PHILHARMONIE DE PARIS – THE ACOUSTIC BRIEF

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ABSTRACT

In 2006, a detailed acoustic program - the so-called "acoustic brief" - was developed for the architectural competition of the Philharmonie de Paris. The brief firstly showed the feasibility of designing a high-quality, enveloping concert hall with a seating capacity of 2'400 and modern seat spacing. Furthermore the brief gave a set of both architectural and acoustic criteria that were to be met by the design team. The requirements of the brief will be put into perspective with the built hall that opened to the public in January 2015.

1 INTRODUCTION

The Philharmonie de Paris concert hall opened its doors to the public on 14th January 2015. The inaugural concert featured the Orchestre de Paris, and was attended by both the President of France and the Mayor of Paris. While there are still some ongoing debates as to whether the hall opened too early (before the completion of all works), and on the construction cost (which officially currently stands at 386 million Euros), the praise is unanimous for the acoustic quality and the innovative character of the concert hall.

Kahle Acoustics from Brussels, in collaboration with Paris-based Altia Acoustique, worked on the project as client-side acoustician, beginning work prior to the architectural competition and continuing on the project during all planning and construction phases, all the way up to the opening. The first (and possibly most important) part of the appointment was to write the acoustic brief[1,2] for the concert hall. There were some (false) assumptions by some parties that the client acoustician would be fixing the basic design shape of the concert hall by restraining the design possibilities to certain well-established shapes such as shoebox or vineyard. To us, however, it was clear from the onset that this was neither possible nor a good starting point. The client brief clearly asked for both a "high-quality acoustic concert hall, comparable in acoustic quality to the best recent realizations" and "an innovative architectural concept" – therefore our idea for the acoustic brief was to ensure acoustic quality by limiting ourselves to defining the framework within which the architectural creativity could be fully developed: an acoustician cannot design an innovative architectural concept without an architect around the table!

The architectural competition was won in 2007 by Ateliers Jean Nouvel (for more information on the other competition entries see[3]). The elaborate composition of the team indicates that the successful concert hall is the brainchild of many creators. Ateliers Jean Nouvel as lead architect had teamed up with Brigitte Métra Associés for the design of the concert hall. Marshall Day Acoustics (Harold Marshall and collaborators) was the design team acoustician, with Yasuhisa Toyota (Nagata Acoustics) taking the role of special advisor to Jean Nouvel. Studio DAP (Federico Cruz Barney) from Paris also joined the team, being responsible for all rooms other than the concert hall (including the seven large-scale rehearsal rooms and the pôle éducatif reserved for musical training and education) and for building acoustics. Later on, Jean-Paul Lamoureux and ASC were also working on the project as acousticians for the contractors. Ducks Scéno of Lyon, a regular collaborator with Jean Nouvel on performing arts projects, was responsible for theatre planning and theatre equipment.

2 CHALLENGES AND INNOVATIONS OF THE BRIEF

Which were the challenges and innovations of the acoustic and architectural brief? The client brief had called for (i) a 2’400-seat concert hall; (ii) a new typology providing a central stage for classical music concerts and a frontal stage for amplified concerts and events; (iii) high-quality acoustics – or shall we say “best possible acoustic quality” and (iv) innovative architecture. And of course, not to be forgotten, ideal acoustic conditions for the musicians on stage.

Detailed studies of reference projects and research into different typologies of rooms and their connection with objective acoustic criteria and subjective acoustical qualities[4,5] led to the following five main recommendations and elements of our acoustic brief. (The original acoustic brief is available for download from www.kahle.be in English and French.)

2.1 Hall shape: avoid a shoebox hall design

For a seat count significantly in excess of 2’000 audience members and with contemporary seat spacing and aisles widths, shoebox halls will either be too long or too wide to ensure intimacy and good acoustics. While there are indeed issues with seats behind the orchestra, placing the stage towards the middle of the hall allows a significant reduction of the average distance from the musicians to the listeners. Furthermore, it was suggested that the hall – contrary to the Berlin Philharmonie and most other vineyard halls – should have balconies, i.e. moderate superposition, further reducing the distances and increasing the feeling of intimacy. In the final hall, no seat is more than 32m away from the stage edge.
At the same time, it was recommended to maintain some beneficial acoustic elements of the shoebox design, including reflection coverage from balcony soffits and lateral reflections.

