Boundary Admittance Measurement Method (BAMM!)

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What is Boundary Admittance

What Is Boundary Admittance?

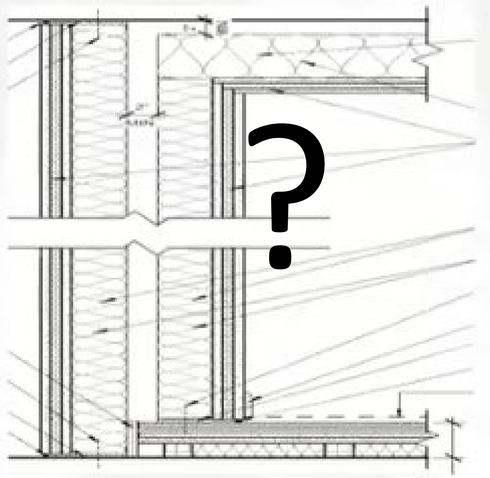
- Boundary admittance is the reciprocal of acoustic impedance and characterizes how easily a surface allows acoustic energy to pass through or be absorbed.

- It is a complex, frequency-dependent quantity that reflects both resistive (real) and reactive (imaginary) components of surface behavior.

Helmholtz-Kirchhoff Integral Equation: Complex Admittance $\beta'(\mathbf{r}_s)$

$$\left.\begin{array}{ll} \mathbf{r} \in E & p(\mathbf{r}) \\ \mathbf{r} \in s & \frac{1}{2} p(\mathbf{r}) \\ \mathbf{r} \in D & 0 \end{array}\right\} = p_i(\mathbf{r} \mid \mathbf{r}_0) + \int_s p(\mathbf{r}_s) \frac{\partial G(\mathbf{r} \mid \mathbf{r}_s)}{\partial n(\mathbf{r}_s)} - G(\mathbf{r} \mid \mathbf{r}_s) \frac{\partial p(\mathbf{r}_s)}{\partial n(\mathbf{r}_s)} ds \qquad jkp(\mathbf{r}_s)\beta'(\mathbf{r}_s) = \frac{\partial p(\mathbf{r}_s)}{\partial n(\mathbf{r}_s)}$$

How to Measure Boundary Admittance



- Acoustical treatment: We can predict the complex impedance and experimentally measure in an impedance tube

- Room Boundaries: We can predict, but there is no standardized measurement method

Minutes of the BAMM Informal Working Group

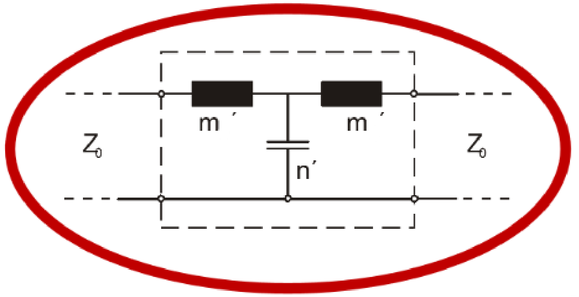
- We were fortunate to have several leading international acousticians in attendance:

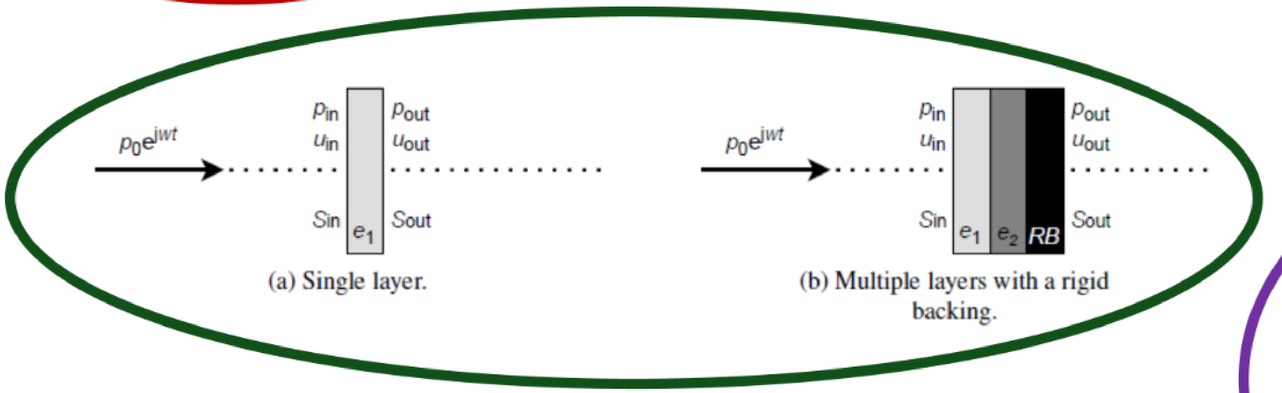
- Trevor Cox, Keith Attenborough, Christian Nocke, Ning Xiang, Michael Vorlaender, Finnur Pind, Toru Otsuru, Peter D’Antonio

- We discussed forming three linked WGs TC AA of **ASA**, TC RBA of **EAA** and **ASJ** (Japan). WG chairs to be determined.

