HOW DRY DO THE RECORDINGS FOR AURALIZATION NEED TO BE?

Anders Buen Brekke & Strand akustikk as, Oslo, Norway. anb@bs-akustikk.no

1 INTRODUCTION

Critical listening to simulated sound fields in rooms and spaces can be done using auralizations. We may assess the rooms, and different audience- and performer positions, by just listening to the models, or to the finished space by playing back recordings in them. This procedure is very similar to the everyday listening to music, or the radio, at home, in the car, at music, theatre or dance venues. Also many, if not most, performances today are done by the use of amplification of sound sources played back in the same room or outdoor venue.

In room acoustical simulations, the room impulse response (IR) is calculated between a source and a receiver position. This IR may then be convolved with a recording which may be listened to by using a headset or through loudspeakers in a room specially prepared for such use. Using the streaming convolution option one my listen to different listener and source positions in the simulated, or measured, room just by switching IR's while the recording is running.

Programs for editing sound also provide the ability to play back signals through different environments by utilising measured, simulated or manually changed or made IR's. These IR's may e.g. consist of rooms and human environments, different kind of historical reverberation units (springs, reverberation plates etc), but also units used for manipulation of music signals. Only your imagination set the limit. The packages both provide databases of such IR's and the ability to record them. The programs are available at a reasonable cost for use on a computer with a sound card.

The method is a low cost way of e.g. producing sound for theatre, radio etc. as the effects are reproduced digitally and you do not need to do a recording in that particular environment for the reproduction to sound realistic. If you want the sound to be as if it is recorded in a car, one just convolves the studio recorded signal with the IR of the interior of a car. A similar ability is also delivered with music reproduction hardware for use in cars and even musical practice rooms [Wenger] and venues [LARES and VRAS].

Many sounds we hear can be looked at as such convolved signals from a source played back in an acoustical environment. We are thus well trained at listening to "convolved" sounds.

This paper deals with the effects of using commercially available or other non anechoic recordings for auralizations How dry do these recordings need to be in order not to influence the acoustical judgements?

2 LITERATURE

The process of auralizations shares some properties with physically and electroacoustically coupled spaces.

2.1 Physically coupled spaces

Already in the 30ties Eyring, Hill and later Harris studied the theory and measured the properties of physically coupled spaces[1,2,3]. Theatres and opera houses with stage-towers and houses coupled to the auditoria are typical examples of such acoustically coupled rooms. During the 80ties RT chambers in concert halls has been widely used as a means to give both a high reverberance and clarity giving double sloped decay[4,5,6]. The same is probably the case with electroacoustically driven systems for artificially increasing the RT in rooms for music and theatre.

2.2 Electroacoustically coupled spaces

Another example of coupled spaces is the recording studio and the listening room. Mankowsky has mathematically studied the problem and came to these conclusions[7]:

- The combined RT is greater than either alone
- The combined RT is nearer the longer reverberation time of the two rooms
- The combined decay departs somewhat from a straight line
- If one room has a very short RT, the combined RT will be very close to the longer one.
- If the RT of each of the two rooms alone is the same, the combined RT is 21% longer than one of them

This information should also apply to our problem of using 'wet' recordings for auralizations.

To some extent this also applies to the playback of acoustical musical instruments in a room as many of them has their own 'RT' with rise and decay times different from zero. An example is the grand piano with its RT, if not damped, of more than 20s in the low frequencies[8]. Bowed and plucked string instruments are other examples. (They not only couple to the room, but the strings e.g. in a grand piano will couple to each other giving double slopes and beats).

3 EXPERIENCES

Listening is the natural way to learn about sound. Auralizations give the opportunity to utilize our huge and long trained natural processing capabilities in that respect. Listening experiences are thus crucial. We also must assess the signals we use for that process.

3.1 Tomba Emanuelle, an acoustics lab

In 2005 I attended a concert in an exceptionally reverberant hall, Tomba Emanuelle, see Figure 1, where a friend of mine, Unni Løvlid, gave a concert singing Norwegian religious folk songs. The RT is about 8s in the mid frequencies with an audience of 25 persons. There is also a commercially available recording made there[9].

