21^{ST} CENTURY LEARNING ACOUSTICS

Redefining possible.

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Acoustical Technical Director / Associate

Introduction

Steve Meszaros

- **B.Sc. (Mechanical Engineering) – University of Manitoba**
- **M.Sc. (Biosystems Engineering) – University of Manitoba**
- **Registered Professional Engineer – British Columbia**
- **Acoustic Consultant 2001 – present**
  - Schools
  - Universities
  - Hospitals
  - Offices
  - Residential
  - Many more…..

Introduction

Who are you?

Have you worked with an Acoustic Consultant?

What do you know about Acoustics?

What is special about modern (21st Century) Schools?

What is your biggest challenge in modern school design?

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What do you know about Acoustics?

What is special about modern (21st Century) Schools?

What is your biggest challenge in modern school design?

- **Designing for the actual use**
- **“future-proofing”**

Summary

Acoustic refresher / background

1. **Why acoustics are important**
2. **Acoustic targets and criteria**
   - reducing distraction
     (sound isolation)
   - enhancing communication
     (room acoustics / background noise)
   - creating a calm environment
     (room acoustics / background noise)
3. **Changes in the 21st Century**
4. **Value of acoustics/Examples**

How do we describe sound?

Sound generally described using:

Magnitude – “Levels” (dB)

Frequency – “Pitch” (Hz)