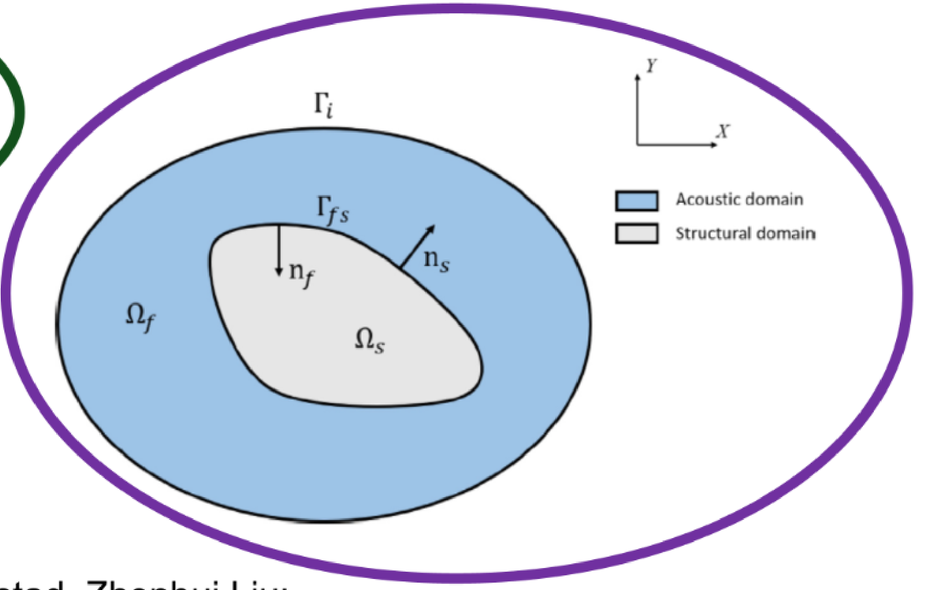
Theoretical Prediction Methods

Two-port models □ **Transfer Matrix Models** □ **Numerical methods**



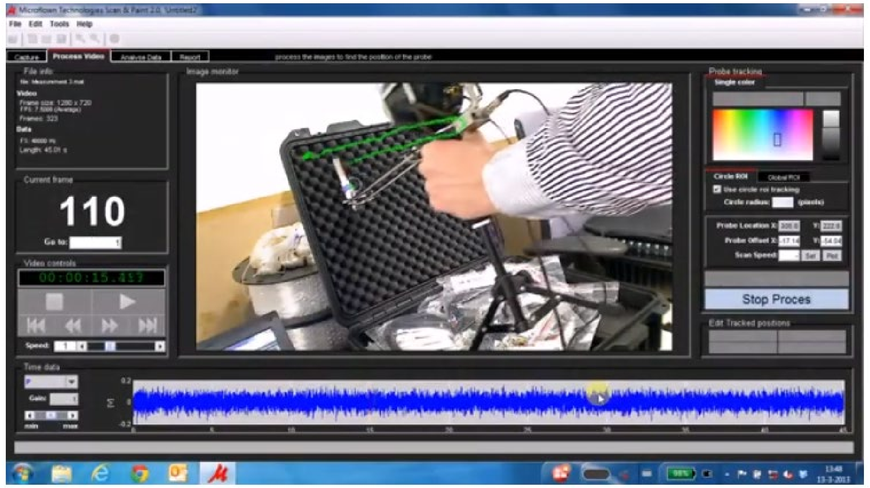


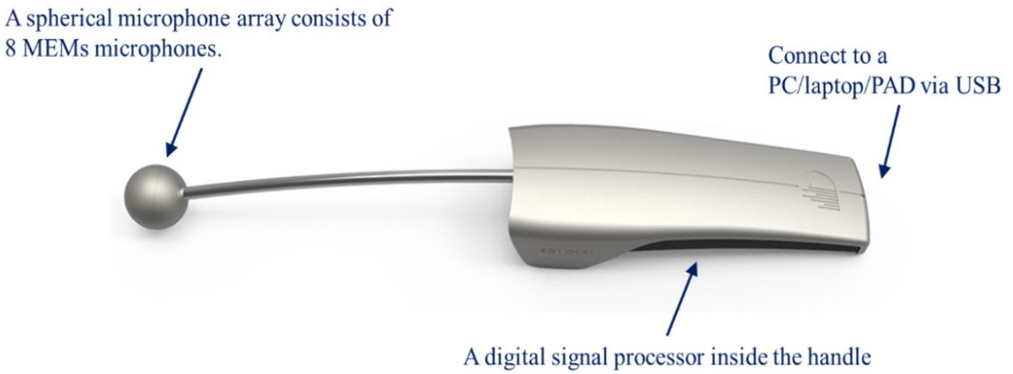
From: Rinaldi Petrolli, Artur Zorzo, Peter D'Antonio: Comparison of measurement and prediction for acoustical treatments designed with Transfer Matrix Models. Euronoise 2021.

