COMMISSIONING OF THE PHILHARMONIE DE PARIS, GRANDE SALLE

T Scelo Marshall Day Acoustics, Hong Kong
P Exton Marshall Day Acoustics, Melbourne, Australia
C Day Marshall Day Acoustics, Auckland, New Zealand

1 INTRODUCTION

The concept for the acoustic design of the Philharmonie de Paris has been presented in Marshall's paper[1]. The implementation of the design up to and during the construction has been presented in Scelo's paper[2]. The investigation and validation using the physical scale model has been presented in Katz's paper[3]. Commissioning the Grand Salle of the Philharmonie de Paris was never going to be straight forward. Its multiple uses, encompassing the classical symphonic, choral and and recital repertoire, contemporary music, Jazz, and World Music are demanding enough. Add in highly adaptable stage and seating arrangements, and the mechanics of making these changes, and a protracted series of measurements both occupied and unoccupied, is inevitable. At the time of writing only partial preliminary symphony mode measurements, including systematic orchestral surveys had been completed and these will be presented in this paper. These measurements, made in two brief windows of availability were achieved using the MDA-developed IRIS system.

2 THE COMPLETION

Putting aside the controversy, the opening concert of the Philharmonie de Paris followed a 2 month period of sustained site visits and inspections. When the dust had settled just enough for the musicians, the Marshall Day Acoustics team was confident that the hall would reveal enough of its character during the first rehearsals and the "hard hat" concert to allow us to conduct some listening and objective measurements . It indeed demonstrated its full reverberation, clarity and wide dynamic range within the first hour of music playing by the patient and very professional Orchestre de Paris.

Figure 1 The Philharmonie de Paris, three weeks to opening

Figure 2: The Philharmonie de Paris, one week to opening

Acoustic items that were originally planned and later installed included some additional diffusion around the stage and at the rear of the stalls, additional operable drapes at the rear of the stage and rear of the stalls seats, and the six large retractable banners in the outer volume. The absence of these was not considered significant enough to affect the commissioning measurements for the symphony concert configuration.

3 COMMISSIONING PROTOCOL

The commissioning protocol proposed for the Philharmonie de Paris included 4 different phases. Each phase was devised to provide further insight into the acoustic performance of the built space as well as allow the Marshall Day Acoustics team to receive constructive feedback from the Orchestre de Paris.

The four phases were:

- Listening tests
- Objective measurements as per the relevant standards
- Orchestra sessions including attending rehearsals, distributing a questionnaire and discussions with the Orchestre de Paris
- Hard hat concert and opening Gala.

4 LISTENING TESTS

Projecting the best quality sound from the stage is probably the most significant function for the concert hall. Initially the acoustic response of the hall was assessed by listening to electronically generated signals produced on the stage. These can be from a metronome, impulses sweep signals or short prerecorded music samples. All sound paths to the audience can be assessed using repeatable sounds, and any subjective variations in the sound quality can be noted.

Therepeated attendance to rehearsals and discussions with the musicians of the Orchestre de Paris, and their management team has provided significant insight into the stage experience, the possible changes in orchestra layout (compared to the Salle Pleyel) and adjustment in the playing style of the orchestra.

During these sessions, some elements for the stage flexibility were adjusted to suit the preferences of the Orchestre de Paris, including:

- Setting the canopy to +14.0m above the stage floor level
- Deploying the drapes at the rear of the stage to 0%, 50% and 100% of the stage width for different repertoire and orchestral layouts
- Varying the extent of sound absorptive banners in the outer volume during orchestral rehearsals.

5 OBJECTIVE MEASUREMENTS

Measurements were conducted the week of the opening in January 2015 and again in April 2015 following the installation of the banners in the outer volume. Further measurements are needed to complete the entire documentation of the acoustic response in its multiple configurations and with the complete set of banners and drapes.

International standard *ISO 3382-1 Acoustics – Measurement of Room Acoustic Parameters Part 1: Performance Rooms*[4] provides guidance on the accepted procedure for this. These guidelines were followed in principle using specialist equipment, including the IRIS[5, 6] room acoustic measurement system developed by Marshall Day Acoustics. This system provides not only the standard room acoustic parameters but also a unique analysis of the three dimensional sound distribution in the hall.

Measurements reported below are preliminary due to limited time in the completed hall. We note that some values presented below are not prepared in accordance with *ISO 3382* standard because an insufficient number of source and receiver positions were employed.

Conditions for the musicians on stage have also been measured, and impulse responses analysed to investigate the behavior of acoustic reflections back to the stage.

5.1 Design criteria - The Programme Acoustique

The design criteria were detailed in the Programme Acoustique [7] and included target ranges for a wide range of values including Reverberation Time (RT), Clarity (C80), Loudness (G), Early Loudness (Gearly), Late Loudness (Glate) and Lateral Fraction (LF80).

As for any hall, acoustic parameters do not represent fully the acoustic quality of a concert hall nor its unique voice. They are indicative and provide a limited picture of the acoustic experience for audiences and musicians.

