CONVERTING AN OLD BARN INTO A CHAMBER MUSIC HALL BY THE MEANS OF ACTIVE ACOUSTICS

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1 INTRODUCTION

To re-use and refurbish existing buildings as much as possible is important in a sustainable world.

This paper describes the process, and the lessons learned during a project in which an old barn was converted into a chamber music hall. In February 2015, world famous pianist Leif Ove Andsnes reached out to this author, asking if it would be possible to convert the old barn in the Barony of Rosendal into a chamber music hall, intended to be the main venue of his new annual International Chamber Music Festival, due to open in August 2016. The initial plan had been to design the acoustics by traditional passive acoustic treatment, but Andsnes feared the room would sound like "a tunnel" due to its shape and wondered if perhaps active acoustics could be part of a solution. This author accepted the challenge and was engaged as the acoustic in the project.

The task was very simple to define and very challenging to solve: 'Can you make the barn sound like a chamber music hall?'

The name of the hall is Riddersalen, translated: The Hall of the Knights.

Note: The many aspects related to different AAS principles is outside the scope of this paper and will not be discussed here.

2 METHOD

It seemed obvious to address the task systematically with the following methodic steps:

a) Build a model A of the existing room, keeping its structure and envelope, and
b) build in stage and audience in A, see Figure 1
c) Build a model B of a generic classical chamber music hall with average dimensions[1], and
d) import the stage and audience from A into B
e) Adjust the surface properties of B until parameters match with averages from classical chamber music halls[1]
f) Adjust the surface properties of A until its Room Impulse Responses (RIRs) are 3dB weaker than the RIRs of B
g) Specify materials and acoustic surface treatment with the surface properties from f)
h) Specify an Active Acoustic System (AAS) that, together with the passive acoustics of A, would combine to match e), i.e. the “ideal” acoustics represented by model B

The intended outcome is to create a virtual hall that is perceived as 11 meters high, 14 m wide, 26 m long, with volume 4000 cbm, and with an occupied RT of approximately 1.5-1.6 s, and an EDT that deviates less than 10% from T30. This intention was part of the specification of the AAS, as it went to tender.

