# ELECTRONIC SOUND ENHANCEMENT SYSTEM IN THE MULTIFUNCTIONAL HALL TÓNBERG IN AKRANES, ICELAND

*Stefán Guðjohnsen*

Mannvit hf.
Acoustical department
Grensásvegi 11, 108 Reykjavík, Iceland
stg@mannvit.is

*Gunnar Birnir Jónsson*

Mannvit hf.
Acoustical department
Grensásvegi 11, 108 Reykjavík, Iceland
gunnarbj@mannvit.is

## 1. INTRODUCTION

When design of the new accommodation for the Akranes School of Music began it was decided that the auditorium at the premises, Tónberg, would be a multi purpose hall. The hall was designed by Skapa and Skerpa Architects, Elín Gunnlaugsdóttir architect. Responsible for the integrated acoustical design was Mannvit hf Dr. Stefán Guðjohnsen. The hall was built by the building contractor Smáragarður with the subcontractor Húsbygg.

In the hall with 177 seats on a slanting floor, special diffusing Sound Reflectors were applied both on the side walls and in the ceiling. Acoustical model of the hall as well as calculations were performed in the Brüel and Kjær software program ODEON. The volume of the hall is very small and therefore it was soon decided that the variable acoustics would be accomplished by the use of an Electronic Acoustic Enhancement system. The system chosen for this hall was the Lexicon Acoustic Reinforcement and Enhancement System, or LARES.

In this paper the general setup and function of the LARES system is explained. The conditions in the hall after the system was implemented are described and compared with actual acoustical measurements made by the Brüel and Kjær measurement System 2250 Investigator with amplifier and Omnipower 4296 loudspeaker and software Qualifier 7830. The measurements were performed by the acoustical specialists of Mannvit hf, Gunnar Birnir Jónsson, Sigrún Ragna Helgadóttir and Stefán Guðjohnsen.

## 2. BASIC ACOUSTICS OF THE HALL

When design of the new accommodation for the Akranes School of Music began it was decided by the owner that the auditorium at the premises, Tónberg, should be a multi purpose hall. It's functionality ranging from being a lecture hall to a small concert hall.

When starting the acoustical design, it became apparent that the dimensions of the hall would pose a problem. The 240 square meter hall had an asymmetric fan shape, widening at the back, and its brute ceiling height varied from 5 to 5,8 meters. In addition to that there was a wooden beam stretching approximately 1,5 meter down from the ceiling five meters in front of and parallel to the planned stage.

First of all a way to make the hall symmetrical had to be worked out. This was accomplished by constructing the stage at an oblique angle to the boundaries of the room and installing seats parallel to the stage edge, giving the impression that the hall is symmetric. A slanting floor under the seating area was preferred even though the slope would be limited by the height to the ceiling in the back of the hall. It was decided that the height of the floor in the back of the hall would be 1,2 meters above the floor in the front with the first row 2,7 meters in front of the stage which was raised 1 meter above the floor. Using this arrangement 177 seats could be fitted comfortably in the hall in 13 rows, see figure 1 for the layout of the hall.

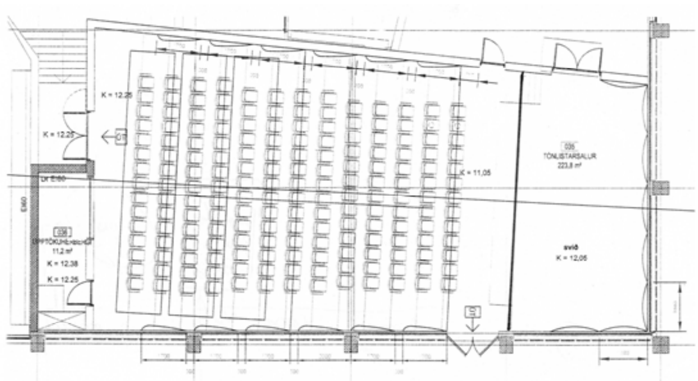

Figure 1: L*ayout of the hall after rearrangement of seats and stage for symmetry purpose.*

### 2.1. Electronic enhancement in small spaces

Considering the acoustical restrictions such as low ceiling height and therefore low volume of the hall and the low beam 5 meters in front of the stage it was soon decided that variable acoustics would be needed in the hall. To achieve this it was clear that certain basic acoustical requirements would have to be fulfilled to ensure that an Electronic Acoustic Enhancement system could improve the acoustics of the hall.