Sound Levels

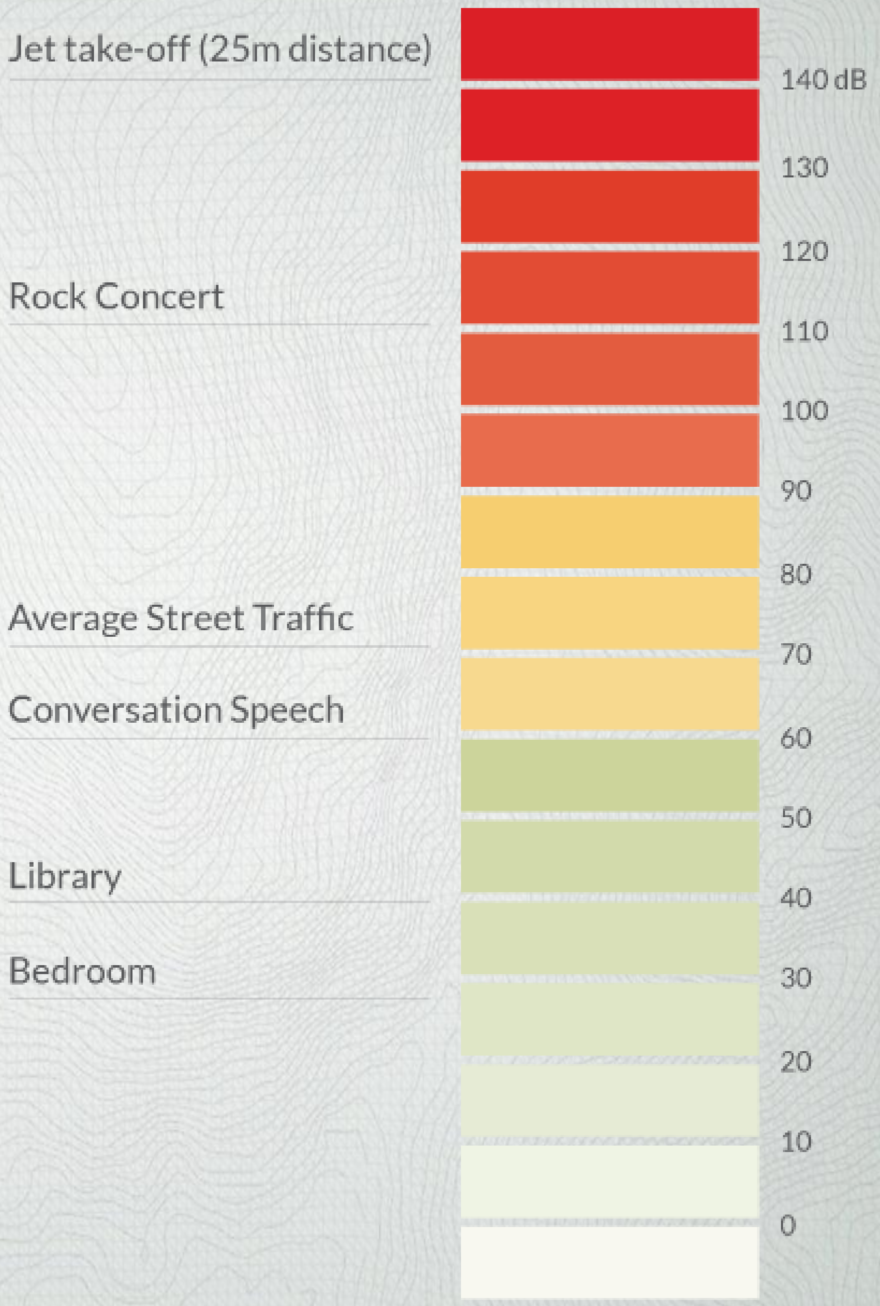
Sound pressure levels

the decibel - dB

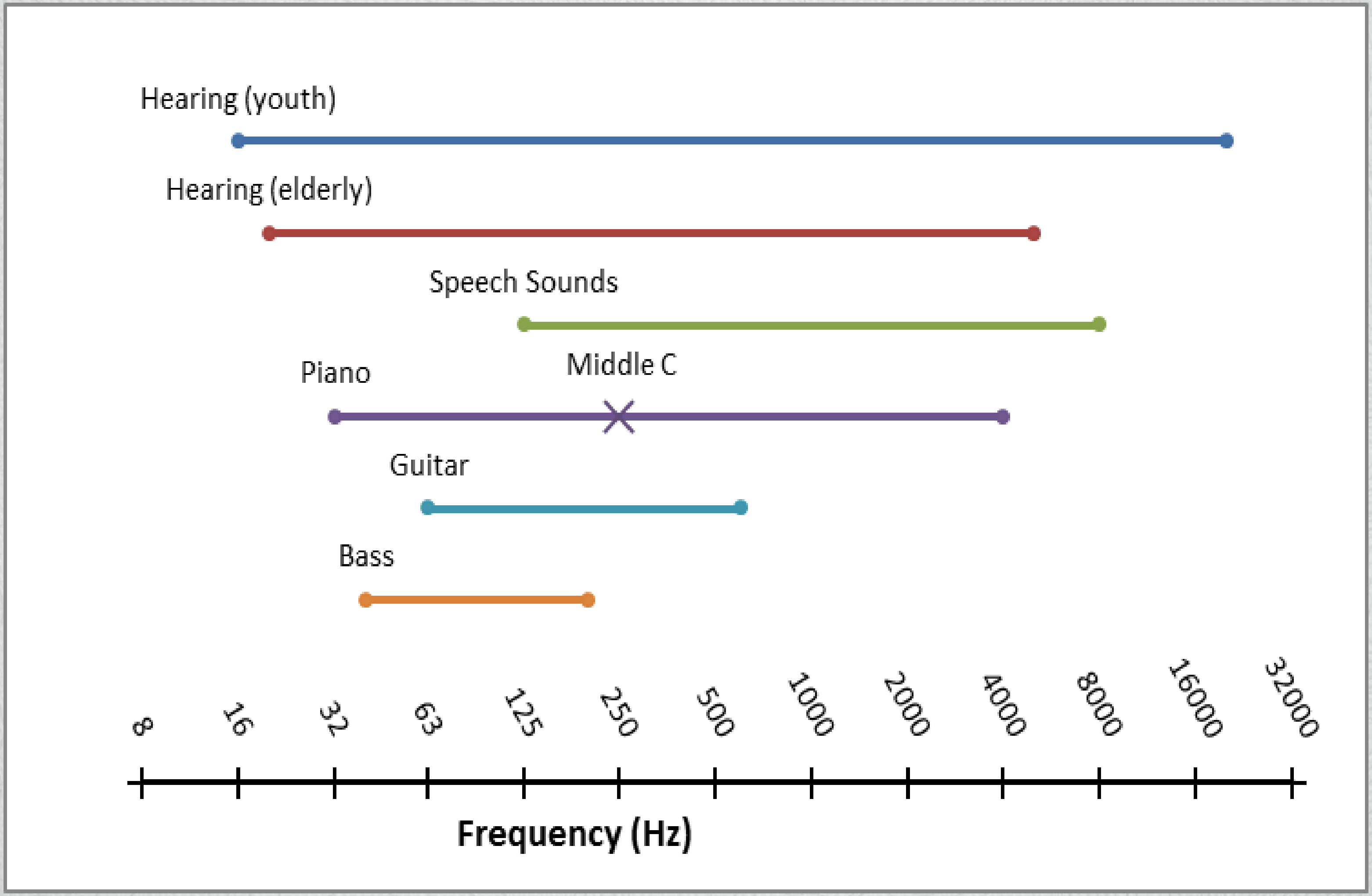
Sound level drops with distance

Add two equal sources:
50 dB + 50 dB = 53 dB

Human Perception:
+/- 10 dB sounds twice or half as loud

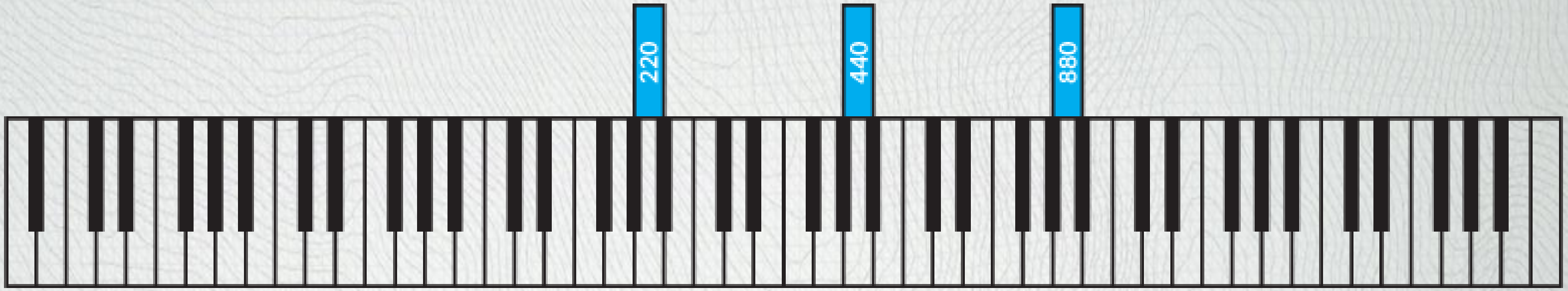


Frequencies of Audible Sound



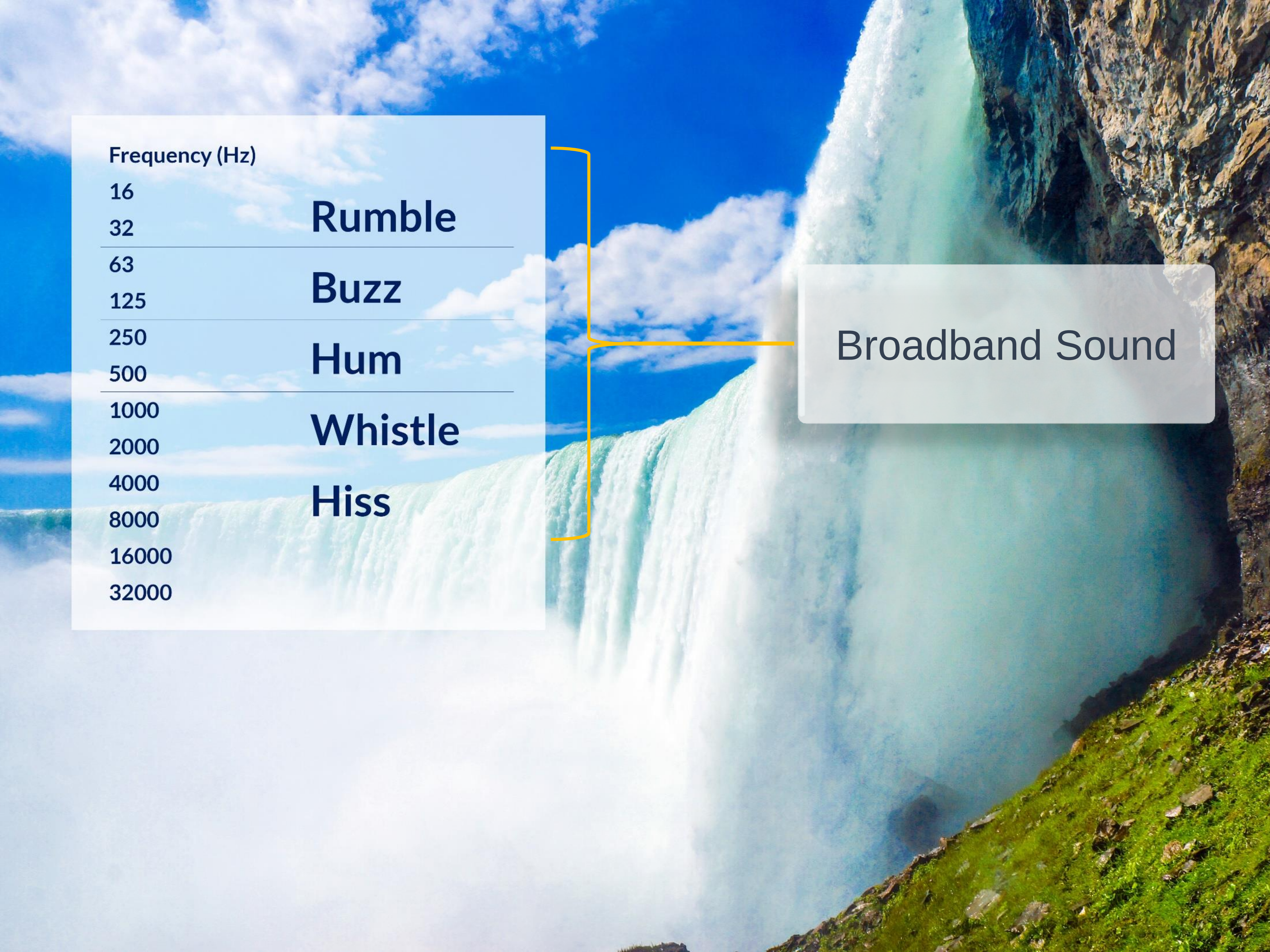
