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Simplified Room Acoustic Measurements

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Simplified Room Acoustic Measurements

Standardised room acoustic measurements are needed for concert halls etc., but they imply heavy measuring equipment. Thus, many interesting rooms are not measured. Most musicians (and even some acousticians) find that clapping and shouting in a room/hall might give an overview of the room acoustics. In the literature we even find that acoustic parameters are derived from scratchy recordings of music. Modern handheld high quality recording technology and possibilities of analysing sound files gives that one should investigate simpler (non standardised) measurements for simpler rooms/halls. This paper gives analysis of Impulse-Responses recorded from balloons, paper bags, clapping, compared with measurements taken with more academic measurement equipment.

1 Introduction

In 1998, Halmrast, at ICA/ASA in Seattle, gave a paper [1] on comparing different measuring equipment, all measuring at the same time in Oslo Concert Hall, comparing *MLS (MLSSA)*, *Separated Sine-Sweeps (DTU/A.Chr.Gade)*, and *Pistol* and an early test version of *MLS* by Norsonic. The results were that, for overall measurements of Reverberation Times, all methods gave about the same results. When comparing other parameters, like Clarity, the measurements did not agree that well [1].

The scope of this paper is not to find a new, academic method of measuring room acoustics or improve how to compare different measuring equipment. As a "clients acoustical adviser", one often find that one needs to get more "short and easy" measurements of room acoustics, for classrooms, cantina, foyers etc. that might not need to fulfil the measurements standards.
Also, we know that many sound technicians and home-studio owners would like easy measurements, but cannot afford the price of the standardized measuring equipment. Therefore easier, and cheaper software for measuring room acoustics are "free-ware" on the web. Which one should we thrust?
It is known that several acoustic consultants and even universities/laboratories have used "non-standard" methods for measuring room acoustics (Paper bags, Balloons, Hand-clapping etc) [2].

The acoustical behavoir of a ballon is described in [4], which shows that a balloon might a a relaable soubd source. The acoustics of a single handclapping is not that well described in the litterature.

Most often, room acoustic measurements were, however, still done using "costy" equipment for the on-site recording using a specialised (expencive) reciever that can be set to a specific "triggger" level before recording.

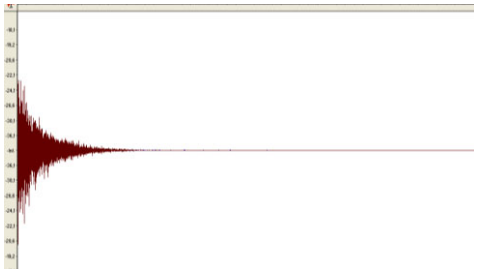
Scope

The scope of this paper is to investigate if room acoustics measurements could be done by just recording a wav. file, using a cheap hand-held "pocket-size"-flash-recorder or any other recorder available in a low-budget-studio, and then bring this impulse response for analysis in some "standardised" program that can take a Wav-file as an impulse, like WinMLS and others. This might secure that the calculations are according to the standards, even if the measurements are not. This might give a better security than just trusting a "free-ware"-program.

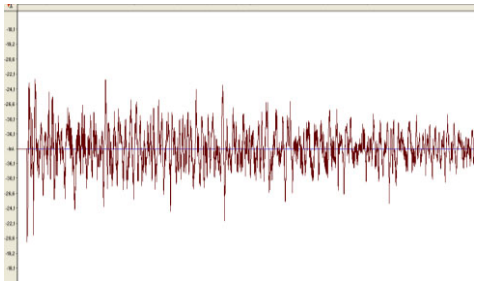
For a composer and acoustician, when being abroad, not knowing what interesting sounds or rooms one might step into, a cheap Edirol/Roland recorder, small as a mobile phone, is of great help. Probably the newer mobile phones also allow recordings of wav.-files of such a quality.
For high-quality recordings, one should of course use external microphones, but that is not the topic of this paper.
So the question is: can we get reasonably good room acoustics measurements just by bringing this light equipment: A balloon and wav-recorder: (44,1kHz wav)

2 "Trimming" the Wav.-impulse-recordings

The recorded wav-files needs to "trimmed" so as to start on the impulse of the recorded sound.
We tried several situations, and found that, for further investigations in WinMLS, the exact time of the start of the Impulse was actually not that important for RT calcultaions.
A wav-file of an impulse source (balloon) might look like this:



If we zoom in at the beginning, we see that, for this recording used, there might be a short time delay before the actual impulse:

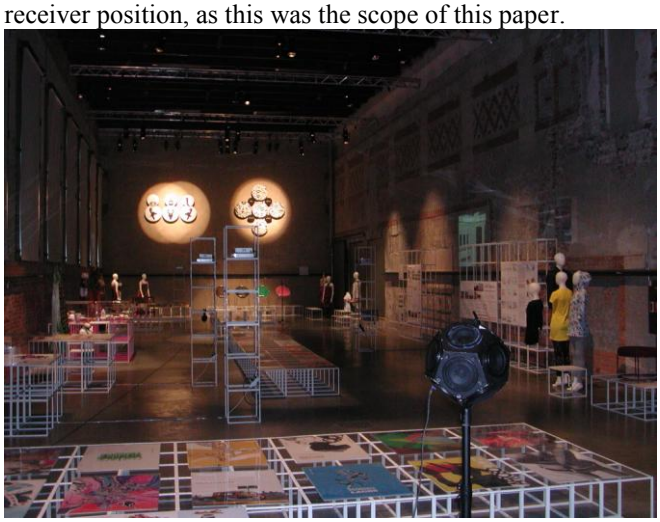


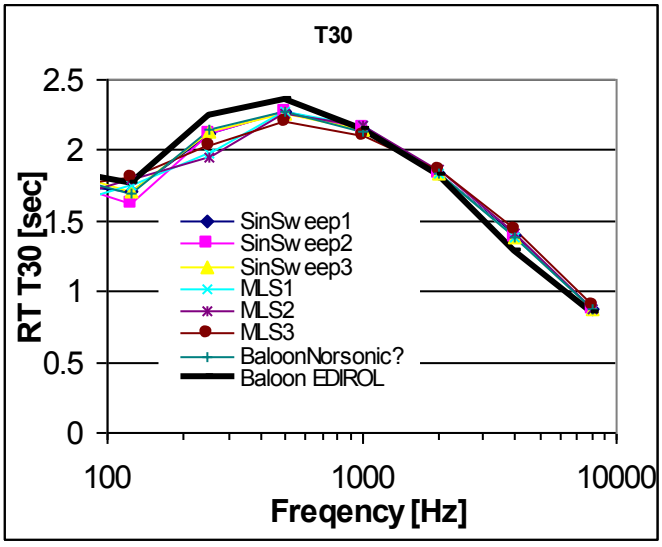
Adjusting the exact time for the START of the wav-file, did not, however; change the results of RT calculations in WinMLS much. This should be investigated further. Some results for other acoustic parameters are given in Appendix.

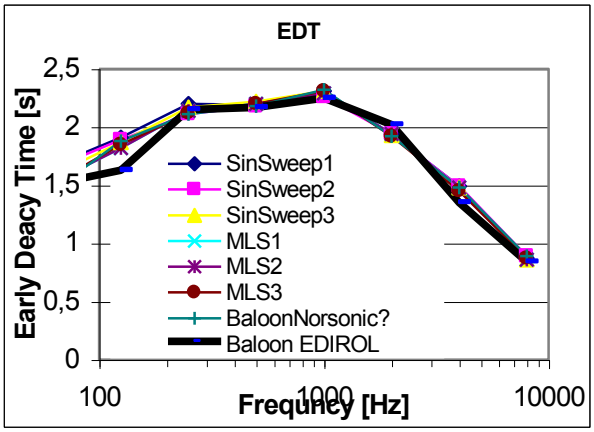
3 Some results

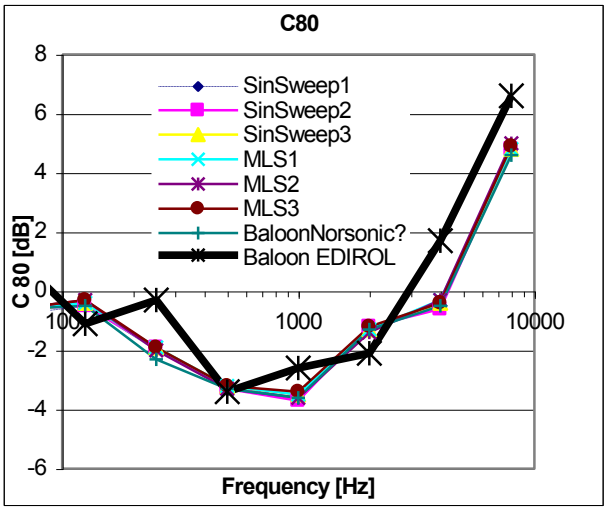
3.1 An Exhibition Hall

(L=34m, W=10m, H=9-12m)
All measurements are taken just form one source and one receiver position, as this was the scope of this paper.





