Acoustic Computer Model – An Example Of Application: Grand Auditorium Rainier III in Monte-Carlo

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ABSTRACT: The architecture of the Grand Auditorium of Monaco is well adapted to a use as a congress hall, but is not to classical concerts. To correct this problem, the authors do not favour an electro-acoustic solution because such a system is used in Grimaldi Hall and gives bad results.
Solutions to obtain natural acoustics in this room are thus proposed: change of the acoustic treatments, of the seats… The models made it possible to display, step by step, the future results. The acoustic performances measured before and after works are given. These measurements confirm that the solutions proposed make it possible to meet all the acoustic criteria of quality listening to classical concerts in this room.

1. CONTEXT OF THE RENOVATION

This hall built some twenty years ago was designed to accommodate congresses and also classical concerts. The design of the volume as well as of the coverings of this room proved satisfactory in its exploitation in congresses but not in classical concerts.
For this reason, our suggestion in the framework of the renovation of the CCAM (Centre de Congrès Auditorium de Monte-Carlo) was to find solutions to give back natural acoustics to this hall necessary for classical concerts and thus to receive the Monte-Carlo Philharmonic Orchestra under good conditions.
To this end, we set up a computer model based on the room acoustics programme developed by our company for 15 years, Hall Acoustics.
This enabled us to:

- Demonstrate the possibility to go back to an optimal, natural internal acoustics in order to receive orchestras.
- Design new coverings, furniture and orchestra shell.
- Display the contribution of each element taken separately, thus justifying every solution of modifications required in this hall.

Only existing cylindrical diffusing elements are still in place, for which the model showed the need for their replacement by large flat tilted panels. This last phase of works will make it possible to finally reach an optimal internal acoustics quality to receive symphony orchestra concerts.

