

ACOUSTICS OF THE SYDNEY OPERA HOUSE CONCERT HALL

Part One: The Client's Perspective

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ABSTRACT

The Sydney Opera House, designed by Danish architect, Jørn Utzon (1918-2008), is a vibrant complex of performance spaces enclosed by one of the world's most iconic structures. Design work commenced in 1957 and the building was completed in 1973. The interior of the Concert Hall was designed by Australian architect Peter Hall after Utzon returned to Denmark in 1966 following a dispute with the Government over a number of issues, including cost over-runs. The Acoustician for the Concert Hall was Vilhelm Lassen Jordan. Since the first concerts in the hall, musicians onstage and critical listeners in the hall acknowledged the hall's acoustics deficiencies. However for many visitors, the extraordinary architecture of the building was sufficiently impressive to cause the building to be listed as one of the world's 10 best concert halls. Finding the means to remediate the acoustics shortcomings in this Heritage-listed world landmark has been challenging. Over a long period of time it has involved acquiring expert advice and balancing that advice with financial and artistic resources as well as the enhanced functionality and ultimate quality to be realised. All this will have to be tempered by heritage imperatives, restricted budgets, and seemingly conflicting goals. Mock-ups of acoustics modifications were conducted in late 2009. This paper will describe the process of gaining authorisation for the mock-up as well as musician and audience reactions to them.

INTRODUCTION

Sydney Opera House is a vibrant performing arts centre set in a stunning location on Bennelong Point, Sydney, Australia (Figure 1). The building was designed by Danish architect Jørn Utzon (1918-2008), who was appointed to the project as a result of winning an international design competition in 1957. The complex opened in October 1973.



Source: Sydney Opera House
Figure 1. Sydney Opera House

Sydney Opera House is much more than an arts centre. It is a State, National and World Heritage listed national icon, listed under UNESCO's criterion (i): *A masterpiece of human creative genius.*

It is widely recognised as one of the greatest buildings of the twentieth century. Its unique profile has become a symbol of the city of Sydney and an emblem for Australia, "a great artistic monument, accessible to society at large" [1]. It is a community centrepiece that brings together Australians from all geographic, cultural and socio-economic backgrounds.

Australia's premier tourist destination and most recognised symbol, Sydney Opera House attracts around 7.4 million visitors every year. One of the world's busiest performing arts centres, 1.25 million people attended the 1,667 performances in 2008/09 and about 320,000 took part in guided tours [2].

Sydney Opera House promotes and supports many of Australia's most significant performing arts companies. There are four resident companies: Sydney Symphony, Opera Australia, The Australian Ballet and Sydney Theatre Company, and a diverse program of events is performed under the *Sydney Opera House Presents* brand. Its seven primary venues: the Concert Hall, Opera Theatre, Drama Theatre, Playhouse, The Studio, Forecourt and Utzon Room offer daily opportunities for audiences to experience the world's best in every form of the performing arts.

Sydney Opera House's influence on the cultural life and identity of Sydney, New South Wales (NSW) and Australia extends well beyond its role as a landmark icon. Its direct and indirect value added annual contribution to the NSW and Australian economies has been valued at more than \$1 billion [3].

Sydney Opera House self generates around 82% of its operating budget through ticket sales, guided tours, catering, retail, sponsorship and philanthropy. The remaining 18% is funded by the NSW Government, which also funds building maintenance.

HISTORY

When it was conceived in the 1950’s, Sydney Opera House was intended to house three venues: The Major Hall, Minor Hall, and a small experimental theatre (now the Drama Theatre). The original intended purpose of the Major Hall was for opera, ballet and symphonic work. The Minor Hall (now the Opera Theatre) was intended for drama.

The plan changed during construction when the Australian Broadcasting Commission, then owners of the Sydney Symphony Orchestra, successfully campaigned for the Major Hall to be dedicated to symphony. In 1966, plans for a proscenium arch theatre in the Major Hall were abandoned and an open concert platform was built (Figure 2). Renamed the Concert Hall, the interior was designed for symphonic music by architect Peter Hall, after Utzon had returned to Denmark. Danish acoustician Vilhelm Lassen Jordan oversaw the acoustic development of the Concert Hall.



