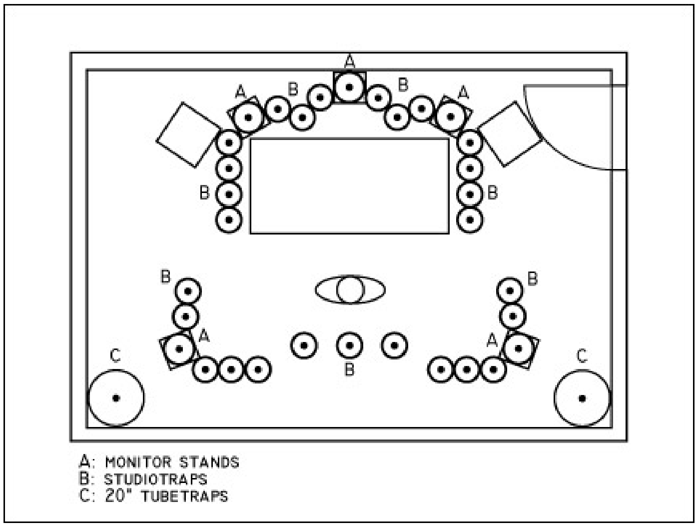
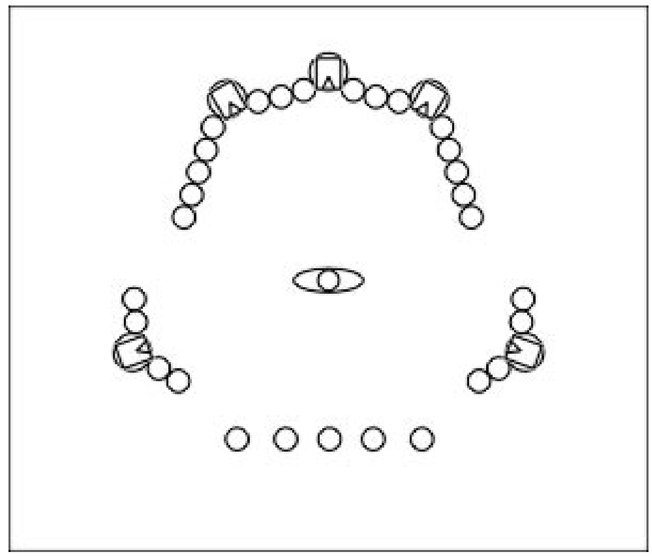
ASC's 5.1 Surround ATTACK Wall

Transcript of a seminar presented by Arthur Noxon P.E., President of Acoustic Sciences Corporation, at the Surround 2001 International Conference and Technology Showcase, December 7-8, 2001, Beverly Hills, CA.



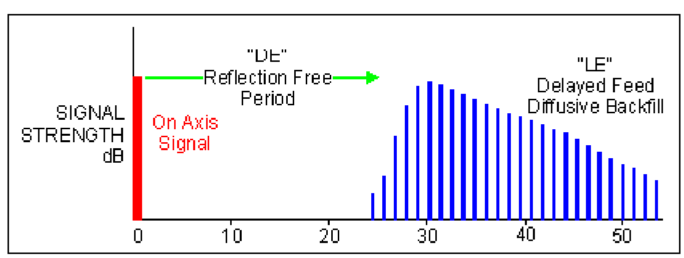
The traditional recording studio has its acoustic package either built into or mounted directly on the surfaces of the room, the walls, ceiling, floor and corners. Acoustic Sciences is fairly well known for the TubeTrap, those cylindrical bass traps that are found standing is the corners of the room and other half and quarter round traps that are mounted onto the surfaces of the room. In 1986 ASC began experimenting with something entirely different. The results were positive and engaging. The system evolved through the help and interest of many people and it is found alive and well in many recording studios today.

The ATTACK Wall is the opposite of traditional room acoustics. It creates an acoustic space that exists well within the room, away from the surfaces. Instead of built in or surface mounted acoustics, the ATTACK Wall is a free-standing acoustic package that is set up well inside the room, away from the walls and corners. It's name, "ATTACK" is an acronym that actually comes from the concept of an All TubeTrap Acoustic Control Kit, although the more aggressive connotation is not completely by accident.



