Analysis of Design Options: Concert Hall, Creative Learning Centre

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1 Options and Design Alternatives

1.1 Introduction

This Appendix to the Environmental Impact Statement for SSD 17_8663 has been prepared to provide a holistic appraisal of the processes by which the Sydney Opera House (SOH) has considered the options and design alternatives for the Concert Hall Upgrades and Creative Learning Centre Renewal Projects. This Appendix sets out the design options considered and explains the rationale for selecting the designs proposed in this SSD application.

The Sydney Opera House is the symbol of modern Australia and a State, National and World Heritage-listed landmark. It is the nation's premier tourism destination and one of the world's busiest performing arts centres. The Opera House has played a powerfully transformative role in Australian life.

The Opera House welcomes 8.2 million visitors a year and presents more than 1,700 performances each year to a combined audience of 1.4 million on site and millions more online. A 2013 Deloitte Access Economics report found that the Opera House contributes $775 million to the national economy every year and has a cultural and iconic value to Australia of $4.6 billion. The building is estimated to contribute more than 8,400 full-time equivalent jobs to the economy.[1]

Use of the Opera House has continually evolved since its inception. Originally planned as a two-theatre performing arts centre , it is now a five-theatre multi-purpose performing arts complex that operates 363 days a year. Significant facilities, systems and infrastructure have reached the end of their operational life.

The Opera House's status as a World Heritage-listed icon attracts an extremely large number of tourists. This was not envisaged when the building was designed. We do not engage with many of these visitors beyond a quick visit and a photograph. The need to improve the public-facing and tourism-related facilities to welcome, inspire and create wonderful customer experiences has been identified as a strategic priority for the organisation. This is also closely aligned with and supports the NSW Government's stated goal of doubling tourism expenditure to NSW by 2020.

At its 40th Anniversary in October 2013, the Opera House embarked on a decade of renewal to secure the building for future generations of artists, audiences and visitors. This includes upgrading or replacing systems that have reached the end of their operational life and reallocating spaces to be more visitor-friendly and to better support tourism activities.

The Renewal Framework is a systematic and considered approach to renewal of the Opera House over the next nine years. It considers new business opportunities, better ways to use spaces, improvements to the front of house and public amenities, as well as renewing the lifeblood of the Opera House, its theatres.

The two projects covered by SSD 17_8663 are key projects within the Renewal Framework.

1.1.1 The Concert Hall Upgrade

The Concert Hall is the largest of all Sydney Opera House interior venues, it delivers a unique and premier performance space that provides a grand setting and cathedral-like ambience featuring it's high vaulted ceiling and white birch timber and brush box panelling.

[1] Deloitte Access Economics, The Opera House: economic, cultural and digital value, October 2013

It is home to the Sydney Symphony Orchestra, Australian Chamber Orchestra and Sydney Philharmonia Choirs. It is not solely used as a classical performance space and provides a premier space that attracts a diverse range of contemporary performance genres and events including popular music, circus, stage shows, film screenings, spoken-word performances, talks, and large-scale corporate and community events. The range of these performances is extensive, they are popular amongst patrons and tourists and have included performances by many of the world's leading artists and arts companies.

During its operation the Sydney Opera House has undertaken minor works along the way to introduce improvements to the efficiency of the venue, such as the introduction of energy efficient LED lighting, etc. The Sydney Opera House has not had an opportunity nor the financial capability to date to significantly upgrade the venue to better improve:

- The acoustic performance of the facility;
- Compliance to current building codes and standards;
- Access to the facility for all;
- Customer experience and enjoyment of the facility;
- Flexibility and capability to meet a diverse range of production demands;
- Flexibility to adapt to newer technologies;
- Safety of back of house operations;
- Efficiency of production installations and turnarounds through improved systems and technology and design;
- Utilisation of the facility and its use for multiple productions; and
- Support facilities such as storage and rehearsal facilities for performers.

Over time the service expectations of premier performance facilities have significantly increased to meet new regulatory compliance, production and customer experience requirements and to improve access for all.

1.1.2 Creative Learning Centre

The Opera House' mission stems from the founding Act, which, as well as protecting, maintaining and developing the building as a performing arts centre, includes:

- Promoting artistic taste and achievement in any of the branches of the arts;
- Scientific research into, and the encouragement of, new and improved forms of entertainment and methods of presentation of entertainment; and
- Encouraging the innovation in the arts.

The provision of the Creative Learning programs at the Sydney Opera House is clearly directed towards furthering this mission. The construction of the Creative Learning Centre will provide the Creative Learning programs with a permanent home.

1.2 Renewal Design Process

The architects engaged on these works - ARM Architects for the Concert Hall works and Tonkin Zulaikha Greer for the Creative Learning Centre project - have undertaken a comprehensive process of options analysis, consultation with heritage and other experts, alignment with key guiding documents (the UDP and CMP) and design review by the Sydney Opera House's Eminent Architects Panel and Conservation Council. The figure below outlines the key design phases undertaken:

Figure 1: Building Renewal Design Phases (Source: SOHT)

The current proposal is the result of detailed consultation with a wide variety of experts and testing of multiple design options including by the following key groups:

- Technical experts: The Opera House has engaged consultant expertise to provide clear, world class advice on all technical aspects of the design, including in relation to acoustics, accessibility, structural engineering and BCA compliance;
- Heritage Architect: Design 5 architects were engaged to advise each Architect throughout the design phases as well as providing services to write the HIS for the Development Application. Design 5 has 12 years' experience at the Opera House and authorship of the CMP Fourth Edition;
- Sydney Opera House users: The Opera House boasts a world class staff with clear technical expertise in accessibility, theatre, visitor experience, events and the detailed technical requirements of artistic programming at the Opera House;
- Resident companies: Sydney Symphony Orchestra (SSO), Australian Chamber Orchestra (ACO), and the Sydney Philharmonia Choirs (SPC) are the key resident companies engaged and consulted for expert advice on the Concert Hall projects through the development of options for the design;

- Eminent Architects Panel (EAP): Are charged with providing technical advice to the Sydney Opera House Trust on matters related to design, architecture and heritage. The EAP reinforces the significance of design excellence and consistency of architectural approach to ensure the Opera House maintains and conserves its outstanding universal values; and
- Conservation Council (CC): Are charged with providing advice to the Sydney Opera House Trust on conservation and heritage-related matters.

The final proposal is based on this consultation and adopts an evidence-based approach, which has carefully considered and balanced the heritage conservation of the building with its on-going function as a living public building to be celebrated by existing and future generations.

1.3 Consideration of Alternative Designs

The opportunity for change at the Sydney Opera House was articulated by Jørn Utzon in the Utzon Design Principles (2002).

> "As the architect of the Sydney Opera House, as the creative force behind its character, I sincerely believe that a large multipurpose structure such as this building, in time will undergo many natural changes.
>
> "The ideas as they were developed in the sixties, evolved as the result of the needs and technique at the time.
>
> "As time passes and needs change, it is natural to modify the building to suit the needs and technique of the day.
>
> "The changes, however, should be such that the original character of the building is maintained.
>
> "That is to say, I certainly condone changes to the Sydney Opera House. Both changes due to general maintenance and changes done due to functional changes.
>
> "Had I completed the Sydney Opera House as the architect in charge, the building would have developed and changed with the time ever since."

As identified in Section 4.1 of the EIS, there is a clear need for change, the Opera House operates in a rapidly shifting landscape with increasing technological innovation, especially in the performing arts, and growing popularity of cultural tourism. Should a 'do nothing' approach be taken the implications would be as follows:

Case for Change	**Do Nothing**
Age and rapidly advancing technology are affecting the operational capacity of the building to meet the requirements of contemporary performers and audiences, and its capabilities as a world-class performing arts centre;	• Technology not updated • Unable to meet requirements of contemporary performers or audiences • Status as a world class performing arts venue diminished
Critical infrastructure components have reached the end of their operational life;	• Technology not updated, left in current state • Increased maintenance costs • Greater chance of 'downtime' or un-planned maintenance
Physical limitations, some stemming from design scope changes made in the late 1960s, constrain safety, accessibility, operational efficiency and financial sustainability; and	• Physical limitations remain • Compliance risks increase in relation to safety and accessibility legislation • Increased costs to implement administrative overlays, with limited operational and artistic effectiveness • Greater reliance on Government funding for operations and maintenance
Changed legal and regulatory requirements, including workplace health and safety, building codes, accessibility and security, have significantly increased compliance risks.	• Increased compliance risk • Increased administrative overlays • Increase operational costs in insurance premiums and staffing

As outlined in Section 4.2 of the EIS, conceptual, schematic and detailed design analysis has been undertaken in consultation with the SOH's Heritage Architect and other technical experts to determine the opportunities and constraints associated with the proposed action. In particular, this analysis focussed on design options that:

- Implement the recommendations of the Accessibility Masterplan (AMP);
- Resolve existing WHS issues;
- Improve the operational efficiency of the building to ensure the Opera House is provided with state of the art performance facilities, consistent with similar world-class performing arts venues;
- Supplement and enhance the World and National heritage values of the site; and
- Minimise the removal or modification of significant building fabric.

Several components of the proposal have been subject to more detailed design scrutiny as they have a more significant impact on the Opera House's structure and fabric. This section focusses on the impacts of these components, including:

- Level 2 passageway in Concert Hall Eastern Foyer;
- Lifts in the CH Northern Foyer (Lifts 29 and 30);
- Acoustic upgrades to the Concert Hall, including changes to the stage, anteroom and wings;
- Upgrades to Concert Hall technical systems; and
- Introduction of the Creative Learning Centre.

1.4 Concert Hall Options

1.4.1 CH Accessibility Upgrades

1.4.1.1 CH Accessibility Passageway

New horizontal connections between the Southern and Northern Foyers and the provision of wheelchair accessible seating in the CH stalls, circle and boxes are identified as key projects in the AMP.

1.4.1.1.1 Do Nothing option:

If the CH accessibility passageway is not implemented, the status quo would remain whereby there is no DDA-compliant path of travel from the CH Southern Foyer to the Northern Foyer and into the venue. Patrons in wheelchairs would only be able to access the caves level of the Northern Foyer, and would still need to be escorted by an Opera House employee via a back-of-house route. Accessible seating locations remain limited to the front of the Stalls only, and this is non-compliant under the Disability and Discrimination Act (DDA) access to premises standards.

Other implications of doing nothing include;

- Legislative and code requirements in relation to accessibility would not be met, including access;
    - To other areas of the venue to provide a compliant number of seats across a range of areas in the auditorium.
    - To all levels of the CH Northern Foyers. (i.e. no DDA compliant access to the proposed lifts 29 & 30).
- Greater operational costs of implementing management overlays to comply with alternative DDA solutions; and
- The Opera House's status as a world class performing arts centre, accessible to the public at large, would be diminished.

1.4.1.1.2 Concept design:

The concept of a passageway in the location identified in the proposal is considered appropriate on the basis that Jørn Utzon's original design for the building envisaged passageways on Level 3 in both the Eastern and Western foyers of the Minor (now JST) and Major (Concert Hall) Halls. This is evidenced by Utzon's drawings in the Red Book (1958) in Figure 2 and also in the photograph in Figure 3, which show these passageways were included in the podium at its completion in 1963.

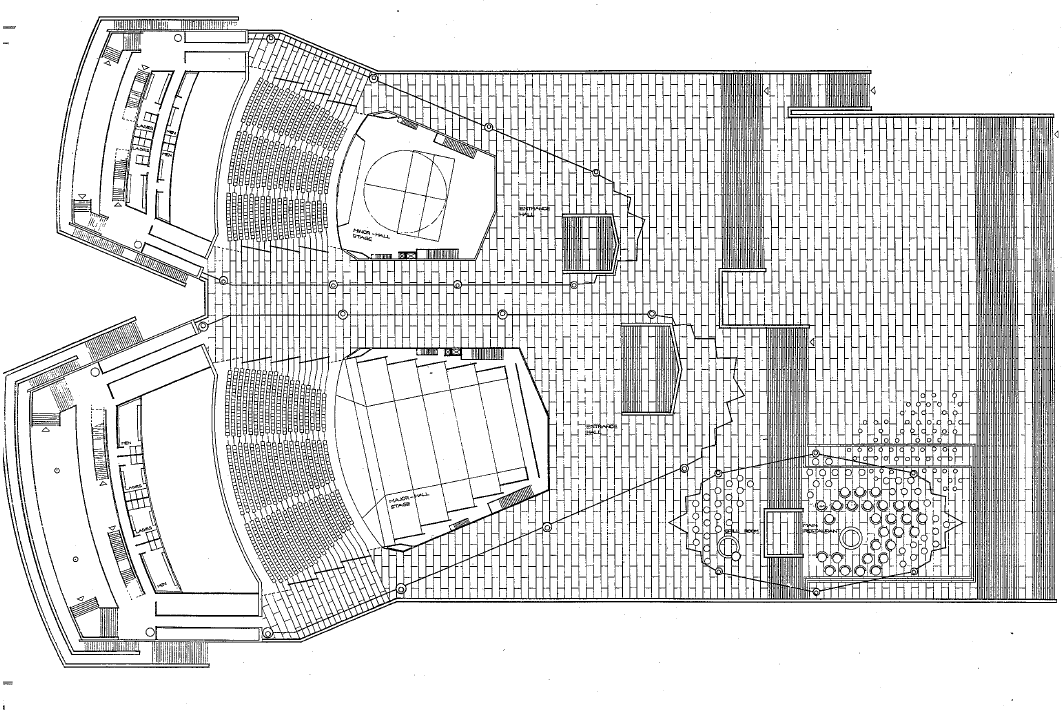


Figure 2: Extract from The "Red Book" – Sydney National Opera House – Jørn Utzon March 1958

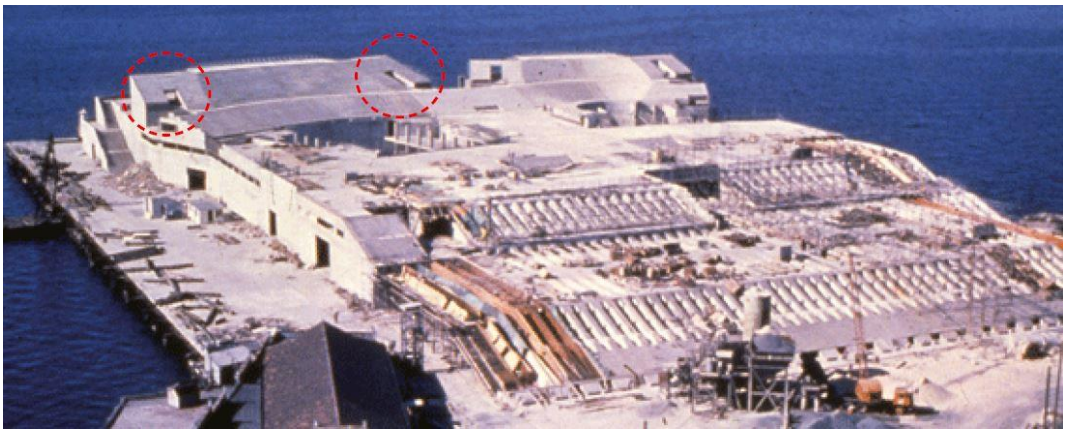


Figure 3: Photograph of completed podium, 1963, showing construction of passageways

It is important to note that while the tunnels identified in Figure 3 were constructed, they were closed over due to design program changes after Utzon's departure in 1966.

While the changes to the geometry of the original passageways preclude their use, the proposed tunnel is very close to the location of Utzon's original tunnel. It is also important to note that Utzon's original concept for the passageways through the JST eastern and western side foyers was further reinforced in 2005 when Jørn Utzon was engaged to investigate a new opera theatre, a proposal that became known as the *Gold Book*.

Figure 4 outlines an image of the *Gold Book* proposal and demonstrates that the architectural plans continue to show Utzon's vision for passageways connecting the southern and northern foyers of the JST at both Levels 2 and 3, similar to the current

proposal. The *Gold Book* proposal has a narrower auditorium, allowing a wider passage and stair in the side foyers than is possible now.

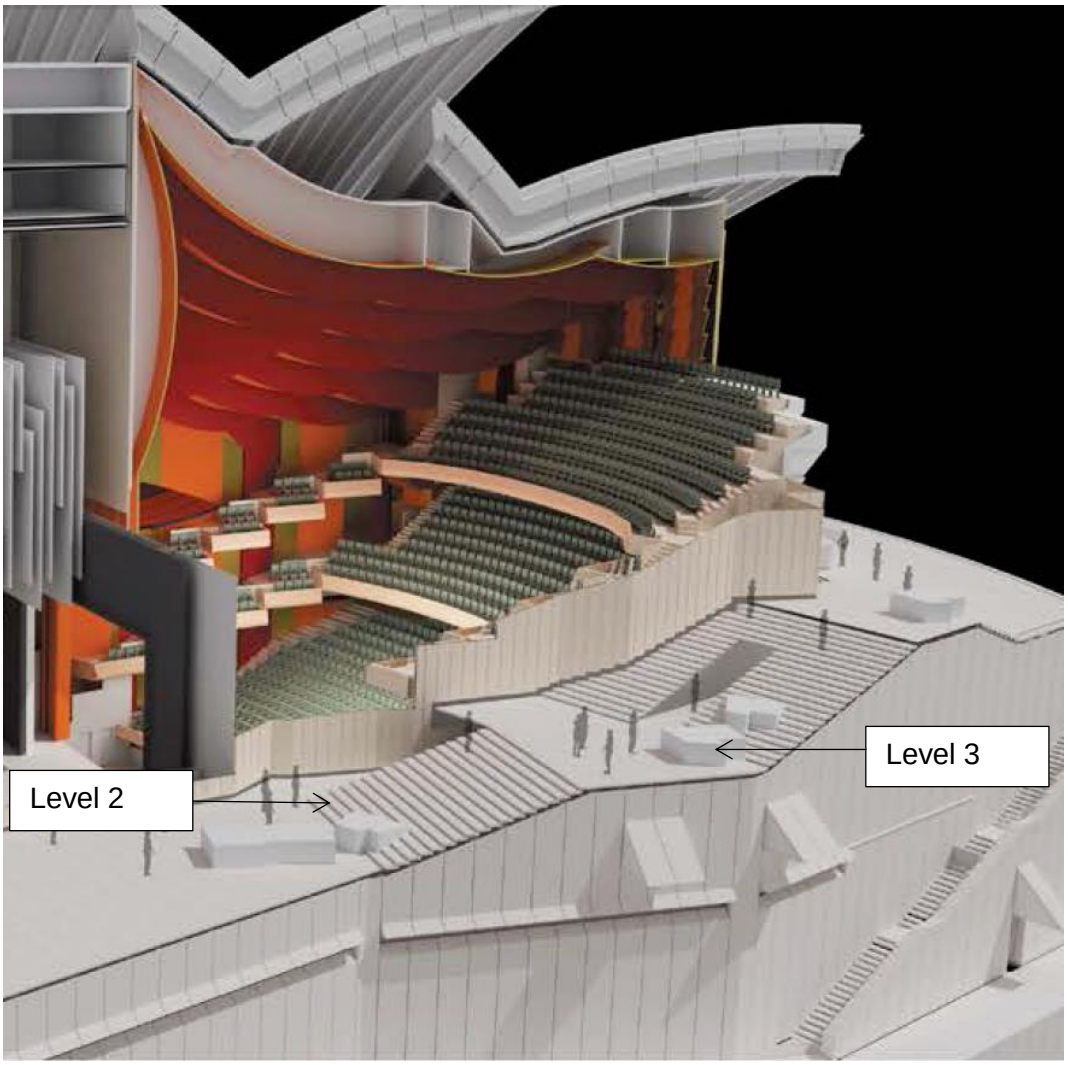


Figure 4: Concept Design of Joan Sutherland Theatre 'Gold Book' illustrating the passageways at both levels 2 and 3

The current proposal for a passageway builds upon this vision for access from the Southern Foyers to the Northern Foyers, while balancing the operational impact on existing spaces and the need to complement the spaces and fabric that they affect.

This design option is also consistent with the key goals of the project to implement the recommendations of the AMP and open up the CH to a wider section of society, in particular, those with reduced mobility (including wheelchair users and a large number of the elderly who cannot manage the significant number of stairs) who have previously been unable to access and experience these spaces. This option will also reinforce the OUVs of the site by ensuring the Opera House remains 'accessible to society at large' for generations to come.

The AMP proposes a symmetrical approach to providing universal access to the areas around the Concert Hall, Southern & Northern Foyer connections.

The practicality of implementing this recommendation was investigated during the conceptual design phase of the project. At this stage, a design option was investigated on both sides of the CH auditorium (the western and eastern side foyers), the construction of two concealed passageways at Level 2, from the Southern to the Northern Foyers combined

with new lifts in the Northern Foyers, an upgrade and extension of Lift 1 and a new Lift 26 in the Southern Foyer. This is shown in Figure 5.

ARM Architecture's initial concept design work tested this symmetrical approach and evaluated whether all proposed lifts were required or if a 'half' approach restricted to either the west side or east side had merit.

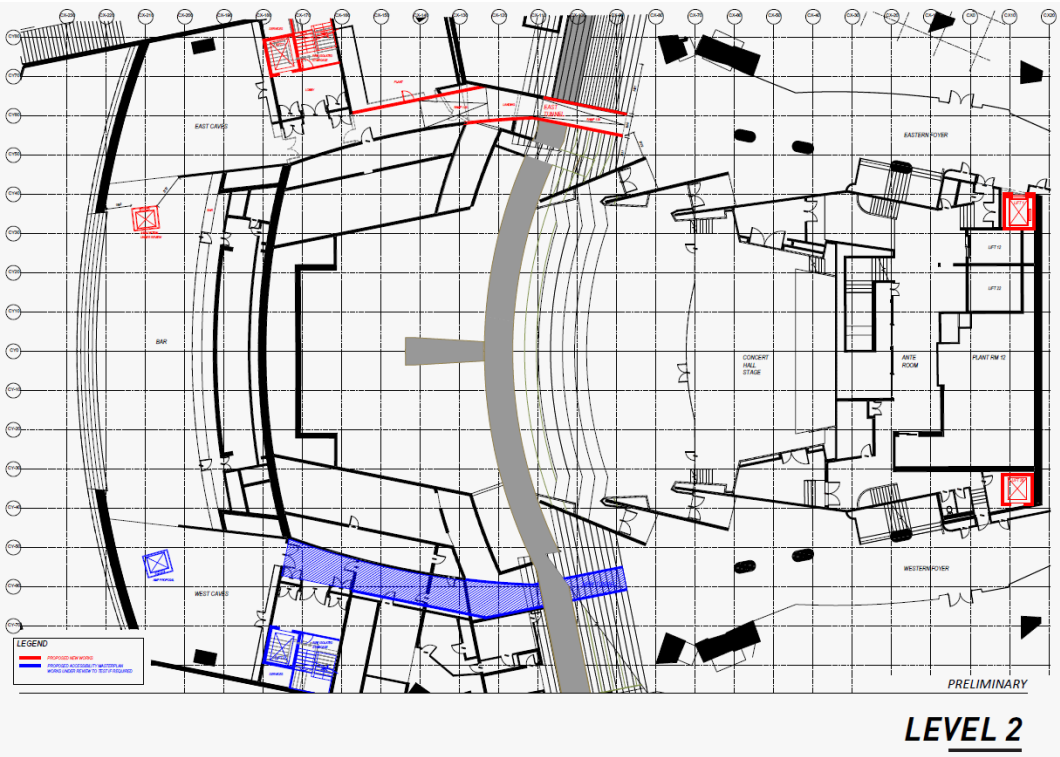


Figure 5: AMP Concept of two passageways from Southern to Northern Foyer at Level 2

During the concept design phase for the CH project, the SOH Executive determined that the option of only one passageway should be taken forward, and that this passageway should be on the Eastern Foyer side, as would a similar passageway for the JST accessibility upgrade be in the Western Foyer of the JST. This would mean the proposed passageways would be on the internal "cleavage" of the building. It would also mean that the impact on significant fabric and spaces would be lessened by choosing to have only one passageway in each of the two halls. With this location it would not affect the external views of the Sydney Opera House from within the World Heritage defined curtilage.

The concept design (Figure 6) located the passageway centrally in the stairs, with the alignment of the entry point parallel to the brush box wall of the auditorium.