Source: Jack Atley
Figure 2. Sydney Opera House Concert Hall

When the Concert Hall opened in 1973, musicians onstage and critical listeners in the hall acknowledged some acoustics deficiencies. However it was widely regarded as one of the world’s 10 best concert halls. Over time, and with changing audience and industry expectations, the hall’s acoustics now rank poorly against international benchmarks.

Heritage

Sydney Opera House was listed on the State Heritage Register in 2003, the National Heritage List in 2005 and the World Heritage List in 2007.

The Sydney Opera House Trust is responsible, on behalf of the NSW Government, for managing the venue, conserving and enhancing the heritage values for the benefit of future generations. This is achieved through a rigorous management process and the involvement of a Trust Building Committee. A Conservation Council also provides independent expert advice to the Trust. The process was endorsed by UNESCO through the World Heritage listing.

Sydney Opera House was privileged to have the original architect Jørn Utzon return as principal architectural consultant in 1998. Utzon established a set of design principles as a permanent reference of his design vision, to

inform the conservation and future development of the building and its setting. The re-engagement of Utzon set the course for the development of an authentic conservation framework.

A Plan of Management [4] sets out the legal requirements for conservation management. Two important documents guide decisions on conservation and change: the Conservation Management Plan (3rd Edition 2003) [5] (CMP) and Utzon Design Principles (2002) [6].

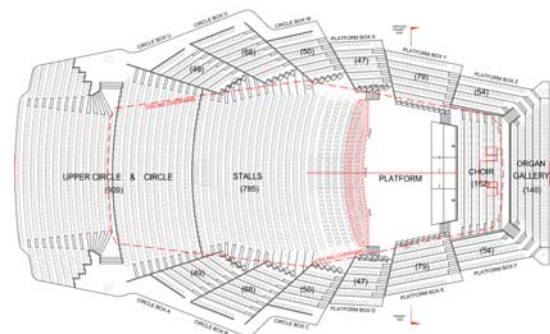
In the Concert Hall, the CMP considers the views to the ceiling crown and grand organ, among other elements, to be of ‘exceptional significance’. They must be carefully considered in the design of any proposed alterations.

CONCERT HALL

Description

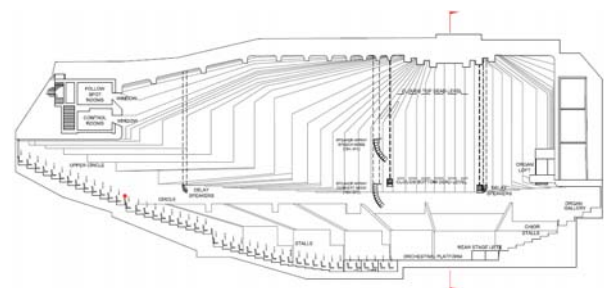
The largest performance venue in the complex, the Concert Hall seats up to 2,679 in-the-round (Figure 3). The walls and floor are made of laminated Australian brushbox timber. The brushbox walls in the stalls and on stage are finished in a sawtooth geometry. The ceiling and seating frames are made of Australian white birch veneer and the seats are upholstered in wool. The southern wall behind the stage features a 10,500-pipe grand organ, designed and built by Australian Ronald Sharp.

The stage platform measures approximately 17m wide at the setting line by 11.5m deep at the centre line. An optional stage extension, made up of five hydraulic scissor lifts, adds approximately 1.5m depth at the centre line. Upstage is fitted with six hydraulic scissor lifts, which may be used to raise the brass and percussion sections.



Source: Sydney Opera House
Figure 3. Concert Hall Auditorium (plan view)

The ceiling crown is unusually high, at approximately 25m above the stage (Figure 4), which creates a massive chamber above the platform.



Source: Sydney Opera House
Figure 4. Concert Hall Auditorium (North-South section): the ceiling crown sits 25m above the stage platform

A set of 18 acrylic rings, or 'clouds' provides a height-adjustable canopy intended to reflect sound back to the stage (Figure 5). At the time of installation, the hollow 'donut' design of the clouds was thought to be acoustically effective, while maximising the amount of light that could penetrate to the stage from the ceiling crown.

Over the years, changes have been made to the technical production systems to enable the venue to keep pace with growth and change, but these were not always done with sensitivity to the acoustic and heritage issues.