2.2 The requirement for a reverberation time (RT) of more than 2.0s

Even though a reverberation time of 2.0s is often quoted as being ideal for symphony concerts, more detailed studies and research shows that this is no longer true for a contemporary concert hall with a seat count of more than 2’000 people. The first reason is that for optimal presence and source definition a significant amount of early reflections has to be designed and created; to balance this strong early response a longer reverberation time is required to optimize both early and late responses. Furthermore, the larger the volume, the weaker the energy of the late reverberation, and for equal audibility of the late response the reverberation time needs to be increased for larger rooms. In the final room, at opening (prior to the installation of acoustic curtains around the back of the stage) the occupied reverberation time was significantly above 2.5 seconds, which was judged to be perfect by some and as being slightly excessive by others. The occupied reverberation time is now just under 2.5s and is judged as being ideal by both musicians and critical listeners – the long reverberation time is required to balance the very strong early presence and reflections, allowing to simultaneously maximize both clarity and reverberance.

2.3 Early and Late Acoustic Response

Psycho-acoustic studies[4,6,7] have clearly shown that when listening to music in a concert hall, our ears and brain simultaneously focus on two different “auditory streams”: one linked to the sources (“source presence” and “clarity of the content”) and one linked to the room (“room presence” and “listener envelopment”). Both need to be optimized separately and only the combination of both leads to a sufficiently strong acoustic response – an issue particularly important for concert halls with more than 2’000 seats. In the acoustic brief this separation of early room response and late room response is clearly explained and indicated – and for both responses optimization possibilities are given that can be accommodated within different architectural concepts.

2.4 Decoupling of acoustic volume and distance to acoustic reflectors

When concert halls grow bigger to accommodate more audience and/or more comfortable seats, in principle the walls and all boundary surfaces are moving further and further away from the sources and receivers. As a consequence, not only the acoustic reflections are getting weaker, they are also arriving later. At the same time the human ear has fixed time constants: put simply, all reflections arriving within 80ms of the direct sound are integrated into the source presence while all reflections arriving later than 80ms are integrated into the room response – irrespective of room size and with the danger that the bigger the room is, the less reflections are integrated into the source presence. In order to counteract this effect, a minimum early reflection surface[8] (in m2) was specified in the brief and it was suggested that those surfaces might be others than the boundary surfaces of the room, so that they can be closer to the sound sources and listeners. The concept is that reflection surfaces (that need to be sufficiently close even in a room for 2'400 audience members) can be different from the boundary surfaces that create the acoustic volume (which needs to be large for sufficient reverberation).

Figure 1: Example of free-floating balconies with additional reverberation volume behind.

It is interesting to note that prior to the Philharmonie de Paris two different concepts already existed that allow this decoupling of reflection surfaces and acoustic volume: one example is the concept of reverberation chambers that provides a more intimate room (for reflections) surrounded by an additional volume (for reverberation), often with the coupling between the inner and outer volume being variable (e.g. KKL Luzern). The other concept is to place large suspended reflectors inside a bigger volume, oriented to send energy from the stage to audience areas (e.g. Christchurch Town Hall). Acoustically both concepts are at least partly similar and can in fact be generalized into the notion of early room response and late room response.

2.5 The requirement for strong lateral reflections

More lateral energy was asked for than in the Berlin Philharmonie and most other vineyard concert halls. Vineyard concert halls can have many acoustic qualities, but a detailed comparison of available acoustic data for both shoebox and vineyard concert halls[9] shows that on average vineyard concert halls have less (and/or less strong) lateral reflections, leading to a reduced listener envelopment. While this shortcoming is to a certain degree intrinsic to the hall shape, it can be compensated by adequate acoustic design features, some of which were discussed in the acoustic brief. It is interesting to note that it was Harold Marshall – acoustic designer of the Philharmonie de Paris – who established the importance of lateral reflections in the late 1960s, following the opening of the Berlin Philharmonie[10,11,12].

