NOISE | VIBRATION | ACOUSTICS

TAMING THE NOISIEST ROOMS:
PRACTICAL ACOUSTICAL STRATEGIES FOR FUTURE-READY SCHOOLS

2026 A4LE MWGL REGIONAL CONFERENCE

“The Gateway: Schools for Tomorrow’s Learning”

mkundakcioglu@hgcacoustics.com

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Presenter

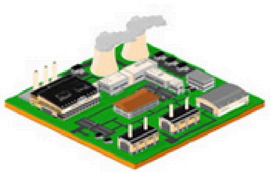
Michael Kundakcioglu, BASc, P.Eng. (Ontario & Alberta, Canada)

- Senior Engineer at HGC Noise Vibration Acoustics

Who is HGC Noise Vibration Acoustics?

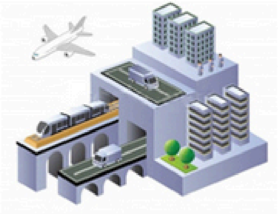
Built Environment

We actively support developers, planners, architects and engineers in addressing all issues pertaining to noise, vibration and acoustics within a structure and in its relationship to environmental zones of influence nearby.



Industrial

We assist industries in every business sector to complete requirements for their Environmental Compliance Approvals. We conduct accurate surveys to identify all significant noise and vibration sources associated with large industrial facilities, plants and operational complexes.



Transportation

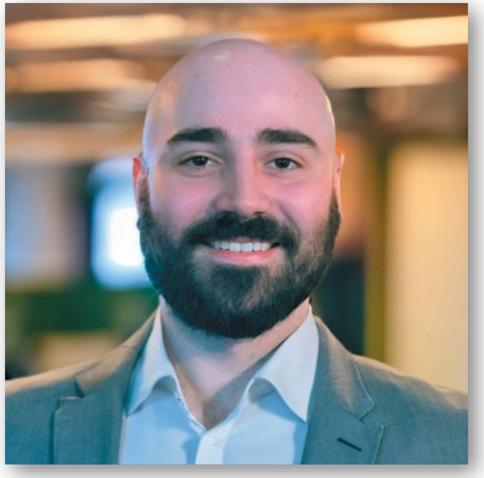
Whether rail, road or air, transportation represents a major potential source of environmental noise and vibration for neighboring communities. We work with all relevant stakeholders conducting impact studies and developing mitigation solutions that facilitate the approval process and alleviate community concerns.

Defence & Security

Defence and Security related technologies and support systems represent potential occupational noise and vibration hazards for their operators and the public at large. We work with officials to research and develop noise abatement strategies and solutions that alleviate exposure concerns.

Product R&D

We have partnered with manufacturers across multiple industries to investigate and incorporate effective acoustic best practices into their product design for greater consumer preference and comfort.



Learning Objectives

1. Identify common acoustic failure modes in shared school spaces and describe the primary root causes that distinguish them from typical classrooms.
2. Apply early checkpoints for planning of adjacencies to reduce the likelihood of post-occupancy complaints.
3. Outline HVAC noise-control strategies for schools that address source selection, distribution design, and vibration isolation in a way that supports target background sound levels.
4. Translate program intent into acoustical performance targets for shared school spaces, and identify the early design decisions most likely to control each target.

Why care about **noise** in schools?

Human Comfort

- Stress, anxiety

Building Function

- Speech privacy
- Speech intelligibility
- Suitability for purpose (learning, presentation, judgement)
- Reduced concentration/proficiency

Regulatory Compliance

- Code and regulatory compliance (IBC, State code, OSHA…)
- Industry standards (LEED, ANSI, ASHRAE…)

Why care about **noise** in schools?

Pain threshold: 110+ dBA	110 dBA
	100 dBA
	90 dBA
Significant stress, Risk of hearing loss: 85+ dBA	
	80 dBA
	70 dBA
Reduced proficiency, Raised voices, Increased health risks? 65+ dBA	
Impacts on concentration? 60+ dBA	60 dBA
Prominent annoyance: 50 dBA	50 dBA
Activity interference: 45+ dBA	
Interference with speech: 40+ dBA	40 dBA
Sleep disturbance 30+ dBA	30 dBA
Annoyance and distraction: 25? 35 dBA?	
	20 dBA

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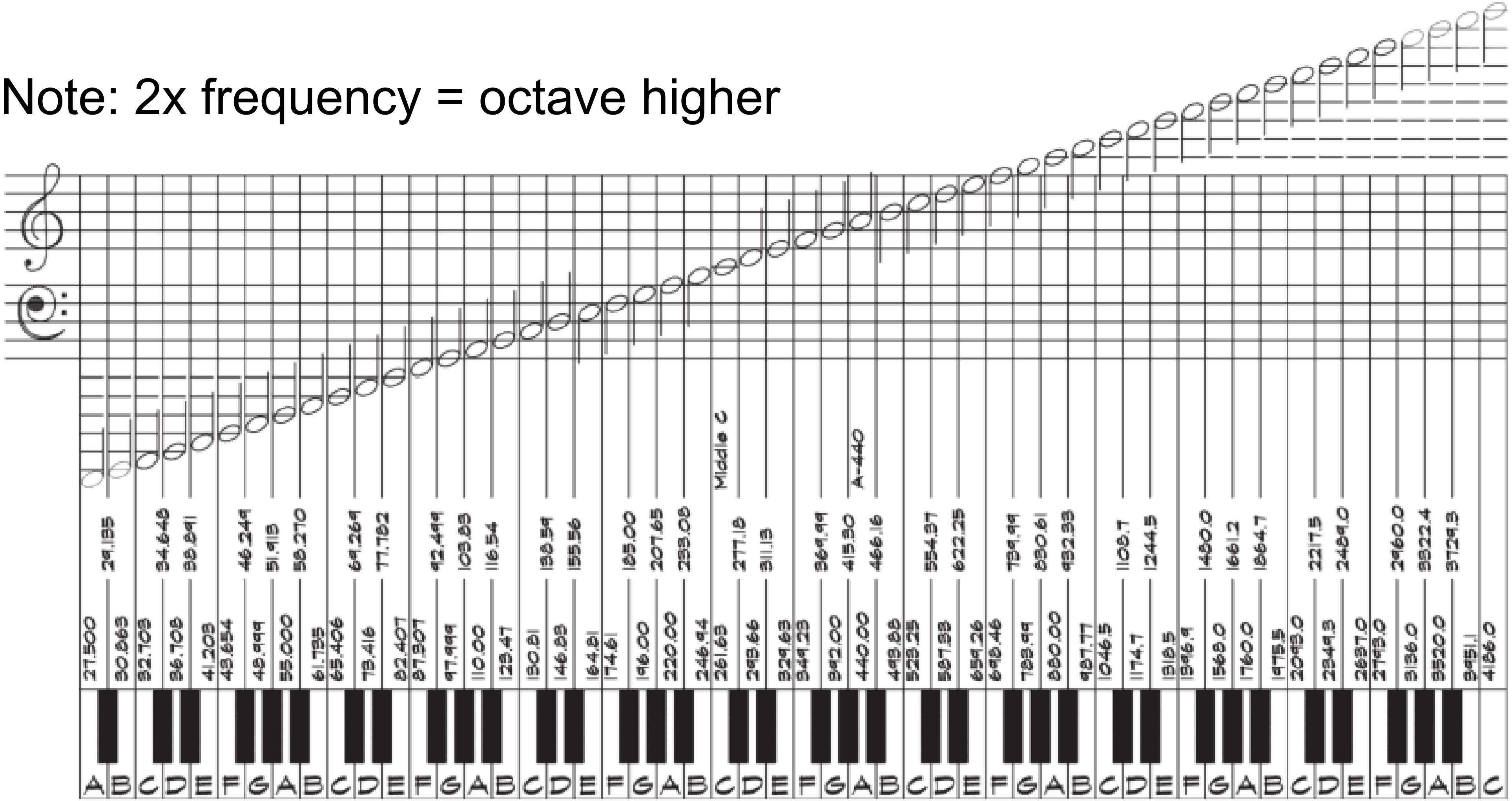
Context of Frequency

Typical piano range: 27 Hz to 4200 Hz

Note: 2x frequency = octave higher



Demo – Frequency vs Volume

16 Hz

32 Hz

63 Hz

125 Hz

250 Hz

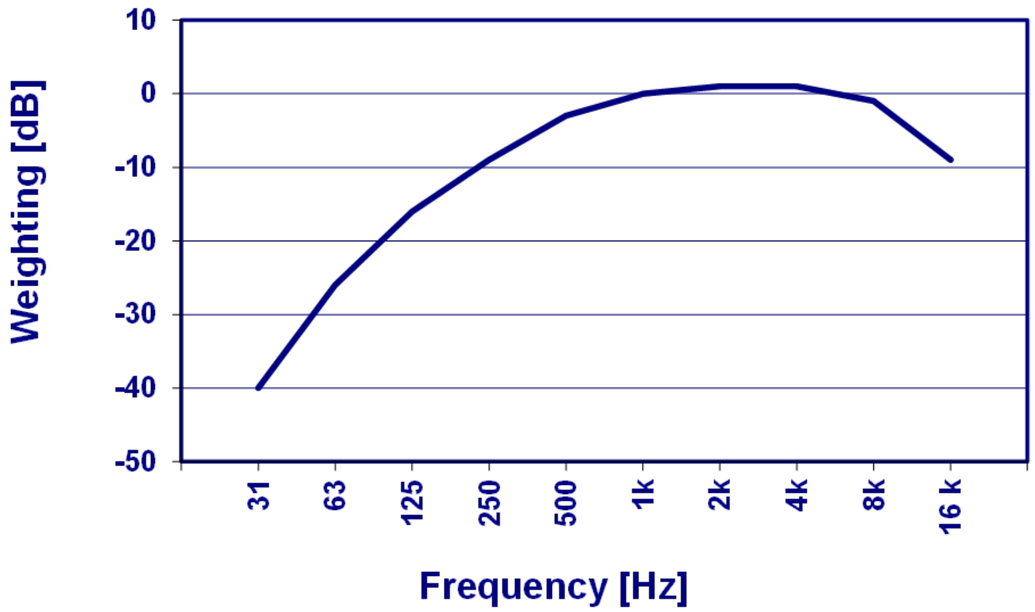
500 Hz

1000 Hz

2000 Hz

A-weighted Sound (dBA)

- Applies a filter to each frequency based on human hearing
- Moderately captures frequency characteristic of loudness contour
- Good single-number descriptor of the sound level
- Often used for overall sound levels (even if someone only says “dB”)



With respect to target criteria:

a 3 dB excess: minor.
a 5 dB excess: moderate.
a 10 dB excess: severe.

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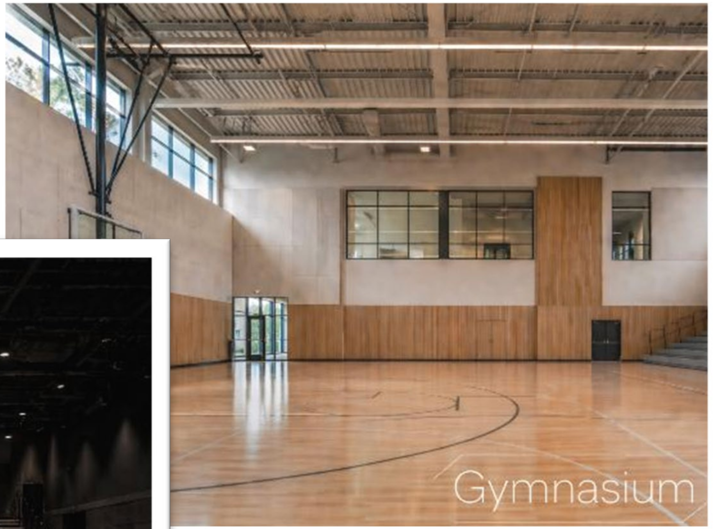
SECTION 1:
WHAT MAKES THESE ROOMS DIFFERENT

The Rooms Everyone Worries About



These Are Not Just Bigger Classrooms

Bigger volume. Higher source levels. More demanding adjacencies. Noisier services.