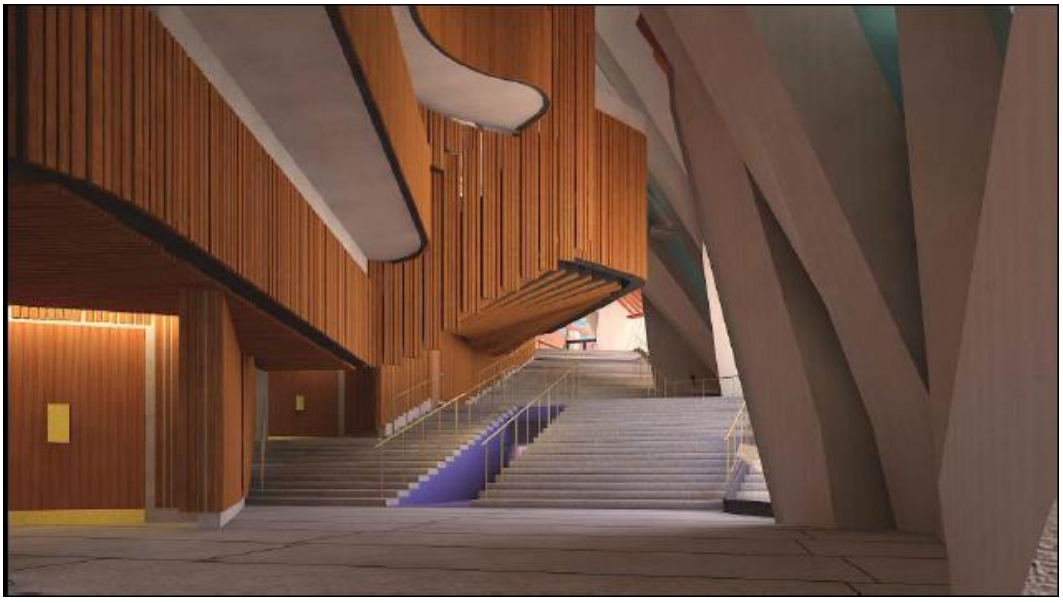


Figure 6: Option showing passage located centrally in stairs, but parallel to brush box

This testing concluded further schematic designs were required to determine the full impacts of the works on the integrity of the internal building spaces and significant building fabric.

Escalators located within the Eastern and Western Foyer stairs were also considered but due to the existing building structure restricting the space required to accommodate escalators this option was ruled out. Escalators also would not provide access for patrons in wheelchairs. The introduction of additional handrails on both Eastern and Western sets of stairs has been adopted to help with mobility impaired patron access.

1.4.1.1.3 Schematic design:

The Eastern passageway was further refined and developed in the first phase of schematic design. The entry was moved further to the east, opening up the view to it from further back in the Southern Foyer as well as being widened to provide a more generous passage width. A revised concept for materiality of the passage surfaces and balustrades was developed. The following Figure 7 demonstrates the change from concept to early schematic design.

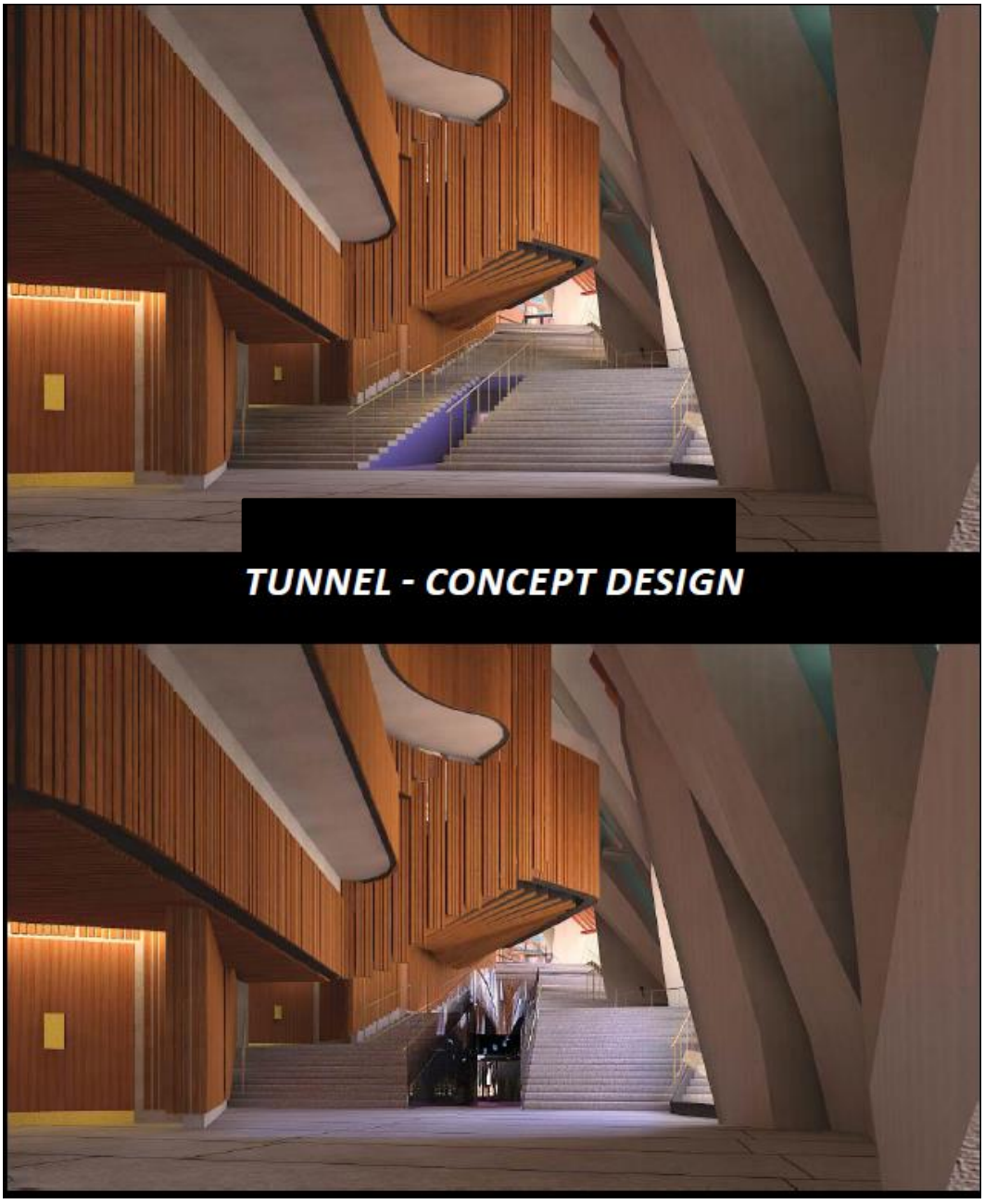


Figure 7: Initial Concept and Schematic Designs for the Passageway

Final schematic design resulted in the alignment and width of the passageway entry in the eastern foyer being positioned to provide users with an obvious path of travel while keeping the existing stairs as wide as possible on either side of the entry.

The entry and surrounding stair balustrade were detailed in bronze glass, which transitioned from solid at the entry to clear for the balustrade. Within the passageway, the wall cladding was polished brass or bronze which linked to the northern foyer lift cladding. One side had a profiled sound wave pattern which anticipated the similar architectural treatment within the Concert Hall. The flooring transitioned from the stone of the eastern foyer stairs to the purple carpet of the northern foyers.

1.4.1.1.4 Design Development:

The design of the passage considered a direct and legible pathway for patrons as the main criteria to provide the required amenity for wheelchair and mobility impaired patrons.

To explore this intent options for the passageway location were explored (refer the following drawings & renders). To satisfy the desire for a legible and direct route, minimise the physical impact on the current stairs and to maintain the visual continuity of the staircase width the passage located centrally to the stairs was agreed as providing the best architectural and heritage resolution.

Other design concepts considered and developed at this time in conjunction with Scott Carver Architects (responsible for the JST upgrades) and the EAP included:

- Detailing must be consistent with existing stair design.
    - Various options were considered for the stair edge and handrail detail. The agreed stair edge detail is consistent with existing details which expose the end of the precast stair treads which best implies the continuity of the treads across the foyer space. The handrail detail is consistent with the new compliant Bronze Handrail kit of parts proposed to be used across all SOH Renewal Projects.
- The materials and detailing in the Southern and Eastern Foyer must integrate with those in the Northern Foyer.
    - This has been achieved by transitioning the granite floor finish in the Southern Foyer through to the carpet floor finish in the Northern Foyer, lining the walls with bronze cladding consistent with the existing bronze materials used elsewhere and detailing it to reflect the “fan” detailing of the timber walls and soffits in the Eastern foyer. Additionally the use of full height drapes to the west wall of the passage both improve acoustics and relate to the use of acoustic drapes in the Concert Hall. A range of finishes and colours were considered for the west wall finish including textured and relief concrete wall panels and full height drapes in different colours (the existing concrete wall cannot be exposed due to many instances of scarring and other damage). Grey drapes are proposed as the preferred option with the detail of the drape material to be finalized in detail development.

The following diagrams show the options considered for the location of the passage and then the final proposition. All options were reviewed with the EAP, CC Heritage Consultant - Design 5 Architects. The consensus reached was that the centrally located passage was the best option to proceed with to satisfy both heritage and DDA amenity requirements.

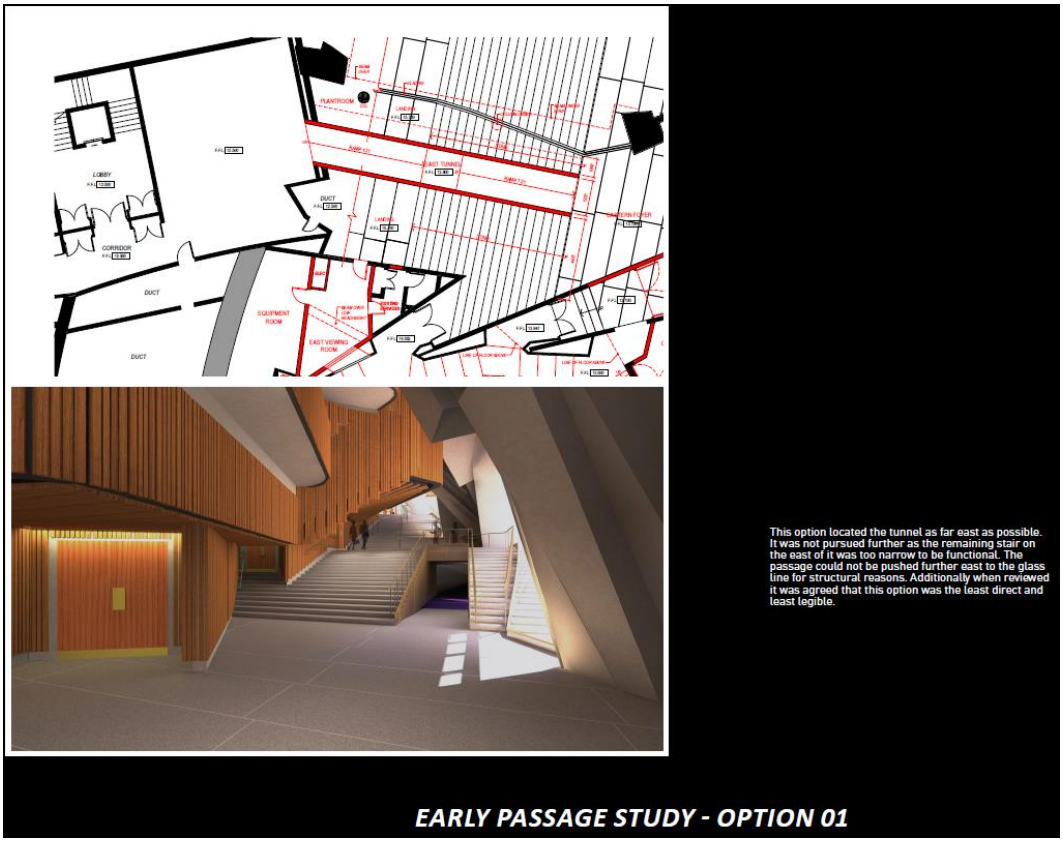


Figure 8: Early Passage Study – Option 01

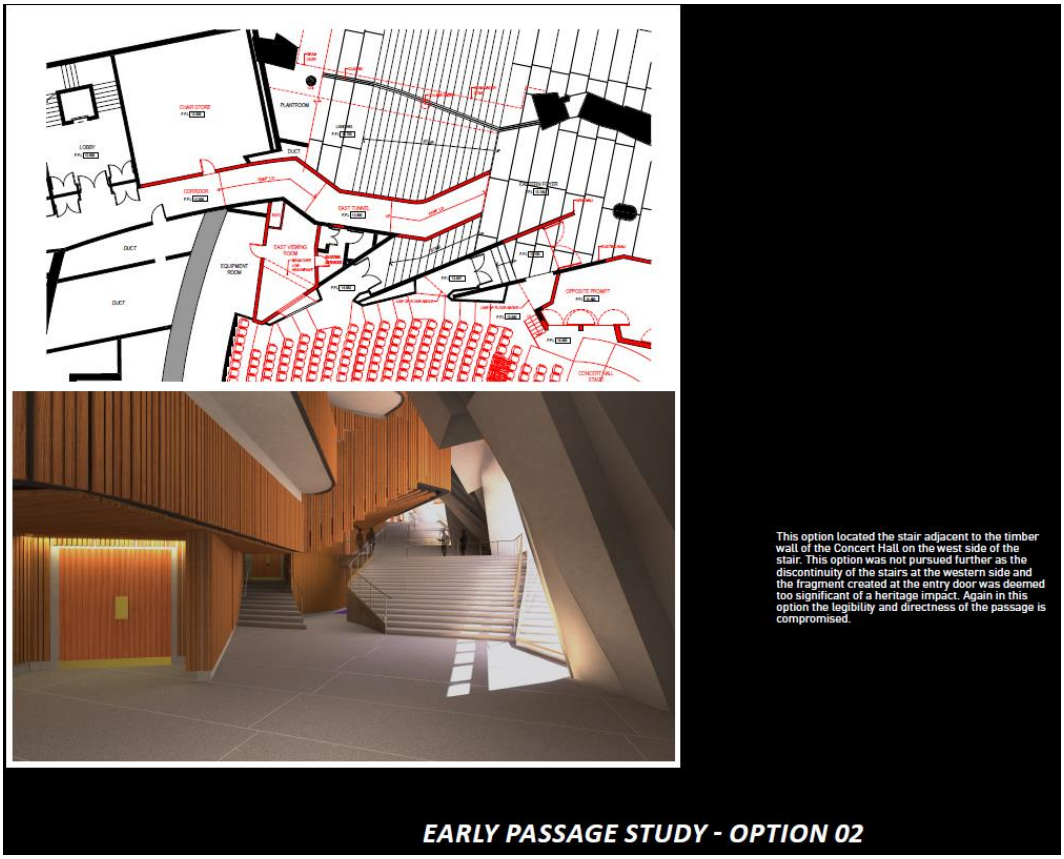


Figure 9: Early Passage Study – Option 02

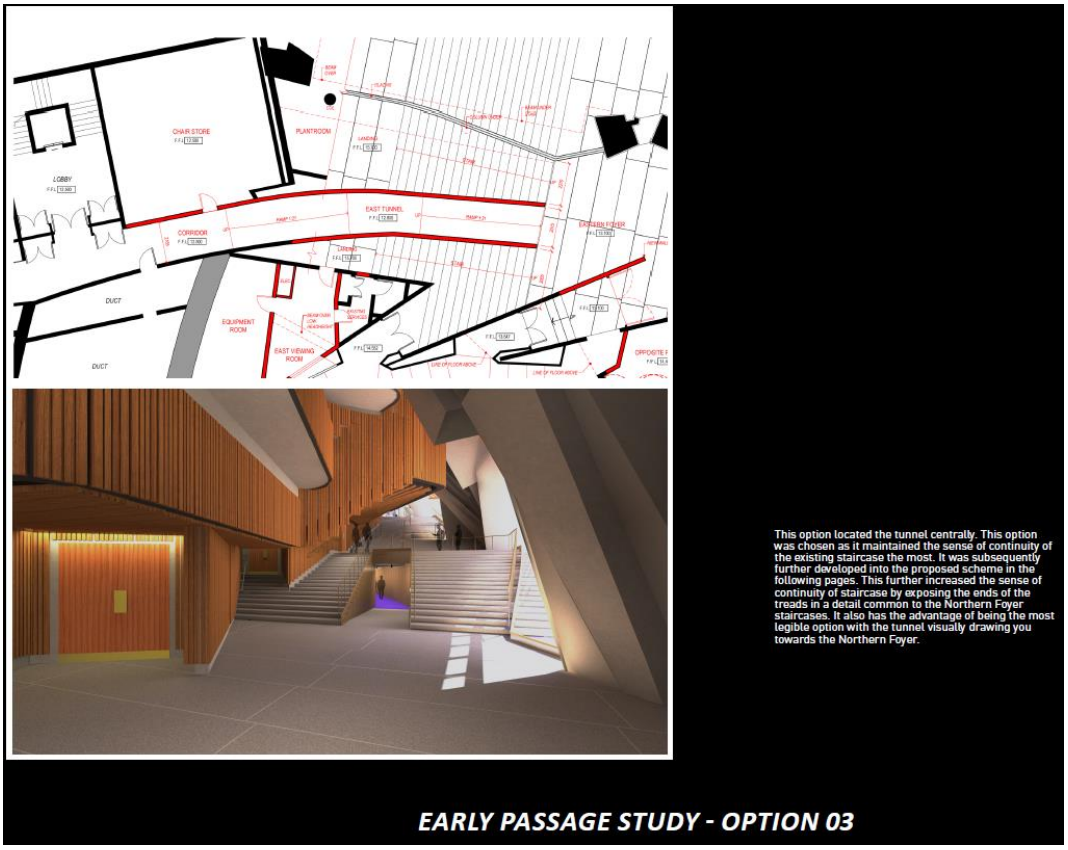


Figure 10: Early Passage Study – Option 03

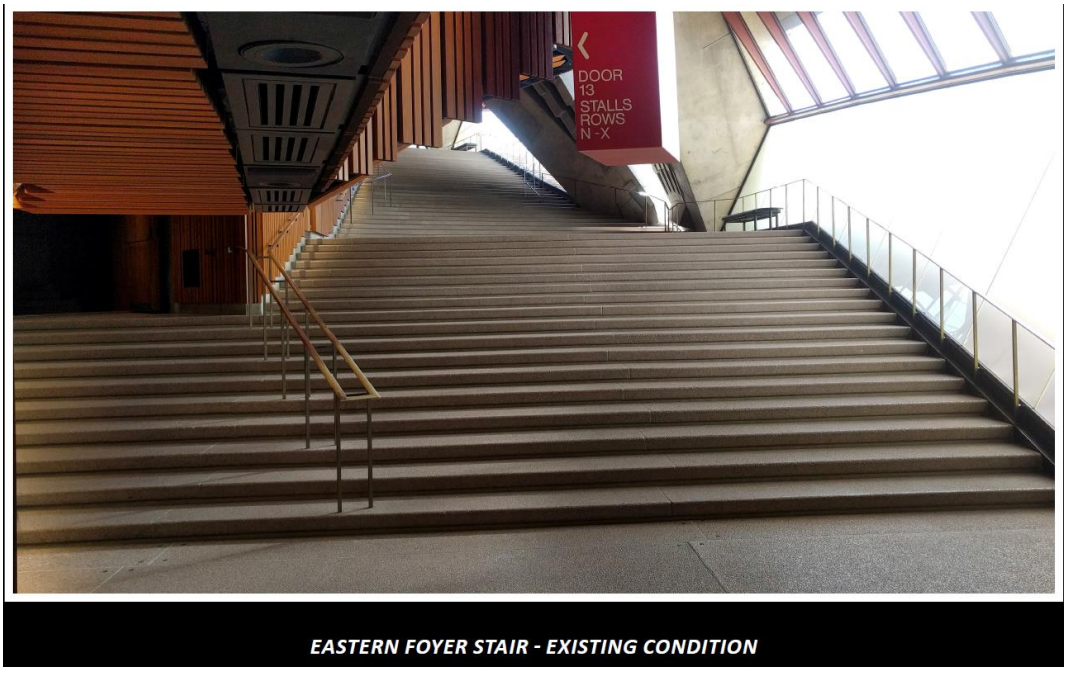


Figure 11: Eastern Foyer Stair – Existing Condition

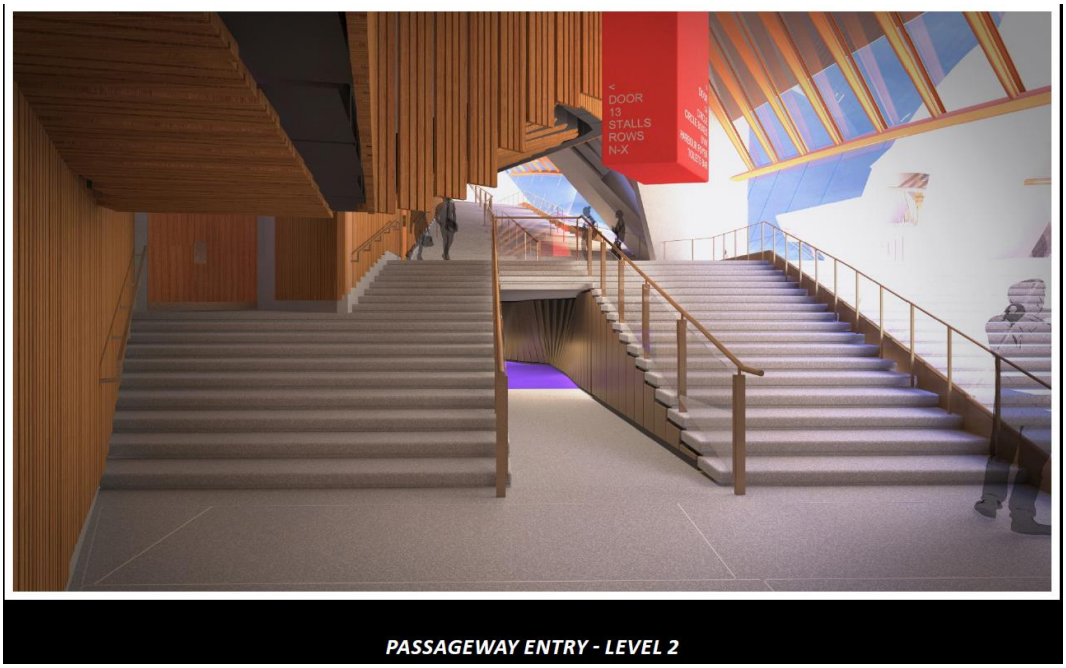


Figure 12: Final Passageway Entry – Level 2

Figure 13: Final Passageway – Looking Towards Caves

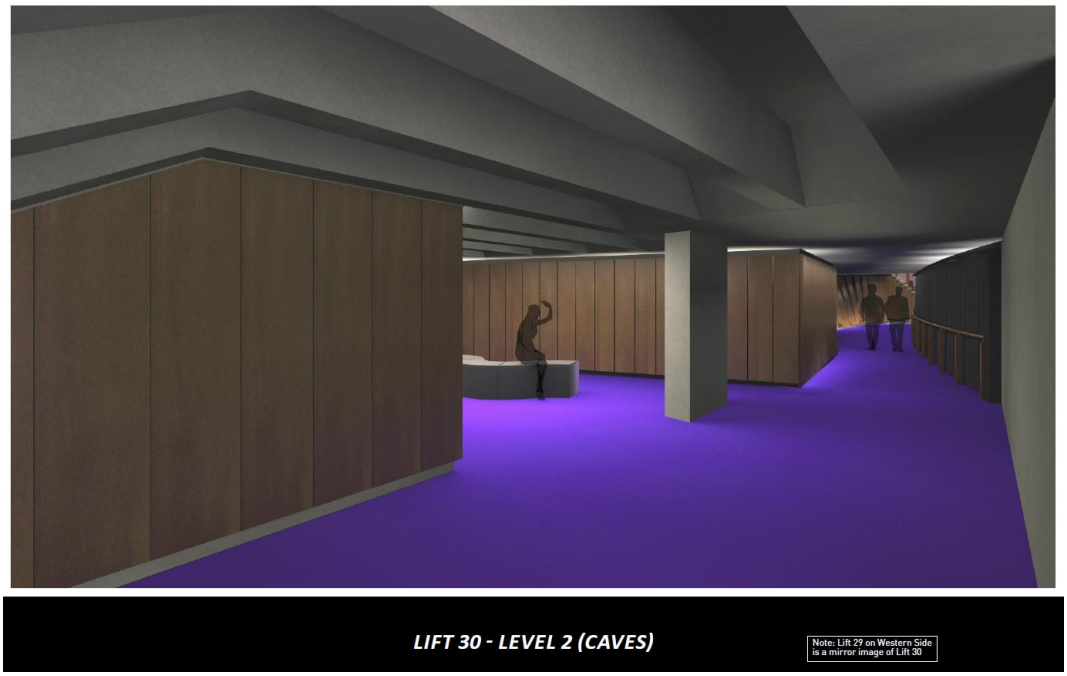


Figure 14: Caves – Final Option Looking South Towards Passageway Entry

1.4.1.2 CH Northern Foyer lifts (Lift 29 & 30)

Background

The AMP recommended updating three lifts and installing three new lifts around the Concert Hall to provide improved access for performers, patrons and staff. These included new lifts 26, 29 and 30 plus an extension of Lift 1 to travel from Ground Floor to Level 4 and Lift 26 linking the Western Foyers to the Concert Hall Southern Foyer and arriving at Level 4. Existing Lifts 7 and 9 were proposed to become front of house lifts connecting Level 2 and Level 3. Conceptual, schematic and detailed design analysis was undertaken in consultation with key stakeholders and the EAP to determine the buildability and practicality of implementing the lift upgrade works identified in the AMP.