If no acoustical treatment is applied in small spaces like this, the early lateral reflections, 50 to 150 ms after the direct sound, are strong in relation to the direct sound. This results in poor intelligibility and coloration of the sound in the hall. Electronic enhancement may be added but the sound will still be muddy, see figure 2.

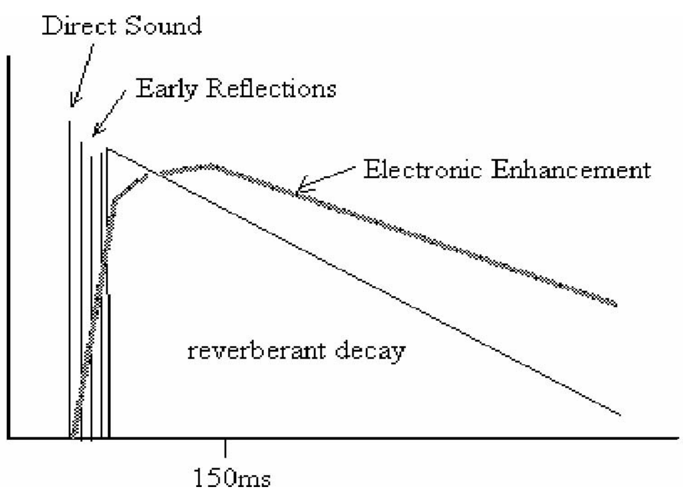


Figure 2: *Direct sound, strong early reflections and the controllable reverberant decay.*

If acoustical treatment is applied by adding absorption and diffusion on the side walls, the early lateral reflections, 50 to 150 ms after the direct sound, are attenuated in relation to the direct sound as seen on figure 3 below. After this, electronic enhancement may be added obtaining excellent results.

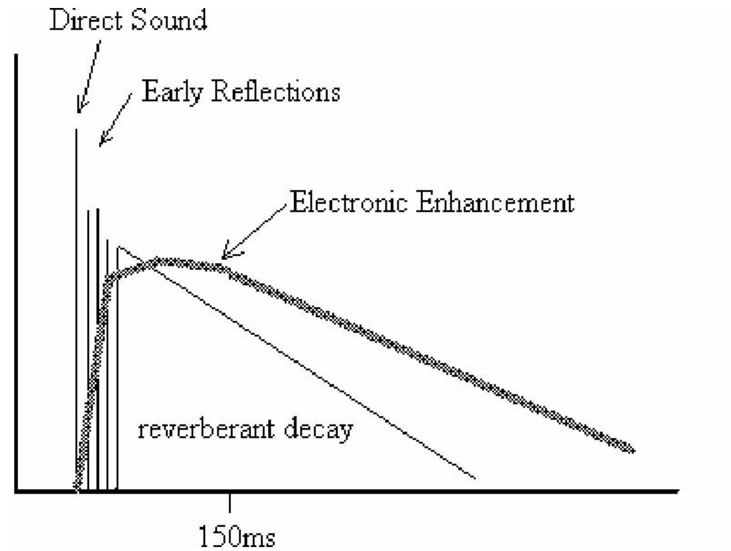


Figure 3: *Direct sound, attenuated early reflections and the controllable reverberant decay.*

**Electronic enhancement system works best**

- when the strong early reflections are attenuated in a controlled way with adequate absorption and diffusion.
- When electronics are used to supply added delayed lateral reflections and later reverberation at the proper level.
- When the basic noise level in hall is very low.
- **The result is clear, uncolored direct sound, supported and augmented by envelopment.**

### 2.2. Designing for the electronic enhancement system

Considering this, diffusing Sound Reflectors were designed and applied on the side walls in the audience area as well as on the stage. Between and above the diffusing reflectors in the audience area curved and perforated modules were installed giving both absorption and diffusion. Behind the perforated modules, running laterally above the diffusing reflectors, six high quality loudspeakers were hidden on each side of the hall. The same kind of absorbers/diffusers were also installed high on the back wall. These also contain six hidden loudspeakers.

Reflectors in the ceiling were designed and optimized with the aid of ODEON. Above and in front of the stage the reflectors are designed to reflect sound to the back of the hall. One meter in front of the stage two high quality boundary microphones were installed into the ceiling system 4 meters apart centered about the stage center. The purpose of these microphones is to feed sound from the stage into the electronic enhancement system. The low stretching beam in front of the stage was covered with thick mineral wool to prevent reflections back to the stage. The space that formed in front of the beam was then used to accommodate a theatric lighting system. Under and behind the beam the ceiling was formed as a curved diffusing area.