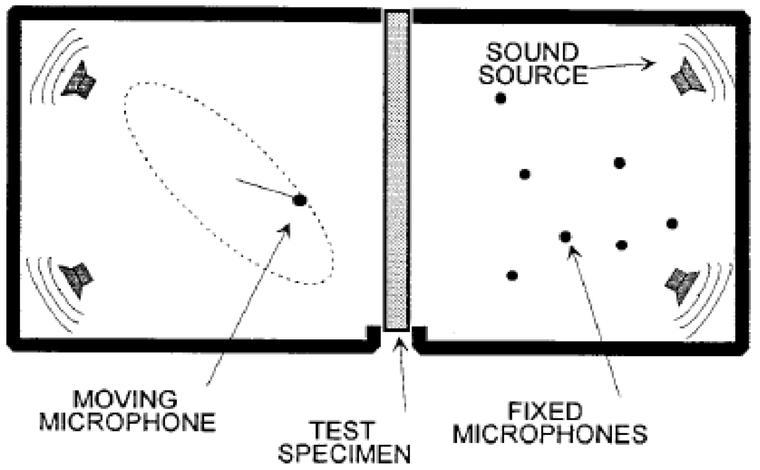


From: Oskar Ask Ullestad, Zhenhui Liu: The application of the coupled acoustic–structural approach (CASA) method on the free vibration of submerged structures. Ocean Engineering 2024