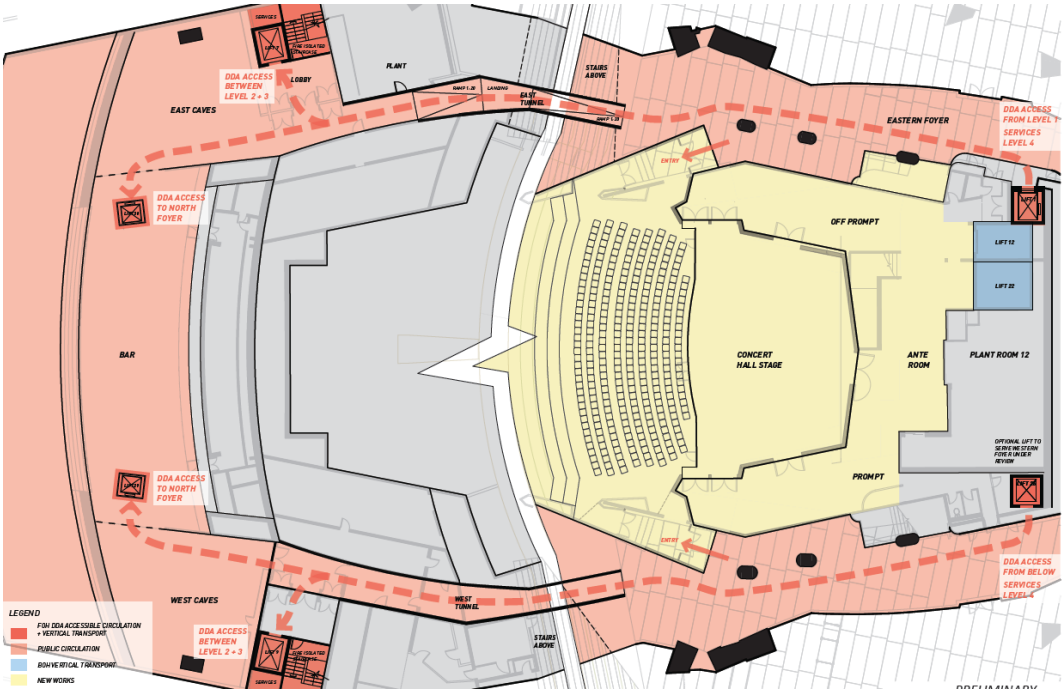


Figure 15: Lifts Proposed in Accessibility Master Plan

The proposed new lift 26 and the extension of Lift 1 to Level 4 were considered but were ruled out due to structural complications and a constrained path of travel at Level 4 being too narrow for wheelchairs.

Lift 26 (connecting the Western Foyer to the Concert Hall Southern Foyer at Level 2) remains an important AMP project that should be implemented in future projects in conjunction with upgrades to the Western Theatres and Foyer in Stage 2 Renewal.

Lift 1 will remain in its current configuration but with a front of house connection to the Box Office Foyer. This is part of the Entry Foyer project which is the subject of SSD 7665.

The practicality of making Lifts 7 and 9 front of house access at Levels 2 and 3 was considered problematic for security as these were adjacent to sensitive back of house areas.

Based on the above, it was determined conceptually that lifts 29 and 30 provided the most benefit for the least impact. The task was to determine the solution with the least impact on heritage fabric.

1.4.1.2.1 Do Nothing option:

If the CH Northern Foyer Lifts (lifts 29 & 30) are not implemented there would be no vertical transportation link and no DDA-compliant path of travel to all levels of the Northern Foyer. The elderly and patrons in wheelchairs would only be able to access the caves level of the Northern Foyer, and would still need to be escorted by an Opera House employee via a back-of-house route. There would be no new accessible seating positions in the Circle and Circle Boxes. Two lifts are required to provide access to accessible seating positions at Level 4 on both the Eastern and Western sides of the auditorium (or alternatively one lift with a connecting “bridge” at Level 4).

If lifts 29 & 30 were not implemented, the same compliance, cost, operational and reputational risks that apply in relation to the CH accessibility passageway (outlined above) would apply.

1.4.1.2.2 Concept design:

In terms of the conceptual analysis, four design options were identified and tested. These options comprised:

- Option 1: a single lift located at the eastern end of the broad stairs in the Northern Foyer, along with an optional connecting “bridge”, necessary to provide an accessible travel path to the accessible seating via Level 4 on both sides of the auditorium. Shown in the following Figure 16.

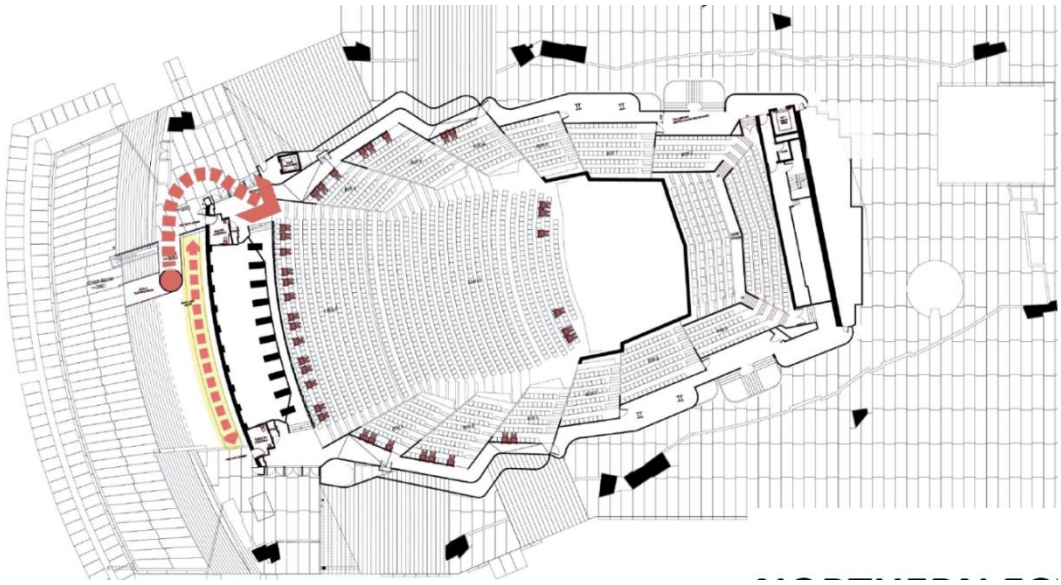


Figure 16: CH Northern Foyer Lift Option 1 (including optional “bridge)

- Option 2: construction of two new lift shafts (lift shafts 29 & 30) within the Northern Foyers towards the edges of the central broad stairs (see following Figure 17)

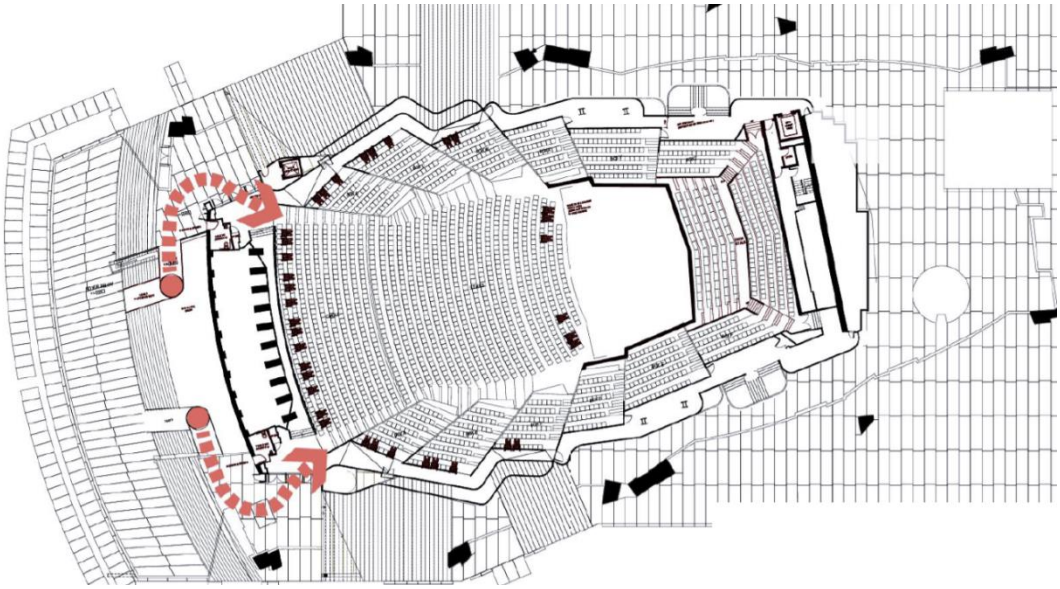


Figure 17: CH Northern Foyer Lifts Option 2

- Option 3: construction of two new lift shafts (lift shafts 29 & 30) within the Northern Foyers at the centre of the central broad stairs and connecting “bridges” to Level 4 (see following Figure 18)

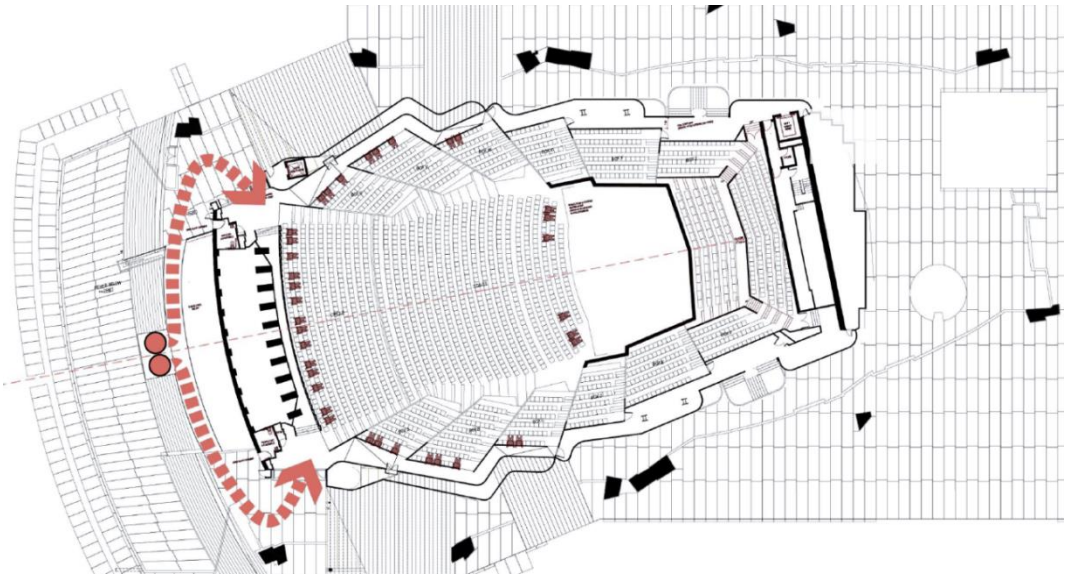


Figure 18: CH Northern Foyer Lifts Option 3

- Option 4: construction of two new lift shafts (lift shafts 29 & 30) within the Northern Foyers towards the outer edges of the Northern Foyer (see following diagram)

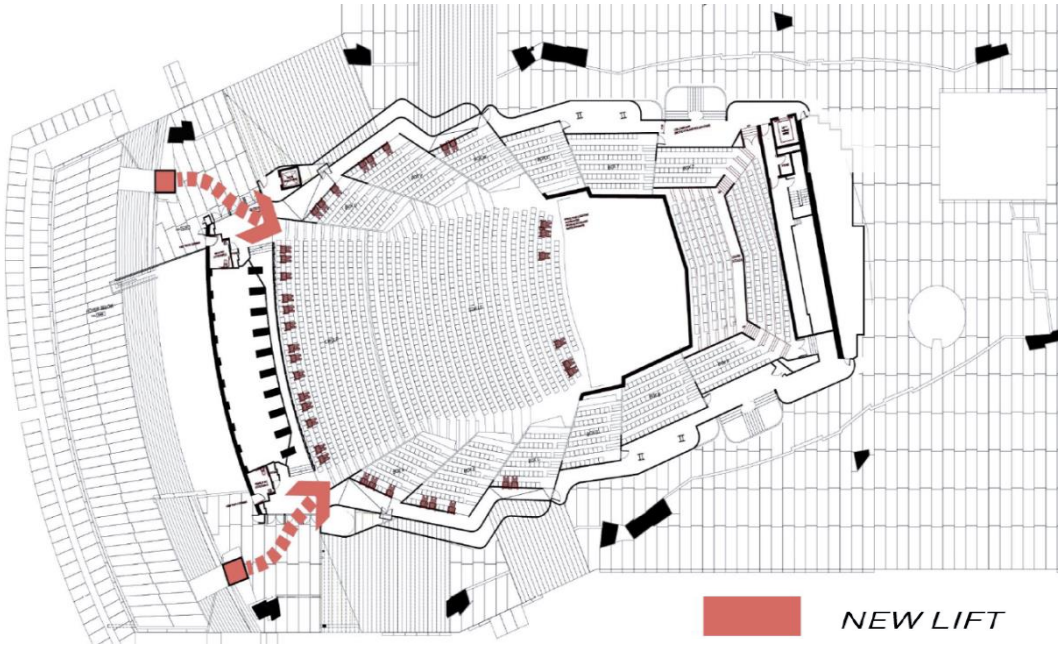


Figure 19: CH Northern Foyer Lifts Option 4

The conceptual design analysis concluded that Lift Option 4 was the preferred option to proceed with for the Northern Foyer lifts.

- Option 01 located a single lift to the eastern end of the central Northern Foyer staircase. It was not pursued further as the heritage impact of locating a new object in this space was deemed too detrimental. A single lift also compromised DDA access to the rear of the Hall by limiting access to the Eastern Side only or it required the introduction of a

new bridge element (shown in the render above). This too was deemed too significant of an impact.

- Option 02 located an additional lift to Option 01 in a mirrored location on the western side of the central stair. It was also not pursued further as the heritage impact was even greater than in Option 01. Two lifts did however solve the equality of access problem to the rear of the Hall without requiring a bridge.
- Option 03 located two lifts centrally in the Northern Foyer. It required a bridge link between both Level 4 landings to enable access to the lifts. It had the additional functionality of allowing lift access higher up into the Concert Hall Control Rooms and Follow Spot Rooms. However again the Heritage impact was considered too severe to offset the additional functionality. This option would have greatly reduced the Northern Foyer's ability to host functions and pre-show talks which are key aspects to this space.
- Option 04 removed the lifts from the central space of the Northern Foyer and pushed them to the eastern and western edges. There is an existing section of external staircase that these lifts are proposed to be located through. This option had the advantage of having no impact on the Northern Foyer as a functional space and the incorporation of the Lift into the existing fabric has the least impact of all options considered. As such this was the option that was adopted.

1.4.1.2.3 Schematic Design:

Having identified Option 04 as a clearly preferred option, the Schematic Design phase focussed on resolving the impact on the Northern Foyer stairs and cranked beams, along with assessing the preferred finishes for the lift, lift shaft and the modifications to the stairs.

The lifts have been sized in order to minimise the impact on the existing building while maximising the number of patrons capable of using the lifts.

Their location within the Northern Foyer has been carefully positioned to minimise their visual and material impact on the existing stairs and external glazing. The lifts are proposed to be glass cars and at Level 4 will have a glass enclosure which is architecturally sympathetic to, and minimises any alteration to, the existing external glazing.

On the other foyer levels the glass lifts and lift access will be enclosed with polished brass or bronze cladding which is sympathetic to the bronze alloy elements throughout the Opera House.

The design of Concert Hall Lifts 29 and 30 were detailed in conjunction with Lift 31 and 36 in the JST Northern and Southern Foyers. This involved an integrated design process including ARM, Scott Carver, TZG, Sydney Opera House Management and the EAP. The lift car detailing was agreed so that all lifts were identical in fit out. The different geometries and the need to integrate with different sections of the external façade led to variation in the detailing of the lift shafts. It was agreed that Lifts 29, 30 and 36 would be concrete lift shafts arriving in clear glazed top sections and Lift 31 (JST Northern Foyer) would be concrete shaft from Level 2 to Level 3 but then glazed from Level 3 to Level 4 and above Level 4. This additional section of glazed lift shaft is designed to bring light deeper into the lower sections of the JST Norther Foyer. It is driven by the smaller in geometry in the JST when compared to the Concert Hall Northern Foyer. This change was considered and deliberate.

Careful consideration was given to the integration of the lift shaft with the profile of the existing off-form concrete stair beams. The polished cladding was designed to reflect the existing concrete beams and ceiling profile creating an illusion that the cut beams have been maintained. This was done in consideration of the heritage importance the profiled concrete beams, as noted in the SOH Conservation Management Plan.

The following series of renders reflect the design of the lifts at the schematic design stage.

Figure 20: Lift 30 Entry at Level 4

Figure 21: Lift 30 Entry – Level 3A Northern Foyer

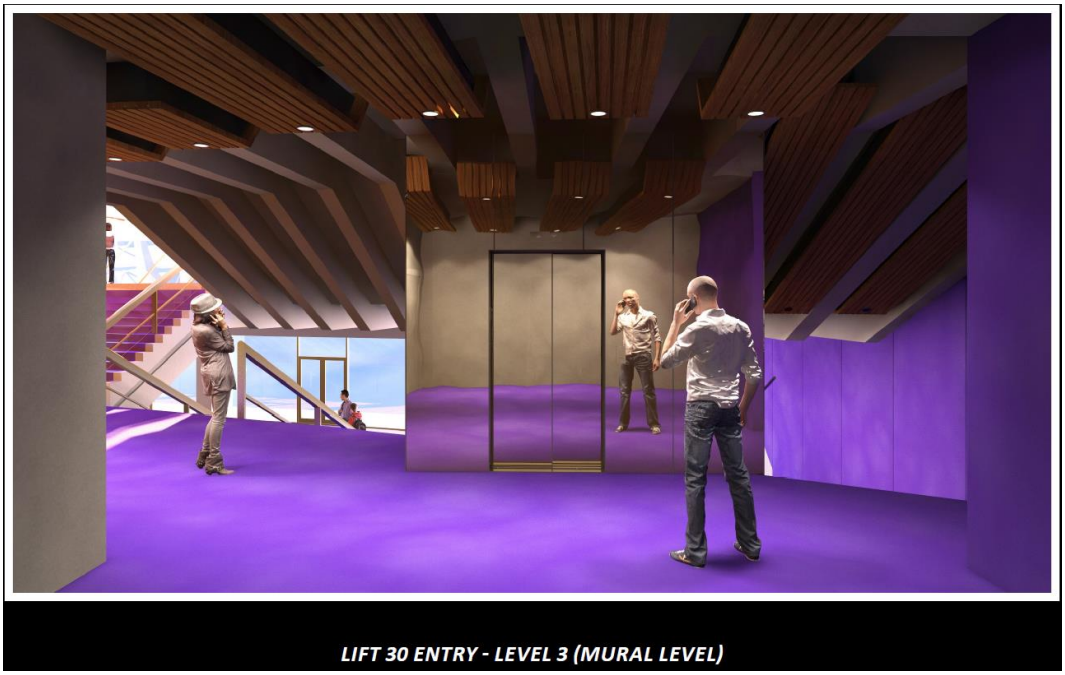


Figure 22: Lift 30 Entry – Level 3 (Mural Level)

Figure 23: Lift 30 Entry – Level 2A

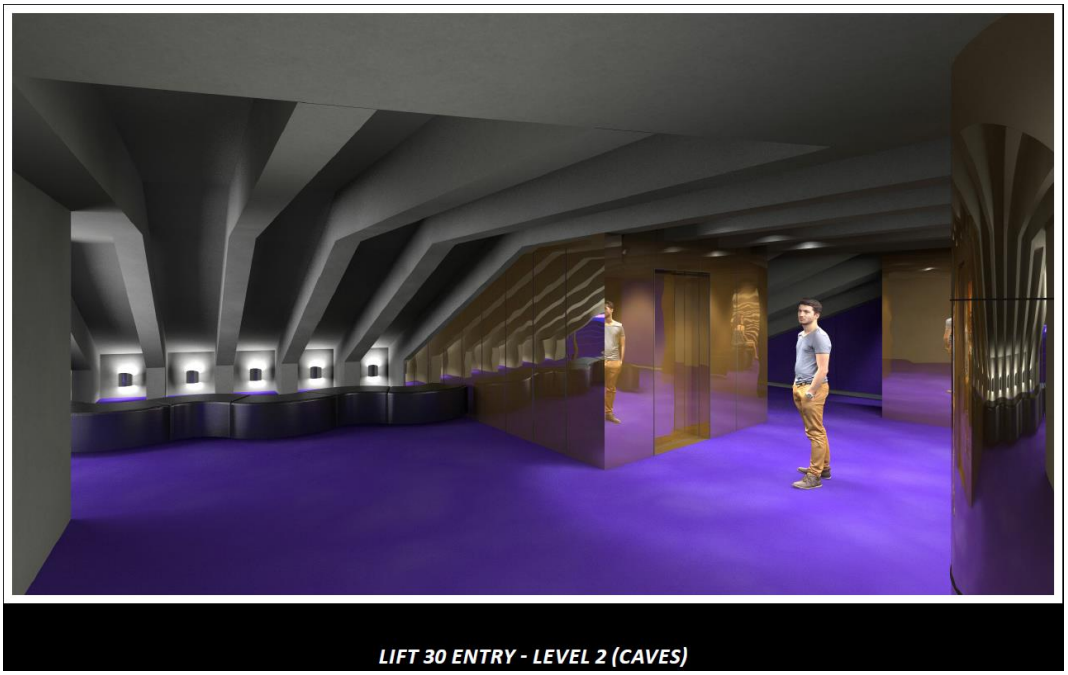


Figure 24: Lift 30 Entry – Level 2 (Caves)

1.4.1.2.4 Design Development:

The design development phase saw more resolution of the positioning and finishes of the two lifts (note that Lift 29 on the western side is a mirror image of Lift 30 on the eastern side).

This phase has arrived at a “cantilevered” car solution for the lift, which results in no visual lift structure at Level 4.

Further design development led to:

- the refinement of the new structure required for the Level 3A landing and its impact on the beams visible in the ceiling at Level 2A. The new structure has been stepped up by 100mm allowing the existing curved fold line of the beams to be maintained and read;
- further refinement, in consultation with the EAP, of the panel layout of the bronze cladding to the lift shafts at the lower levels; and
- Removal of the carpet cladding from the column and the side wall of the Caves area

These details are depicted in the following series of renders.

