# LEDE Control Room Design

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# Studio Sound

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*LEDE is a US registered trade mark of Syn-Aud-Con

**The Live End Dead End (LEDE) concept is a relatively recent approach to control room design and there are very few fully certified rooms at present in operation. This is the background—both theory and practical experience—of Tres Virgos, one of the first LEDE studios built.**

IT WAS a dream, a simple dream at that. A dream conjured out of necessity and fed by hope. It was a dream that probably got a little out of hand. We were going to build a new studio that was simply a nice place to make music.

Our first studio was a 4-track opened in 1975 in a garage in Mill Valley, California, a San Francisco suburb. Each of the partners, Mike Stevens, Robin Yeager, Allen Rice and I had come into the studio business as musicians or from allied music-related fields.

The studio under Robin's management grew rapidly to 16-track. Unfortunately we were getting famous, not just with musicians, but with our neighbours as well who just loved hearing vans load up at 4.30 in the morning. Each session brought new success and a summons from the Law to keep it quiet.

By 1978 we knew our days were numbered. We started to think about the *new* studio.

Our demands seemed simple. We believed that a place which is to be used to record music should make musicians feel good. Feelings are what music is all about and a studio should take on the characteristics of the players regardless of the form of their creative expression. A studio should be able to handle everything from solo cello to a full rock ensemble.

Studio technology, aside from its cosmetics, should be invisible to both the performer and the producer. The musician, producer, engineer, microphone and loudspeakers, and the listener and record buyer, should be one linked chain responding to the emotion of the music. No portion of the set-up from cue system to master tape can be askew. A control room is a monitoring system in which producers and engineers perform. It is their stage and it should allow them to acoustically view the performance as the microphone hears it and as the tape captures it. A control room should not impose its will on the performance.

If you do achieve these lofty goals then it stands to reason that any tape recorded there will translate exactly on any playback system.

Off we went in search of *the* studio design. Allen Rice first learned about a new design theory called *LEDE* (Live-End, Dead-End) at a seminar held by Synergetic Audio Concepts (Syn-Aud-Con) in Southern California. Syn-Aud-Con holds the trade mark on *LEDE* and shares development credit on many new technologies.

The new kind of control room design was supposed to be revolutionary. The idea was to put the soft stuff at the front of the room and the hard stuff at the back and nice things would happen to your tapes and your ability to hear. *LEDE* developed out of a new level of scientific acoustic measurement technology called Time Delay Spectrometry (*TDS*). This patented measurement system was developed by Richard Heyser, of the Jet Propulsion Laboratory.

A studio owner and designer named Chips Davis had actually translated the theory to reality in his own control room at Las Vegas Recording in Nevada. Chips had received the first certification and authorisation to use the trade mark *LEDE* from Syn-Aud-Con. His room had been measured and it performed predictably! It did what it was supposed to do. Allen insisted that we consider the *LEDE* design and proved his point with a couple of hundred dollars worth of building materials, a pair of UREI *813 Time Aligned* loudspeakers and a weekend of hard work. On Monday morning we owned what might have been the first *LEDE*-style garage. The frequency response flattened out to the point where we could toss away our ⅓-octave graphic equalisers, the stereo perspective was like wearing a headset and the imaging was really amazing. More amazing now that we know how really primitive our early efforts were.

The success was short lived for soon the sheriff and the county encouraged by our outraged and very tired neighbours were at the door with padlocks.

We started searching for a location for our nice little new studio. Due to considerations including our budget, skills, quality and emotion we were going to build the new room ourselves, with our own hands. We talked to designers who we thought might be qualified to provide a real *LEDE* room for the new Tres Virgos, and although most backed away from the project Chips Davis said yes almost instantly.

Chips had built a couple of rooms since Las Vegas Recording, but he wasn't quite satisfied with any of them. They weren't what Chips knew he could deliver to a committed set of owners building from the ground up. We promised Chips that there would be no compromise. What he designed we would build. What he specified we would do—on the agreement that if it didn't work we would probably do him great bodily injury.

In January of 1980 we signed a very attractive lease on 2,900 sq ft of warehouse space in a most convenient location in San Rafael, California. We planned to add an additional 900 ft by creative lofting over halls and offices. The full 20 ft ceiling height was to be utilised over the studio and control room.