Source: Jack Atley

Figure 5. Existing acoustic reflectors, known as 'clouds'

Venue use

The Sydney Opera House Concert Hall is one of the most famous performance venues in the world. The greatest classical, contemporary and variety performers have played the venue and many of the world's leading artists aspire to perform there. It is also the venue of choice for many events of national and international significance.

The Concert Hall is the home of Sydney Symphony. The orchestra performs on an average of 120 days per year, plus additional rehearsal days. As the resident company, Sydney Symphony's need for acoustic excellence must be fulfilled.

However, outside of the Sydney Symphony program, the venue accommodates a wide range of arts programming that makes varied technical and acoustic demands. The number of amplified events in the venue has increased significantly and now exceeds the number of purely acoustic activities. In 2009, 197 (65%) of the 303 performances in the Concert Hall required amplification.

Contemporary artists such as k.d. lang, Tony Bennett, Harry Connick Jr, Wynton Marsalis, Brian Wilson, America, Buena Vista Social Club, Foo Fighters, Michael Ball, Liza Minnelli and Michael Bubl  have performed in the venue in recent years. The venue has also been used for Australian Idol finals, dance, opera, circus, comedy, physical theatre and spoken word events. In 2009, it was converted to a state of the art Dolby cinema for the World Premiere of Star Trek 11 (Figure 6).

While there are significant artistic benefits to the diversity of the venue use, changes to the program have not only been artistically driven. The economic and financial imperatives of operating the venue have led to the need for increased commercial activity. A successful commercial joint venture program with Sydney Symphony has also emerged.

The commercial programs balance the classical program, develop and broaden the audience base and maximise

revenue opportunities. This trend will continue and is central to the strategic plan for performing arts programming at Sydney Opera House.



Source: Sydney Opera House
(Paramount Pictures, Star Trek 11 World Premiere)

Figure 6. Concert Hall cinema overlay

Technical overlay

The standard configuration of the Concert Hall is designed for symphony. However the hall is often used for both acoustic and amplified events in a single day. The commercial events require a sophisticated overlay of temporary staging, lighting, rigging, sound and audio visual elements. The efficient and cost effective turn-around of technical overlay, including acoustic treatments, is critical to accommodate the range of activity.

There is an open platform, with the height-adjustable canopy of reflectors. Lighting is concealed within the ceiling and is set up for standard orchestral lighting, with some scope for colour washes and specials.

The venue is fitted with a stereo line array system by D&B Audiotechnik (Figure 7). This system replaced a central speaker cluster in 2009 and has substantially improved the quality of amplified sound and the visual aesthetic of the hall.

The sound system installation was not only designed to improve amplified performance. It was also designed to speed the turnaround time between productions. The installation allows the sound system to be flown into 6 pre-programmed configurations without the need for any labour to rig the system. In addition, a large excavation in the rear stalls area has allowed the sound team to position a console, processing equipment and pre-configured cables, significantly reducing set up time and greatly enhancing the final sound result.



Source: Jack Atley

Figure 7. Concert Hall line array system

A new electrical reticulation and distribution system, with separate audio and lighting supplies, was also installed in 2009. The upgrade has improved the audio system by removing electrical noise and interference, caused by earth looping issues.

There is a hanging system made up of 14 lines driven by electric winches. There are also four maintenance winch sets. It is not a flying system and cannot control flying cues. The system is used to dead-hang rigs when additional technical overlay is required.

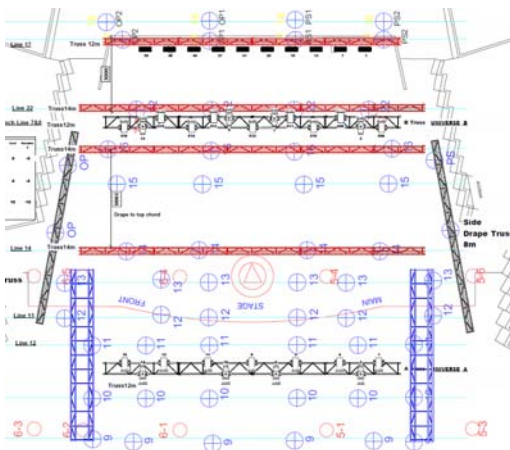
Prior to the recent upgrade works, the clarity of the venue for amplified performances was often the subject of criticism. A system of temporary drapery has been used to great effect, along with the upgraded line array system, to control reverberation and improve the quality of amplified sound (Figure 8).