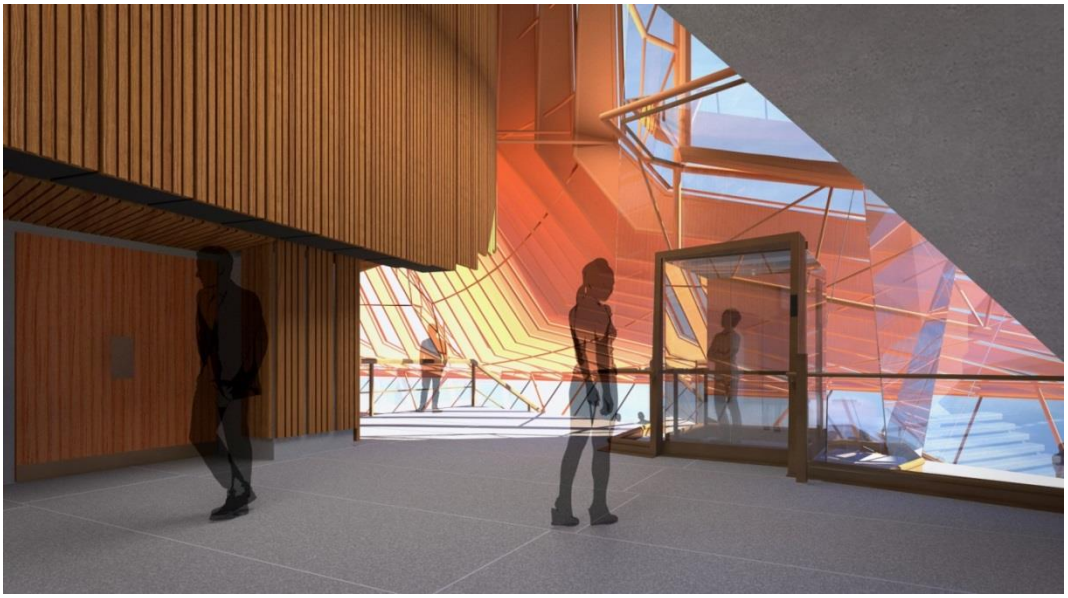


Figure 25: Lift 30 Level 4

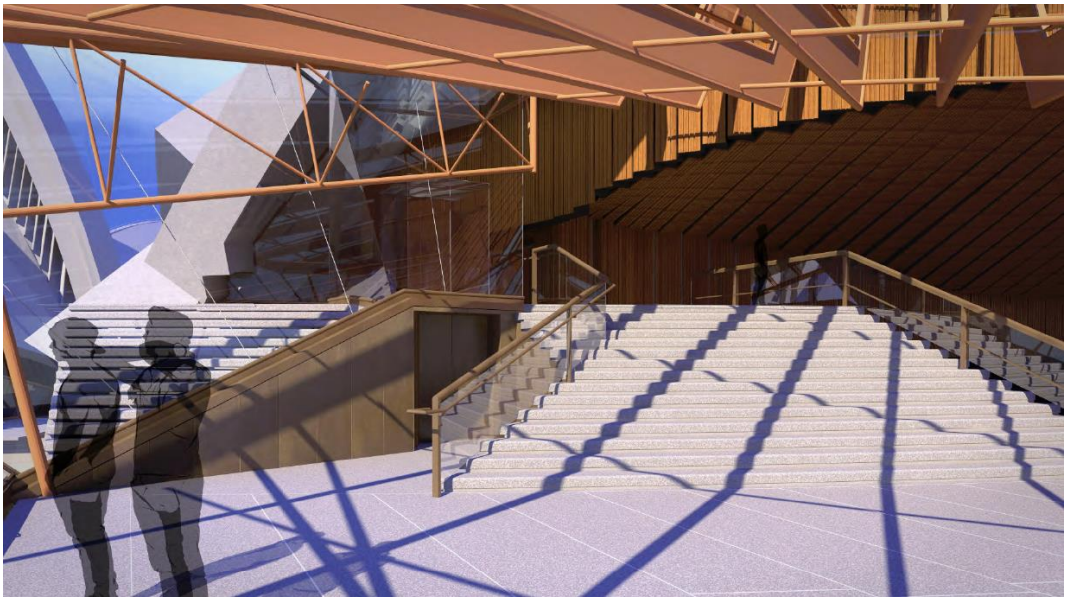


Figure 26: Lift 30 Level 3A

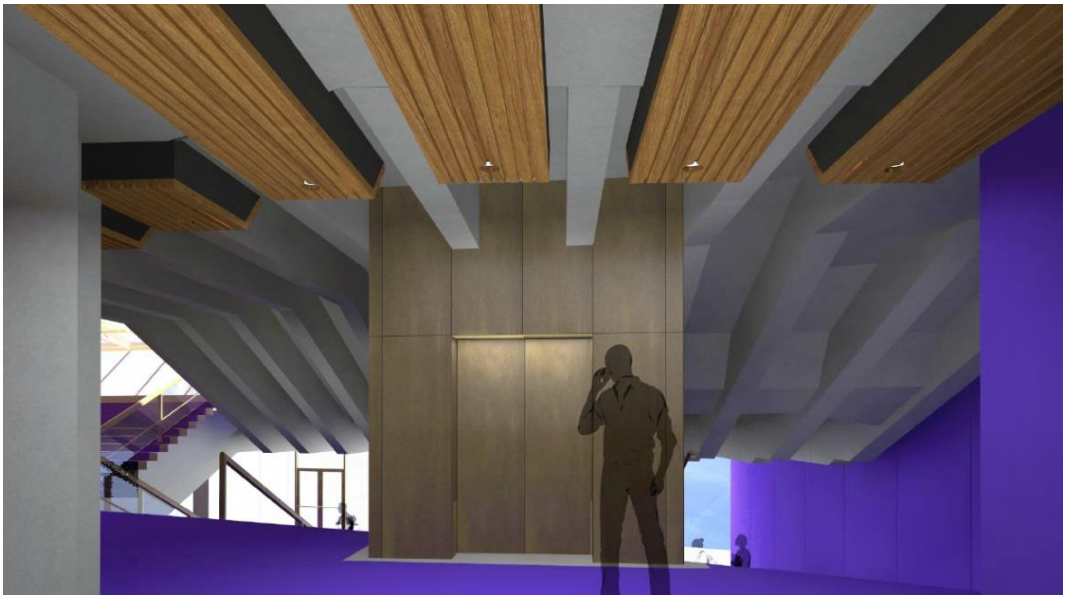


Figure 27: Lift 30 Level 3

Figure 28: Lift 30 Level 2A

Figure 29: Lift 30 Level 2 (Caves)

The use of bronze cladding is similar to that used in Lift 17 which was installed as part of the Western Foyers upgrade in 2009. The interior of Lift 17 is shown in the following photograph.

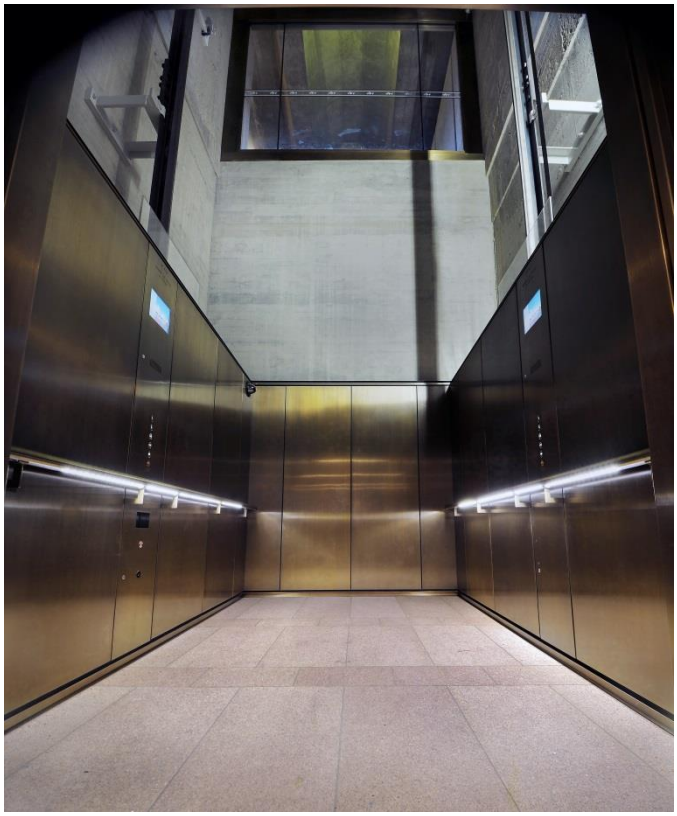


Figure 30: Lift 17 Interior, Western Foyers (existing)

1.4.2 Acoustic Upgrades to the Concert Hall

The Sydney Opera House Concert Hall has two types of acoustic challenges – operating in acoustic (or orchestral) mode and operating in amplified mode, such as for contemporary music or cinematic films or stage productions.

The priority of the SOHT is to fix the orchestral music challenge, as this is directly related to the original Peter Hall appearance of the room and is driven by the physical shape and surfaces that create that appearance. In this mode the current acoustics are far from world class and therefore detract from the venue's aspiration to always be one of the world's leading venues. The amplified mode is an overlay on top of the fixed acoustic mode, and is only invoked on a temporary basis when the programming for the Concert Hall demands it. The design must enable a simple and elegant transition from orchestral to amplified mode as this is required on a daily basis.

Since the inauguration of the Sydney Opera House (SOH) Concert Hall in 1973, the acoustic challenges have been well known, both publicly and amongst the core users of the venue. There have been repeated attempts to improve the acoustics with varying degrees of success.

> *"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." (Taylor,Claringbold, ICA2010: 20th International Congress on Acoustics, 23-27 August, 2010)*

An article in the August 2011 Limelight magazine, which surveyed musicians, critics and audience members, rated the Concert Hall in 18th place out of 20 major venues.

Several acousticians have studied the Concert Hall since its inauguration and have made recommendations for improving the hall's acoustics, including:

- Kirkegaard Associates (1996, 2007)
- Karlheinz Müller (1996)
- Peter Knowland and Associates (1997)
- Arup Acoustics (1998)
- Nagata Acoustics (2003)

These studies indicate a general consensus about the concert hall's most serious acoustic flaws:

- The surface area of the overhead reflectors is too small to be effective;
- The mass of the hall's wall and ceiling surfaces needs to be increased to improve bass response;
- The shaping of the 'saw-tooth' panelling flanking the stage and lower stalls audience creates seriously disturbing high frequency distortion;
- The height and shape of the stage platform needs to be altered to enable the best orchestral configuration and ensemble sound;
- Background noise is excessive.

Particularly challenging is the large volume area above the platform, and that is most unusual for a concert hall – normally the larger volume is situated over the audience. The basic geometrical structure – originating from the constraints of the outer shell – together with the size of the Concert Hall are responsible for a number of acoustical deficiencies. The large volume over the stage is a direct result of the original design competition brief that also required opera and ballet with a fly tower to be included in the Main Hall. The change of brief mid-construction to a dedicated Concert Hall only has left sub-optimal geometry for the hall acoustics.

All of these acoustician's reports have identified the need for an improved acoustic reflector(s) above the platform; this would enhance the strength and audibility of the reflected sound to the orchestra. This would also prevent excess amounts of energy from escaping to the upper volume above the stage and being reflected back down to the ensemble with a confusing delay.

For a substantial number of audience seats the artists on stage appear more distant acoustically than they do visually. The reverberation that typically brings music to life and positions the listener in the middle of the sound is restricted to a sound "cloud" coming from above for most of the seats. This creates a sound impression that does not match the impressive visual perception.

For the musicians of the orchestra on stage as well as singers in the choir stalls there is a distinct lack of acoustical contact and support. This impacts the sense of ensemble, timing and intonation that are essential for any orchestra.

> "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. Its structure is wrong. Its configuration is flawed. The mass of its walls and ceiling are a small fraction of what they should be. The background noise is excessive. There are draft conditions for both performers and audience members. Access to the stage is difficult and wholly unsuitable for movement for performers and instruments. Hearing conditions for performers are inadequate. Quality of sound heard by audiences is disappointing and far from world class.
>
> In short, a host of problems must be addressed in a balanced and holistic way. Simply solving the hearing conditions for performers will not create a concert hall that will be able to stand proudly within this World Heritage architectural envelope." (Kirkegaard, 2007)

The Concert Hall is used as frequently by its resident companies (Sydney Symphony Orchestra, Australian Chamber Orchestra and Sydney Philharmonic Choir) as it is with SOH's internal production arms The Opera House Presents (SOHP) and external hirers. A combination of resident company and SOHP or external productions being programmed on the same day is common. For example, an SSO rehearsal followed by an Ideas at the House talk, or contemporary artist, both of which have distinctly different acoustic requirements.

Feedback from SOH Technical and Production Departments, Resident Companies and Sydney Opera House Presents is that the changeover from acoustic to amplified mode is time-consuming and expensive, and also prevents additional events being programmed after an acoustic mode event (e.g. SSO rehearsal) as there is not enough time to undertake a changeover. In addition, the visual result of the methods currently available to set the hall for amplified performance is not befitting for the Sydney Opera House.

Therefore there is a significant challenge in providing the best possible reverberant and acoustic baseline that can be transitioned into a relevantly absorbent venue for amplified music and speech. Given the number of amplified performances that are programmed after acoustic rehearsals it becomes important that the changeover for these variable acoustics to be turnkey.

Another challenge in addressing the Concert Hall's acoustic challenges has been that no holistic approach has been possible due to lack of funding and scheduling availability. Thus single issues have been addressed, rather than approaching the solution as whole-of-venue.

With the support of the NSW Government and appropriate scheduling and funding earmarked for the Concert Hall renewal works, the opportunity exists to resolve the acoustic deficiencies in this world-renowned venue so that the aural experience matches or exceeds the visual impression.

A positive and enveloping listening experience should be expected at this premier Sydney Opera House venue that is currently lacking.

1.4.2.1 Do nothing option

The "do nothing" option would leave the Sydney Opera House well behind most comparable venues for performance of music in its many forms. This would be unacceptable for Australia's most iconic performing arts venue.

Similarly, failure to address the issues involved in changing over the venue between performance modes, acoustic to amplified music and vice versa, would mean ongoing WHS risks and increasing costs from the manual work necessary to install and uninstall sound absorbing drapes and other similar treatments that are currently used for the amplified performance mode. It is important to note that such performances are a substantial part of regular programming at the venue. These performances are an important part SOH's artistic strategy and also generate substantial income for the SOH

1.4.2.2 Acoustics Issues and Solutions Summary

At the concept design stage, the SOH's acoustic consultants, Müller-BBM, developed an "Issues and Solutions Summary". Based on Müller-BBM's measurement results, stakeholder workshops and subjective listening tests the table presents the key issues regarding the acoustics in the Concert Hall, the impacts of these issues and Müller-BBM's proposed solutions to them. This table is reproduced here as Table 1: Acoustic Issues and Solutions (Concept Design Stage).

The proposed "solutions" to solve the acoustic issues were:

1. Acoustic Orchestral Mode Modifications
    a. Modifications to the stage platform (podium) and surrounds
    b. Acoustic reflectors
    c. Diffusive surfaces on the stage surround, box fronts and rear walls
2. Amplified Mode Modifications
    a. Variable Acoustic Canopy
    b. Banners and Drapes
    c. New Sound System

The Concept Design by Müller-BBM was peer reviewed by Larry Kirkegaard, and also by Raf Orlowski of Rambøll. Müller-BBM's response to these peer reviews is encapsulated in the following:

> "Both reports offer valuable input regarding clarification of the acoustic issues raised in our report, and our proposed solutions to them. In our opinion each report provides a slightly different emphasis on isolated aspects of our approach, without questioning wholesale our fundamental concepts (see summary table in the report of Raf Orlowski p. 16). Commonality in both reviews is that the proposed solutions are seemingly minimal, rather than excessive. ***As respecting the heritage nature of the Concert Hall architecture is a primary requirement in our brief, we must respectfully retain our position that we are doing as much as is necessary regarding the improving the acoustics and the changeover from acoustic to amplified events, whilst interfering as little as possible with the heritage fabric of the Concert Hall***." (emphasis added)

Müller-BBM carried out a comprehensive series of acoustic measurements which provided objective data throughout the seating areas.

The following key parameters are presented in the reports:

- Clarity Index, C80 dB
- Clarity Index (Speech) C50 dB
- Distinctness D50, %

- Strength, G dB

The objective results showed that key parameters related to clarity and loudness are significantly out of range of what is normally acceptable in a good concert hall. Also, the results are in broad agreement with the subjective responses recorded in interviews where they relate to audience response.

Of particular note, is that the sound is weak in many parts of the auditorium and the clarity is lower than it should be.

The individual components of the proposed acoustic upgrade are:

- Modifications to the stage platform (podium) and surrounds (Section 1.4.2.3)
- Acoustic reflectors (Section 1.4.2.4)
- Box fronts, stage surrounds, and rear diffusion (Section 1.4.2.6)
- Overstage lighting array (Section)
- Amplified mode (Section 1.4.2.7)

The following sections discuss how these components have progressed through the Concept Design, Schematic Design and Design Development phases.

ID	ISSUE	IMPACT	SOLUTION
1	Lack of acoustical contact between musicians on stage	• Precise timing is hard to achieve • Correct intonation is impeded • Ensemble sound is affected	• Arena seating for orchestra provides more direct sound paths • Overstage reflectors • Canon port reflectors • Inclined upper part of box fronts around stage
2	Lack of acoustical contact between the choir singers	• Precise timing difficult to achieve • Correct intonation is impeded • Ensemble sound is adversely affected	• Chevroning of choir rows • Canon port reflectors • Choir reflectors
3	Lack of acoustical contact between orchestra and choir	• Timing and intonation are adversely affected	• Overstage reflectors • Canon port reflectors • Reduced distance from choir to conductors position
4	Lack of acoustical support from the auditorium to stage	• Response for the own instrument is late and lacks definition	• Inclination of stalls rear balustrade • Canon port reflectors • Inclined upper part of box fronts around stage
5	Inhomogeneous balance of orchestra sound for front section of stalls	• Reduced perception of woodwinds, brass and percussion	• Arena seating with lowered stage height.
6	Prominent reflections from box fronts in stalls and lower circle seats	• Distracting localization of single reflections (especially when direct sound is shaded)	• Horizontally diffuse cladding for box fronts
7	Missing perception of envelopment in large parts of the audience, reverberation coming from the front only	• Audience is not surrounded by the music • Lack of engagement • Reverberation clouds the sound rather than presenting a transparent sound	• Ceiling reflectors • Diffuse structure on rear walls of the boxes
8	Missing support for dynamic changes in the music	• Weak and unimpressive broadening of sound in orchestra crescendo	• Lateral wall reflectors
9	Disconnect between audience and stage in upper circle	• Perception of a large distance • Lack of intimacy and engagement in the performance	• Downstage reflectors
10	Focussing effect around the lower circle	• Perception of reinforcement and shifting of the perceived focus of sound upwards	• Ceiling reflectors
11	Timing for instruments in the rear part of the stage	• Percussion and brass playing ahead of the conductor	• More compact seating induced by arena stage layout
12	Temporary high noise floor levels	• Covering musical details and disturbing pianissimo passages	• Adjustments in the air ventilation system and other background noise
13	Hall is too reverberant for amplified music	• Sound design is limited by natural acoustics	• Automated absorbent banners • Adjustment of reflector surfaces • Variable stage façade • Thick carpet on stage floor
14	Time-consuming changeover between acoustic to amplified performances	• Cost of labour expensive • Loss of venue hire revenue as promoter consider turnaround risk too great	• Variable overstage reflectors • Automated acoustic banners and drapes
15	Disturbing reflections	• Reducing intelligibility, perception of echoes	• Automated absorbent banners
16	Existing sound system no longer fit-for-purpose, end-of-life	• System not suitable to cover many existing and future requirements of sound design	• Coordinating acoustic measures with requirements of a modern 3D sound system
17	Noise transferal issues between Concert Hall and The Studio, and Concert Hall and Drama Theatre	• Disturbance for artists and audience in sensitive performances or rehearsals	• Decoupling of floor below stage • Insulation weighted sound level measurements

Table 1: Acoustic Issues and Solutions (Concept Design Stage)

1.4.2.3 Modifications to the stage platform (podium) and surrounds

1.4.2.3.1 Concept Design

The concept design proposed a new, mechanised “arena-style” riser formation for the Concert Hall. This is a format of orchestral layout that has been used successfully in many venues, including the Berlin Philharmonie and Danish Radio Concert Hall in Denmark.

The Sydney Symphony Orchestra has had experience using this arrangement, having partaken in previous testing in the Concert Hall. Both they and the Australian Chamber Orchestra have advocated for the introduction of this feature.

The semi-circular riser heights can be adjusted individually. The new podium access level would be lowered to 900mm above the stalls level. The current front stage edge position remains unchanged and a 2 m wide stage extension has been included. This way, all existing audience seats in this area are retained. This 2 metre wide stage extension between the orchestra and audience is important as it assists in the reflections of the strings into the audience.

The concept design also proposed an upgrade to the stage timber floor, along with a rearrangement of the choir seating to a chevron pattern.

The modifications to the podium as proposed in the concept design are shown in the following Figure 31.

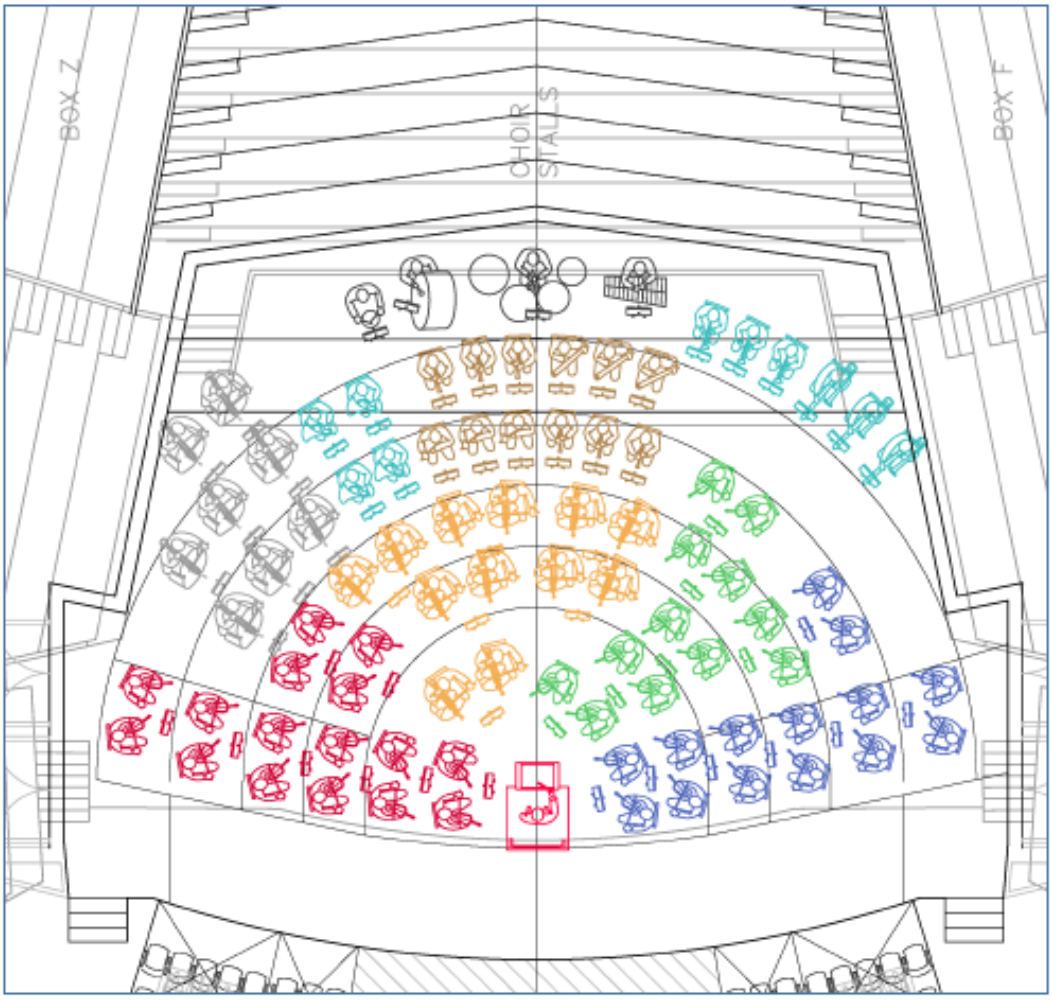


Figure 31: Concept Design Podium Layout

In addition to the changes to the podium, the concept design also proposed changes to the podium surrounds and backstage – raising the anteroom floor to be at the same elevation as the lowered stage, and rearranging the wings to provide better access to the podium.

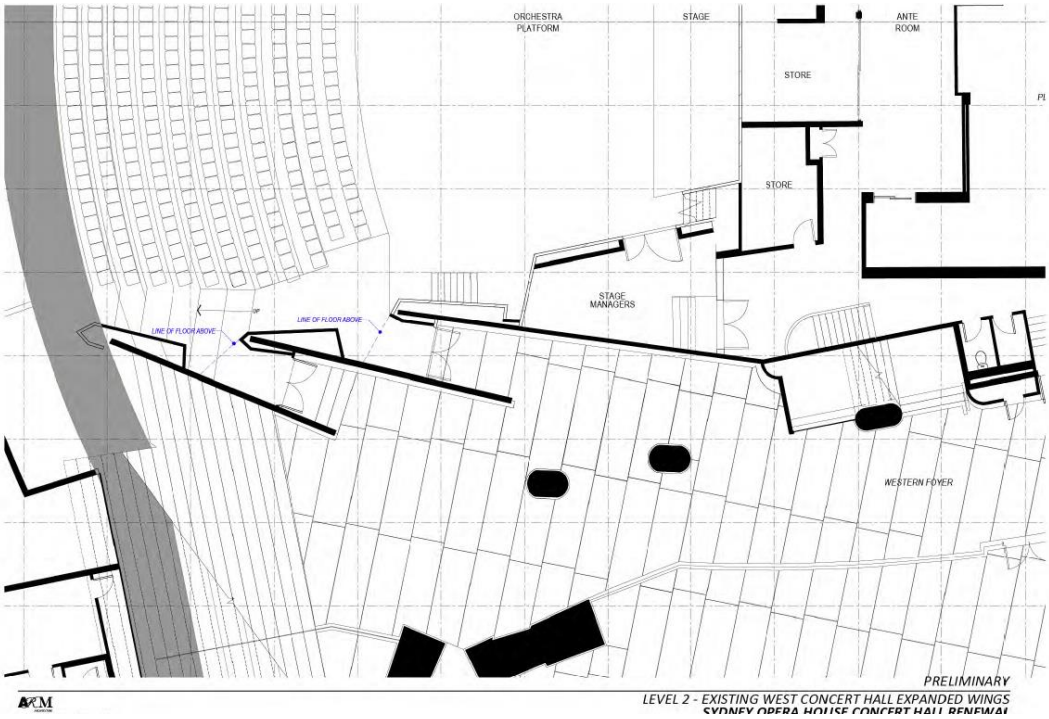


Figure 32: Existing Stage Wings (Western Side only shown)

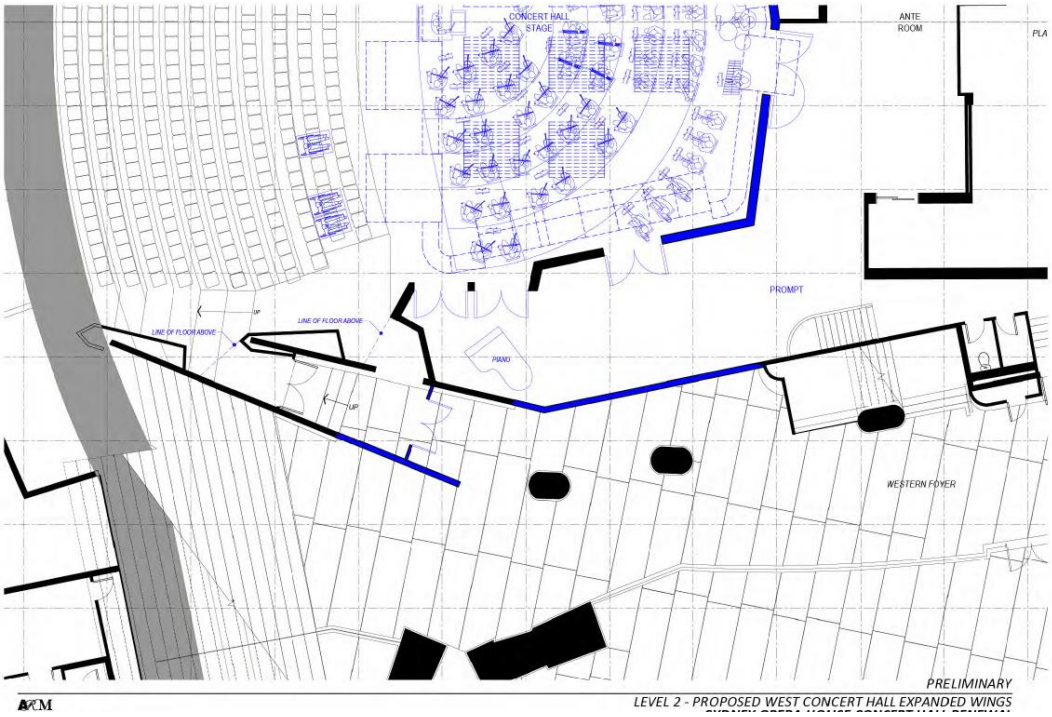


Figure 33: Proposed Stage Wings (Western Side only shown)

The above figures show the proposed change to the stage wings to provide better access to the podium. These changes impact the eastern and western foyers of the Concert Hall. The following set of images show how these changes will appear in the foyers.