February 1, 1980, saw the beginning of the construction project that was to last 22 months until opening day and probably for ever to complete the off-line facilities and to accommodate future plans.

So that we're all on somewhat common ground perhaps this would be an ideal time to list the seven criteria established by Syn-Aud-Con to qualify for *LEDE* certification.

1 There should be a low-frequency asymmetrical outer shell, free of pronounced resonances at low frequencies. This shell to be large enough to allow the development of bass frequencies.
2 There should be a symmetrical inner shell. The crossover frequency between the outer bass shell and the inner geometric frequency shell should be:

$$f_x = \frac{3\ (\text{velocity of sound})}{\text{smallest room dimension}}$$

3 An effectively anechoic path should exist between the monitor loudspeakers and the mixer's ear which extends for at least 2 to 5 ms beyond the studio's initial time-delay gap.
4 A highly diffused (at geometrical frequencies) sound field should be present during the initial onset of the so-called Haas effect.
5 The monitor loudspeakers, microphone technique, and mixing console should not 'mask' the desired anechoic path from the monitors to the listener, including the period beyond the monitor to the ear's physical distance (studio ITD + 2 to 5 ms).
6 No early early sound (EES) should be present. This is sound that arrives at the mixer's ears ahead of the direct sound travelling through the air. EES occurs when monitor loudspeakers are not shock mounted and therefore radiate through the structure and re-radiate in the air, usually from the ceiling, near the listener.
7 The hard-surfaced rear wall, rear side walls, and rear ceiling should be so spaced temporally as to provide interwoven comb filter patterns which become a high-density early sound field without measurable anomalies.

We agreed that if we were to become *LEDE* certified, we would have to really understand the reasons and the logic behind the system. It all became clear as Chips explained *TEF, TDS* and the *LEDE* concept: "*TDS* is a vast improvement on pulse testing which has been in extensive use for over 40 years.

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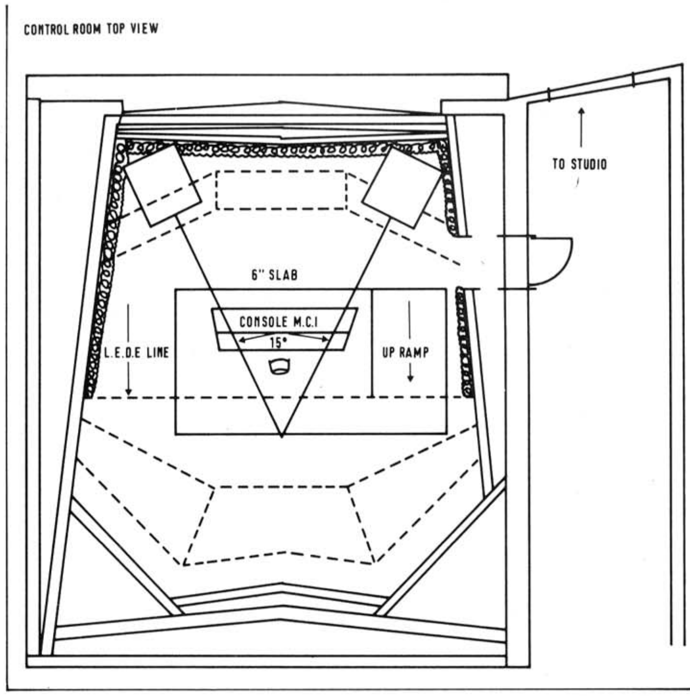


Briefly described, the receiver or tracking filters are delayed in time and do not start the receiver sweep until the signal reaches the microphone. This time delay sweep can then see the direct wave without having any interfering room reflections (60 dB of signal-to-reflection). *TDS* can delay the receiver and open the receiver window for longer periods of time until the first reflection is shown on the screen of the analyser. The frequency, the depth in dB, can be seen and the time delay calculated to determine the surface from which the reflection came. Tuning can continue out in time until there are no other reflections, or the window is so wide that only the total sound of the room can be seen.

"Point-wave duality is an intrinsic property of the Fourier transform map. What appears as a point in one description, will show up as a wave in the alternate description. Therefore, anything that happens in a restricted interval in one description will show up as broad wave-like smears in the other description.