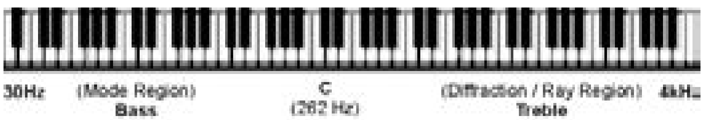
All studio design follows certain basic acoustic principles and so does the ATTACK Wall. We will look into how it satisfies the requirement for promoting a strong and clean direct signal, how it provides a reflection free zone and how it generates a time delayed diffusive backfill. The ATTACK Wall satisfies the LEDE principle in studio acoustic design for both stereo and surround mixing environments.

Recording studios design is based on the well known "LEDE" type principle. Here we see a sound level in dB vs time in milliseconds sketch of the ETC or Energy Time Curve that defines the LEDE type acoustic signature. It begins with the



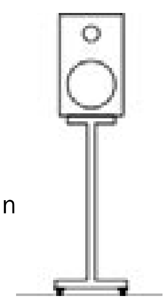
engineer receiving a strong and clear direct signal. Next is the Reflection Free Period that lasts about 25 milliseconds, during which the engineer should not receive any reflected version of the direct signal. Following this, there is to be a time delayed diffusive backfill flushing back into the engineering position.

This back fill keeps the recording space alive and comfortable to work in. Without it, one would be working in an anechoic space and that is very exhausting, especially in those late night hours. All recording studio acoustic packages should meet the LEDE type criteria, whether the acoustics are built into the walls, mounted on the walls or set out well into the room, whether the control room is used for stereo or surround mixing.

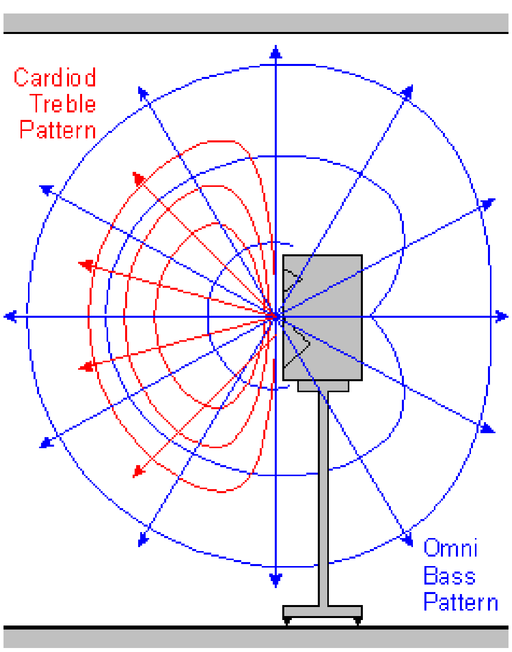


The piano keyboard represents the musical frequency range. We have middle “C” which separates the musical bass from treble. Most of the sound in the treble range travels along straight lines and is easily represented by ray tracing. The sound in the bass range however expands in all directions equally. Both types of wave front behavior have to be included in the analysis and development of a recording studio. The TubeTrap is an acoustic device, a cylinder, whose entire surface absorbs bass but whose front half reflects treble, the back half absorbs treble. Because of this unique property, the TubeTrap has become a particularly useful device in shaping acoustics in rooms.

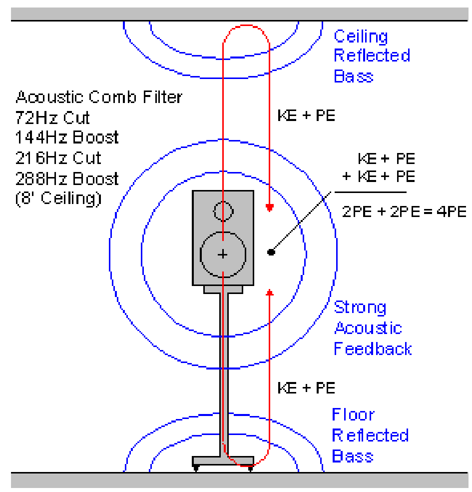
Many recording studios have monitors that are set on stands creating a midfield monitoring space. The designer type studios usually have their monitors built right into the walls, soffit loaded but many studios are not designer built and simply have their midfield mains sitting out in the open, on stands.