Figure 34: Architectural renders showing existing and proposed modifications to the CH Western Foyer looking north (Eastern Foyer is a mirror image)

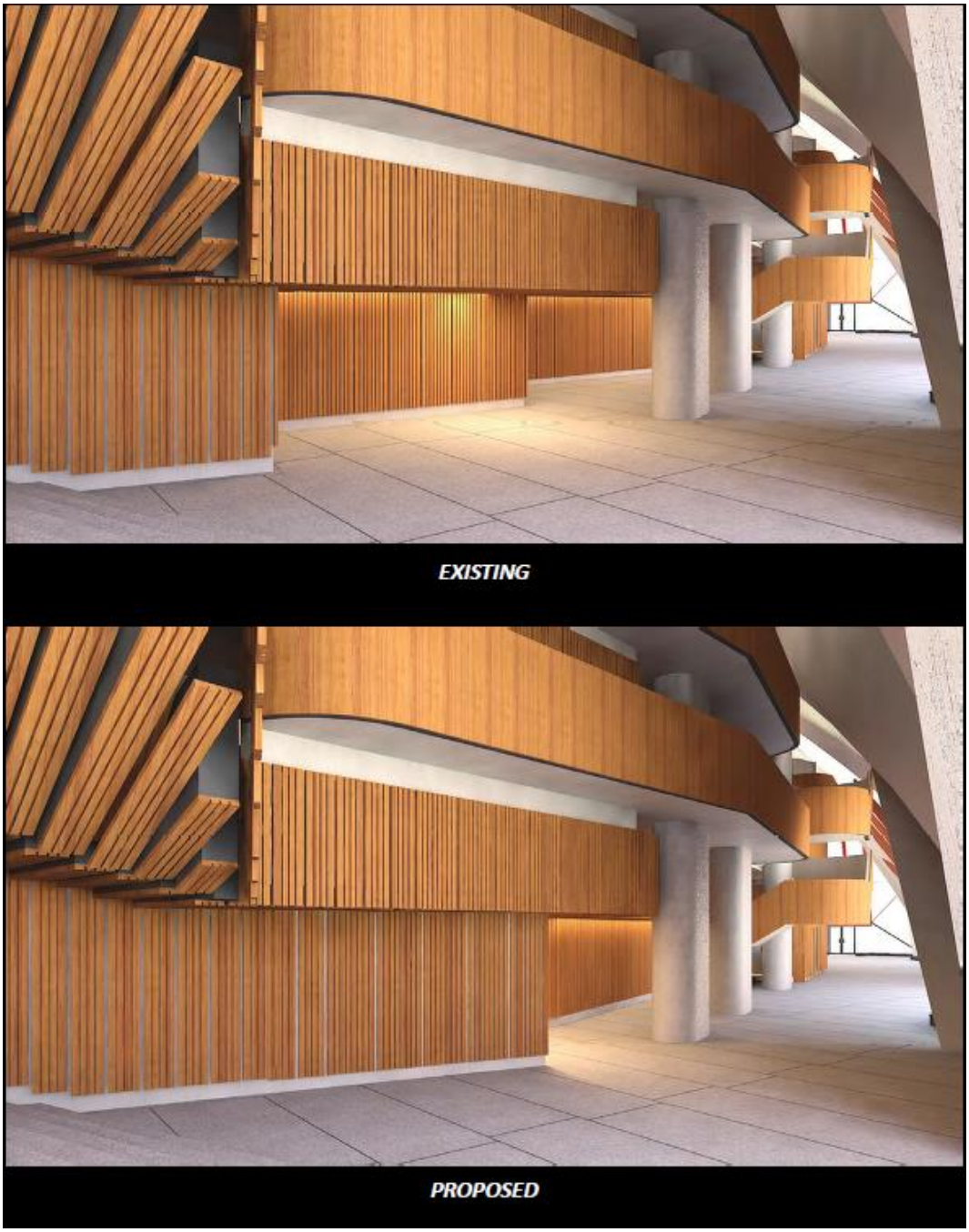


Figure 35: Architectural renders showing existing and proposed modifications to the CH Western Foyer looking south (Eastern Foyer is a mirror image)

1.4.2.3.2 Schematic Design

The schematic design phase saw further refinements of the design for the stage and podium, and specifically the chevron pattern to the choir stalls was deleted. The proposed design is shown in Figure 36.

This design includes the automated forestage lift (stage extension) and automated seat removal and understage storage of the forestage seating rows (A, B &C).

The schematic design phase did not see any change to the proposed wing expansion as discussed above.

The schematic design included the provision of retractable and removal stairs to access the choir stalls from the stage. This design provided for the stairs to be deployed with the stage risers in either the up or down positions. The schematic design also included acoustically diffusive surfaces on the walls surrounding the stage, including perforations on the rear stage wall below the choir. The diffusive surface is an essential component in the acoustic solution and has been interpreted by the architects as the pattern of the soundwave created by a musical note. These features are shown in Figure 37 and Figure 38 with further detail provided in Section 1.4.2.6 below

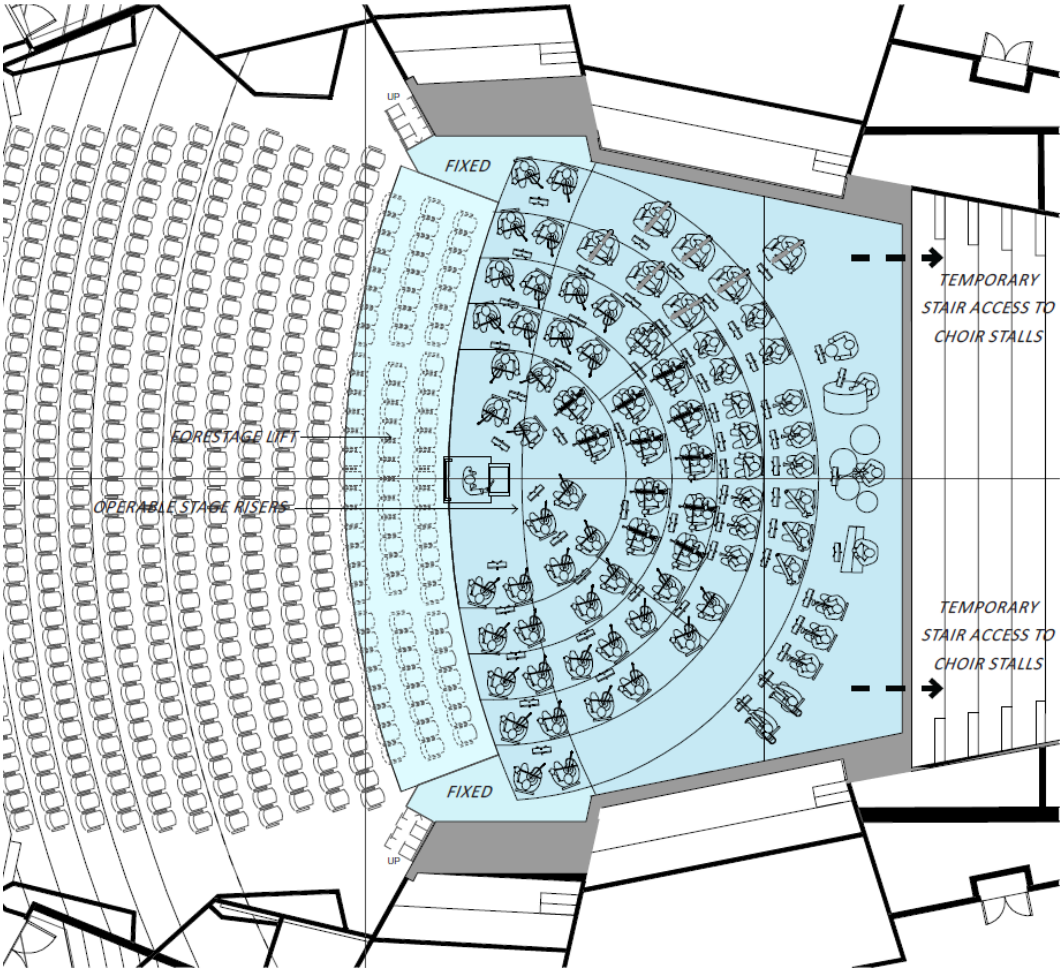


Figure 36: Concert Hall Schematic Design – Stage Layout

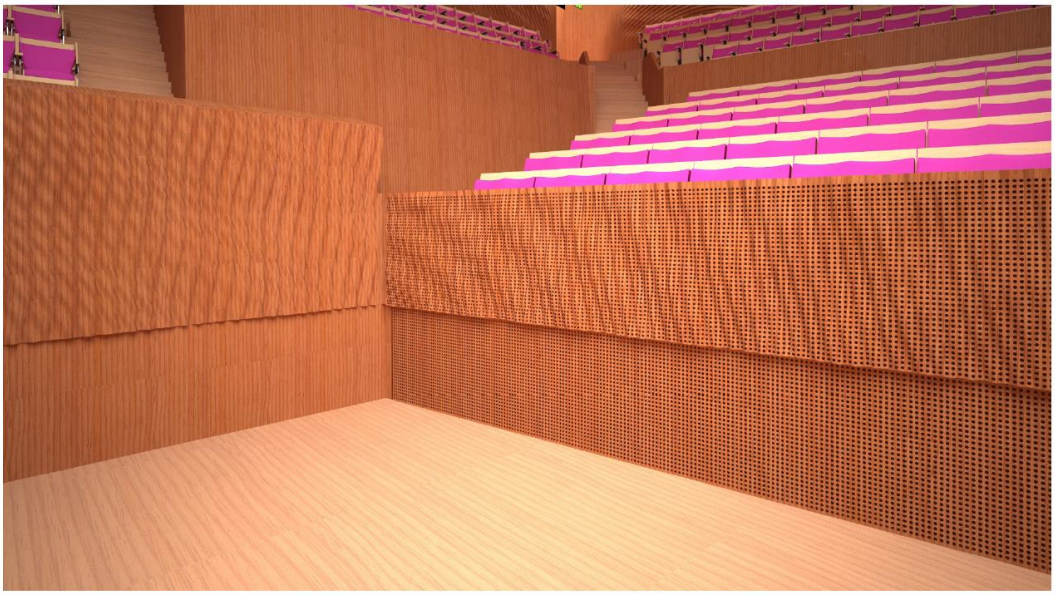


Figure 37: Concert Hall Schematic Design – Stage Surrounds showing Acoustically Diffusive Finish and Perforations in Rear Wall

Figure 38: Concert Hall Schematic Design – Flat Stage with Choir Stairs Deployed

1.4.2.3.3 Design Development

The design development phase has removed the perforations from the rear wall of the stage surround. This is shown in Figure 39.

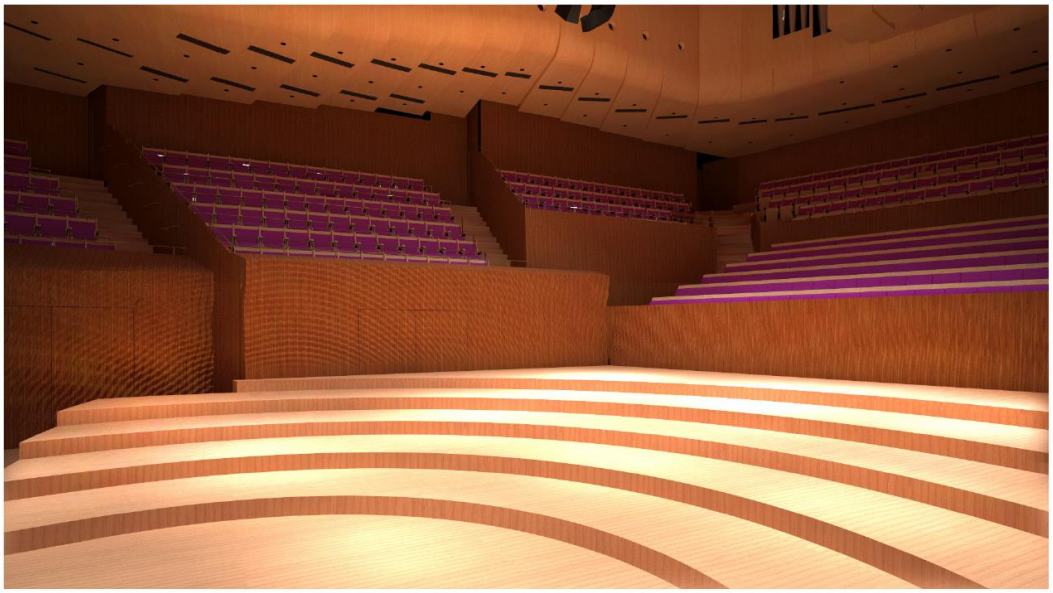


Figure 39: Concert Hall Design Development – Stage Surrounds with Stage Risers in Place

1.4.2.4 Acoustic Reflectors

In addition to the modifications proposed to the stage and surrounds for unamplified music performances, the acousticians have proposed the use of suspended and retractable reflectors to address some of the acoustic shortcomings of the Concert Hall.

1.4.2.4.1 Concept Design

At the concept design stage, the proposed reflectors included:

- Ceiling reflectors suspended close to the ceiling of the Concert Hall;
- Forestage, overstage and choir reflectors suspended above the stage; and
- Retractable “drawer” reflectors in the walls of the Concert Hall.

The above configuration is shown in Figure 40.

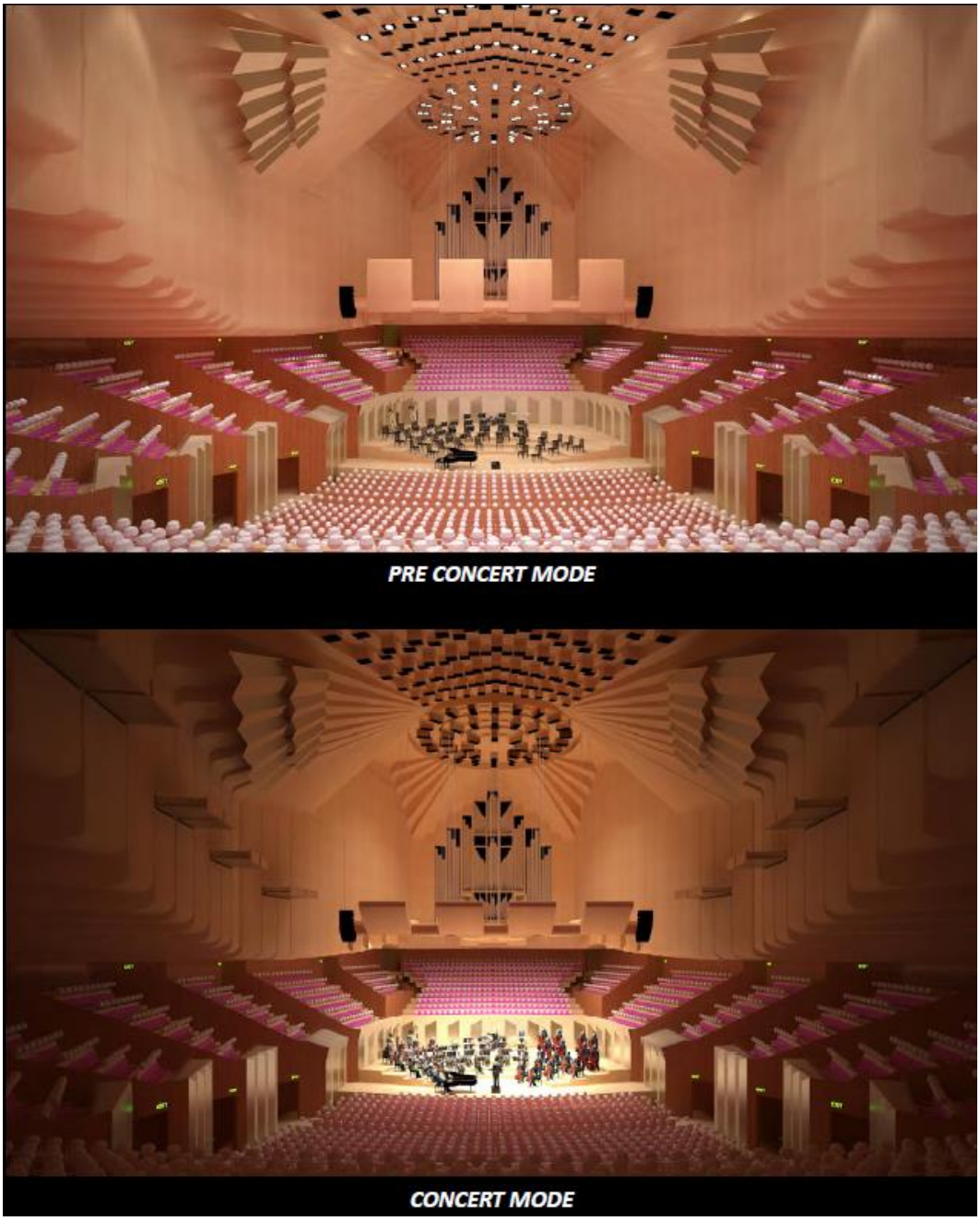


Figure 40: Concert Hall Concept Design – Acoustic Reflectors shown in Pre-Concert and Concert Modes

1.4.2.4.2 Schematic Design

The proposed acoustic improvement to the Concert Hall requires the integration of a new over-stage reflector array and new side wall reflectors. The arrangement of the over-stage array was designed to accommodate the specified acoustic performance, coordinate requirements to introduce additional over-stage theatre equipment and minimise interference for sight lines to the Concert Hall organ.

The selection of materials, finish and shape for the over-stage reflectors was considered from a desire to integrate their visual impact with the heritage interior by using a radial petal arrangement, making reference to the magenta of the existing seating fabric and referencing the visual richness of the finish on instruments such as the grand piano.

The side wall reflectors are designed to retract into the existing side walls (when not required) and finished in the same timber as the existing walls to minimise their visual intrusion upon the original design of the hall.

The proposed reflector configuration is shown in the renders in Figure 41 and Figure 42.

Figure 41: Concert Hall Schematic Design – Acoustic Reflector Array (view from stalls)

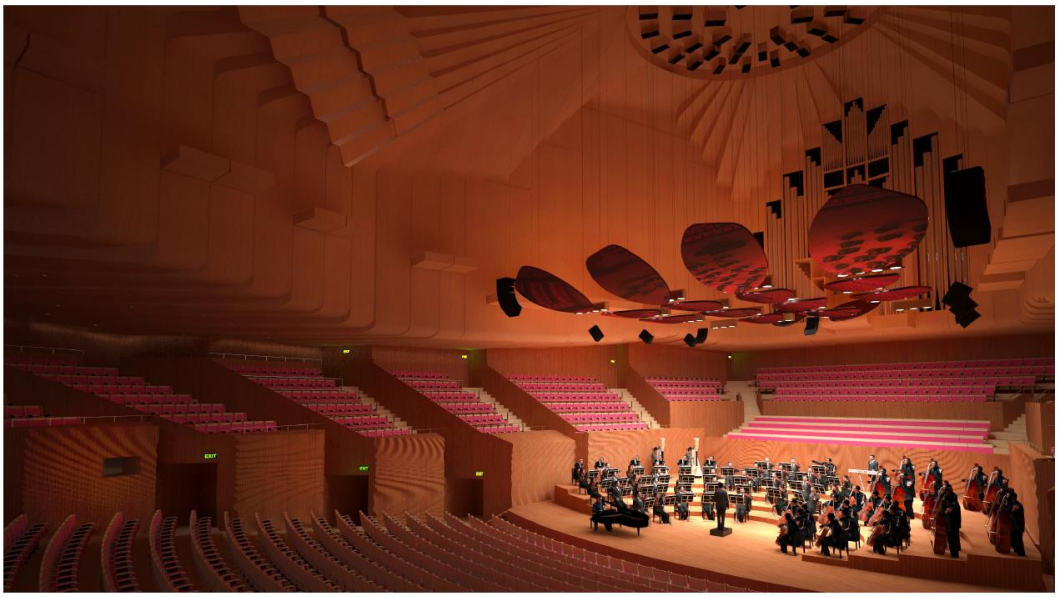


Figure 42: Concert Hall Schematic Design – Acoustic Reflector Array (view from Box A)

1.4.2.4.3 Design Development

The design development phase saw further refinement of the acoustic reflectors. The ceiling reflectors have been deleted and the design of the overstage reflectors has been refined.

During design development full size prototypes of the over stage and side wall reflectors adjacent to the stage, along with a full size mock-up of the stage risers, were temporarily installed and a series of rehearsals and concerts were performed to test the acoustic performance and assess the visual impact of the new reflectors. The results of the acoustic testing and responses to the design were very positive. This led to refinement of the design with the over stage and choir reflectors being optimised and curved in two axes and the side

wall drawer reflectors also being curved. A photo of the prototype testing on 9 November 2016 is shown in Figure 43.

Figure 43: Concert Hall Reflector Prototype Testing - 9 November 2016

Following the success of this test two further prototype tests were conducted in the Hall exploring the colour and finish of the reflectors. The result of this process has been the selection of the magenta colour in the semi-gloss finish and this is supported by the EAP. The exact shade of magenta is still to be refined further.

The plan view of the proposed overstage, audience, choir and retractable “drawer” reflectors is shown in Figure 44. Architectural renders of the Concert Hall in acoustic performance mode are shown in Figure 45 and Figure 46.