- A classroom acoustic problem affects one room and one teacher
- These rooms affect the whole school
- Getting them wrong is visible, expensive, and hard to fix after the fact

Acoustic Criteria Across School Space Types

Design targets drawn from the following sources:

- ANSI S12.60,
- ASHRAE 2023 Applications Handbook, and
- LEED BD+C for Schools.

Values represent typical design targets; project-specific criteria may vary.

Space	RT Target	Background Noise	STC to Core Learning Space
Classroom	≤0.6 s	35 dBA / NC-30	STC-50
Gymnasium	≤2.0 s	NC-45 to NC-50	STC-60
Cafetorium	0.8–1.2 s	NC-35 to NC-40	STC-50-55
Music Suite	0.6–0.8 s	NC-30 to NC-35	STC-60
Drama / Black Box	0.7–1.0 s	NC-20 to NC-25	STC-60
Multipurpose Room	0.8–1.2 s	NC-35 to NC-40	STC 50–55

Why They Fail Differently

Four main risk factors compared to classrooms:

- Larger volume
- Critical adjacencies due to centralized location
- Larger mechanical systems due to larger volume
- Higher noise levels due to programming

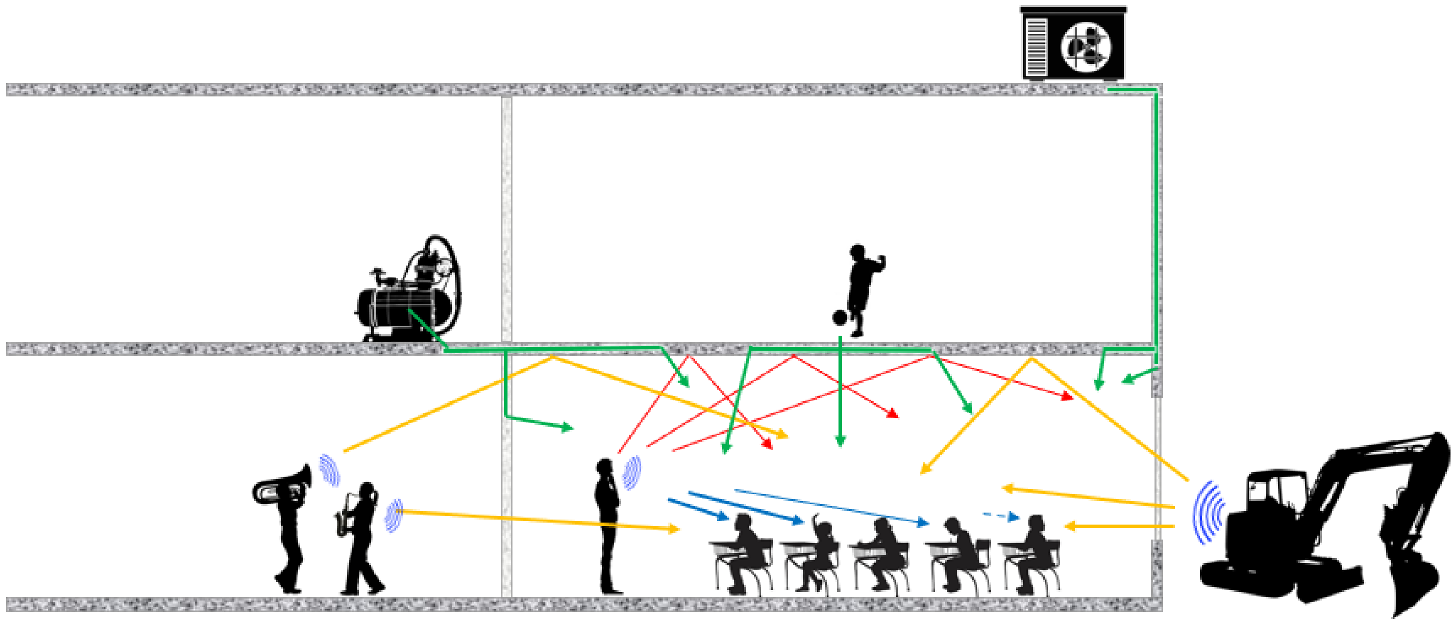
Predictable result of decisions made, or not made, early in design:

- Speech unintelligible during assemblies
- Music rooms audible in adjacent classrooms
- Gyms so reverberant that a referee's whistle sounds the same as shoes squeaking
- Community use programs that cannot function as intended

Three Failure Modes

When these rooms fail, it is almost always traceable to one or more of three causes:

1. **Excessive Reverberation**
2. **Inadequate Sound Isolation**
3. **HVAC and Background Noise**

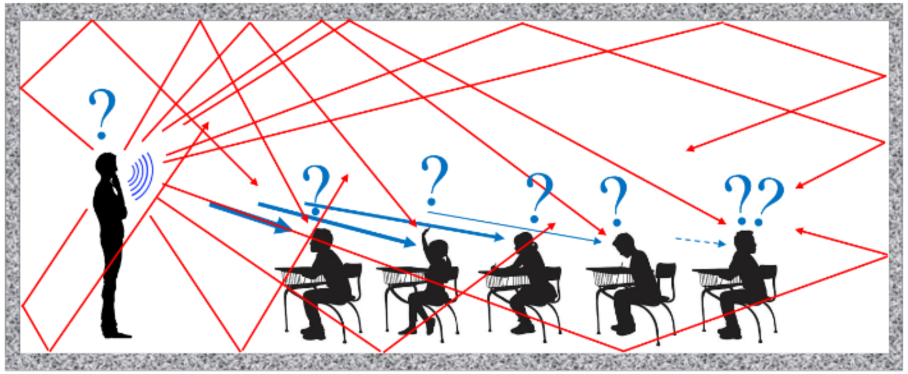


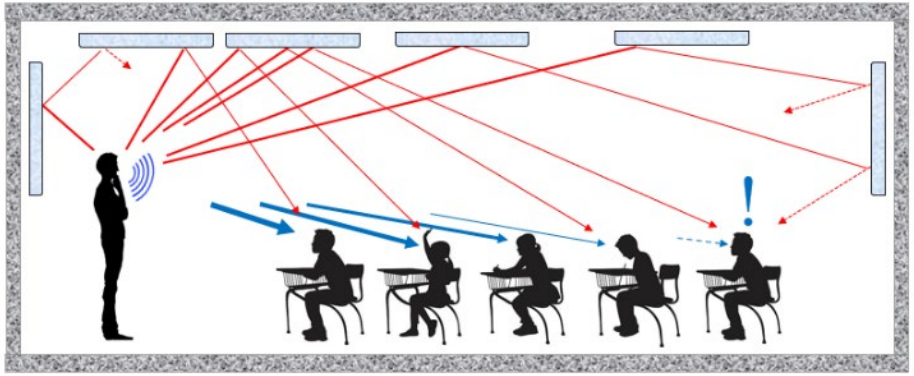
![HGC logo]

Failure Mode 1: Reverberation

Reverberation:
When the room competes with the source

- Sound reflects off hard surfaces and builds up in the room
- The speaker's voice competes with its own earlier reflections
- In a gym, reverb time (RT) can exceed **3–4 seconds!**
- ANSI S12.60 targets **≤0.6 s** for a classroom; a gym used for graduation needs to perform closer to that target, not 4 seconds





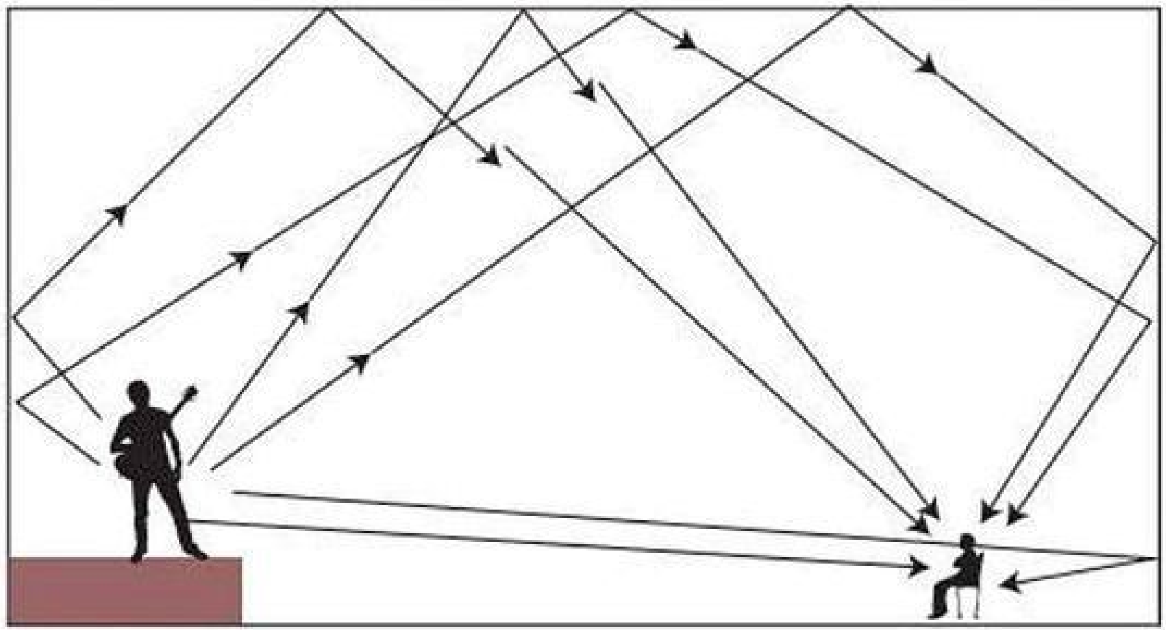
Failure Mode 1: Reverberation

Volume is the enemy!

- Reverberation time increases with room volume
- Doubling the volume of a room roughly doubles the amount of absorption
- Larger rooms almost always require dedicated treatment (not pictured below)!

Failure Mode 1: Reverberation

- Too reverberant – sounds “echoey”
- Not enough reverberation – sounds “dead”
- Both extremes can be problematic



Failure Mode 1: Reverberation

- Too reverberant – sounds “echoey”
- Not enough reverberation – sounds “dead”
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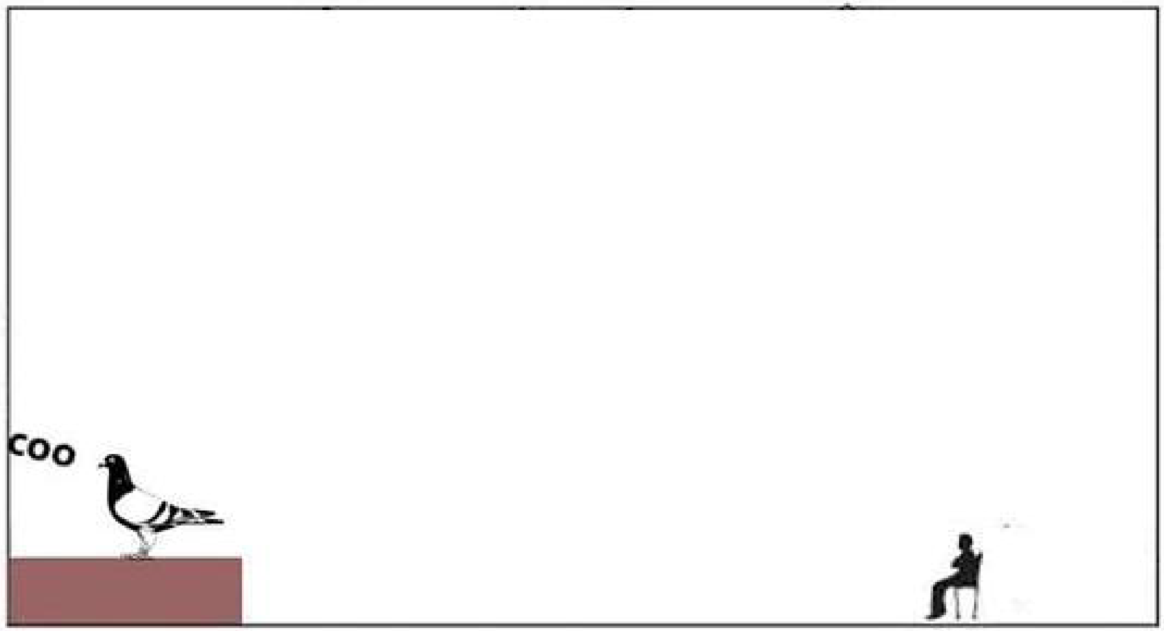
Critical Exception:
Sound from a pigeon does not reverberate.



