ACENTECH

ACOUSTICS CONSIDERATIONS IN THE INTEGRATED DESIGN BUILDING

October 2, 2017

Learning Objectives

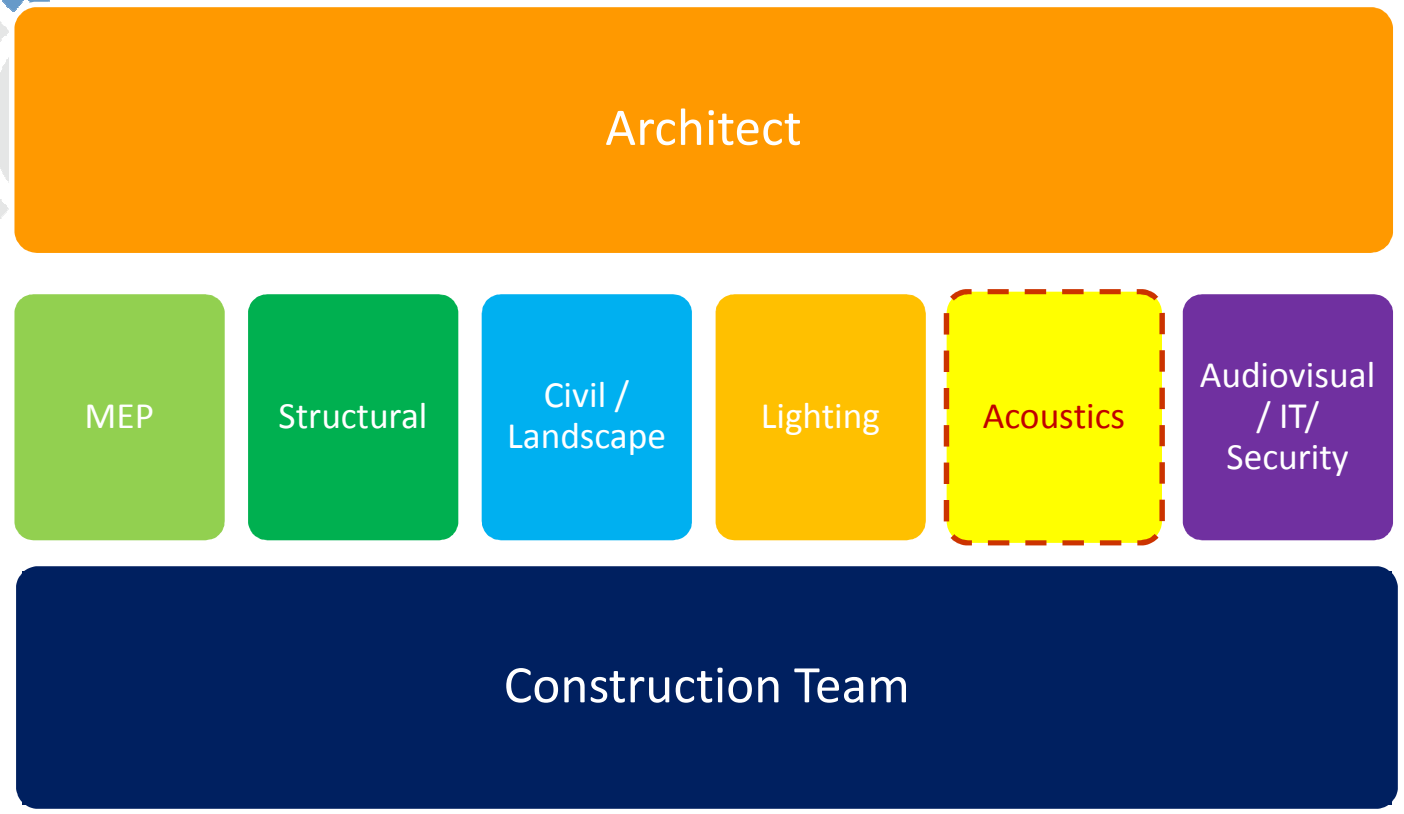
1. Understand the basics of acoustics
2. Understand how to categorize different acoustical issues faced on architectural projects by using UMA IDB as an example.
3. Understand how to upgrade demising constructions to reduce sound and impact transmission
4. Understand how to select acoustical finishes to improve the acoustics within a room

Who am I?

Rose Mary Su
Senior Consultant, Architectural Acoustics

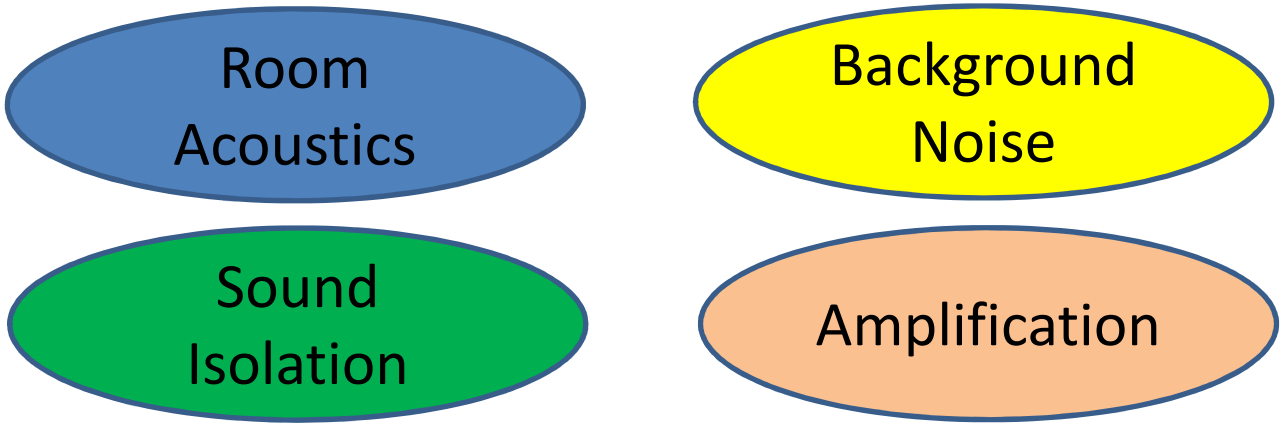
Acoustician for the design and construction of UMA Design Building

Our Role on a Project



A Quick Outline

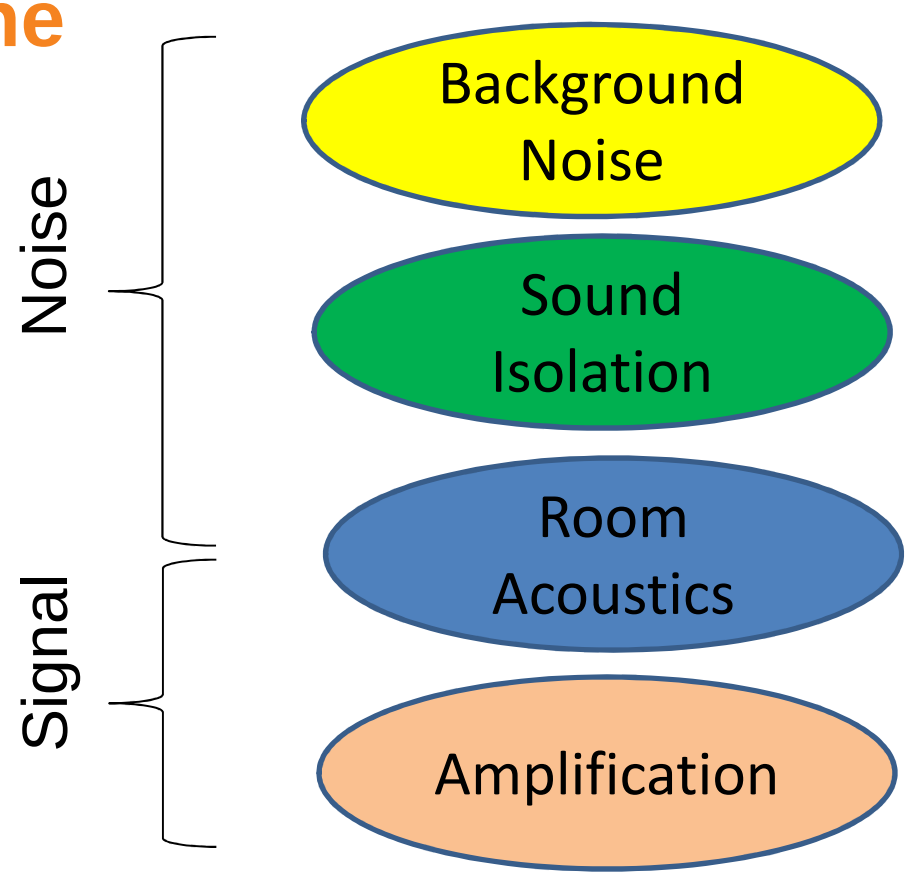
- Introduction to Sound / Acoustics
- Architectural Acoustics is four things:



- Applies to all gathering spaces, including theaters, conference rooms, classrooms, etc.

