



You *Listen* to Brick

An Introduction to Acoustic Consulting

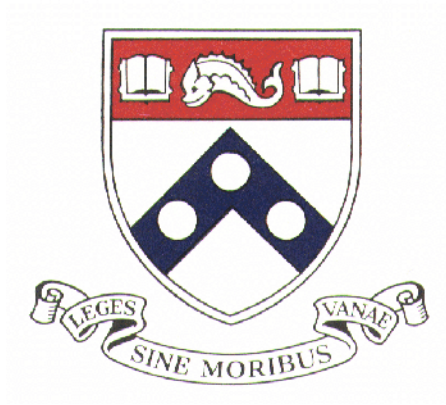
Physics for Architects

Davis S. Butner

09.21.18

"A great building must begin with the unmeasurable,
must go through measurable means when it is being
designed and in the end must be unmeasurable."

- Louis Kahn



threshold



HARTSHORNE PLUNKARD
ARCHITECTURE



THEATRE
PROJECTS



Architectural Acoustics

A Local History





PSFS Building, Lescaze + Howe, 1932





Guastavino Ceiling Tile, Grand Central Terminal



Wallace Clement Sabine (1868–1919)

$$RT_{60} = \frac{0.161V}{S_e(1 + \frac{\bar{a}}{2})} \quad \text{where} \quad \bar{a} = \frac{\text{effective absorbing area}}{\text{total area}}$$

Sabine's Equation

Reverberation – Prolongation of Sound

Absorption – the process by which a material, structure, or object takes in sound energy when sound waves are encountered

$$RT_{60} = \frac{0.161V}{S_e(1 + \frac{\bar{a}}{2})} \quad \text{where} \quad \bar{a} = \frac{\text{effective absorbing area}}{\text{total area}}$$

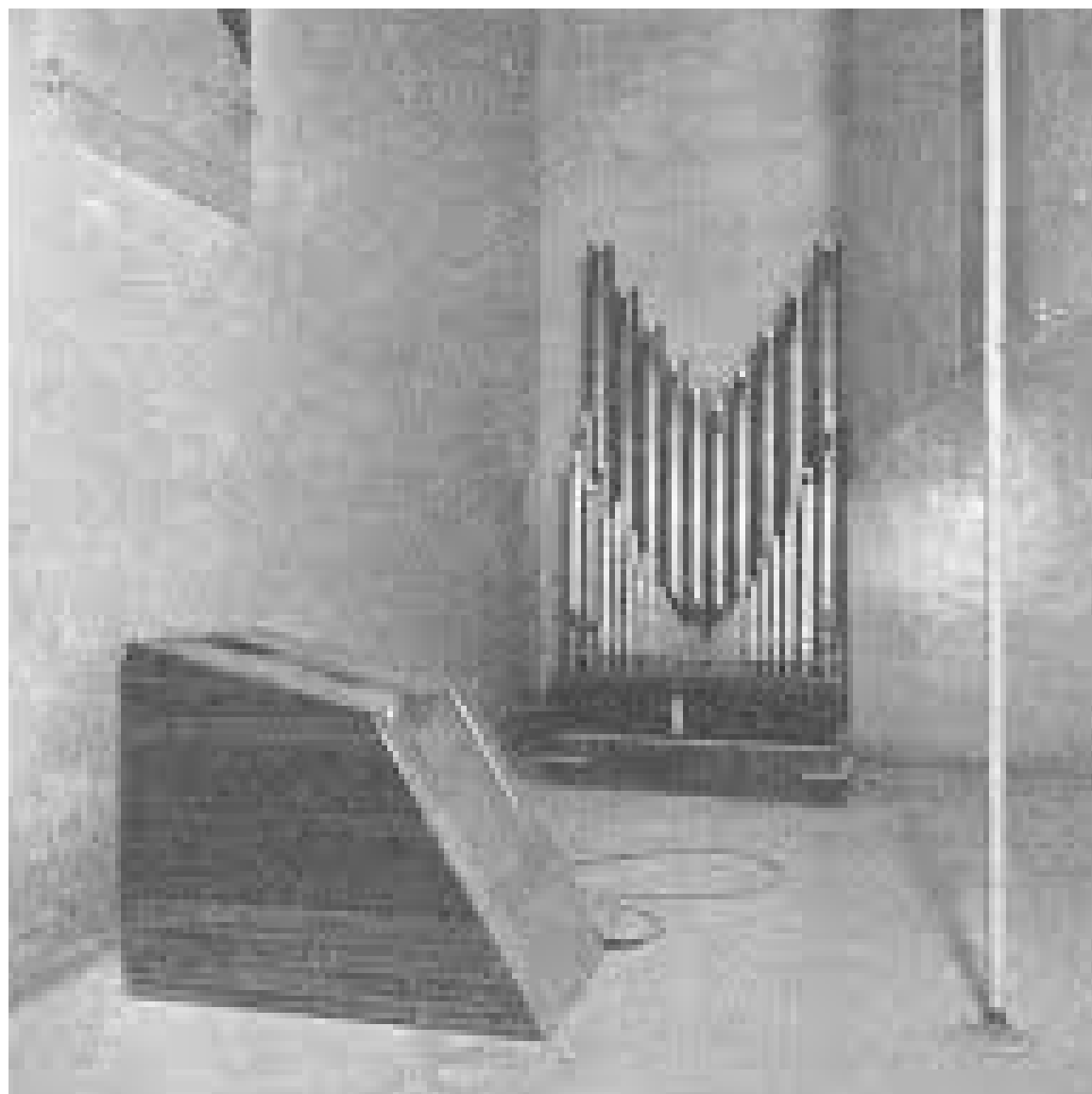
Volume of a Room

Absorption Coefficient (0 to 1)

Speed of Sound (@20°C)

Reverberation Time
Time it takes to drop 60dB







What Does an Acoustician Do?

A Job Description

Room acoustics (Chap. 3)

- Cubic volume (and coupled spaces)
- Shape and proportion (length-to-width, height-to-width)
- Finishes (selection and placement)
- Audience layout (floor slope, speaker-to-listener distances)
- Seating and other furnishings
- Special treatment (suspended reflectors, resonant absorbers, quadratic-residue diffusers)

Sound isolation (Chaps. 2, 4, & 6)

- Site noise characteristics (sound level, character, duration)
- Outdoor barriers, nearby buildings, vegetation, and earth berms
- Location of activities within buildings (zoning, buffer spaces)
- Wall, floor, and ceiling constructions
- Background noise criteria (HVAC system, electronic)
- Coordination with room acoustics

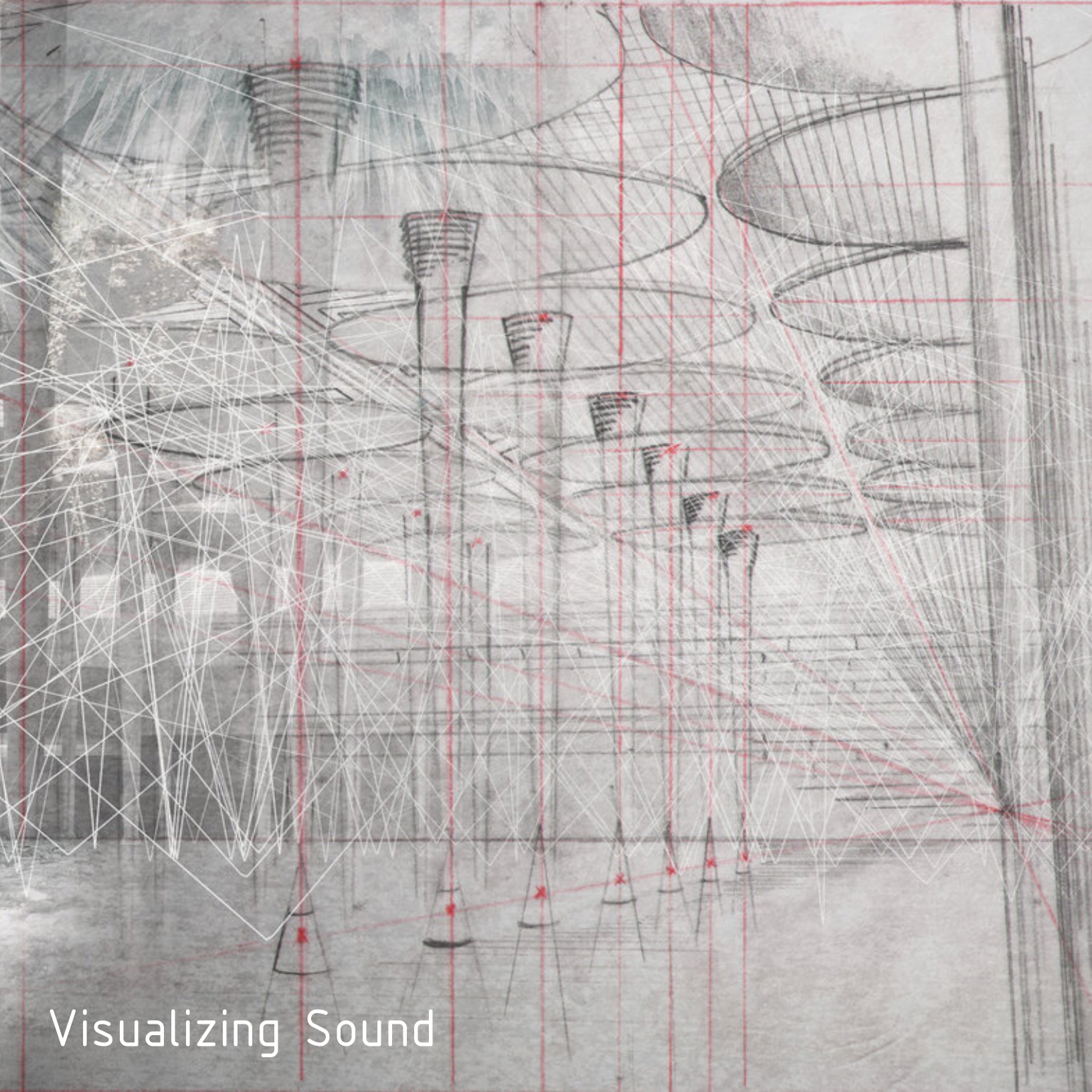
Essential elements of
architectural acoustics