Figure 1: Tomba Emanuelle, Emanuel Vigelands grave tomb, is open to public every Sunday. The interior is covered with a gigantic painting describing the whole human life cycle. The right picture is from a room acoustical model of that room.

In connection with a project, I made a room acoustical model and did measurements there. The room is also present in the Altiverb RT database available at the web[10]. The given information became an acoustics lab. By listening to the Vita recording of song done there, as well as convoluted with the calculated and measured IR' from the room, one can assess the theory given above.

Interestingly convolved slow piano or even electric guitar "romantic music" works in that room. The decay of the instruments probably is comparable to the room. Melody lines can easily be heard. Listening to auralizations of rock music is, however and at no surprise, less pleasant due to the rumbling bass. This is less of a problem when listening to the room acoustics model, but is present when listening to convolutions with the measured IR's.

Playing back the 'Vita' recording through the measured IR from the Tomba Emanuelle makes the impression of a more distant and reverberant recording. The measured IR can be made drier in Altiverb by manipulating it manually. Even when using a 50% RT the convoluted signal sounds slightly more distant. Such experiences are the Mankovsky theory in practice.

3.2 Recordings for auralizations

In general recordings done in an anechoic room is preferred for auralizations. The RT of the recorded signal does thus not influence the convoluted one, and it can be used for any room, dead or live. A database of dry recordings e.g. comes with the Odeon and Catt room acoustics software. A few anechoic recordings are also commercially available like the 'Music for Archimedes'[11] or Wengers 'Anechoic choral recordings'[12].

Interestingly Denons 'Hi-Fi Check CD' use sound tracks which do not come from anechoic studios[13].

There are some drawbacks of such anechoic recordings especially if we compare them to the benefits of the commercial recordings.

Recordings in anechoic rooms also lead to the problem of lost information. What is better? - To record using one or two microphones in a normal room getting information of the whole instruments radiated energy, or to do it in an anechoic environment loosing parts of the radiated sound even if the microphone grid is fairly dense. To my opinion, the former method is much simpler and faster and is in fact the way recordings for CD productions are done.

3.3 Some benefits of commercially available sound tracks

- They are (mostly) done with good professional performers
- The sound is normally produced at a high quality level using high budgets for the purpose
- Popular music often is reproduced dry and extremely clear, classic and acoustic music might be less so
- They are in stereo and even surround sound
- The selection is large even with sources of the highest class sounding instruments
- You may listen to your favorite music, making your creative and productive work more pleasant and better.
- The client might know the recorded signal
- You might find recordings of performers that may use the room or site you are modeling when finished

Sounds can be and will be assessed by doing comparisons. Even if the absolute room acoustical values might be slightly off the "dry values", comparisons between different designs and/or positions will still be valid.

3.4 Some experiences using commercial recordings

Recordings of popular music can be extremely clear, in particular the vocals. Some high clarity recordings, often with close vocal and precise and brilliant percussion tracks on them, may tend to sound harsh and unnatural in auralizations using room acoustical models. An example is: Janet Jacksons 'Empty'.

In my experience recordings with a 'round' and warm sound like Jan Garbarek 'Gautes Margit' and Joe Satrianis slightly reverberant 'Love Thing' work well in computerized auralizations of almost any rooms.

The dry and precise AC/DC tune 'Gone Shootin'' is particularly well suited, as the guitar riff, music and lyrics have a certain monotony through the song which makes them useful for doing comparisons of different positions in a hall while the music is running. Deep Purples 'Getting tighter' also has that useful repetitive monotony. Both are recordings from the 70ties.

4 INVESTIGATIONS

Calculated IR's from the room acoustical Odeon model for Scene II in the new Oslo opera house, and from the Tomba Emanuelle, has been used for the study.

4.1 Method and used programs

A dry IR is calculated @ 1m distance from the source S1 using Odeon v. 9.0, se Figure 2. The wet IR is taken from a seat at about 14m distance from the source S1, well outside the reverberation radius of 3.6m. We also use a 'semi wet' IR taken from a distance of about 2.8m from the source S1.

