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Diagnosis of an historical performance hall: case study

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DIAGNOSIS OF AN HISTORICAL PERFORMANCE HALL: CASE STUDY

Abstract
The Opera of Vichy is an historical Italian style performance hall. Initially solely devoted to opera performance, the economical trends have pushed towards concert and theatre. A first major refurbishment was performed in the 1990s and prior to that a diagnosis of that hall was performed in order to characterize the acoustics of the facility prior to actual work being carried out.
While the historical preservation constraints did not allow for much acoustical work to be performed, the hall proved to be quite decent. However, in order to improve the intelligibility for theatre purposes, a new diagnosis was recently carried out so as to support the relevant computer simulations.
After a brief reminder of the historical background of the project, this paper submits the diagnosis procedure that was followed, as well as its main conclusions regarding the fitness of the hall for the various performances.
It turns out that such a diagnosis can be a convincing tool in order to help both the design team and the end user understand the implications - and the limitations too - of the existing facility and its possible developments.

1 Introduction

For a long time, the French town of Vichy used to be a fashionable thermal facility, where leading citizens and princes would go. This accounted for the presence of a large casino which was completed by an opera in 1902. Due to the significant public, the resident orchestra during the summer season was typically made of musicians from the Paris Opera, as well as from invited artists from all over the world; 90 shows would typically be performed each summer [1]. In 1935, an international congress of composers was held there under the chairmanship of Richard Strauss.

By the 1970s, the fashionable and rich public was gone, and the opera was enjoying the slow tired life of a provincial theatre, till a fire did some damage in 1986. However, in 1987, the township bought the facility from the state and started a major refurbishment of the facility, which culminated in a closure for heavy work.

Nowadays, the opera has been restored to its prime glory, complete with yellow velvet seats while the paintings on the walls and ceiling were cleaned.

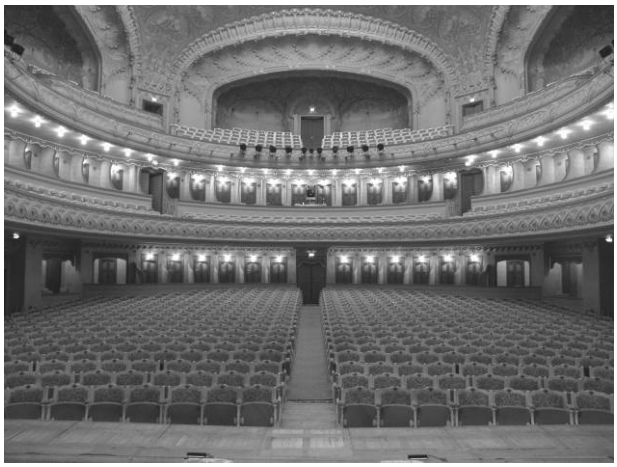
Prior to this restoration, an acoustical diagnosis of the facility was performed, as a reference point, though the historical preservation ruled against any improvement of the existing acoustical conditions.

Recently, another diagnosis was performed, in order to assess the feasibility of a reinforcing sound system. Both diagnoses will be discussed in this paper**.**

2 The Opera Hall

Designed by architects Charles Lecoeur and Lucien Woog, this facility can seat over 1400 over the floor level and two galleries. It features honour boxes by the fore stage, as well as smaller boxes at floor level and mid-upper gallery. With a 12 x 15 m stage in a 23 m high stage tower, and its orchestra pit, the facility can accommodate all great works.

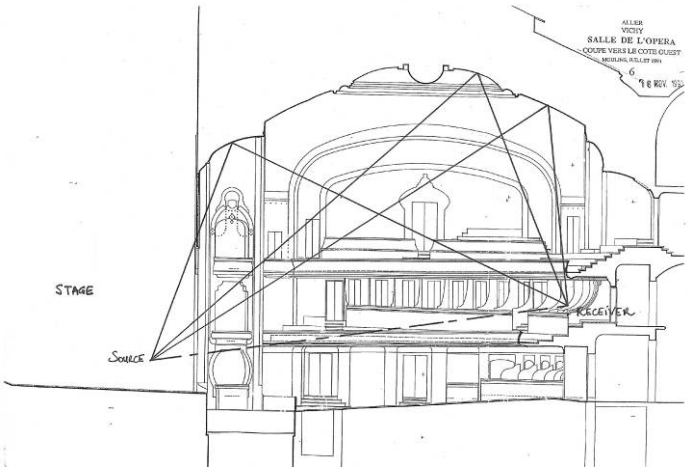
However, it also does feature a cupola over the middle of the facility. The conjunction of this cupola and the galleries sometimes makes for surprising auditory effects, and the front seats of the middle of the mid-upper gallery are well known for echoes.