Source: Sydney Opera House
(Sydney Opera House Presents, Ornette Coleman, 2008)
Figure 8. Technical overlay for amplified concerts

Renowned Audio Director Bruce Jackson was instrumental in driving the acceptance of the draping solution at Sydney Opera House as a practical solution in improving amplified sound performances. This is something that is critical to our business plan and corporate reputation. Bruce Jackson was commissioned as an advisory to the Concert Hall sound system upgrade project and had used similar solutions for other projects around the world.

The drapes are standard 380 GSM theatrical cloths, placed between the lighting truss positions (Figure 9) to reduce the sound swirling into the crown void above the stage and affecting the sound intelligibility.



Source: Sydney Opera House
Figure 9. Drapery truss configuration

Further drapes are used to mask the side walls, and the rear stalls wall. A carpet is laid across the platform, creating not only a more intimate acoustic for the performances but also providing a more focussed stage presentation for lighting.

Audience, media and promoter acceptance and approval of the cloth canopy have been unanimous. Sydney Symphony now requests the canopy for any commercial presentations requiring amplification.

THE CLIENT'S PERSPECTIVE

For the managers of the venue, there are many issues to consider in optimising the Concert Hall's position among the world's best. The acoustics are one of a range of technical issues and cannot be considered separately. Improving one element in isolation could be detrimental to the venue's technical capacity in other areas.

A master planning approach is being taken to ensure that any acoustic improvements contribute to improving the overall technical capacity and heritage significance of the hall. Work is being done to lay the groundwork for a range of technical projects. The main driver is to improve the hall's capability for the full range of venue uses.

Architecture

The Concert Hall is not a conventional 'shoe box' shape. The configuration and mass of the walls and ceiling are light weight, and the ceiling is higher than that of comparable venues. The open and unobstructed views of the hall have a high heritage significance ranking. The visual transparency of any acoustic canopy over the stage, including minimising light reflections, is important to maintaining the significant views.

Challenges

Sydney Opera House presents a number of unique and not so unique challenges for acousticians working to improve the Concert Hall.

Sydney Opera House is a state government funded organisation and like many similar venues has strict budget constraints. As an international centre of very high profile, there is also a considerable expectation of the technical facilities and on-going aspirations for bench marked venue improvement.

Sydney Opera House operates 363 days a year and all of the venues are operating at or near capacity. There were 303 performances in the Concert Hall in 2009. Closing a venue for renovation impacts the artistic program and revenue generation, as it would in any venue. But importantly for Sydney Opera House, it also affects the vital tourism business. Consequently, decisions to disrupt venue operations for upgrade works are not taken lightly.

The shape of the building represents another unique challenge. The Concert Hall is located inside the largest roof sail. The traditionally rectangular requirements of a theatre must be configured into a triangular space. The ceiling void is a seriously confined space, filled to capacity with services, stage machinery and technical equipment.

The apex of the exterior sails rules out opportunities for expansion above or to the side of the hall. Space for potential expansion beneath the stage and auditorium is limited by structural concrete beams that sit directly below the floor and run the full length of the hall. The hall's envelope is unlikely to change.

ACOUSTIC STUDIES

In 1996, Maestro Edo de Waart and members of the Sydney Symphony raised concerns about the acoustics on stage and in the auditorium. A number of acoustics experts assessed hall and reported their findings:

- Kirkegaard Associates (March 1996) [7];
- Karlheinz Müller (May 1996) [8];
- Peter Knowland and Associates (January 1997) [9]; and
- Arup Acoustics (May 1998) [10].

Arup's report (1998) concluded that, without major structural modifications to the hall's geometry, acoustical improvement would require a series of steps, including an overhead reflector, stage modification, replacing lightweight materials with dense materials and addressing background noise issues. Generally, this conclusion is consistent across the professional opinions gathered.