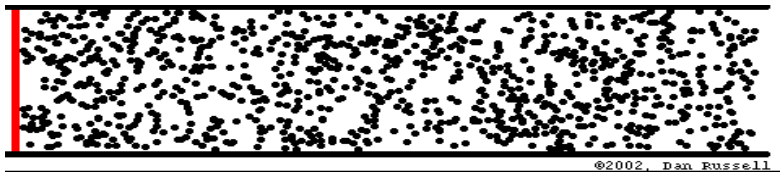
A Quick Outline

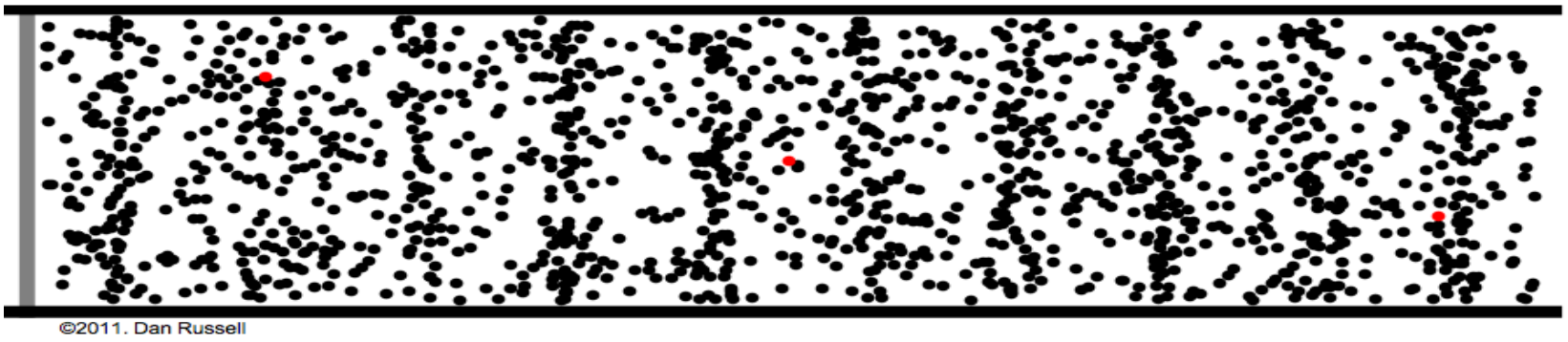
S/N



0. Introduction to Sound

Sound is **vibration** through an **elastic medium.**



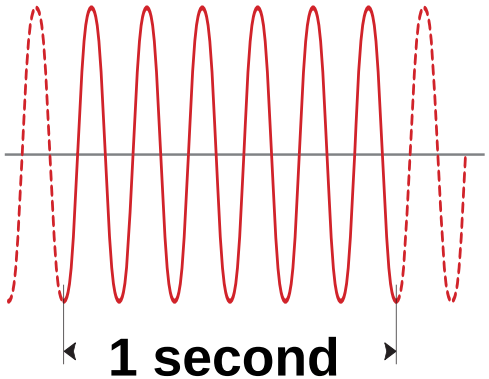


A Few Properties of Sound

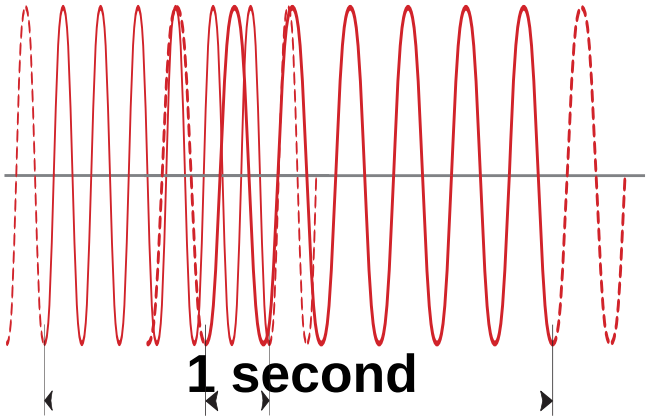
- Amplitude
- Frequency
- Propagation
- Speed
- Diffraction and other wave-behavior

Frequency

High Frequency
("Hissy")

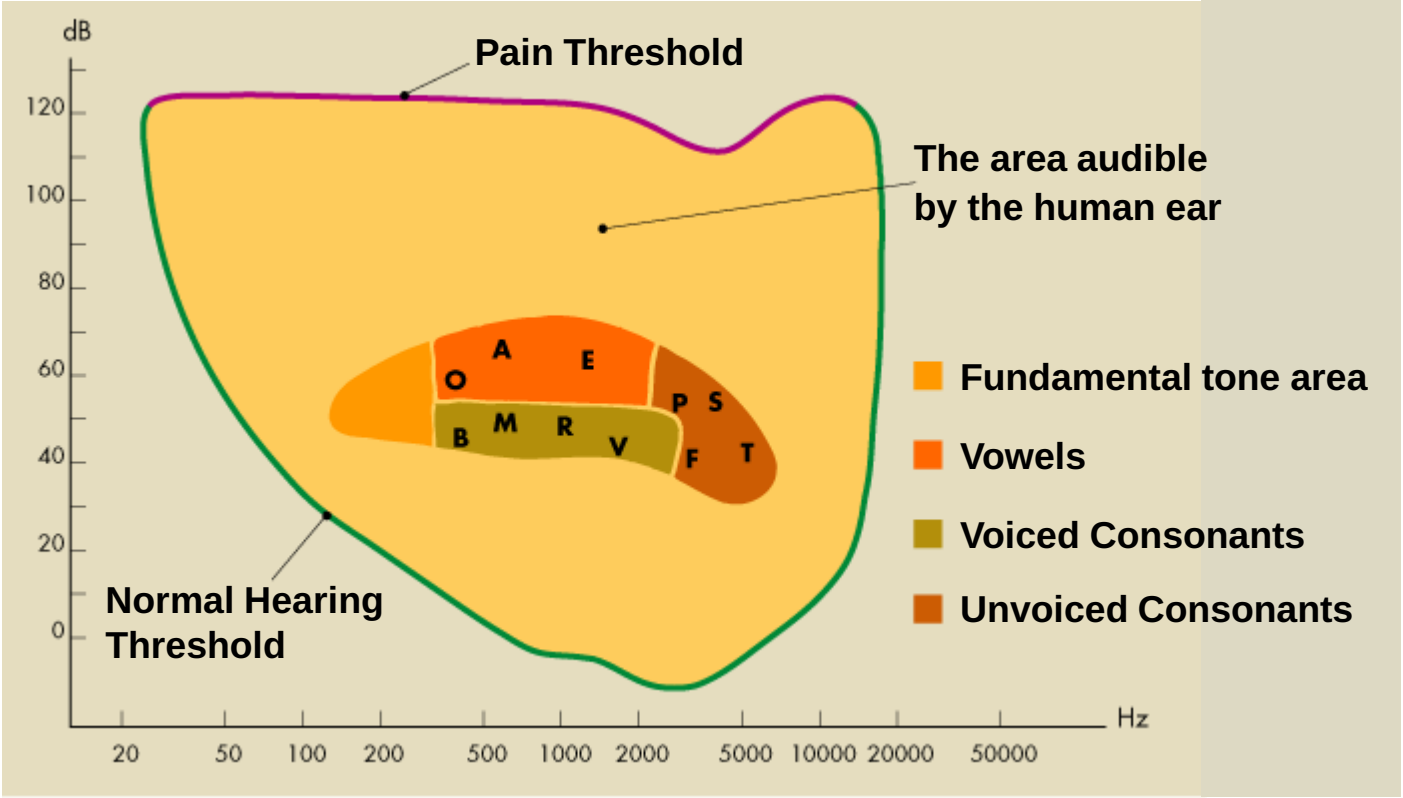


Low Frequency
("Boomy")