Proposed BAMM Measurement Methods

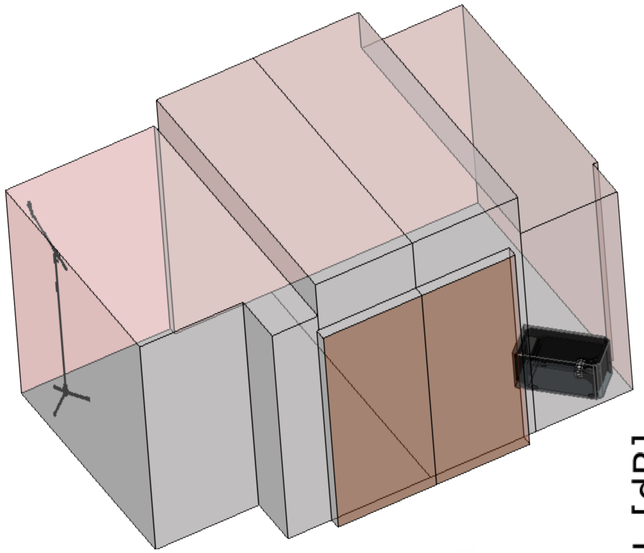


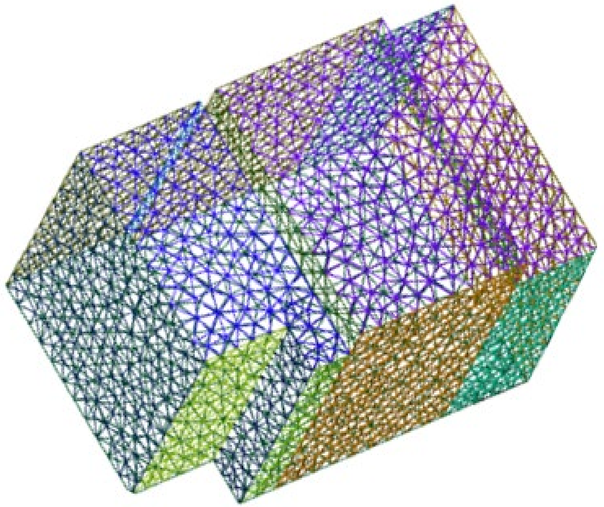


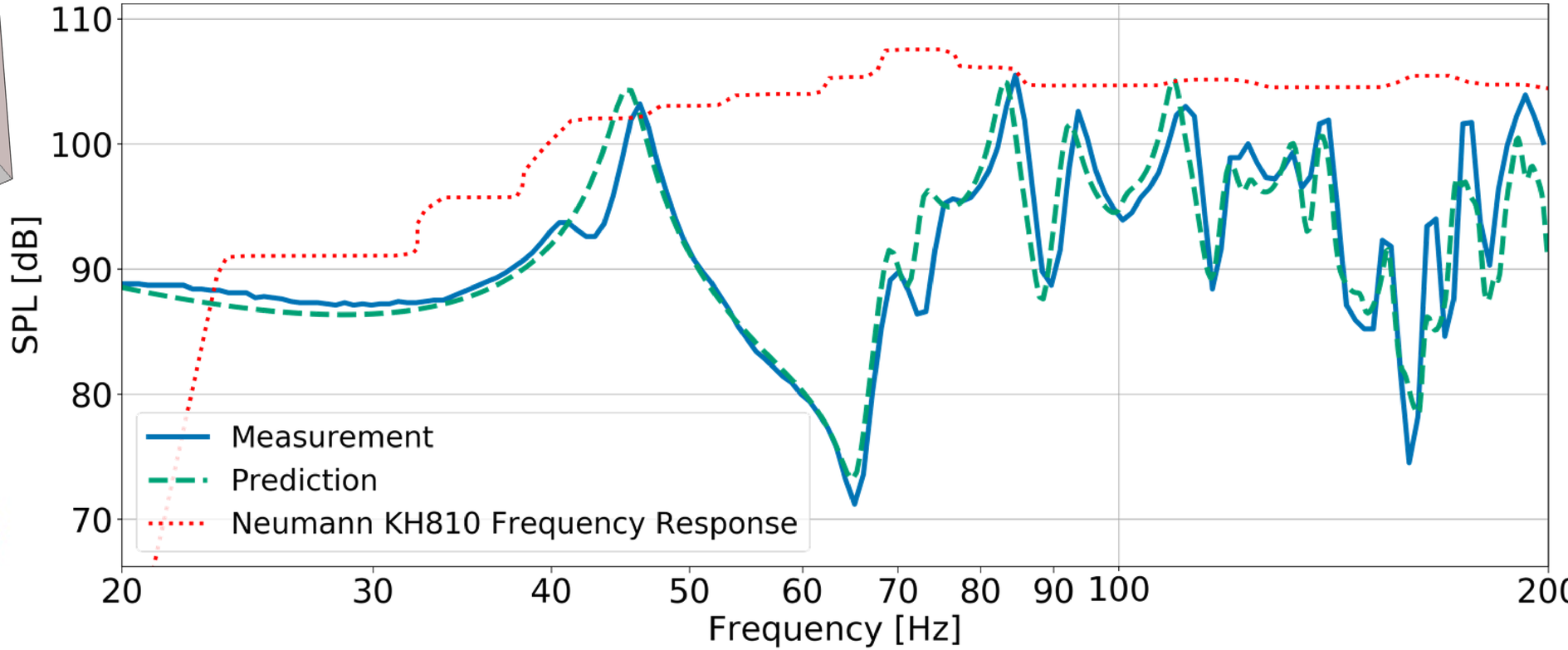


Admittance Estimate: REDI Acoustics Laboratory

- CMU and Gyp-Ply-Gyp boundary construction (Y=0.02)







Attaching the admittance to ASTM E90

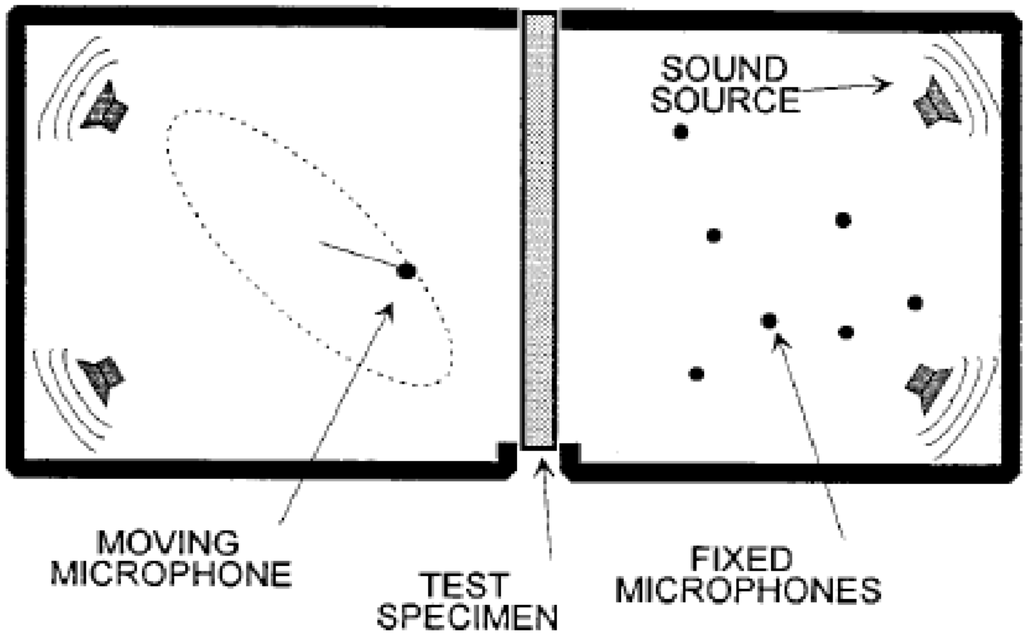
- Several acousticians have devoted many hours standardizing the scattering and diffusion coefficients ISO 17497-1 and 2, respectively, and unfortunately, they have not yet been adopted by commercial laboratories.

- Our goal is to connect the BAMM measurement method when adopted to the E90, in the hopes that it will be adopted by commercial labs measuring TL and STC.

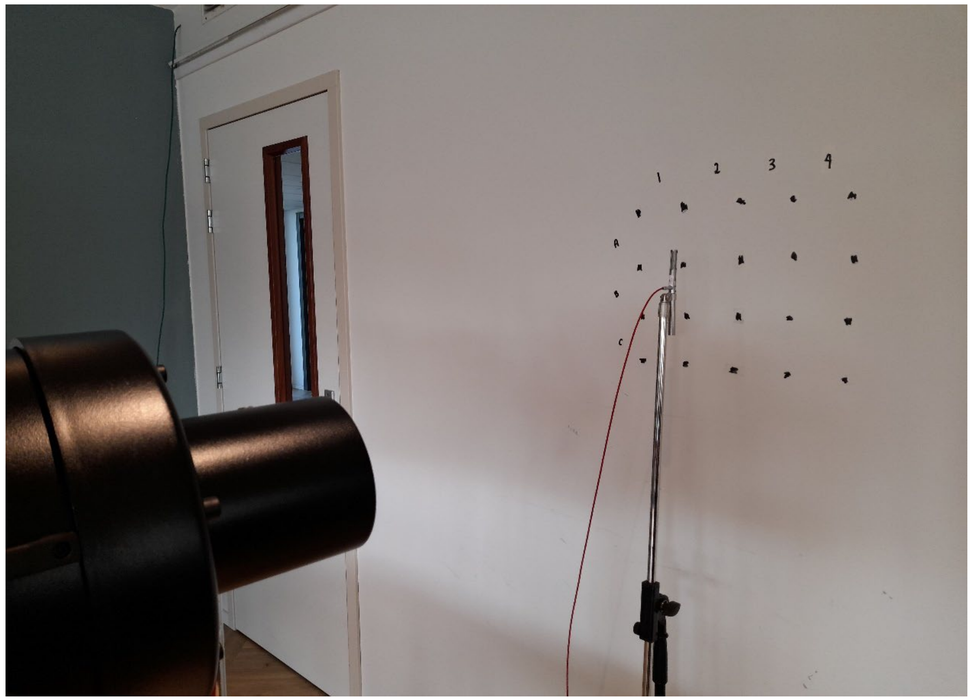
- This is proposed because most of the boundary constructions (Test Specimen) are already in place and it would be efficient to add an additional boundary admittance measurement.