Frequencies for Musicians

Each octave higher doubles in frequency

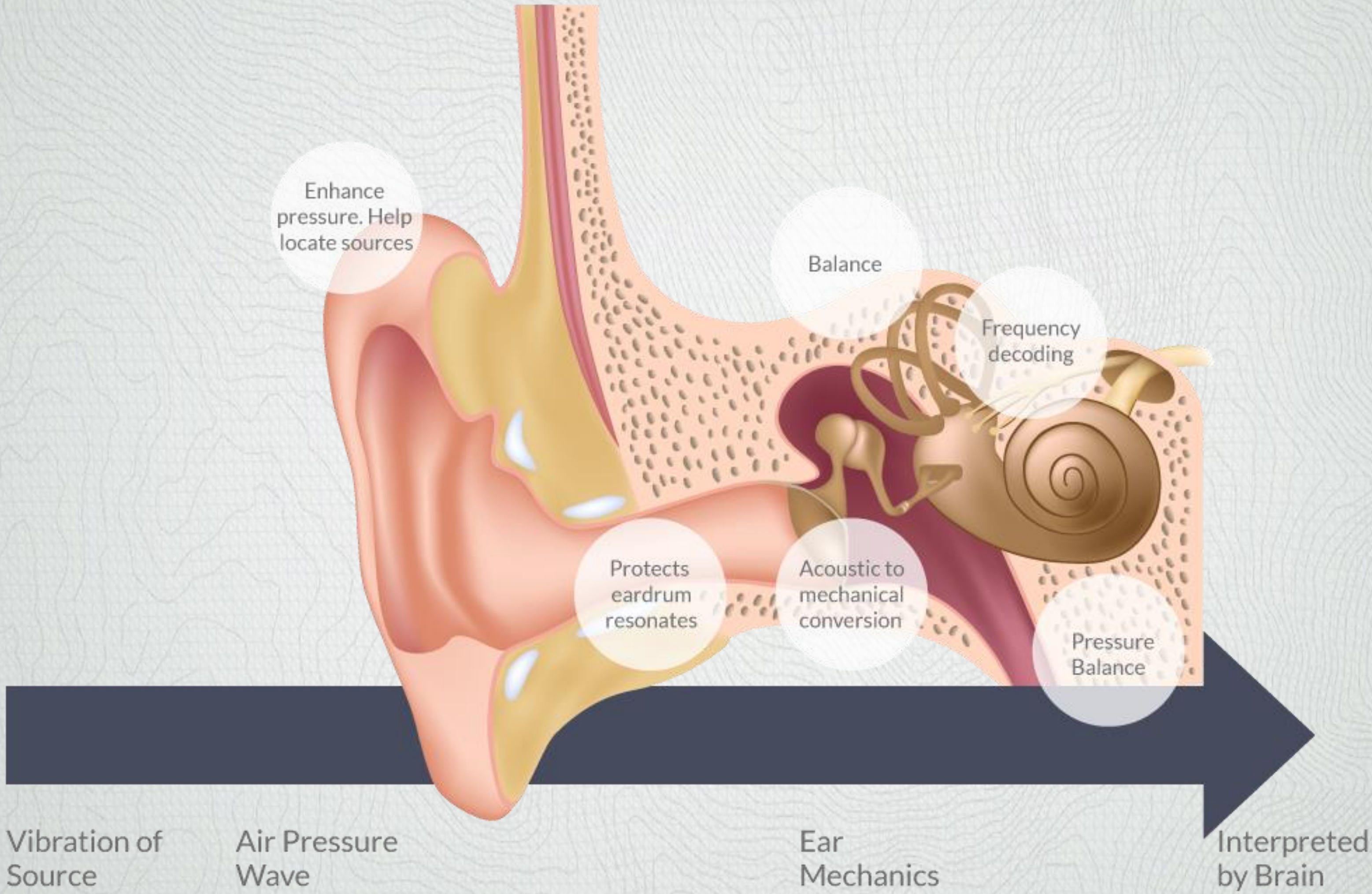


A musical scale corresponds to a logarithmic frequency scale

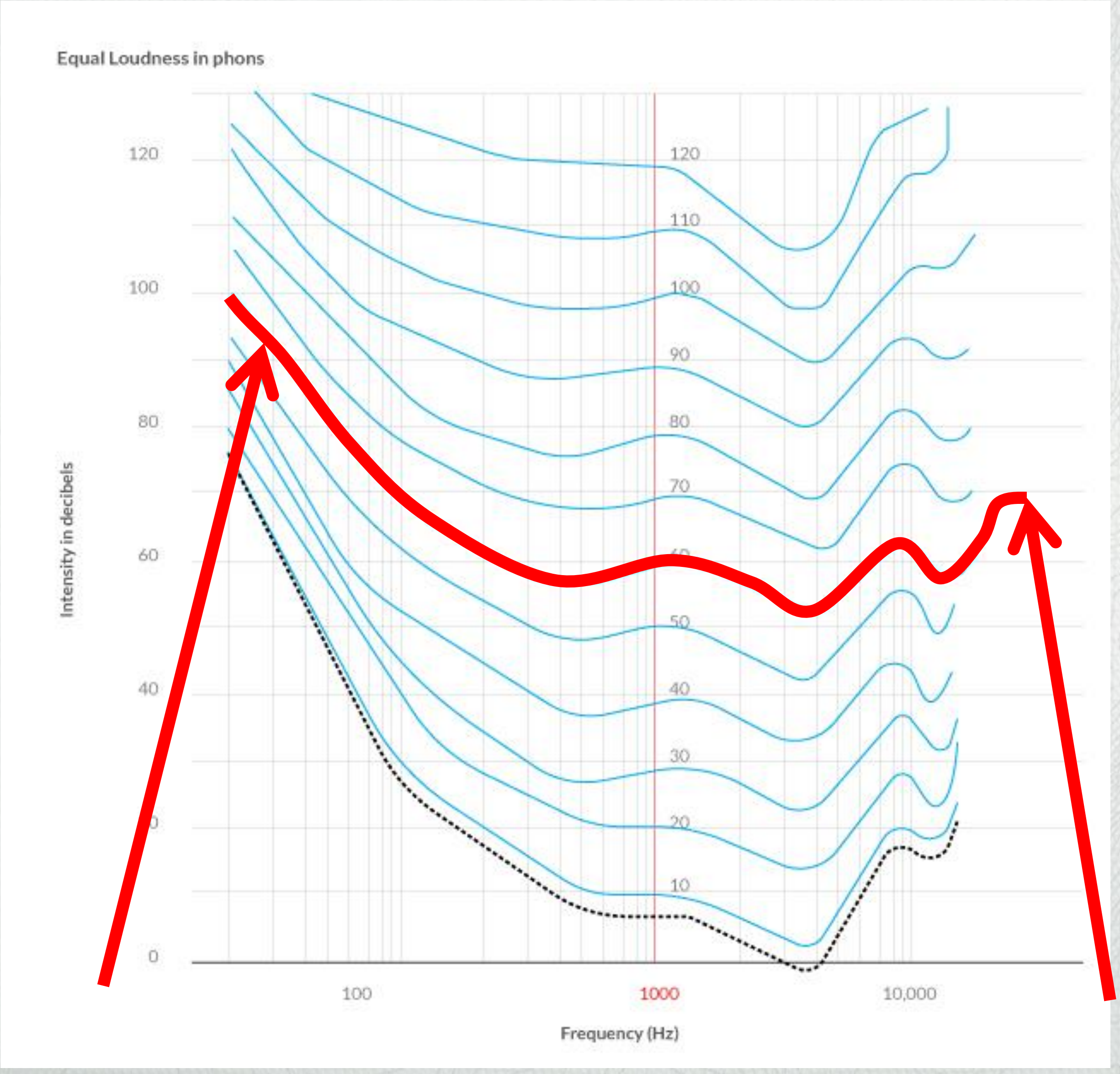
Acoustical measurements are presented in octave or 1/3 octave bands


Frequency (Hz)
16
32
Rumble
63
125
Buzz
250
500
Hum
1000
2000
Whistle
4000
8000
Hiss
16000
32000
Broadband Sound