2. SITUATION BEFORE WORKS

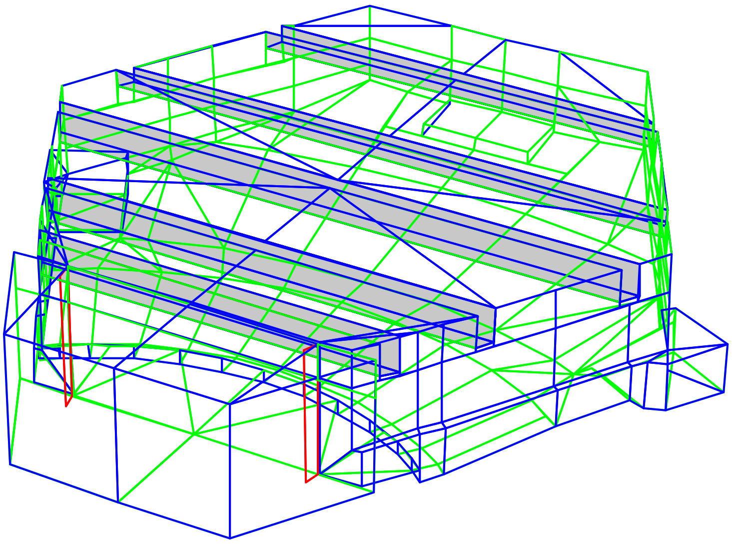

Figure 1 - *Existing volume with ventilation shafts and bridges*

EXISTING RESPONSE

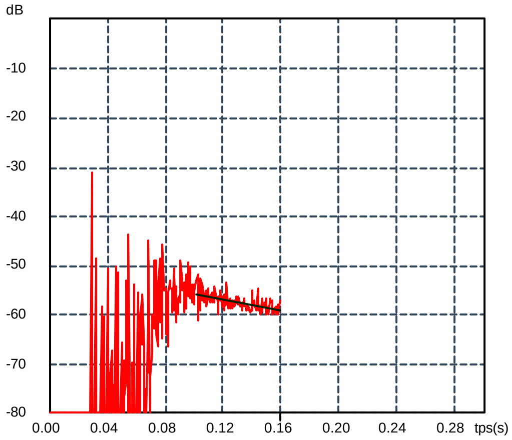

Figure 2 - *Echogram at 1000 Hz, T60 = 1.08 s*

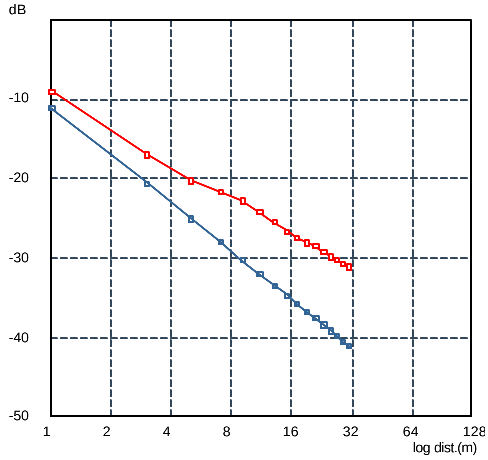

Figure 3 - *Attenuation with distance –4.2 dB/doubling distance*

The problems of this hall are:

- Very low reverberation, hence a feeling of dryness
- High attenuation with distance, hence a low loudness in the middle and the end of the hall
- Wrong perception of the orchestra by the conductor.

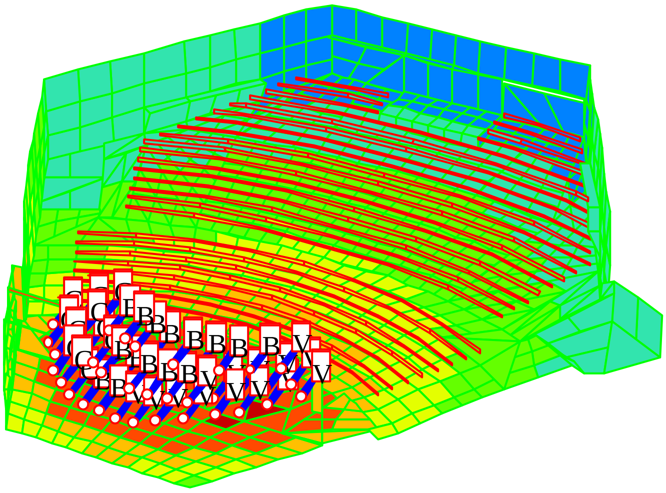

Figure 4 - *Sound coverage by an orchestra 3 db(a) / colour change*

In order to make this hall's acoustics compatible with its use as a concert hall, the required works are:

- Change of all the panels of the front and side walls. Replacement by flat and tilted panels.
- Removal of the ventilation shafts located in the ceiling.
- Lightening of the existing footbridges.
- Diminution of the stage frame with removal of the vertical panel and grille.
- Smoke extractor above the stage.
- Installation of an orchestra shell.
- New reflecting stage front panel.
- Change of the seats and integration of raisers as acoustic reflectors.

In the current state of works, the change of the front side walls panels is not made. The results of measurements carried out on 27 February 2002 are presented in table 1.

Parameters at 1000 Hz	T60 (s)	Clarity (dB)	Definition (%)	Attn w/distance (dB/dd)	Gmid (dB)	Lateral Fraction (%)	
						Orchestra	Audience
Acoustic performance	1.5 to 1.70	1	45	-2.9	6.6	16	13

Table 1 - *Project phase, T&A version, orchestra shell configuration*

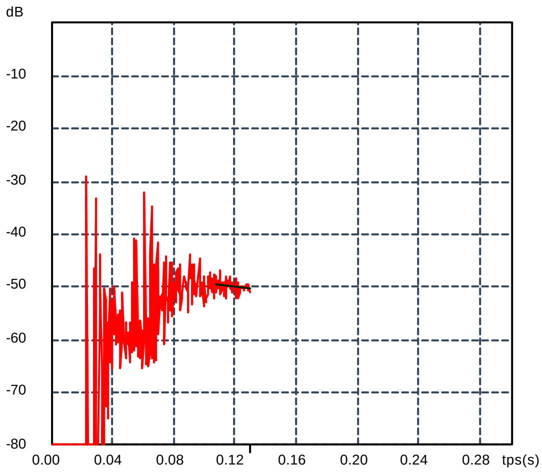

Figure 5 - *Echogram with and without acoustic raisers on the seats: 0.2 second increase*