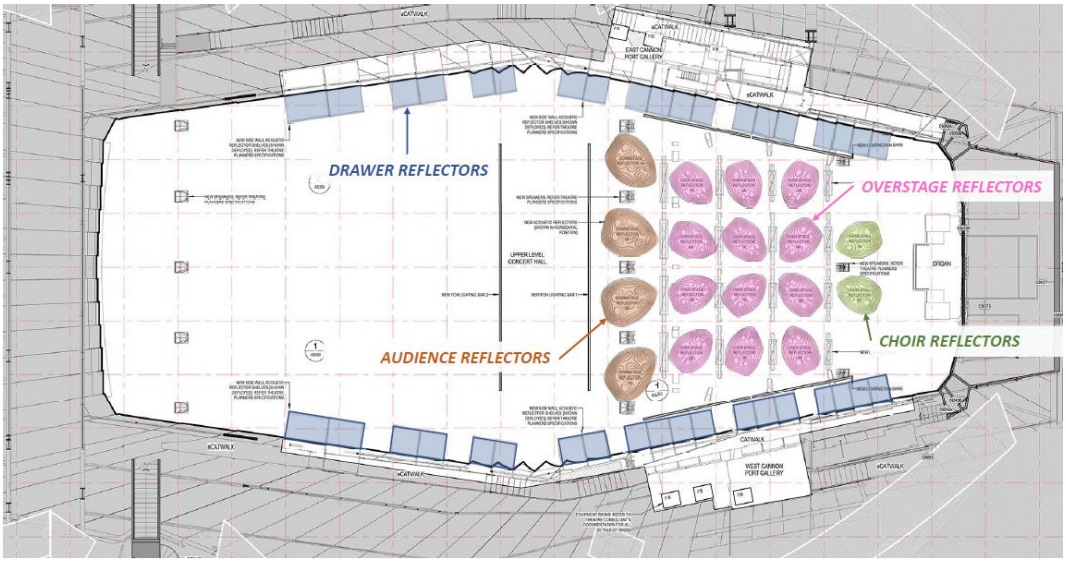


Figure 44: Concert Hall Design Development - Plan of Reflectors

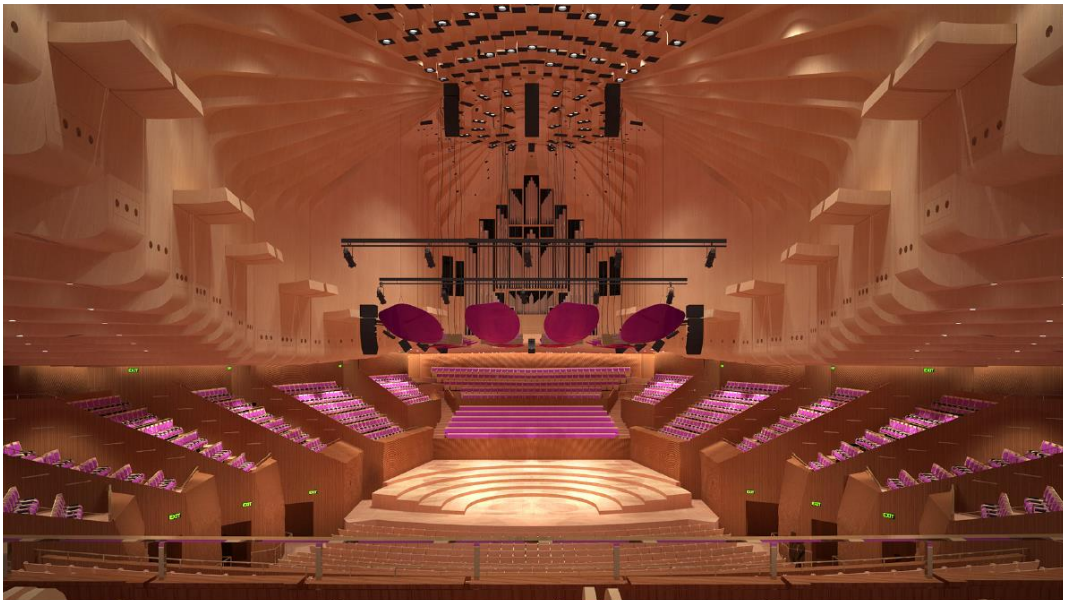


Figure 45: Concert Hall Design Development – View from Upper Circle – New Acoustic Elements – House Lighting

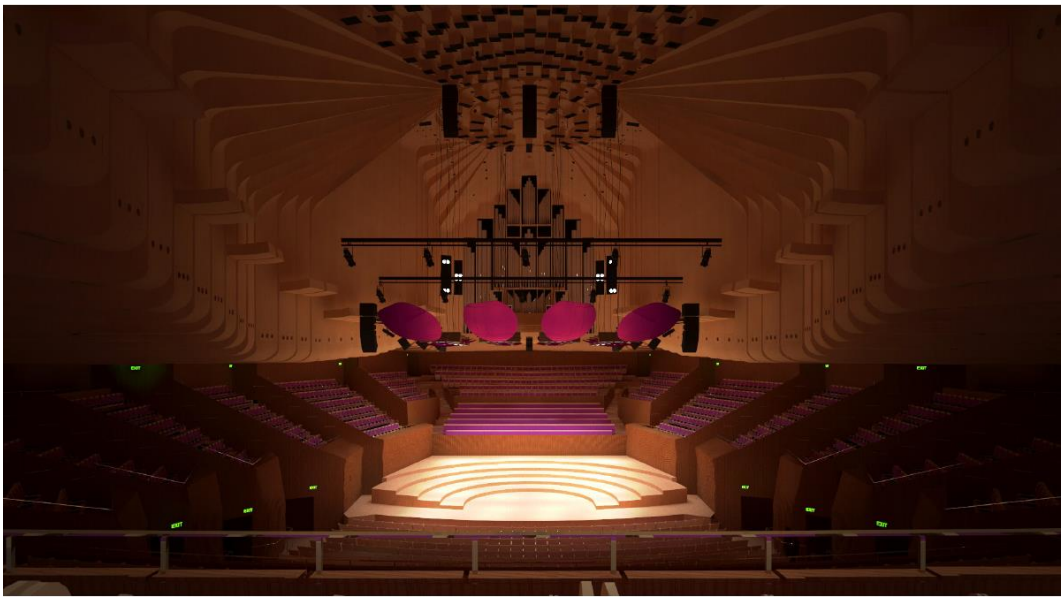


Figure 46: Concert Hall Design Development – View from Upper Circle – New Acoustic Elements – Performances Lighting

1.4.2.4.4 Further Design Development after Review

Further design development was undertaken after a constructability and operability review of this design was undertaken. This review identified that the drawer reflectors over the audience area would be extremely difficult and costly to construct, and that an alternative design was preferable.

Theatreplan were engaged to replace Schuler Shook as Theatre Design Consultants. Theatreplan revised the design of the side wall reflectors, located over the audience area, to be a hinged design that folds back into the side walls of the Concert Hall.

This final arrangement of overstage and side wall reflectors is shown in Figure 47. The array of overstage reflectors has not been changed, however the configuration of sidewall reflectors has been modified to improve sound reinforcement to the platform for the orchestra.

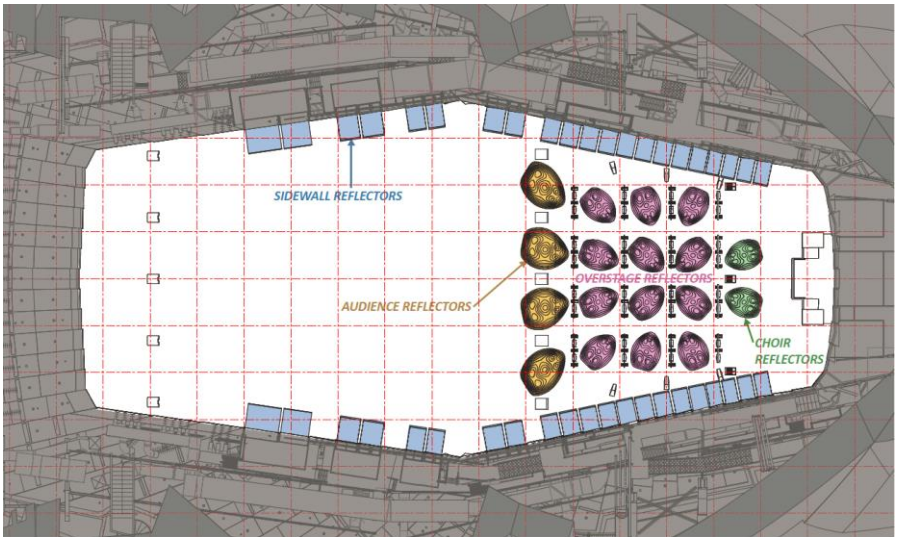


Figure 47: Diagrammatic Plan of New Acoustic Elements

The configuration of the sidewall reflectors and overstage reflectors are shown in the following renders – Figure 48 to Figure 53.

Figure 48: View from Upper Circle – New Acoustic Elements – House Lighting

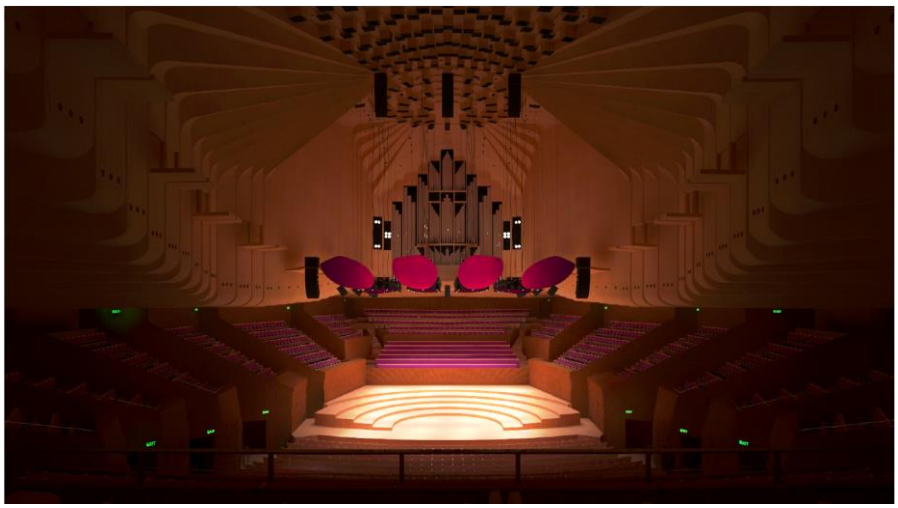


Figure 49 : View from Upper Circle – New Acoustic Elements – Performance Lighting

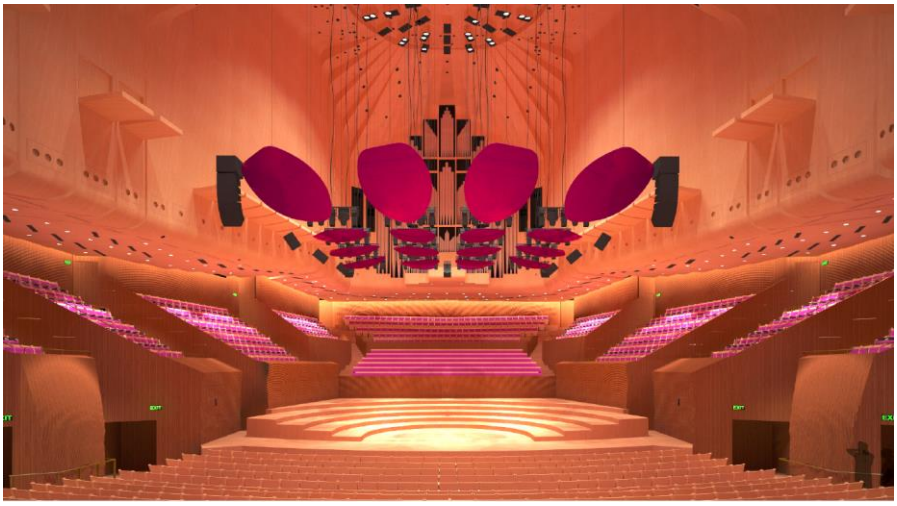


Figure 50: View from Rear of Stalls - New Acoustic Elements – House Lighting

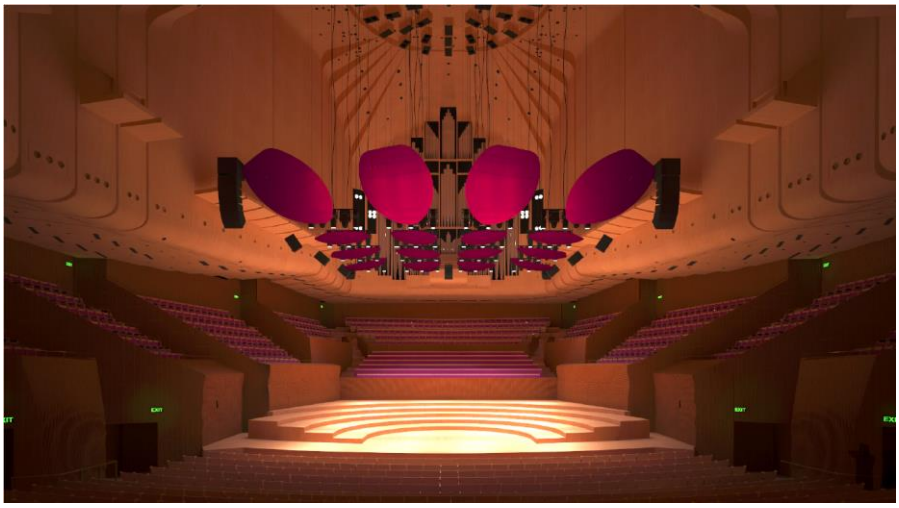


Figure 51: View from Rear of Stalls - New Acoustic Elements – Performance Lighting

Figure 52: View from Box A - New Acoustic Elements – House Lighting

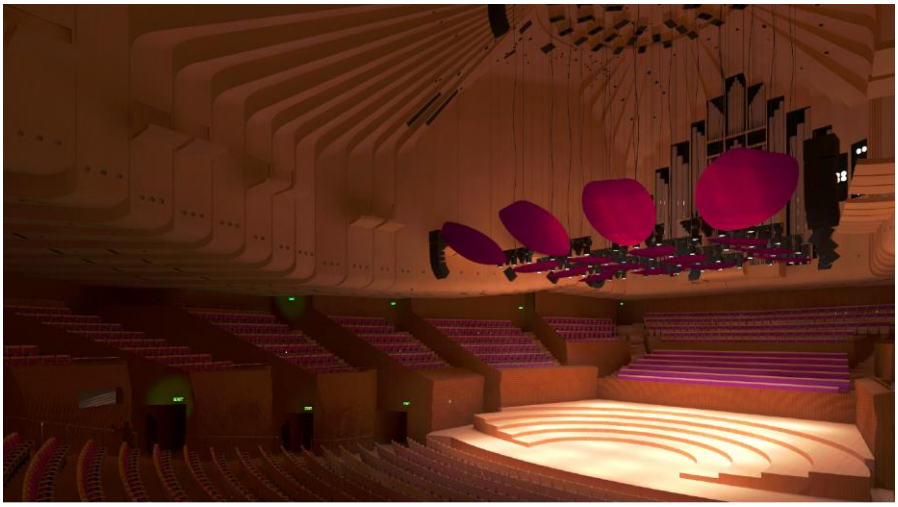


Figure 53: View from Box A - New Acoustic Elements – Performance Lighting

1.4.2.5 Overstage Lighting Array

Part of the lighting brief required that both down lighting and front lighting be provided for the orchestra.

The design solution needed to consider:

- An even coverage of downlight across the stage;
- Improving the angle of the front lighting to reduced glare.

An additional (and significant) constraint was the proposed design for the new overstage acoustic reflectors (petals), which prevent the use of the existing crown lighting for down light and limit the use of the existing front lighting positions for front light.

1.4.2.5.1 Concept Design

At the Concept Design stage, as shown in Figure 40 above, the lighting array included long continuous pods at the front, back and sides of the podium area, which also incorporated the side wall horizontal reflectors in the podium area.

The combination of these with the overstage reflectors was considered to be too visually obstructive, particularly with respect to the views towards the grand organ.

1.4.2.5.2 Schematic Design

At the Schematic Design stage, as shown in Figure 41 and Figure 42 above, the lighting array was changed to a series of discrete pods located in line with and between the overstage reflectors. The pods were to be clad in bronze.

1.4.2.5.3 Design Development

The initial stages of design development, continued with the bronze clad lighting pods. It was identified that additional front lighting of the podium was required, and two “front of house” lighting bars were proposed as shown in Figure 45 and Figure 46 above.

The Eminent Architect’s Panel’s (EAP) advice was that the lighting bars were intrusive and it was preferable that these be removed.

At this stage, Theatreplan were engaged to replace Schuler-Shook as theatre design consultants. Theatreplan reviewed the Schuler-Shook design and proposed a design that did not require the FOH lighting bars. This design included both front lighting and down lighting within the overstage pods, along with 2 movable lights in each pod that can be used

for amplified music and other theatrical style performances. This design is shown in Figure 54 and Figure 55.

Figure 54: ARM/Theatreplan design for lighting pods

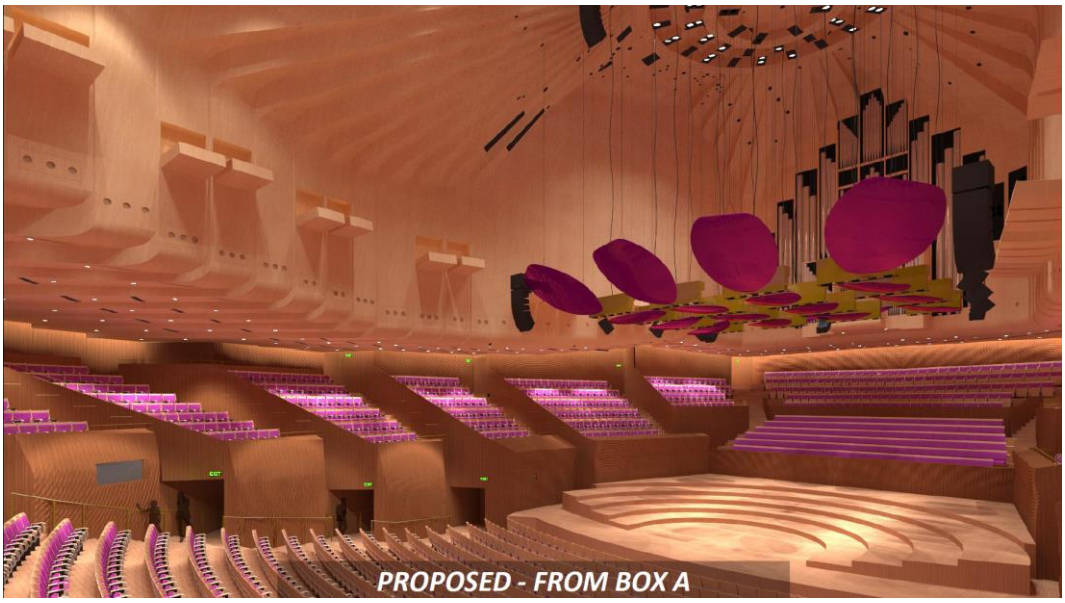


Figure 55: ARM/Theatreplan design for lighting pods

The EAP's advice was that the Panel supported the removal of the FOH lighting bars, but they were concerned that the larger clad pods created a visual ceiling and therefore the pods were too intrusive. The EAP recommended that lighting bars to the same length as the pods should be considered and that these would maintain clear vision between the acoustic reflectors and that although the light fittings would be more visible, there would be lines of sight between the fittings.

This design was further developed and is shown in Figure 56 and Figure 57.

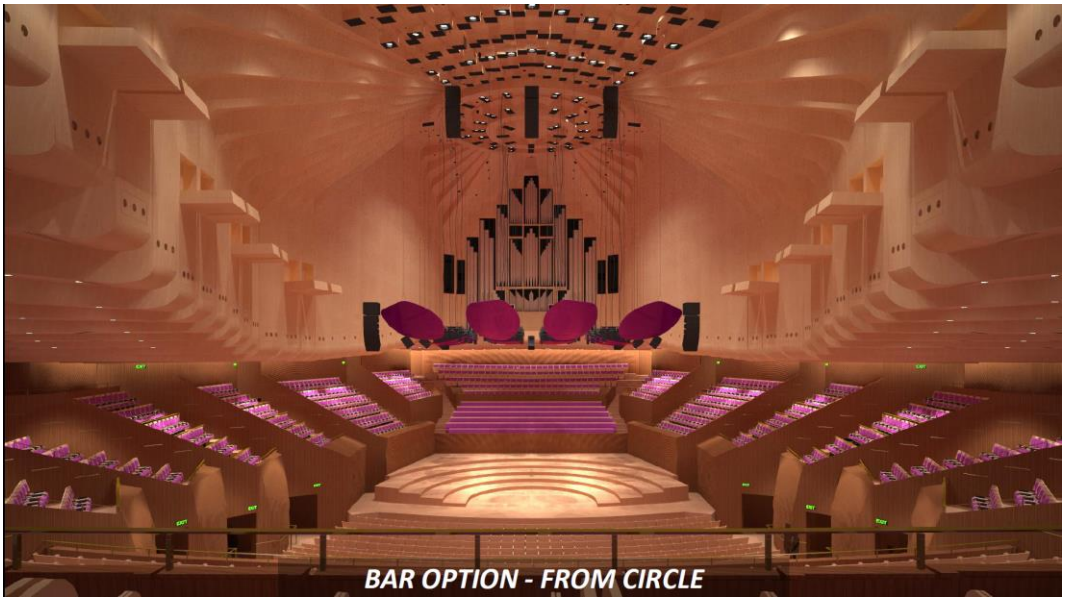


Figure 56: ARM/Theatreplan design for lighting bars

Figure 57: ARM/Theatreplan design for lighting bars

1.4.2.6 Box Fronts, Stage Surround & Rear Diffusion

The design of the existing stage surround, side box fronts and rear wall of the stalls was previously altered from the original interior design to improve the acoustics of the Concert Hall. As part of the current Concert Hall Renewal project, the new acoustic design improvements proposed require a new surface treatment to these elements to create greater acoustic diffusion. The type and extent of the surface treatment has been designed in consultation with acoustic consultant Müller-BBM.

As identified in Table 1 above, the following acoustic problems require treatment to the box fronts, stage surround and rear wall:

- Prominent reflections from box fronts in stalls and lower circle seats; and
- Missing perception of envelopment in large parts of the audience, reverberation coming from the front only.

1.4.2.6.1 Concept Design

The proposed treatments to the box fronts and stage surround as developed during the concept design phase are shown in Figure 58, Figure 59 and Figure 60.

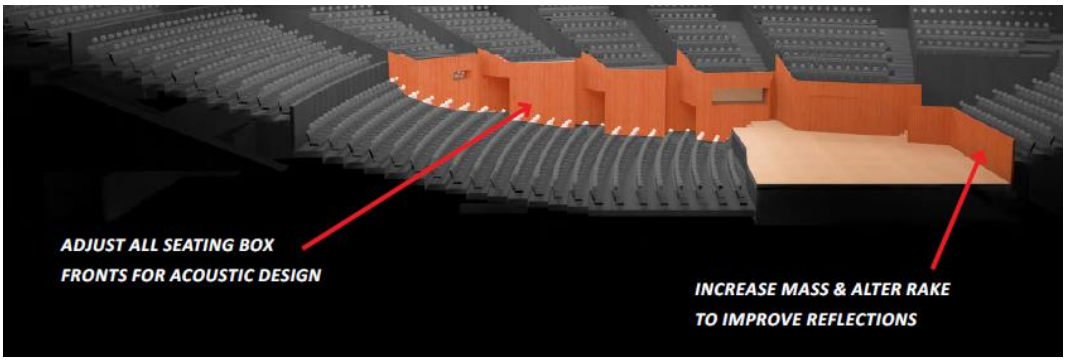


Figure 58: Concert Hall – Required Treatments to Box Fronts and Stage Surrounds

Figure 59: Concert Hall Concept Design– Proposed Treatments to Box Fronts and Stage Surrounds

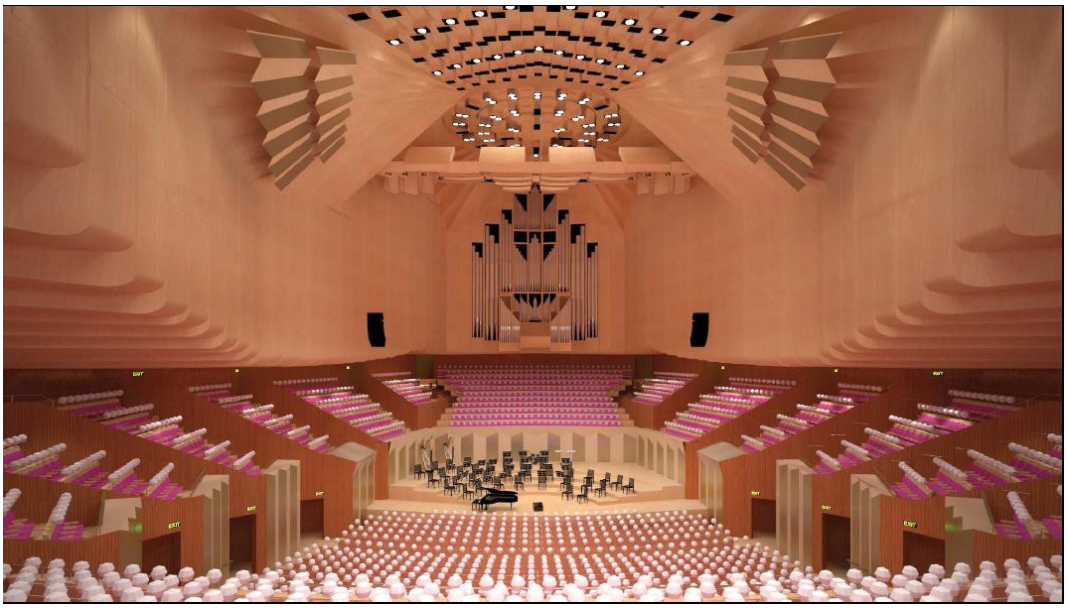


Figure 60: Concert Hall Concept Design– Proposed Treatments to Box Fronts and Stage Surrounds

1.4.2.6.2 Schematic Design

The schematic design phase for the treatment of the stage surrounds, box fronts and rear wall of the stalls is described by ARM Architects as follows:

> 'The design idea for the vineyard-style box fronts, the stage surround and stalls wall began with the prospect of using direct visualisation of music itself as a diffusion pattern.

‘Our research led to studies in Cymatics, which means “wave, a subset of modal vibrational phenomena.” Typically, the surface of a plate, diaphragm or membrane is vibrated, and regions of maximum and minimum displacement are more visible in a thin coating of particles, paste or liquid. Different patterns emerge in the excitatory medium, depending on the geometry of the paste and driving frequency.”

‘Our application uses a parametric surface response to sound energy waves and frequency. The surface is initially triangulated on a 40-mm grid and then smoothed to generate the finished shaping. Due to the interference pattern generations, it is possible to achieve an almost infinite number of wave configurations and patterns.

‘As the amplitude of these three-dimensional patterns is also infinitely variable, it is directly possible to make adjustments to precisely suit the acoustic diffusion requirement. The range of up to 150mm of amplitude will generate a highly tactile and visually delightful surface for the box fronts.

‘The box fronts could be cut from various surfaces or even a combination of surfaces including timber. Using CAD/CAM technology, these surfaces can be exactly defined, with whatever material is chosen.

‘The design approach of making sound energy visible makes not only for a highly malleable acoustic response, but also a coherent story and application. Instead of a design idea that might otherwise be destined to fail, this methodology is both direct and responsive.’

The walls to be treated in this manner are shown in the plan view in Figure 61.