A trial was conducted with Sydney Symphony in 2001 to determine whether a single solid reflector would produce any discernable difference on stage. A prototype reflector was made from a plywood scenery flat borrowed from Opera Australia. It was not designed as an acoustic reflector, but enabled the concept to be tested. The visual and heritage impact on the venue were to be assessed once the acoustic effect had been determined.

Arup Acoustics' report *Acoustic Evaluation of a Trial Orchestral Reflector* (2001) concluded that:

Overall, the study confirms that an orchestral reflector is effective in improving acoustical conditions both in the audience areas and the platform. This combines to provide an overall improvement to the Concert Hall acoustic.

Notwithstanding this, other changes to the Concert Hall (as concluded in the Arup Acoustics May 1998 report) would need to be considered as a package of works to improve the Concert Hall acoustic... [11]

In 2002, Sydney Opera House received funding from the NSW Government for the Venue Improvement Program, a series of major projects across the building. A small amount was included to investigate and develop concepts for future acoustic improvements to the Concert Hall. Nagata Acoustics of Japan was engaged as the acoustic consultant for those investigations.

Nagata completed an acoustic benchmarking report (2003), which compared the Sydney Opera House Concert Hall with 11 international concert halls considered to be 'world class'. The Sydney Opera House Concert Hall ranked low among the benchmark venues [12].

Following modelling and acoustic studies, Nagata recommended installing semi-circular orchestral risers; a solid overhead reflector; and a number of 'housekeeping' projects such as sealing areas of the ceiling to prevent sound leakage, and acoustic treatment to the air conditioning system.

The recommendations were not implemented at the time due to heritage considerations, budget and structural constraints. An independent assessment by heritage consultant Design 5 Architects confirmed that a large solid reflector would not be suitable in the Sydney Opera House Concert Hall from a heritage perspective.

A prototype set of semi-circular tiered risers to Nagata's specification was trialled in 2006 (Figure 10). Sydney Symphony found the configuration to be successful in providing a more effective ensemble arrangement. The risers could offer a partial solution.



Source: Sydney Opera House

Figure 10. Tiered riser trial with Sydney Symphony

In 2007, Nagata Acoustics were not available to continue with the investigation and development of options due to a high workload at the time. Kirkegaard Associates was then appointed to work with Sydney Opera House as acoustic consultant, to continue the development of concepts for the future acoustic improvement of the venue.

In a report dated 8 August 2007, Kirkegaard concluded that:

The Concert Hall is a dramatic architectural space inserted into a void which had been intended for an Opera Theatre. From that basic fact derive the series of compromises which have created dysfunctional aspects of the concert hall [13].

Kirkegaard made a set of recommendations, intended to be the foundation of a master planning process to incrementally improve the acoustics within the constraints of the venue.

RECENT TRIALS

Sydney Opera House was built on a tradition of full scale prototypes used for proof of concept. This tradition has been maintained over the years for the development and design of all major works.

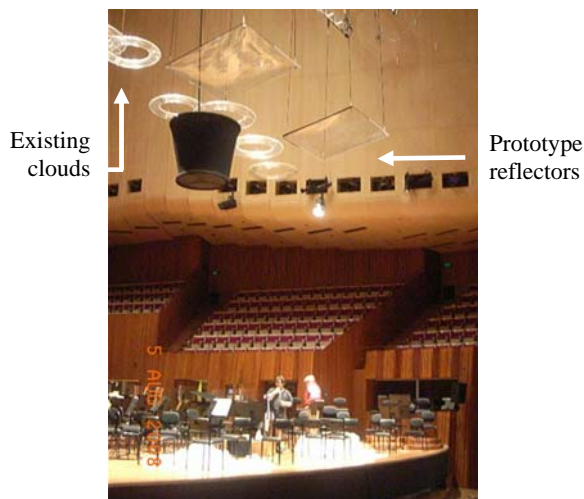
Kirkegaard's recommendations needed to be tested in situ before they could be considered as part of the overall masterplan for the Concert Hall and before any further commitment for funding or resources could be secured.

Visual trials

With the understanding that a single overhead reflector would not be acceptable from a heritage perspective, Kirkegaard recommended an array of convex square reflectors, which could be adjusted to achieve appropriate coverage and control of reflected sound.

