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CONTROL ROOM REVERBERATION IS UNWANTED NOISE

P R Newell (1), K R Holland (2), T Hidley (3)

(1) Independent Acoustics Consulant
(2) Institute of Sound and Vibration Research (Southampton University)
(3) Tom Hidley Designs

A Proposal for the Abandonment of the Concept that Control Rooms Should Possess any "Representative" Reverberation

ABSTRACT
It has been customary practice is most situations to produce control rooms with reverberation times approximating to, or slightly less than some statistical "average" domestic listening room. Numerous methods have been used in attempts to remove peaks and dips in the reverberation times of the rooms, which create idiosyncratic colouration of the monitoring conditions. This has led to musical balances which may not "travel well" when reproduced in other rooms. Despite fifty years of efforts to produce rooms which subjectively sound both consistent between themselves and "typical" of the outside world, the general state of inter-room compatibility is still not good. This paper argues that only by minimising control room monitoring RT can greater commonality be achieved; but this requires the abandonment of any adherence to the old policy of mimicking any perceived domestic "norm".

Sources of Inconsistency

There are only two sources of inconsistency between control rooms or any other listening rooms: the monitoring systems and the room acoustics. In conjunction with each other however, this combination, even when ostensibly well designed, has conspired to produce some alarming degrees of difference in subjective sound quality. In fact, the difficulties in producing rooms with a consistent sound quality, irrespective of shape and to some degree size, has put constraints and pressures on the designers of loudspeakers, searching for a way to make the loudspeakers themselves less subject to perturburances in the responses caused by the different rooms in which they may be used. To be fair to the loudspeaker manufacturers the room problems should be sorted out by the room designers, at least in professional circumstances, but the consistency problem, particularly at low frequencies, has been difficult to resolve.

The modal patterns of conventional rooms are very complex. Even two rooms dimensionally identical can show great deviations in their low frequency reverberation times, not only according to the materials and thickness of their walls, but also to what may exist on the other side of the walls. Control rooms constructed of dry wall partitioning are particularly prone to having their low frequency characteristics dominated by the dimensions of the more massive brick or concrete structures in which they are assembled. The resolution of the calculations of low frequency modes within such rooms is not trivial, and is further modified by anything else which may be constructed in the greater space.

Tiring of such inter-room inconsistency, producers and recording engineers have relied to a very great extent on the close field or "near-field" loudspeakers, placed on or close to the mixing console. At less than the critical distance at which the room begins to dominate in the perceived response of the loudspeaker, recording staff have been more content with what they heard from the same loudspeakers in different rooms. Once a particular set of loudspeakers had been chosen (varying from individual to individual in terms of with which ones each person felt that they produced the most consistent mixes and sounds when related to the outside world) each producer and/or engineer would frequently continue using that type until something even better for them became available.

The small loudspeakers had a further advantage of relating more closely to the frequency range of the majority of domestic reproduction systems. Whilst this is indeed a worthy reference to conduct, as nobody would wish to short-change or disappoint the majority of the listening public, too great a reliance on the small monitors frequently left one or two octaves of low frequencies completely unmonitored, and much low level fine detail could not be detected. In some instances, this fine detail could have been used to great effect if only it could have been heard, but in other cases, the fine detail included noises, harmonic clashes, the operation of gates or compressors, and/or a host of other artifacts of the recording. Currently, these are frequently noticed first only by the music lovers who choose to spend a great deal of money on their domestic hi-fi and CD collection. That such a situation exists does not bring any great honours to our profession. Quality control is our responsibility, not that of the retail purchaser of the finished product.