Acoustical model of the hall as well as acoustical calculations were performed in the Brüel and Kjær software program ODEON. The picture below shows that now the lateral early reflections have now been attenuated in relation to the direct sound.

Finally, air conditioning and heating are formed by blowing air into the cavity in under the raised section under the seats with several grills on each step with wide openings for low speed airflow thereby minimizing noise. The resulting noise level in the hall is in the order of NR 20.

## 3. THE ELECTRONIC ENHANCEMENT SYSTEM

After close consideration a decision was made to use the LARES Electronic Architecture System. **LARES** is the abbreviation for **L**exicon **A**coustic **R**einforcement and **E**nhancement **S**ystem. Basically the LARES System is programmed to control the lateral reflections and the reverberation time.
The picture below shows the direct sound, attenuated early reflections and the controllable reverberant decay

The results are that the system which is fed from the two boundary microphones complies exceptionally well with the acoustical requirement parameters needed to be fulfilled for different kind of performances.

### 3.1. LARES

In short the system is built up using the Lexicon 960L high speed DSP system with a special firmware program written by the senior Audio and Acoustical Scientist David Griesinger of the Lexicon professional division. The system also uses other DSP modules as well as multichannel high quality amplifiers, two high quality Schoeps boundary microphones and 52 more or less hidden high quality loudspeakers from LARES. The system creates controllable reverberation time and lateral reflections in the hall as well as variable reverberation time on the stage. Multiple Time Variant Reverberators – MTVR allows a small number of microphones and a large number of loudspeakers. Up to 18dB of feedback reduction can be achieved with two Lares frames **-** (each with 8 independent reverberators.)

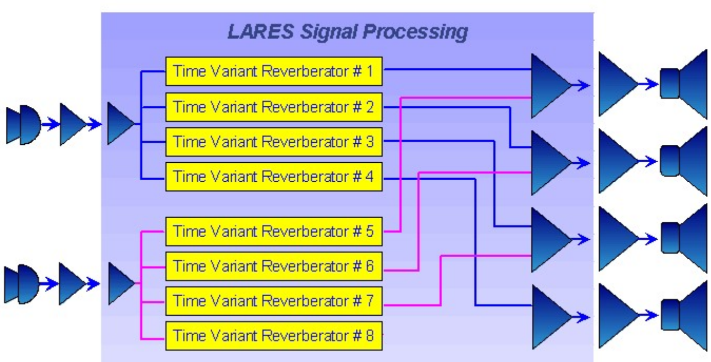


Figure 4: *Lares multichannel time Variant Reverberators.*

The LARES Electronic Architecture system, the first system of its kind in Iceland, was installed in the multi purpose hall Tónberg by the contractor HljóðX in Reykjavik Iceland and then commissioned by Mannvit hf Dr. Stefán Guðjohnsen and finally commissioned and tuned by the highly experienced Audio and Acoustical Scientist Steve Barbar from LARES.

The system is controlled by a Crestron remote control system. From the control pages on the Crestron System, one Control Panel on the stage and one in the sound control room, the system is turned on and off in sequential way and then the selection of reverberation time.

The natural reverberation time in the hall without the system being turned on is around 0,75 seconds.

Then the following reverberation time is selectable:

- Acoustics of a lecture hall with reverberation time around 0,9 seconds keeping full speech clarity and high STI for listeners in every seat of the hall without any close microphone
- Reverberation time around 1,2 seconds - Rhythm music
- Reverberation time around 1,5 seconds - Chamber music
- Reverberation time around 2,4 seconds - Large Opera hall
- Reverberation time around 3,2 seconds - Church
- Reverberation time around 6,5 seconds - For demonstration
- Reverberation time around 12,5 seconds - For demonstration

The conditions in the hall after the system was implemented have been described and are here compared with actual acoustical measurements made by the Brüel and Kjær measurement System 2250 Investigator with amplifier and Omnipower 4296 loudspeaker and software Qualifier 7830.