Mechanical system noise and vibrations (Chap. 5)

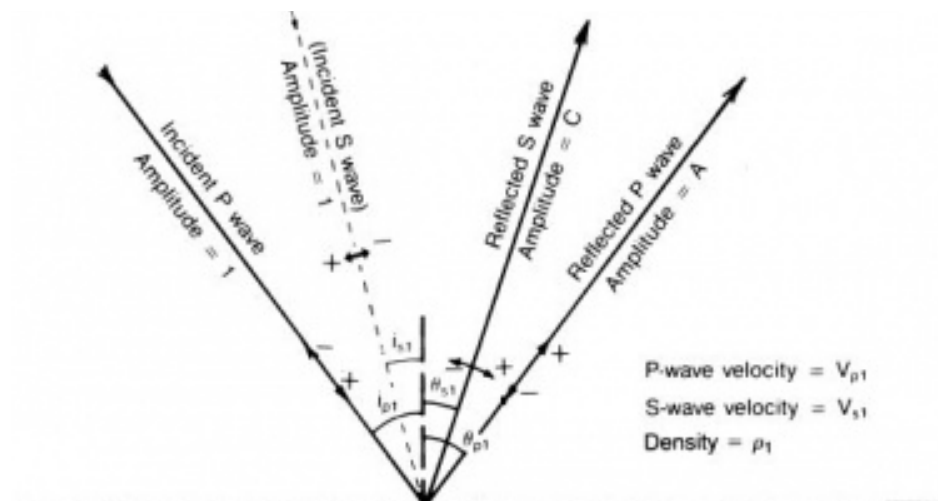
- Equipment noise characteristics
- Location of mechanical equipment
- Vibration isolation (springs, pads)
- Air duct and pipe treatment (linings, mufflers, laggings)
- Background noise from air outlets (coordination with sound isolation)

Electronic sound systems (Chap. 7)

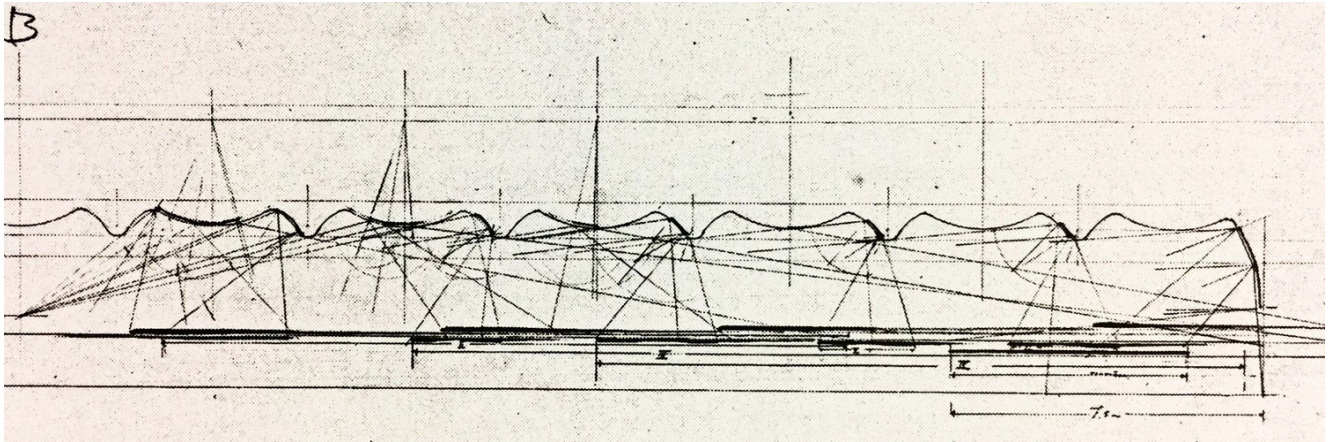
- System compatibility with room acoustics
- Loudspeaker selection, placement, and orientation
- System components and controls
- Background masking (loudspeaker layout, sound spectra)