5.2 IRIS measurement system

The 3-D measurement system, “IRIS” is an integrated software and hardware room acoustics measurement system. It utilises a compact tetrahedral microphone array, a Core Sound TetraMic which is able to resolve incoming sound in terms of level, time and direction.

Figure 3: Tetrahedral microphone in the inner volume (left) and in the outer volume (right)

An example of the “IRIS plot” produced by this system is shown in Figure 4. It represents the sound arriving at the receiver as a series of vectors. The vectors are normalised to the direct sound intensity and the angle of incidence. The colour corresponds to the time of arrival after the direct sound.

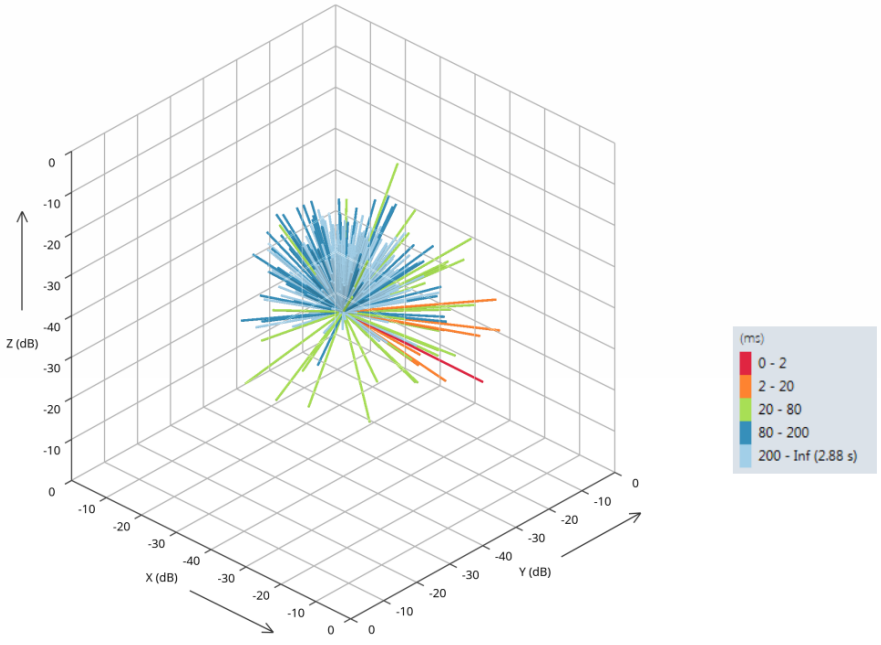

Figure 4: Example of Iris plot measured in the Philharmonie de Paris

5.3 Symphony mode

Measurements were undertaken during the "hard hat" concert on 12 January 2015 and over night on the 18 January using 3 source positions on the symphony stage and 14 receiver positions within the audience. These measurements were carried out in the unoccupied room in the Symphony configuration, with music stands and chairs on the stage. The table below summarises the average values across all source and receiver positions.

Table 1. Symphony mode, no banners, opening week

Acoustic Criterion	Physical Conditions	Programme Acoustique	Measured averaged value at mid frequencies
Reverberation Time (RT)	Symphony Mode Unoccupied No acoustic banners	Not specified	3.2s
	Symphony Mode 70% Occupied No acoustic banners	2.2 - 2.3s	2.5s
Clarity (C80)	Symphony Mode Unoccupied	-3dB to 0dB	-0.7dB
Loudness (G)	Symphony Mode Unoccupied	3dB to 6dB	2.2dB
Early Loudness (Gearly)	Symphony Mode Unoccupied	-2dB to +2dB	-1.3dB
Late Loudness (Glate)	Symphony Mode Unoccupied	0dB to +4dB	-0.6dB
Lateral Fraction (LF)	Symphony Mode Unoccupied	> 0.16	0.20
Stage Support (ST1)	Symphony Mode Unoccupied	Not specified	-15.3dB

5.4 Jazz/World Music - unoccupied - 4 banners only

Measurements were undertaken over night on the 11 April 2015 using 1 source position on the symphony stage and only 2 receiver positions within the stalls audience. These measurements were carried out in the 85% occupied room. Four of the six banners were deployed in the outer volume with one full height drape suspended behind the stage and two short drapes suspended between the overstage lighting bars. This corresponds to half of the stage dressing available. At the time of the measurements the planned drapes at the rear of the stalls within the inner volume were not installed.

Table 2. Jazz/World music mode, occupied, 4 banners only

Acoustic Criterion	Physical Conditions	Measured averaged value at mid frequencies
Reverberation Time (RT)	Jazz/World Music Occupied 4 banners in outer volume	2.1s

5.5 Symphony mode - banners and audience effects

Measurements were undertaken over night on the 12 and 16 April 2015 using 3 source positions on the symphony stage and 14 receiver positions within the audience. These measurements were carried out in the unoccupied room in the Symphony configuration, with music stands and chairs on the stage and 4 to 6 banners deployed in the outer volume. The table below summarises the average values across all source and receiver positions.