Before proceeding with full scale acoustic tests, the recommendation needed to be tested for its aesthetic and heritage suitability to the hall. It was also important to assess the expected impact of the proposal on the other technical production needs, including rigging points.

Two prototype reflectors were made to Kirkegaard's specifications. The prototypes were rigged over the stage (Figure 11), where our architects and heritage consultants assessed their visual appearance. Of particular concern was the level of transparency and light reflection affecting views to the grand organ and ceiling.

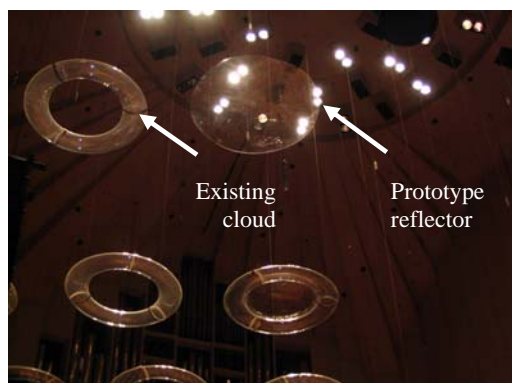


Source: Sydney Opera House

Figure 11. Square reflector visual test

According to the conservation objectives for Sydney Opera House, where change is needed to enhance the overall heritage significance of a space like the Concert Hall, it should be *as much as necessary but as little as possible*.

The study needed to start from the option with the least visual change possible. The team considered the use of solid circular reflectors to increase the acoustic coverage while maintaining an appearance in keeping with the existing clouds (Figure 12).



Source: Sydney Opera House

Figure 12. Circular reflector visual test

A third option was considered, which would require the least change to the visual appearance of the existing clouds, while increasing the coverage of the canopy. Convex discs were manufactured to infill the holes in the existing clouds (Figure 13).



Source: Sydney Opera House

Figure 13. Infills used in existing clouds

From a heritage standpoint, all of the options were considered potentially acceptable for further development, although the circular discs (Figure 12) seemed to lack substance compared to the other options. Light reflections would need to be resolved with the square reflectors (Figure 11).

Acoustic testing was then needed to assess the degree of improvement to the acoustic coverage and control offered by each option.

A full set of infills (Figure 13) was installed in the 18 existing clouds. Kirkegaard determined through listening tests that, while not a complete solution, there was a noticeable improvement to stage coverage. Kirkegaard noted that “the reflector array was still too sparse to provide a satisfactory level of sound reflection on the platform” [14].

Sydney Symphony agreed to trial the infills and the musicians were offered an opportunity to comment. The change for the musicians was discernable enough that Sydney Symphony requested that the infills be kept in place. The infills remain in use today as an incremental improvement towards a fully effective overhead canopy.

This trial illustrates the point that acoustics cannot be considered in isolation from the overall operation of the venue. Although the infills are temporary and removable, some production challenges have been raised through their use. In particular, some of the rigging lines run through the holes in the clouds. A labour cost has emerged, as the infills need to be removed and stored whenever temporary rigging is required.

Whatever the final solution for the canopy becomes, it must be designed with consideration for fly lines, lighting and all other production needs over the stage, as well as the load capacity of the structure above.

Acoustic trials

A trial was established in 2009 to test the combined effect of a more extensive overhead array, flat wall panels covering the sawtooth geometry and an electronic architecture system. By far the most extensive trial to date, it produced a significant amount of acoustic data, which will be discussed in detail in the companion to this paper, Part Two: The Acoustician’s Perspective [15].

Finding a window in which to complete the trial was a challenge for Sydney Opera House management. A week was needed in which Sydney Symphony was in residence and where the program was not interspersed with commercial concerts requiring additional technical overlay.

Sunday 6th September 2009 was programmed with an Australian Chamber Orchestra matinee performance, with the hall in acoustic mode. This was followed by a technical changeover into the acoustic drape configuration for an amplified evening performance by Ben Folds.

Following the evening performance, a crew of some 40 technicians worked overnight to install the acoustic prototypes and a supplementary lighting rig, in time for a Sydney Symphony rehearsal the following morning. Production management, rigging and lighting services were provided by the Sydney Opera House Production Services department. The crew was supplemented by Australian Crewing and Endeavour Skilled Trades.