Human Hearing

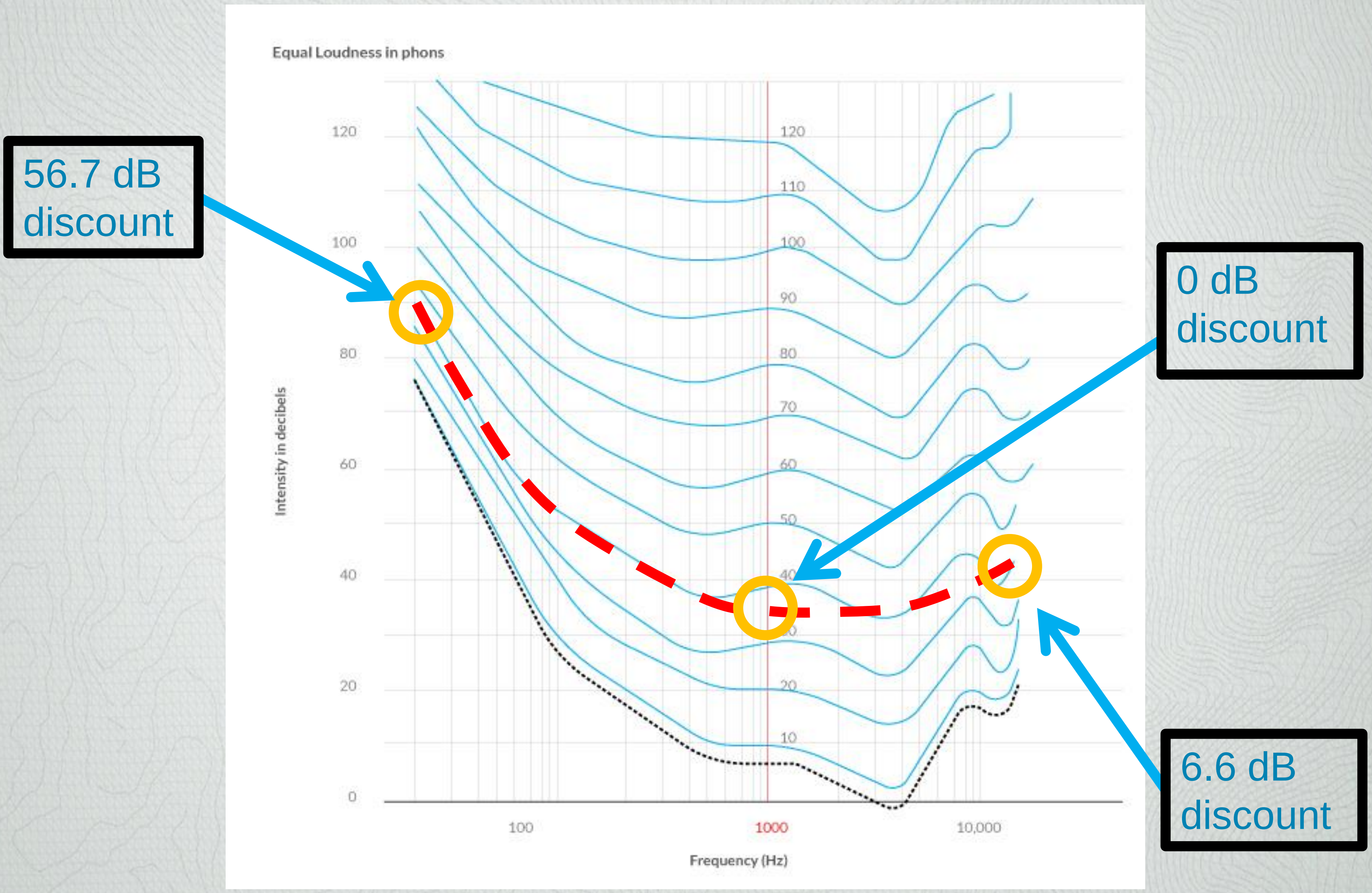


Equal loudness contours

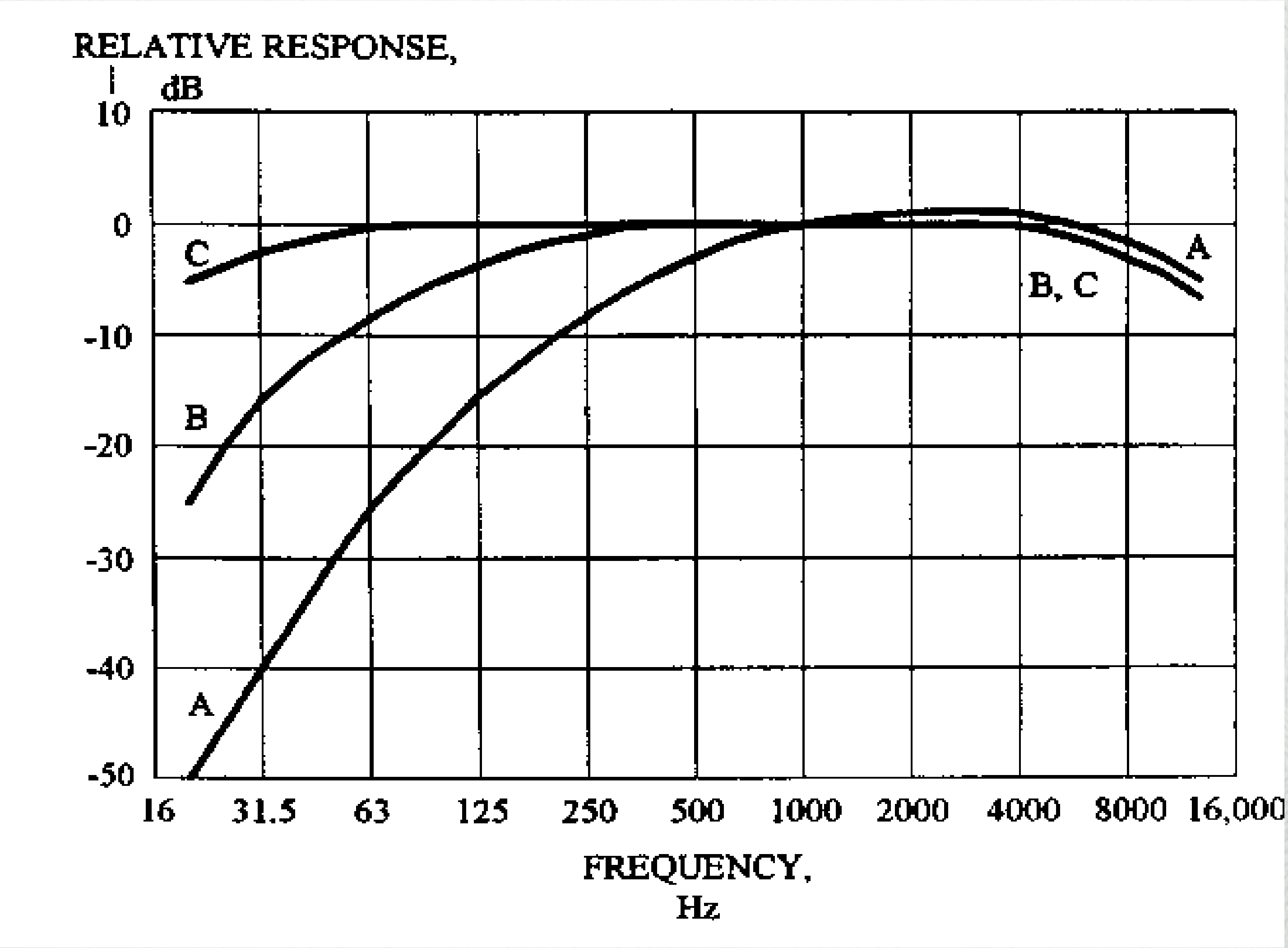


Our ears are less sensitive to low frequencies and high frequencies

A-weighting curve



A-weighting curve



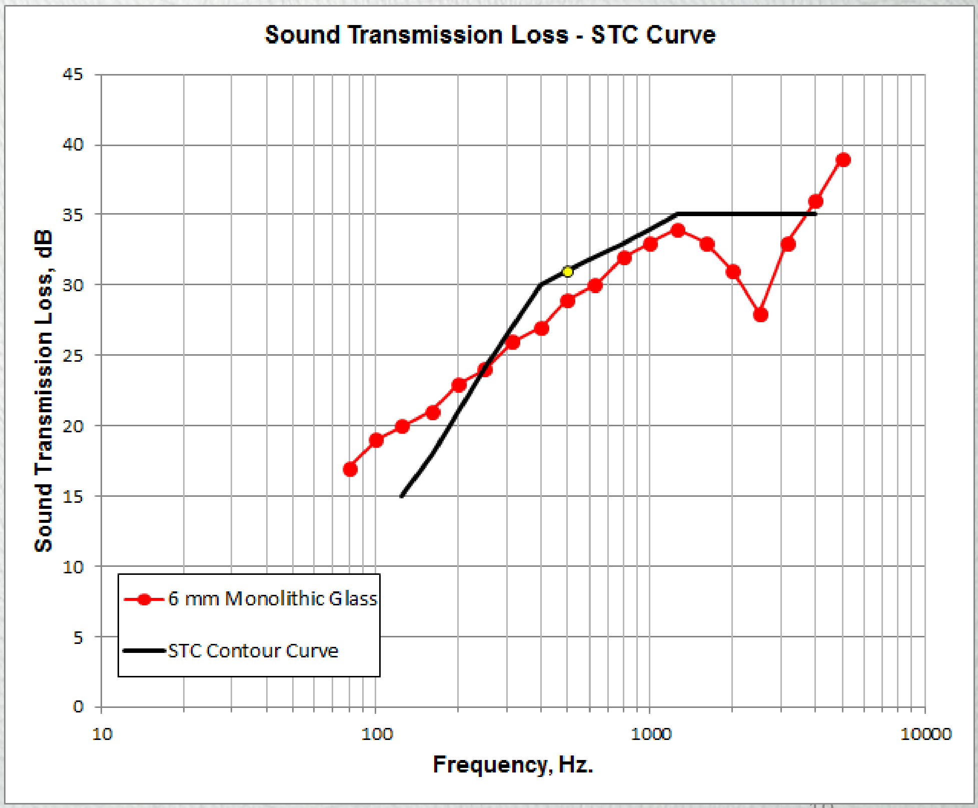
Sound Transmission Class (STC)

Sound Transmission Class (STC)

- Single number rating
- Based on sound transmission loss (TL) data (ASTM E90 & E 336)
- Weighted average of assembly performance (deficiencies)
- Based on isolating human speech
- Walls and floor/ceilings

In Common use

- Codes
- Specifications
- Compliance Documents



Sound Transmission Class (STC)

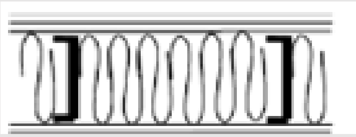
Benefits

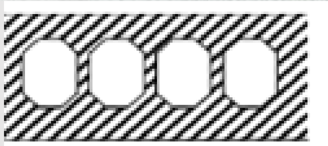
- Simple to use for preliminary selection
- Easy to compare various partitions

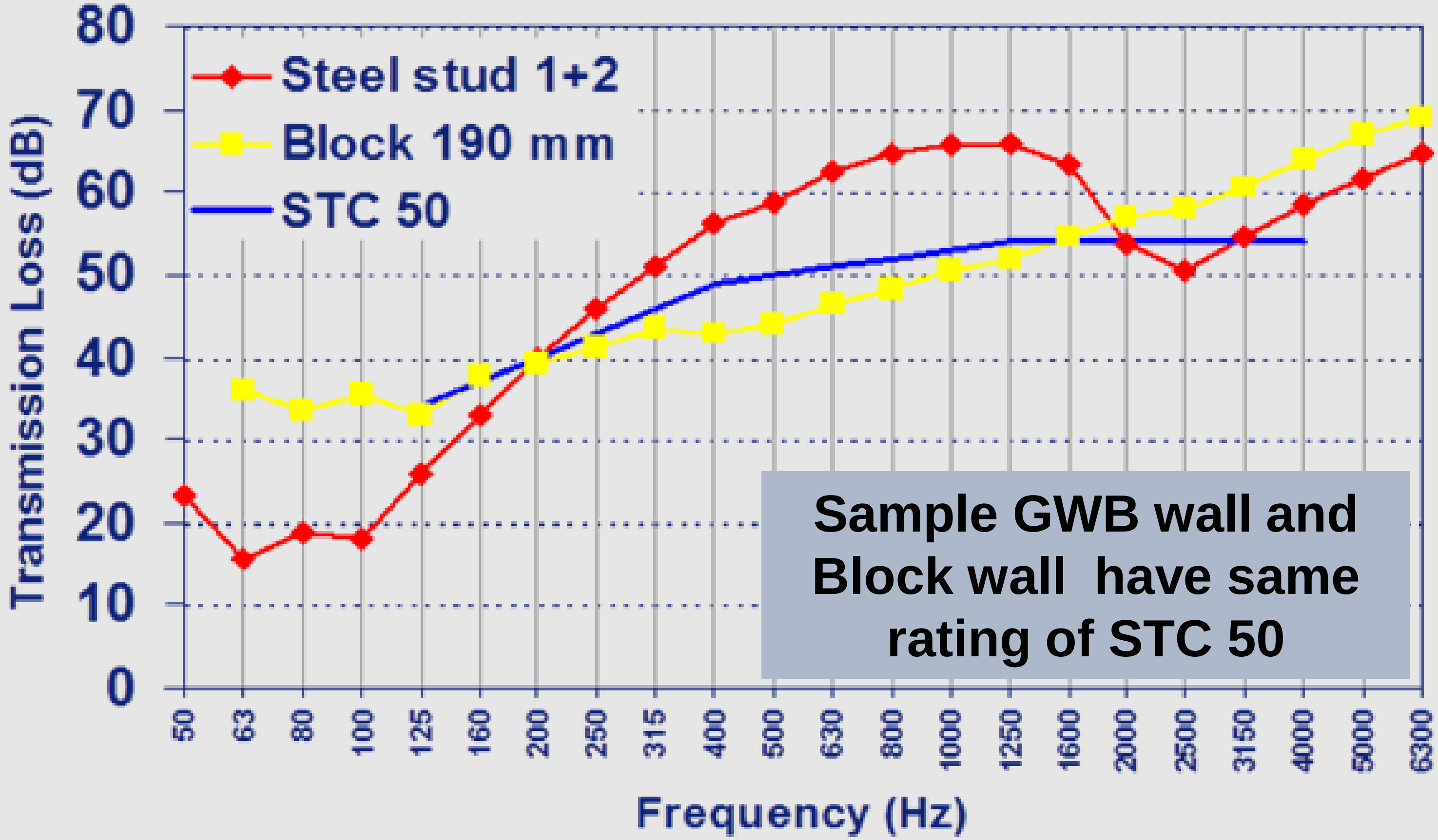
Disadvantages

- Inadequate where sound isolation is critical
- Lost detail
- Does not ensure occupant comfort or privacy
- Not applicable to subwoofers and low frequency mechanical