Conventional Design Concepts

There have been a number of attempts to smooth out the modal responses of rooms in a search to provide a reverberation time/frequency performance which could closely approximate to

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the specified requirements, but without the irregularities which contribute to the undesirable, individualistic sound of so many rooms. To mention a few, there have been damped Helmholtz resonators, tuned to absorb undesirable frequencies which may predominate a room's RT. At best, the results are only approximate. There has been the "Live End, Dead End" approach of Wrighton and Berger, which sought by means of an absorbent front half of a room to leave a suitable time interval between the incident wave's first pass of the ear, and the subsequent "life" or pseudo-reverberation produced in the rear half of the room. By this means, reverberation was perceived as reverberation (I use the term loosely here) without colouring the direct sound from the monitors. A further means of achieving a more uniform RT with frequency is by means of quadratic residue diffusers, which by suitable placement in a room can achieve a high degree of very diffusive reflexions, free of the discrete and possibly unwanted specular reflexions which can predominate at certain frequencies in conventional rooms.

Amongst others, there is the Geddes approach of the steeply double sloped wall, sloping in the vertical and horizontal directions, designed to disrupt the stronger axial and tangential modes in order to drive all modes into the less regular and more easily controlled oblique form. In addition to the above, there is the multi-faceted approach, scattering the modal energy into a broader overlap. Such rooms have frequently been used in conjunction with monitors whose directivity was tailored to the rooms, such that "patchworks" of reflective and absorbent surfaces could be positioned to yield an overall desirable RT/frequency characteristic. These rooms usually incorporated "bass traps", low frequency absorbers of considerable volume, to deal with the less directional frequencies below 300Hz or so.

In the hands of capable designers having a comprehensive knowledge of the underlying reasons behind each approach, there have been differing degrees of successes and failures. Sometimes luck has lent a hand, whereby the personnel of a certain studio had a natural empathy with the techniques used, or at least soon learned to adapt to their characteristics; but luck could sometimes work in the reverse sense. A major problem which arose was that whilst each technique could be used to approximate to one given specific RT goal, although these could be measured to correspond very well with their target figures, subjectively, they all sounded different. What is more, none of them produced their pseudo-reverberation in a way that was typical of real domestic conditions. Only the RT figures matched well; the perception was entirely different.

What Domestic RT?
In itself, the concept of an average domestic reverberation time is a highly dubious target to aim for. It seems to be locked in to our thinking, probably from times when music was more localised, and when the sound reproduction equipment and the housing of the majority of probable purchasers of the music were likely to be more similar than they are today. In recent years, some well-known recording artistes have been selling in the order of ten million records a year, worldwide. The internal acoustic of an all concrete and brick, Southern European house is very different from either a granite built Scottish house, a Far Eastern wood or bamboo house, or a heavily furnished Californian apartment, yet all must now be considered as quite probable final destinations for much of today's internationally marketed music. All purchasers pay roughly the same prices for their recordings; so all could claim the right to expect their domestic conditions to be equally considered, which is clearly impracticable. What is more, there is a very great percentage of the music buying public who now predominantly listen either in motor cars or on headphones, and for these people, reverberation, pseudo reverberation or even significant reflexions hardly exist. So, why do we still produce control rooms with any significant degree of reverberation at all?

Alternatives
Undoubtedly, anechoic rooms are not very pleasant environments in which to spend very much time. Indeed, many people find them unnatural, disturbing, and in some cases, even stress inducing. Especially when loud music is reproduced under such conditions, there is cause to believe that it triggers a "fear" response in many people, when the dynamic range exhibited between the silence and the music causes their brains to warn them of impending danger. In nature, such wide dynamic ranges are usually only experienced in times of natural disaster, where great energies are being released. On the other hand, anechoic conditions are highly repeatable in any given frequency range, which is why they have been so widely used for comparative and absolute measurements. Under anechoic conditions there is a tendency for loudspeakers with the best amplitude/phase compromises, and hence the best transient responses, to show a degree of reality which is noticeable to a greater extent than from any loudspeakers in conventional rooms. Shroeder's "Phase Organ" experiment suggests that this would be so, as the perception of the "tones" he produced by varying the phase

relationships of harmonics in a pulse train under anechoic conditions, was totally lost once reflective surfaces were introduced into the listening environment.