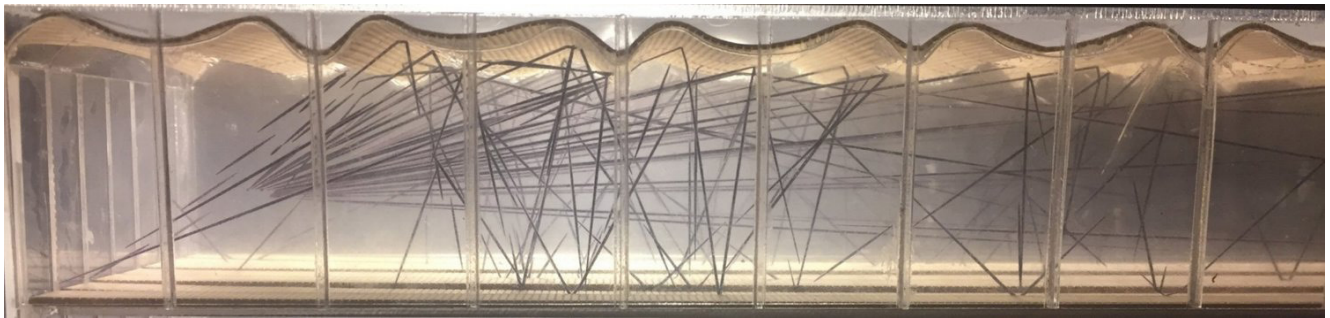
Visualizing Sound



Snell's Law

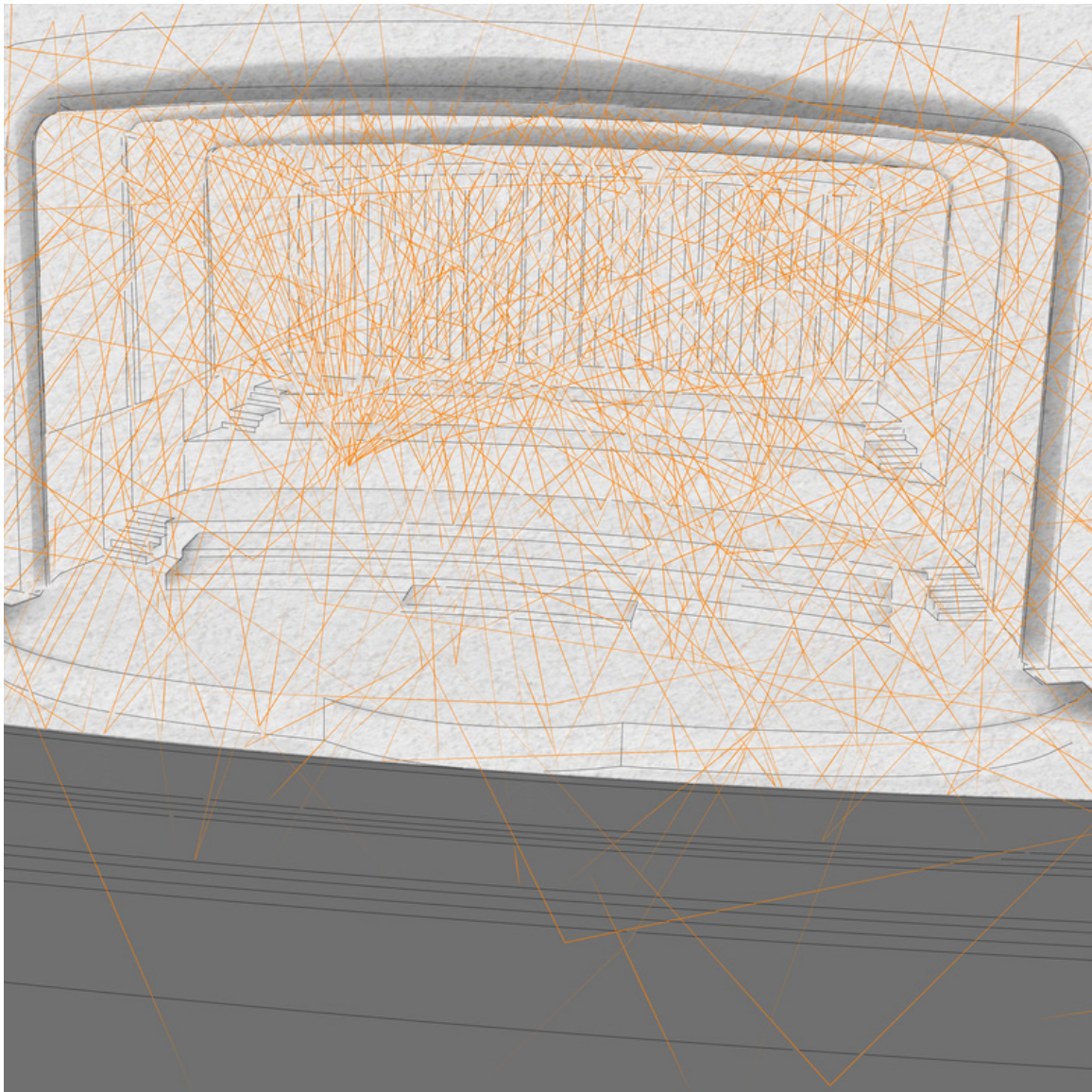


Viipuri Library Auditorium - Alvar Aalto

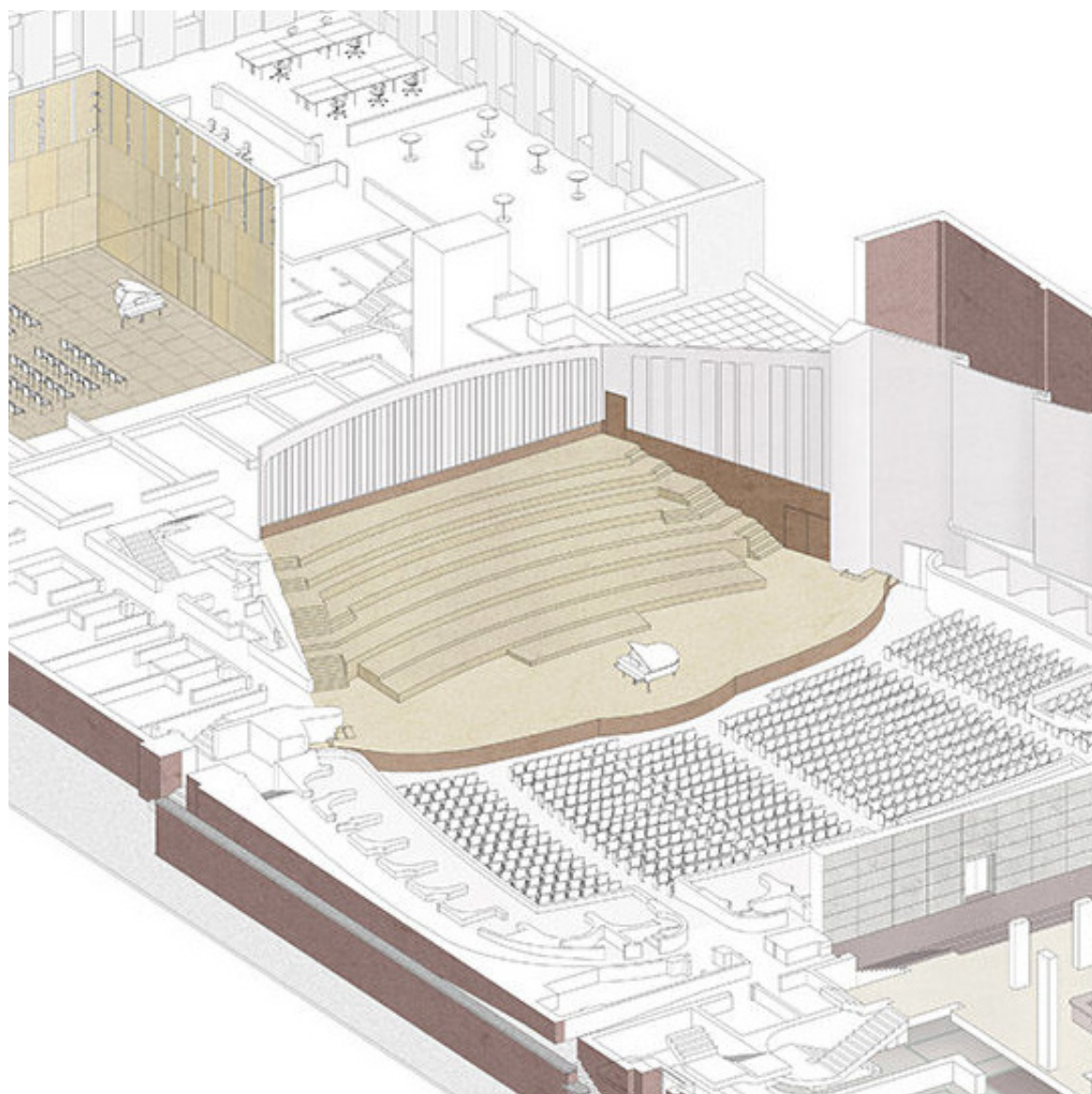


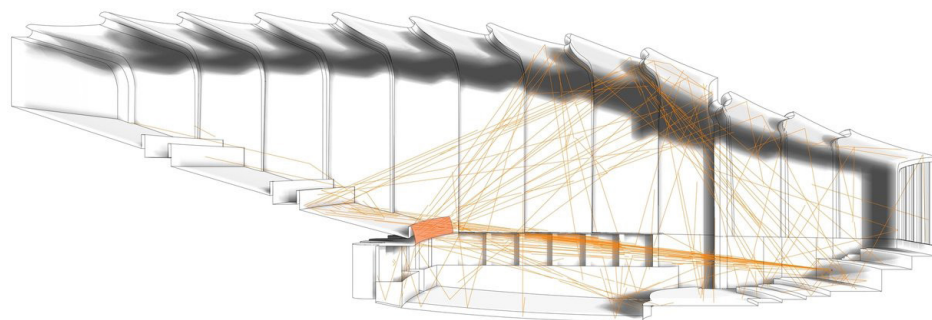
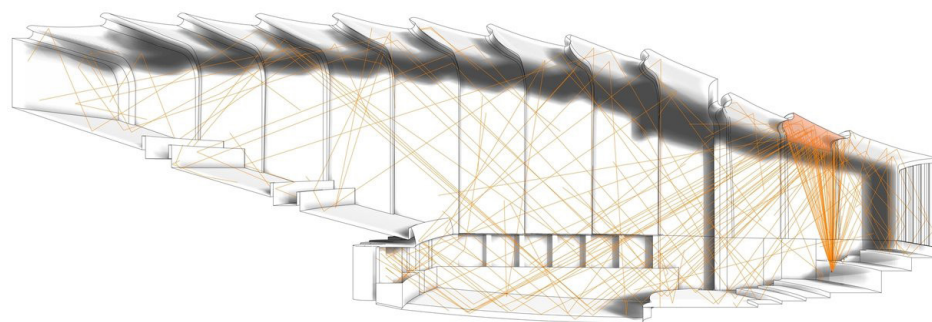
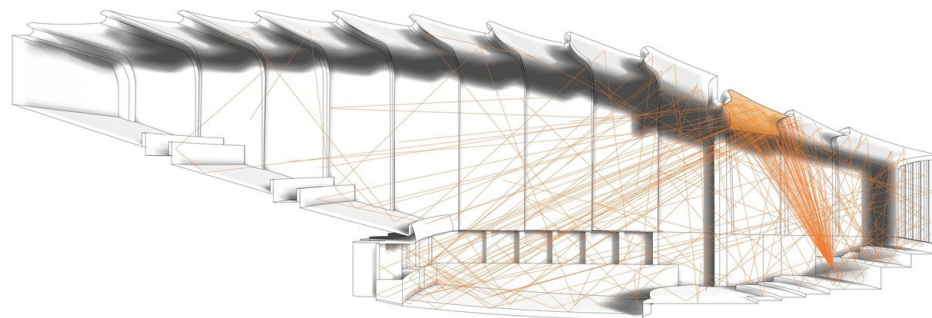


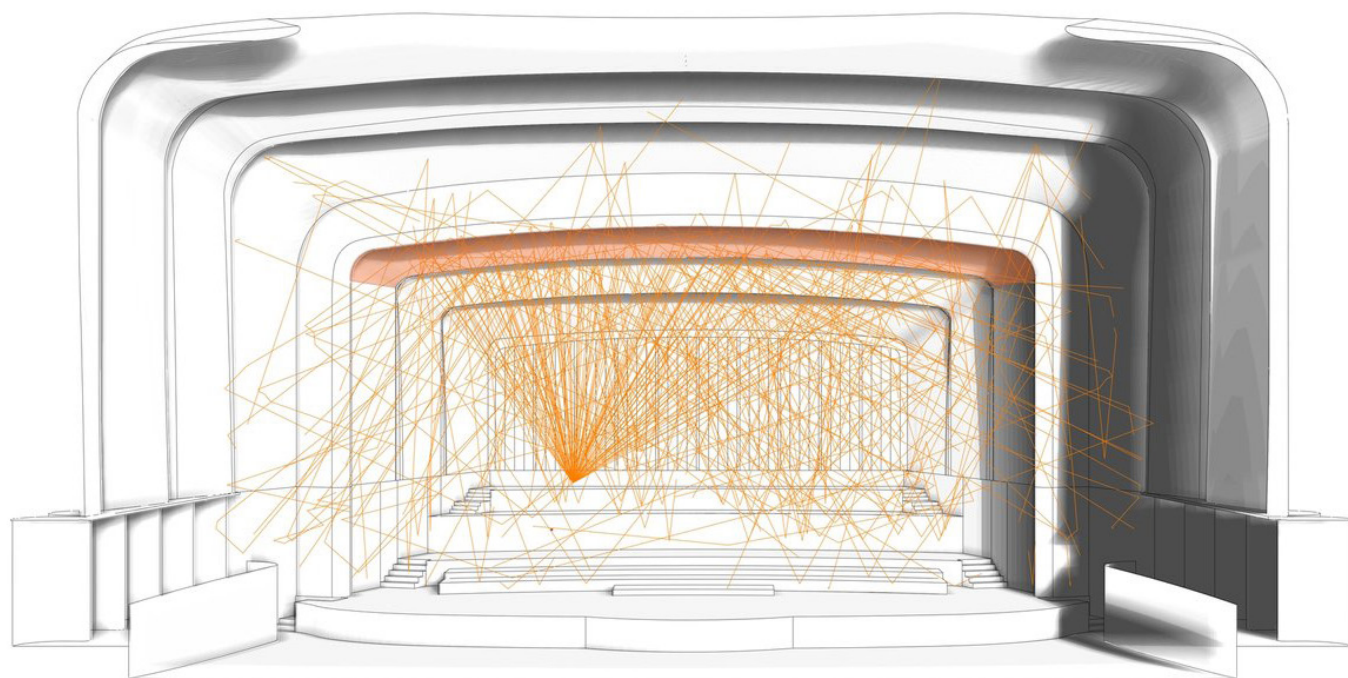
What Does an Acoustician Consider?