The reason is a coo sticks.

Failure Mode 1: Reverberation

What does reverberation sound like? Finding the sweet spot:

Speech:

5s	2s	1.3s	0.6s	dry

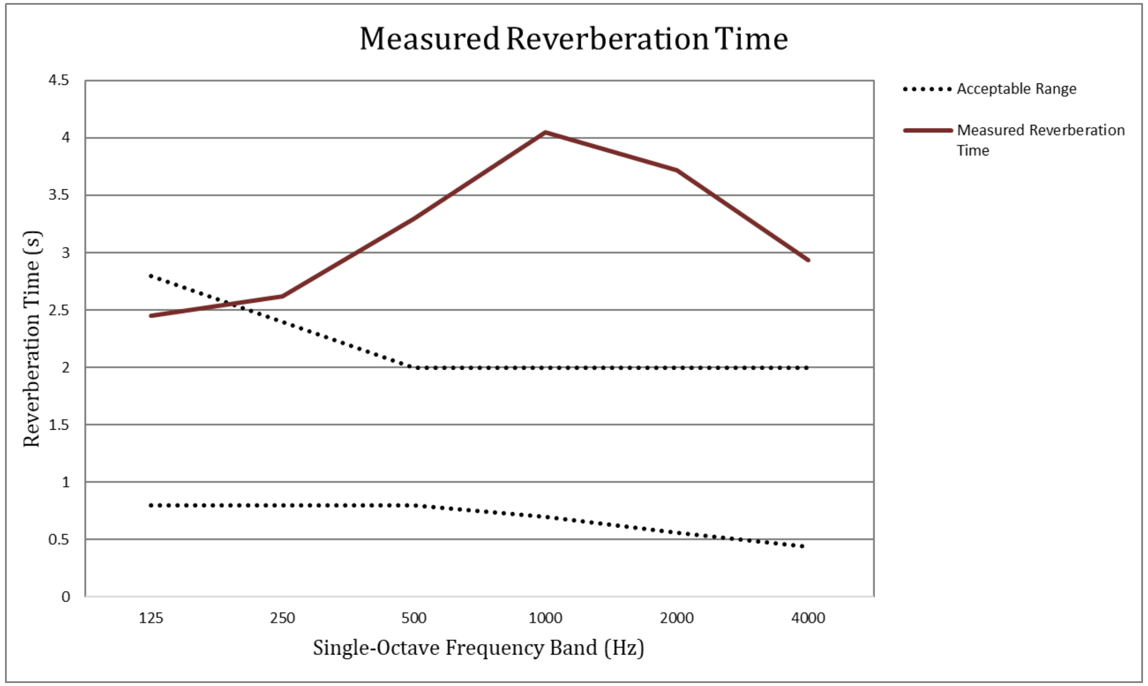
Music:

2.5s	2s	1s	0.6s	dry

Case Study 1: Unintelligible Small Gym

Reverberation time was so excessive that speech could not be understood from a couple of feet away.

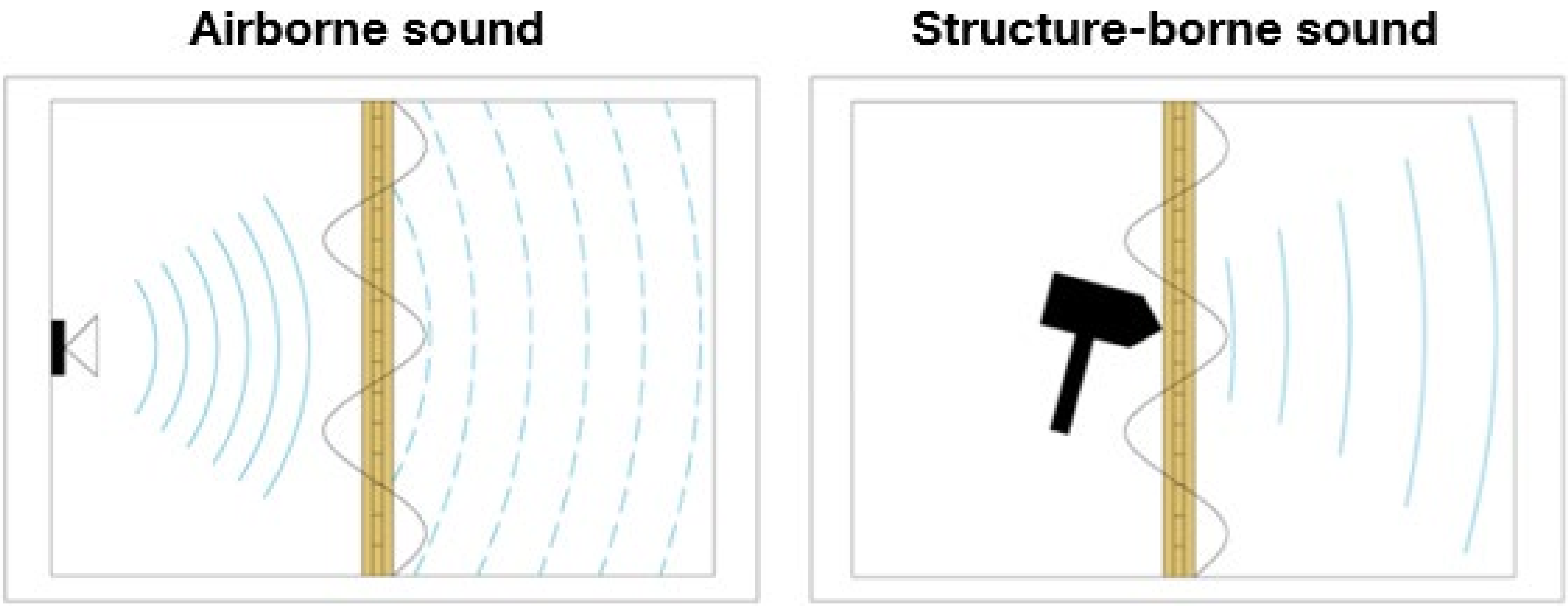
Why? The acoustic ceiling tiles meant to control reverberation in the gym were painted over, removing their absorption characteristics. There were no secondary treatments.



Failure Mode 2: Sound Isolation

Failure Mode 2: Sound Isolation

How does sound travel?



Failure Mode 2: Sound Isolation

Sound Transmission Class (STC)

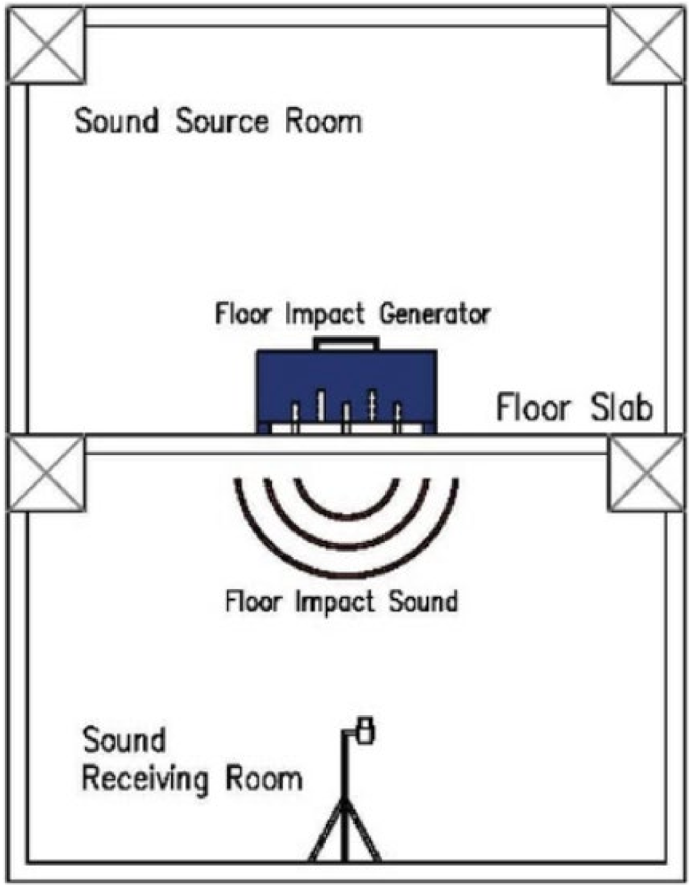
Airborne Sound

- Voices
- Music
- High frequencies

- *Not footsteps*

Failure Mode 2: Sound Isolation

Impact Insulation Class (IIC)



Structure-Borne Sound

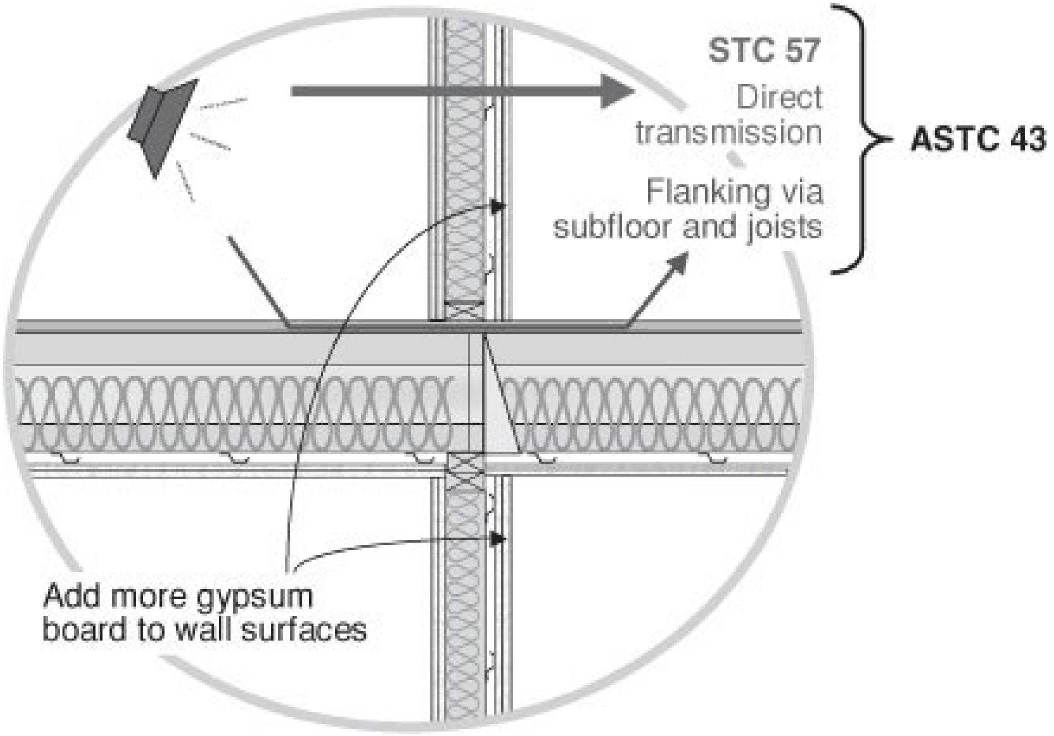
- Footsteps
- Dropped Items
- Furniture Movement

Failure Mode 2: Sound Isolation

How else does sound travel?