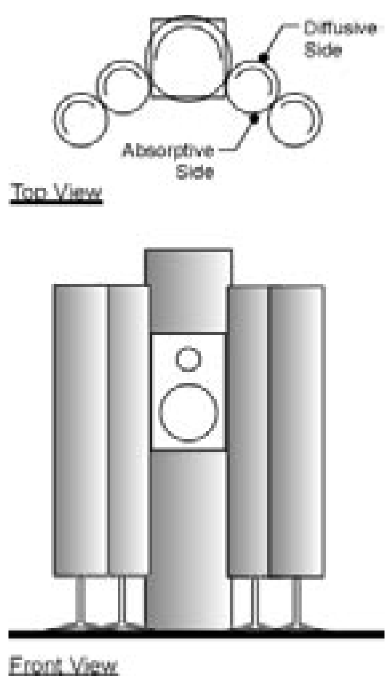
The midfield monitor acts like most dynamic speakers. Treble expands out generally in a forward direction from the monitor while the bass expands out with equal power in all directions. The treble range directivity has a cardioid pattern while the bass range pattern is omni.



The ears of the mixing engineer are about 4 feet off the floor and so are the monitors. Unfortunately, most monitoring rooms have an 8 foot high ceiling. The direct wave from the woofer of the monitor is strongly affected by the reflections from both the ceiling and the floor. These two reflections travel 8 foot round trip paths and meet together right in front of the speaker driver. This causes the air in front of the driver to have a density that is not normal, but that has been preconditioned with an 8 foot or 7 millisecond delayed version of the original signal.



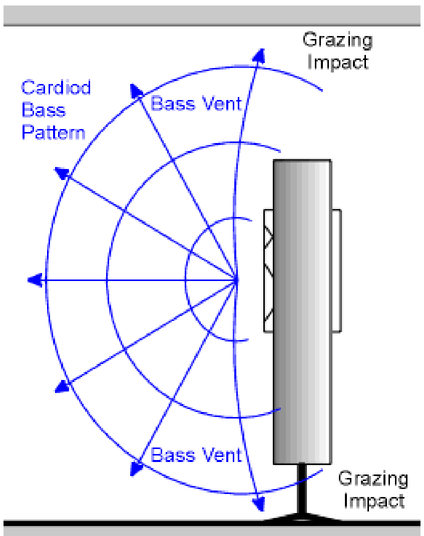
A downtown designer studio will have the mains mounted in the wall, typically “soffit loaded”. A monitor stand can be modified to play better by adding a baffle. This supports the expanding bass wave, directing more of it towards the engineer and allowing less to expand in the wrong direction, away from the speaker and into the room. Baffles have to be carefully built so they do not color the speaker they are trying to help by reinforcing the wrong frequency range. A good baffle design should support the bass and absorb the midrange. The stand that supports the midfield speaker can also be modified to do more than simply look good while holding the speaker up off the floor. It can be converted to become part of the baffle “wall”, helping to further manage the expanding wavefront.

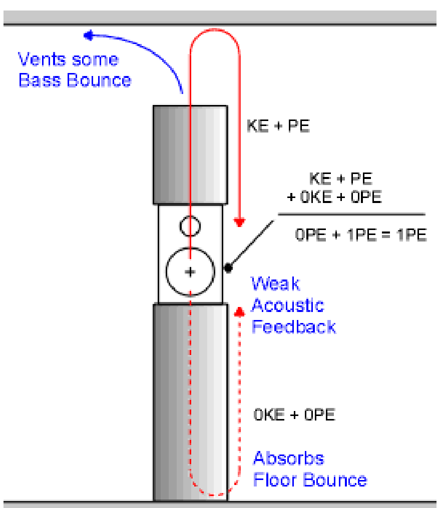


Here is shown a setup of StudioTraps and TubeTraps used to configure a free standing acoustic baffle/pedestal. This is the basic building block for the ATTACK Wall. It compensates for and cleans up the distortions introduced into the direct signal that are caused by speaker that is supported midfield on a speaker stand.

