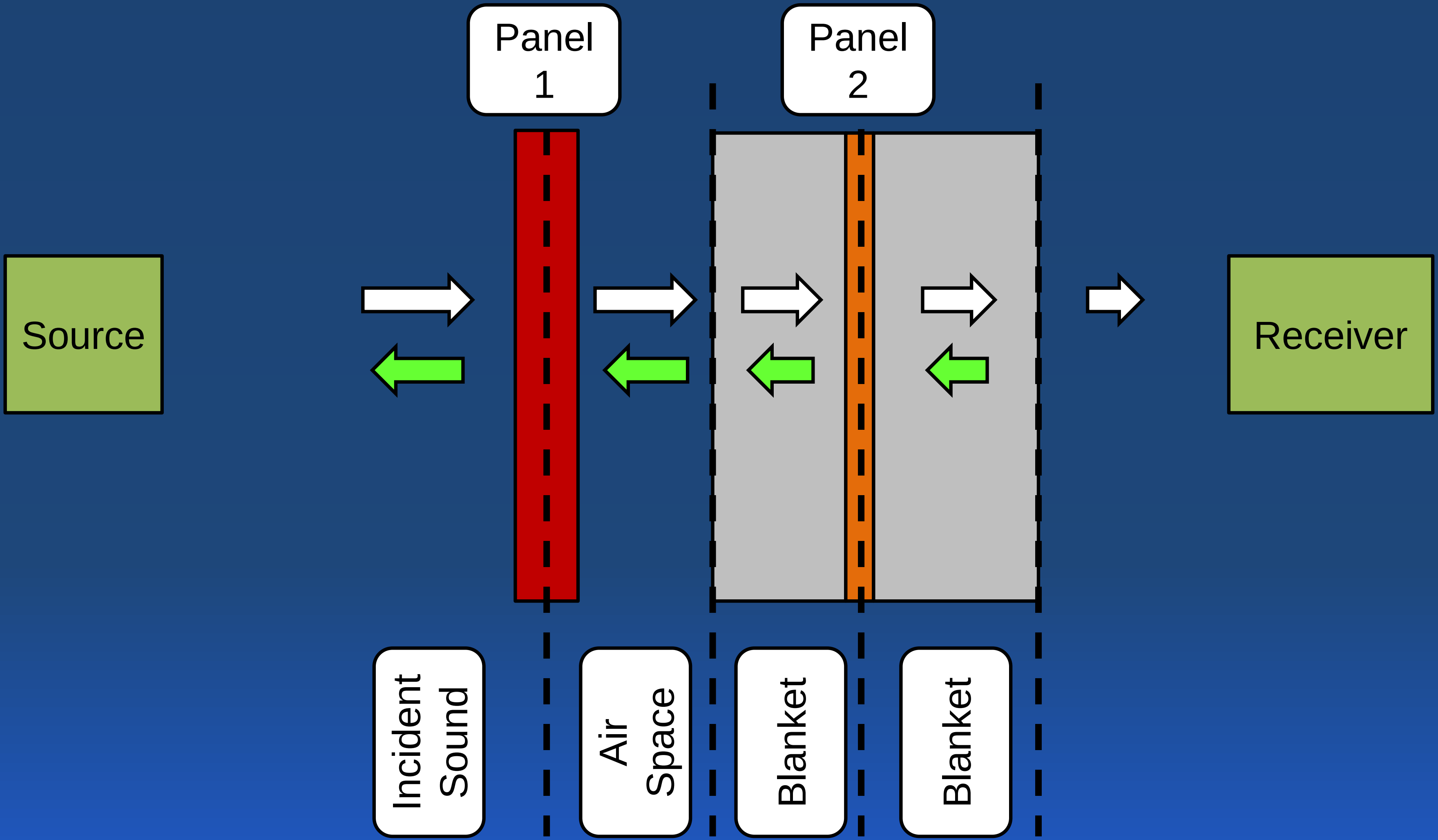
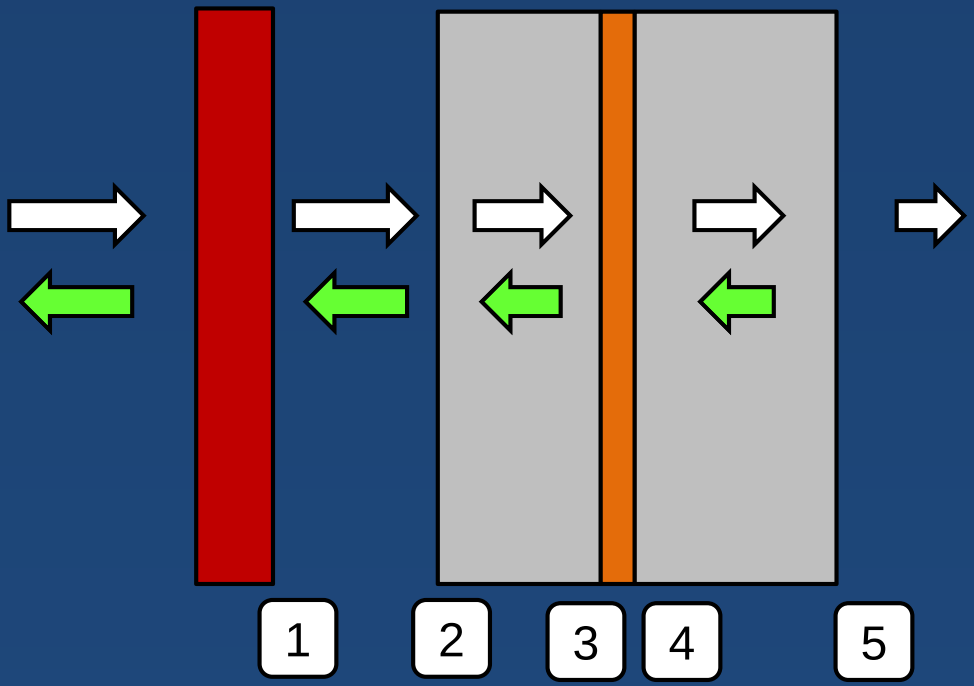