,Fig.1 View from the stage.

Operation prior to rehabilitation

While the opera was used for its intended initial use, it also was used as a concert hall. Due to the rather small distance to the industrial city of Clermont-Ferrand, such concerts were quite well attended, with the full capacity of the hall being put to good use. Of course, some limitations of the hall, like the appearance of the echo or some strange spatial effect, could be felt now and then. This was especially sensitive when a soloist would start playing on one side of the stage and everybody at mid-upper gallery would then turn in the opposite direction looking for that lone instrument player in the audience!



,Fig.2 Cross section of the hall illustrating the echo phenomena due to the cupola.

Improving or not improving: historical landmark versus usable space

The township had long planed a refurbishment of the whole building, in which the former casino would be turned into a congress centre while the opera would be used as both a plenary hall and an opera and concert facility. This meant that the acoustics had to be improved in order to try and improve the intelligibility and get rid of that echo.

However, while the former casino enjoyed a limited protection status by the Ministry of Culture, that was mainly limited to the preservation of its roof and facades plus a couple of specific rooms, the opera was under full protection, including the inside spaces. However, as serious work was to be performed on the walls and galleries, it was quite an opportunity to try and insert some absorptive or diffusive material. The management was of course quite receptive to it. Not so was the Architect in charge of Historical buildings, who flatly stated that the sometimes bad acoustics of such a place was just part of the historical feeling of the place! Just to make his point, he cynically pointed out that to him it really was not a problem that the facility would close down as long as the original appearance and characteristics were kept!

So, one could forget about any hope of significant acoustical improvement. The seats were changed (according to the original design at the upper gallery, and according to the more comfortable upholstered arrangement in effect later on – this one being allowed on the grounds that it had rather quickly been implemented). The parquet was thoroughly refurbished, and the paintings were refreshed, while the old creaking doors were rebuilt as the originals.

Of course, no provisions were allowed for the hanging of a curtain along the curved back wall, nor any provisions were allowed either for the hanging of additional loudspeakers for an eventual acoustic reinforcement. One had to try and make do with the available acoustics. Needless to say, the famed echo was still as present as ever.

Feeling again the limitations: the need for more work

Ten years later, the operation of the Opera hall had slightly evolved: while it still was used as an opera and concert facility, there clearly was a market for theatre performance. This means a better intelligibility than for music. Usually, the best seats are considered to be found in the centre of the hall at orchestra level. However, it was often felt by the audience that the intelligibility was far from good at those seats. More to the point, it was actually felt that the acoustics were much better at the upper level gallery!

The management attempted to improve the situation with the help of a few loudspeakers and stage floor mounted microphones. Of course, due to the fact that no provisions had been made for their hanging, they had to be set on heavy tripods, with much care applied to try and avoid the audience tripping on them, which rather strongly limited their possible location.

A diagnosis was then performed in order to try and find out what was actually happening, and whether the existing temporary sound system could be improved. More to the point, one was also keen to try and understand whether acoustic enhancement could be considered.

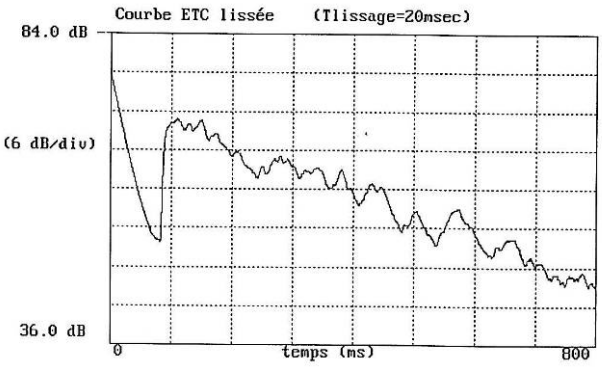
.Fig.3 View of the stage and loudspeakers located in former honor boxes.

3 Initial diagnosis

When the refurbishment of the hall was decided, an acoustical diagnosis was performed notably using the Melissa system. This diagnosis was meant both as a starting point for the future work and as a mean of investigation for possible improvements of the acoustics of the facility.

It first of all turned out from that diagnosis that the rather low (30 dB) sound insulation of the hall towards the foyer proved disastrous as the latter featured a background noise level of 51 dB(A) generated by the old ventilation equipment. Furthermore, the reverberation time was found to be 1.6 s at 1000 Hz, and rather constant over the frequency range of interest safe for the 4000 Hz band. More to the point, it was found out that the position of the stage curtains had practically no influence on the outcome, thus accreditating the idea that the stage volume did not really participate in the acoustics of the facility.