$$\text{Frequency (Hz)} = \frac{\text{cycles}}{\text{second}}$$

Normal Hearing

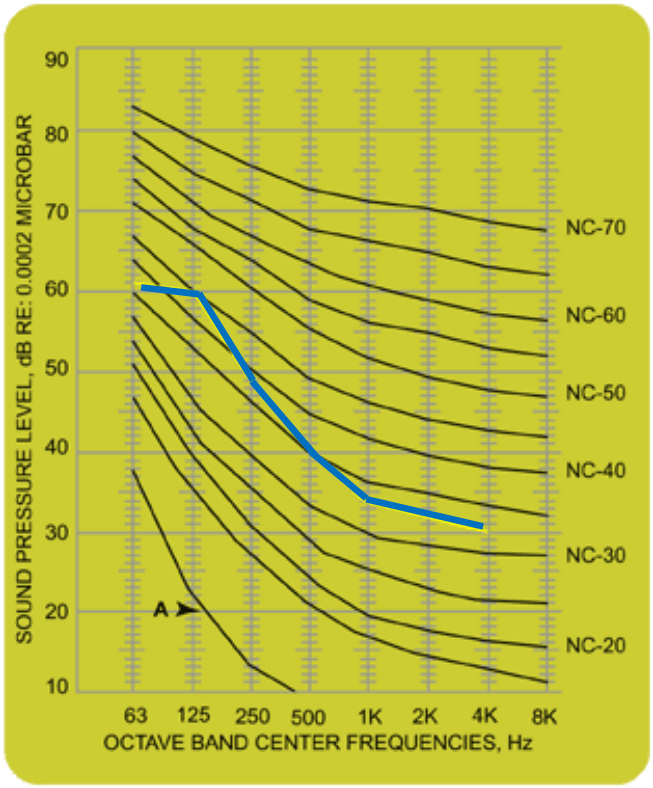


1. Background Noise

Background Noise

Background Noise Goals

Background Noise

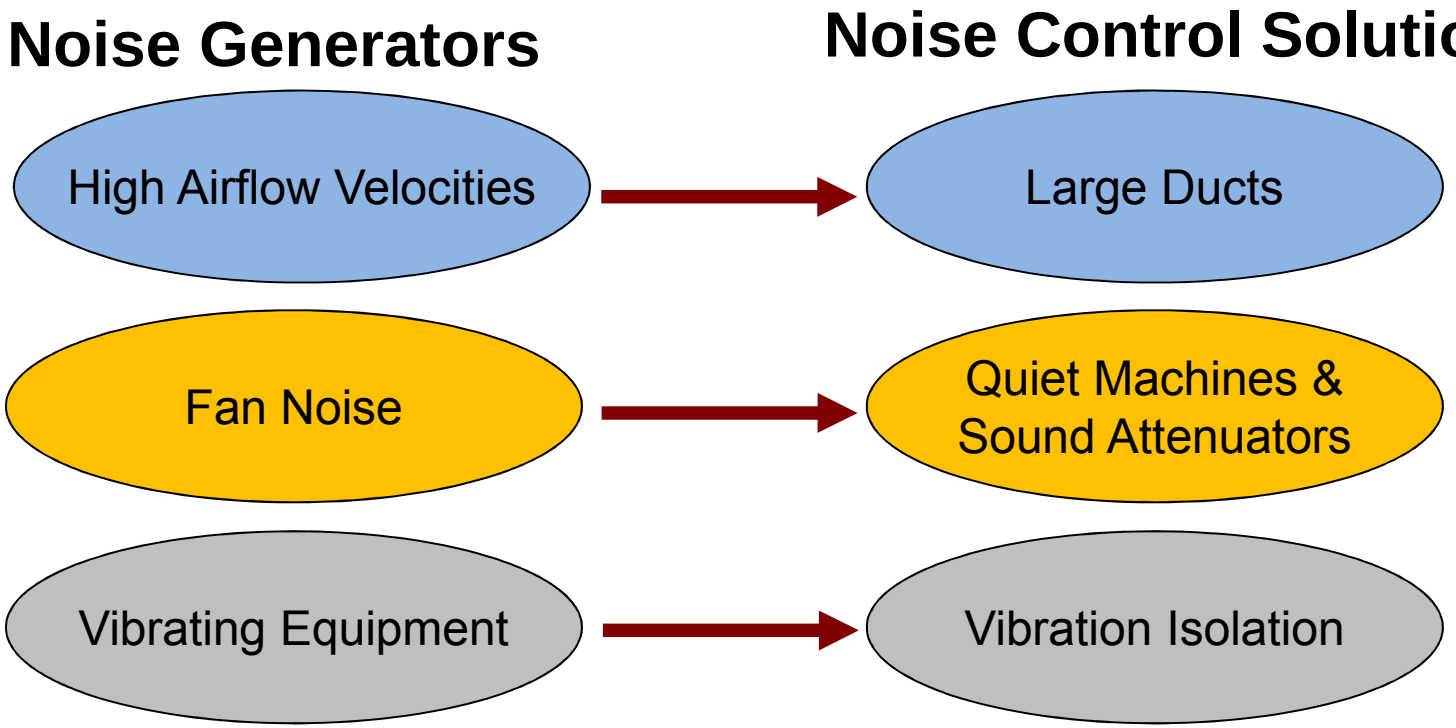


TYPICAL PROJECT NOISE GOALS

Pro Recording Studios:	Threshold
Concert Halls:	Threshold
Professional Theaters:	NC–15–20
High School Auditoria:	NC–20–25
High-end Board Rooms:	NC–25
Classrooms:	NC–30
Typical Offices:	NC–35–40
Lobbies:	NC–45

Background Sound – HVAC Systems

Background Noise

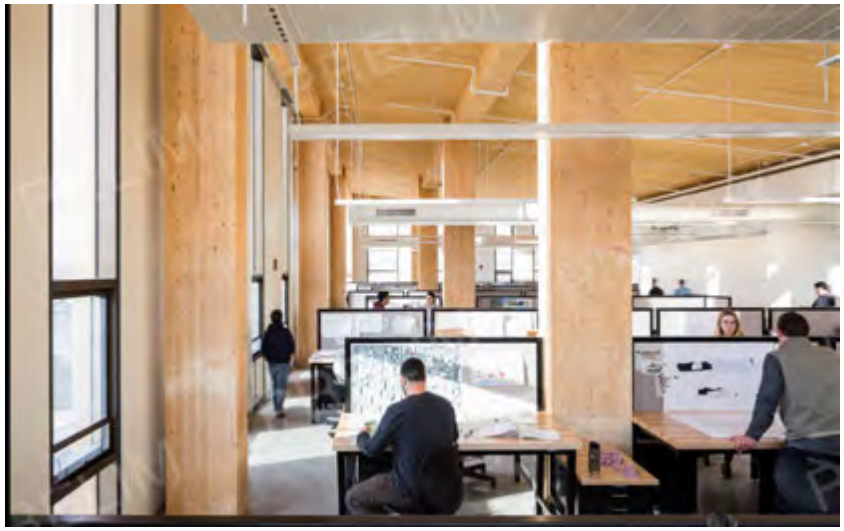


Around Campus

Background Noise

The Integrated Science and Life Science buildings are generally noisier than the Design and Visual Arts buildings due to the air ventilation system

Science Building – Photo: Warren Jagger Photography



Design Building - Photo: Esto Photography

Within the Design Building

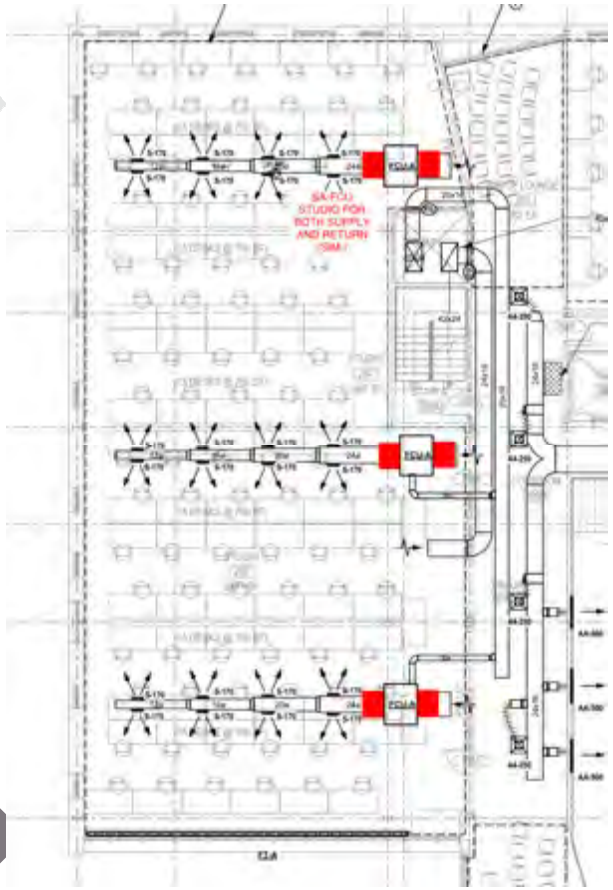
Background Noise

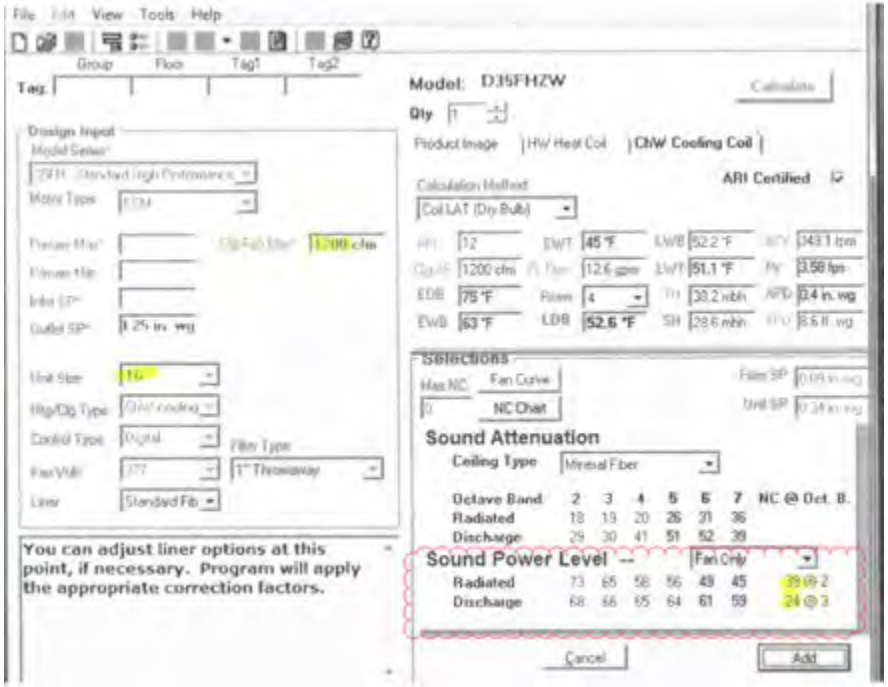
- Different spaces have different design goals
- The Wood Shop has more tolerance for higher background sound levels than the Seminar Rooms