Individual Elements

Panel	Air Space	Blanket

Attributes:	Attributes:	Attributes:
Mass per unit area	Depth	Flow Resistivity Porosity Structure Factor Mass / unit area Stiffness Depth

Pressure Ratio Expressions



$$Z_1 = \rho c \coth(j\omega l/c + \psi)$$

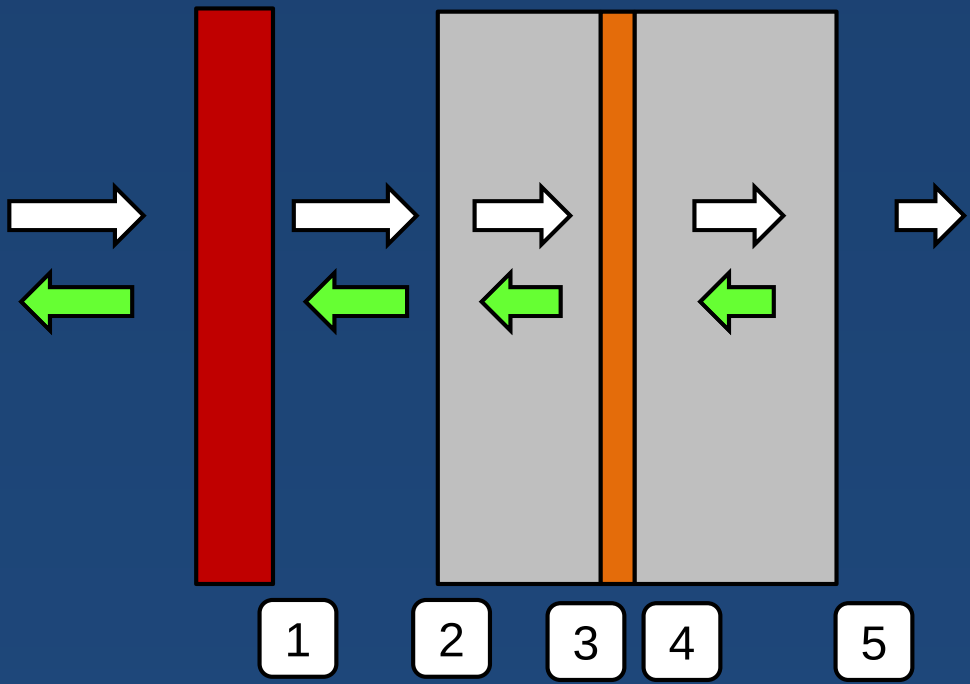
$$\vdots$$

$$Z_5 = \rho c$$

$$\frac{p_0}{p_1} = 1 + j\omega\sigma_1/Z_1$$

$$\frac{p_0}{p_5} = \frac{p_0}{P_1} * \frac{p_1}{p_2} * \frac{p_2}{p_3} * \frac{p_3}{p_4} * \frac{p_4}{p_5}$$