For the purposes of the trial, the 18 acrylic clouds over the stage were derigged and re-rigged on temporary tri-truss in a closer configuration (Figure 14).



Source: Jack Atley

Figure 14. Existing cloud canopy, temporarily reconfigured on tri-truss

The array was supplemented with additional square panels both downstage and upstage (Figure 15), made of 12mm plywood for the purposes of the trial. Details of the configuration are discussed further in Part Two of this paper [15].



Source: Jack Atley

Figure 15. Prototype array, showing reconfigured clouds supplemented with additional plywood panels

Reflective flat wall panels covered the sawtooth walls in the stalls and on stage (Figure 16). The tilt and pivot angles of the walls were also adjusted for optimum effect. The prototypes were built from Medium Density Fibreboard (MDF) by Endeavour Skilled Trades.



Source: Jack Atley

Figure 16. Prototype flat MDF wall panels

Wool borders of 1m height were hung around the upper auditorium walls to attenuate high frequency reflections causing echoes.

An electronic architecture system was installed by Acoustic Control Systems of The Netherlands to enhance low frequency energy through loudspeakers [16]. For the trial, a system of microphones and speakers was rigged around the hall and within the canopy. On-stage speakers can be seen in Figure 16.

The trial took place over a one week period, during a series of rehearsals and performances by Sydney Symphony and Sydney Philharmonia Choirs. Both organisations actively participated in the trial, and offered unrestricted access to their rehearsals and performances. Sydney Symphony has been a long term collaborator on the project. However, the inclusion of Sydney Philharmonia Choirs in the program brought an opportunity to collect new data on choral repertoire.

Musicians were provided with a 'diary' in which to record their individual experiences and provide real time feedback to the Kirkegaard team. Direct consultation between musicians and acousticians was ongoing throughout the week. This enabled adjustments to be made to the position and focus of the prototypes during breaks.

Audience surveys were distributed to explain the trial and offer opportunities to provide feedback. Responses were received from about 15% of the audience, which was in line with expectations. Many of the respondents were regular subscribers, who have a strong investment in the hall.

Feedback received from both musicians and audiences was overwhelmingly positive, with no negative reports from musicians and only a handful of ambivalent or negative audience responses. Some audience members expressed concern for the visual appearance of the venue, should any permanent changes be made. This highlighted the importance of the visual aspect to those experiencing the performances.

PROGRESS

Sawtooth Walls

Kirkegaard found that the highest incremental improvement in the trial could be attributed to the flat wall panels. This was recommended as the most cost effective element to progress.

Since the 2009 trials, Sydney Opera House has allocated funding to progress with a longer term trial. Custom-made infills will be constructed and fitted with an architecturally appropriate facia to integrate with the existing wall finishes.

A design process has commenced and the trial is expected to be implemented by the end of 2010, subject to Heritage approval.

Concert Hall Masterplan

In parallel with the acoustic investigations, Sydney Opera House commissioned Arup Theatre Planning in 2009 to develop a Western Venues Theatre Systems Masterplan. The intent of this was to capture in one document the required upgrade of systems and related structures in the four western venues in the complex, including the Concert Hall. The Masterplan details a review of the structural geometry of the Concert Hall and the load calculation assumptions.

The Masterplan has indicated a way forward to improve structural loadings, rigging systems and maintenance access that will improve functionality and inform the bigger picture of the hall's required development.

CONCLUSION

The development of the Concert Hall acoustics needs to be measured holistically and within the overall programming and operational demands of the venue. Recommended improvements to the acoustics represent a multi million-dollar investment and consequently require integration with the plans for the entire Sydney Opera House complex.

A number of masterplans and strategies are in place and it is through these instruments and a rigorous heritage framework that Sydney Opera House enacts a considered and coherent approach to building development.

The organisation works closely with the NSW Government to implement the building strategy, however at the time of writing the funding under the 2002 Venue Improvement Program is fully committed. Sydney Opera House will continue to implement, where possible, incremental improvements through existing resources and will maintain its vigorous advocacy of further development funding.

This paper has endeavoured to outline the history and context of the work on the Concert Hall acoustics. The detailed works currently proposed represent an opportunity to ensure that Sydney Opera House, the resident company Sydney Symphony, and touring artists from around the world can be truly proud of this landmark venue.

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