Limitations of STC …







Sound Transmission Class (STC)

Subjective impression to noise isolation:

STC Rating	Degree of Acoustical Privacy	
<45	Poor:	Normal speech audible and usually intelligible
45	Marginal:	Normal speech audible and sometimes intelligible
50	Good:	Normal speech audible but not intelligible
55	Very Good:	Raised voices usually audible but not intelligible
60+	Excellent:	Raised voices not audible

***Assumes a quiet background sound level, typical for residential living areas (~35 dBA)**

Room Acoustics

Room Acoustics

- Control of sound reflections within a space
- This is done by selecting appropriate finishes with varying sound absorbing properties

Reverberation Time (RT60)

Time required for the sound to diminish 60 dB

Target depends on the use of the space and its volume

- Musical uses benefit from longer RT60
- Speech has higher clarity with low RT60 times

Why Acoustics Are Important

Why Acoustics are Important

SAT scores decrease with poor acoustics

Bronzaft (1975, 1981)

- **Measured noise and test scores on two sides of a school**
  - One side adjacent to train line
  - Before and after noise mitigation from the train line

Evans and Maxwell (1997)

- Chronic noise exposure reduced reading scores
  (even when tested in a quiet environment)
- Noise exposure is related to impairment in speech perception

Haines, Brentnall, Stansfeld and Klineberg (2003)

- "Results from recent quantitative research consistently demonstrate that children are a high risk group, vulnerable to the adverse effects of noise exposure, especially effects on cognitive performance, motivation and annoyance."

Why Acoustics are Important

SAT scores decrease with poor acoustics

- **Shield and Dockrell (2008)**

“Activities affected by noise include memory, reading, motivation, and attention”

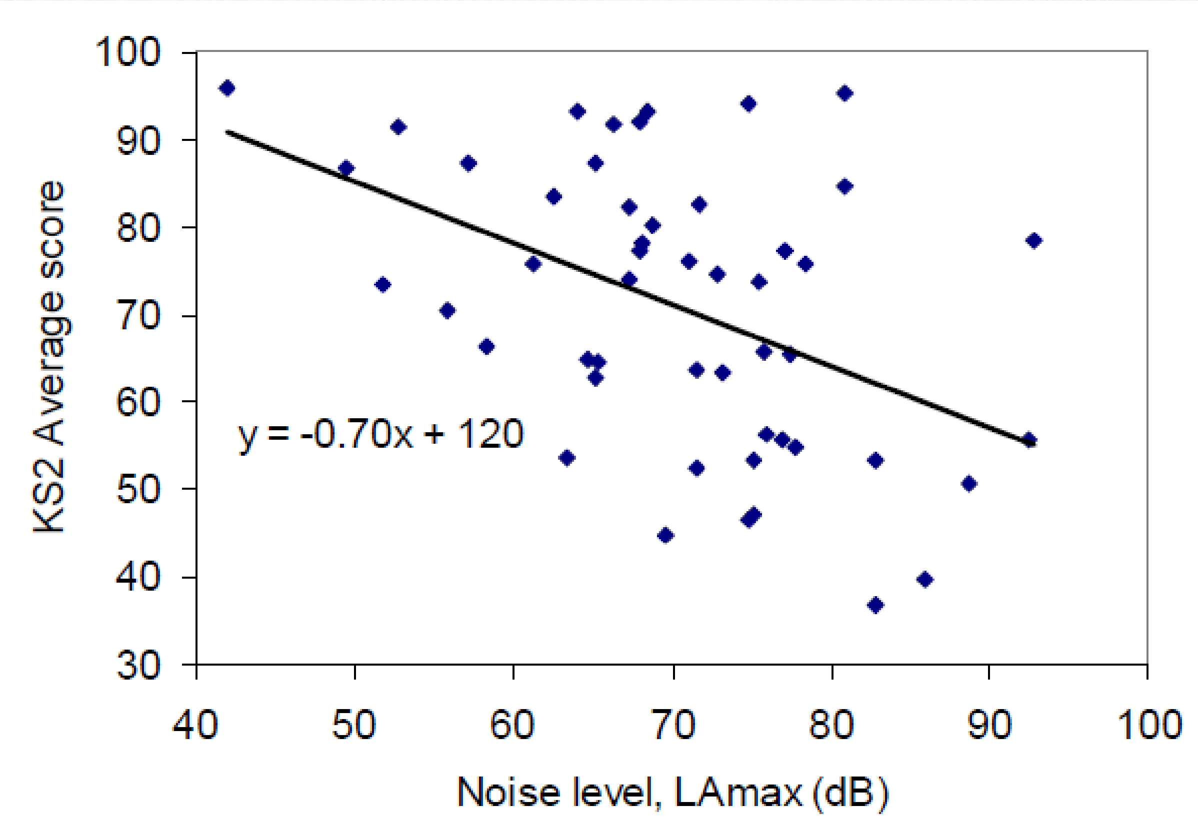
“Children with special educational needs were found to be more susceptible to the effects of classroom babble upon verbal tasks than other children.”

“it is essential to give careful consideration to the acoustic design of a school in order to optimize conditions for teaching and learning.

Why Acoustics are Important

SAT scores decrease with poor acoustics

Shield and Dockrell (2008) – KS2 = English, Math, Science



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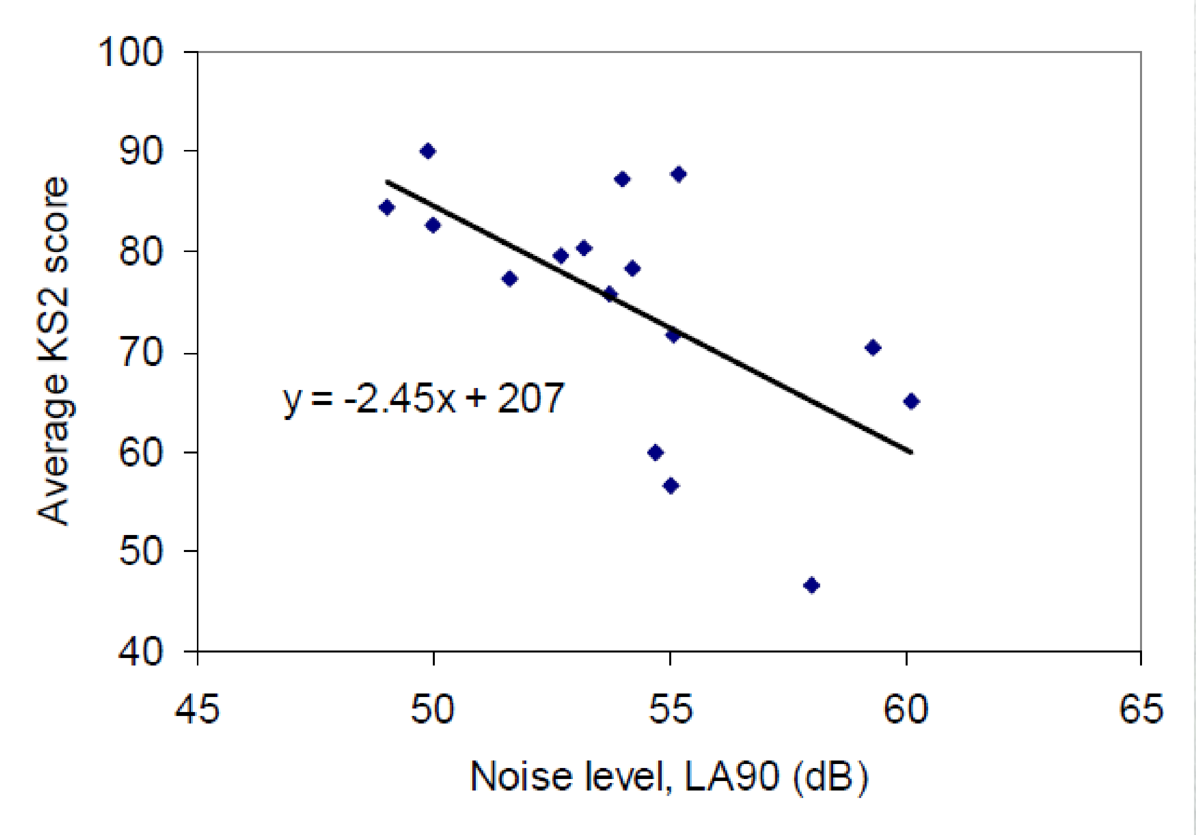