Pressure Ratio Expressions



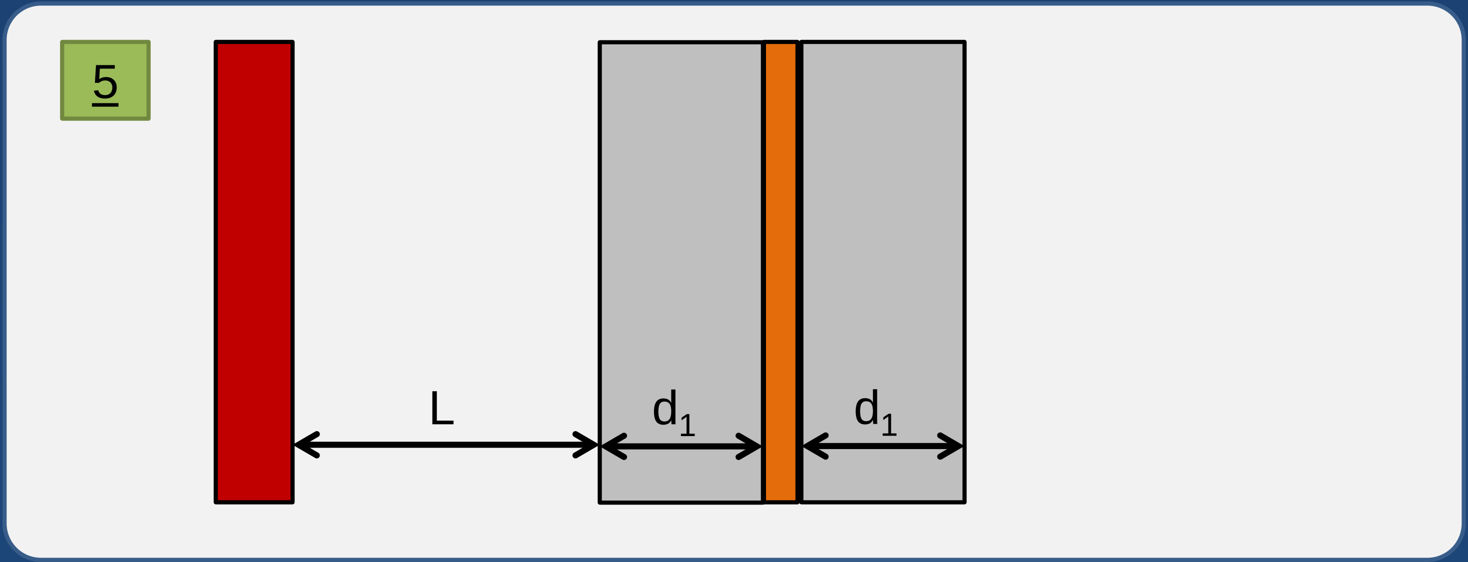
$$p_0 = e^{-jk_0x} + Re^{jk_0x}$$

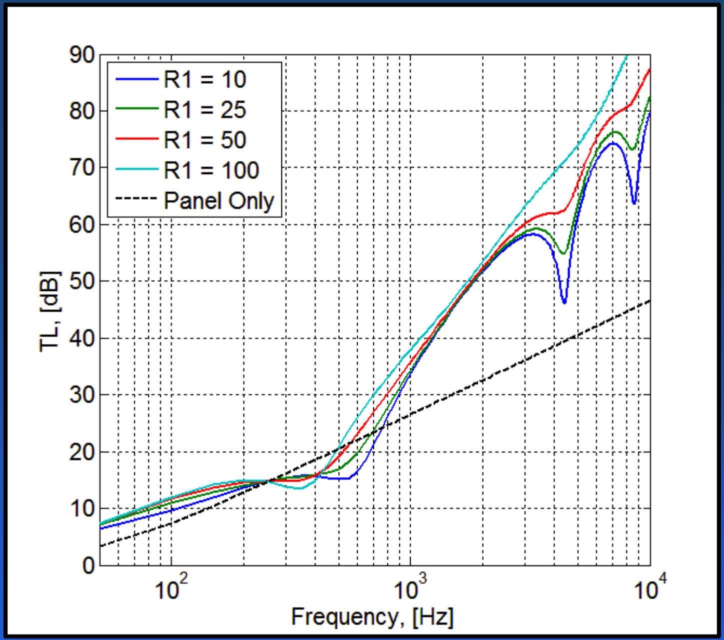
$$v_0 = \frac{1}{\rho c}\left(e^{-jk_0x} + Re^{jk_0x}\right)$$