<u>Flanking:</u>

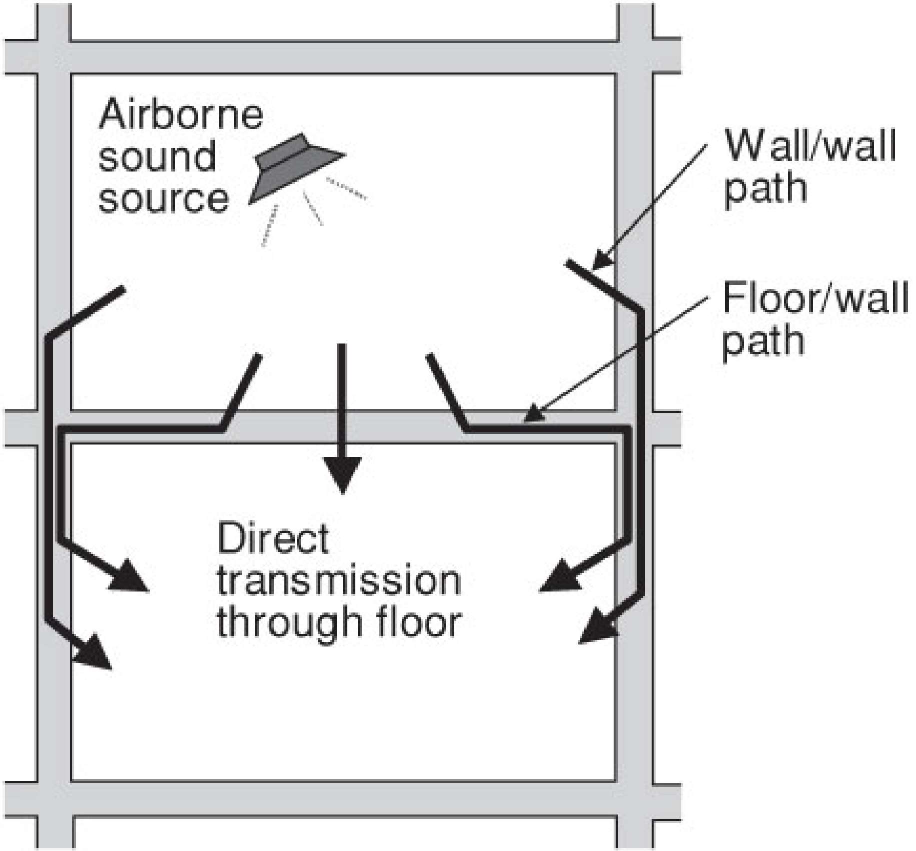
- Indirect sound transmission
- Over, under, or around
- Not through the demising partition
- Ex: exterior wall or corridor wall junctions



Failure Mode 2: Sound Isolation

Common Flanking Paths in Schools

- Continuous structure above a partition
- Open ceiling plenums
- Poorly sealed penetrations,
- Air transfer ducts
- Doors with inadequate seals



The detail that gets value-engineered out is usually the one doing the most acoustic work

Failure Mode 3: HVAC and Background Noise

HVAC Noise

- NC (Noise Criteria) curves describe the 'spectral character' of that background noise
- Large special-use rooms require larger mechanical systems, which move more air, and are harder to quiet than what serves a standard classroom
- Rooftop units directly overhead, high-velocity diffusers, and long ductwork without adequate lining are the most common culprits

Taming the Noisiest Rooms:
Practical Acoustical Strategies for Future-Ready Schools

The Three Failure Modes STACK

In these rooms, the failure modes reinforce each other and add together

- A reverberant cafetorium raises the apparent background noise level, which reduces speech intelligibility
- High HVAC background noise increases the sound levels, further masking speech
- Poor sound isolation from an adjacent music room raises background noise, even further masking speech

The result is a completely unintelligible graduation ceremony

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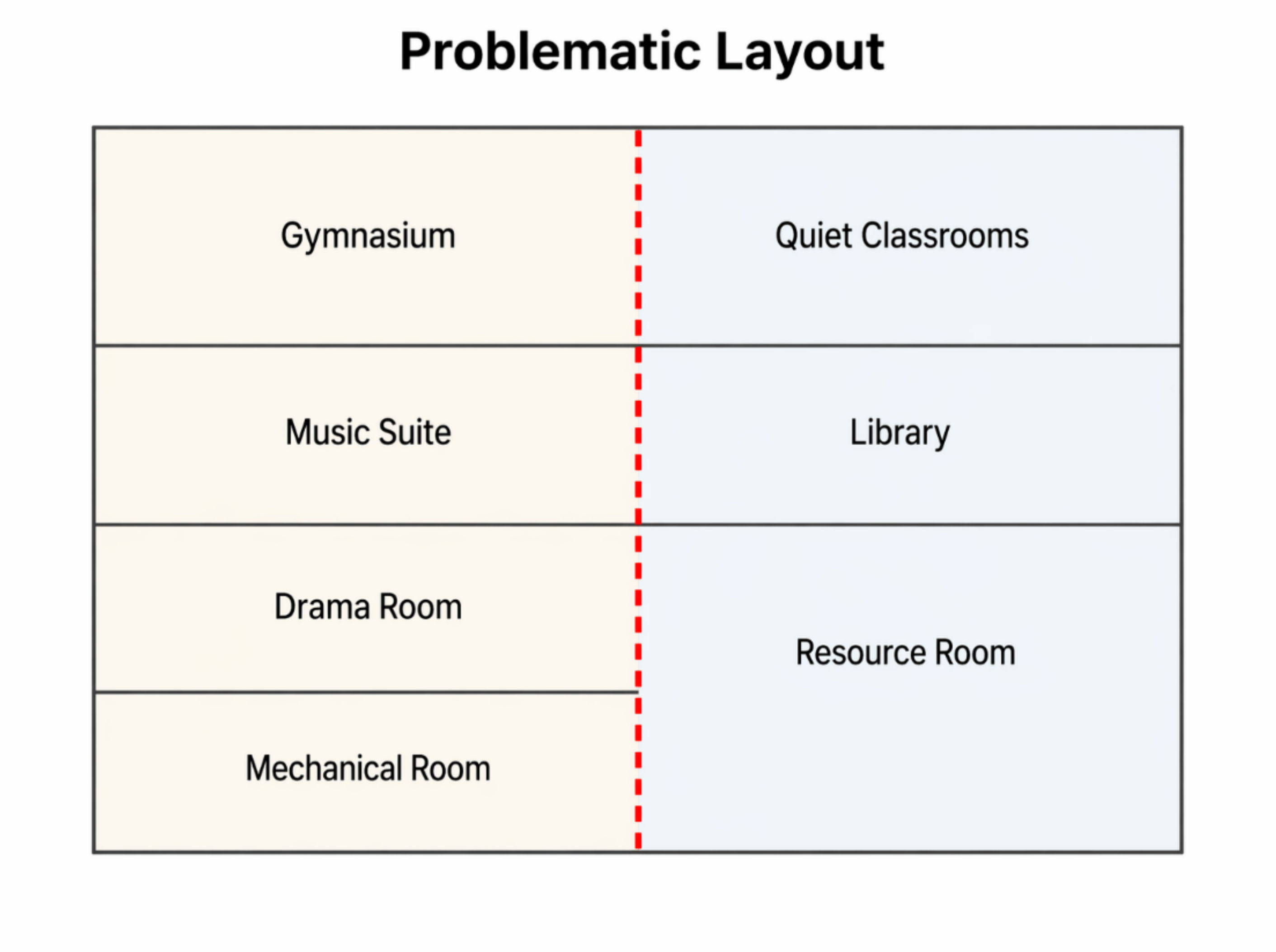
SECTION 2:

SOLUTIONS: START WITH PLANNING, NOT PRODUCTS

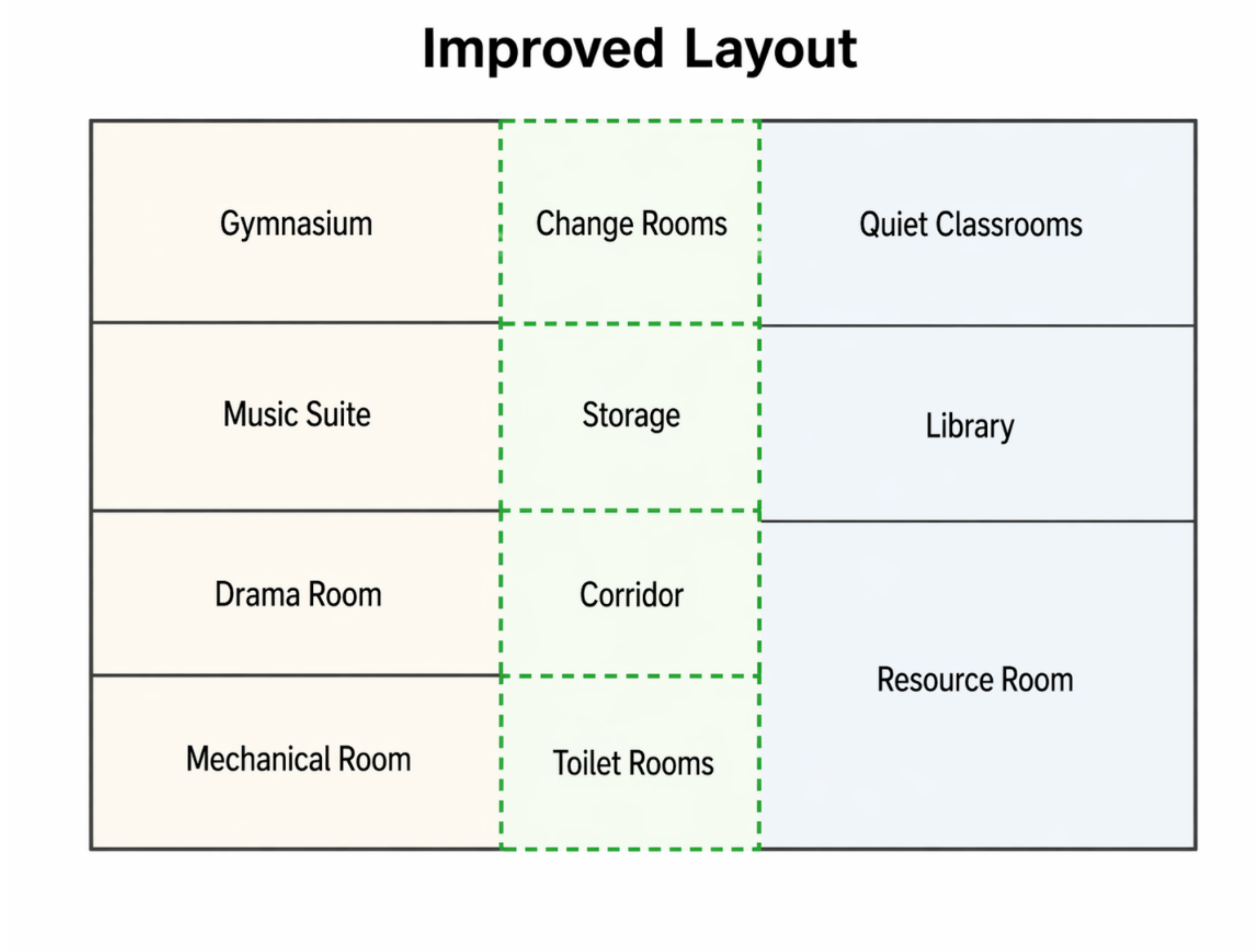
The Cheapest Solution is Planning

No amount of acoustic treatment can fully compensate for a bad adjacency decision made at schematic design.