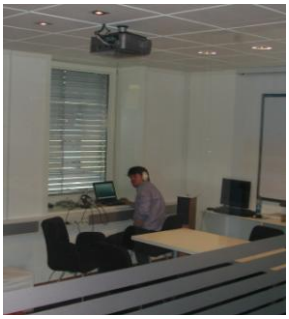




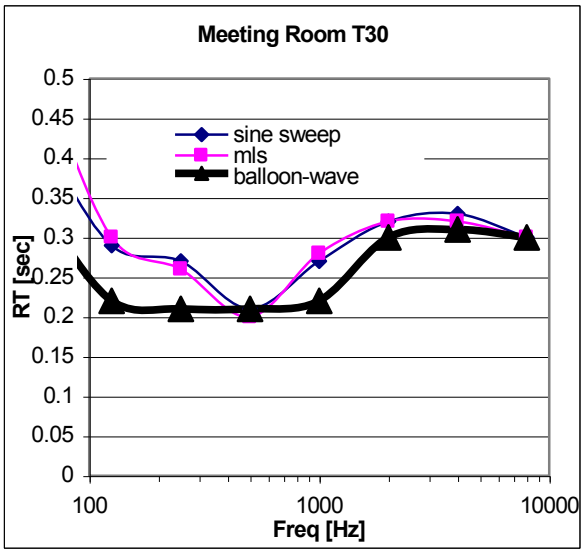
We find that the Reverberation Times (T30 and EDT) corresponds very well between the "balloon" measuements and the more standard measurments. Also for C-values, we find good agreement. (Better than for the study in [1])

3.2 A Small meeting room

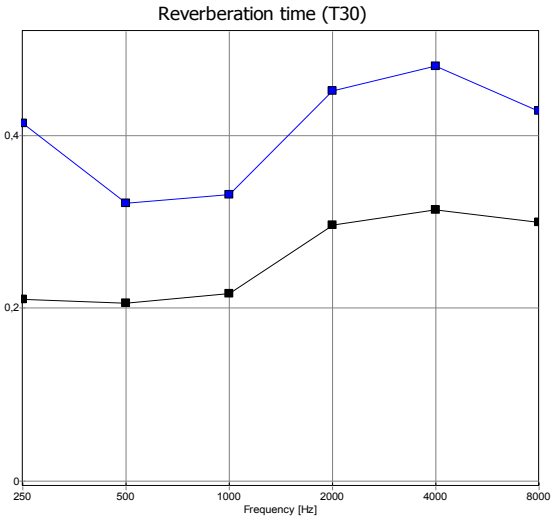
(at Brekke & Strand Acoustics)
(L=5m, W=4m, H=2,5m)



If we compare the measurements with standardised equipment (sine wave and MLS in WinMLS) for this meeting room, we find good agreement with the balloon/wave-recordings , but perhaps some differences for the lower frequencies. (Remember that these are just "one to one" comparisons of measurements of a single source and a single receiver)