Constraint equations at each interface

Solve the set of equations for the wave coefficients

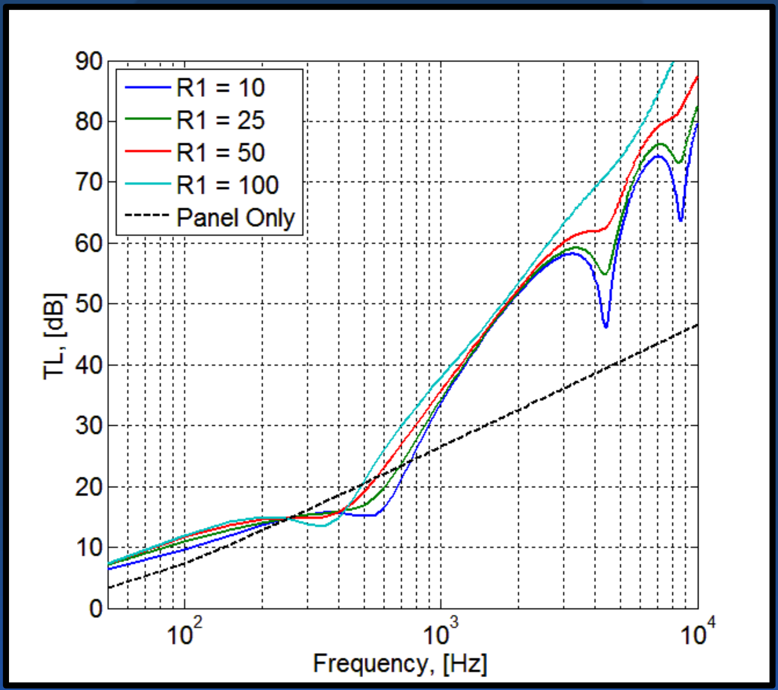
Complete Structure: 5



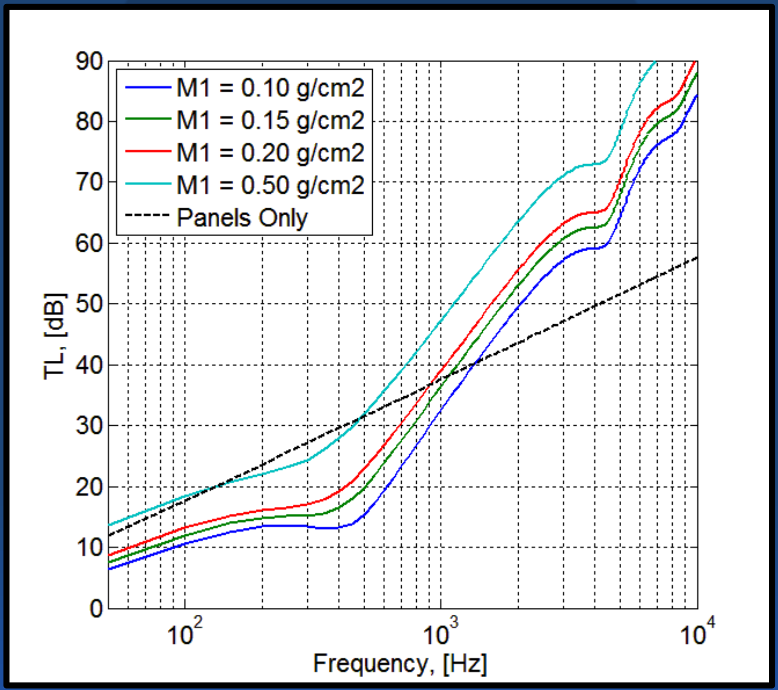


Design Considerations

Effect of Flow Resistivity

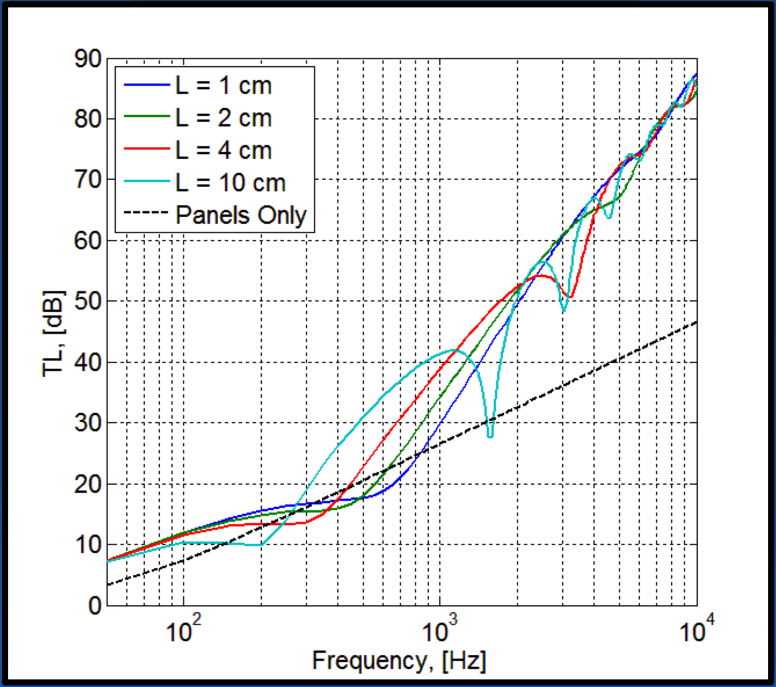


Effect of Panel 1 Area Density

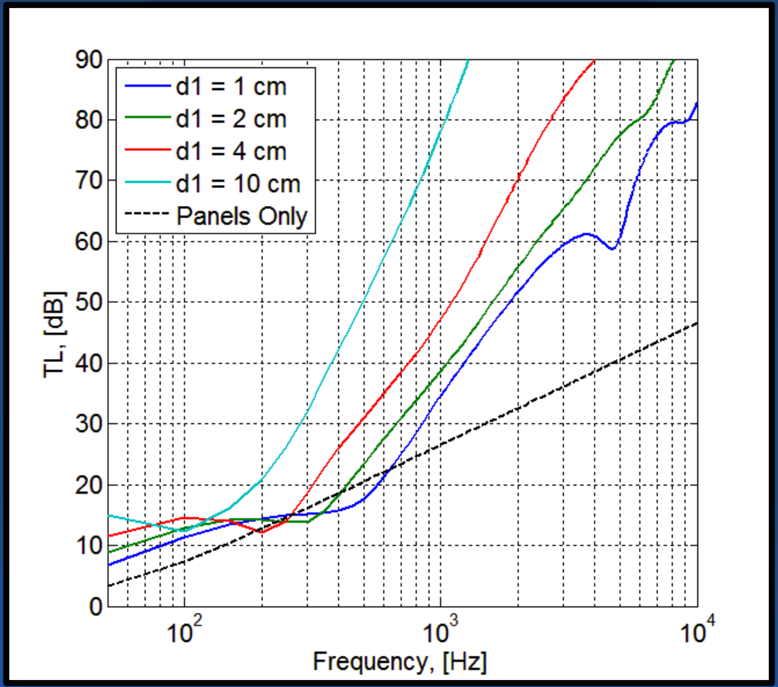


Design Considerations

Effect of Air Space Width



Effect of Blanket Thickness



Experimental Considerations

Theory:

- Normal incidence plane waves
- Unconstrained elements of infinite lateral extent

Reality:

- Finite-sized panels
- Mounting creates edge constraints
- Flexural waves in the panels
- Difficulty obtaining purely-planar incident waves
- Existence of flanking paths