"The signal used in *TDS* has a constant total energy density and a uniquely defined partition into potential and kinetic energy densities. Using the *TDS* wave analyser as the 'front end' of our measurement system and the fast Fourier transform as a predictable 'storage bin' has resulted in measurements that are several orders of magnitude better in resolution than more orthodox fast Fourier transform impulse techniques.

"Use of a *TDS* analyser in conjunction with a fast Fourier transform as a demodulator and 'storage bin' to obtain energy density versus frequency curves (EFC), energy density versus time curves (ETC), and frequency versus time curves (FTC), have been packaged into what is called the Time, Energy, Frequency (*TEF*) measurement system **(Figs 1** and **2)**.

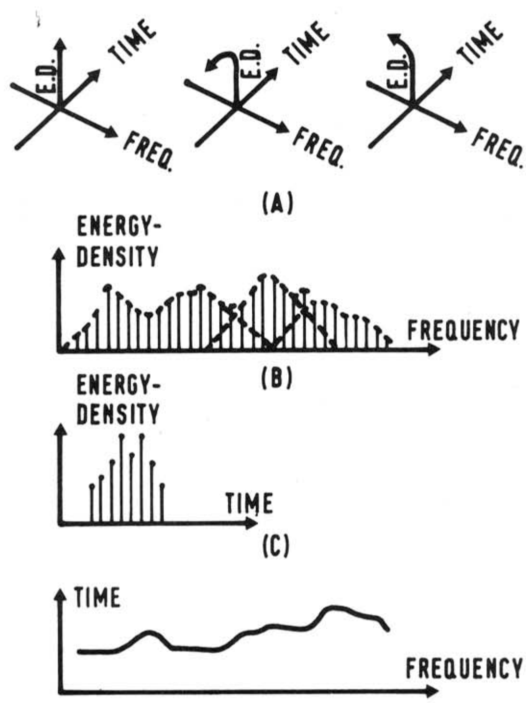


FIG.1

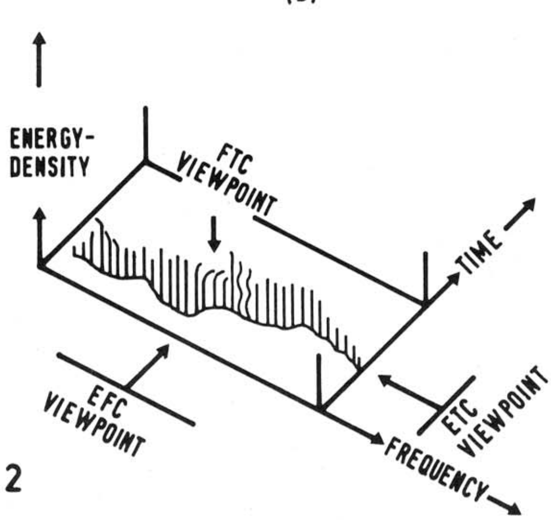


FIG.2

"*LEDE* is basically the complete opposite of all other control rooms. That is, the rear of the room is hard and reflective while the front is as absorptive as possible.

"Let's start with the front of the control room, and explain the reasons behind the absorptive half. Through *TDS*, we've found that mixing of early reflections from the hard ceilings and walls of conventional control rooms with the direct wave causes very deep anomalies in the order of 25 to 30 dB. (Anomalies are any deviation from the original response, therefore, distortion.) These anomalies are broadband and very deep when generated by very early reflections. They occur from the low mid to the uppermost frequencies beyond the audible range. The anomalies, from improper acoustical design, are caused by addition and cancellation of signals arriving at the mixing position out of phase, the phase depending on the time interval or the distance of the early order reflections.

"The acoustical anomalies and anomalies due to improper loudspeaker design cannot be equalised into a smooth, flat reproduction spectrum. To equalise a control room under these conditions with the equalising microphone at one position (in the mixing position), you could obtain a reasonably flat response. Move the microphone 2 in and the curve becomes a gross, maladjusted, unequalised mess. Try this in your control room. Move the microphone in the area of the mixing position and watch the response curve change.

"*LEDE* acoustical design minimises this effect and helps keep a uniform frequency response in the mixing position. The anomalies are real and do exist in hard-front control rooms. We can see these effects and mathematically study

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their cause and effect with the aid of time delay spectrometry.