Certainly anechoic conditions provide the best circumstances for detecting fine detail in the sound. Such conditions enable pin-point stereo imaging, and a tightness and reality in the overall perception, but it is largely their unpleasantness in the human comfort sense that has prevented them from becoming the natural quality control and monitoring environments. In anechoic conditions, the problems of creating loudspeakers with smooth responses at extreme off-axis angles is alleviated by the fact that "out of the normal listening area" anomalies are absorbed, and hence do not return to the listening position.

Practical Solution
It has been becoming apparent to a growing number of people that the optimum monitoring conditions for current recording requirements would be an anechoic room in which human beings would feel comfortable. The achievement of this requires a room with a dual acoustic, one for the monitoring and one for the people working within it. If the front wall is made to be both massive and reflective, and the main monitor system is flush mounted <u>in</u> this wall, then the wall itself provides an excellent baffle extension for the radiation of low frequencies, but cannot be "seen" in ray-diagram terms by the monitor loudspeakers themselves. By making the wall suitably irregular on its surface, very pleasant specular reflexions can be returned to the persons within the room in response to their speech and actions, but nothing of the musical signal from the loudspeakers can be returned to the front wall, and hence back to the listener, as all other wall and ceiling surfaces are made as highly non-reflective as possible over as wide a frequency range as possible.

To further brighten the room, a reflective floor can be used, which helps to reduce the directionality of the "front wall only" approach. The subjective neutrality of the floor reflexions is best described if we consider a large anechoic box, in which we fix securely a loudspeaker and a measuring microphone. Were listeners to enter the box, (standing vertically with heads adjacent to the microphone) listen carefully to the sound, then listen for any perceivable changes when a hard, reflective surface was placed along one side, they would surely notice both a change in tonality (by reflective colouration) and a possible change or loss of precision in the horizontal position of the apparent source of the sound. In each case, before and after the introduction of the reflective surface, the response at the listening position could be measured and plotted via the microphone.

Let us now consider the situation if we were to rotate the box through 90°, by rolling it over on to one side such that the reflective surface, which we had placed alongside one wall, was now on the floor. As the microphone, loudspeaker and reflective surface had all been fixed in position before the rotation, then their relative positions would be fixed, so a further measurement taken in this position, would be absolutely identical to the one taken previously. On the other hand, if a listener were to re-enter the box, with his or her head in a similar position as before, (though of course now rotated through 90° relative to the previous standing position in the box) a very different perception of the sound would be noticed, as the reflexions would now be arriving at the ears from below and not from one side. Colouration would tend to reduce, back towards that of the anechoic conditions. Furthermore, the horizontal positioning would return to pinpoint accuracy, and little if any disturbance would be noticed in the vertical positioning.

The reason for this is that our ears, or at least those of by far the greatest majority of people, are enormously more sensitive to position and colouration by disturbances in the horizontal plane than in the vertical plane. Being restricted to largely two dimensional movement over the surface of the earth, in fact usually moving very little during lives in terms of distance from a floor, it is not surprising that evolution has tended in this direction. Until the introduction of the air-launched bomb and the land-mine, humans have had no real threat to their existence from predators attacking from above or below.

Subjective Perception in Low RT Control Rooms
When listening in stereo in a control room designed according to these principles, and especially when an absorbent screen is placed at the back of the mixing console, then exceptionally uncoloured sound with precise stereo imaging can be experienced over a large area of such rooms; dependent upon the suitability of the monitor system of course. Enough rooms built using the above principles are now in existence worldwide to be able to give a clear description of the general trends and tendencies in the way that they are used, and the results which they produce. The principle, to the best of our knowledge, was first introduced by one of the authors (Hidley) in the mid-1980's in

his "Non-Environment" control rooms, in which the monitors were intended to respond subjectively as closely as possible to driving into 2pi space. By its very nature, the concept is highly tolerant of shape and size variations, as anechoic (for the monitors) means as close to zero reverberation as possible, and zero is the only number which can be multiplied by any variation factor yet remain the same. The problem with reverberant approaches, be they reflective or diffusive, is that any given "reverberation" time, produced by a variety of means, will produce noticeable variations in the perception of the subjective response of those rooms, and hence will disturb the room to room consistency of the monitoring conditions between rooms using different techniques of control.