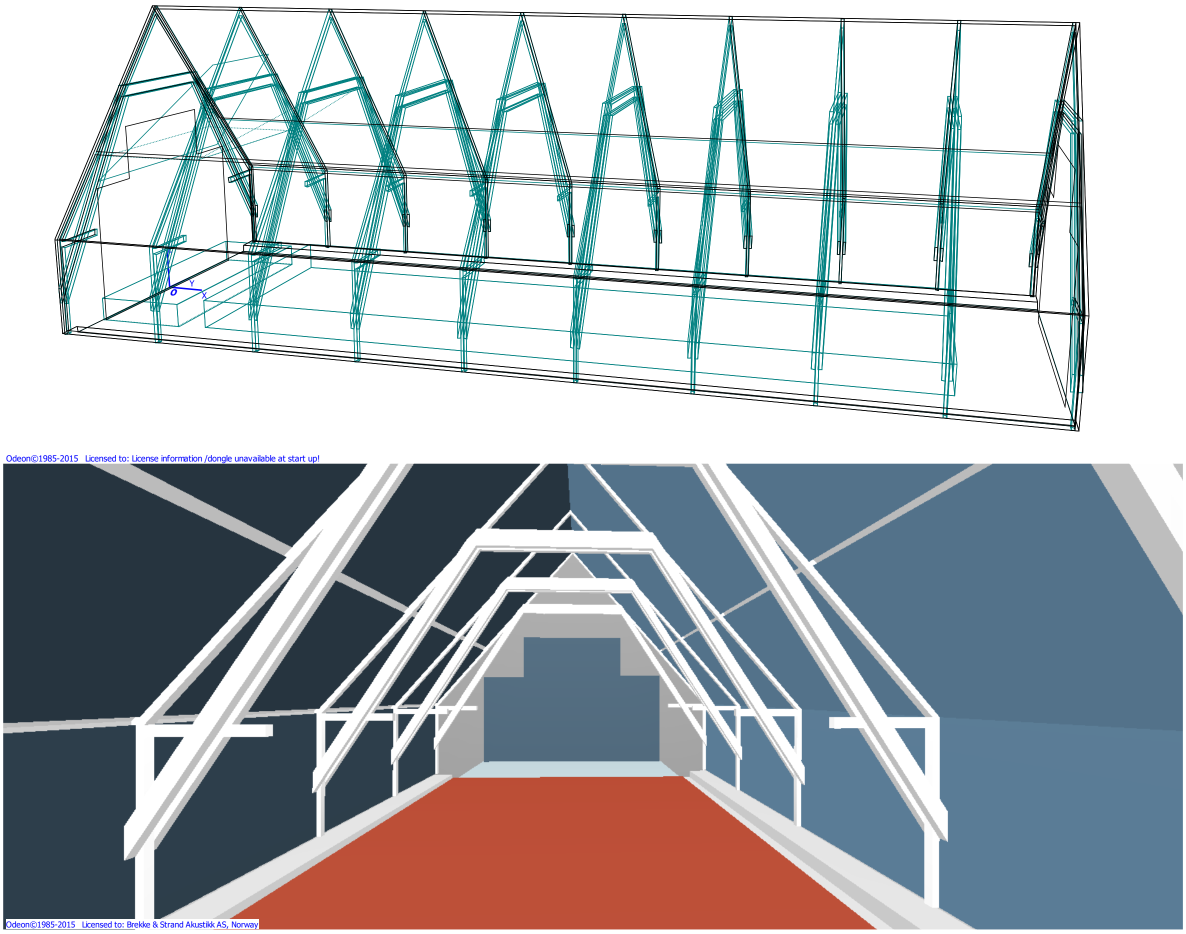


Figure 1, top, 3D model A, the main room of the barn, with a) structure, roof, walls and floor, and with b) stage and audience included. The volume of A is 1700 cbm, which is only 43% of the required 4000cbm of model B. Bottom, interior of the model.