A baffle board increases the efficiency of a woofer, similar to a short horn that is used to load air onto the diaphragm of a woofer. The expanding wavefront is also directed more to the front than behind the speaker. There is always much less bass in the space behind a baffle loaded woofer. More than loading, this baffle system stops short of both the wall and the floor, causing the bass wave front to skid around the edge of the baffle and impact both the ceiling and floor at an angle and softly. This venting of the bass wave just before impact reduces the strength of the phase cancel/add effect due to the otherwise strong bounce back effect.

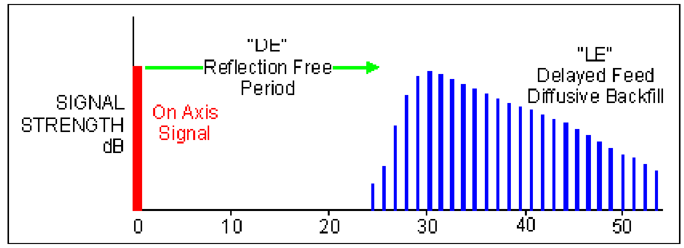
The effect of combining wavetrains (comb filter) from strong and simultaneous floor and ceiling reflections with the direct signal at the face of the speaker is reduced by adding vents at the edges of the baffle board. In addition to the venting effect of the baffle, the bass bounce at the floor can be further reduced by adding a bass range sound trap in the reflection pressure zone of the floor bounce.





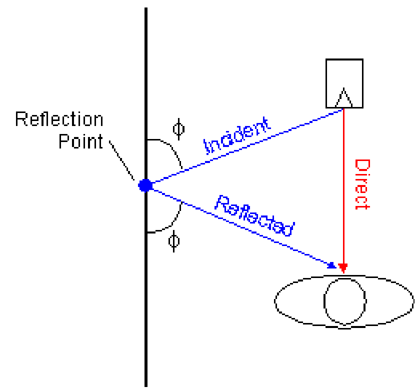
The net effect of edge venting and bass trapping the floor bounce is to eliminate the excess buildup of time delayed pressure signal right near the woofer diaphragm. Especially important is that the conversion of Kinetic to Potential Energy does not happen unless the two wavetrains are of equal strength. By weakening one over the other, the Kinetic Energy of the other is never converted to Potential Energy and remains unfelt by the woofer.

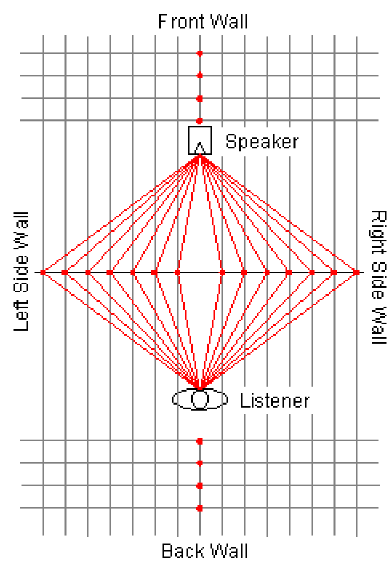
The treble range emitted from a loudspeaker generally heads straight towards the engineer's ears and the immediate surrounding area, as if it was a flashlight pointed in the right direction. The bass does not behave so directionally. The bass part of the direct wave is quickly modified by the interaction of floor and ceiling bounces with the air in front of the woofer. The ATTACK Wall Baffle cleans up the frequency dependant acoustic impedance mismatch that the woofer feels when it is supported midfield on a monitor stand out in the open air of a room. An improved and more accurate direct signal is delivered to the engineer when the speaker is playing into smooth air, free from acoustic feedback. The next section of studio design is to develop a reflection free zone for the engineer to work inside of.



Typical "LEDE" Type ETC Signature

This sketch illustrates the various elements involved in a loudspeaker playing towards an engineer while both are alongside a wall. The direct signal travels from the speaker to the engineer. The reflected signal travels out, hits the wall and bounces towards the listener. Sound waves are a 3 dimensional effect but here, only that part of the wavefront that actually interacts with the listener is being traced out. Note that the angle of incidence equals the angle of reflection.