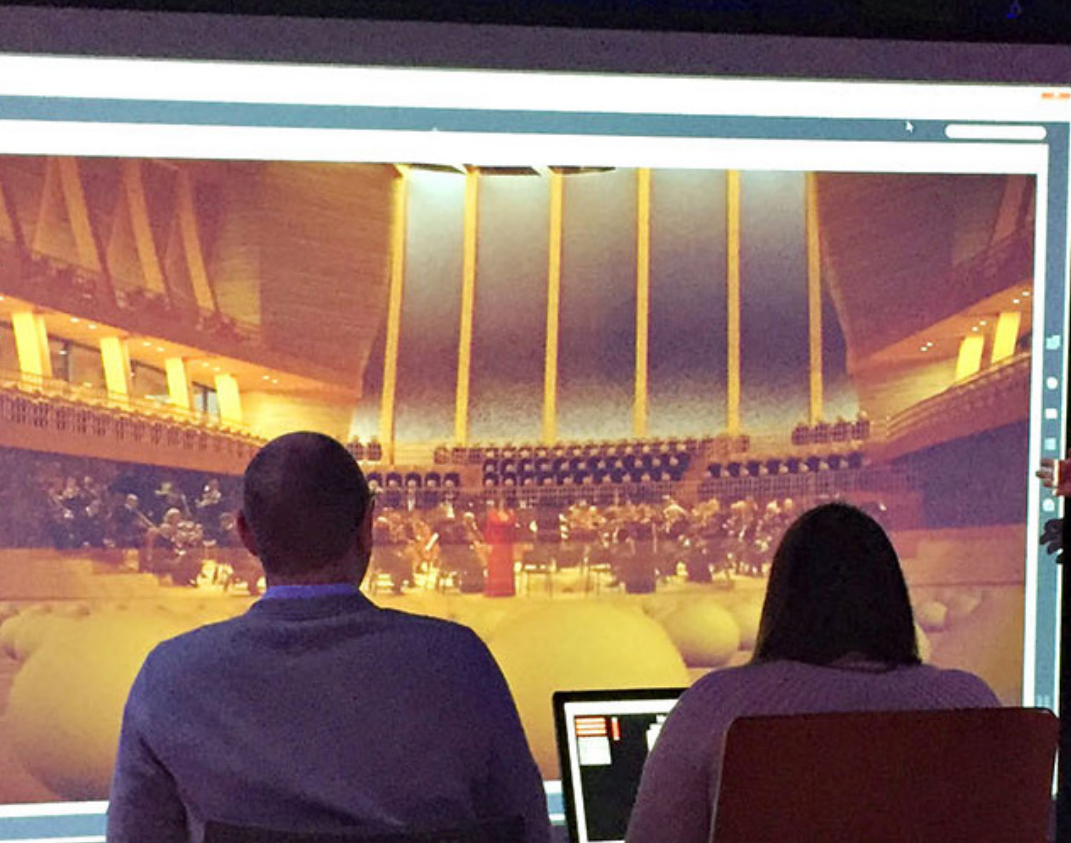


Liverpool Philharmonic Hall Analysis, Threshold Acoustics, 2014

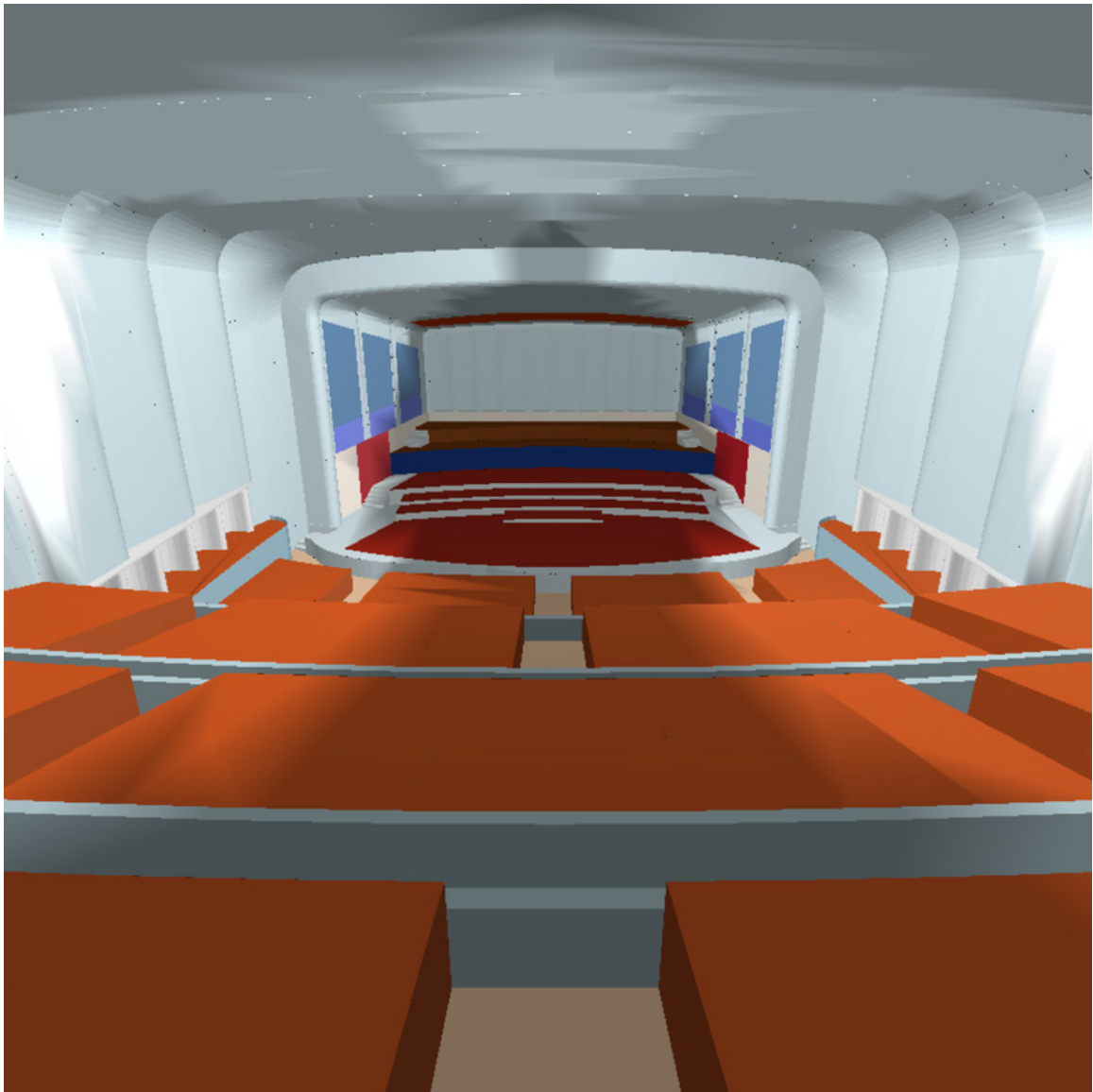


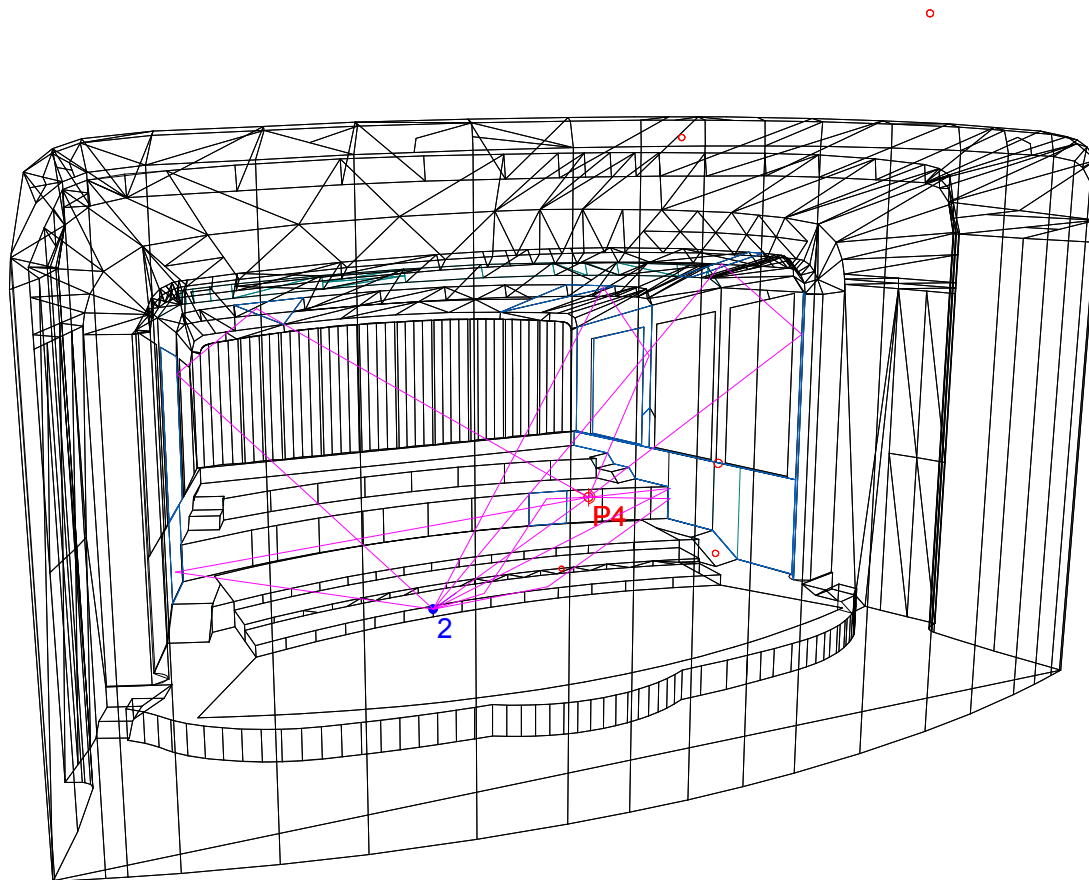