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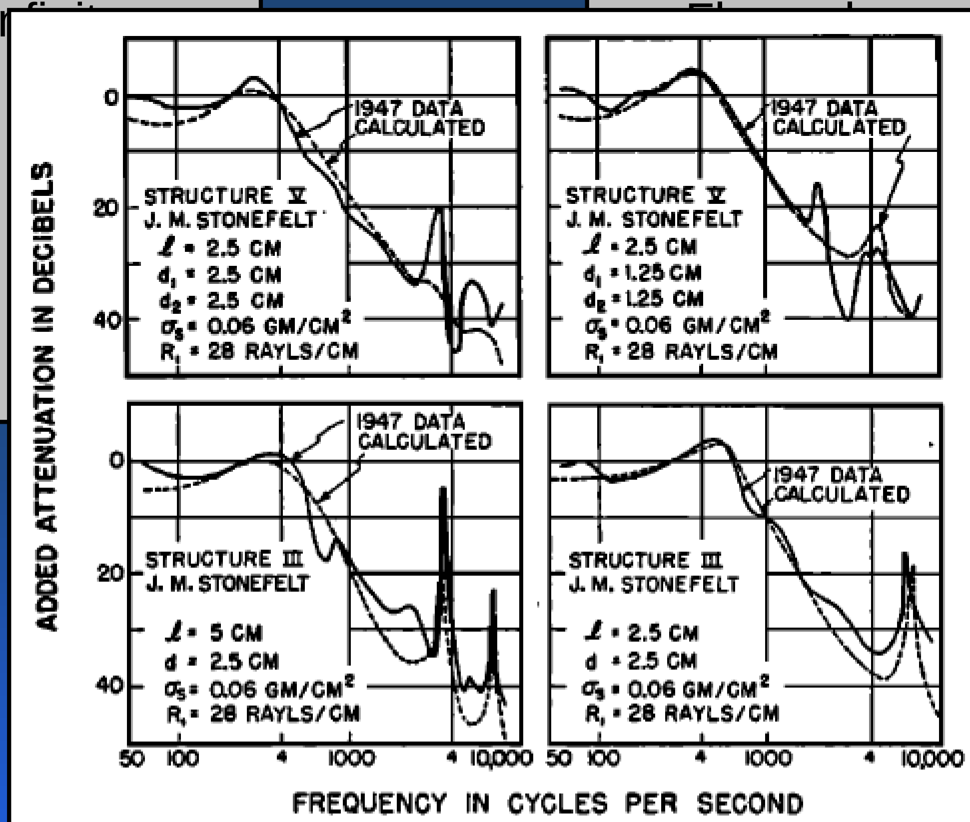

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**The issue of flexural waves in the panel are addressed by adding sheets of mica to the panels for damping

**Transverse waves in the air space ahead of the structure are minimized in the experiment by using fiberglass between the loudspeaker sources

Significance

Ability to predict TL of complicated systems

Basic approach can be modified to accept more complicated elements, structures

The work has been cited by many authors in the acoustics community: Bolton et al., Cummings et al., Kang, Lauriks et al., Mulholland et al., …

Other authors have utilized more complicated element types, layered systems

Many real-world applications

- Aircraft
- Offices & Residential
- Cars & Trains

Conclusions

Presented a theory that uses the impedances of various elements to compute acoustic pressure ratios

Predictions matched well with measurements

Fibrous blankets provide a resistive component which reduces the sharpness of the dips at high frequencies

TL is affected by different design criteria at different frequencies

A resistive element is necessary to decouple the two impervious panels & reduce the effect of the M-A-M resonances

Constraints play a significant role in measurement-theory agreement; care must be taken

Thank You!