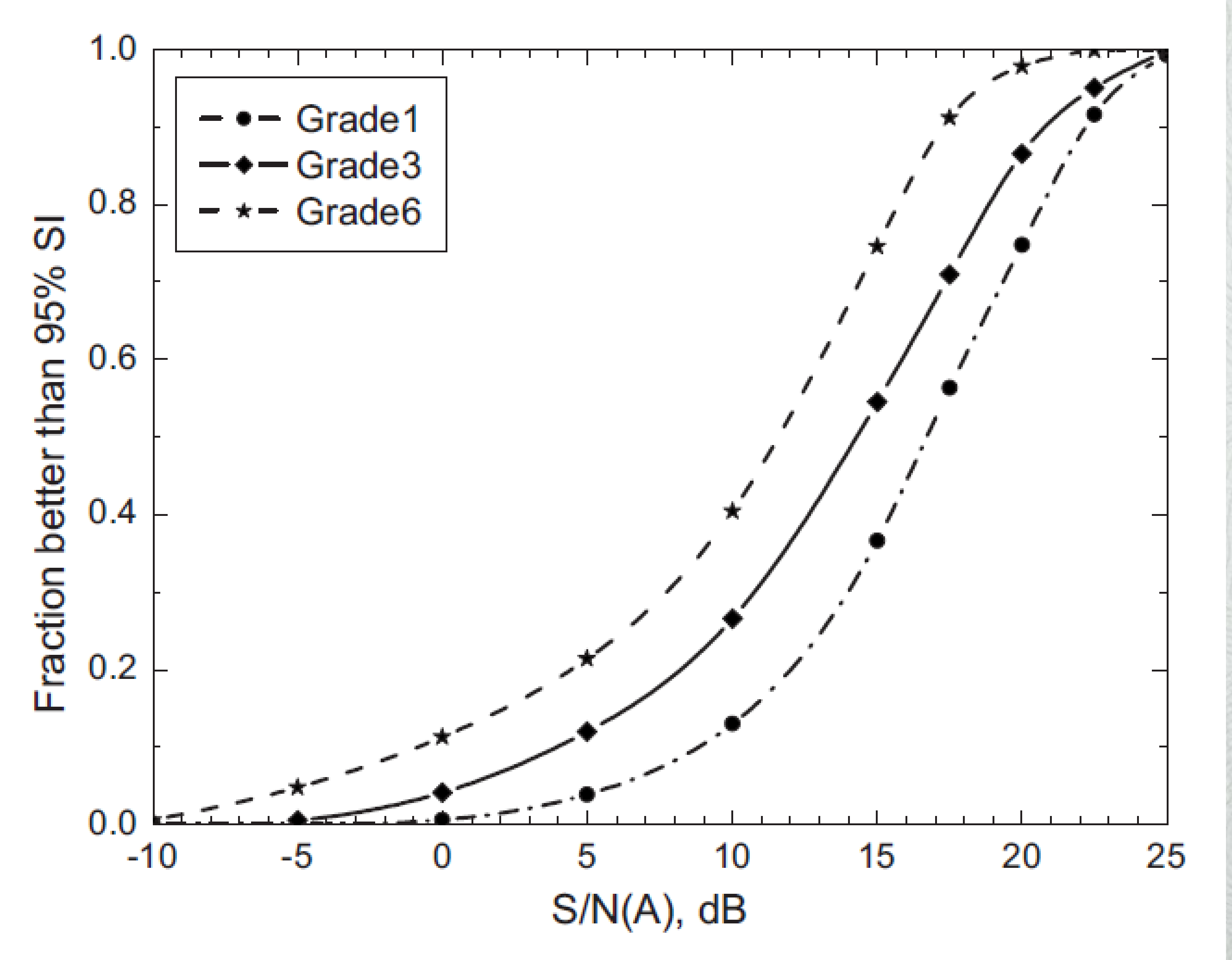
Why Acoustics are Important

Design “should consider the most acoustically sensitive activity” – John Bradley

- **Speech communication is the most acoustically sensitive activity**
- **Quiet**
  - Reduces strain on teachers voices
  - Increases intelligibility (SNR)
  - Young, hearing impairment, ESL need quiet

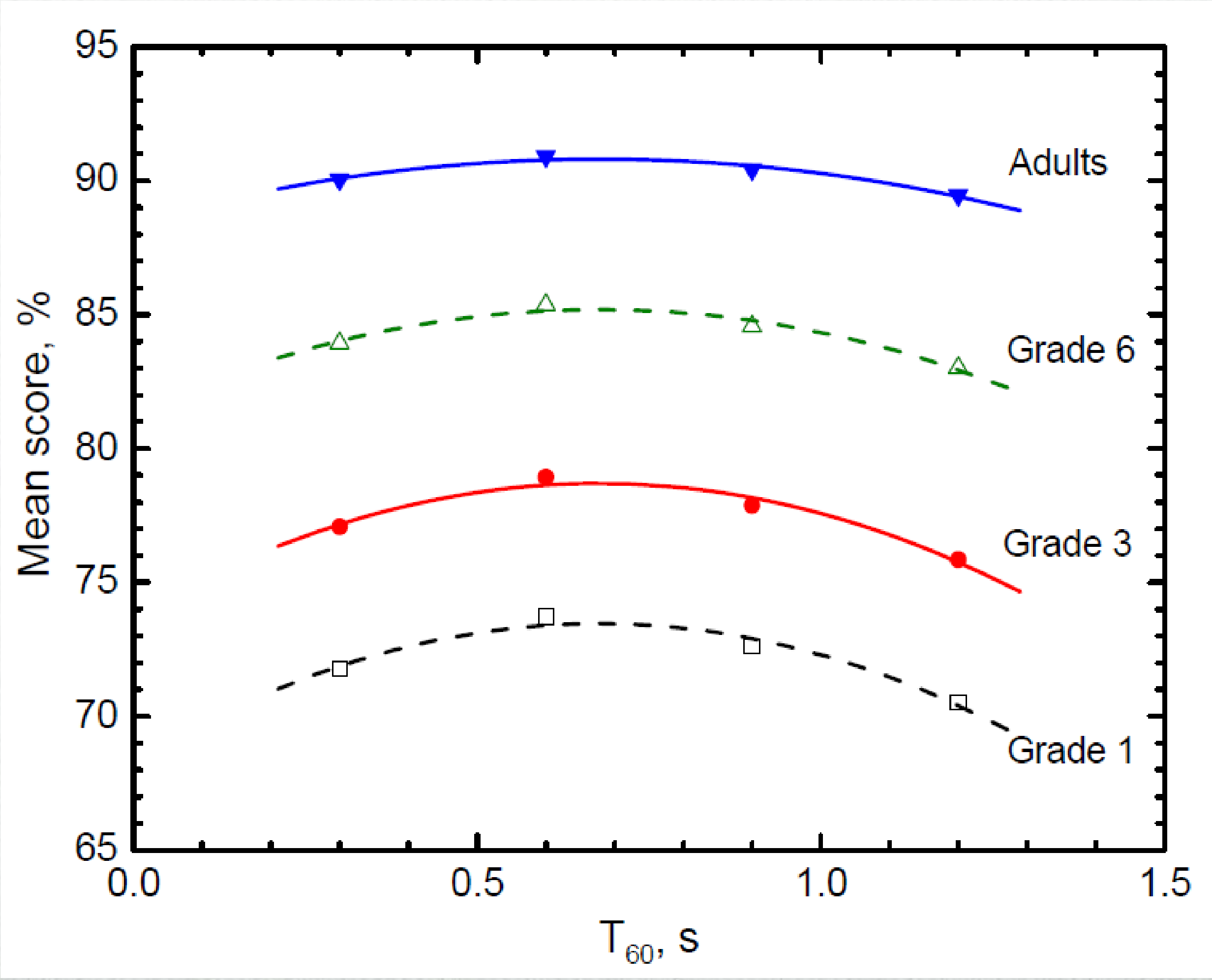
Why Acoustics are Important

- **Bradley and Sato (2008) – Average Teacher ~ 60 dBA**



Why Acoustics are Important

Reverberation time has an ideal point ~0.6 to 0.7 seconds



Acoustic Targets and Criteria

Acoustic targets and criteria

Acoustical Society of America

ANSI/ASA S12.60-2010/Part 1 American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools

Key Points:

- **Focus on ‘traditional’ Classrooms**
- **Background Noise Levels <35 dBA**
- **Reverberation Time (RT60) = 0.6 – 0.7 s**
- **Sound Isolation**
  - 50 – classroom to classroom
  - 53 – classroom to W/C
  - 45 – classroom to corridor
  - 60 – classroom to music / auditorium / mechanical / gym / cafeteria
- **Impact Noise (IIC) 45 – classroom to classroom**

6

Changes in the 21st Century

Changes in the 21st Century

?