3. INITIAL DESIGN BY TISSEYRE & ASSOCIES

3.1. Installation of an orchestra shell

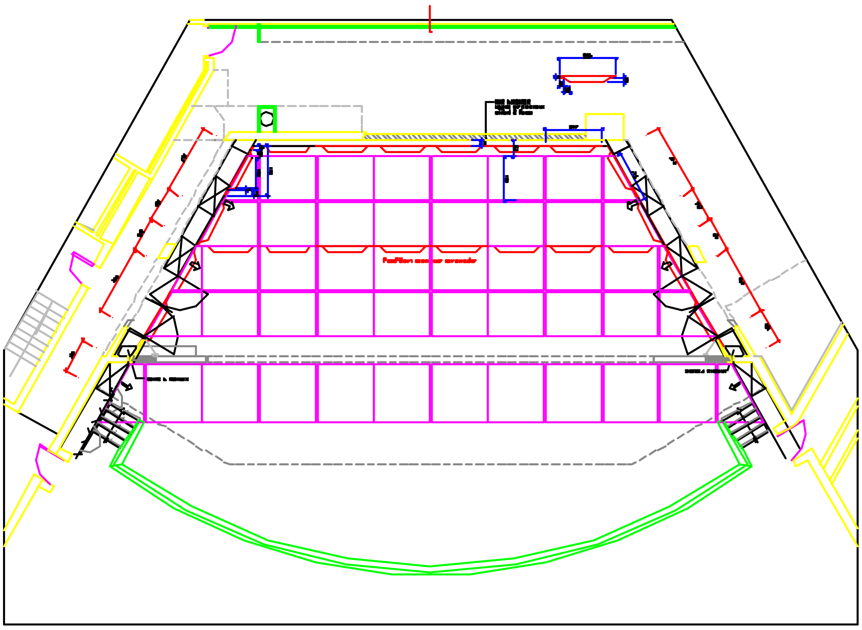

Figure 6 – *Drawing of the orchestra shell*

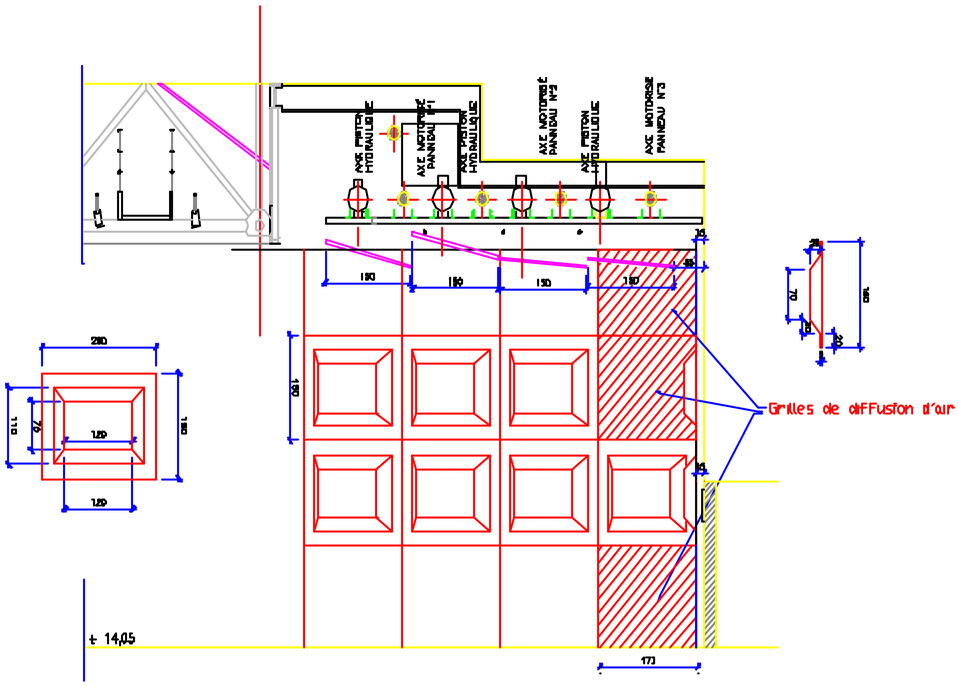

Figure 7 – *Details of the orchestra shell*

3.2. Change of seats

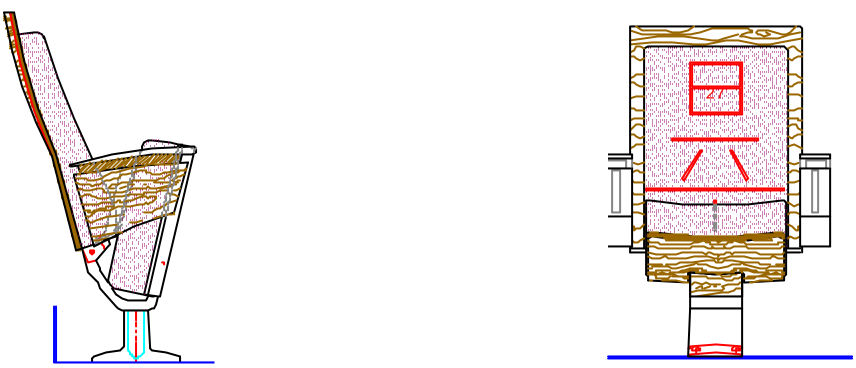

Figure 8 – *Standard seats, α = 0.9 (1 kHz)*

Figure 9 – *Modified seats with raisers, α = 0.7 (1 kHz)*

3.3. Final seats

Figure 10 – *View of the seats with raisers*