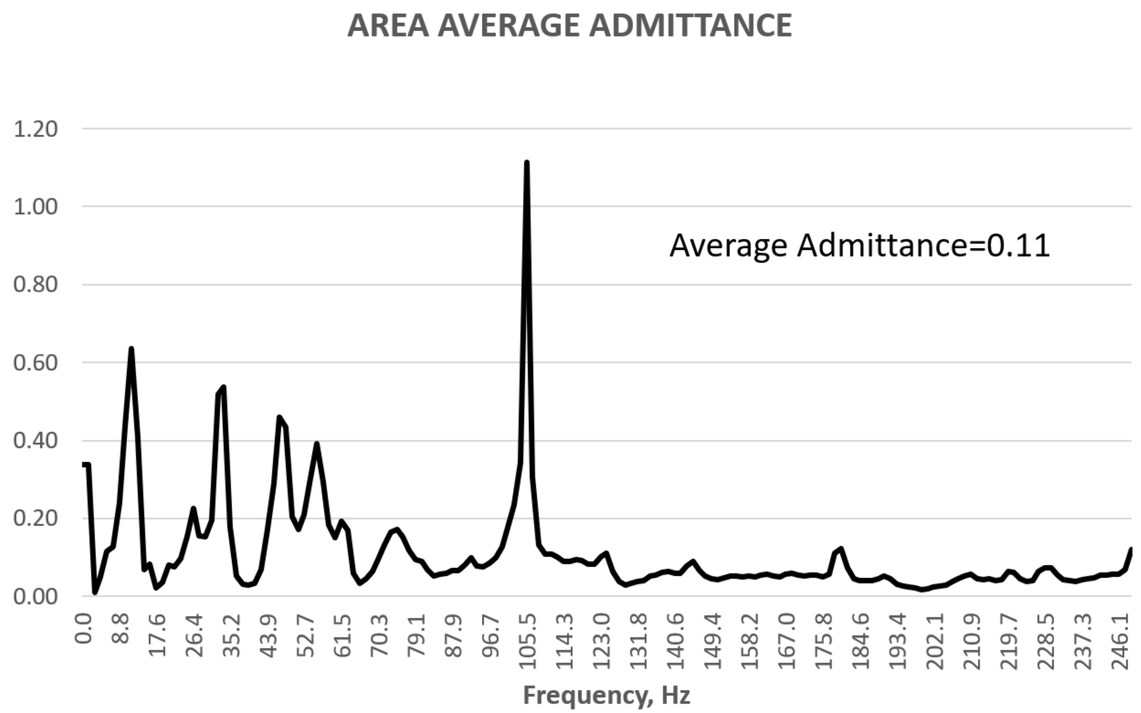
Repeat the Admittance Estimate approach on the previous slide in the Source Room:

- Mesh the Source Room and Test Specimen in an FEM program
- Measure the modal response with the Test Specimen in place, using a subwoofer in one corner and a mic in the opposite diagonal corner.
- Assume the low admittance of the concrete boundaries and search for an sample admittance that matches the modal response.



