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Room Acoustic design for electronic enhancement systems

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Abstract
Within the last 10-15 years, electroacoustic enhancement systems have become a real tool to improve the acoustic conditions in multi-functional halls, both as full systems, where the total acoustic field is created electronically, and as an extension of existing acoustic conditions in the hall.

However, one common misconception is that it is possible to "repair the acoustics" or fix problems with an electroacoustic enhancement system. The fact is that good acoustic conditions are necessary for the successful implementation of an electroacoustic enhancement system.

This paper will give a brief overview of the current technology and present the typical acoustic requirement and examples of solutions
Keywords: room acoustics, electroacoustic enhancement

1 Introduction

Electroacoustic enhancement systems have been used for more 50 years, mainly as a method of increasing the reverberation time in halls. One of the first examples is the Royal Festival Hall in London, [1] where an Assisted Resonance system was installed soon after the hall was opened to increase the reverberation, in particular at mid and low frequencies. In the last 20 or so years, more elaborate systems have been in use, providing both extra reverberation but also able to generate early reflections, in other words able to create an artificial acoustic environment.

2 Typical topologies

In general, one can distinguish between two principally different approaches, In-line systems and Feedback systems [2]. However most modern systems are a combination of both approaches.

2.1 Inline systems

The Inline system is essentially creating a fully artificial acoustic environment by sampling the sound at the source (on the stage) and producing the acoustic field through loudspeakers. Examples of this are the LARES system and the ACS system. The advantage of this that the system can also produce early reflections and that it can easily be used as a part of a reinforcement system. The disadvantage is that full late reverb is also electronically generated, and at least for some system does not fully create a naturally sounding reverb.

2.2 Feedback System

The Feedback system is in a way a continuation of the early assisted resonance systems. Examples of this approach is the Carmen system. The idea is that the sound in the hall is sampled and reinforced. In other word, the existing reverberation is reinforced. This makes it quite easy to create natural sounding reverberation. The disadvantage is that the system does not provide early reflections, in other words there are no clear control of the spaciousness of the acoustic field. Some newer systems also add actual reverberators, making it possible to create longer reverberation than just by reinforcing the sound field. Examples of such system are for instance the MCR system (Multi Channel Reverberator).

2.3 Current systems

As stated above, most currently commercially available systems, use a combination of inline and feedback approach. Examples of such systems are Constellation, Vivace and Amadeus. Common for them are that they are built around a central processing unit (like the classic InLine systems) but they also use microphones in the auditorium.

3 Acoustic requirements for electroacoustic enhancement systems

As said earlier it is a misconception that an electroacoustic enhancement system can fix all acoustic problems. While it is possible to enhance reverberation in a hall with a feedback system, a system in general requires very "well behaved" acoustic conditions in the space, both concerning reverberation, reflection patterns and background noise levels.

Typically, a hall fully designed for an electroacoustic enhancement system, will be designed with the same guidelines as for a cinema. However, as these halls are sometimes bigger than any cinema (for instance LOGOMO has a maximum capacity of 3000 people), the cinema specs cannot always be used directly or rather scaled up to fit these halls.

3.1 Reverberation

For InLine and combined systems, it is essential that the reverberation time is flat with frequency. The room should not be totally "dead" as some ambience is needed to cover up any reflections from hard surfaces (doors, floor etc) and other audible reflections. But still the ideal reverberation time at least for an InLine system will be close to that of a cinema hall.

If the hall geometry provides sensible (early)reflections, it is possible to just extend the reverberation time of the hall with a feedback system. In this case the reverberation time of the hall is not so important, however again, defects in the reverberation can not necessarily be fixed with the system.

3.2 Reflection patterns

The systems cannot remove unwanted reflections but can add needed reflections. For example, any kind of echoes or flutters, will also be amplified by the system, so in case the room has this kind of problems, it will be necessary to add absorption or scattering to reduce these.

3.3 Background noise

At the systems in question are essentially reinforcement systems, they will also reinforce any background noise. This implies that the maximum permissible background noise levels, will actually be significantly less in a room designed for an electroacoustic enhancement system, than in a normal multipurpose room.

4 Design examples

In the following 3 different halls with rather different approach are presented.

