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.

"LEDE is a US registered trade mark of Syn-Aud-Con"
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).

"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 equalized 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 minimizes 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...
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 first sound. This is why the Haas effect is experienced as a single sound, and not as a series of overlapping sounds. 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 first sound, and the listener is not aware of the echo. This is called the Haas effect. At greater distances the listener hears echoes or flutter. A hardbacked wall that is 10 ft or less away does not acoustically exist in our brains. The brain doesn’t recognize 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 and produced a smooth curve. Comb filters are what we can hear and see the front loudspeakers.

“We have discovered at Tes Virgos how to extend the apparent Haas effect out to 40 ms in both 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 problems. We can display, angle, direct and bounce the sound that strikes the rear wall back to the mixing position. This stacking of an infinite 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 controllable narrow bands. This is accomplished by band 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 turn and face the rear wall, cup your ears, and none of the sounds 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 room make an LEDE design an incredible mixing environment. You have complete control of placement, depth and localization.”

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 increase because we didn’t have any money anyway. What we spent was 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 improve a broadband, massive, rigid boundary system that weighed less than cinder block while equaling 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 sand laid stucco (concrete), on both sides of the 2 × 6 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 rattle! The air conditioner is mounted on an adjacent building. The music room, control room and office are all separate 4-ton capacity units. Quietly, very quietly, our two 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 material. 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 Bannan. 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 been 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 Tes Virgos was the concept that in multitrack situations (the normal in a studio) your ability to capture music is limited by your ability to pass the highest 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, Tes 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.