The dry, semi wet and wet IR's as well as the convolved IR's in wav format were converted from 24bits stereo to 16bits mono using River Past Audio Converter and fed into WinMLS 2000 for calculations of the room acoustical parameters and plotting the Schroeder curves.

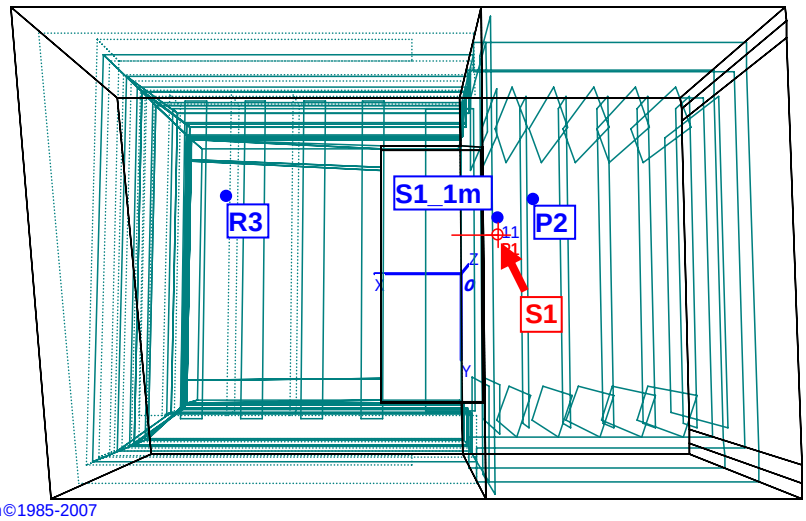

Figure 2: Odeon room model of the Oslo Opera Scene II. Source S1 (red cross), and receivers R3 at about 14m, S1_1m at 1m and P2 at 2.8m distance from the source (blue dots). The reverberation radius of the room is 3.8m @ 1 kHz.

4.2 A dry IR convolved with a wet IR from the same room

By convolving the dry (1m distance from S1) and wet (14 m from source) calculated IR's we get a convolved IR Schroeder curve as shown in Figure 3.

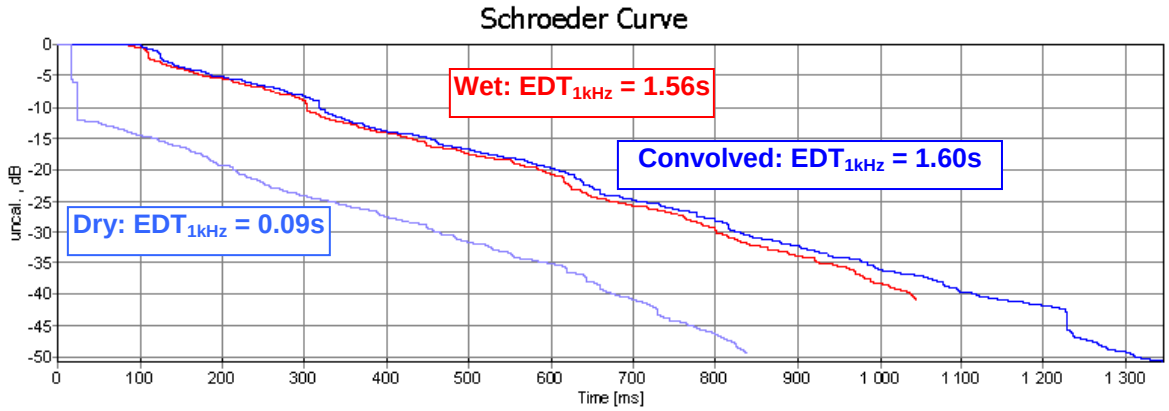

Figure 3: Example of a "dry recording" convolved with a "wet" one. S1_1m (light blue, dry), S1R3 (red, wet) and S1_1m convolved with S1R3 (blue).