Microflown Admittance Measurement





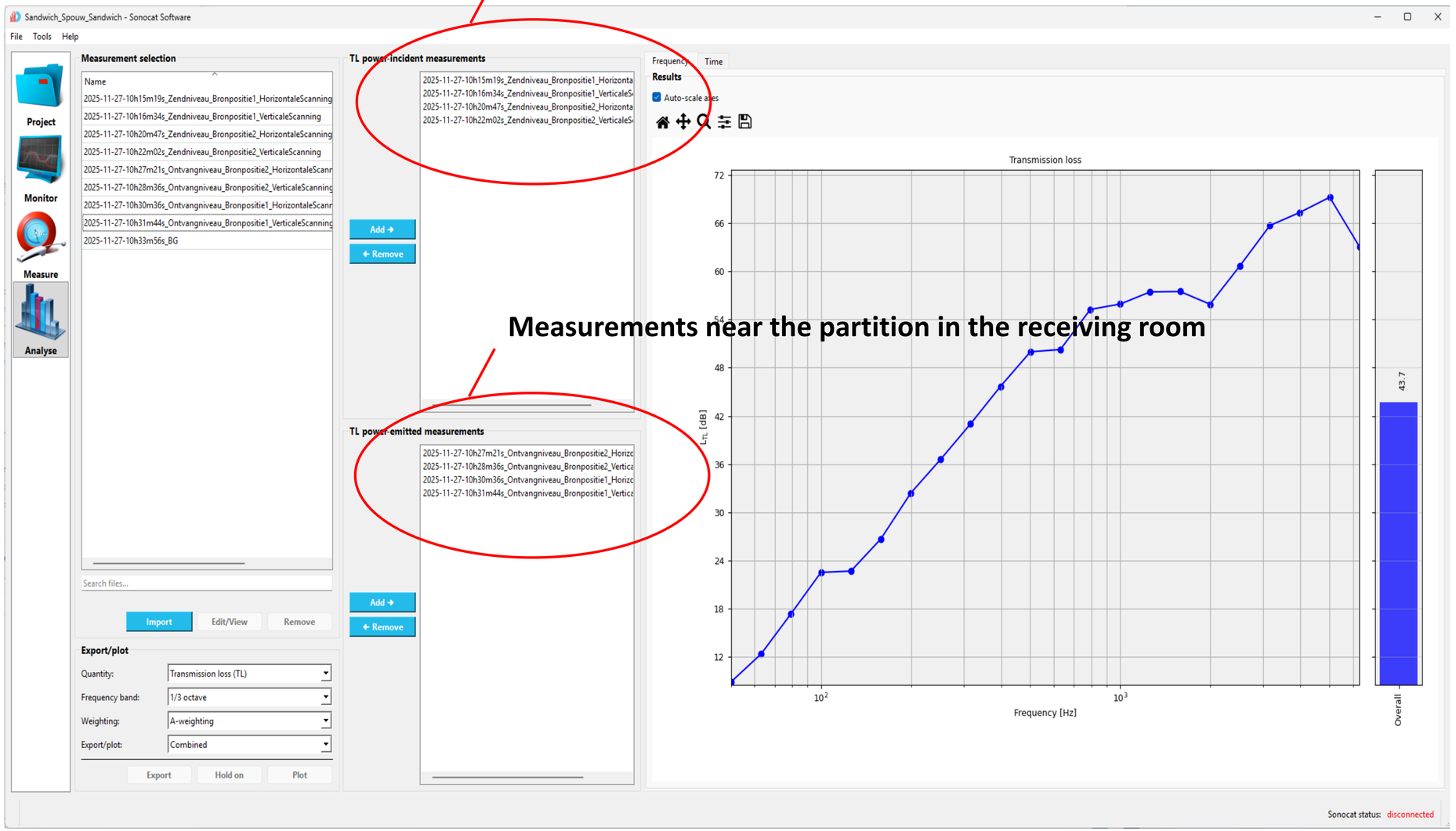
Double gypsum panel with an air gap (2x12.5 mm + 45 mm air gap + 2x12.5 mm), mounted on an aluminum frame.

Sonocat Intensity probe

- **Transmission facility at Level Acoustics Eindhoven, the Netherlands**
- **Test specimen: steel panel – gap – steel panel**

Sonocat transmission loss

Measurements near the partition in the sending room



Measurements near the partition in the receiving room

In-situ Portable Impedance Tube

100mm impedance tube with in-situ adapter

Tested in the NRC Ottawa E90 wall facility

Wall specimen (STC 54)

- 2x4 wood studs, 2’ o.c. spacing
- 5/8” Type X, 1x directly attached, 2x on resilient channels