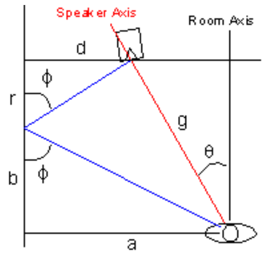




A speaker and engineer are set up parallel to the sidewalls and perpendicular to the end walls. Sound reflects off each sidewall and both end walls. The location of the reflection point depends on the position of the wall. This graph plots out the reflection points for any number of side and end wall configurations. End wall reflection points start behind the speaker and behind the listener and move back with the wall position. The side reflection points are always halfway between the speaker and listener on the surface of the sidewall.

If the speaker is off to the side, then the direct signal does not take a parallel path to the sidewalls. The reflection point is no longer at the halfway point on the wall. For this more general case, the formula can be written so that the location of the reflection point is known based on the angle between the speaker axis and the room axis and the distance the wall is from the speaker and the distance the listener is from the speaker.

Once the angle between the speaker and the room axis is known the reflection points for any side or end wall location



Speaker Axis at some angle θ with respect to Room Axis

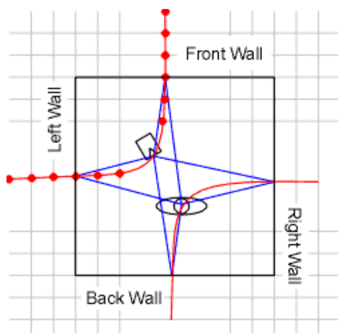
$r = f(d,\theta,g)$
Exit angle = Incident angle: $\frac{a}{b} = \frac{d}{r}$

$b = g\,cos\theta - r$
$a = g\,sin\theta + d$ $\longrightarrow$ $\frac{g\,sin\theta + d}{g\,cos\theta - r} = \frac{d}{r}$ $\longrightarrow$ $r\,(g\,sin\theta + 2d) = dg\,cos\theta$

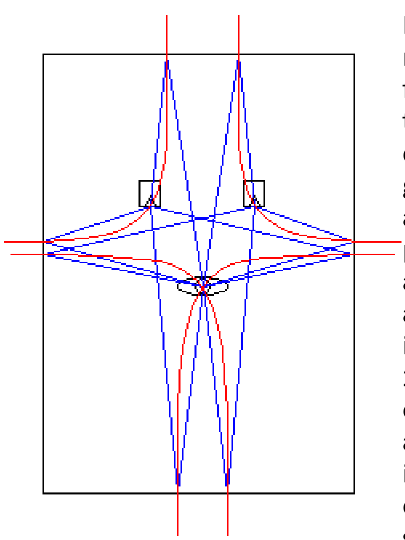
$r = \frac{dg\,cos\theta}{g\,sin\theta + 2d}$, and similar formulas for each of the other remaining walls

For a desired listening arrangement with fixed g and θ , r = f(d).
So the primary reflection point locations are determined solely by the distances to the various walls (d).

can be calculated. When the results are plotted out, the locus diagram results as shown. A sample set of room walls is selected to illustrate where the reflection points would be. The ray tracing between the speaker, the wall reflection point and the listener is made to further the reflection path. Note that the farther away the wall is located, the closer the reflection point becomes to the halfway point between the speaker and listener.

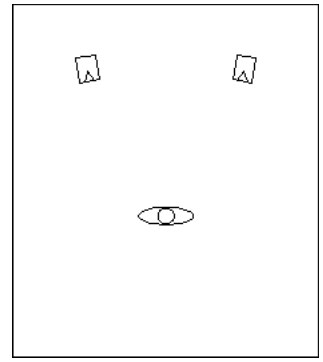


There are no reflection points inside the smallest imaginary room where the speaker and listener are in opposite corners of the room. In this study, secondary reflections are not considered but in a real room analysis, they also should be included in the evaluation of early reflection points.