We see that the original wet (red) IR and the convolved (blue) are fairly similar. The EDT increases about 2,6% which is smaller than the JND of about 5%. The 1m distant recording seem to be sufficiently dry to do the job for the auralization in that room.

If we neglect the feedback from the loudspeaker to the microphone, this would be equivalent to playing back an amplified source through an omnidirectional loudspeaker close to the source in the room. That process does not seem to alter the resulting EDT at an audible level.

4.3 A more distant IR convolved with a wet IR

Now what happens if the dry recording is wetter?

We use a 'semi wet' (dark red) IR and convolve it with our wet (red) IR to get the green Schroeder curve as illustrated in Figure 4. Now we see a significant effect! The EDT has increased some 30% which is some 6 JND's. Thus, one could conclude that using this 'semi wet' recording for auralizations would overestimate the running reverberation, EDT in the room. The room would sound wetter than it really is.

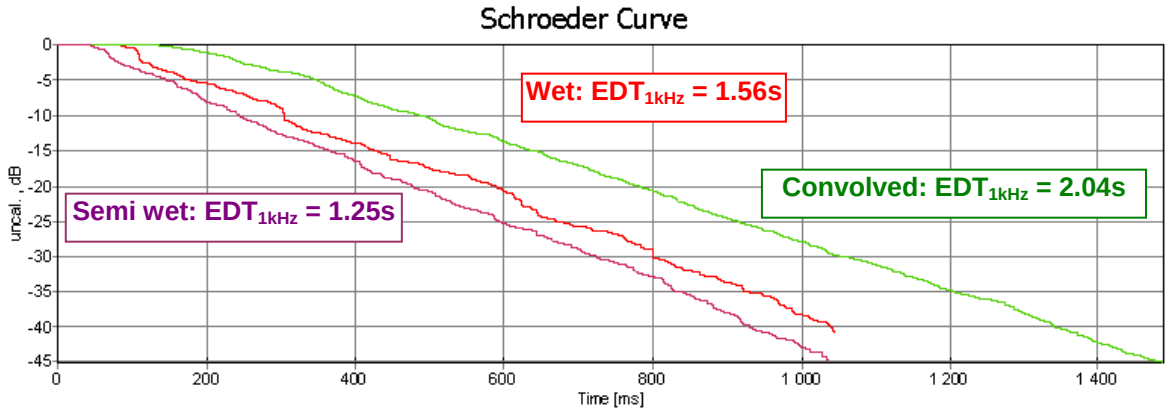

Figure 4: Example of a semi wet IR convolved with a wet IR. Examples are calculated impulse responses from the Scene II. P2 (dark red, semi wet), S1R3 (red, wet) and P2 convolved with S1R3 (green).

4.4 A test in the extreme Tomba Emanuelle

Now how dry does the recordings need to be?

If we use the reverberation radius as the measurement scale, a recording done within about 30% of the reverberation radius of the room apparently should be sufficiently dry to do the job for auralizations. But by testing that hypothesis in a very reverberant room, like the Tomba Emanuelle, we see that the level of the reverberation also seem to influence, see Figure 5.