Alex Schreyer Photography

Predicting HVAC Noise

Background Noise





Controlling HVAC Noise

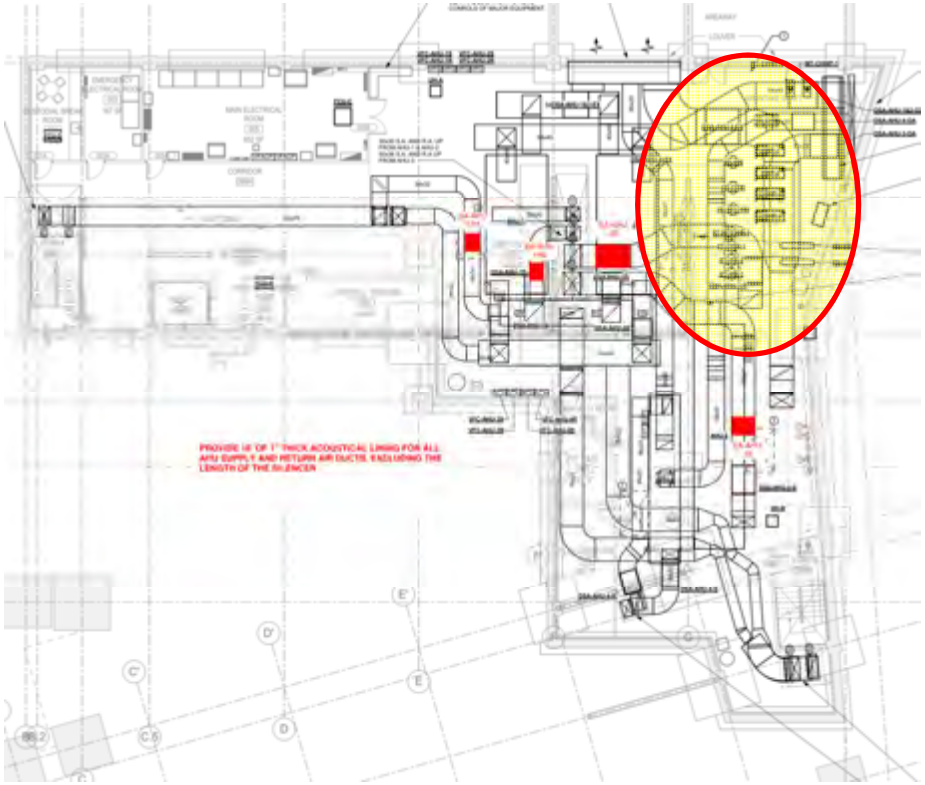
Background Noise

Price HVAC

Controlling HVAC Vibration

Background Noise

Sound can also be transmitted via solid medium rather than air, called structure-borne noise



Vibration Isolation of HVAC Equipment

Background Noise

From the project specification:

3. Pumps:

   a. Base Mounted Pumps:

      1) Base: Concrete housekeeping pad. ← concrete inertia base with 0.75" min. static deflection spring isolators
      2) Isolator Type: None, anchor to structure.

Kinetics Noise Control

Embelton

Vibration Isolation Short-circuits

Background Noise

Community Noise

Background Noise

Cooling Towers

Cooling Towers with Noise Barrier Enclosure at Lederle

Community Noise

Background Noise

- Sometimes equipment can appear noisy but is actually not so
- Analysis of data ahead of time is critical in predicting noise to the community
- UMass Life Science Building

Strobic Air – High Plume Fan

Construction Noise and Vibration

Background Noise

- Our design analyses often tackle ***steady-state*** noise and vibration sources
- Sometimes we also have to tackle ***transient*** noise and vibration sources

New England Conservatory

Background Noise

UMass Life Science Building

Background Noise

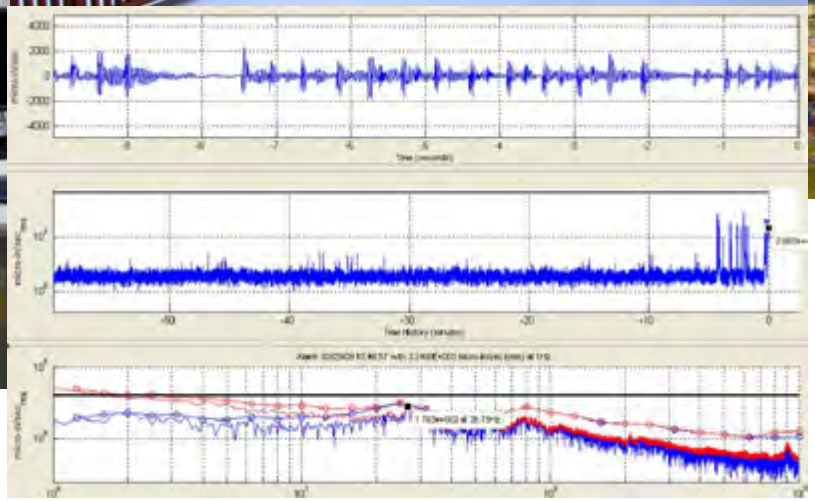


Photo: Wilson Architects

2. Sound Isolation

Sound Isolation

- Outdoor-to-outdoor
  - Rooftop Equipment Barrier
  - Outdoor music venues
- Outdoor-to-indoor
  - Envelope construction
    - Curtainwall design
    - Fenestration
- Indoor-to-indoor