The piece de resistance was of course the MLSSA measurements. It was found out that while slight echoes were discernable in the 1000 Hz band all over the place, at the mid-upper gallery they really soared as direct energy was much lower than reverberated energy.



.Fig.4 Smoothed energy time curve at the mid-upper gallery.

4 The second diagnosis

Twelve years later a new diagnosis was performed on the facility as no commissioning measurements had been performed after the rehabilitation. The results were somewhat funny: the background noise levels in the foyer had increased to such an extent (64 dB(A) with the ventilation operating) that it was necessary to turn it off during performances. The ventilation of the hall proper did not fare any better and also had to be turned off during performances.
The reverberation time was found to be conserved at 1000 Hz (1.6 s) but slightly lower than during the initial diagnosis at upper frequencies, which could be accounted for by the upholstering of the seats.

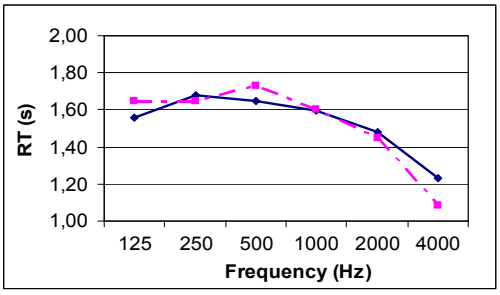


Fig.5 Comparison of reverberation time curves at 1rst (plain line) and 2nd (dotted line) diagnosis.

This later diagnosis was essentially meant to act as a basis to try and find out whether the speech intelligibility inside the theatre could be improved. Therefore, in addition to new MLSSA measurements, a computer simulation was performed on the theatre, in order first of all to help find out how the acoustics actually worked, and how it could eventually be improved through either a sound reinforcement system or judiciously positioned absorbtive materials or reflective panels.

Of course both measurements and model confirmed that first of all, the reverberation time of the hall is too high to be compatible with a good intelligibility using the natural acoustics of the facility. More to the point, the big volume leads to a quick decrease of the sound with the distance between a source on stage and a receiver in the audience. As intelligibility necessary depends on signal / noise and reverberated field / direct field ratios, both these parameters are in contradiction with good conditions for theater performances.

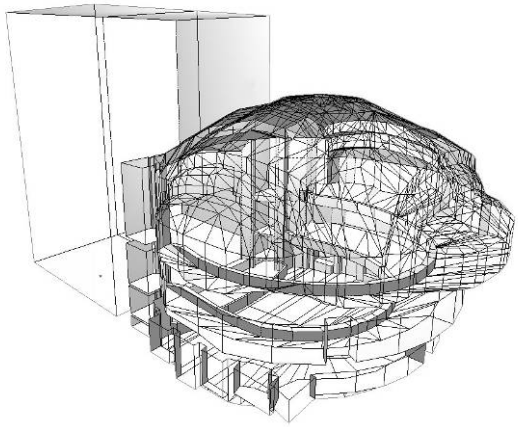


Fig.6 View of the computer modelling of the hall.

Consequently, it turned out that intelligibility without sound system was no better than 0.6 for the best seats in front of the stage and quickly decreased until 0.4 in the back part of the floor level and the two balconies.

More to the point, the measurements shows that the increase of the speech intelligibility when using the implemented sound reinforcement system was very slight and not homogeneous. This is essentially due to the presence of too many loudspeakers, their lack of directivity and their non-optimized location, leading to an increase of the reverberated field to the detriment of the direct one.

Therefore, the influence of temporary addition of acoustic absorption on the curved reflective walls of the hall through heavy curtains has been checked. The calculations showed a significantly improvement of the intelligibility (gain around 0,1) but not sufficiently for the center part of the floor level.

Last but not least, the possibility of using a reflective panel was thoroughly investigated. It turned out that such a panel suspended over the fore stage could improve the intelligibility (though of course one would ultimately still be left with the finding of a suitable suspension method, simultaneously for the safety requirements, the acoustical requirements, and the whims of the Architect in charge of historical buildings).

Adding a sound system inside such a facility is of course quite a bit of a challenge due to its natural acoustics. So one finds oneself pretty much cornered into using high directivity loudspeakers so as to limit the reverberated energy broadcasted inside the venue. Nevertheless the results were pretty encouraging and showed that an intelligibility of 0.6 could be reached in the larger part of the audience.

5 Conclusion

The facility of Vichy was initially conceived only for opera performance. Its use for theater performance showed the limitations of the acoustic properties of the hall in terms of speech intelligibility.

The performed diagnosis was useful to precise the reasons of the problem, find out different tracks of solutions to improve the intelligibility and make understand the necessary acoustical specificities for each kind of use of a hall.

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