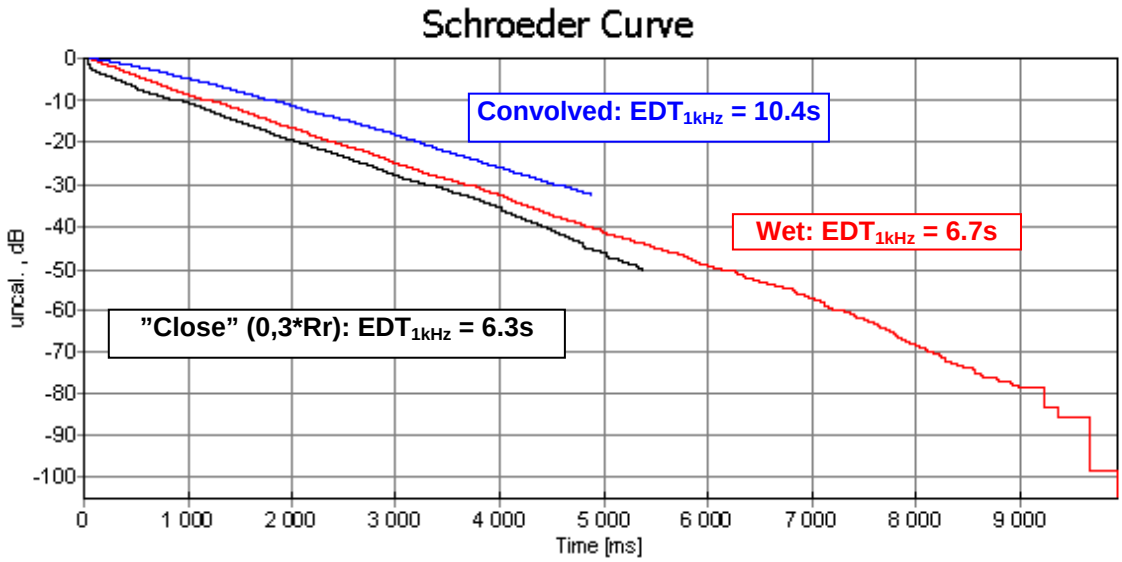

Figure 5: Example of a close (d=0.3*reverberation radius, Rr) recorded IR (black) convolved with a wet IR (red) making the convolved (blue) IR.

Here the EDT (falloff from 0—10dB) seems to be dominated by the unusual high reverberation curve, and thus, reverberant sound level. This most likely is a special case for such extremely reverberant rooms. The 'dry' curve in Figure 3 look more normal when compared to Schroeder curves for IR's measured at 1m. Normally the EDT (and thus the Schroeder curve) will fall steeply and often beyond -10dB before the steady reverberation appears.

4.5 Wet IR as dry IR convolved with an extremely wet IR

How about using a normally considered wet IR in the extreme Vigeland tomb?

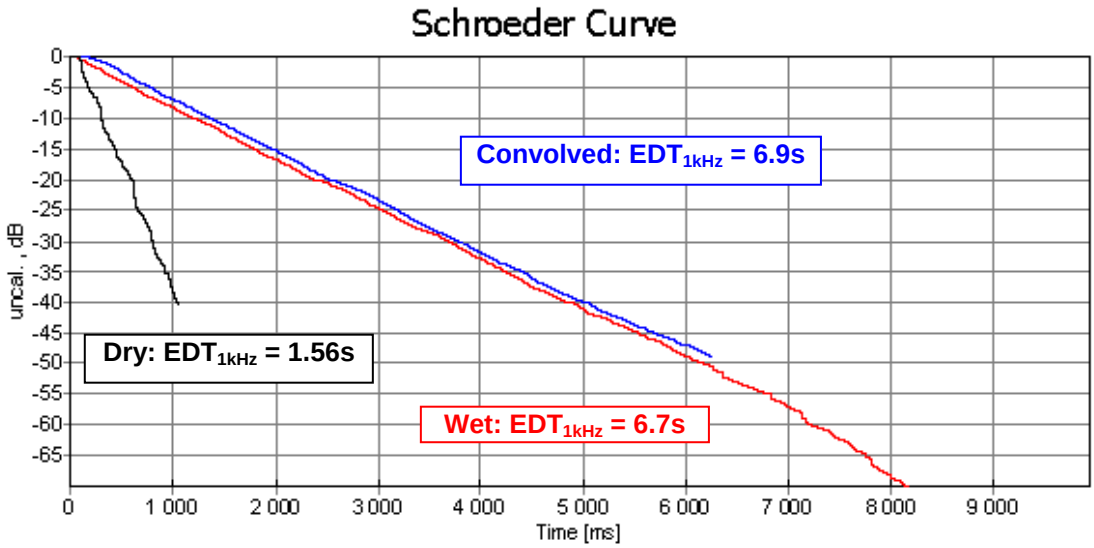

Figure 6: Example of a 'wet' IR here working as 'dry' (from the stalls in Scene II), a wet IR from Tomba Emanuelle (red), and the resulting convolved IR (blue)

In Figure 6 we see that a normally 'wet' IR from the stalls in Scene II convoluted with the extremely wet IR from Tomba Emanuelle make a extremely wet IR very similar to the original IR.