Example: Poor Planning



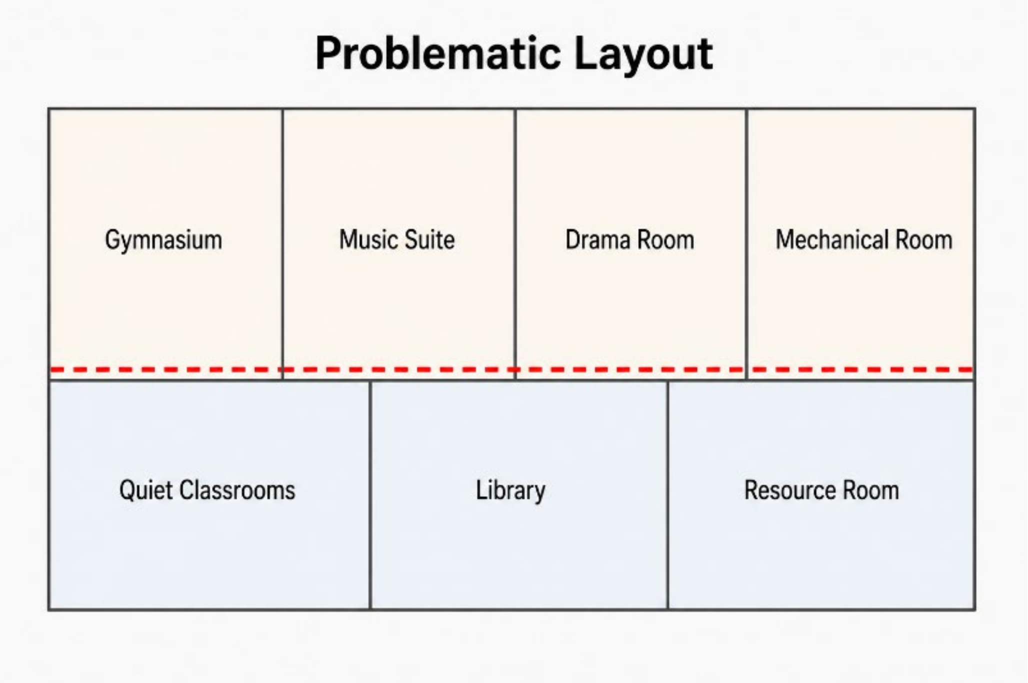
Example: Better Planning



Vertical Stacking Matters Too

The plan view is only half the picture!

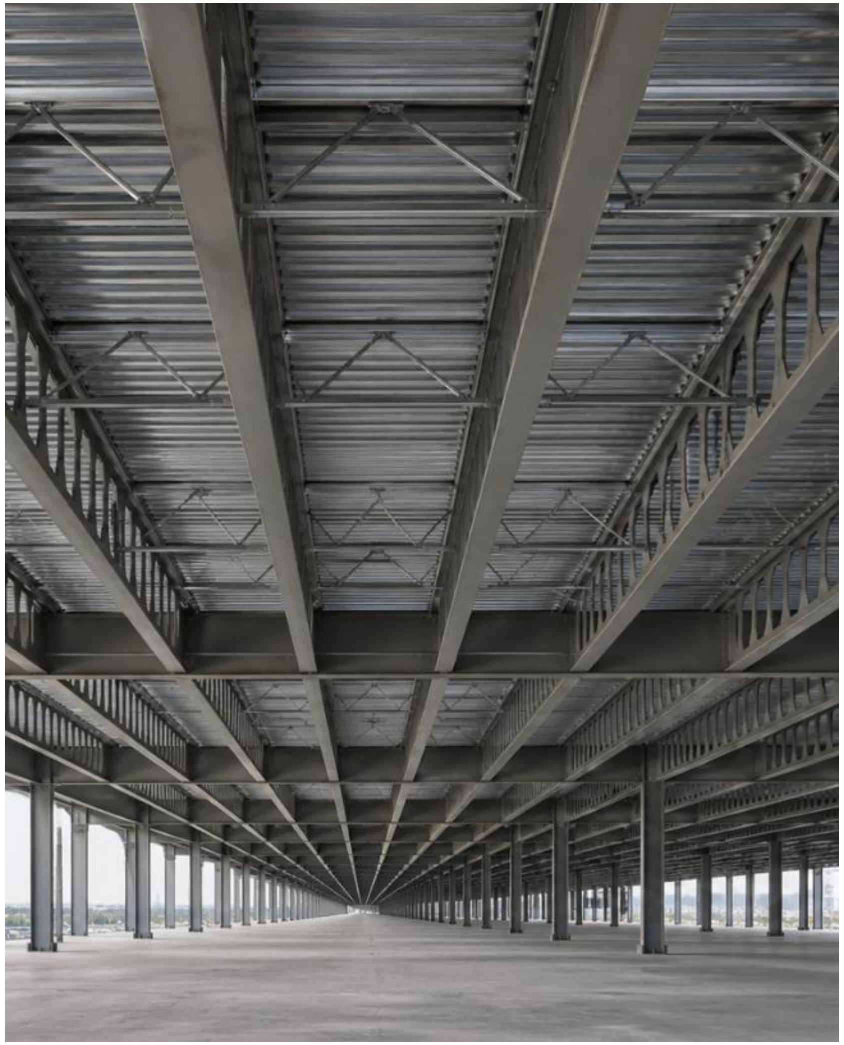
- Noise travels vertically too
- A gym on the second floor over quiet classrooms is a persistent source of impact noise and low-frequency vibration
- Music rooms above or below any occupied teaching space require structural isolation, not just wall treatment
- Rooftop units directly above classrooms or drama spaces are one of the most common sources of post-occupancy complaints



Long-Span Framing

Long-span structure is an acoustic risk factor

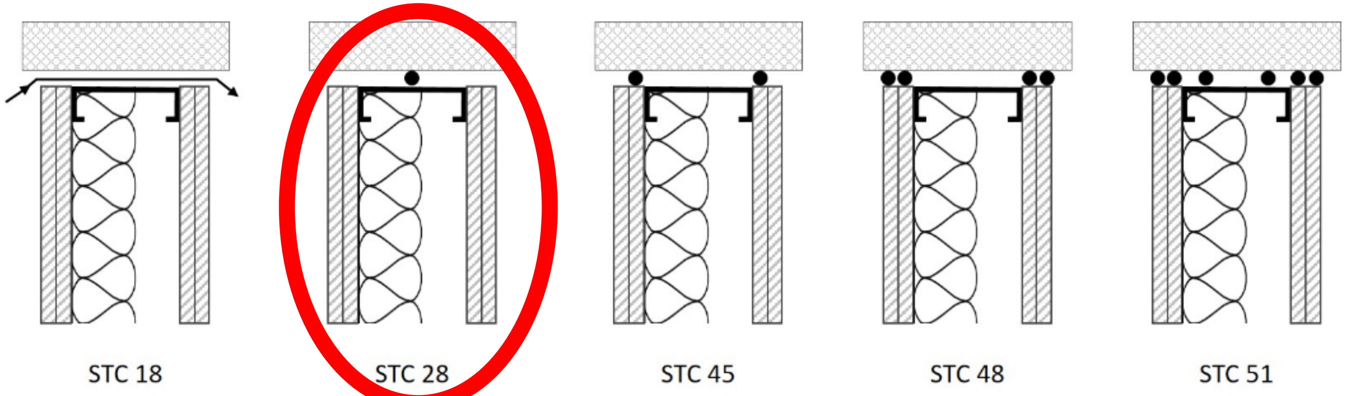
- Open-web steel joists and long-span composite decks are efficient structurally, but they transmit structure-borne noise very differently than conventional construction
- Lower mass and higher flexibility reduce their resistance to impact and low-frequency sound transmission
- Gyms and cafetoriums frequently use long-span framing, which is also where the highest impact loads occur
- Vibration from basketball, dropped equipment, and large crowds can travel significant distances

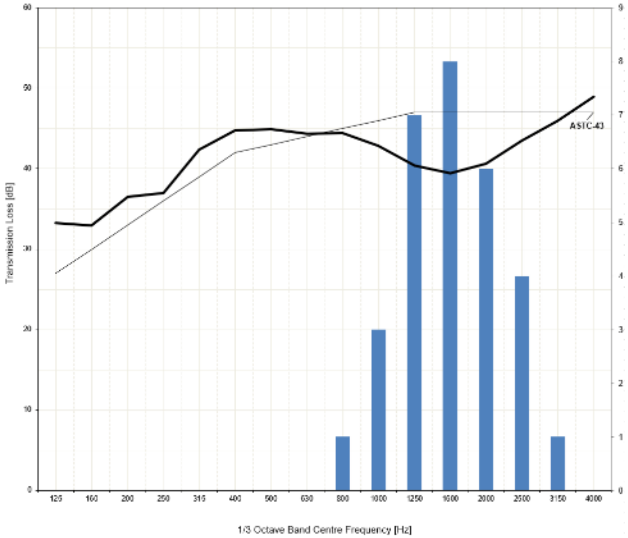


Case Study 2: Unreliable Construction

A classroom to classroom was designed with STC-50+ walls, but field testing showed a much lower performance.

Why? The construction team only caulked the top and bottom stud tracks





Early Design Checkpoints

Six questions to ask at schematic design:

1. What is on the other side of every wall, floor, and ceiling of this room?
2. Are incompatible uses separated by buffer spaces, or sharing a direct partition?
3. What is the structural system, and does it create flanking paths between noisy and quiet zones?
4. Where is the mechanical equipment, and what spaces sit below or beside it?
5. Has the acoustic consultant seen the space plan before the structural grid is locked?
6. Is the flexibility of this space's intended use reflected in its acoustic targets?