In the "Non-Environment", "Monitor-Dead" rooms, one very strongly noticeable trend is towards recording and mixing on the large, in-built monitor systems, with the small close-field systems returning to their original position in the hierarchy as secondary references to a domestic world. Users report few surprises when taking the mixes away to play at home, in the car, or on headphones, which is hardly unexpected as the rooms remove one of the very large variables from the mixing environment, and by also removing the bias towards one form of reproduction (the domestic reverberation time) other listening environments are more fairly considered at the mixing stage.

Doubts

Two questions which frequently arise from people who have not experienced such rooms are "Is there not a tendency to use too much reverberation in the mix, because the room sound is so dry?", and "In the absence of any low frequency reinforcement from the room itself, do the monitors not sound bass light, and do mixes not subsequently leave the studio bass heavy?" In practice, the answer to both questions is "No". The RT that does exist in many control rooms is much shorter than that which would tend to be artificially applied for musical purposes, hence the two are not very closely related. The reverberation which is applied however, is in relation to a lower background ambience, so can be heard much more clearly. In fact, one becomes very aware of the individual spaces in which the instruments were recorded. Differences in the choice of type and position of the recording microphones become much more clearly heard, as do the aspects and defects of any artificial signal processing. Problems and distortions are heard where they should be heard, in the control room, which again can be used for quality control at the recording and mixing stages.

With respect to the relative level of low frequencies, well, as I stated earlier, one of the most noticeable aspects of these rooms is the tendency to rely much more on the large monitor systems, which if well designed allow proper relative monitoring of the whole low frequency band, so "guessing" what is happening at 40Hz becomes less of a lottery. Psychological adjustment to the short low frequency reverberation times seems to be accomplished quite quickly, and after one or two false starts, mixing personnel soon lock-on to the required techniques. In fact, some of the false starts are caused by the engineers and producers still applying subconscious "correction factors" which experience has taught them to be necessary in more conventional rooms.

Noise

What is becoming more and more apparent as the use of these rooms spreads, is that control room reverberation should be considered to be nothing other than unwanted noise. Like tape noise or non-linear distortions, it masks detail by introducing a noise floor below which it becomes very difficult to hear other noises, distortions, or low level signals. Many important aspects of a sound may exist at times in a region of say 65dB below peak. A tape noise floor of -60dB will make perception of these sounds very difficult, and may even mask distortions. The reverberant hang-over of a sound can in a similar way easily mask the low level detail of a sound existing two or three hundred milliseconds later, and it is many of these low level signals which provide clues to the spaces in which the instruments were recorded. What makes control room reverberation even more of a potential problem to monitoring than is tape noise, is that the tape noise is part of the finished item. Undesirable though it may be, the same tape noise which masks the problem in the control room, will still be present to mask the self same problems in the homes of the purchasers of the recordings. The same cannot be said however for any masking due to control room reverberation. Although it may cover problems at the recording and mixing stages, the unheard problems can become only too apparent to critical listeners in the outside world, and as I stated previously, quality control is not their job, it is ours! They have paid for a finished product and they are justified in expecting the best value for their money.

Control room reverberation has long been a problem for inter-room consistency, and all that any of the conventional approaches have achieved is little more than pushing the response bumps around. Little consensus has been reached as to precisely how RT control should best be achieved, but now that such a large percentage of end listeners will not be listening in conditions anything like the statistical norm, it has put the whole concept of control room reverberation standards in doubt. Given the additional clarity of perception being experienced in the "Non-Environment" type of rooms, and the subjective removal of about 15dB of masking noise from the mixing environment, surely the concept of any monitoring RT, other than as close to zero as possible, has no future relevance.