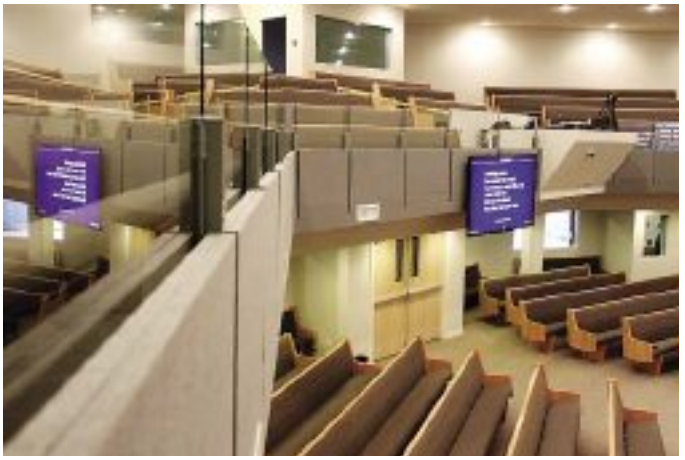
Bass Traps

Muddy bass that overwhelms other sound is a problem plaguing many HOWs. Is there an acoustic solution? **Frank Wells** investigates

LOW FREQUENCY SOUNDS ARE troublemakers, plain and simple. Excepting for exotic (for Houses of Worship) implementation of directional bass cabinet arrays and for some DSP controlled systems, when bass signals leave a woofer they disperse in all directions equally, including up! That's a whole bunch of sound energy going where you don't need it to go. Where there's insufficient mass in the obstacles to inhibit low-frequency sound transmission, bass frequencies will travel through doors or walls or windows (think about what you hear from a jacked-up car sound system at a traffic light – the high frequencies are largely captured within the vehicle, but the low-end bleeds through, vibrating the entire vehicle). Where there is substantial mass at a room's boundaries, such as concrete block walls, the pressure waves can reflect back into a room, out of phase with the direct signal from the speakers, adding to and subtracting from the direct sound, depending on frequency and timing of the interaction.

Sound pressure levels, or loudness, can be likened to blowing up a balloon. At first, blowing into the balloon is easy, but when more air pressure is built up in the balloon, more external pressure is needed to make further pressure change inside the balloon. At some point, the balloon has all the internal pressure it can handle, and it bursts. Cranking up mix volume in a highly reflective auditorium or sanctuary makes for increasing levels of sonic interference. The room won't burst when the sound pressure level is too high, but the frustration level of the congregation might spill out. You can't overcome low-frequency build-up issues with more volume, rather, you'll make things worse.

As sound levels decrease in relation to distance (remember the inverse square law: level/intensity is inversely proportional to the square of the distance from a source), distance can be your friend, except that your HOW has likely gone to great lengths to install a sound system that is designed to deliver relatively equal levels to all members of an audience. In an uncontrolled space, it's highly probable that there will be hot spots where room modes (a collection of resonances where direct sound is boosted by reflections) will be objectionable.



Primacoustic traps on a balcony front

Acoustic trap-absorbers from Primacoustic coloured to blend with the architecture at the front of a sanctuary

Technologies like steerable arrays and low-volume distributed sound aren't magic. They will provide work-arounds in some situations, but in many other situations, there won't be an electronic solution sufficient to overcome low frequency issues. The best solution would be to have the sound from the loudspeakers reach worshippers once, directly from the loudspeaker, then disappear from audibility. That's easy in an open field or an anechoic chamber, but not so easy in the real world. Bass trapping can provide a solution, or at least some relief from the problems of bass build-up.

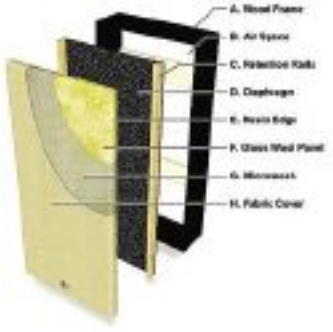
What is bass trapping?