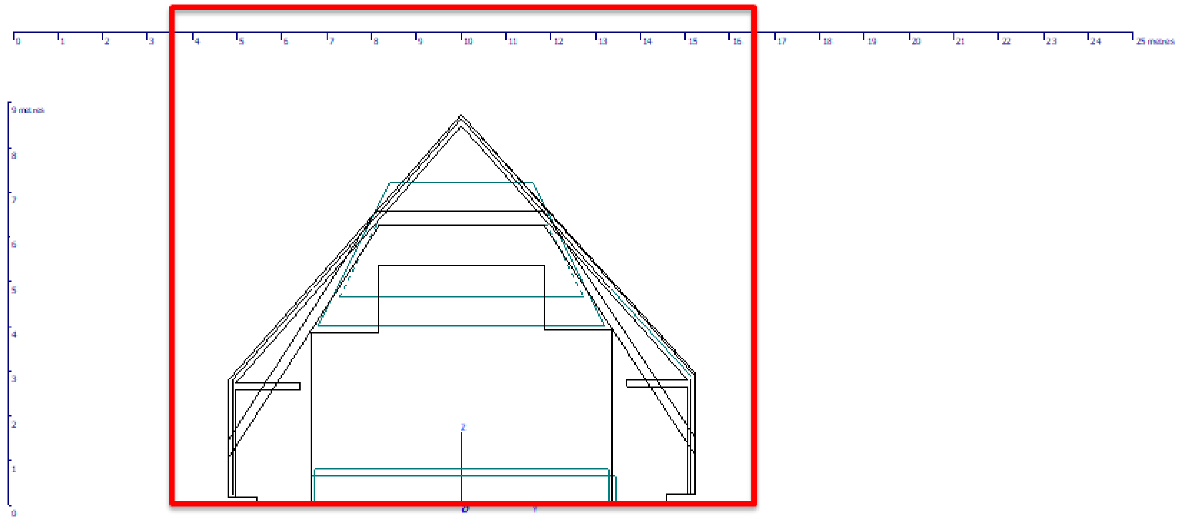


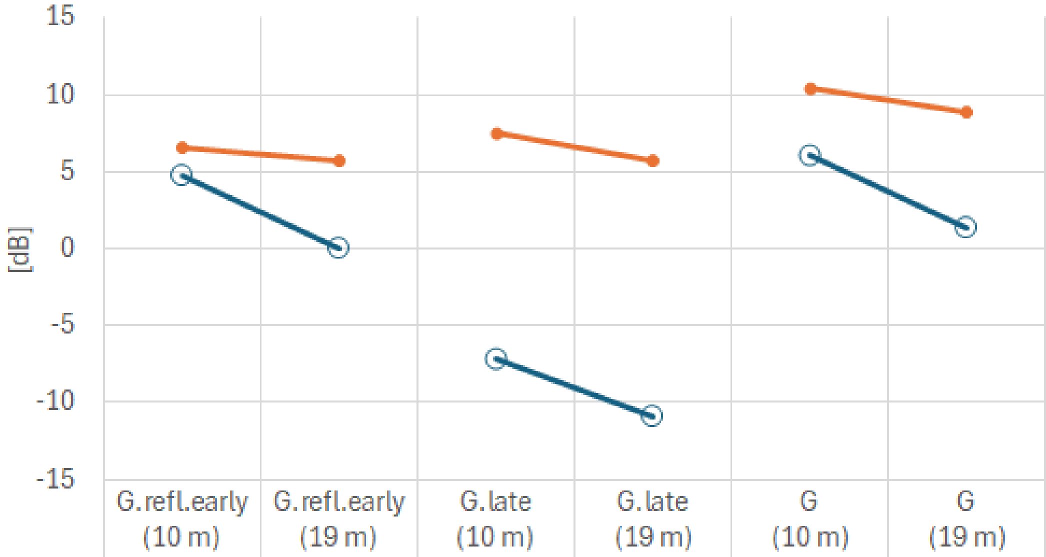
Figure 2 Overlay of cross-sections, model A and B. The red rectangle is the envelope of model B, the generic classical concert hall, chosen as the acoustic target for the project. B is a shoebox with height H=11 m, width W=14 m, length L=26 m, and a volume V=4000cbm.

3 SIMULATIONS

As expected, the original hall, model A with wooden surfaces and audience, step b), had way too much early energy, and still too little late energy. Further, as expected, there was no way to meet the target represented by model B with only 43% of the required room volume. If introducing acoustic treatment sufficiently to reduce the early energy to a suitable level, the late energy would be even more reduced. These initial simulations confirmed that there was no simple solution, and that one should stick to the plan, the method described above. Moreover, it made clear that the main challenge was to manage the early reflected energy. Late energy was already satisfying the -3dB condition in step f).

With step e) and f) completed, the G-values aimed for (with AAS ON) and the highest allowable values in the passive hall (with AAS OFF), are given in Figure 3. C80 values at 10 and 19 m are 13 and 9 dB respectively in the passive hall, and consistently 0 dB in the active hall.

Comment: While the late (>80ms) part of the impulse response requires some 14-15 dB enhancement of the reflected energy (G.late) all over the room, the need for enhanced early energy is restricted to receiver positions more than 10 m from the source on stage. In contrast to common beliefs among AAS designers, early energy boost is often not required, and should sometimes on the contrary be avoided. Of course, early energy directly affects clarity, C80-values, which appears to be a matter of taste among personnel tuning the systems.



	G.refl.early (10 m)	G.refl.early (19 m)	G.late (10 m)	G.late (19 m)	G (10 m)	G (19 m)
AAS OFF	5	0	-7	-11	6	1
AAS ON	7	6	8	6	10	9

Figure 3, Simulated G-values of early reflected energy, late energy and total (including direct sound) energy with passive hall (AAS OFF) and active hall B (with AAS ON)

4 PERCEPTION-ORIENTED INTERPRETATION

Though the peak height at the center of the room is almost 9 meters, the average height is around 6 meters due to the roof shape. Combined with a width of 10.5 meters, this forms a very narrow sound channel, indeed a tunnel-like shaped room. Even blind-folded or with eyes closed, our brain will be able to perceive the narrowness of the room, because of sound being reflected off walls and roof. A complete elimination of reflected sound is not practical in a performance, and neither is it necessary, as explained by Figure 4 and caption text.

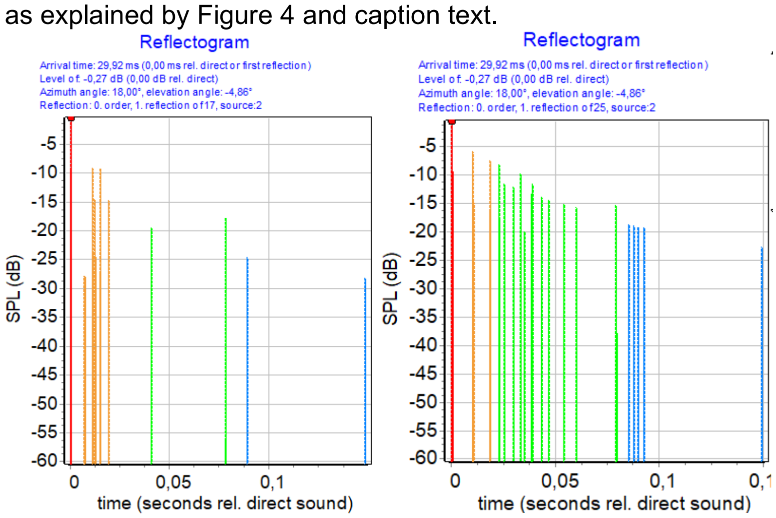


Figure 4 Reflectograms at 10m from the source on stage, in models A and B (right), show that the first prominent reflection in both models is at 11 ms, coming from the front wall (behind stage). In A there is no single lateral or vertical reflected components stronger than those in B, that could provide cues telling the brain that A is narrower than B. This allows active acoustics to mimic the early energy profile of the more spacious hall B.