Ryan Schultz
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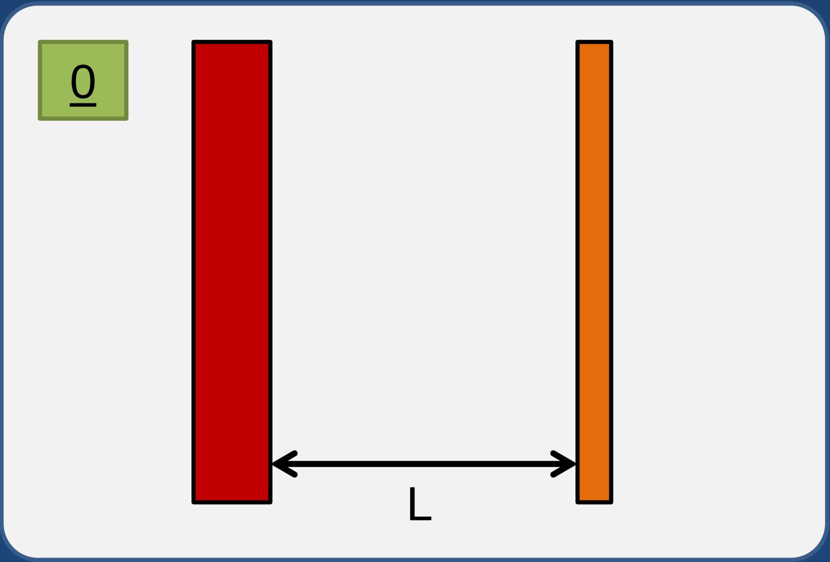
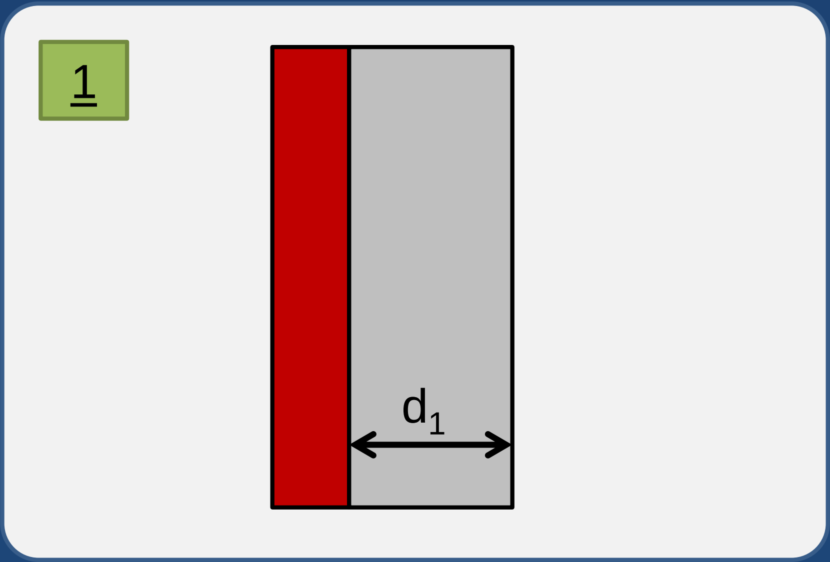
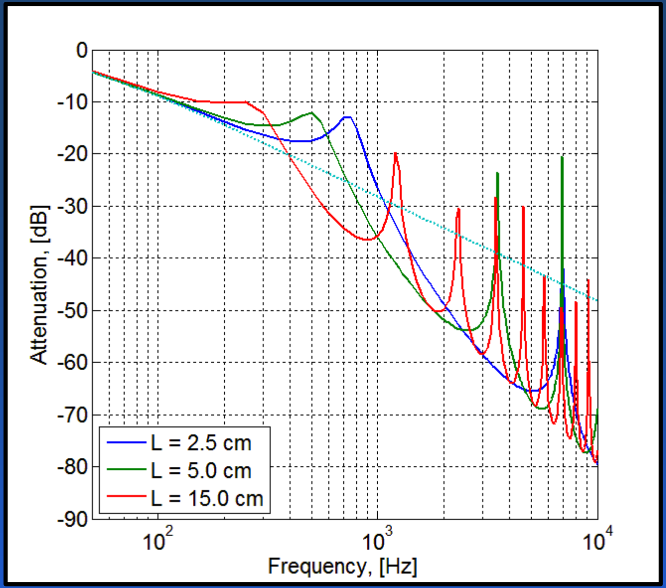
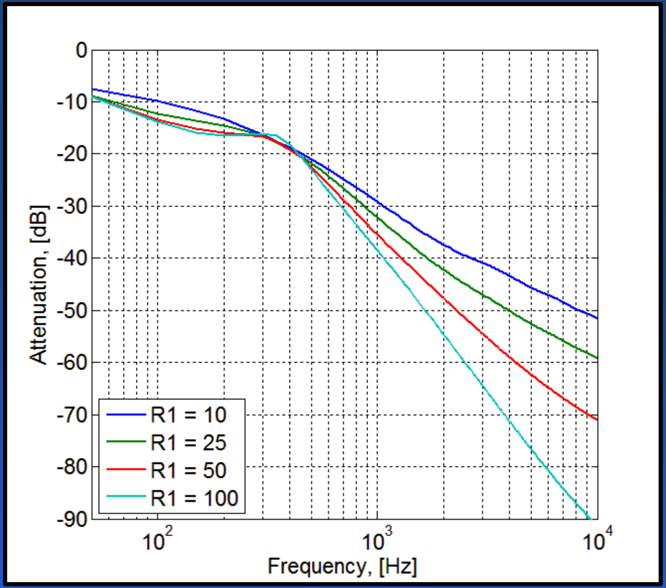
Simplified Structures: 0 & 1









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