4.6 Discussion

The example in Figure 3 illustrates the effect a pick up of sound in a room close to the source probably will be sufficiently dry to do as source signals for auralizations in the same or a similar room. This also corresponds with the ever more common practice of well established artists to do recordings in their home environments. Also many of the best recordings of folk music done in Norway are done in home environments. (My father pioneered private folk music productions from the mid 70ties and runs a record company besides being a professional folk musician. Many of his productions are recorded at home or at dance venues, the natural environment and format for that type of music)

An interesting practical example is the Norwegian Broadcasting Company which recorded nearly every desk of the orchestra and singers during the opening performance of the new opera. The playback through the Norwegian TV net basically was an auralization of the main auditorium, but using the 'technician's mix' of the sources and added reverberation levels. His comment that the apparent room acoustics the listeners heard was the work of his, more than the contribution from the room, probably is right.

During the spring time the Norwegian Opera Orchestra has recorded all the Mozart Opera overtures. The recordings were done in the new orchestra rehearsal room using close microphones. After mixing the sound the recorded music was played back in the empty rehearsal room and recorded again for the master recordings probably to make the recordings wetter. This essentially is an auralization which may be done in a room acoustical model as well.

Such close recordings could prove to be promising for use in auralizations of e.g. orchestra music. At least it should be investigated more closely.

5 CONCLUSIONS

So, how dry do the recordings for auralizations need to be?

We need to investigate this more closely, but we may draw some preliminary conclusions:

- The recording for auralizations needs to be drier than the room we want to investigate by a 'fair amount' We need to do tests to find more closely how much drier it needs to be.
- The level of the Schroeder curve needs to be lower than the IR for the room we want to investigate by at least 10dB (A hypothesis that needs further investigations)

Further I would conclude:

- The current investigations and studio practices point towards a promising possibility of using close recordings in normal rooms for auralizations of e.g. an orchestra.
- You may use your favorite music for auralizations if they sound drier than the room you like to assess.

6 ACKNOWLEDGEMENTS

Thanks Lars Strand for being positive and inspiring about the idea of doing this work. I also would like to thank Dr. Bo Engdahl for reading through this article and giving his helpful and enthusiastic comments.

7 REFERENCES

1. Eyring, Carl F. 'Reverberation time measurements in coupled rooms', J. Acoust. Soc. Am. Vol III, Number 2, 181-206 (October 1931).
2. Hill, A.P. 'Combined reverberation time of electrically coupled rooms' J. Acoust. Soc. Am. 63-68 (1932).
3. Harris and Feshbach.On the acoustics of Coupled Rooms' J. Acoust. Soc. Am. Vol. 22. No 5. 572-578 (September 1950).
4. Beranek, Leo. 'Concert Halls and opera Houses Music, Acoustics, and Architecture' Second edition, Springer verlag, (2004).
5. Gade, Anders, 'Trends in preference, programming and design of concert halls for symphonic music', Proc. Acoustics 08 Paris, 345-350 (2008).
6. Summers et al. 'Statistical-acoustics models of energy decay in systems of coupled rooms and their relation to geometrical acoustics, J. Acoust. Soc. Am. **116** (2), 958-969 (August 2004)
7. Mankovsky, V.S., Acoustics of Studios and Auditoria, Focal Press, London, pp.30-47 (1971).
8. Hall, Donald E. 'Musical Acoustics' Thir edition, Brooks/Cole, (2002)
9. Løvlid, Unni. 'Vita' CD Grappa (2005)
10. http://www.audioease.com/IR/VenuePages/vigeland.html
11. Denon, CM Digital 'Denon HI-FI check CD' (1992)
12. Bang & Olufsen. 'Music for Archimedes' (1992)
13. Wenger. 'Anechoic Choral Recordings CD/DVD User's guide' (2003)