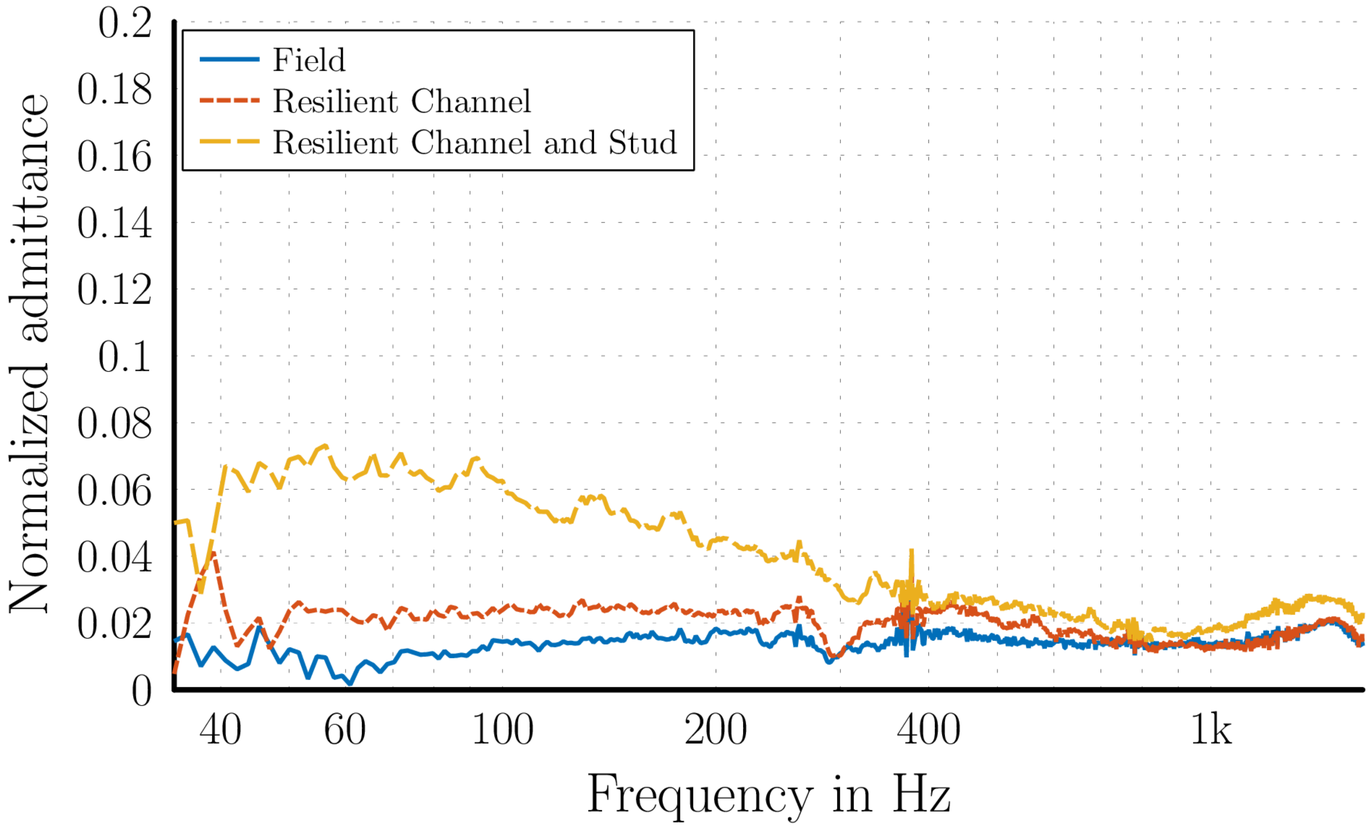
Advantages

- Complex admittance
- Compare on/off stud/RC

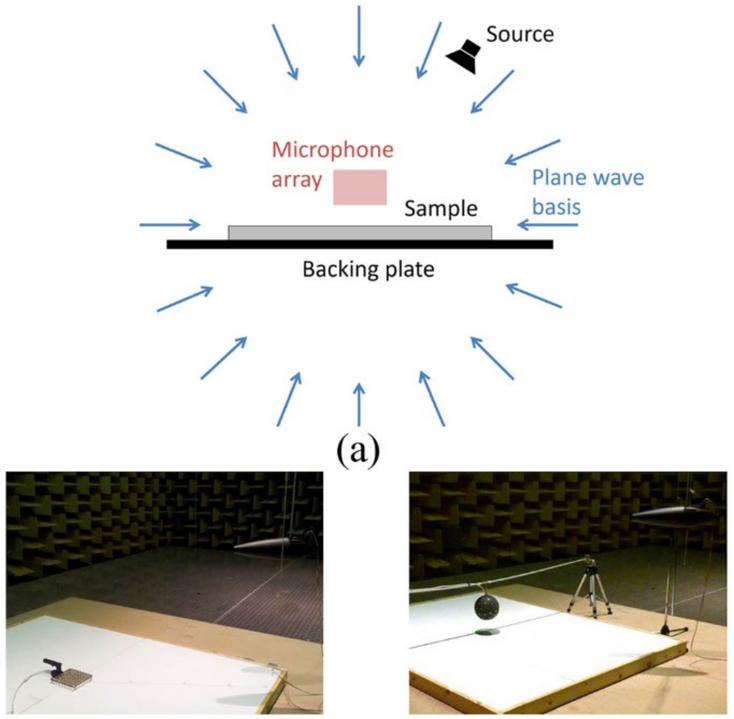
In-situ Portable Impedance Tube

Normalized admittance

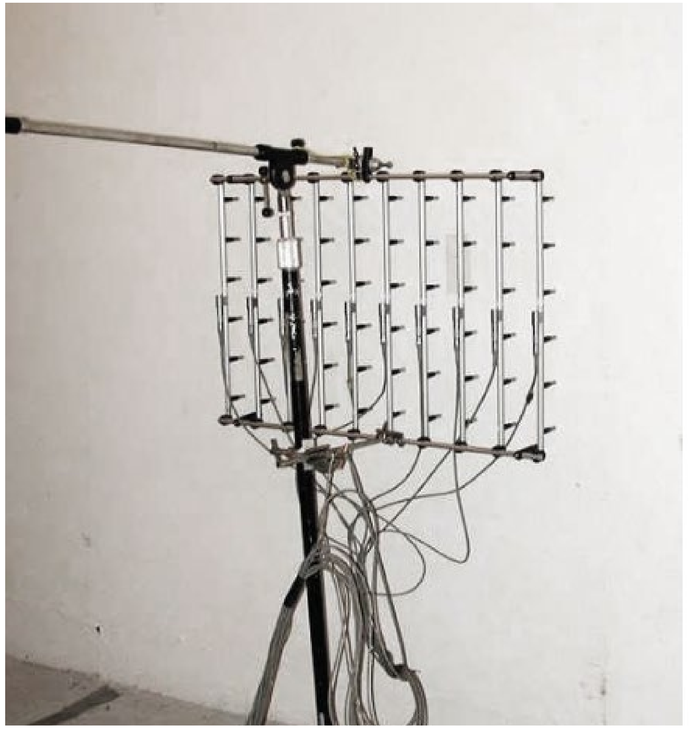
- Field vs on RC vs on RC+stud



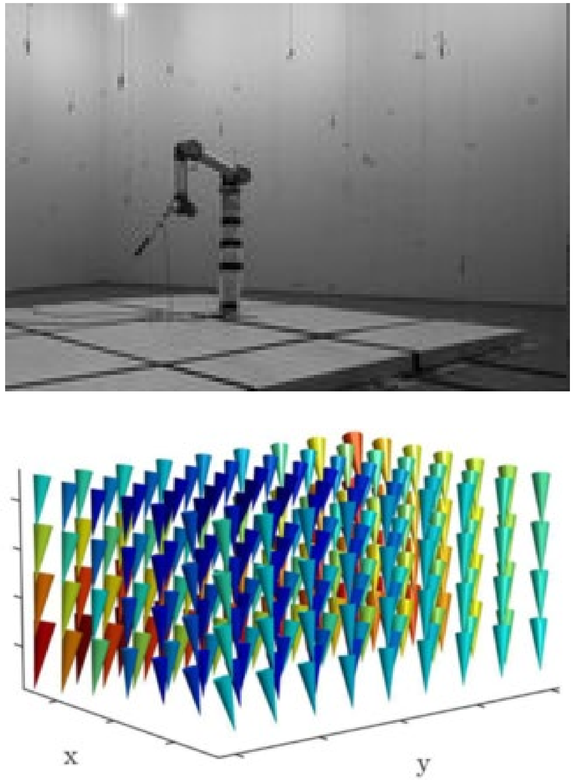
Multi-Microphone



Richard and Fernandez-Grande, JASA 146 (2019)



Jacobsen and Roig, Acta Acustica 99 (2010)