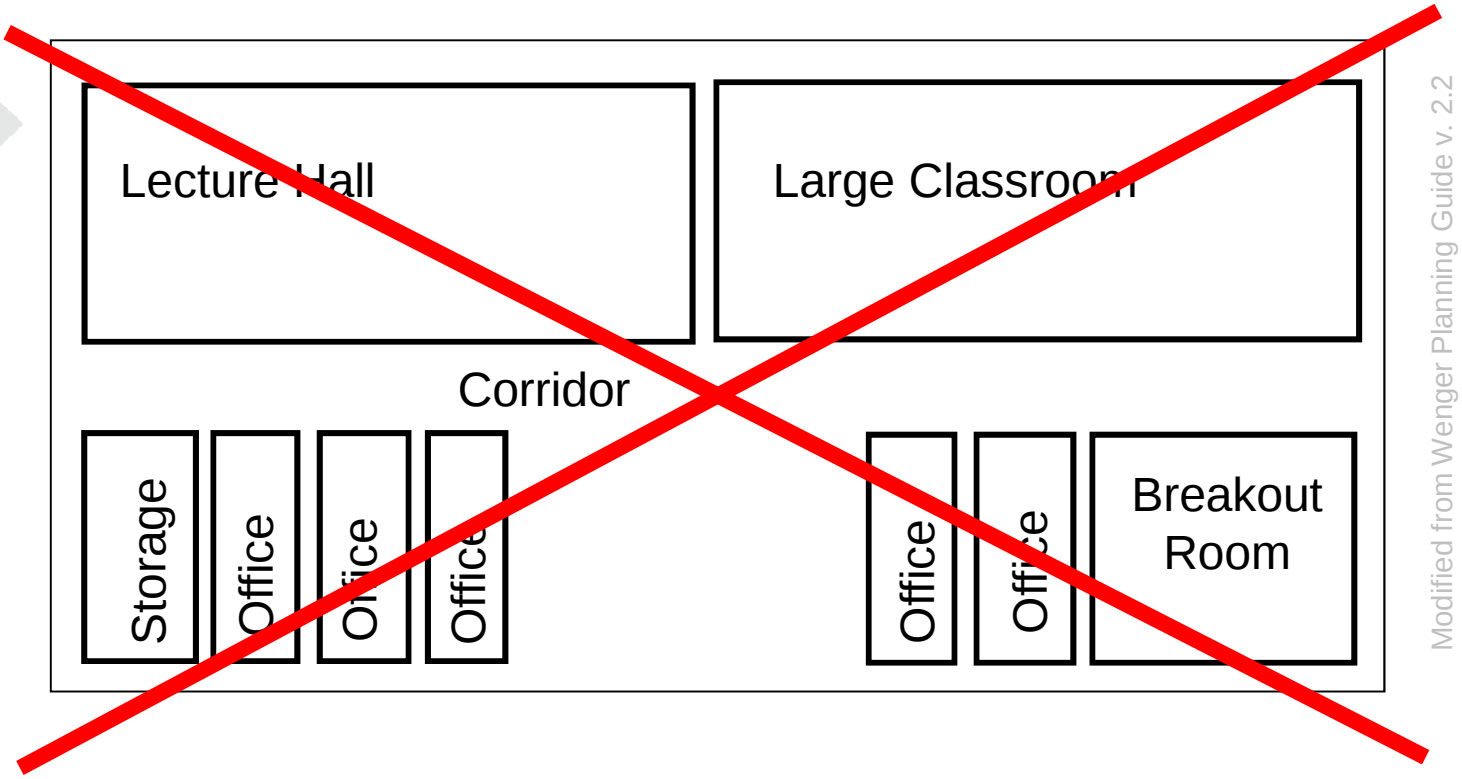
Sound Isolation

Sound Isolation

Boston University Practice Rooms

Sound Isolation: Space Planning

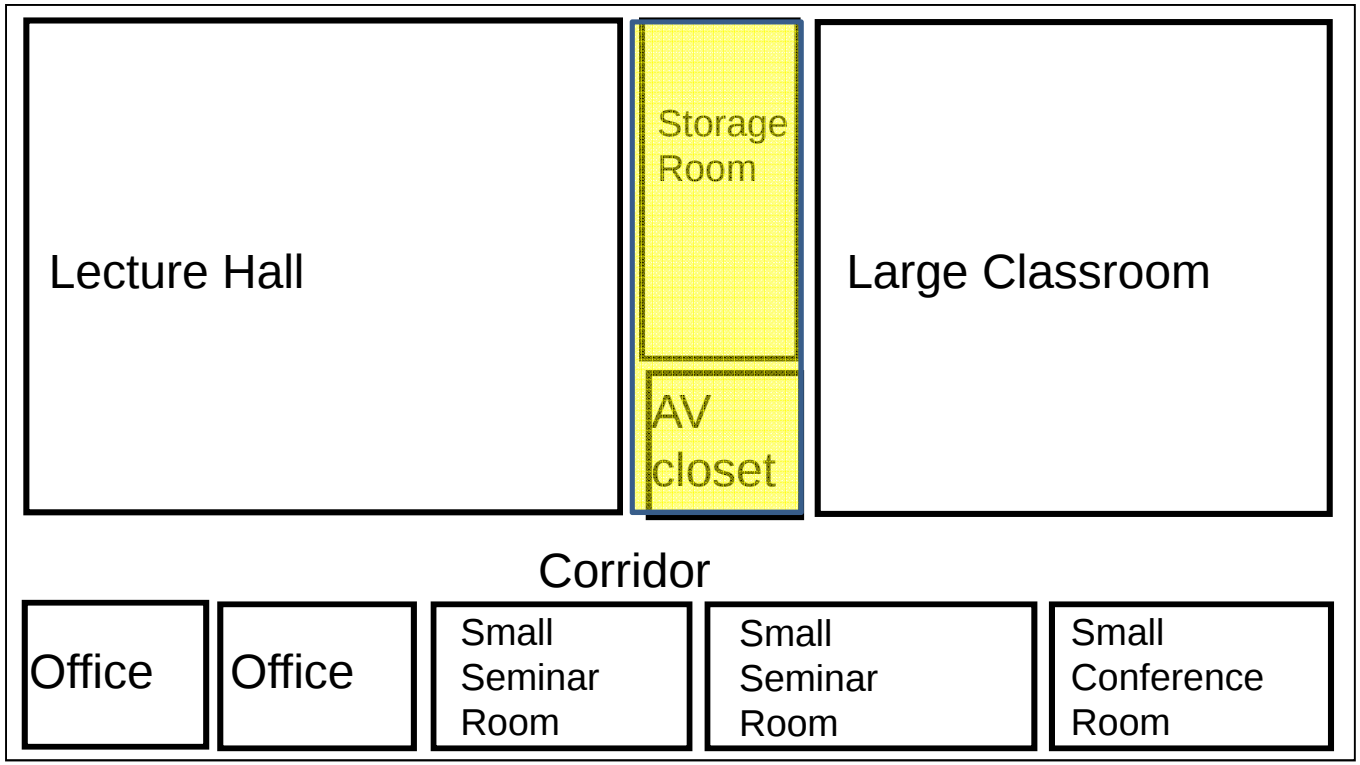
Sound Isolation



Modified from Wenger Planning Guide v. 2.2

Space Planning

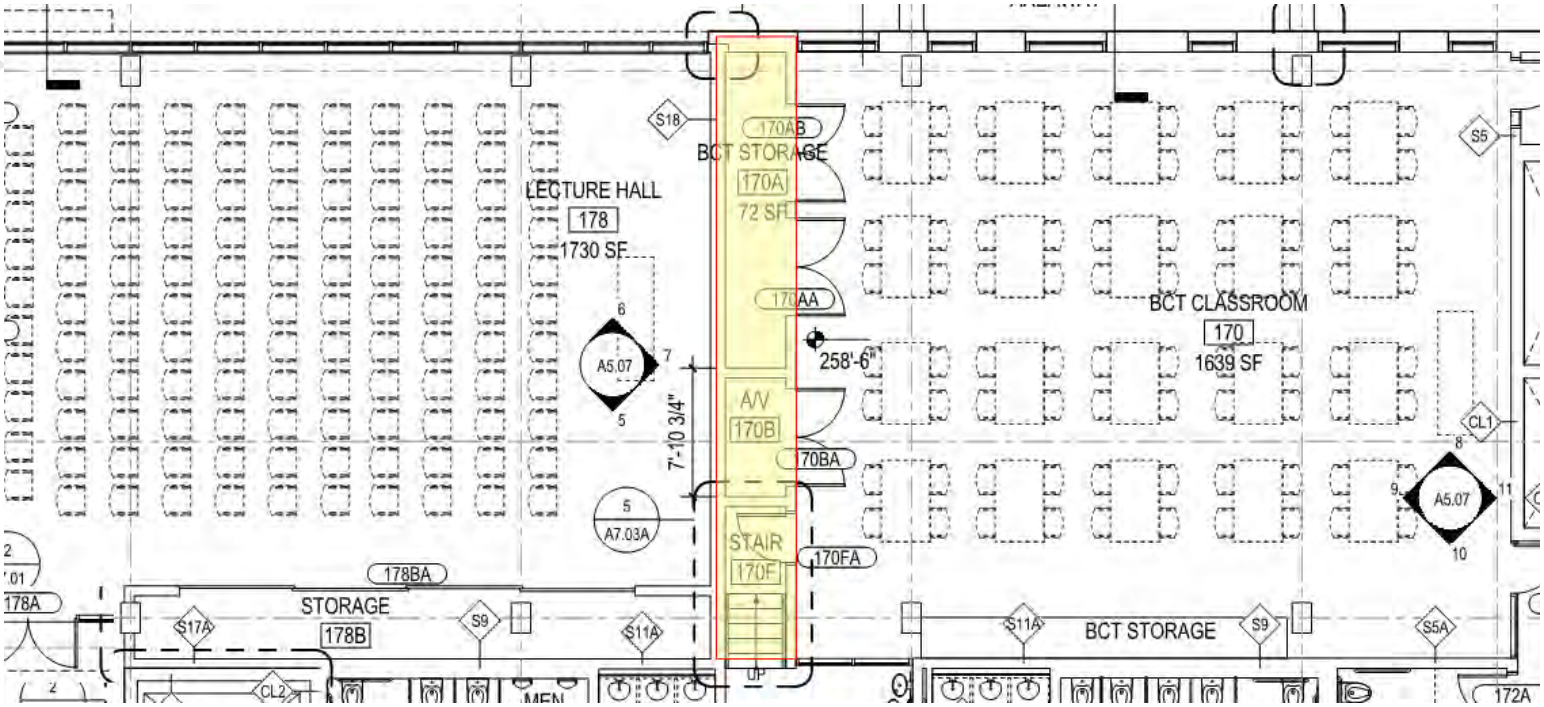
Sound Isolation



Modified from Wenger Planning Guide v. 2.2

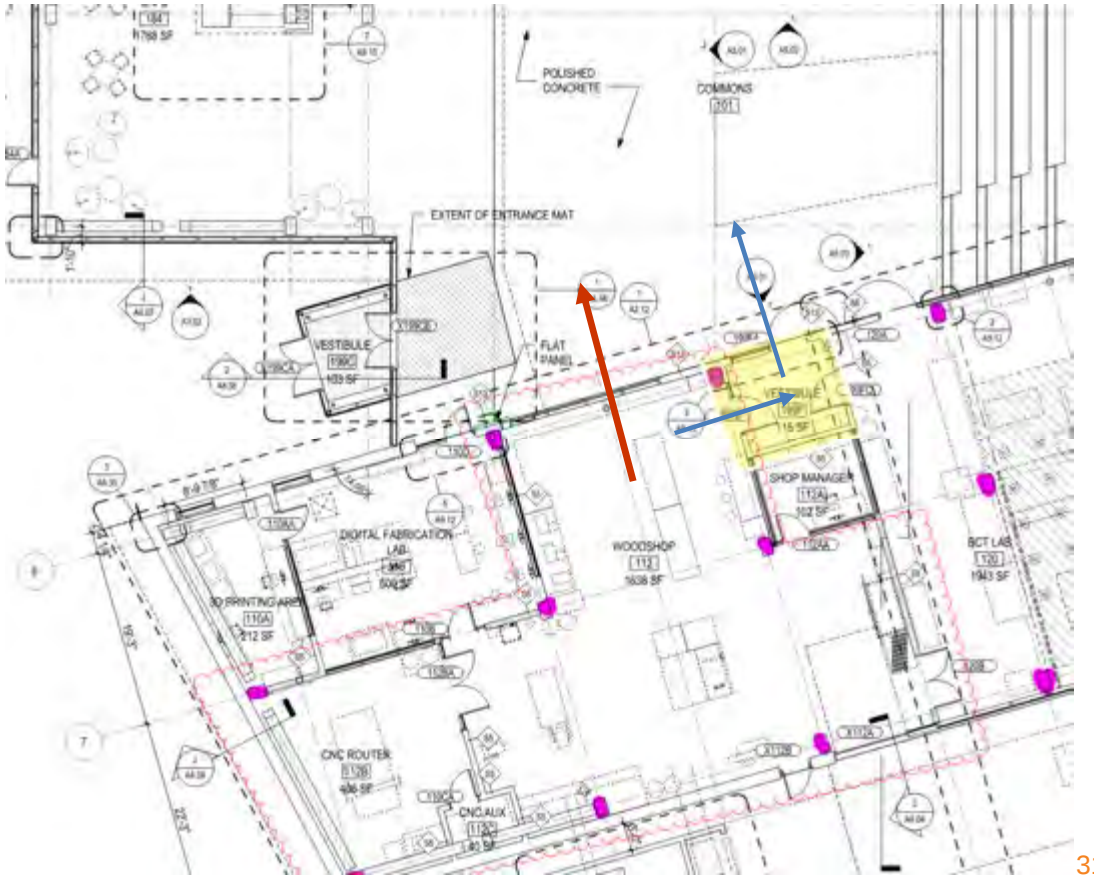