Table 3. Symphony mode, unoccupied effect of banners

Acoustic Criterion	Physical Conditions	Measured averaged value at mid frequencies
Reverberation Time (RT)	Symphony Mode Unoccupied No acoustic banners	3.2s
	Symphony Mode Unoccupied 4 banners in outer volume	3.0s
	Symphony Mode Unoccupied 6 banners in outer volume	2.8s

6 ORCHESTRA SESSIONS AND QUESTIONNAIRES

6.1 The Orchestre de Paris

The engagement with a top quality professional orchestra is a highlight in the handover and assessment of the new hall. The hall exists to be an extension of the musicians' instruments in the projection of their sound to the audience. The hall must also function well for the musicians so that they can feel confident that their sound can carry to all parts of the hall. They must hear the nuances of the sound from all other musicians on the platform.

The Orchestra de Paris moved in the Philharmonie de Paris a week prior to the opening and rehearsals began in the dedicated spaces. With construction works in progress, the Orchestre de Paris collaborated closely with Marshall Day Acoustics during the days prior to the "hard hat" and opening concerts.

6.2 Questionnaire to Orchestra

A questionnaire was developed and offered to musicians following a presentation of the design. Musicians were encouraged to provide feedback by answering a set of questions about their experience in playing in the new Hall, and adding further comments if they wish. Marshall Day Acoustics has used this method with good results to engage with the performers and work with them to develop a good rapport with the new performing space.

6.3 Questionnaire to Choir

The questionnaire included only 7 questions. The questionnaire and the results are presented below. The red arrows represent the standard deviation from the average response. In addition, musicians were asked to provide comments. Some of these will be shared at the conference. The results presented here are based on the initial 62 responses received.

1. **How well can you hear your own sound**?

	Easily				Not well
Mean value 1.8	1	2	3	4	5

2. How well can you hear your section?

	Easily				Not well
Mean value 2.3	1	2	3	4	5

3. How well can you hear the blend of the orchestral sound?

	All instruments sound separate				Sound appears well blended
Mean value 3.0	1	2	3	4	5

4. How do you find the reverberation in the Philharmonie?

	Resonant				Dry
Mean value 2.0	1	2	3	4	5

5. How do you find the timbre of the Philharmonie?

	Bass heavy				Bright
Mean value 3.0	1	2	3	4	5

6. How well do feel that your sound fills the auditorium?

	Easily				Not well
Mean value 2.1	1	2	3	4	5

7. What is your overall acoustic impression of the Philharmonie?

	Hard work				Gratifying
Mean value 4.2	1	2	3	4	5

7 CONCLUSIONS AND REVIEWS

The tuning concert took place the day before the grand opening and was presented as a rehearsal. In fact, it was the first rehearsal of the Orchestre de Paris on the stage, conducted by Paavo Jarvi, in the hall at 75% capacity with 200 seats yet to be installed.

The grand opening gala for the Philharmonie de Paris happened under the attention of a significant media presence. There is little scientific merit in discussing the evening aside from highlighting the presence of a global audience, musicians and critics. This is a testimony of the significance of the Philharmonie de Paris in the music world community.

In the initial months of operations, the Philharmonie de Paris hosted 270 concerts and sold more than 300,000 concert tickets between January and June 2015. It is proving to be a successful concert hall that is highly regarded for its architecture and acoustics, as demonstrated by the overwhelming critical acclaim.

Acknowledgments - Marshall Day Acoustics would like to thank all those who assisted with achieving this extraordinary result. Specific thanks are offered to Mr Jean Nouvel and the Atelier Jean Nouvel for entrusting Marshall Day Acoustics with the acoustic design of this very significant concert hall. Special thanks are also offered to the Philharmonie de Paris team, in particular Mr Laurent Bayle, Mr Patrice Januel and Mr Geoffroy Vauthier for their support. Additional thanks to Eckhard Kahle and his team for their collaborative, collegial and dedicated participation. Finally, special thanks are offered to the musicians and management of the Orchestre de Paris for their patience, enthusiastic participation and extraordinary appreciation of this unique and new acoustic paradigm.

8 REFERENCES

1. A. H. Marshall, "*The conceptual acoustical design for la Philharmonie de Paris, Grande Salle"*, Proc. Auditorium Acoustics, Paris (2015)
2. T. Scelo, "*The implementation of the acoustic design for la Philharmonie de Paris, Grande Salle*", Proc. Auditorium Acoustics, Paris (2015)
3. B. Katz, "*La Philharmonie de Paris - Acoustic scale model study*", Proc. Auditorium Acoustics, Paris (2015)
4. ISO 3382-1:2009, "*Acoustics—Measurement of room acoustic parameters. Part 1:Performance spaces*" (International Organization for Standardization, Geneva, Switzerland, 2009).
5. D Protheroe and B Guillemin, "*3D impulse response measurements of spaces using an inexpensive microphone array*", Building Acoustics, Vol. 20(2), pp. 141-156 (2013)
6. D Protheroe and C Day, "*Lateral fraction measurements with a 3D microphone array*", Acoust Aust, vol. 43, pp. 69-76 (2015)
7. Kahle Acoustics and ALTIA, "*Le Programme Acoustique de la Philharmonie de Paris*", 2006