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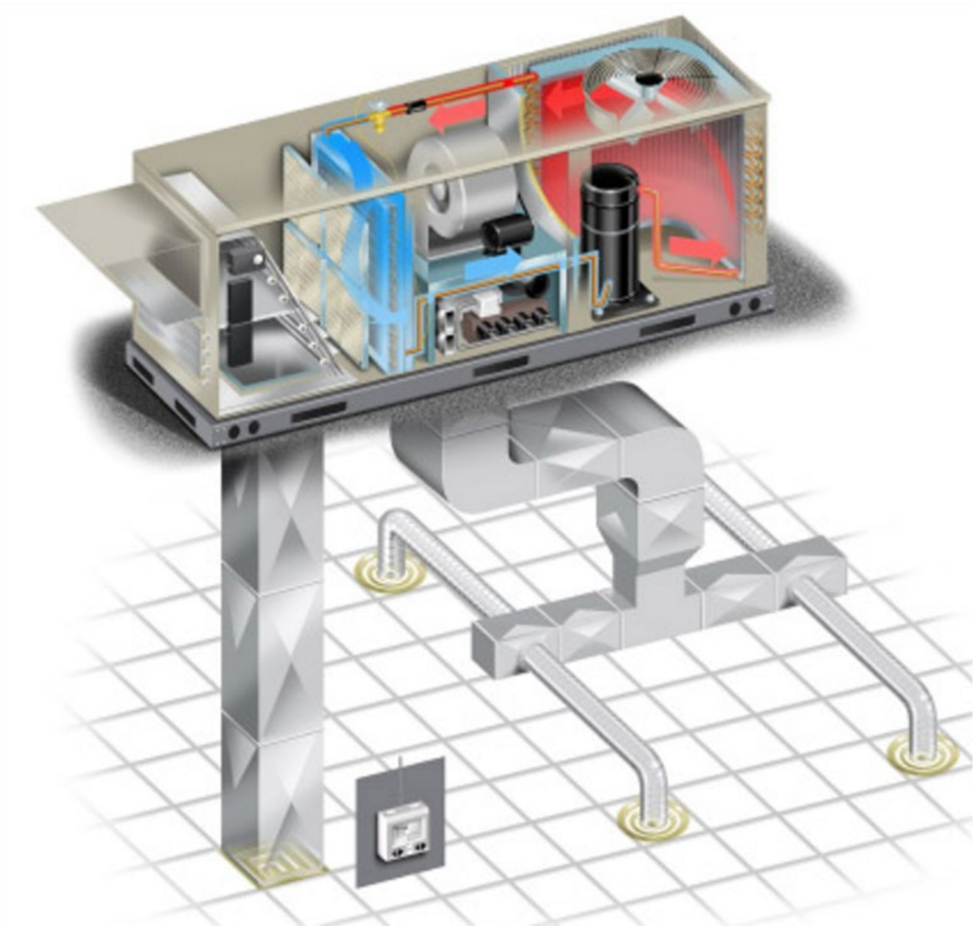
SECTION 3:
HVAC NOISE & BACKGROUND SOUND

The Most Common School Complaint: HVAC Noise



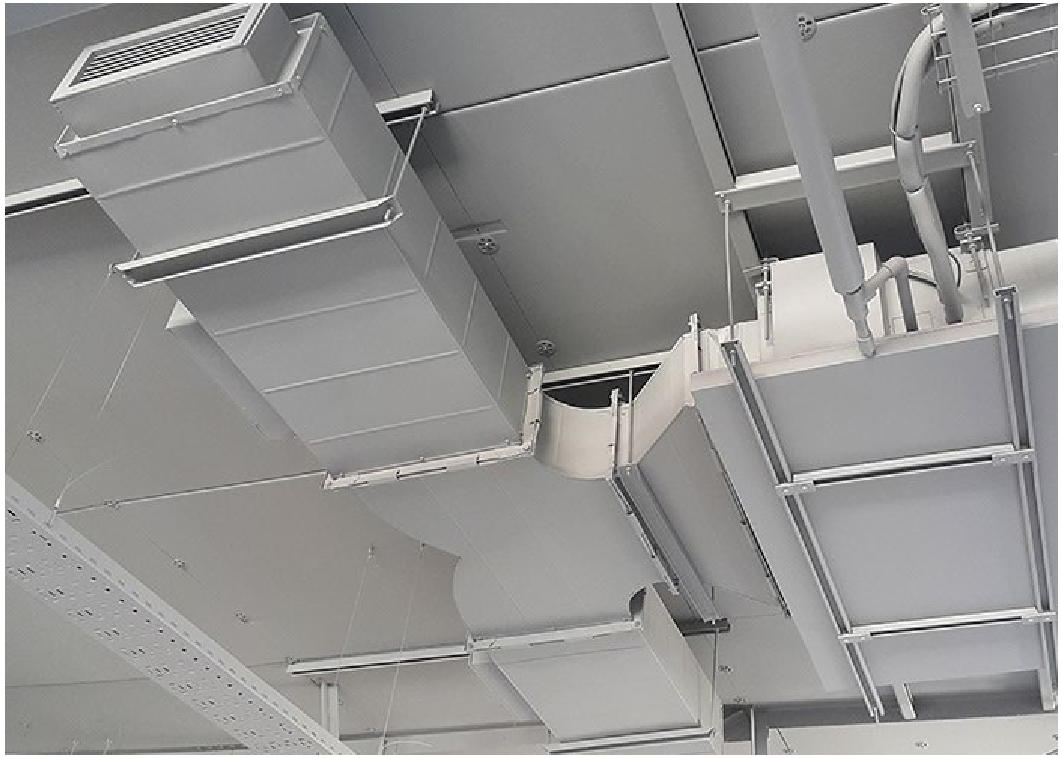
The most frequent acoustic complaints in schools are still due to HVAC noise from mechanical equipment.

- A single poorly selected or poorly installed RTU can push a classroom from NC-30 to NC-45 or higher; well above any reasonable target for speech intelligibility
- This matters for special-use rooms because the same systems serving ordinary classrooms are scaled up significantly for gyms, cafetoriums, and multipurpose rooms
- If RTU selection and installation practice is already marginal for classrooms, it is almost certainly inadequate for the larger spaces

Why HVAC Design Is Difficult For These Rooms

Larger rooms mean larger systems… and larger mechanical challenges

- Gyms, cafetoriums, and multipurpose rooms require significantly higher airflow rates than classrooms
- Higher airflow means higher duct velocities, larger diffusers, and more powerful fans… more noise
- Large open volumes with hard surfaces further amplify noise



Source, Path, Receiver

Every HVAC noise problem has three components:

1. **Source:** the equipment generating the noise.
   - Fans
   - Compressors
   - Diffusers

2. **Path:** how the noise travels to the occupied space.
   - Duct-borne transmission
   - Breakout through duct walls
   - Structure-borne vibration through equipment supports

3. **Receiver:** the occupied space and its sensitivity.
   - A drama room at NC-25 is far less tolerant than a gym at NC-45

Common HVAC Failure Points

Where do HVAC noise problems actually come from?

- **Rooftop units directly overhead:** structure-borne casing radiated noise transmits through the roof deck into the space below, regardless of duct lining
- **Undersized ductwork/diffusers:** high air velocity through small ducts and diffusers generates significant turbulence noise, independent of fan noise
- **Inadequate duct lining or silencers:** fan noise travels down unlined ductwork and radiates directly into the room through diffusers
- **Open return air paths:** return air without acoustic lining or a silencer allows noise to travel freely from the unit back into the space
- **Fan selection driven by first cost:** lower-cost fans are often noisier at the same airflow; the acoustic penalty is paid by the occupants, not the budget

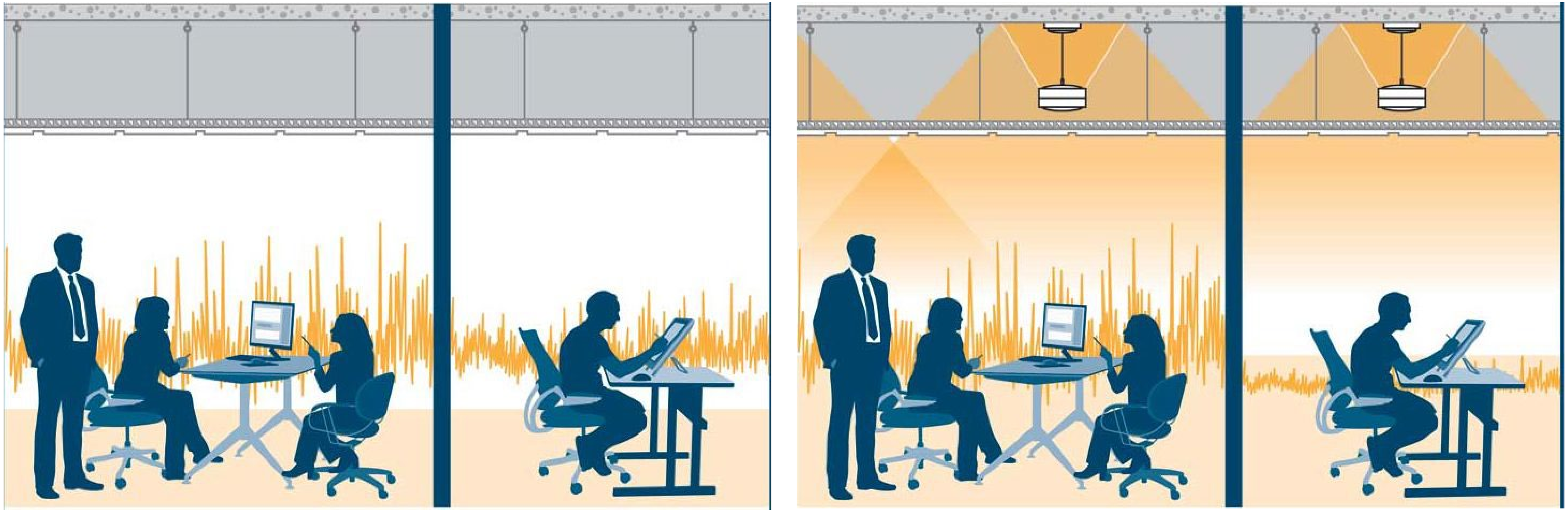
HVAC Design Strategies

How do we solve these problems?

1. Source	2. Path	3. Receiver
Select fans and units based on published sound power data, not just airflow capacity	Acoustically line supply and return ductwork for a minimum distance from the unit. Use silencers on supply and return where duct lining alone is insufficient	Coordinate diffuser type, size, and placement; location relative to listeners matters
Specify manufacturer acoustic data and verify against NC targets at design stage	Size ducts and transitions to keep air velocity in check (see ASHRAE for airflow guidelines)	Add absorption in the room to reduce buildup of HVAC noise
Use variable frequency drives (VFDs) to reduce fan speed and noise during low-occupancy or speech-critical modes	Isolate mechanical equipment from structure with spring or elastomeric mounts	Confirm NC levels by calculation before construction documents are issued

Background Sound: Lower is Not Always Better

- A steady, neutral background sound can decrease audibility, distractions
- Can come from HVAC, road traffic, or electronic masking system
- The NC targets represent a balance; low enough to support the intended activity, high enough to provide a degree of acoustic cover