Space Planning at IDB

Sound Isolation



Woodshop Planning

Sound Isolation

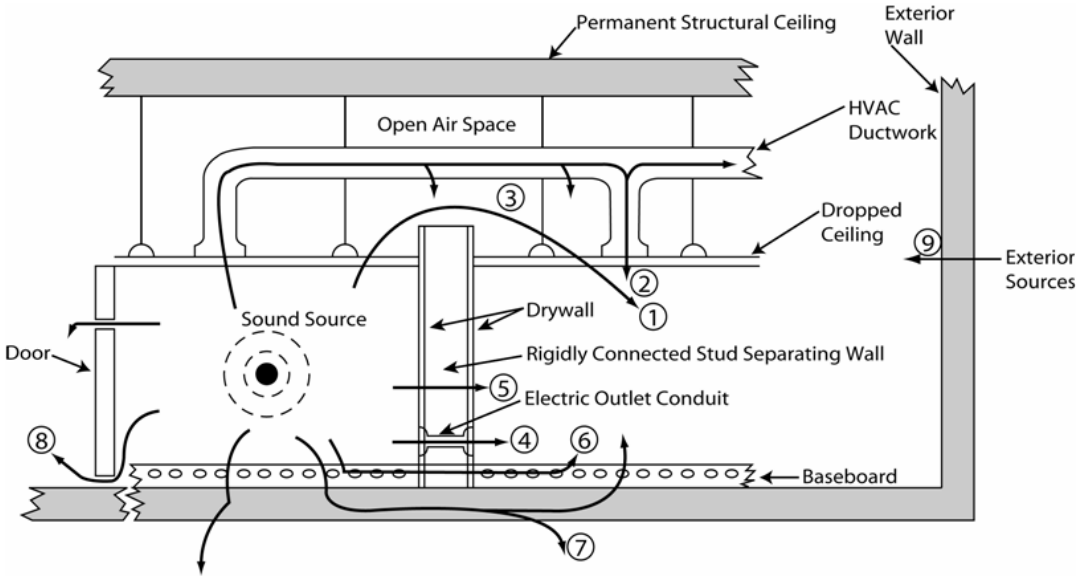


Sound Isolation

Sound Isolation – Flanking Paths

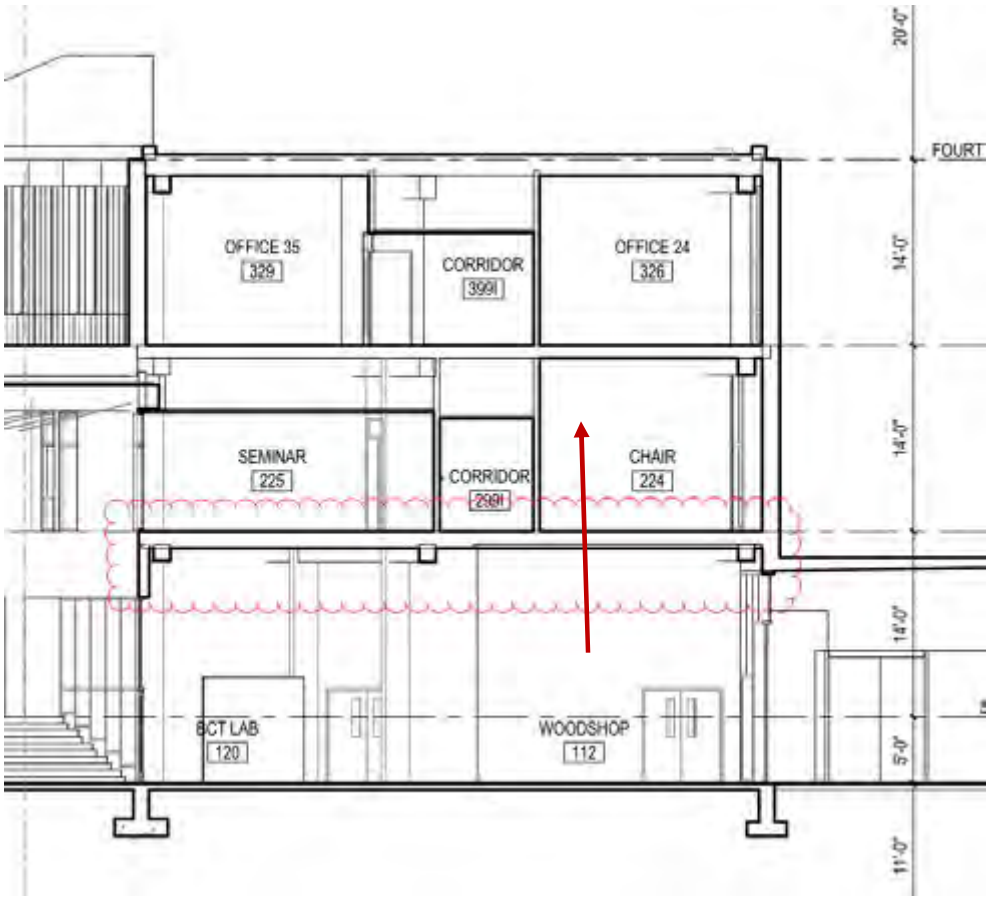
"I've got a great wall. Why can I hear noise from the other side so clearly?"

Sound can also be transmitted via solid medium rather than air, called structure-borne noise