Nolan et al. JASA145, (2019)

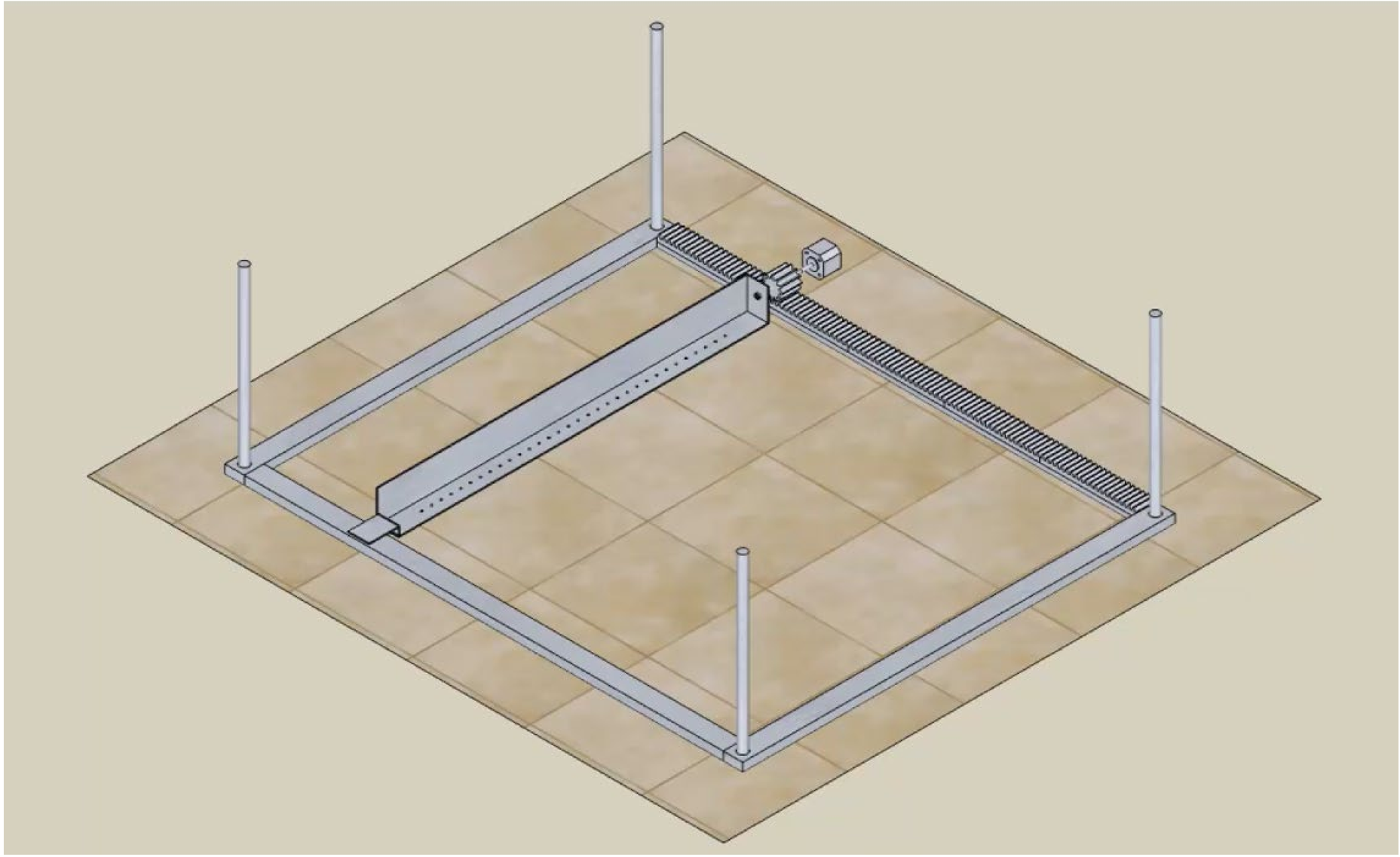
(...)

Spatial measurement: microphone arrays, sequential measurements, robots, …

Full sound field estimation: Reconstruct p-u on the boundary -> impedance/admittance

Precise characterization of incoming field, can establish dependencies on incidence

Scanning Multi-Microphone



THANKS FOR YOUR ATTENTION!

This is just the beginning.....