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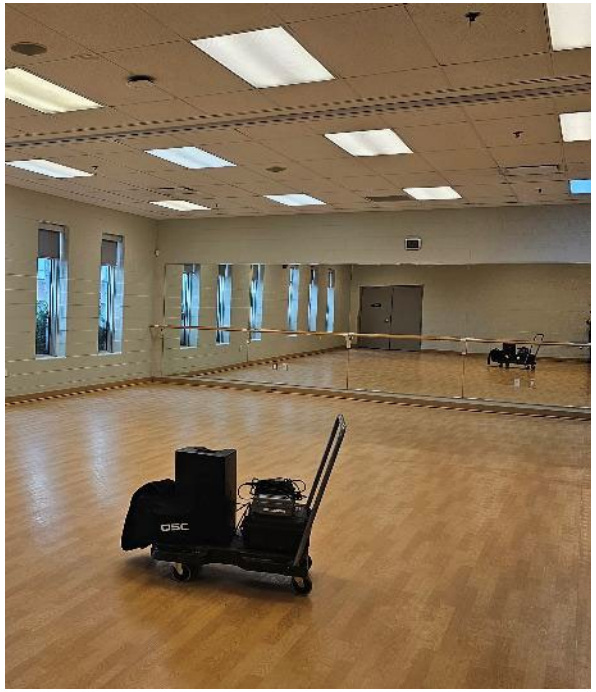
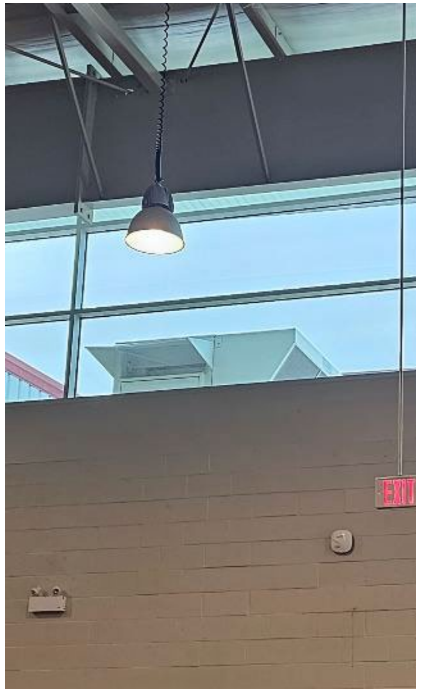
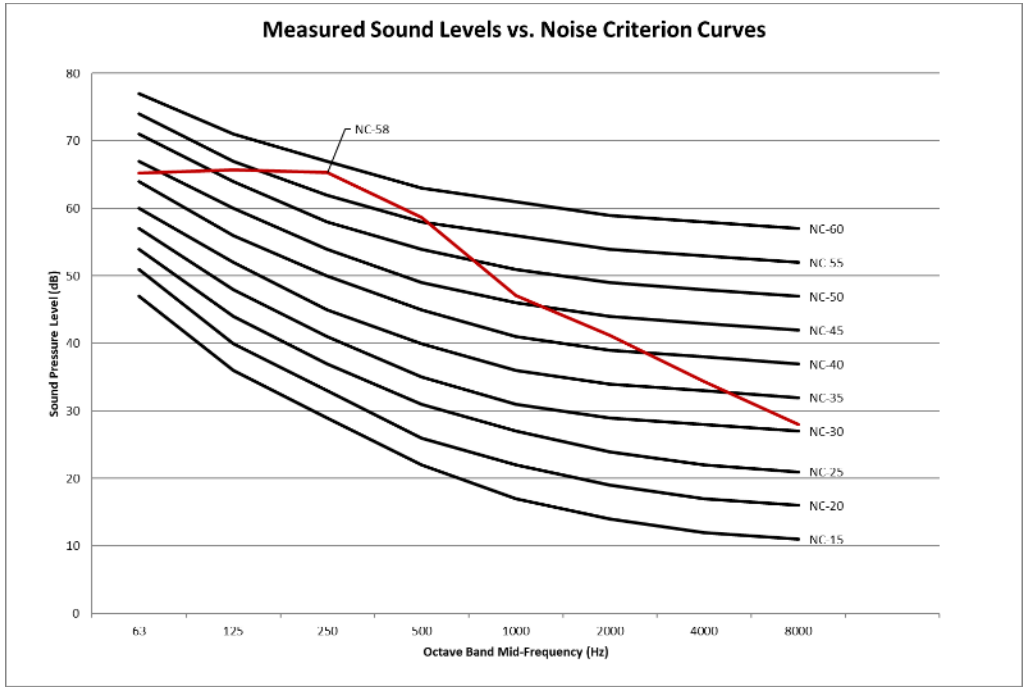
Case Study 3: RTUs with Bottom Discharge / Return

Duct-borne noise was so loud in a dance studio that students could barely hear the instructor let alone focus while practicing.

Why? The rooftop unit directly above the space discharged and returned air directly into the space / ceiling plenum with no HVAC noise mitigation measures.







Commissioning and Verification

Design intent means nothing if it is not verified!

- Acoustic performance should be measured at commissioning, not assumed based on drawings
- Background noise measurement with HVAC systems operating at design conditions takes less than an hour per space and identifies problems before occupancy
- Reverberation time measurement confirms whether installed treatment meets design targets
- Common commissioning findings in special-use rooms: HVAC operating above NC targets, absorption installed incorrectly or incompletely, partition seals not deployed or not functioning
- Early measurement allows remediation before the space is handed over, after occupancy, remediation is disruptive, expensive, and often incomplete

SECTION 4:
FROM PROGRAM INTENT TO PERFORMANCE TARGETS

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What Makes a Room Sound Good?

Three main factors affecting learning environments:

1. **Adequate source sound level:** larger rooms require more *power* and/or *reinforcement*

2. **Appropriate background sound level:** so the speaker can be *heard* above the room

3. **Appropriate reverberation:** so reflections reinforce rather than *obscure*

Special Goals for Special Spaces

The primary goal for the acoustical environment depends on the space

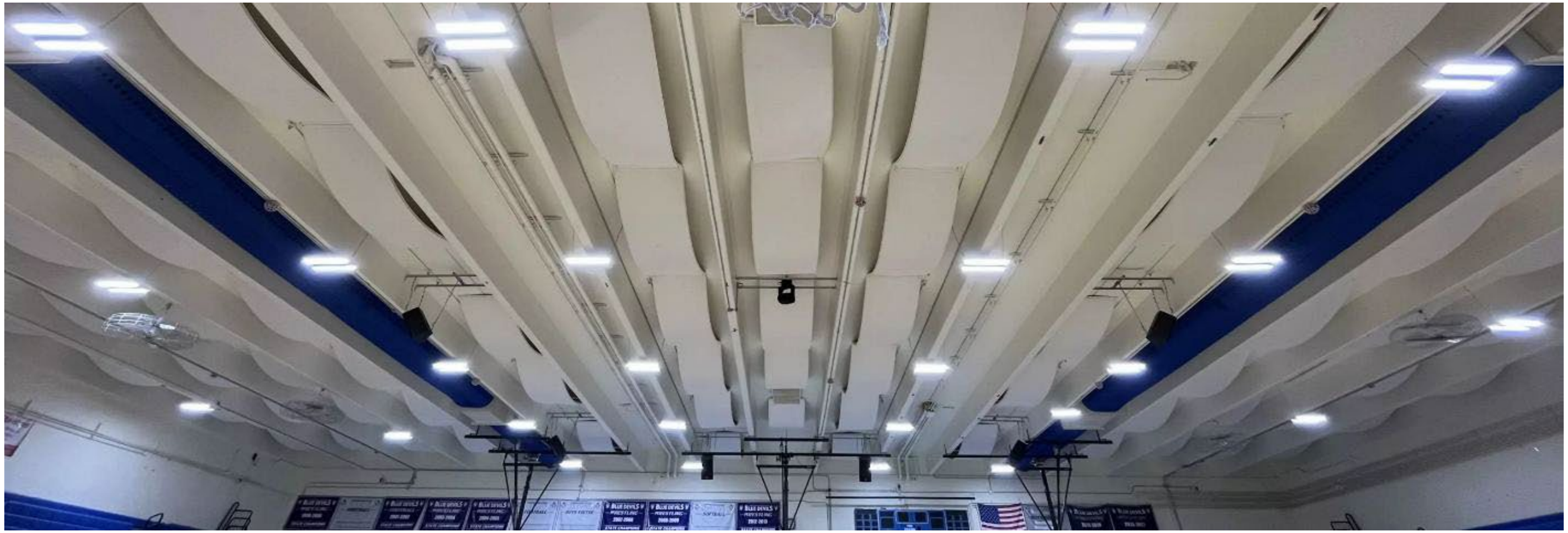
Space	Primary Acoustic Goal
Gymnasium	Control reverberation without deadening the space
Cafetorium	Balance speech clarity with tolerance for activity noise
Music Rehearsal	Support ensemble listening controlling excessive (or not enough) liveness
Drama / Black Box	Achieve low background noise and flexible reverberation
Multipurpose Room	Meet the most demanding intended use, not the average

*Designing to the **average** use of a **flexible** space almost guarantees it performs **poorly** for the most important use.*

Gyms: The Reverberation Problem

Gymnasiums are naturally reverberant

- Untreated gym RT values of 3 to 5 seconds are common
- LEED BD+C targets ≤2.0 s for gymnasiums, but even 2.0 s is marginal for speech intelligibility during an assembly or graduation
- The room volume means the absorption demand is enormous



Gyms: The Reverberation Problem

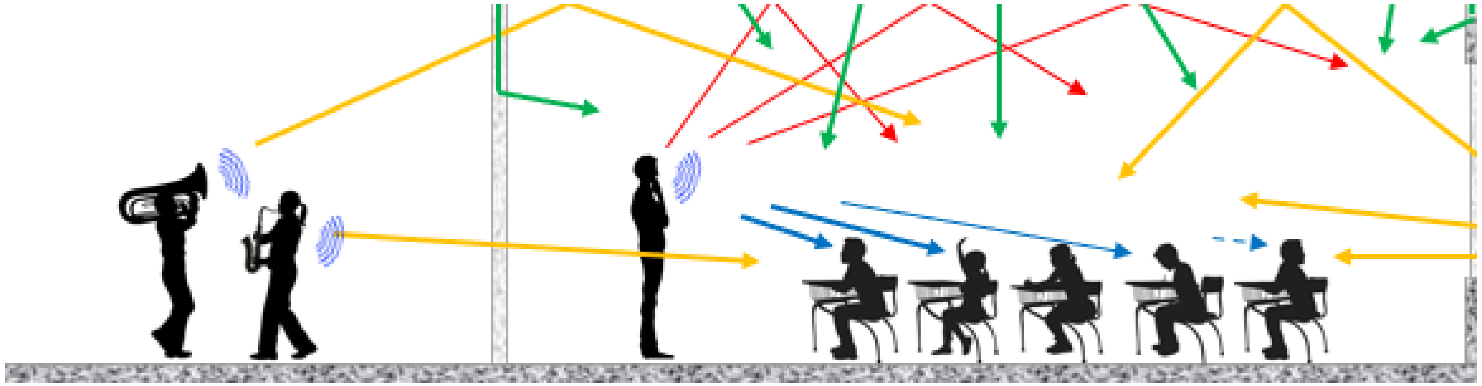
Practical Treatment Strategies

- Wall panels at mid and upper height
- Suspended vertical baffles or acoustic steel deck
- Sound reinforcement; almost always required for speech functions in a gym
- Well designed HVAC systems; reduce background noise during speech-critical events without compromising ventilation capacity (e.g., silencers, longer duct runs)

Music Rooms: A Different Kind of Difficult

Music rooms need liveliness… but not too much!

- ANSI S12.60 targets 0.6 to 0.8 s RT for music rehearsal spaces; longer than a classroom, shorter than a performance hall
- Too short, and the room sounds dead, ensemble playing becomes difficult, and students cannot hear each other blend
- Too long, and individual parts smear together, intonation suffers, and the director cannot hear what is happening
- STC-60 to even STC-65 depending on the project is a hard requirement; music rooms generate very high sound levels across a broad frequency range



Drama / Black Box: The Quietest Rooms

Drama spaces demand the lowest background noise in the school

- ASHRAE targets NC-25 to NC-30 for drama and performance spaces; comparable to a recording studio
- Achieving NC-25 in a school building requires careful HVAC design, structural isolation, and acoustic detailing that goes well beyond standard practice
- Black box theatres have large volumes and high ceilings; without treatment, RT60 can be excessive for both speech and amplified performance
- Flexible seating configurations change the room's absorption characteristics significantly; the acoustic design needs to account for the fully empty condition, not just the full-house condition

Cafetoriums & Moveable Partitions: A Moving Target

Flexible spaces must be designed for their most demanding use

- A cafetorium used for lunch, assemblies, and theatrical performances has three different acoustic profiles
- Designing to the average means it performs poorly for the most critical use
- Movable partitions are common in multipurpose rooms, but their real-world acoustic performance is almost always significantly below their rated STC value
- The program needs to explicitly state the priority use so the acoustic targets can be set accordingly

Cafetoriums & Moveable Partitions: A Moving Target

Movable partitions rarely perform as rated

- Operable partitions are rated for STC in laboratory conditions
- In the field, the floor seal is the most critical element and the most frequently compromised
- Gaps as small as 3 mm can reduce effective STC by 10 points or more
- Rated STC 45 partitions commonly achieve ASTC 30 to 35 in the field

Absorption is Not Generic

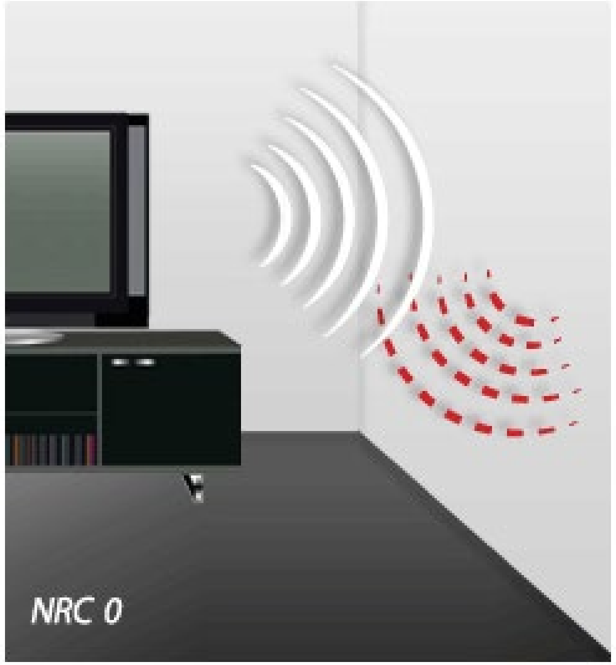
Adding sound absorption reduces sound reflections (reverberation).