3.4. Change of the wall coverings: reflecting panels

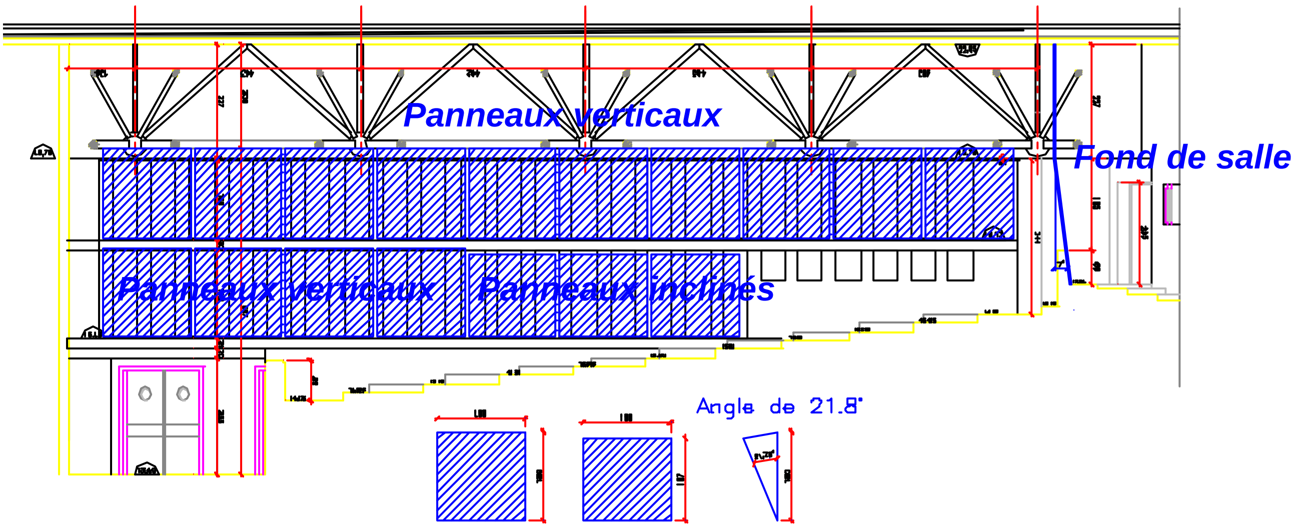

Figure 11 – *Drawing of the reflecting panel*

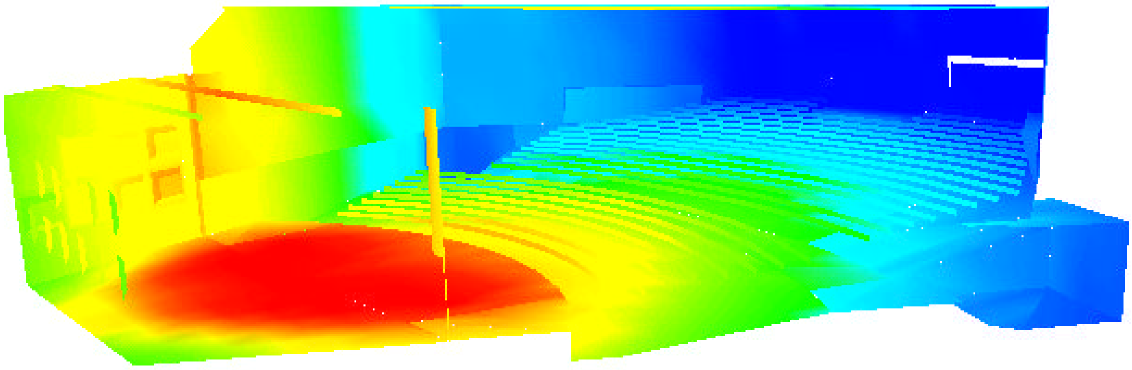

Figure 12 - *Sound coverage, symphony orchestra – 2 dB(A) / change of colour*

4. PHOTOS OF THE HALL AFTER TRANSFORMATION

5. ACOUSTIC PERFORMANCE AFTER THE FIRST CONSTRUCTION PHASE

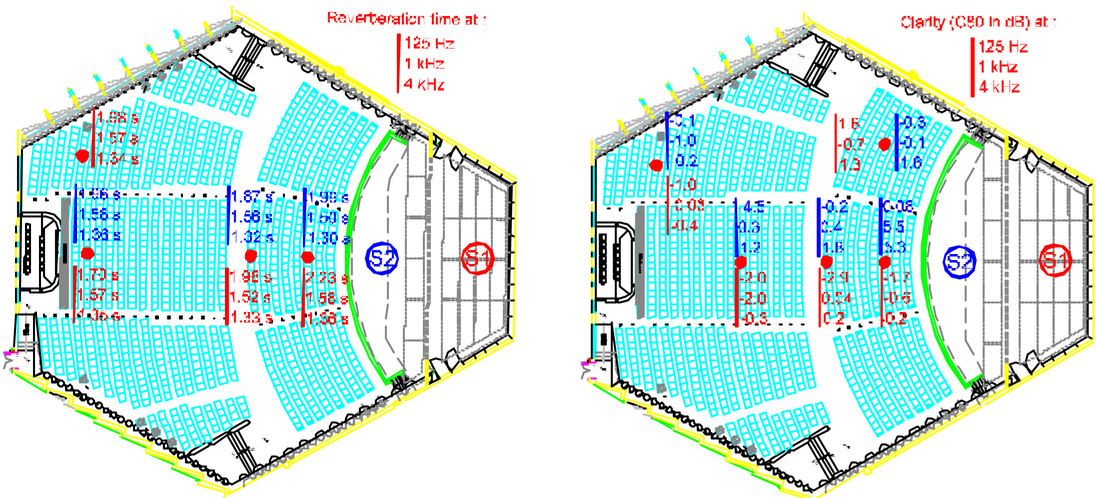

Figure 13 – *Reverberation time (left), and clarity (right)*

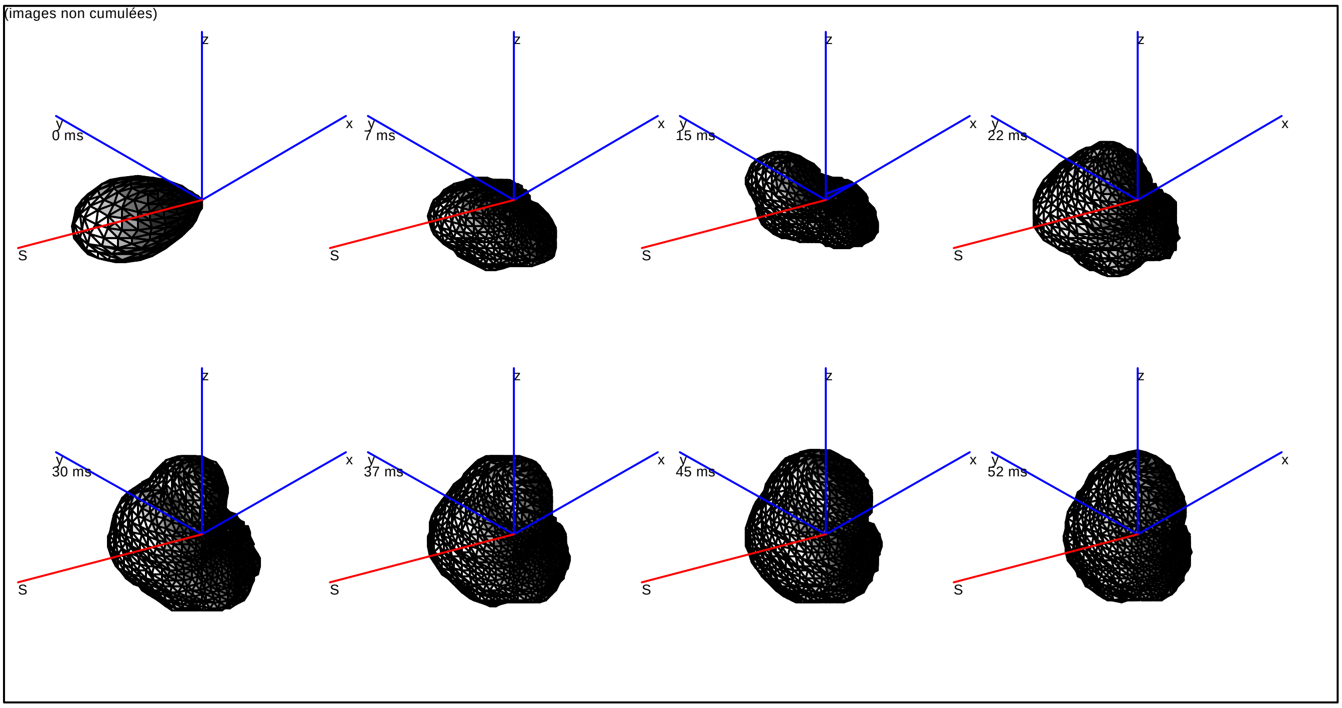

Figure 14 - *Reception directivity in large formation (reception point on right side of conductor). Version Tisseyre & Associés*

6. CONCLUSION

Measurements confirm the results obtained by calculation:

- The 1 kHz reverberation time is increased from 1-1.1 s to 1.5-1.6 s. Changing the wall panels will ensure the optimal value of 1.7 s.
- Sound coverage is improved, from – 9 dB(A) (from first to last row) to the optimal value of – 3 dB(A)
- The loudness is increased from + 3 dB(A) to the optimal value of + 8 to + 9dB(A)
- The clarity is lowered from + 4 dB to – 1 dB
- The lateral fraction is not modified.

These measurements confirm the quasi-compliance to all the objective criteria with respect to its use as a symphony concert hall.
This hall will be highly satisfactory for small ensemble concerts. In order to reach the same goal for symphony concerts, it is necessary to increase the reverberation time and the lateral reflections by changing the front and rear wall panels (as defined in our initial study).