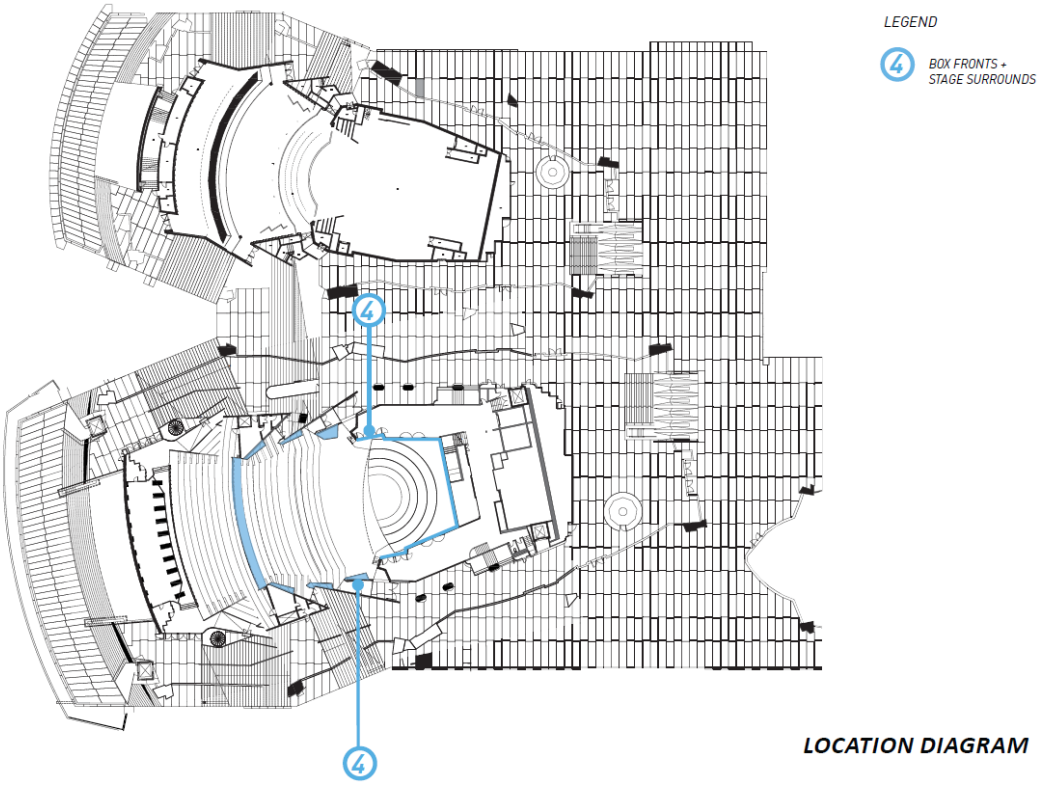


Figure 61: Concert Hall Schematic Design – Plan showing Diffusive Surface Treatments

Renders of the schematic design diffusive surfaces are shown in Figure 62 and Figure 63.

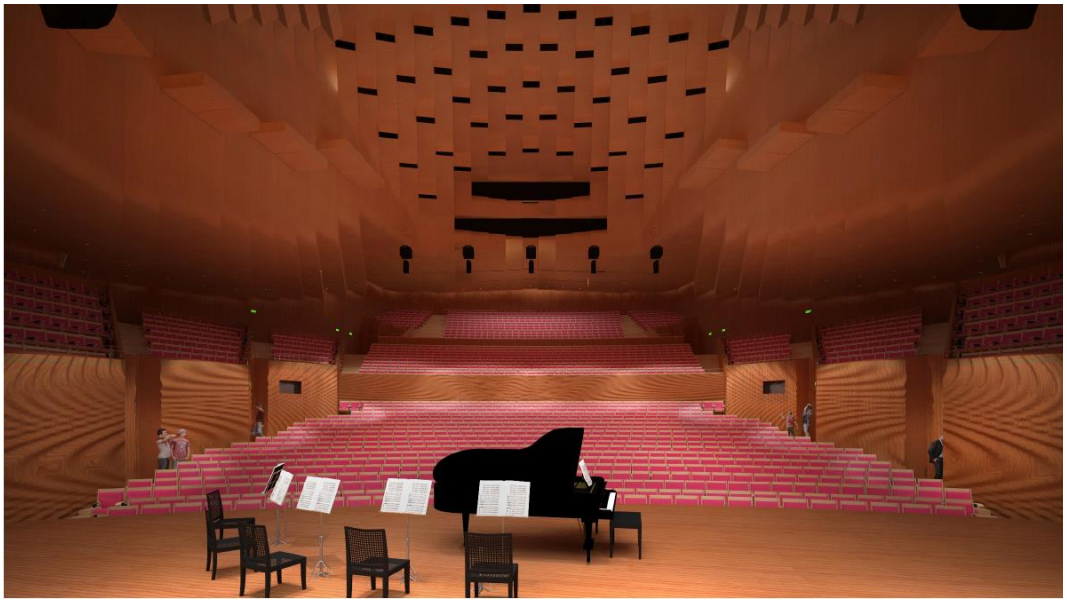


Figure 62: Concert Hall Schematic Design – Proposed Box Fronts and Rear Wall of Stalls (from stage)

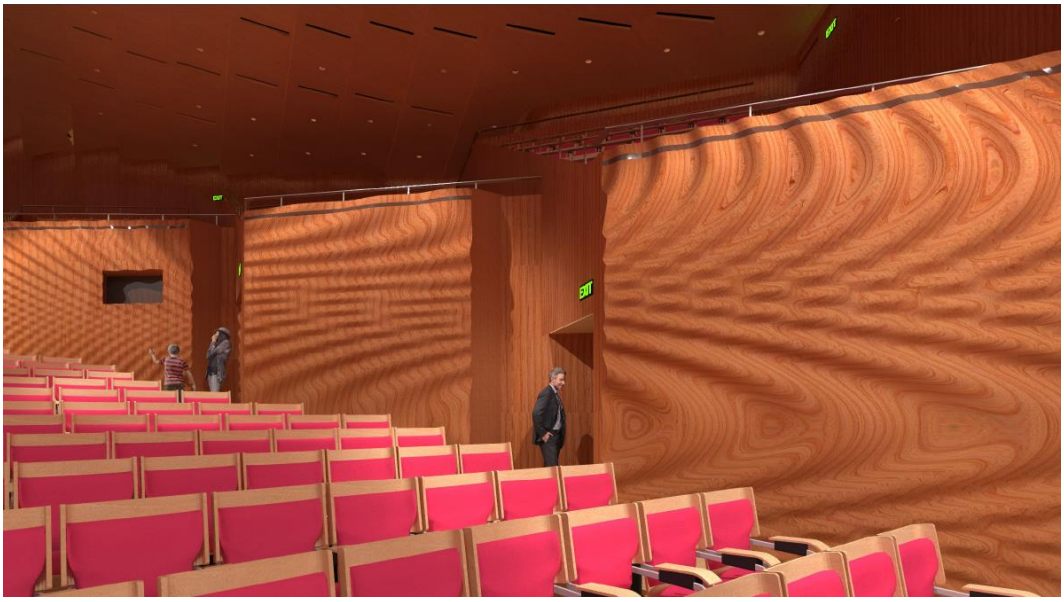


Figure 63: Concert Hall Schematic Design – Proposed Box Fronts (from Row E)

1.4.2.6.3 Design Development

The Design Development phase for the Concert Hall has led to further development of the proposed diffusive surfaces. The addition of profiled diffusive and angled surfaces to the following parts of the existing interior walls to ensure optimum acoustic reflections and diffusion:

- The side box fronts, the walls surrounding the stage and the rear wall of the stalls all are designed to have a non-repetitive relief pattern of 100mm maximum depth constructed from brushbox timber to match the existing timber finish.
- The rear wall of the upper circle level, rear wall of the choir stalls and the rear walls of boxes C,D,E,F,W,X,Y,Z all are designed to have a non-repetitive relief pattern of 50mm maximum depth constructed from brushbox timber to match the existing timber finish.

- The extent of the diffusive surfaces is indicated in Figure 64: Concert Hall Design Development – Final location of Diffusive Surfaces below. Both elements are supported by the EAP.
- The box fronts around the stalls have been tilted backwards slightly, and this allows fo the large ceiling acoustic reflectors to be omitted.

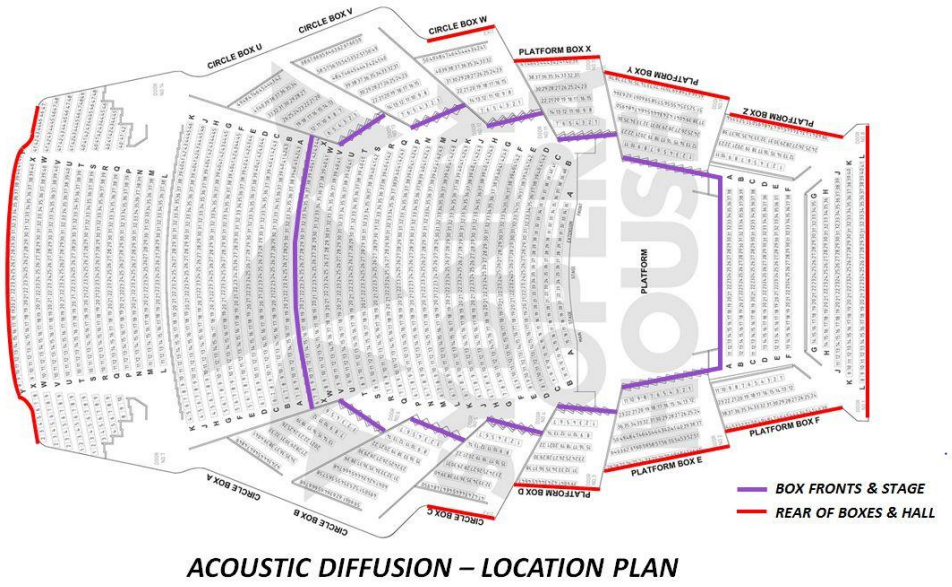


Figure 64: Concert Hall Design Development – Final location of Diffusive Surfaces

Various options for the pattern and profile of the diffusive wall panels have been explored. They have been based on patterns generated by musical wave geometry. This has allowed a variety of options to be easily generated and acoustically tested. The proposed pattern has been tested by the acoustic engineers and also been prototyped in the brushbox timber finish..

Architectural renders of the proposed diffusive surfaces are shown in Figure 65, Figure 66 and Figure 67.

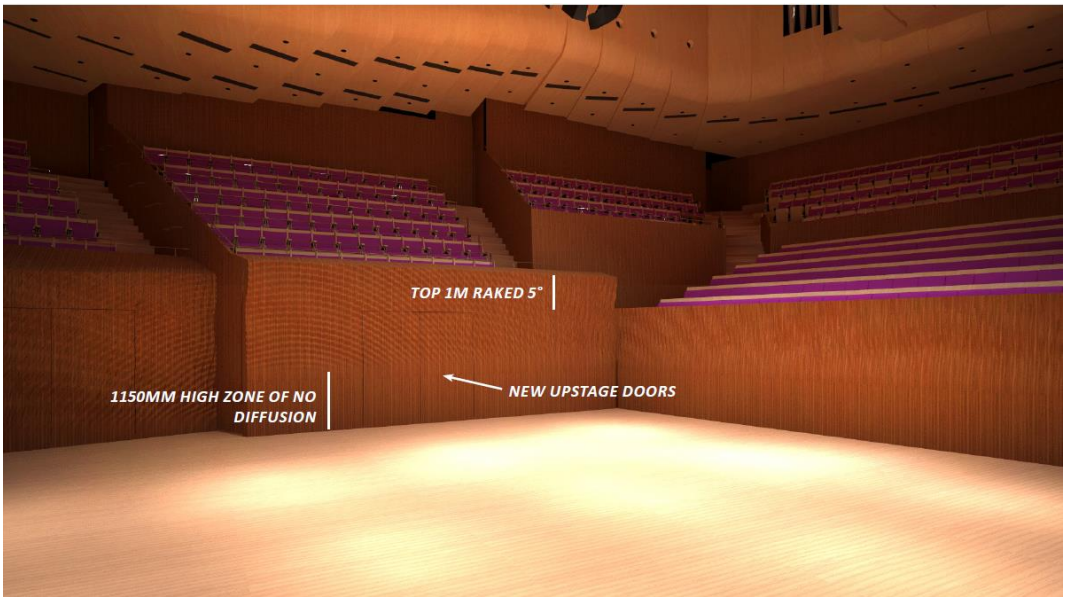


Figure 65: Concert Hall Design Development – Stage Surrounds (stage risers down)

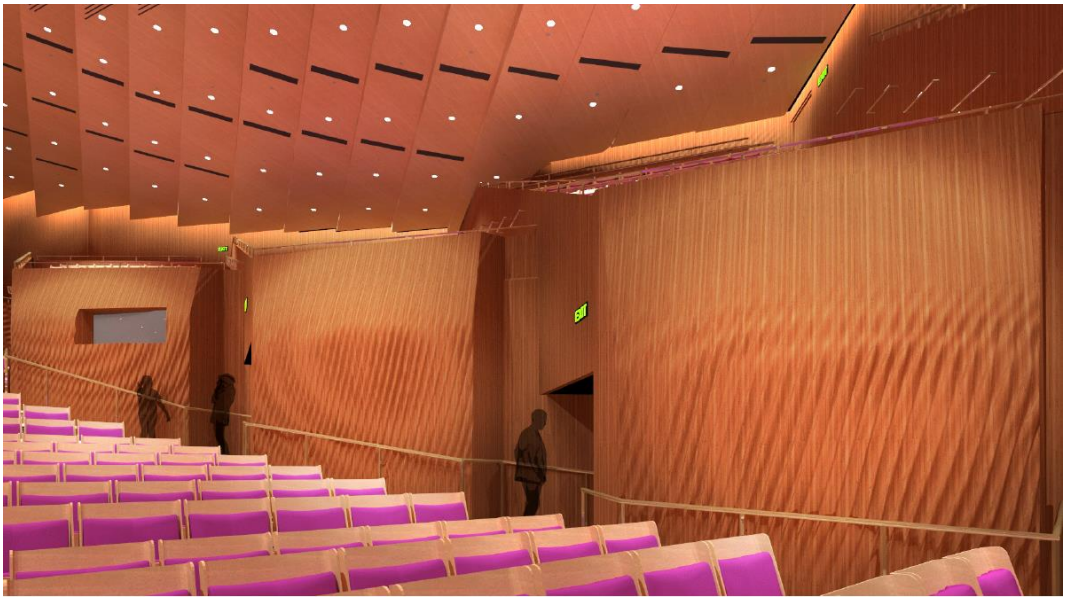


Figure 66: Concert Hall Design Development – Box Fronts Diffusive Surfaces (from Row E)

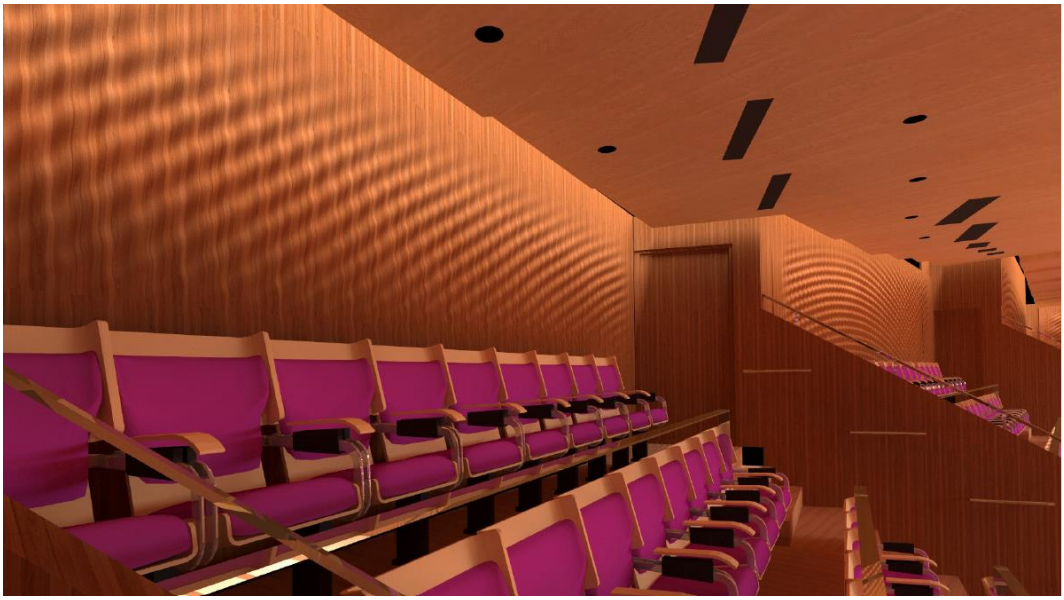


Figure 67: Concert Hall Design Development – Box Rear Wall Diffusive Surface

1.4.2.7 Amplified Mode

Amplified performances (contemporary music, films, and talks) are a substantial proportion of Concert Hall programming. As noted in Table 1 above, the Concert Hall displays the following acoustic problems for these performances:

- Hall is too reverberant for amplified music;
- Time-consuming changeover between acoustic to amplified performances;
- Disturbing reflections; and
- Existing sound system is no longer fit-for-purpose.

The SOH currently employs temporary “overlays” to transform the venue to be suitable for these types of amplified performances. The changeover from acoustic to amplified mode, and back again, imposes significant time and labour costs on the SOH, including workplace health and safety risks for the technicians who undertake the changeovers. The time and

cost risks are such that some promoters overlook the Concert Hall for these types of performances.

In addition, there is an opportunity to greatly improve the visual appearance of the hall when configured for amplified music.

Figure 68: Concert Hall Set Up for Talk Performance in January 2018

Figure 69: Concert Hall Set Up for Film Performance October 2017

Figure 70: Concert Hall Set Up for Contemporary Music Performance

The design process has developed the following interventions to overcome these problems:

- Automated absorbent banners and drapes;
- Adjustment of reflector surfaces;
- Variable stage façade; and
- New sound system.

Figure 71 depicts the areas which are in need of acoustic absorption to improve amplified performances.

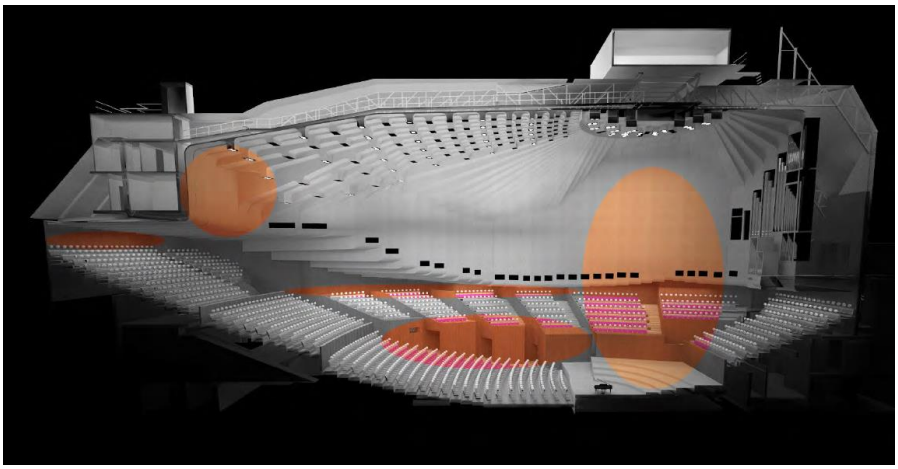


Figure 71: Concert Hall Section – Areas in Need of Acoustic Absorption

1.4.2.7.1 Concept Design

The concept design phase proposed the use of automated banners and drapes in the following locations:

- Rear of box walls;
- Front of boxes;
- Rear of stalls;
- Rear of circle; and
- From the ceiling above the stage and surrounding the reflector array.

- Additionally, the over stage reflectors were designed to fold open to reveal an absorptive material creating a ceiling over the stage.

The banners in the concept design phase were to be black throughout. These proposed banners and drapes are shown in Figure 72, Figure 73 and Figure 74.

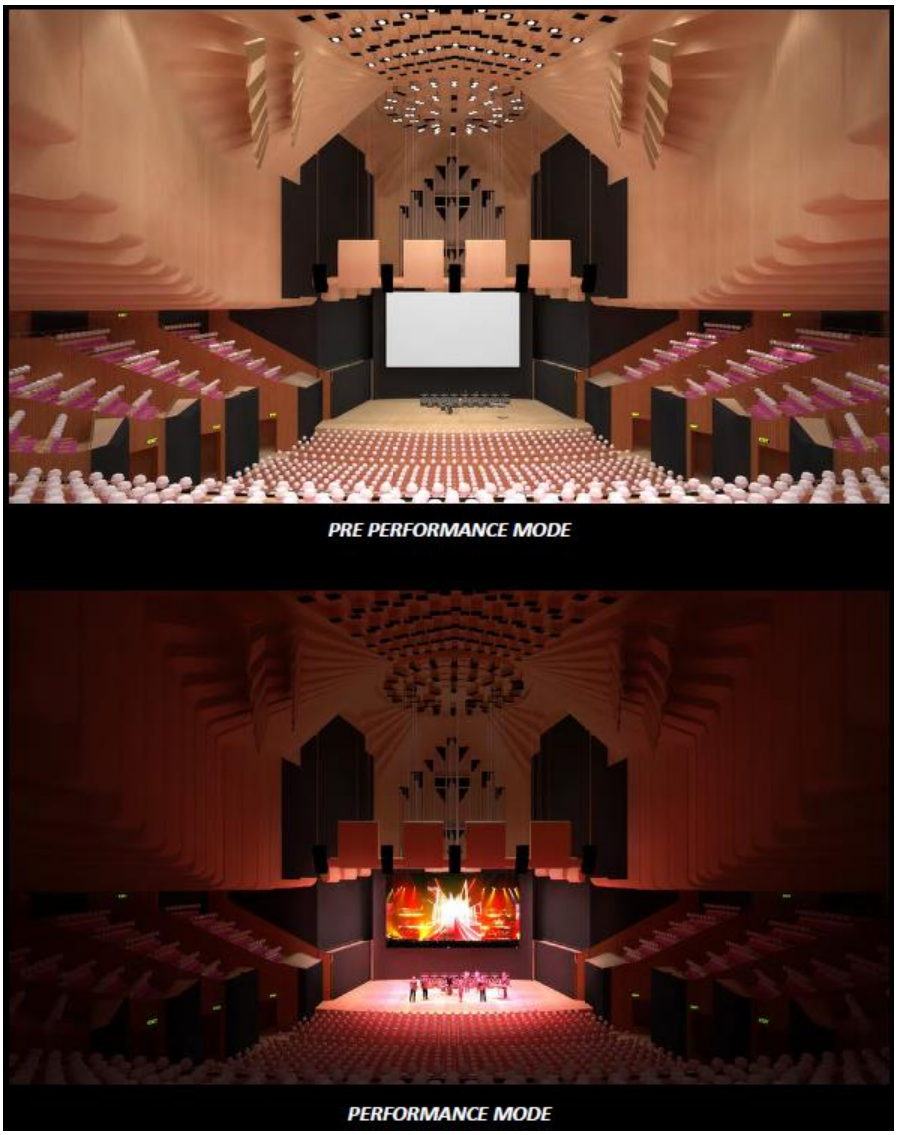


Figure 72: Concert Hall Concept Design – Acoustic Banners and Drapes (from circle)

Figure 73: Concert Hall Concept Design – Acoustic Banners and Drapes (from Box A)

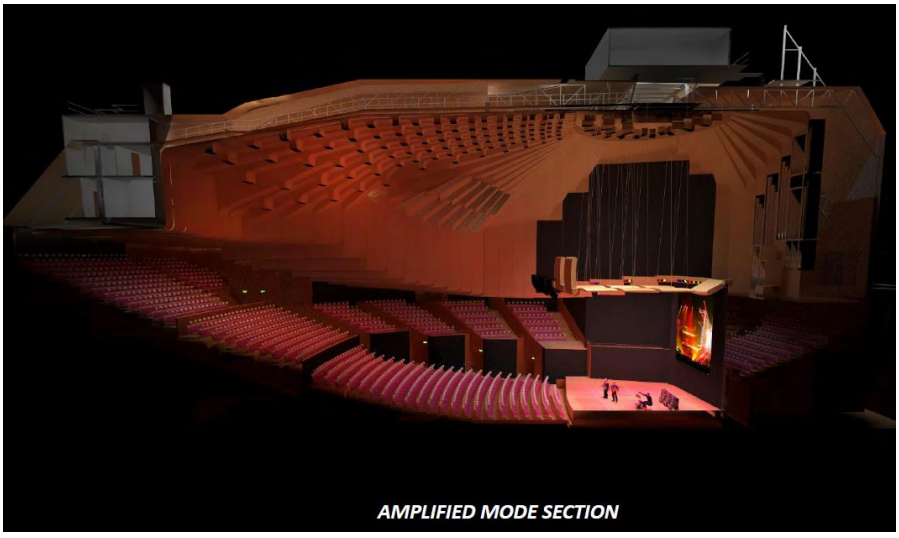


Figure 74: Concert Hall Concept Design – Section showing Amplified Mode

1.4.2.7.2 Schematic Design

With the change of configuration for the overhead acoustic reflectors that was developed in the Schematic Design phase, a concurrent change to the automated banners and drapes was necessary. The folding, rectilinear overhead reflectors became petal shaped and their internal reflective elements were removed and a more intense pattern of drapes from the ceiling crown above the stage were proposed.