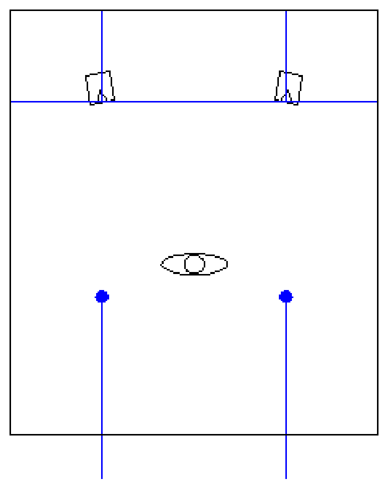


By taking the single wall reflection diagram and flipping it over we get the stereo reflection diagram. The graph is a general presentation of all possible wall reflection points for the iso triangle arrangement of speakers and listener typically found in the control room of a 2.0 recording studio. An example room is outlined and the 8 reflection points identified. Then the path of each reflection is traced, starting at a speaker, connecting at the intersection of the wall and reflection locus of points and then straight to the listener. There are 2 reflection points on each wall.

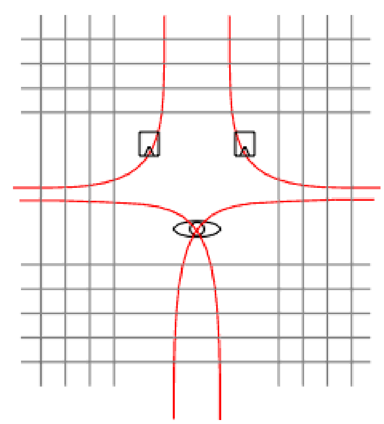
The recording engineer needs to work in a reflection free zone in order to listen to the speakers without experiencing distortion in musical tone or image position due to early reflections. By knowing the path each early reflection takes and blocking it, a reflection free zone can be created. Here, we take note of the set of reflections that cause distortion in stereo mixing in any sized room and arrange to block all of them with a simple gobo type setup.



A well-known stage in the evolution of a recording studio occurs after all the electronic equipment is loaded into the room, set up, plugged into power and each other. Like a race car before the shock absorbers are installed, it starts and feels great, you can rev it up a few times, but back it out of the driveway and take it out on the road and you quickly find yourself dangerously loosing control. Hence, the birth of studio acoustics.

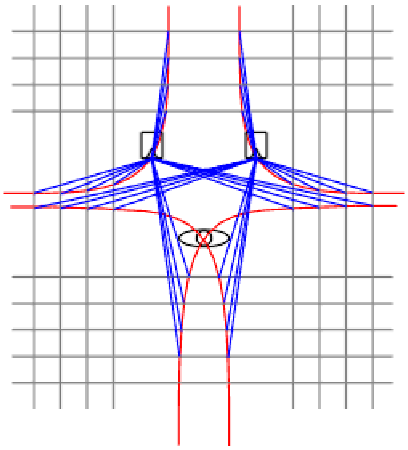


The first set of reflection points that need controlling are those that cause flutter echoes. They are easily demonstrated as a low frequency pseudo-tone caused when a high frequency clicks emitted by the speaker bounces back and forth over the same path between parallel walls. The engineer hears the sound emitted from these multiple reflections even though the listening position is not directly in line with the flutter paths. The ability for the sound to travel along a repeating path must be eliminated from the control room.

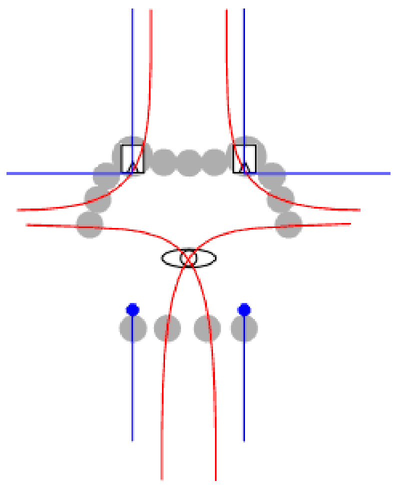


As before, the locus of all possible early reflection points can be plotted out for any speaker/ listener combination. By overlaying the graph with wall positions, the exact location of the wall reflection can be determined.