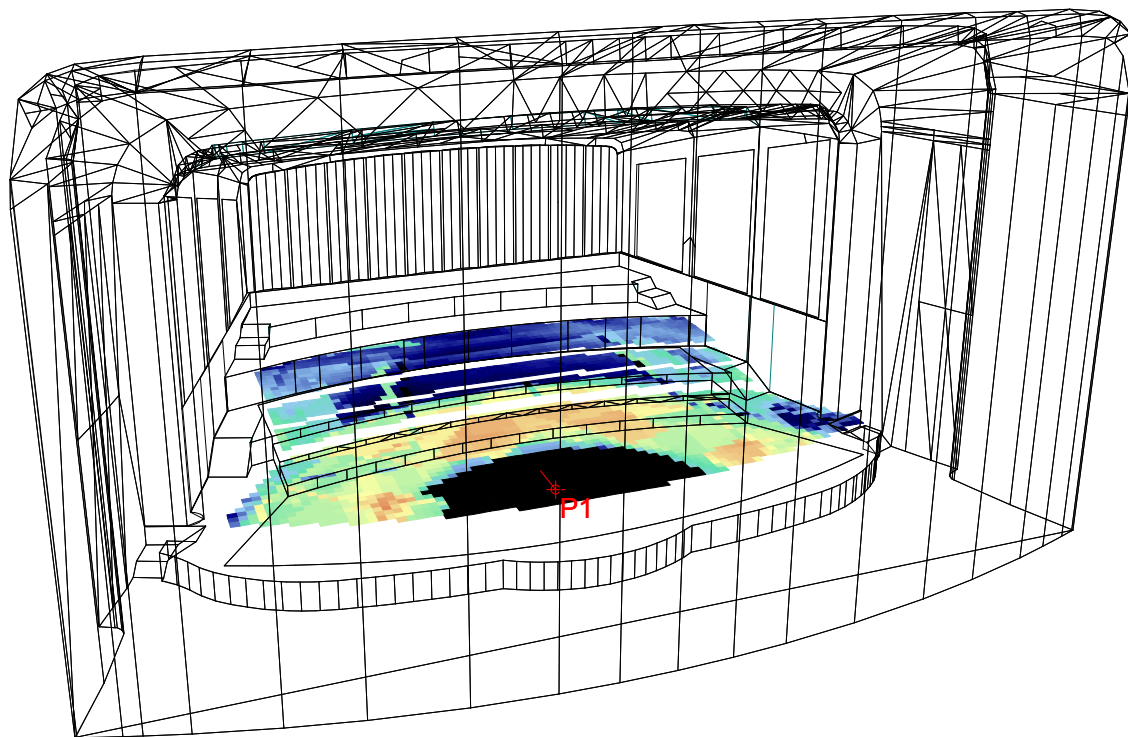




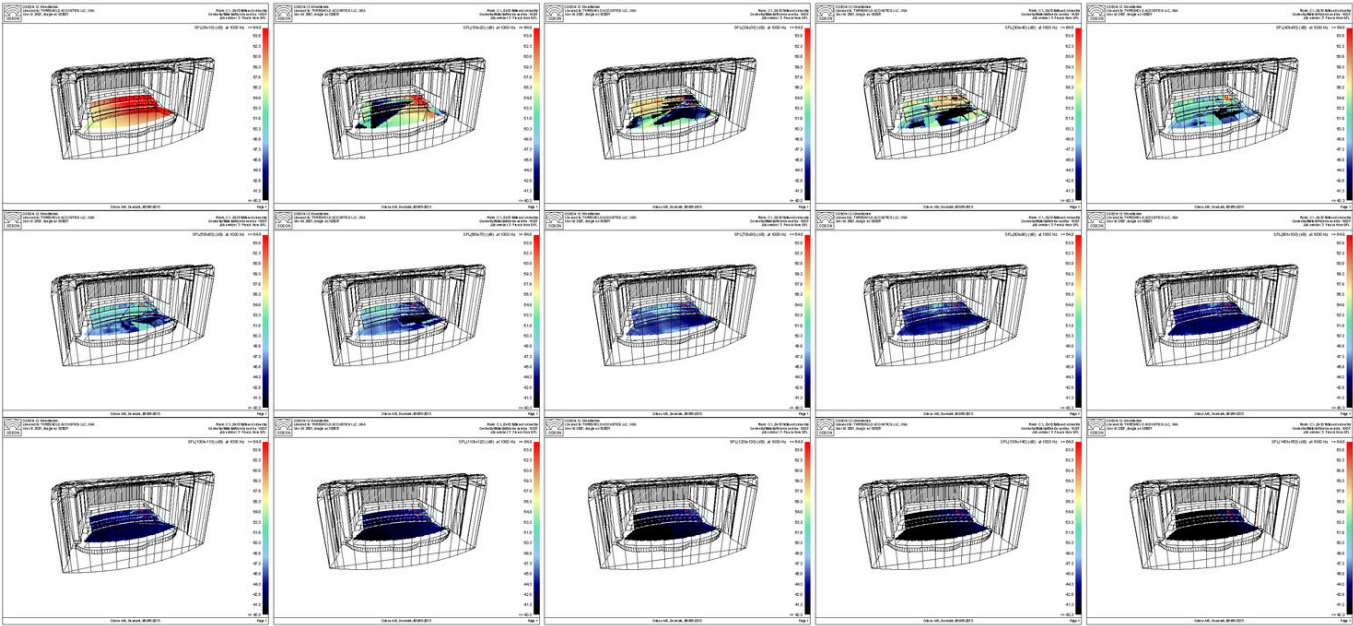
Auralizing Sound

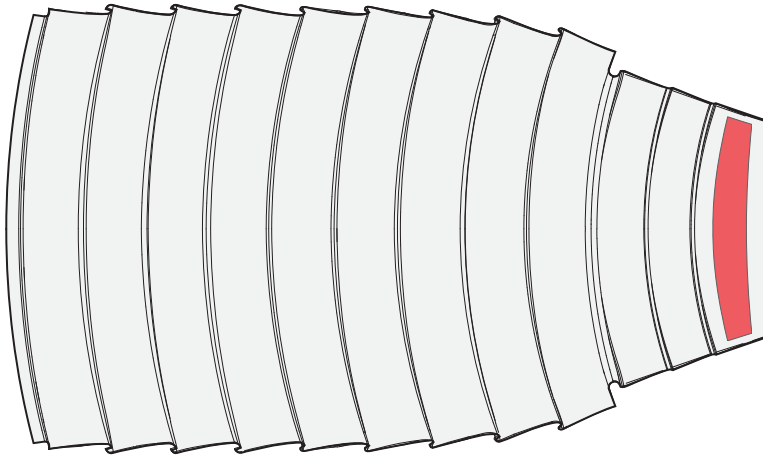
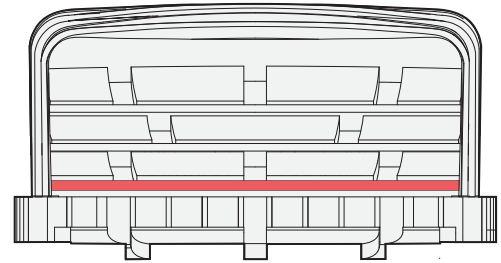
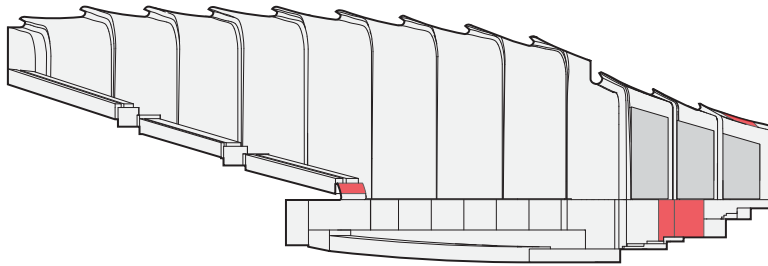