5 VISUAL CONSIDERATIONS AND REQUIREMENTS

Naturally, the client had requirements for the visual impression of the hall, and wanted white surfaces on walls and under the roof. Broadband, and mid-high frequency absorbers are available in white finish from many manufacturers, but they are not very robust against mechanical wearing and tearing and were thus restricted to being used on the higher surface parts. Both visually and mechanically more exposed are the lower parts of the walls, say up to some 3 meters above the floor. For these surfaces a special treatment was developed: Wooden slat panels. Even in this solution there is a direct conflict between visual and acoustic considerations. The more effective slat panels have wider slits, while the visually more preferred panels have narrow slits or even no slits. A trade-off was necessary. At a higher production cost, the panel edges were cut at 45 degrees instead of 90 degrees, forming slats with conical instead of rectangular section. This reduces the acoustic inductance of the air mass in the slit, and in effect causing the slits to be acoustically wider than they looked like. Another important choice was to cover the porous absorber behind the slat panel with a white sheet, lowering the optic contrast between the slits and the white painted wooden panels. There is always a shadow in the slit, so the contrast can never be zero unless a grey or tanned colour is chosen for the panels.

6 TUNING THE AAS

In any room with AAS, and particularly so a room like in the current case, which is relying totally on the active acoustics, *tuning*, or *voicing*, is very important. For unknown reasons, tuning personnel tend to be clarity-lovers, often leading to a shorter EDT, thus less reverberance than wanted. However, with careful adjustment, it is possible to raise C80 slightly without compromising EDT. Related issues are the common double-slope, and the difficulties to achieve a sufficiently high G with god sound quality maintained, which both are suspected to be difficult to overcome without a certain minimum of independent channels in a regenerative or hybrid system. While most systems are able to produce a reverberation tale, audible at chord stops and sudden note ends, far fewer are able to produce an audible reverberance in running music, which is a sought-after quality of a good performance room. A double-slope is often perceived as if there is a coupled room.
The Schroeder curve is often useful in order to analyse the performance of an AAS, and in particular the aspects of C80, EDT, G.early, G.late and the total G. Given a certain decay slope as measured by T30 or even T60, the double-slope will be defined by a characteristic “knee”, i.e. at the time of transition between the initial slope and the next slope.

Theoretical examples:
If T60=1.6 s, and the knee is at 80ms with level -3dB, then C80 is 0 dB and EDT is 1.6 s, thus the knee is inaudible, and invisible in the Shroeder curve.
If on the other hand the knee level is lowered to -4dB at 80 ms, C80 will be 2dB and EDT will be1.44 s, which is merely 10% lower than T60, which is often considered OK.

Practical example (current case):
In the current case the system was voiced (tuned) by John Pellowe of Meyersond, the manufacturer of the installed system. An example of a systems sensitivity to voicing was demonstrated. At breakfast between two consecutive voicing days, we discussed possible changes in the Schroeder curve over a napkin sketch (by consultants and architects often referred to as napkin design). We met up early in the hall and after less than 15 minutes of adjustment, tweaking if you like, we it as a 2nd setting, measured the acoustics again and compared it with 1st Setting from the night before, see Table 1.

Table 1, Voicing of completed hall, two different settings, see text. Tm is 500-1k average of T30, STI is speech Transmission Index, IACCE3 and IACCL3 are 500-2k averages of inter-aural cross-correlation, early and late part of binaural impulse response BRIR, respectively.