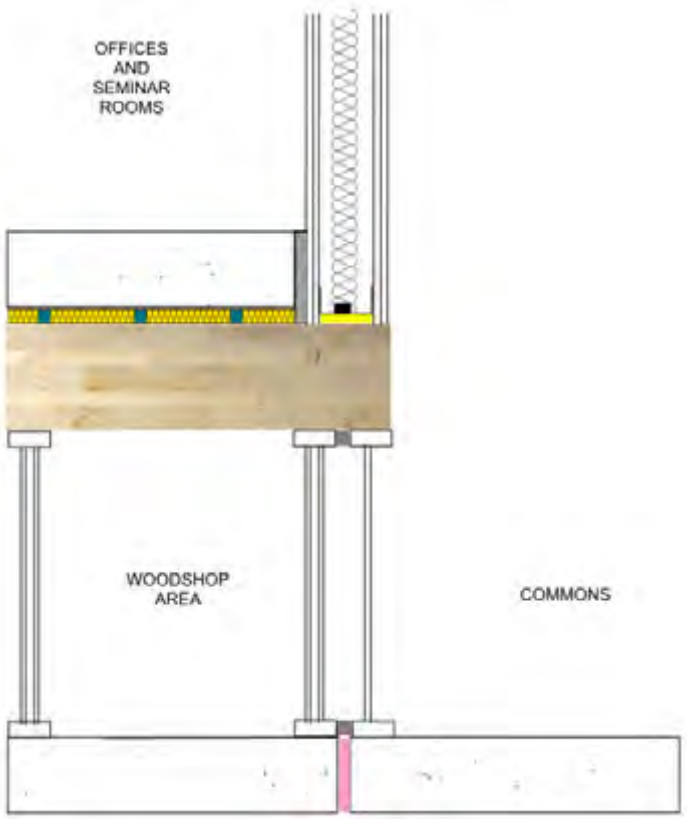
Woodshop Planning at IDB

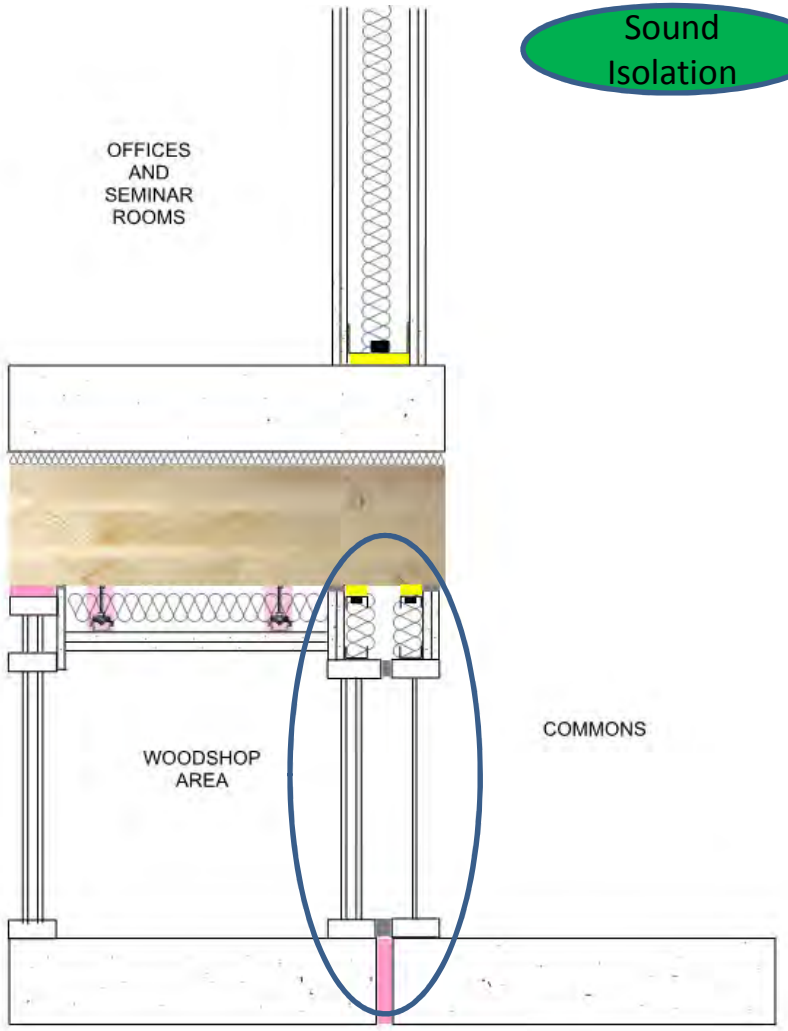
Sound Isolation



Details with CLT

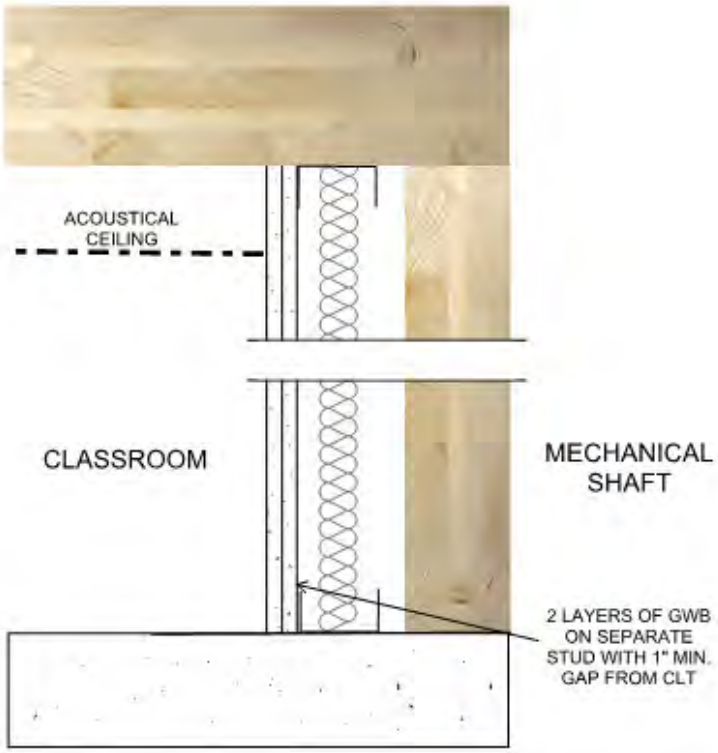
Sound Isolation





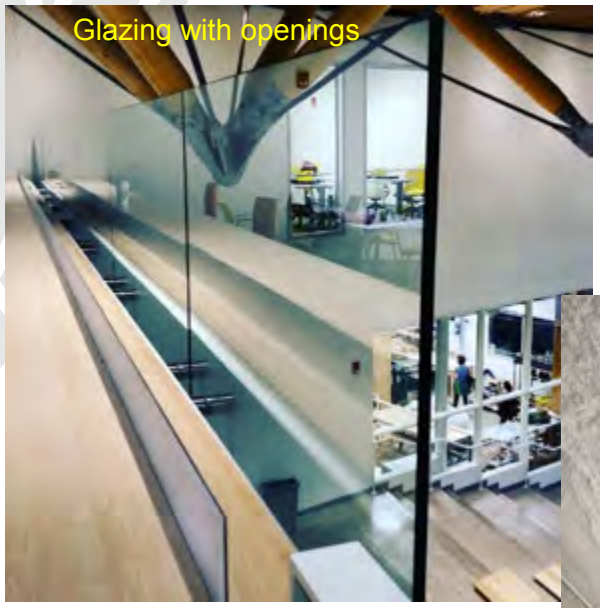
Working with CLT – Airborne Noise

Sound Isolation

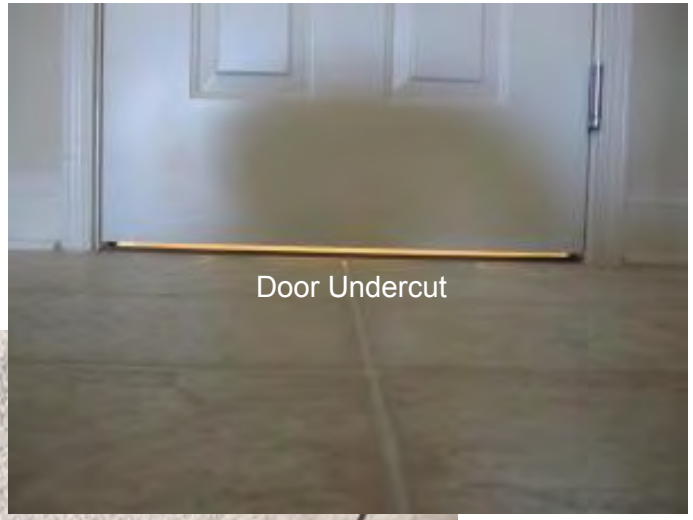


What does not block sound?

Sound Isolation



Design Building - Photo: Alex Schreyer



3. Room Acoustics & Amplification

Room Acoustics

Amplification

Design Building - Photo: Alex Schreyer

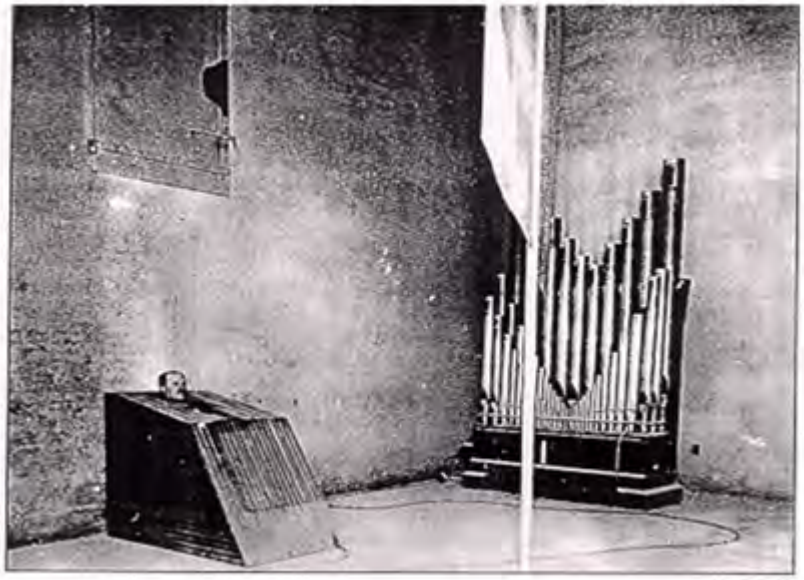
Outdoors Versus Indoors

Room Acoustics

Amplification

Wallace Clement Sabine Discovered a Formula for Reverberation Time

Room Acoustics



$$\text{Reverberation Time} \approx \frac{\text{Volume}}{\text{Absorption}}$$

- Sabine used organ pipes and a stop watch to measure the decay of the sound
- He found the body of an average person decreased RT by about as much as six seat cushions.

Natatorium – 6 Second RT

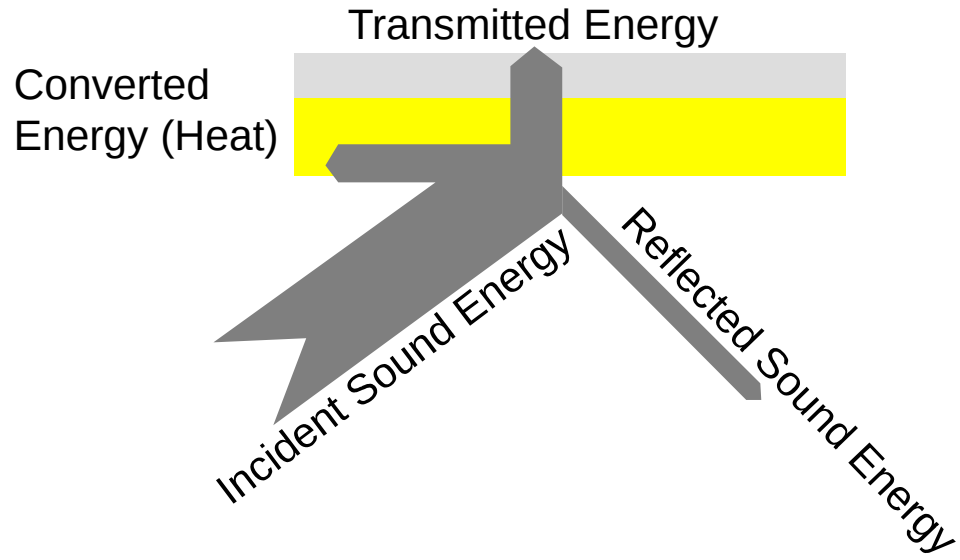
Room Acoustics

- 6 second RT without treatment
- 1.7 second RT with an absorptive ceiling

What is Sound Absorption?