Liverpool Philharmonic Hall (current risers)
SPL Mapping - French Horn



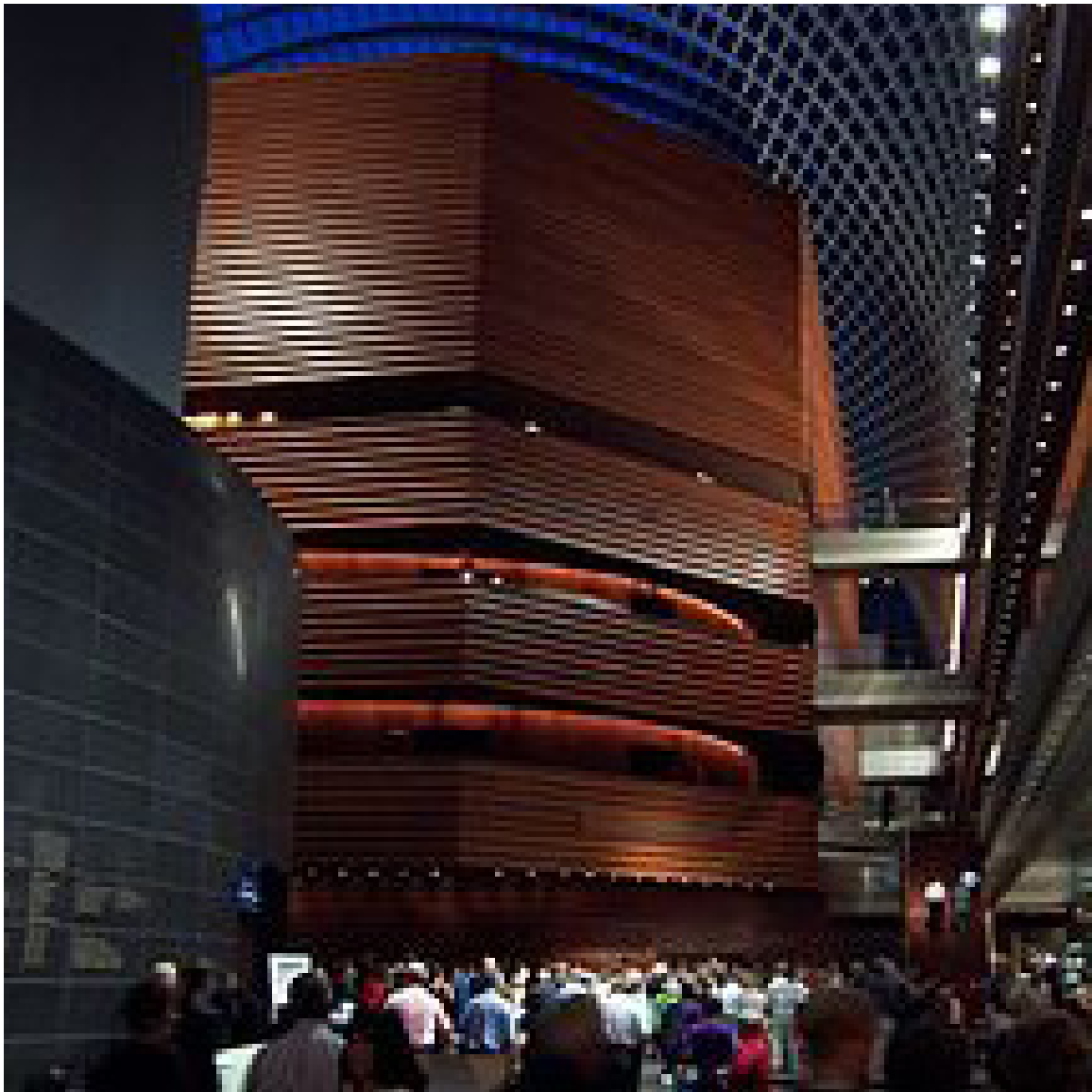


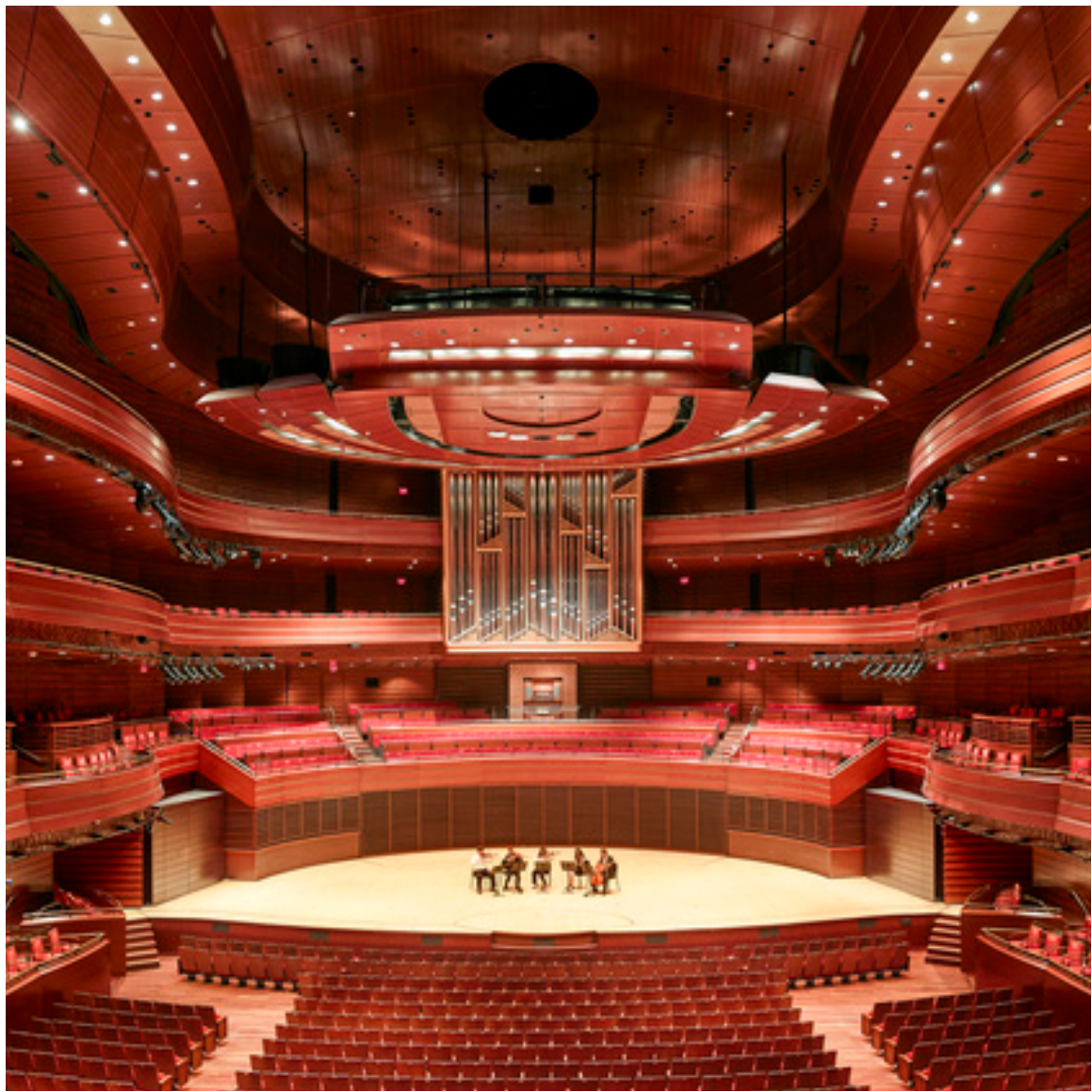
Placement of Absorptive Fabric

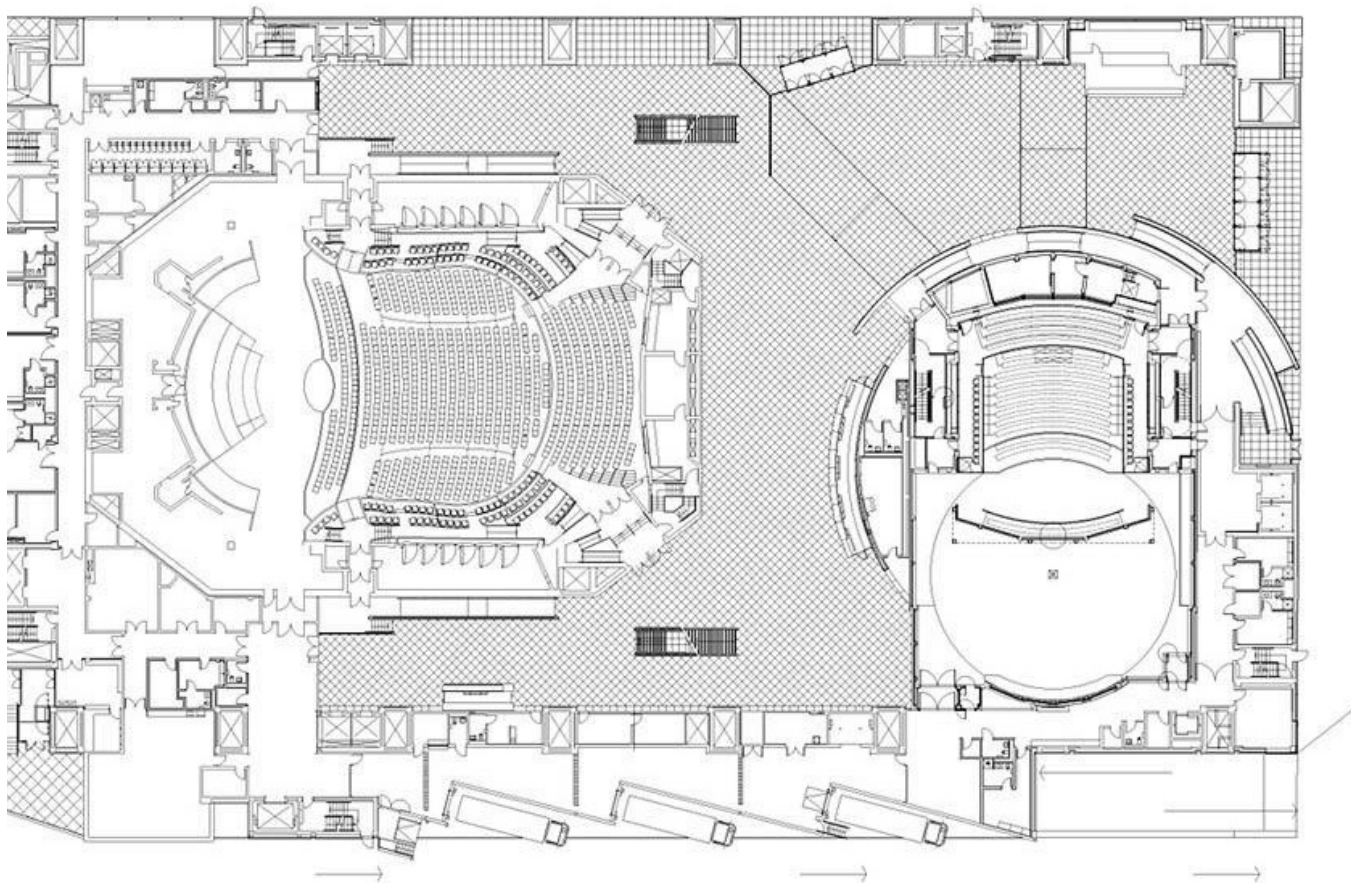


Isolating Sound









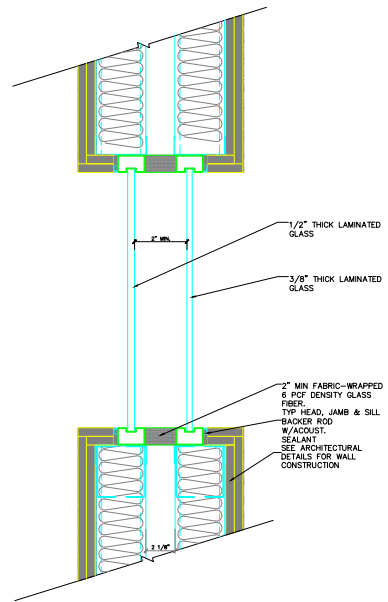
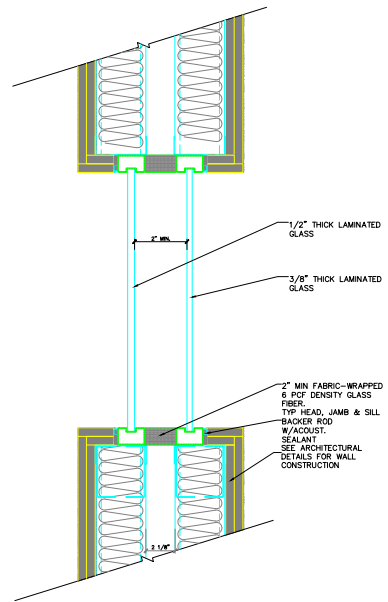
0 10 50 100 ft