4.1 G-live Lab, Tampere and Helsinki

The G-live labs in Tamper and Helsinki, are restaurants with live music. The enhancement systems used are proprietary systems designed by the Acoustics Group of the Aalto university and build around a Genelec loudspeaker system. The system is essentially an InLine system; however, it is also used for normal amplification. This means that it is possible for the sound engineer to dynamically adjust the system and use it as part of the show.

Both halls were designed with an emphases on "visual impact", using novel interior ideas, such as a stage floor in Helsinki made from glass boards/strips, glued together to make a 100 mm thick glass stage.
In Helsinki, the main acoustic surface is a thick absorption on the ceiling surface, combined with curtains, both on the stage and along the outside window wall. The height of the space is less than 3 m, meaning that the ceiling absorption proved sufficient to achieve the acoustic requirements.

Figure 1: G-Livelab Helsinki, view towards the stage

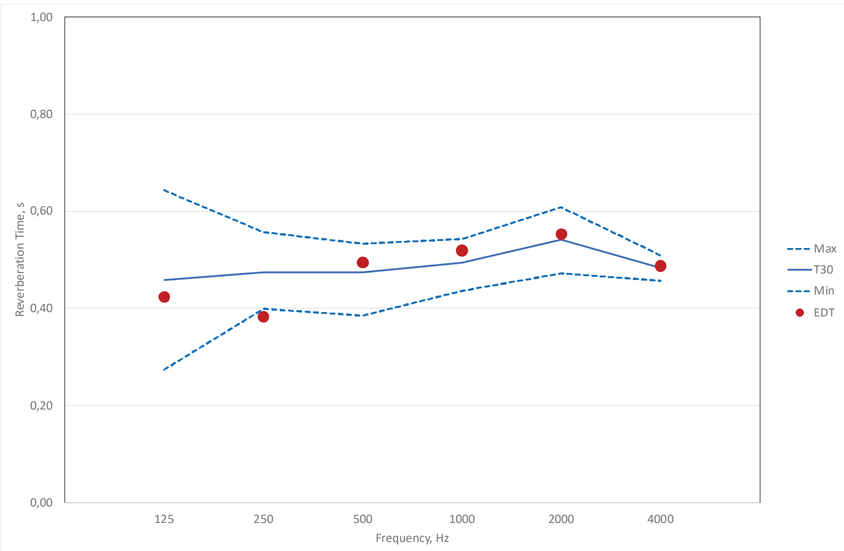

Figure 2: Reverberation time in G-livelab Helsinki

The G-Livelab in Tampere is in two floors with a vaulted ceiling. The whole ceiling is treated with a combination of mineral wool and perforated boards with mineral wool behind. The walls in the space are also treated mainly with perforated boards with mineral wool behind. Furthermore, some of the bended to provide a bit of scattering. The venue was the winner of the mondo*dr 2020 EMEA & APAC as the best concerthall in 2020.

Figure 3: G-Livelab Tampere, view from the balcony towards the stage

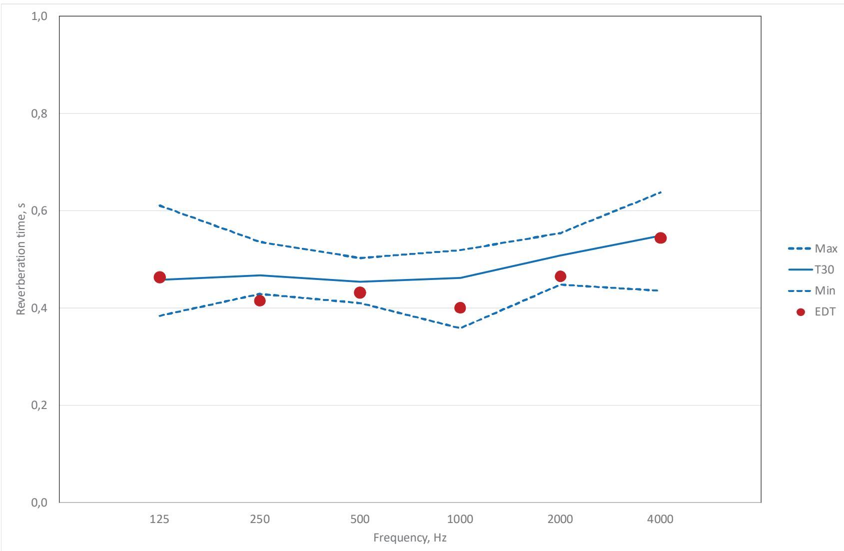

Figure 4: Reverberation time in G-Livelab Tampere

As can be seen from figure 2 and 4, the reverberation time in both cases is quite short. Both measurements are done in the empty hall, so in conditions with audience, the reverberation time at higher frequencies will be somewhat lower, in particular in the Helsinki venue. Also, other acoustic parameters showed very homogenous acoustic conditions throughout he whole space. For example, the STI_{geo} drops less than 0,15 over a distance of 25 m in the Helsinki venue and also both C_{80} and C_{50} are fairly constant within the whole space.