3 SUMMARY OF THE ACOUSTIC AND ARCHITECTURAL CRITERIA OF THE BRIEF

In addition to the qualitative descriptions and guidelines given in the acoustic brief for the Philharmonie de Paris, the brief contained the two following tables quantifying various acoustic and architectural criteria that were to be fulfilled by the design.

Acoustical Parameter	Value at mid-frequencies
Reverberation Tim (RT)	Mean between 2.2 and 2.3s with all variable acoustic absorption retracted (*fully occupied with orchestra on stage*) Mean between 1.4 and 1.6s with all variable acoustic absorption in place (*empty auditorium*) Mean between 1.2 and 1.4s with all variable acoustic absorption in place (*full house, empty stage*)
G, without audience	Mean between 3 and 6dB. The variation with respect to the position of the source and receiver (ΔG) must be ±3dB. Acoustic variability (mean of G using the variable acoustic features) must be greater than 2dB.
G80, without audience	Mean between -2 and +2dB. Required variability: >3dB.
G[80ms, ∞], without audience	Mean between 0 and 4dB. Required variability: >1.5dB
C80, without audience	Mean between -3 and 0dB. Required variability: >2dB
LF, without audience	Mean > 0.16, LF >0.15 for at least 80% of the seats.
1-IACC, without audience	Mean >0.55. 1 – IACC >0.5 for at least 80% of the seats.
Bass ratio, without audience	Between 1.1 and 1.3.
Treble ratio, without audience	Between 0.9 and 1.0 at 2kHz and between 0.75 and 0.85 at 4kHz.
ST1, without audience	Required variability: >3dB. Possibility to reach values ≤ -16dB Possibility to reach values ≥ -14dB. Variation across the stage: < 2dB with respect to the mean value.
Noise rating	< NR10 and 15dB(A)
Tolerances	Corresponding to the threshold of hearing (5-10% for the RT, usually 1dB for the other criteria, 5% for the LF and 1-IACC).

Table 1: Summary table of acoustic criteria from the acoustic brief.

Architectural Parameter	Requirement
Volume per person	Ideal: between $12m^3$ and $13m^3$. Acceptable: between $11m^3$ and $14m^3$.
Total volume	Approx. $30000m^3$ (between 28000 and $32000m^3$) to obtain 12 to $13m^3$ per person in the audience and for 2400 seats.
Reflective surfaces	$1400m^2$ including $500m^2$ close to the musicians (less than 15m from a point of the stage).
Height of the auditorium	The height will be chosen by the design team to obtain the appropriate volume of $30000m^3$. It is understood and considered acceptable that the total height (omitting the acoustic reflectors) above the stage can be greater than 20m.
Height of the reflectors above stage	Required variability: between 10 and 16m for a continuous big reflector (canopy) and 8 to 14m for a set of smaller acoustic reflectors
Variable acoustic absorption (curtains or other elements)	More than $1200m^2$ of removable absorbing material is required.

Table 2: Summary table of architectural criteria from the acoustic brief.

4 IMPLEMENTATION OF THE BRIEF

The acoustic-architectural design proposed by the architects and their acousticians – including free-floating balconies in a bigger acoustic volume, with “clouds” and “ribbons” providing early reflection surfaces and a free-form yet optimized shape – is a highly creative and pertinent response to the requirements and requests formulated in the brief.

An example is given in the following image, showing how the “ribbons” create lateral reflections for seats in the top balcony:

Figure 2: Philharmonie de Paris, final construction phase, view from top rear balcony, with canopy at stage height. Top of canopy with lighting ring: one can see strong acoustic (and visual) reflections from the stage to the top balcony via the “ribbons”, the partial rear walls of the top balcony, as well as via balcony fronts and “cloud” reflectors.

The design of the Grande Salle of the Philharmonie de Paris as well as the commissioning are presented in detail in other papers that are part of this conference[13,14,15].

5 REFERENCES

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