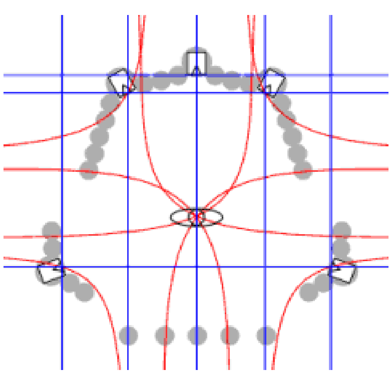
This demonstrates the path taken by that part of a sound wave that hits a wall and then reflects back towards the listener. Only the first half of the total path between the speaker/wall/listener is shown. In order to eliminate a wall reflection it is necessary to



block the ray of sound that is traveling on the reflection path between the speaker and the listener. One way to block the sound path is to add sound absorption at the reflection point, a common practice in recording studios and other high performance audio rooms. However, it can also be done by blocking the path at any other location along it's path.

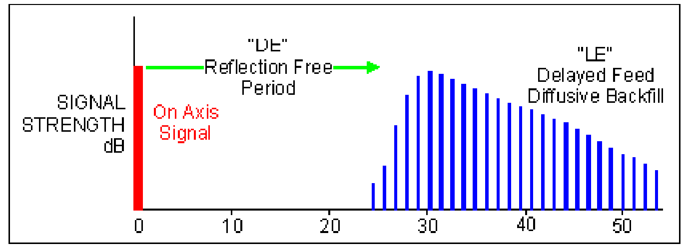


This arrangement of acoustic baffles is called the ATTACK Wall. It effectively blocks all early reflection paths regardless of how close or far any of the walls are located to the mixing set up. This same system can be set up at either end or directly in the middle of any room and not experience early reflections. It can be set up off axis in a room with the distance to each wall being different and there are no early reflections. The ATTACK Wall configuration of baffles effectively blocks all possible paths that cause flutter echoes or early reflections.



Here is seen what happens when 5 speakers are set up in the official surround format, speakers at 0, 30 and 110 degrees. A pattern of baffles can be developed that effectively blocks all possible flutter paths and early reflection paths. At the mix position there exists a reflection free zone for any sized rectangular room. Likewise for any location within any room as long as the audio axis is kept parallel to the room axis. The theory behind this design scheme is perfectly general and can be applied to any playback configuration with any orientation in any shaped room.

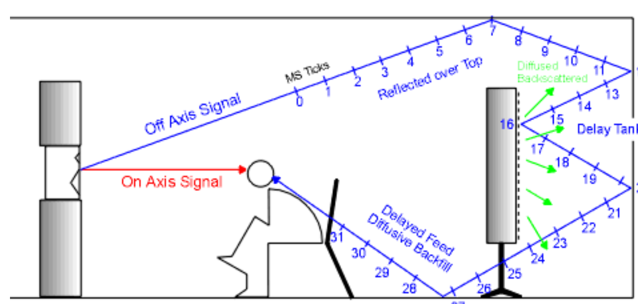
The acoustic signature of a recording studio requires a clean direct signal followed by about 25 milliseconds of time that is free from “early” reflections. The baffle/stand system presented here has been shown to clean up and present a strong direct signal in an early reflection free environment.



This can also be accomplished by simple covering all the walls, floor and ceiling with deep sound absorbing materials, an anechoic chamber. Although engineers could work well in such a space, they soon become exhausted, the engineer has no late night endurance. People don’t like sensory depravation. Adding a diffusive tail, a time-delayed backfill of incoherent sonic chaos finishes out the task of acoustic design in any studio.