4.2 LOGOMO, Turku

The complex of Logomo is situated in Turku, the oldest city in Finland. Logomo is a new home for various cultural, creative and business events. The main Logomo hall was opened in November 2011. The rest of the

complex, including a further four performance arenas, studio areas, exhibition spaces, office spaces, a restaurant and workrooms for artists, was opened in 2014.
For the main hall to be suitable for differently sized activities physical versatility should be acquired a system with a massive movable seating stand that rides back and forth on compressed air cushions. The stand can be positioned in three different locations to form three configurations for the hall: small (S), medium (M) and large (L) (see figure 5).

The hall has a Meyer Sound Constellation system installed. The system is pre-programmed for the diffe
The objective for the acoustic design was to ensure sufficiently well controlled reverberation time, but also ensuring some “ambience” and, in particular in the large setting, to avoid clear echoes or audible reflections. In order to achieve this, the geometry of the backwall of the stand was optimized to avoid reflections with a combination of absorbing and scattering surfaces.

The side walls are mainly different kinds of perforated metal plates, with some additional scattering surfaces, in particular in the front of the hall.

Figure 5: LOGOMO hall in the Small, Medium and Large settings

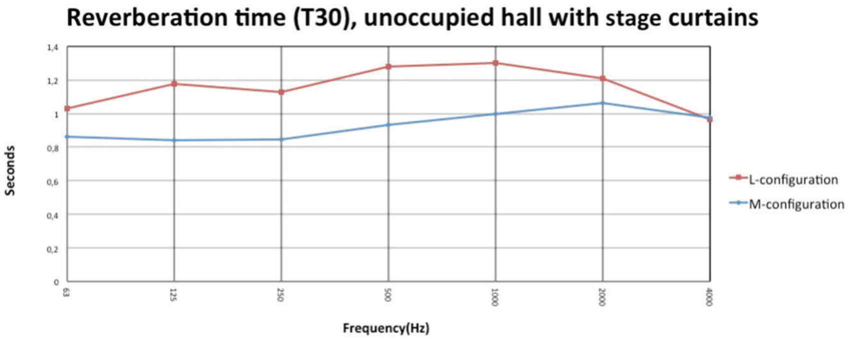

Figure 6: Measured reverberation time for the Medium and Large configuration

As can be seen from figure 6, the reverberation time does not increase dramatically even for the Large configuration. There are no detected discrete reflections or other acoustic defects in the hall.

5 Discussion and Conclusion

In this paper, a short review of the topologies of the electro acoustic enhancement systems as well as review of the room acoustic requirements for these systems are presented and 3 different venues with electroacoustic enhancement systems are presented.

It is clear that electro-acoustic enhancement system has become a tool for creating variable acoustics for multipurpose venues. There are ready made systems that will work for many halls but the use of electro acoustic enhancement should perhaps not be seen as only a question of installing a full system. It is still clear that if one is designing a dedicated concert hall, then an electroacoustic enhancement system is not the first choice.

However, it is also clear that these systems can successfully be used to extend the acoustic/reverberation in halls which are perceived as too dry for acoustic music. The important is that this will only work if the hall does not have actual acoustic defects. In other words, in some case in will be necessary to first add absorption to remove echoes/audible reflections and the use electronics to enhance the reverberation.
The advantage of the current combination systems is that they can be adapted to different conditions, and solve separate issues, such as hearing on stage or overall reverberation. The main difference compared to earlier systems, is that the sound quality is has improved to a point where it can be difficult, even for a trained listener, to detect if the system is on or not.

So electroacoustic enhancement systems is clearly one of the tools which can be used, both to create excellent multipurpose halls and also to some extend to extend the acoustic conditions in existing halls.

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