Changes in the 21st Century

4 Cs:

- Creativity
- Creative Thinking and Problem Solving
- Communication
- Collaboration

Multi-media (Audio/Video)

- Recording (microphones)
- Amplified sound (speakers)

Building Design

- Open Classrooms
- Learning Commons
- ‘Neighborhoods’

Changes in the 21st Century

Flexibility

Future-proofing

Matching design to actual use

Options to consider:

- Operable walls
- Modular construction
- No walls

Best Solution:

Communication between users and designers

Value of Acoustics and Examples

Value of Acoustics

Sound Isolation

- Deal with stopping distraction (both indoor and outdoor)

Walls

  - Simple GWB and LIGHT GAUGE steel studs with fibrous insulation (5/8” Type ‘X’ GWB / 6” SS w batt / 5/8” Type ‘X’ GWB)
  - Concrete block (8”)

Windows

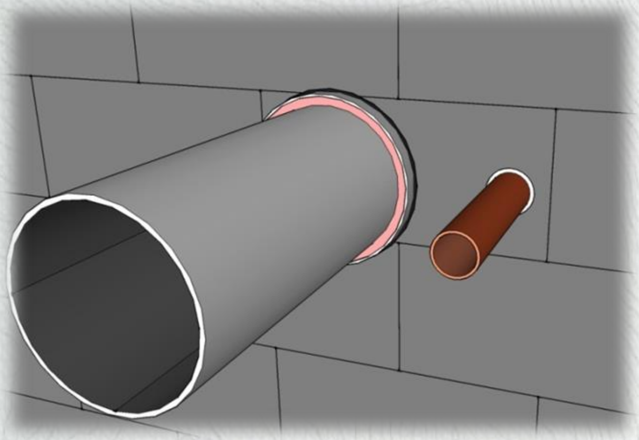
  - 3/8” glass ~STC 35 (OITC 32)
  - ½” laminated glass ~ STC 38 (OITC 34)
  - ¼” lam / ½” airspace / ¼” lam ~ STC 42 (OITC 33)

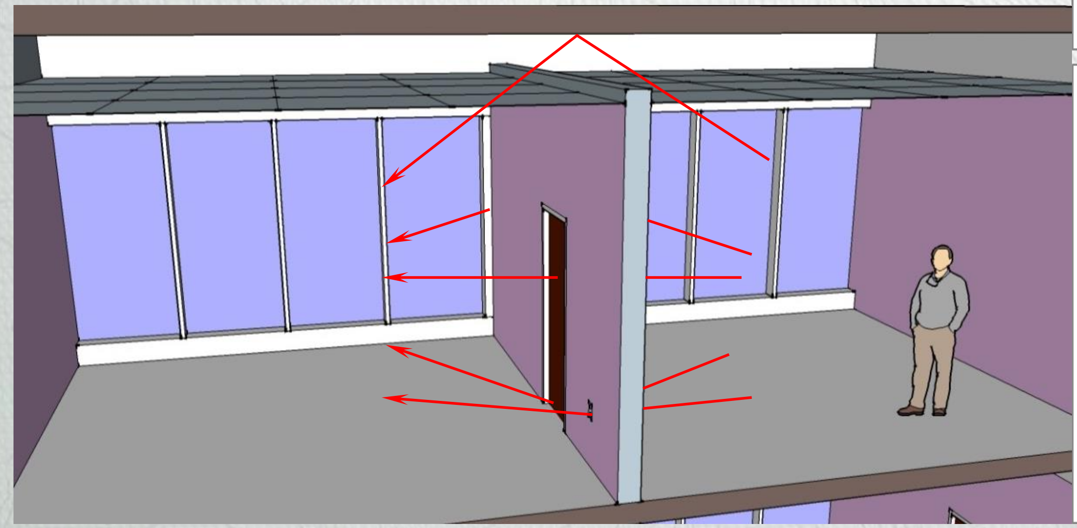
Doors

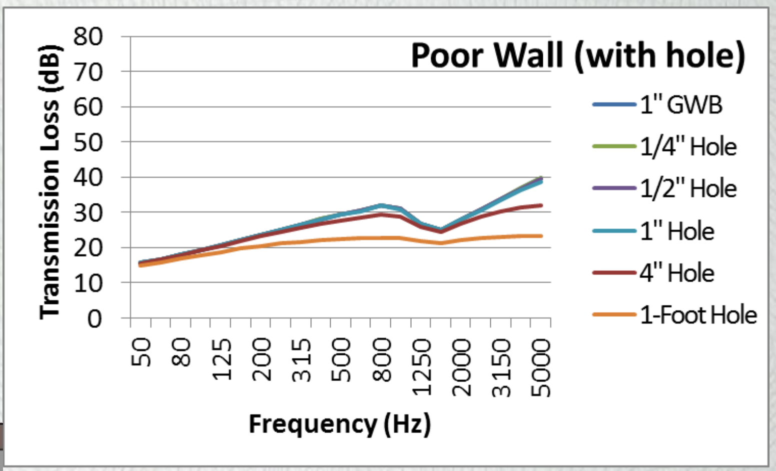
- Solid core wood or insulated metal, no seals ~ STC 20
- With full perimeter seals and drop seal ~ STC 30

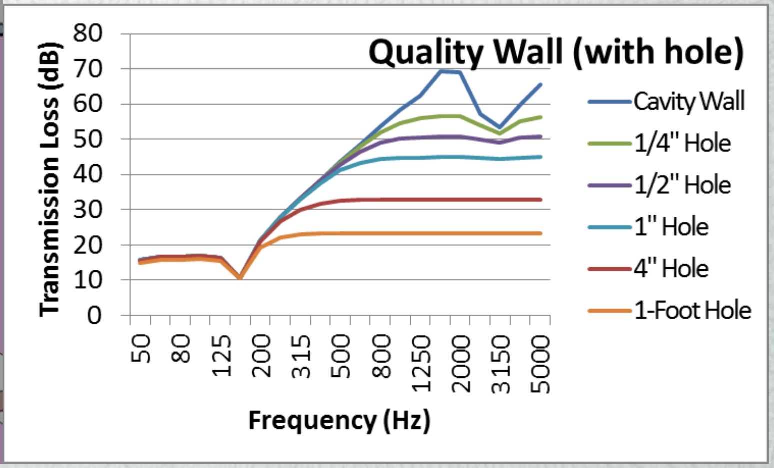
Value of Acoustics

Flanking / Holes







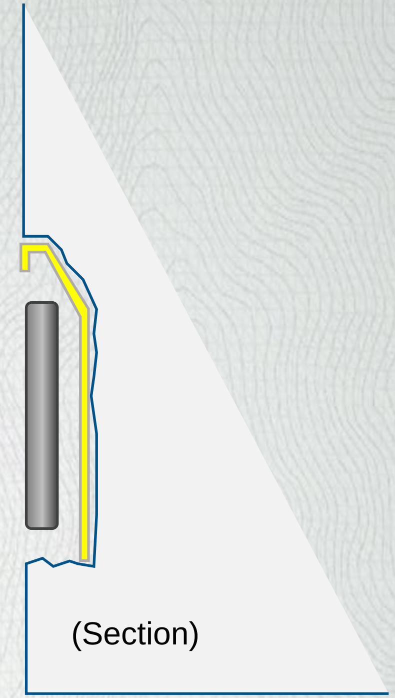


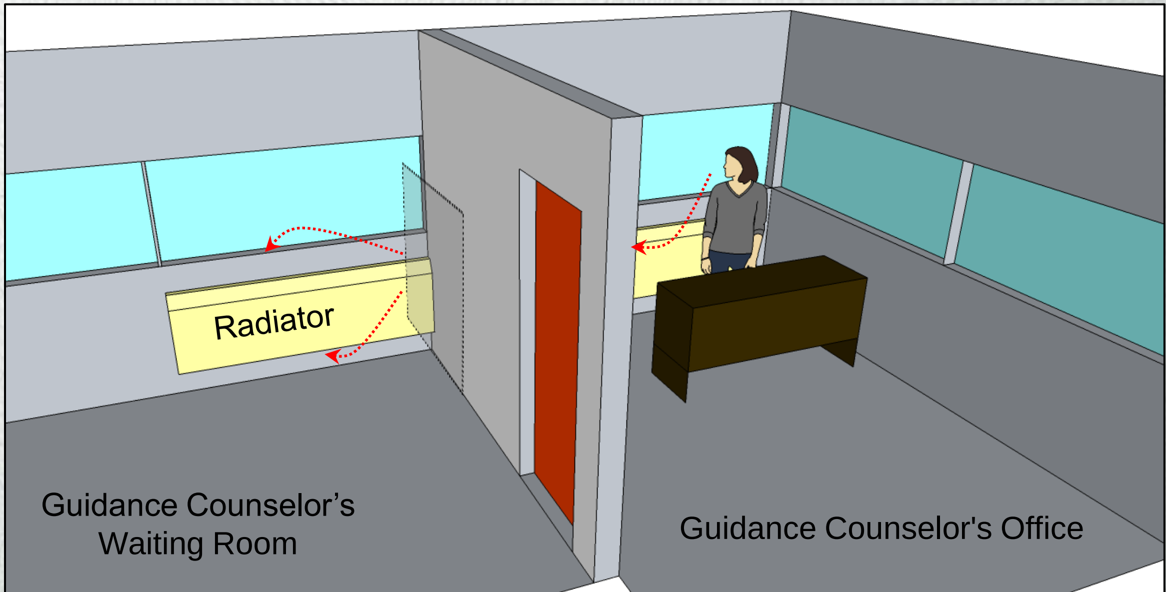
Valuable Example

Partition:

- High School Guidance Counselor’s Office
- Waiting Room

- Partition cut around radiator
- Radiator is continuous and open through wall





Value of Acoustics

Room Acoustics
- Communication
- Calm Environment

Solutions:
- Fibrous/porous (thicker or spaced from wall)
- Ceiling Tiles
- Baffles

Cautions:
- Microphones
- Speakers

	Small Volume	Medium Volume	Large Volume
Special Acoustic Requirements	**Audiology Booth**	**Studio**	**Auditorium**
High Acoustic Requirements	**Interview Room**	**Music Room Teleconferencing**	**Multi-purpose**
Medium acoustic requirements	**Private Office**	**Classroom**	**Gym**
Low Acoustic Requirements	**WC/Storage**	**Corridor**	**Lobby/Atrium**

SPECIFIC DESIGN

ACOUSTIC TILE TYPICALLY SUFFICIENT

Valuable Example

Room Acoustics Issue

- Space with ¼” mineral fibre tiles glued to sloped ceiling
- Attempted to fix with PA systems

Value of Acoustics

Background Noise

- Increase SNR (comprehension)

Sources

- Mechanical Rooms / rooftop mechanical
- Ducted mechanical
- Fan coil units

Value of Acoustics

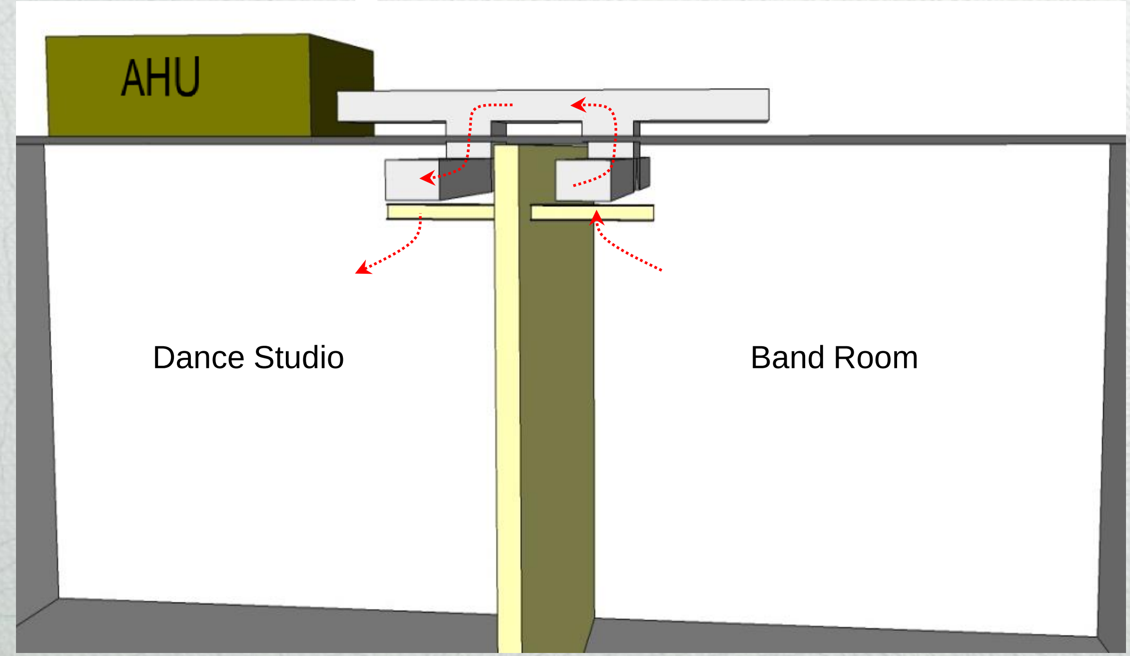
Mechanical Noise Controls

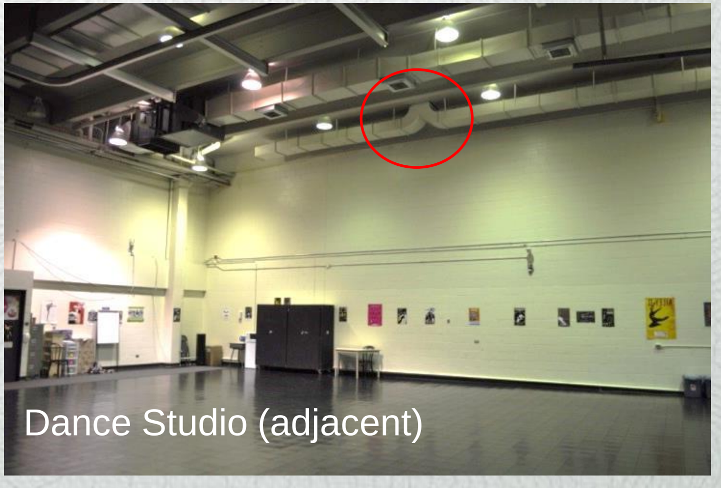
- Walls/ceilings (including ACT)
- Duct silencers
- Vibration isolation (demo)
- Distance

Valuable Example

Mechanical Noise

- Noisy
- ‘Cross-talk’





Other Acoustic Considerations

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Environmental Noise

- Transportation and other external noises (including rooftop)
- Construction noise
- Impact on outdoor areas and indoors

Floor Vibration

- Students walking in corridors causing upper floors to shake

Impact Noise

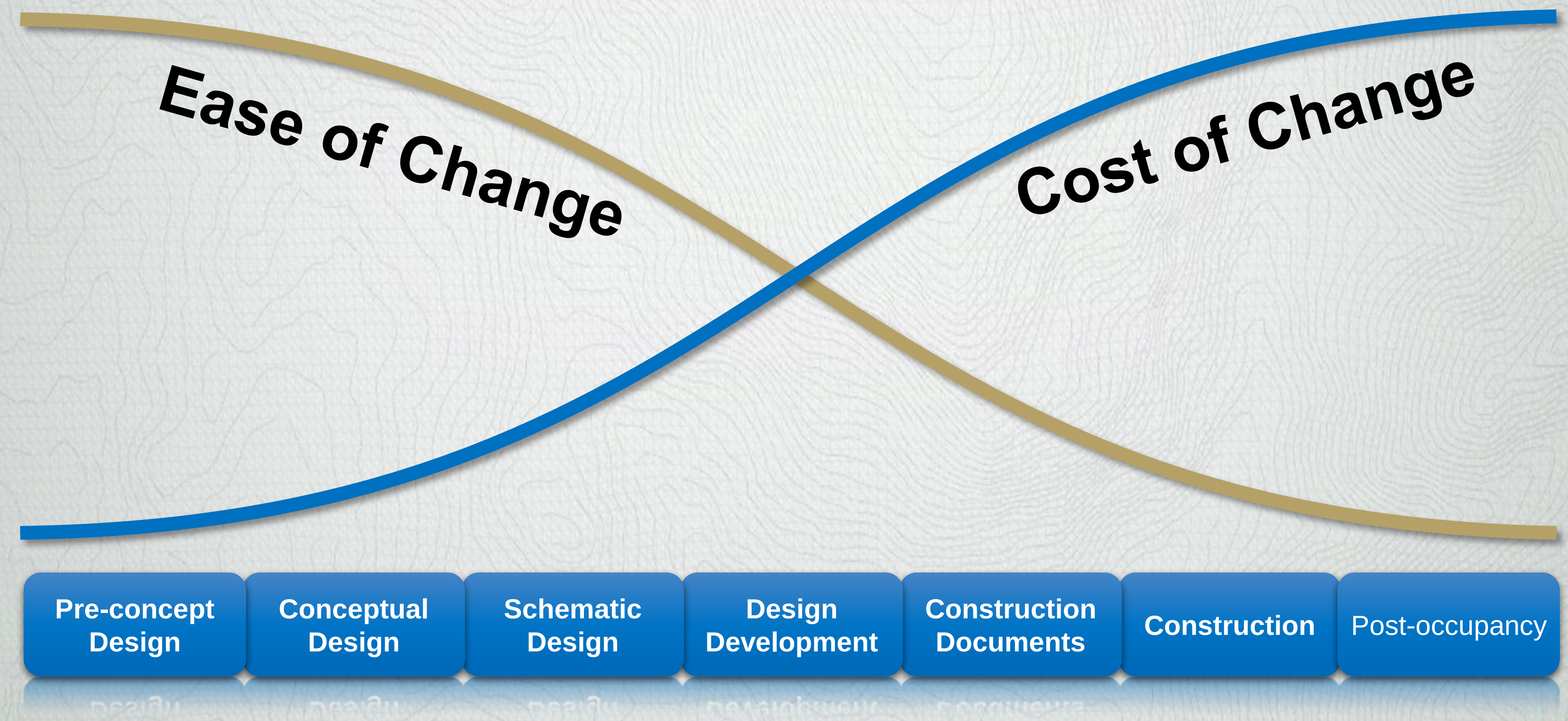
- Thumping footfalls

Details

- Acoustics details are paramount to success
- No ‘silver bullet’, ignoring one aspect can be problematic

Other Acoustic Considerations

The best time to consider acoustics is
as early as possible when problems can be identified and
corrective action can be easily incorporated.



Quick Summary

1 **Room Acoustics**

2 **Sound Isolation**

3 **Background Noise**

THANK YOU

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