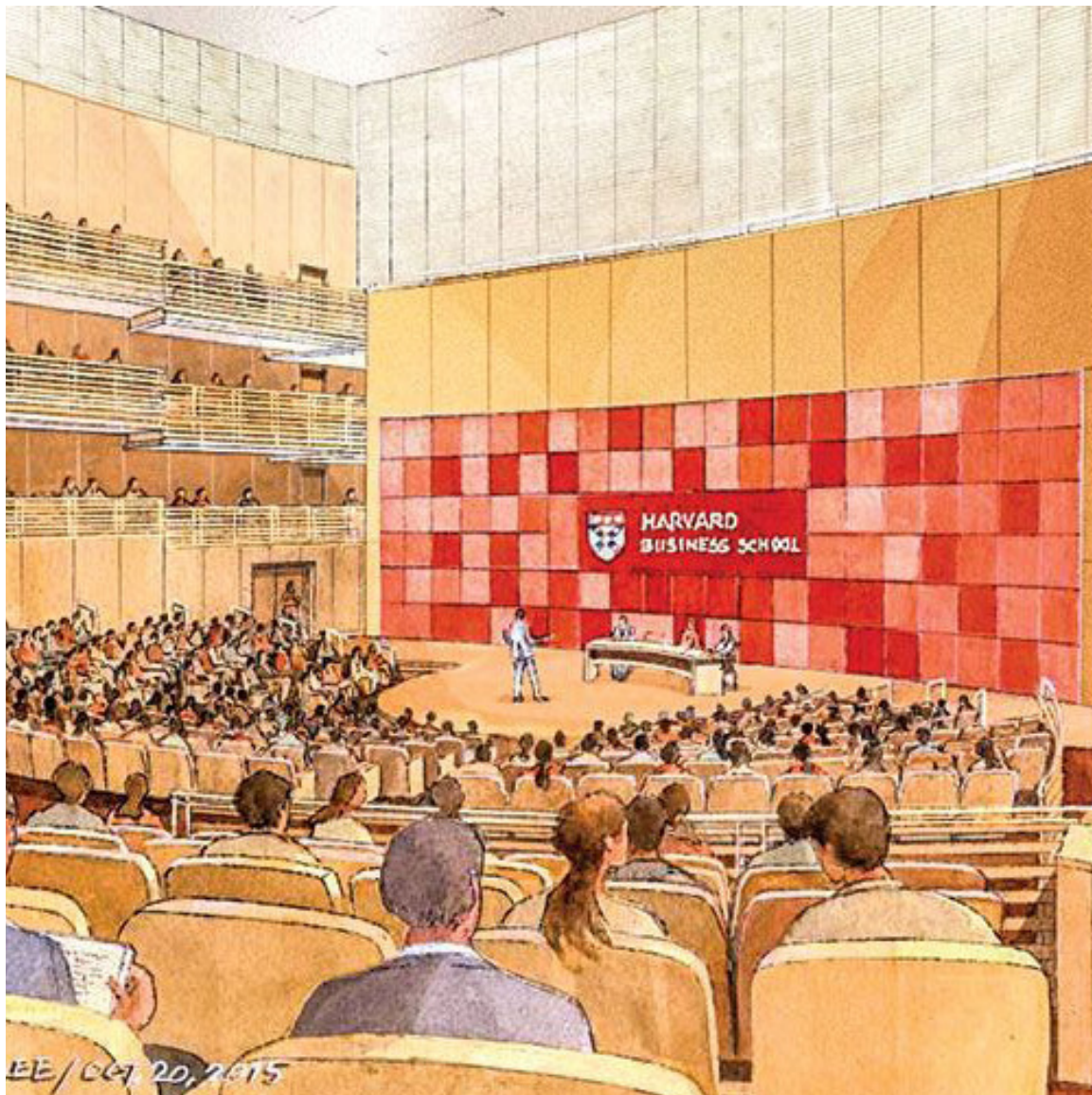








Sound Testing



Klarman Hall, Harvard Business School



threshold

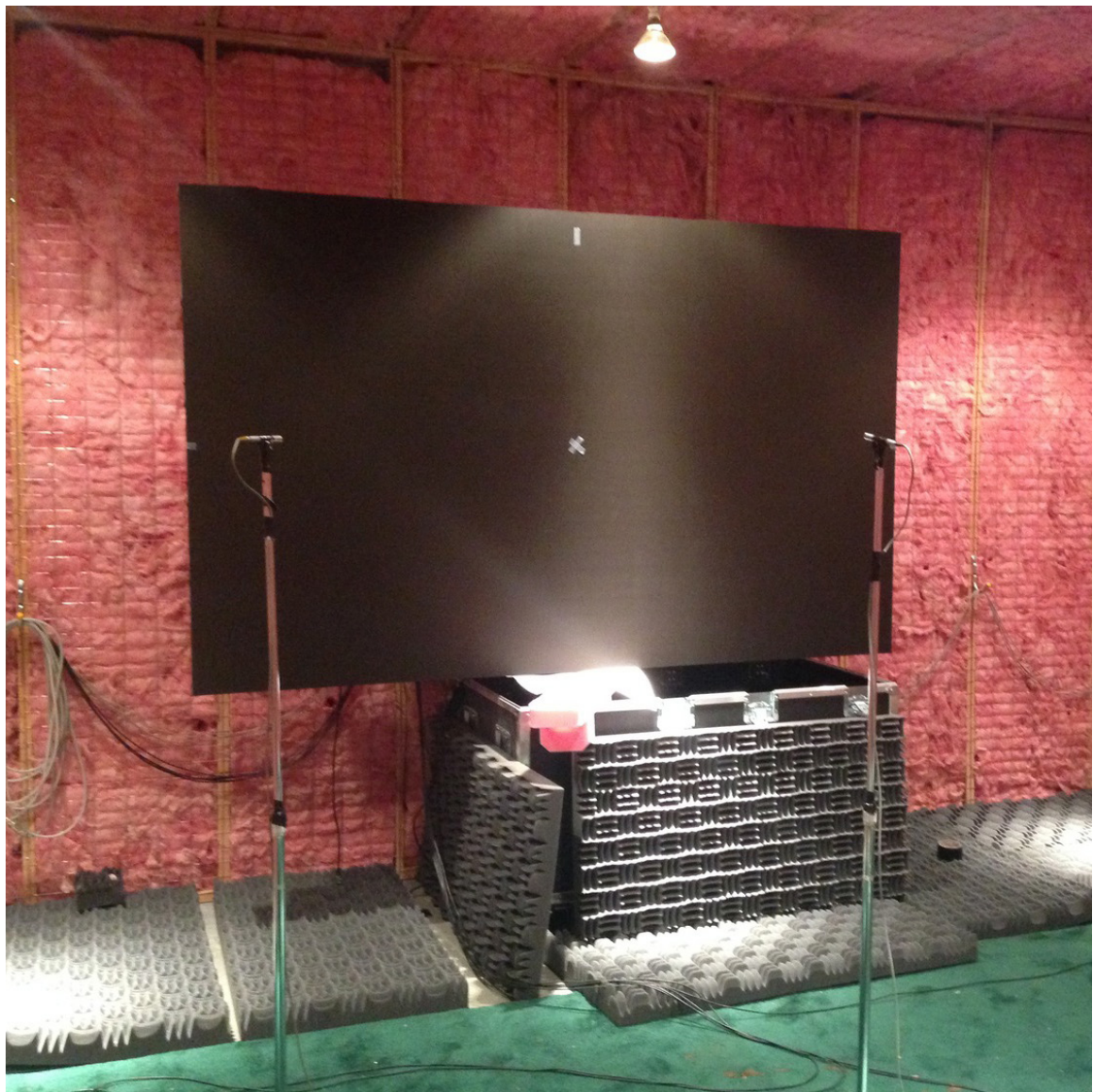


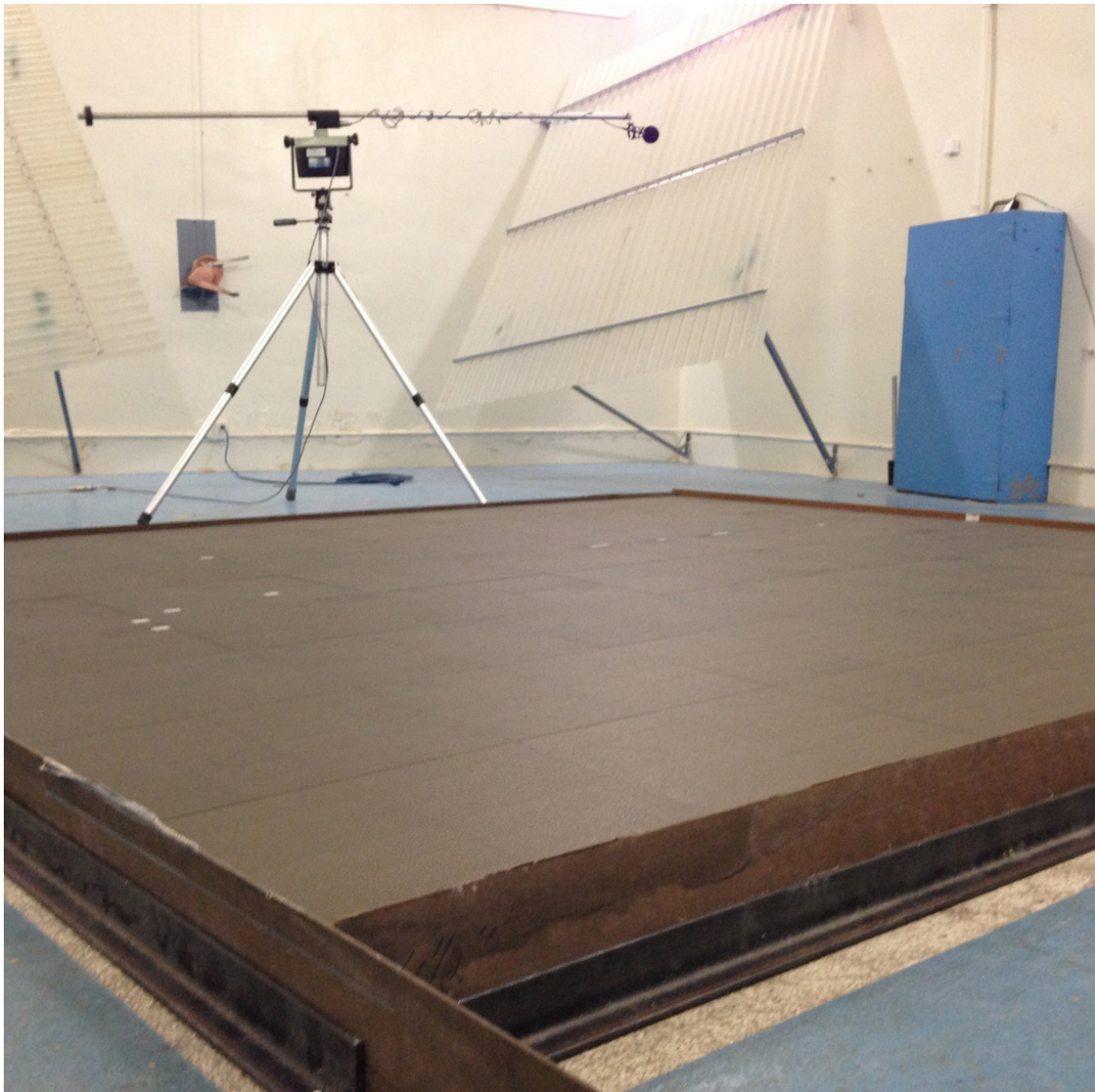