As the name implies, a bass trap is a device designed to capture low-frequency sound energy. Bass traps won't eliminate the room modes, but can help reduce reflected low-frequency sound, hopefully to the point where it's practical to address remaining issues with EQ and loudspeaker directivity. All sound absorption materials and devices work by transforming acoustic energy through a mechanical or kinetic energy state to a heat state. At high frequencies, this is relatively easy with products like the familiar foam sound absorption products. The high frequencies bounce around and diffuse inside the foam cells, causing minute physical movement of the material, which is dissipated as a tiny amount of heat. Low frequency sound blasts through foam, and isn't much attenuated by even several inches of denser materials like rock wool or compressed fiberglass. For these types of materials to be effective, they would need to be very dense and very thick. Giving up a few metres at the back of a room to install a deep bass trap is not going to be an attractive solution in HOWs, but that would be the only way that conventional materials can achieve the mass necessary to have any effectiveness with bass frequencies.

Fighting back with physics

Some applied physics can mitigate the need for bass traps to be massive. One such solution, which has, in a fashion, been in use for hundreds of years, is the Helmholtz resonator. As blowing air across an empty bottle can produce a tone, a Helmholtz resonator is an enclosed volume of space, resonant at a particular frequency, that can help contain a narrow frequency band of energy. A practical Helmholtz resonator can be designed as a rectangular box, with slots or holes as ports to define the resonant frequency or frequencies.

A common type of modern bass trap is built into a rectangular housing, typically a few feet in height and several inches thick. These wall-



An exploded view of a Primacoustic FullTrap

Vicoustic Super Bass Extreme Helmholtz resonators

mountable traps have semi-rigid front panels of wood or sometimes metal. This panel acts as a diaphragm would in a microphone, moving when hit by a soundwave. Inside the housing is a rigid rectangle of compressed fiberglass (5cm to 10cm in depth being common). The sound hitting the front panel is converted to mechanical energy and an air gap and the insulation dampens the movement of the panel so the sound doesn't re-propagate the energy as it returns to its resting position. The depth of the panel assembly, the thickness (mass and rigidity) of the front panel and the size of the diaphragmatic panel determine the effective frequency band of the trap.

Another common design replaces the rigid front panel with an aesthetic covering hiding a 'limp mass' sheet – a sheet of vinyl that's been impregnated with particles to increase its density and weight. This sheet moves in sympathetic waves to the incoming sound, but is not stiff enough to function as a transducer diaphragm to re-propagate those sounds. As with traps with a semi-rigid front panel, the trap uses an air cavity and rigid insulation internally. Its effective frequencies can extend up into the mids and highs, with its effective low-frequency bandwidth determined, again, by size and volume and material densities. There are additional traps made that vary or combine the approaches in common use.

A stand mounted bass trap from Auralex, corner placed

Setting your traps

Remember also that we noted that bass signals are omnidirectional. To some degree, the reflection issues are likely to be coming from the front of the sanctuary, and from the side walls, and from the ceiling. A full solution might involve ceiling mounted traps or hanging clouds, as well as wall traps on rear, front and side walls. Aesthetics are going to play a role in the acceptability of a sonic solution that involves bass trap installation, particularly in a cathedral, mosque or temple. Such facilities are often filled with hard reflective surfaces that are also ornate and part of the visual appeal of the HOW. Bass traps can be cloth covered and disguised, but it won't be acceptable for them to be too obviously visible, regardless of their acoustic value.

Single Vicoustic Helmholtz resonators can be stacked in corner mounts

Ceiling mounted Primacoustic traps

You can experiment with room modes by playing tones through the sound system and walking the sanctuary. Hot spots, or dips in level, at particular frequencies are indicative of problem frequencies. A real-time analyser, with its mic deployed at the hot spots, can give you an idea of what frequencies are the most problematic, which is where your worst room modes are centred. Bass traps can be a DIY project, but in the case of a HOW, where the solution will be a good number of highly visible devices, it's worth bringing in an acoustician to design a solution, to scientifically determine how many traps are needed, and where. A HOW might also discuss their problems with reputable manufacturers; many manufacturers will be happy to assist in the development of a solution.