Different solutions address different frequencies!

The NRC represents average absorption at mid-range frequencies ONLY (250 Hz to 2000 Hz).

- NRC of 0 = no absorption (higher reverberation)
- NRC of 1 = fully absorptive (no reverberation)

Gyms and music rooms frequently have low frequency buildup that NRC-rated panels do not address



Case Study 4: Excessive Reverberation

A camp was building a new dining hall and were concerned with excessive reverberation in the large open space.

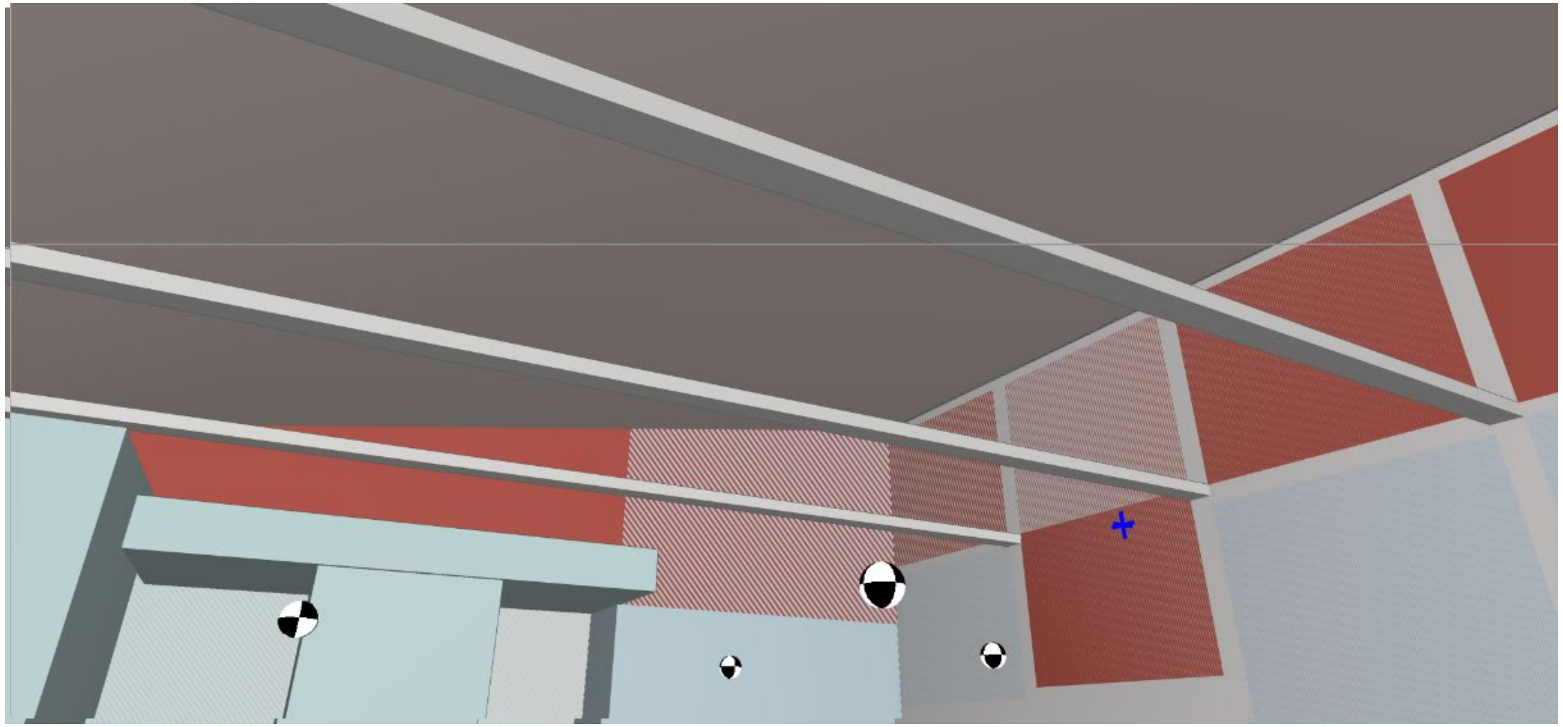
They were considering installing either baffles within the trusses or suspended from the ceiling, in addition to some mid-NRC wall panels.

Case Study 4: Excessive Reverberation

Modeling showed at RT of 2.2 seconds without any treatment (the target was closer to 1.3 seconds).

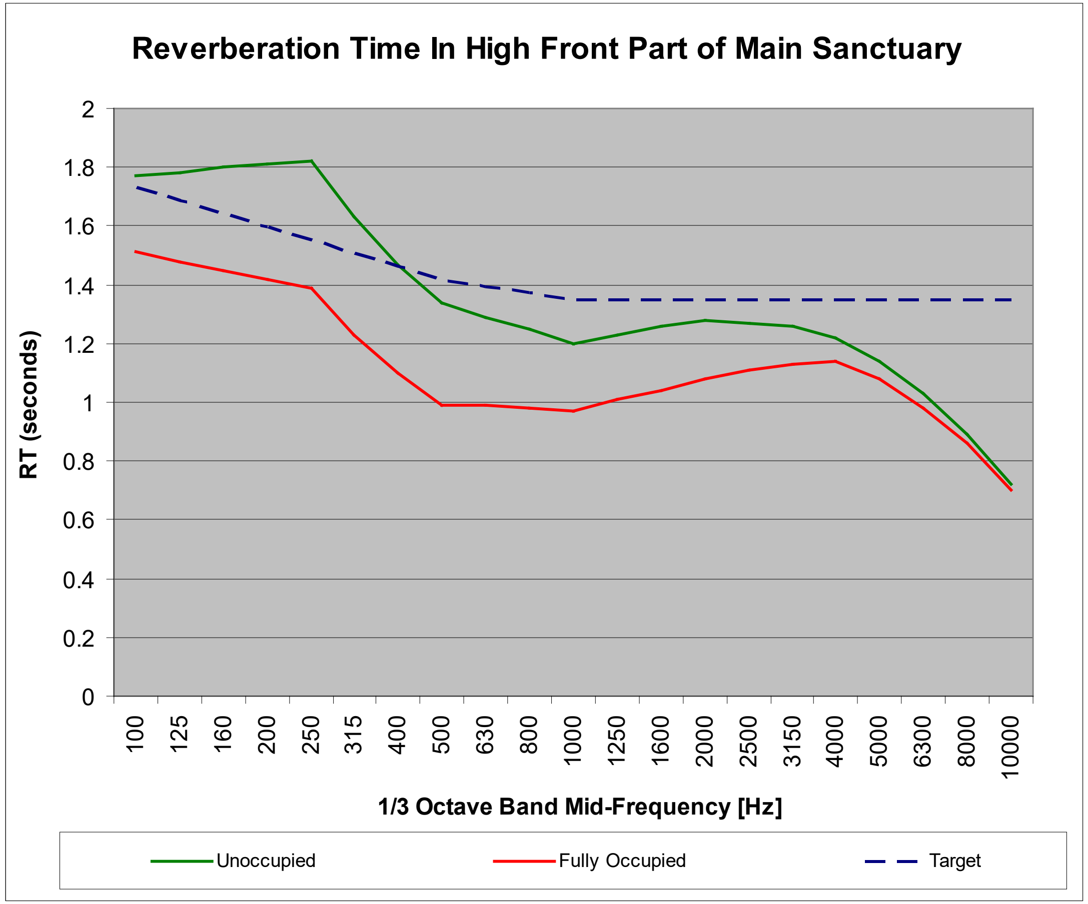
Even with all the proposed treatment, our model showed 1.75 seconds.

By adjusting the product location (leaving the CLT exposed!) and performance, we reduced the modeled reverberation to 1.38 seconds.



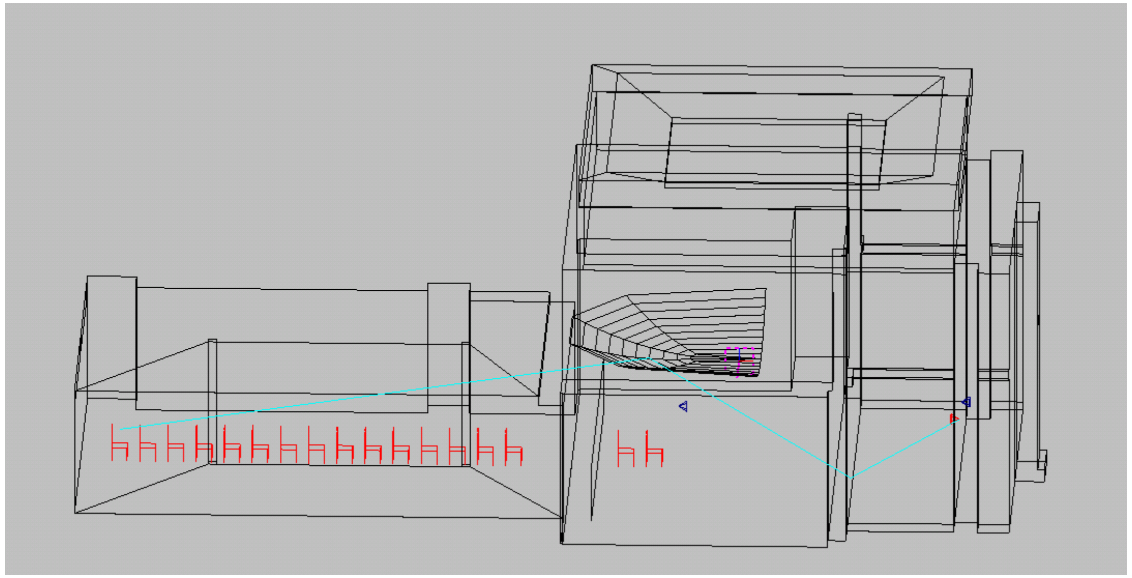
Case Study 5: Insufficient Reverberation

A religious sanctuary had issues with people at the back hearing the clergy; there was too much absorption!



Case Study 5: Insufficient Reverberation

Our modeling showed a significant improvement with the installation of an angled convex reflector:



This approach avoided any notable aesthetic changes to the room finishes around the sanctuary.

Closing

1. Special use-case rooms in schools fail acoustically for predictable reasons that are different from typical classrooms.
2. The most effective solutions are adjacency and stacking decisions made at the schematic design stage.
3. HVAC noise control requires source, path, and receiver thinking from the start.
4. Set targets for spaces based on the most demanding intended use, not the average intended use, and verify them at commissioning.

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