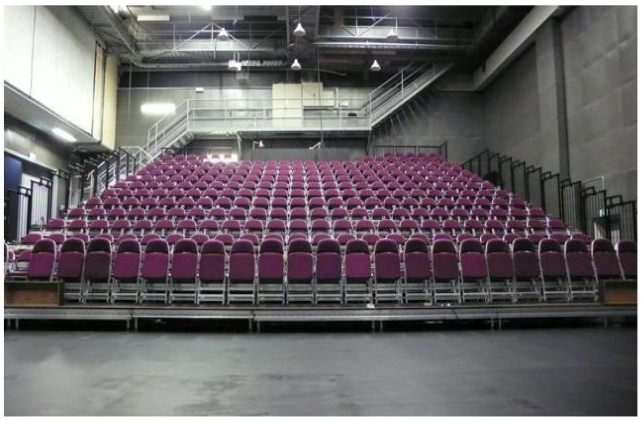


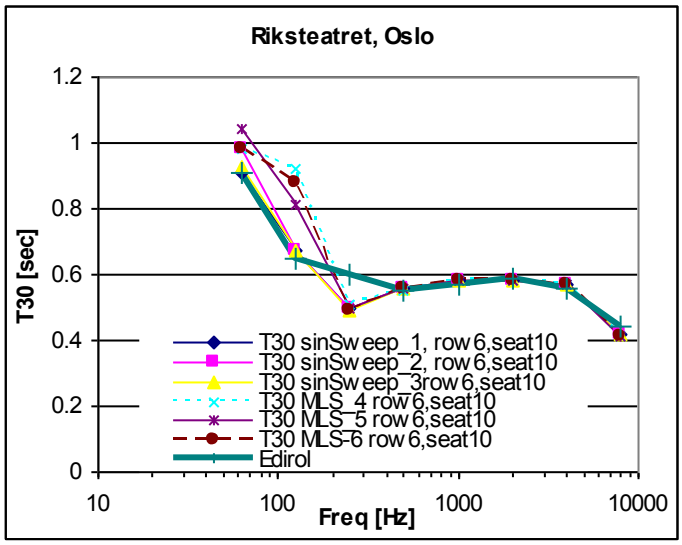
Balloon measurements of T30 for the meeting room with/without furniture, shows that the simple wav-recordings give a good indication of the change of the room acoustics, and as mentioned, such a "survey" of room acoustics for smaller rooms, is the main topic of this paper.



3.3 Riksteateret, Oslo

L = 32m, B= 19m and H = 11m

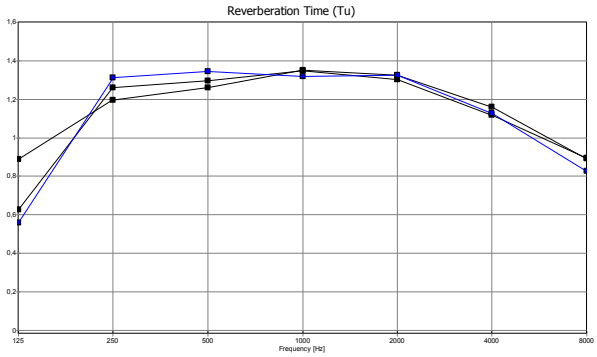




These measurments were also done just from one single position on the stage, to one single position in the middle of the auditorium. It is shown that the one point wave-balloon-wave measurement gives a good overall indication, within the deviation for the more standardised measurements.

3.4 Hand clapping

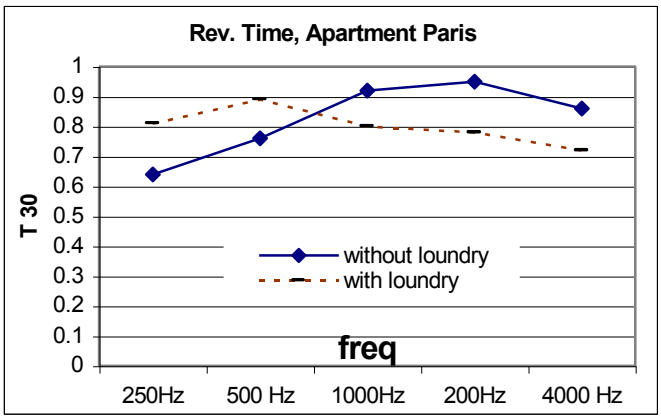
An old building, to be restored
(Munkegata, Tr.heim, Norway)
Here we see the results from three recordings of handclapping for the same source and rerceiver position:



We see that handclapping might be a realiable source for higher freqencies.

An Appartment in Paris
This example gives the usefulness of a "non academic" acoustical measurements, in an apartment in Paris, which had comments on bad acoustics/too long reverberation times. The flat was investigated with recordings of hand clapping. These were done in two settings, with and without laundry on the rail between the two floors.

When introducing laundry the reverberation time was reduced from some 0,95 to 0,80 sec. for the middle/high frequencies.



We again see (not surpring) that the results from hand clapping shows a reasonable result for higher frequencies, but somewhat more questionable for lower frequencies. (Also remember that the goal for this study was to investigate simple one point recordings)

4 Discussion

For acoustically important halls, of course the measurements should be following the ISO standards. However, we find that the standards gives that many, (smaller) rooms are not measured, due to the cost of the heavy equipment needed. Therefore, we have analysed measurements using much lighter equipment. The measurements given in this study compares the result using different measurement methods at single receiver points. Covering detials by giving averages over more source and receiver points in the hall is not an issue for this paper.

5 Conclusion

For an "overall" measurements of room acoustics, simple wav-file recordings of impulse sources like balloons analysed by a good room-acoustic software programme

shows good results compared with measurements done in the same positions with more standard equipment. This would hopefully give a larger amount of measurements of halls and auditoria, but one should forget the importance of measurements according to ISO-standards, for "important" projects/halls.