"The live end of the control room is, I think, the most important part of the room. The Haas effect is a simple, but very important, fact of the *LEDE* control room. The Haas effect is the ability of the brain to discriminate against echoes and delays of sound that arrive approximately 10 to 20 ms after the original waves. The sound is still present but psychoacoustically does not exist so far as the listener is concerned. If the listener is 10 ft or less from a wall, the sound wave travels past him to the hard wall and back—a total of 20 ft—and he will not be aware of its origin. This is called the Haas effect. At greater distances the listener hears echoes or flutter. A hard-backed wall that is 10 ft or less away does not acoustically exist in our brains. The brain doesn't recognise or receive it. Again, this is the Haas effect. Therefore, we have, for the listener, eliminated the back wall, created an infinite distance in space psychoacoustically, and all we can hear are the front loudspeakers.

"We have discovered at Tres Virgos how to extend the apparent Haas effect out to over 40 ms with the Haas effect extenders **(Fig 3)** and by the tight control of the reflected Energy Density in time.

"Now that we have a disappearing back wall, we have to treat it acoustically, and this is where everything becomes like a game of acoustic pool at 1,130 ft/s. We splay, angle, direct and bounce the sound that strikes the rear wall back to the mixing position. This stacking of an immense number of reflecting paths from the back wall is very precise and is figured extremely closely as to time interval.

"What we are trying to achieve is a very dense and diffuse total sound spectrum by combining the paths of the back wall into a series of controlled narrow band comb filters. Successfully done, the overall result is a very smooth total sound spectrum without any broadband anomalies. This procedure also masks console reflections, tape machines, people, etc, so that what is heard by the mixer is a true and extremely accurate sound.

"If the back wall is designed incorrectly, the possibility of having reflections arriving outside the 20 ms time interval would be disastrous. Inside the 20 ms range, an initial time delay gap of a much larger room is present at the mixer's position. You can turn and face the rear wall, cup your ears, and none of the sound from the monitor loudspeakers ever seems to come from anywhere but the monitors. It is totally undetectable in direction, but audible in level. Careful diffusing of the rear wall and a very soft, nearly anechoic front wall are what makes an *LEDE* design an incredible mixing environment. You have complete control of placement, depth and locality."

We couldn't argue with the concept and the idea of knowing a control room's performance before the first day of construction, was really attractive.

In order to achieve our goal we adopted the attitude that we were indeed designing a system into which every piece and part would be specified in advance, to the limits of practicality. Obviously, budget limits madness, but creativity and predictability and hard work can overcome budget. We didn't want to have to do this again and, frankly, there was no real budget set because we didn't have any money anyway. What we spent we raised as we went by personal investment and mortgaging every tangible personal asset we could find.

We understood that all of our efforts would be in vain if the construction fell short of excellence.

The outer boundary wall system with its asymmetrical outer shell called for the most creative planning. Local building restrictions prevented us from using filled cinder block with a scratch coat of stucco (an ideal technique). Due to weight restrictions, we had to improvise a broadband, massive, rigid boundary system that weighed less than cinder block while equalling its acoustic properties as a low frequency containment system.

This system was comprised of the following sandwich over Fibreglass-filled 2 × 6 ft panels. One layer of high density industrial grade particle board, one layer of Celotex (sound board) and 1 in of hand laid stucco (concrete), on both sides of the 2 × 6 ft panels.

The entire studio and control room systems were isolated, floated and built like a ship. All construction was to tight tolerances and all construction was screwed and glued except for final finish trim strips which were nailed and glued. No rattles! The air conditioners are mounted on an adjacent building. The music room, control room and office all carry separate 4-ton capacity units. Quiet, very quiet. All lateral support connections between walls, ceiling and at all intersections were made with a 'Motor Mount' system we devised that allows for both structural integrity and virtual total isolation. Every seam, joint and corner was caulked with a variety of black, white and green gooey stuff specified for the application.

The acoustic absorption panels were of our own design, and *TDS* measurements show them to be at least twice as absorptive as the leading cut foam absorption product. They were also far less expensive too, if you have slave labour!