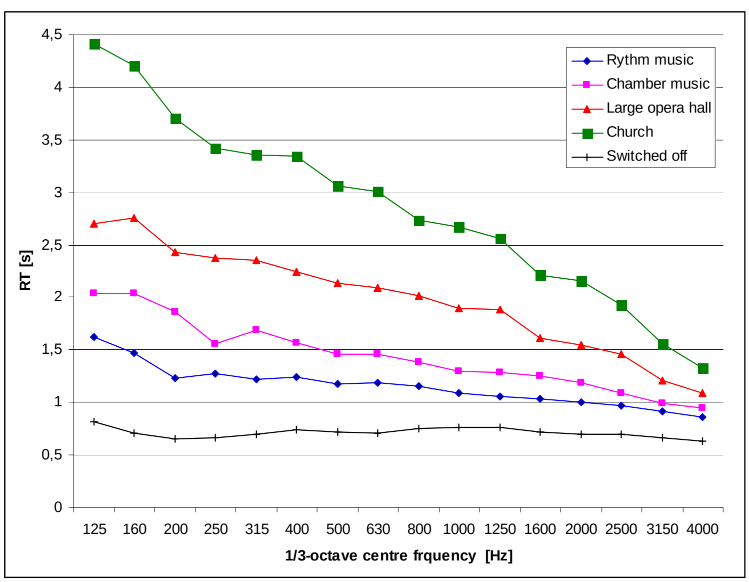


*Figure5: Reverberation time measurements in the hall with different system settings.*

To be able to fully evaluate the hall quality for different uses one would have to measure the following parameters with all the different settings of the Electronic Enhancement System and compare the results with the requirements for different type of performances.

- Bass Ratio (BR) - comparable to Warmth
- C80, C50-Clarity - clarity for music and for speech
- Diffusion - no distinctive reflections
- EDT - early decay time in seconds
- RT – reverberation time in seconds
- ITDG, t1 - time difference at a listening position between direct sound and first arriving reflection in milliseconds
- IACC - Intraoral Cross Correlation Coefficient
- Closeness - evolvement
- Spaciousness - wideness
- ST1 - Stage Support for musicians on stage
- Strength G - Difference between sound pressure level SPL in dB at listeners ear and SPL 10 meters away from sound source on the stage
- Texture – measure of listeners experience when the direct sound arrives at his ear followed by many different reflections before the reverberant decay

At Mannvit there is an ongoing study to evaluate the above parameters, using the DIRAC software from Brüel and Kjær for measurements and calculations.

Another extremely important way is to have trained listeners listen to different performances with the Electronic Enhancement System set to suitable program and have the listeners judge the acoustical quality.

The hall has received favorable critique in case of many different performances, from conferences to different form of concerts.

Following are photographs taken in the hall:

*Figure 6: Seats in the hall, diffusers/reflectors on the walls with hidden loudspeakers- ceiling*

Figure 7: *Hall seats seen from the stage* - *Reflectors* - *theatre lights* - *16:9 native projector*

.

Figure 8: *Stage with group of musicians testing the acoustics in the hall*

In figure 8 above a group of strings are performing testing the hall. On each side of the stage a pair of high quality linear array loudspeakers may be seen as well as subwoofers under the stage on each side. These loudspeakers are not part of the Acoustic Electronic Enhancement System, but are used for live performance cases as Sound Reinforcement System. Along with the 18 lateral surround loudspeakers the system forms a complete Dolby Surround Movie System. In the middle of the stage is 5 meters wide screen for DVD performances and for Power Point presentations.

## 4. CONCLUSION

The conclusion is short. From the comparison of the performance and critique of the hall for various types of conferences and concerts and the actual study of the measured acoustical parameters, it is clear that the Akranes School of Music owns a high quality multi functional lecture and conference hall.

Since the inauguration of the hall TÓNBERG on November 17th 2007, many conferences and around 100 concerts have been held there.

## 5. REFERENCES


[1] David Griesinger and Steve Barbar "Recent experiences with electronic acoustical enhancement in Concert Halls, Opera Houses and Outdoor Venues." *www.lares-lexicon.com 2007*

[2] *Stefán Guðjohnsen" Hljómburður Tónleikasala" Árbók VFÍ/TFÍ 2002*

[3] *Stefán Guðjohnsen"Samþættur hljómburður – Sýndarhljómburður fjölnýtisala" Árbók VFÍ/TFÍ 2004*

[4] *Steve Barbar " Acoustic Enhancement" SVC April 1, 2005*

[5] *Anthony Tommassini – New York Times " Enhancing Sound in a Hush-Hush Way" August 18, 1999*

[6] *Sigrún Ragna Helgadóttir "Schroeder Diffusers" 17-19 August 2008*