Room Acoustics

- The ratio between energy not reflected and incident energy for a sound wave hitting a surface
- Turning sound energy into heat



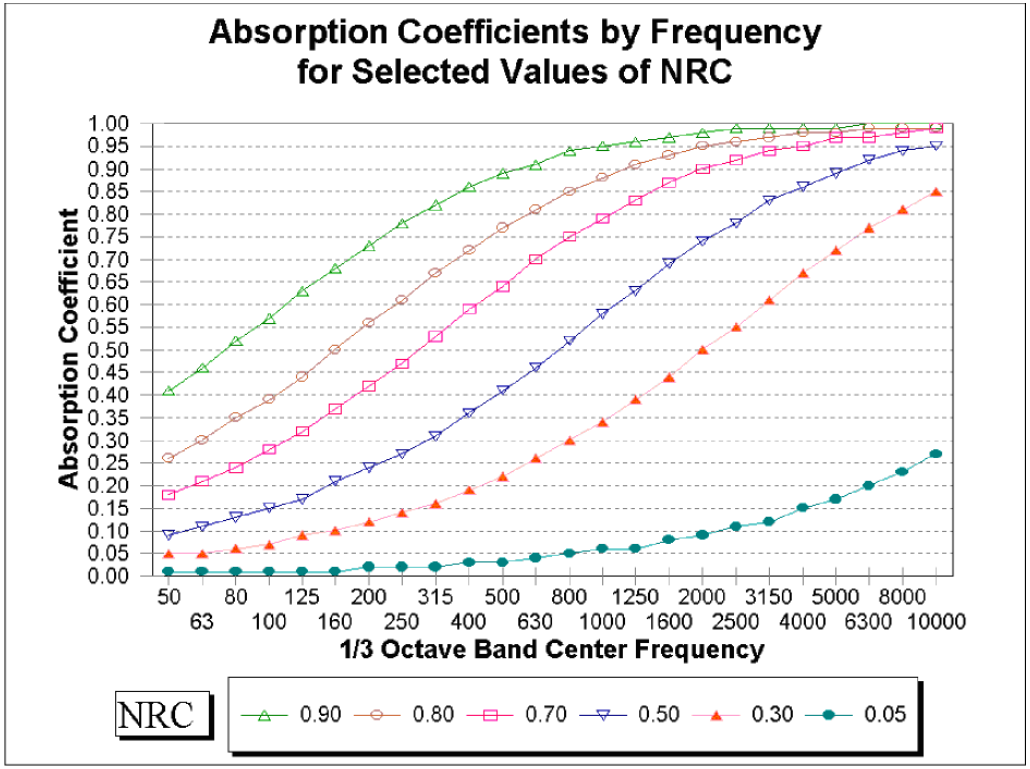
Coefficient of Absorption

Room Acoustics

Material	Coefficient of Absorption
Brick, concrete block, glass	0.05
Carpet combined pile and foam	0.30
Heavy velour	0.55
Glass wool (fiberglass)	0.95

Absorption Versus Frequency

Room Acoustics



Sound Absorption in IDB

Room Acoustics

- Spray-applied cellulose behind the slatted wood
- Wood-fiber cement panels with absorption backing
- Acoustical panel ceilings
- Fabric-wrapped wall panels

Design Building - Photo: ESTO

What is NOT sound absorptive in IDB

Room Acoustics

- Wood
- Concrete
- Gypsum Wallboard
- Glass

Design Building - Photo: ESTO

A Negotiation with Design

Room Acoustics

Form vs. Function

Design Building - Photo: ESTO

Using SketchUp → Acoustics Modeling

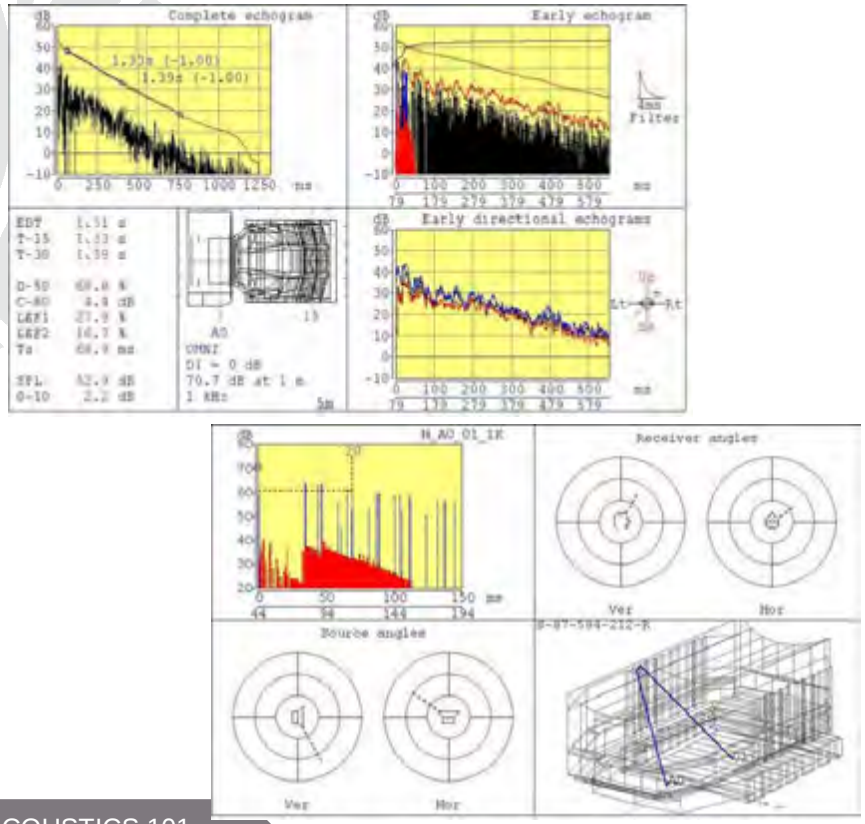
Extremely useful for complex geometry

Room Acoustics

Amplification

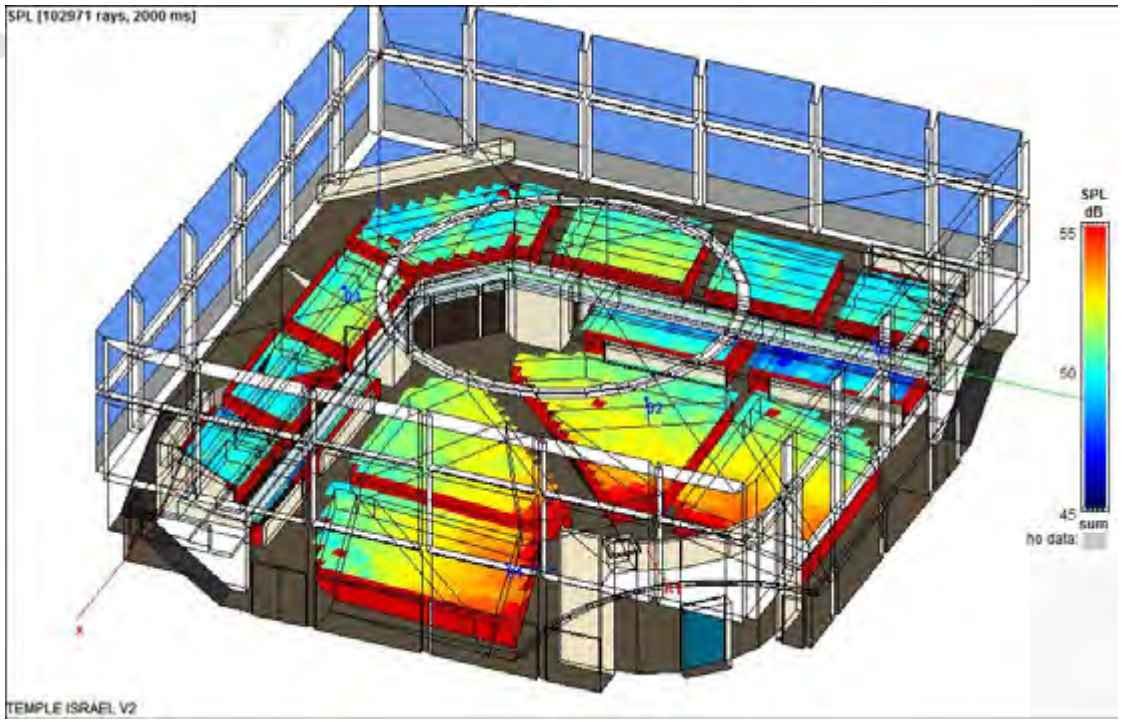
Acoustics Modeling

Room Acoustics



Modeling for Speech Reinforcement Systems

Amplification



Auralization

Room Acoustics

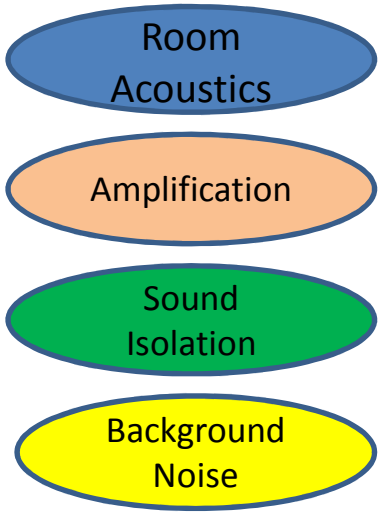
Amplification

Sound Isolation

Background Noise

Listening to the space before it is built

Imagination is the limit!



- Explore different room geometry
- Explore various interior finishes
- Introduce noise into the model
- Add sound systems into the space
- Explore various architectural constructions

Questions?

Rose Mary Su
rsu@acentech.com