The inner and outer wall geometry, the control room specific reflection and diffusion geometry and the psychoacoustic parameters were all worked out by Chips in a process that called on him to draw from every resource available.

While we were still in the early construction phase Chips was joined in Las Vegas by *TEF* licensee, Ed Bannon. As our construction crawled along, due to both attention to detail and lack of funds, Chips and Ed set out to solve some mysteries in the electronics chain. Once you had a control room that was effectively passive to the loudspeakers, the loudspeakers started letting you hear things that had to be in the electronics chain. Phase distortion and shift became painfully apparent. All the other little mismatches, problems and glitches which were hidden by time smear and various anomalies in most control rooms would surface like dragons in our new control room. Ed's understanding of phase coherence and his insistence that a signal stay in electronic phase alignment from the mikes to the loudspeakers, and in acoustic phase (time) alignment from the loudspeakers to the listener, was invaluable.

Part of the theory of the electronics system Chips and Ed specified for Tres Virgos was the concept that in multitracking situations (the normal in a studio) your ability to capture music is limited by your ability to pass the high level transients of the loudest rock instrument, the kick drum (131 dB). Thus the studio's MCI *500B Series* console 38 V power supplies allow you to use voltage not current to push your signal around. Push a signal with current and you overdrive the system into changing phase. Massive power on the loudspeakers helps though, in our case using Crown *M-600* power amps. Nearly 1.3 kW per side linked with a special circuit (Delta Omega) that for all purposes 'sees the loudspeaker as a dead short'. We use a lot of *PZM* microphones, too. Because of this we can hear their subtleties in our control room and they are phase coherent.

Headroom means never having to trim your masters in a mix. Headroom means never having to clip. Headroom coupled with coherent phase means monitoring for hours at 120 dB impulse with no pain and no noticeable degradation of hearing integrity. Also, no ear fatigue.

So far, Tres Virgos has been visited by dozens of studio owners, designers and musicians from all over the world. The reaction has been universally enthusiastic. We maintain an open door policy (at the discretion of our clients) and love to show the studio off.

We're proud to have been a part of the birth of this new science and are thrilled with the number of both certified *LEDE* control rooms and non-certified attempts that have given their owners the benefit that even minimal adherence to the principles can provide.

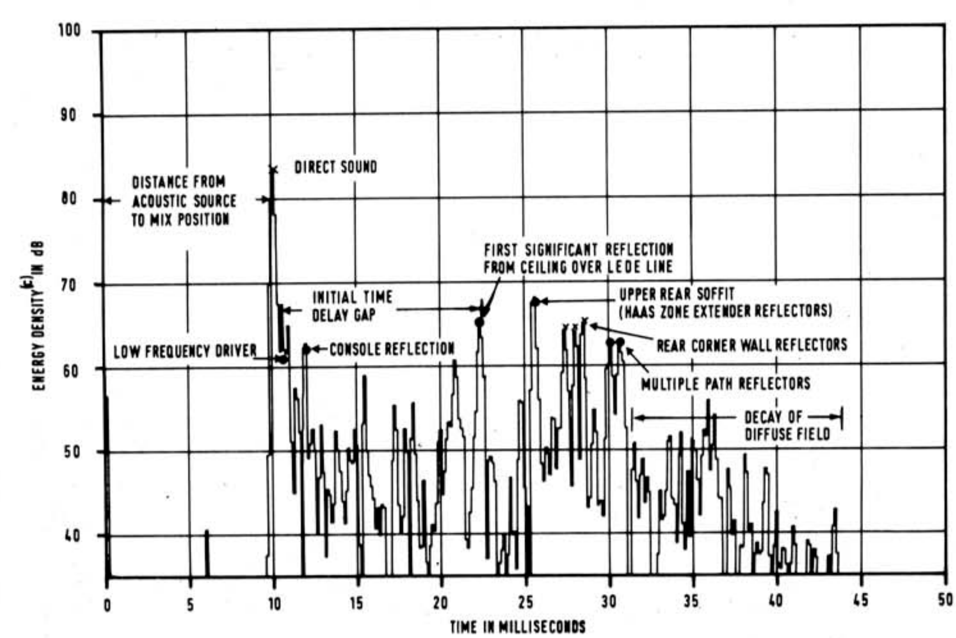


FIG. 3