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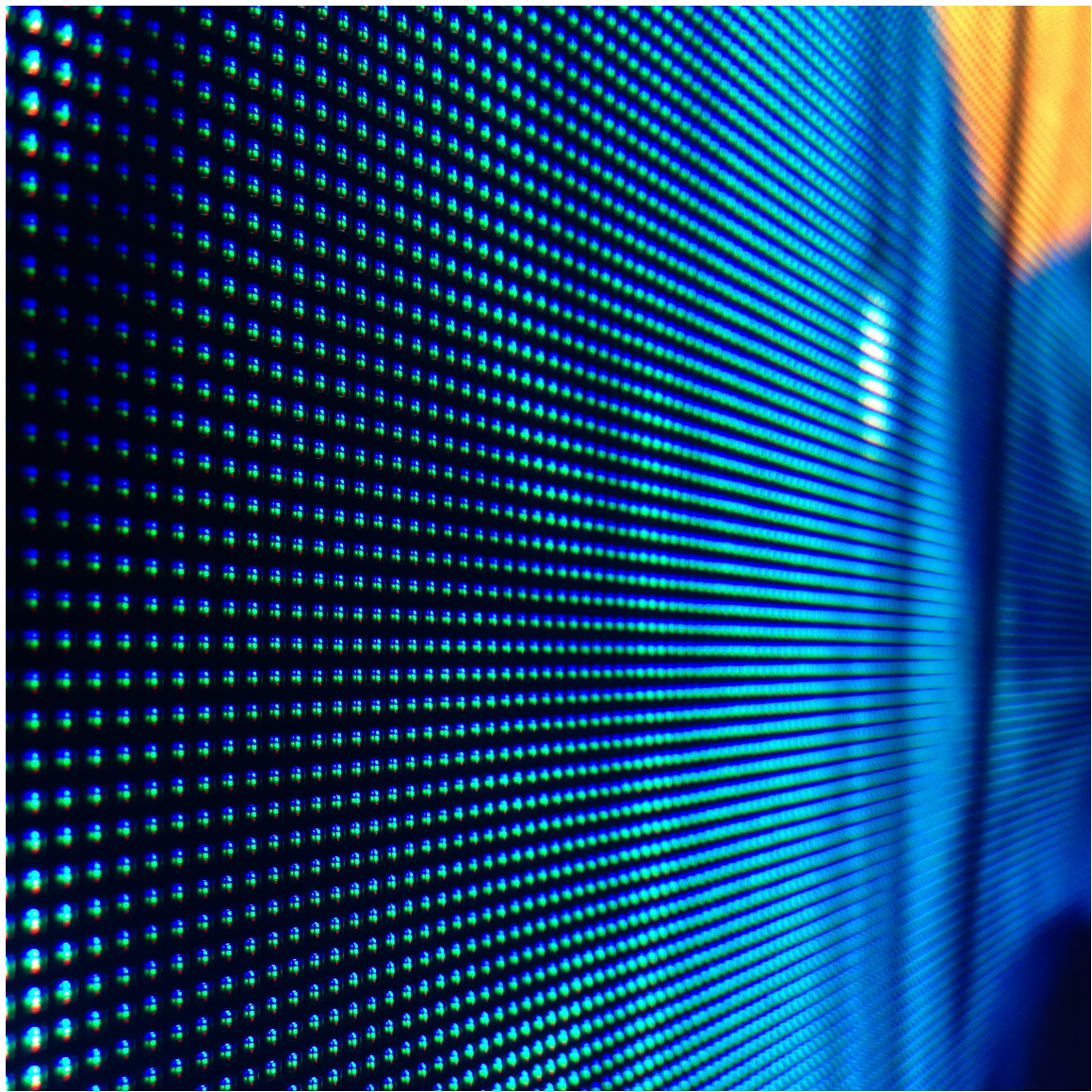
WILLIAM RAWN ASSOCIATES
ARCHITECTS















1000 Seat Sound Test, August 15th, 2018









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