Acoustical Parameters	Tm	EDT	C80	STI	IACCE3	IACCL3
1st Setting	2,0	1,2	2,6	0,60	0,29	0,13
2nd Setting	2,2	1,8	0,1	0,55	0,26	0,10

Reference hall	-	1,6-1,8	0,0	-	< 0,35	< 0,15

7 SUMMARY

This paper describes a project that started back in February 2015 when world famous pianist Leif Ove Andsnes reached out to this author, asking if it would be possible to convert the old barn in the Barony of Rosendal into a chamber music hall, intended to be the main venue of his new annual International Chamber Music Festival, due to open in August 2016. Soon, it became clear that this could not be done with regular acoustic treatment, while it was considered possible with very careful combination of passive and active acoustic design. So, the previous plan was abandoned and replaced with a very risky, but potentially promising, and eventually a very successful one. Lessons learned, with relevance to future projects, are presented. Importantly, among them, the methodology in which the virtual size was increased and reshaped by first building an acoustic model of the virtual chamber hall we wanted, then altering the acoustic properties of the physical room with passive measures, while specifying an active, hybrid acoustics system that together would fit the wanted acoustics of the ideal room.
Among the lessons learned was the importance of passive acoustical treatment that would reduce the early energy sufficiently, and that AAS sometimes should restrict the insertion of early energy into the room. The quality of the final result can be very sensitive to tweaking in the tuning/voicing process. A sufficient amount of independent channels (loops) in regenerative and hybrid AAS is very important for the resulting sound quality. A chamber music hall like the current one needs 14-15 dB enhancement of the late sound energy in the audience area, meaning that the system's performance will be very audible, requiring a high-quality system. Measured RT spectra ar presented in Figure 5. Figure 6 is a presentation of the project in 8 pictures.

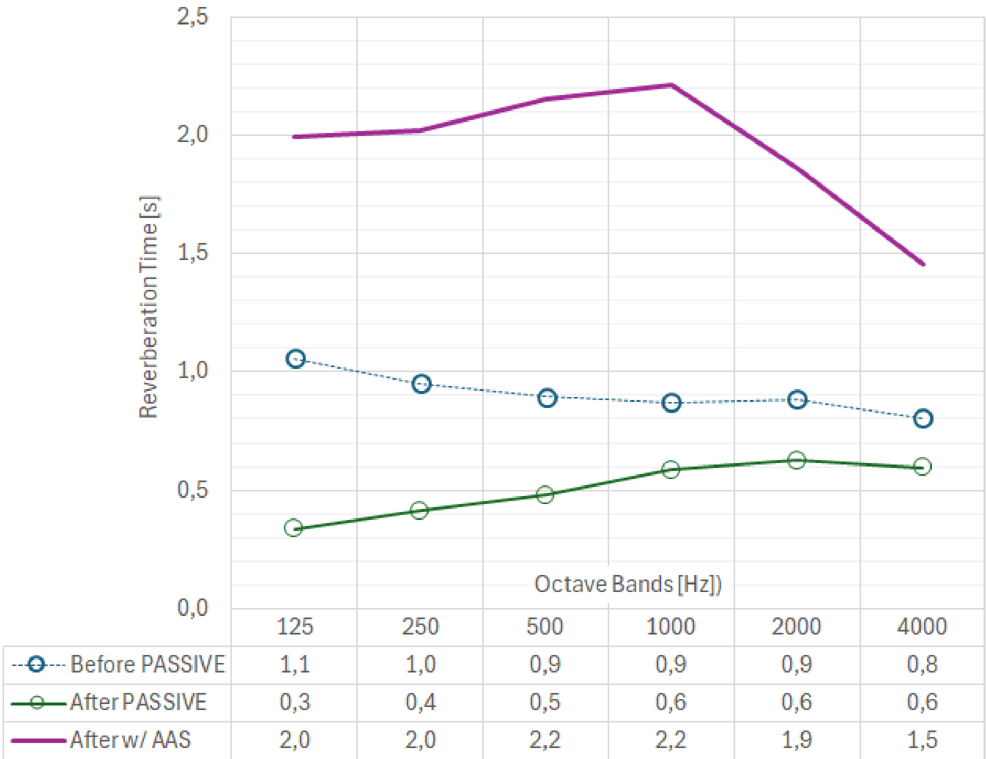


Figure 5 Reverberation time measurements before and after the rebuilding.

8 REFERENCES

1. A. Buen, Early Design Criteria for Small Multipurpose Cultural Houses, Baltic-Nordic Acoustic Meeting (BNAM), Bergen, Norway 2010
https://www.akutek.info/Papers/AB_EarlyDesignCriteriaSmallHalls.pdf

9 APPENDIX: THE PROJECT IN PICTURES


“It looks like this…”


“… can you make it sound like this?”


Completed hall with AAS


Opning night


Testing, tweaking, testing, and so on

BRIR measurements


Pianist and Festival President


Pellowe (Meyersound), Author, Erikstad (National Television Producer)

Figure 6, the project in pictures; picture 4-7 are screenshots from NRK Television