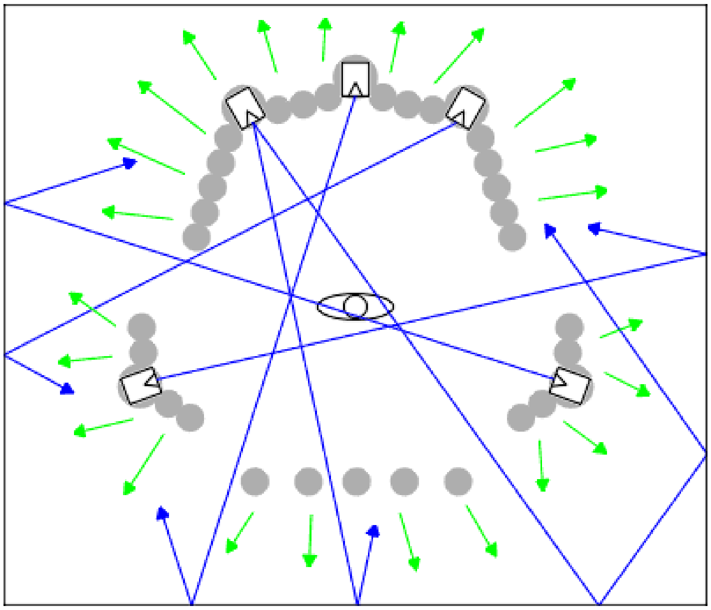
A conventional recording studio design is called a LEDE type studio, LiveEnd DeadEnd. Although the original LEDE type studio concept was a study in pure geometry, a room shape that gave no early reflections, one that did not use absorptive or diffusive devices. This oddity quickly gave way to a more conventional way of setting up a studio in a rectangular room. The front half of the room was made acoustically dead and the back end of the studio was made acoustically diffusive or live. As long as the distance to the back wall was about 12 feet, the requirement of a LEDE room was met. However, these rooms had the clear distinction of one end being dead and one end being live, hence the acronym LEDE. But when it comes to surround audio, there is no “End”. What is the DeadEnd for one speaker becomes the LiveEnd for another speaker. 5.1 Studio design seems to not be able to meet the LEDE requirement, at least using conventional design practice.

The baffles used in the ATTACK Wall are double sided. The front faces the mix position and is full bandwidth absorptive. The backside faces the bare walls of the room and is very diffusive. Each set of baffles is open at the bottom and top. Sound that hits the ceiling bounces over the baffles and sound that hits the floor bounces under the baffles. These rays hit the wall behind and are reflected onto the diffusive backside of the baffles. At this point the sound has been sufficiently delayed and diffused. It is scattered back again towards the bare wall where it is finally reflected back over and under the baffle wall and into the engineering location.



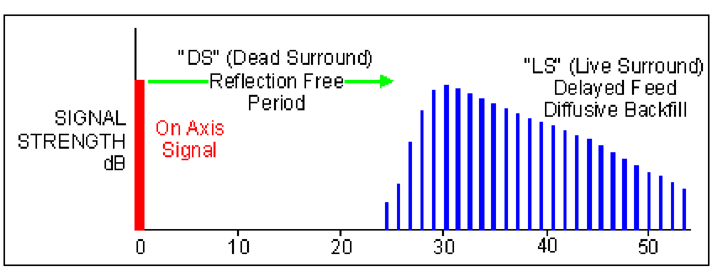
Vertical Circulation Paths

In addition to the over and under action by the vents above and below the baffles, there are also lateral vents in the overall 5.1 ATTACK Wall setup. By ray tracing sound from each speaker that exits through each vent and on through a sequence of wall reflections, a lateral condition of diffusive backfill is created. The space between the reflective side of the baffle system and the bare walls works well when kept in the 3 to 6 foot range. Larger rooms retain the reflection free condition but the onset of the diffusive backfill becomes more time delayed and weaker in level.



Lateral Circulation Paths

By using properly designed and positioned acoustic baffles, essentially gobos, the three stages of proper recording studio design can be met. The strong and undistorted direct signal is launched from the speaker array. The sequence of early reflections that distort musicality and imaging are eliminated and a backfill of time delayed diffusive energy is returned to the mix environment. The most interesting aspect of this is that not only the speakers are in a surround configuration but the diffusive backfill is also delivered to the engineer in a surround format. The old fashioned LiveEnd DeadEnd style of studio design cannot produce a surround mixing environment. In this new medium the ETC definition for studio design remains the same but its spatial or geometric representation is forever changed. The new design criteria is identified by the acronym LSDS ™, LiveSurround DeadSurround ™.



Typical "LSDS"™ Type ETC Signature

The original reflection free zone first conceived by Chip Davis was a geometric space that was reflective but sized and shaped to avoid reflections during the first 25 milliseconds following the direct signal. Nobody really built these rooms but the idea spawned two decades of one-dimensional LiveEnd DeadEnd studio designs. Now, studio design has come full circle due to the seemingly insurmountable mutually exclusive requirements of surround studio speaker positions. What started as a geometric surround studio design concept has become an acoustic surround studio design reality. Although it took TubeTraps to pioneer the concept, it will be up to the professional studio designers to adopt this next wave in studio design, the LSDS ™ type studio.