Acknowledgments

Thanks to Brekke&Strand Akustikk

References

[1] Halmrast,Tor. Gade, A.Chr, Winsvold, B;: "Simultaneous Measurements of Room-Acoustic Parameters using different Measuring Equipment. ICA/ASA98, p 347-348

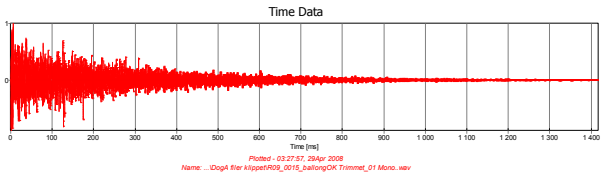
[2] Katz, Brian: "International Round Robin on Room Acoustic Impulse Response Analysis Software 2004" Acoustics Research Letters Online [DOI: 10.1121/1.1758239] Published Online 23 August 2004

[3] Defrance, G. Polack J.D..Katz, B.: "Measurements in the new Salle Playel". ISRA, Int. Symp. on Room Acoustics, Seville, sept 2007

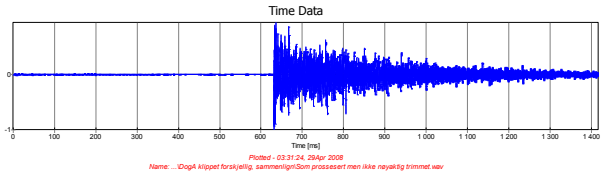
[4] Nash, Anthony: "On the Acoustical Characteristics of a Balloon", ISRA, Int. Symp. on Room Acoustics, Seville, sept 2007

Appendix:
ASPECTS OF "TRIMMING" THE WAV-IMPULSE-RESPONSE

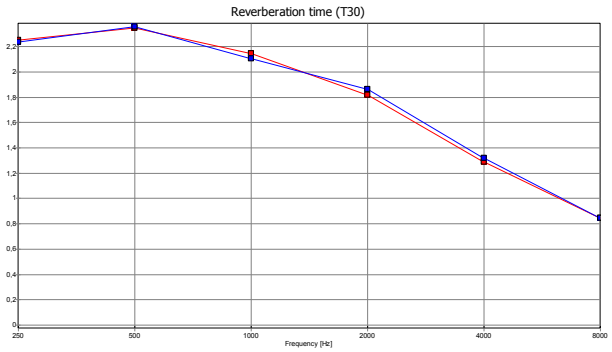
A very well "TRIMMED" Impulse Response from a balloon recording (Exhibition Hall):



A "NOT TRIMMED" Impulse Response from the same recording:



The RT (T30) calculations for the two TRIMMED" and "NOT TRIMMED " recording from WinMLS of the balloon Imp. Responses are very similar, not showing that the "trimming" of the wav- impulse response has any great importance.



However, for more detailed Room Acoustic Parameters, the wav-recorded Impulse Response should be cleverly "trimmed".

TRIMMED F(Hz)	125	250	500	1000	2000	4000
SNR(dB)	38.0	47.8	48.2	48.2	47.8	50.0
EDT(s)	1.63	2.15	2.17	2.25	2.02	1.35
T30(s)	**1.70**	**2.25**	**2.35**	**2.14**	**1.82**	**1.29**
T20(s)	1.84	2.13	2.35	2.17	1.83	1.25
Tc(ms)	123.7	133.5	176.5	168.8	152.3	87.4
C80(dB)	-1.0	-0.3	-3.4	-2.6	-2.1	1.7
D50(%)	37.1	41.4	23.8	23.8	24.5	45.9

STI	0.49
RASTI	0.40

NOT-TRIMMED F(Hz)	125	250	500	1000	2000	4000
SNR(dB)	40.0	47.9	47.9	48.2	48.0	49.4
EDT(s)	*7.65*	*7.03*	*7.30*	*7.39*	*7.31*	*8.03*
T30(s)	**1.60**	**2.23**	**2.36**	**2.10**	**1.87**	**1.32**
T20(s)	1.81	2.12	2.33	2.14	1.90	1.27
Tc(ms)	*746.6*	*766.9*	*809.3*	*803.4*	*765.1*	*722.6*
C80(dB)	*-29.8*	*-35.6*	*-40.0*	*-51.6*	*-44.1*	*-47.3*
D50(%)	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*

STI	0.48
RASTI	0.41

We see that the T30/T20 values compare quite good. The EDT, however, should NOT be measured by this balloon-wav method without a very skilled "trimming". That also goes for other, more detailed paramters like Tc, C and D. For investigating such papameters from a balloon-wav-recording, a good "trimming" is important.

(STI and RASTI seem not to be influnced much by trimming. This might indicate that these paramters perhaps might not enough detailed information, but that is another issue.)

PS! Newer versions of software for analysing wav- imp. responses will include also triggering for a "non-trimmed"-respones.