An options analysis around colours was developed and reviewed with the EAP. Black, magenta (picking up the magenta colour of the seating in the Concert Hall) and white birch were all considered. The culmination was that the EAP supported the magenta tone (or similar) for upper drapes and the drapes adjacent to the performance space on the stage remained black.

Figure 75: Concert Hall Schematic Design – Amplified Mode (from circle)

Figure 76: Concert Hall Schematic Design – Amplified Mode (from Box A)

1.4.2.7.3 Design Development

At the design development phase the architects and acousticians developed the following new absorptive elements and their location in the room:

- Absorptive fabric banners directly above the stage;
- Absorptive fabric banners to the stage walls and upper walls adjacent to the stage;
- Absorptive fabric banners to the box front walls;

- Absorptive fabric banners to the walls at the rear of the boxes;
- Absorptive fabric banners to the rear wall of the lower and upper circle; and
- Absorptive fabric banners to the rear wall of the stalls.

The fabric banners are designed to have a specified weight determined by their absorption. Two options were considered, one with a custom designed fabric incorporating a decorative pattern similar to the diffusive wall panelling and the second with no pattern incorporating block colour. Both were to have a colour palette that grades from the existing seat magenta to black at the stage to ensure it is suitable for the proposed performance mode and visually appropriate to the significance of the Concert Hall.

These proposed elements are shown in the following series of renders with the option to have block colour (and no pattern) the preferred final solution.

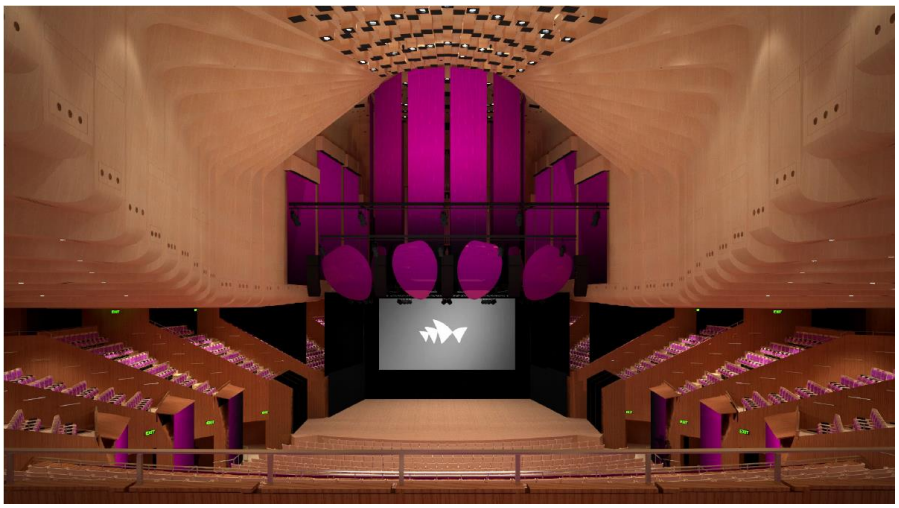


Figure 77: Concert Hall Detailed Design – Amplified Mode (house lighting, from circle)

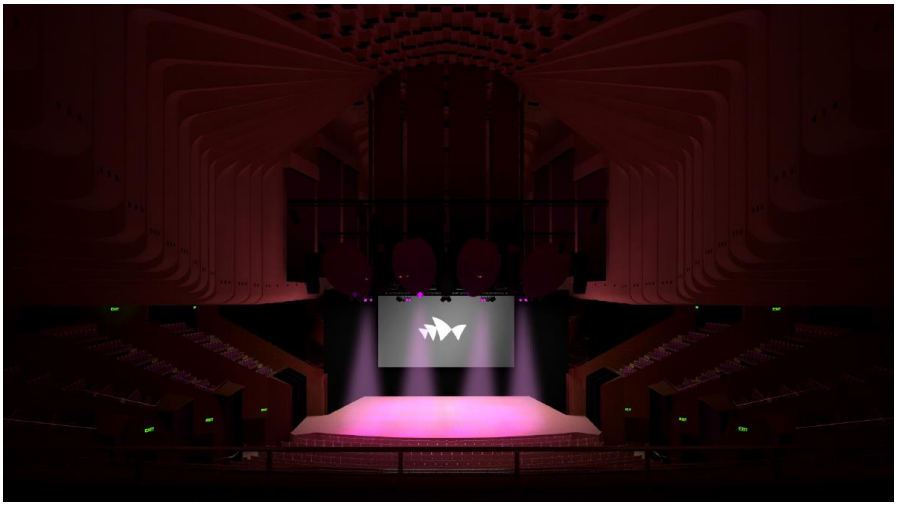


Figure 78: Concert Hall Detailed Design – Amplified Mode (performance lighting, from circle)

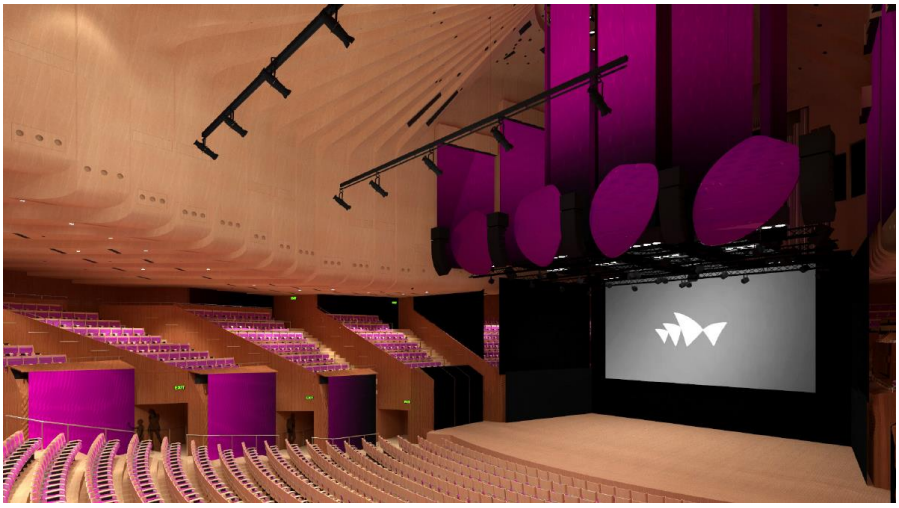


Figure 79: Concert Hall Detailed Design – Amplified Mode (house lighting, from Box A)

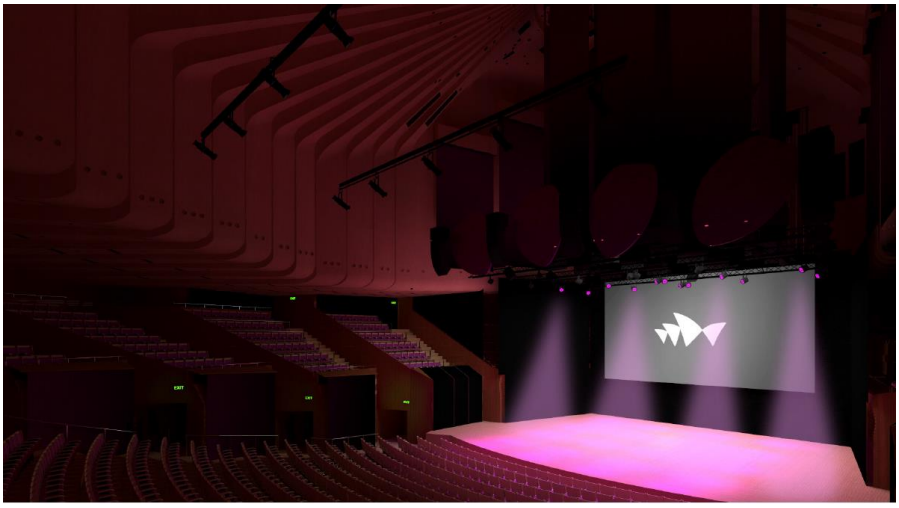


Figure 80: Concert Hall Detailed Design – Amplified Mode (performance lighting, from Box A)

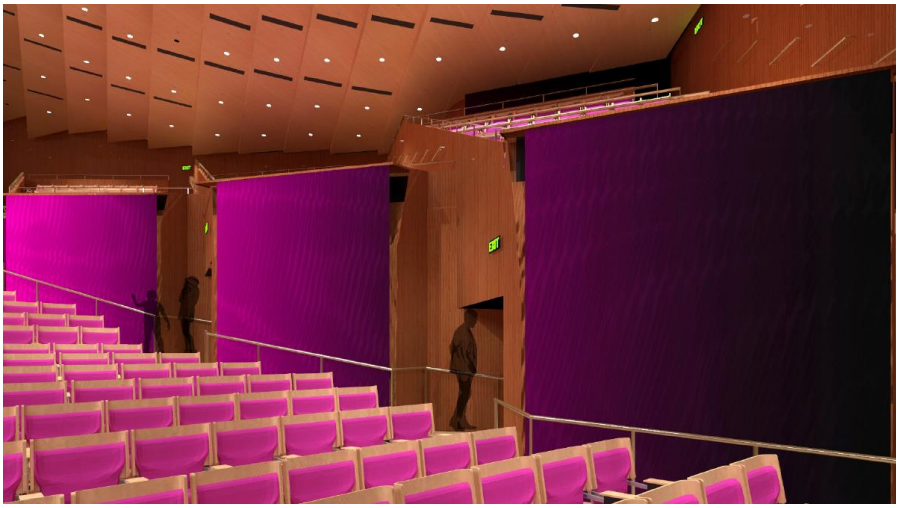


Figure 81: Concert Hall Detailed Design – Box Front Banners (from stalls)

1.4.2.7.4 Further Design Development after Design Review

Similar to the further development of the sidewall reflectors, the design review identified constructability, operability and maintainability issues with the design of the crown banners. A number of options for an alternative design were considered.

The design review concluded that the "Varibanner"™ would provide a more dependable solution than roller style banners. The Varibanner is described by the manufacturer, Triple E, as a Venetian Variable Acoustic Banner. A Varibanner is shown in Figure 82 and Figure 83.

Figure 82: Varibanner in Deployed Position

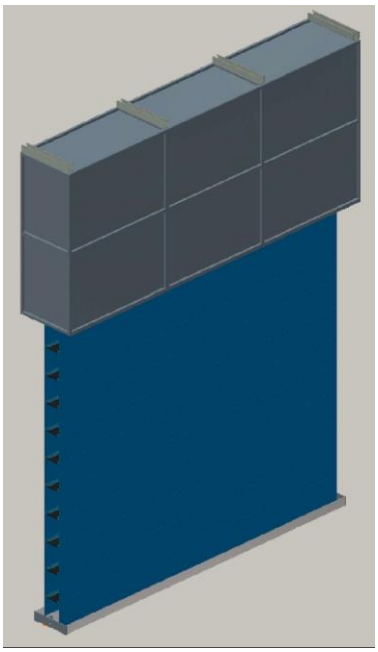


Figure 83: Varibanner Schematic Diagram

An option with the banners concealed in a white birch box, suspended beneath the crown but against the crown was presented to and rejected by the EAP. This option is shown in Figure 84.

Figure 84: Crown Banner "Boxes" Suspended Below Crown

ARM and Theatreplan then reviewed placing the banners above the crown, similar to as previously proposed, however using the Varibanner mechanism. To achieve this a larger

number of banners in the outer ring is required to avoid the steel structure in the ceiling above the crown. This option is depicted in Figure 85 to Figure 88.

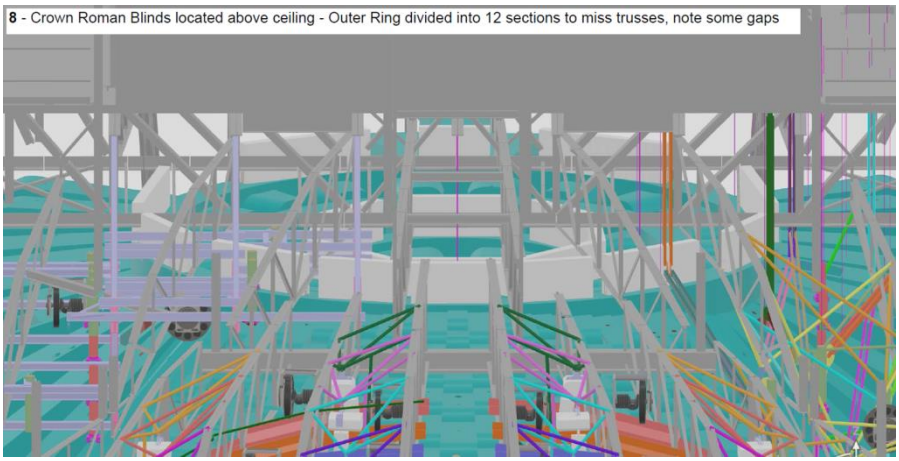


Figure 85: Varibanner Configuration Above Crown for Outer Ring

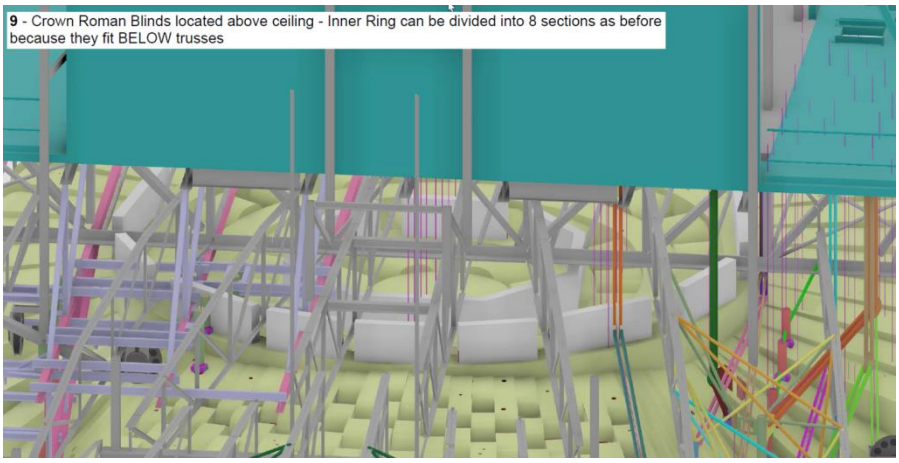


Figure 86: Varibanner Configuration Above Crown for Inner Ring

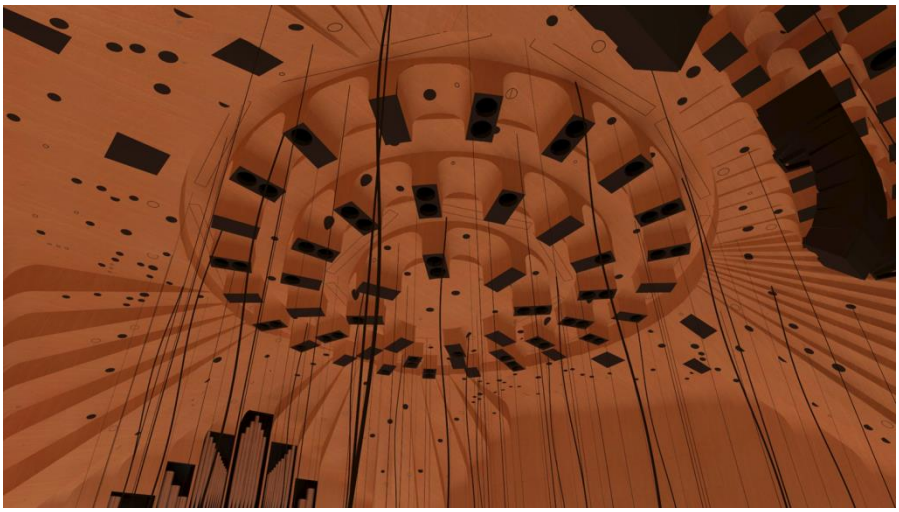


Figure 87: Crown Configuration with Varibanner Option

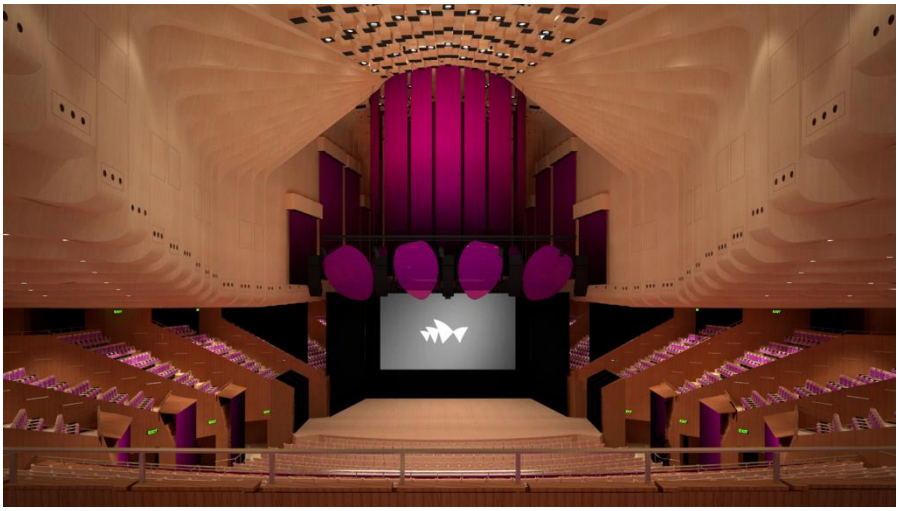


Figure 88: Crown Banners Deployed – House Lighting

This option was presented to the EAP and it was recommended to go forward on this basis.

1.4.2.8 Theatre Machinery and Technical Zone

The current Concert Hall winching and flying equipment is accessed and housed above the Concert Hall ceiling and below the existing Plant Room 21. Plant Room 21 houses mechanical equipment that services the Northern, Eastern and Western side foyers.

Existing access paths and catwalks for operational staff to access the current theatrical equipment are difficult to navigate, limited in coverage and represent a safety issue.

The SOH design brief called for a greater flexibility of performance types as well as an increase in the efficiency of the changeover between these performances within the Hall. This necessitates a major intervention above the Concert Hall ceiling to accommodate an expansion and renewal of the theatre technical equipment (which at 50 years old has reached the practical end of its useful life).

The existing Concert Hall Rigging System features a variety of winch equipment and a design that has been established piecemeal over time. The capacities of these winches, the location of the point hoists (pin spots) and the loading capacity of the ceiling structure mean that the rigging system:

- Doesn't offer the flexibility or lifting capacity for the production requirements of current and future events; and
- Requires large crews to perform fast changeovers when the Concert Hall stages multiple events on the same day.

1.4.2.8.1 Concept Design

The concept design phase proposed that the Rigging System be renewed to provide enhanced flexibility, increased capacity and improvement in changeover productivity and will comprise:

- Stage Lighting Trusses suspended by multiline hoists;
- A grid of ceiling penetrations covering the stage, served by assignable point hoists, to enable a high degree of positional flexibility for suspended loads;
- A low density network of chain hoists, using the same ceiling holes, for heavier loads; and
- A control system to drive and manage the Rigging System and other flown elements such as acoustic reflectors.

To enable the renewal of the Rigging System, the space above the stage between the auditorium ceiling and the acoustic barrier beneath the sail will be substantially cleared of existing services. Plant Room 21 will be relocated and a new acoustically isolated winch room built in its place to accommodate hoists and winches.

A working floor will be constructed above the Concert Hall Ceiling and integrated to the existing truss structure. The working floor will enable technicians to safely and quickly assign hoist cables to ceiling holes and position other rigging systems to cater for the rigging requirements of events.

Figure 89 depicts a cross section of the Concert Hall showing the proposed changes to the Technical Zone. At this stage it was proposed that the mechanical equipment housed in Plant Room 21 would be moved to the northern end of the hall closer to the areas it services.

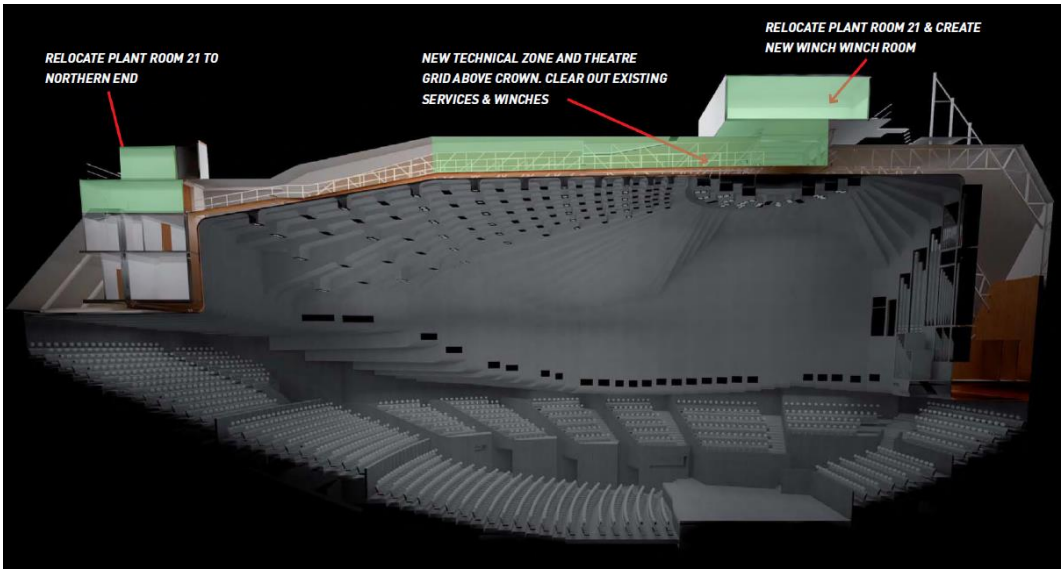


Figure 89: Concert Hall Concept Design – Section Showing Changes Proposed to Technical Zone

1.4.2.8.2 Schematic Design

The schematic design phase did not see any significant change to the concept designs proposed for the theatre machinery and the technical zone.

1.4.2.8.3 Design Development

The design development phase refined the proposed changes to the theatre equipment and technical zone, including modifying the plan to relocate Plant Room 21 to the northern end of the ceiling space.

To accommodate the new winch room the existing Plant Room 21 equipment will be relocated. The plant servicing the Northern Foyer will be relocated to new wing platforms either side of the current plant room. The plant servicing the East and West Foyers will be demolished and these spaces serviced by local fan coil units. A cross section of the proposed changes to the Concert Hall is shown in Figure 90.

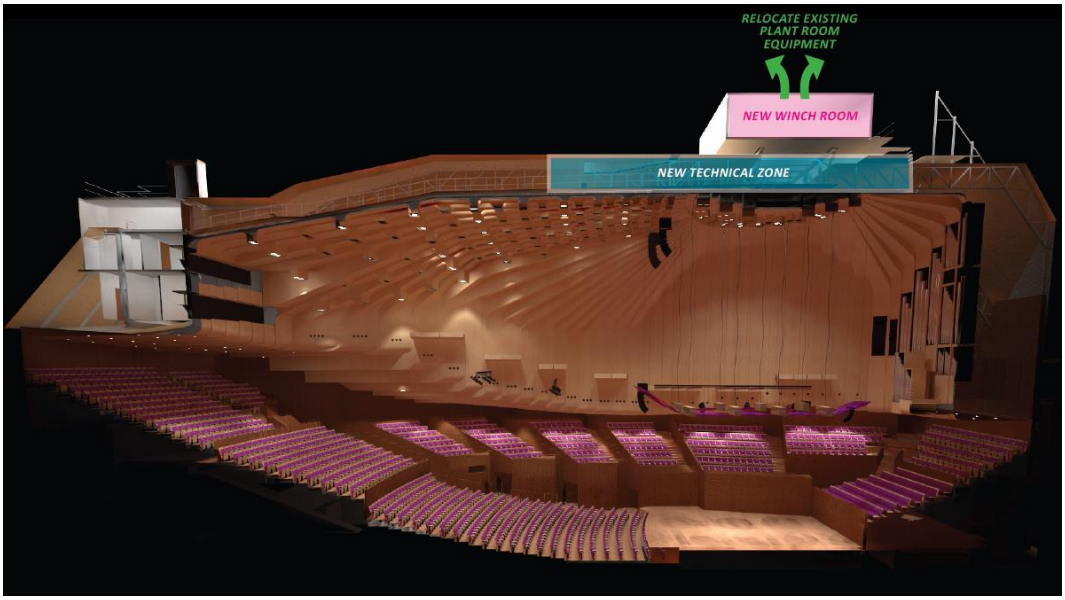


Figure 90: Concert Hall Design Development – Section Showing Changes Proposed to Technical Zone

The accommodation of the winches at a higher level in the vacated plant room allows a rationalisation and expansion of the theatrical grid below it to provide improved and safer access for operational staff to access and manage the operation of the flying lines and different rigging equipment configurations.

This increased winching/flying capacity requires a greater number of penetrations in the existing ceiling. This in turn allows greater flexibility and adds service capability to new areas of the Hall. These additional ceiling penetrations are coordinated with the existing ceiling profile to minimise modifications to its current appearance. Existing penetrations that become redundant with the new configuration will be closed off with matching white birch plywood. The new penetrations will include tubes above the ceiling into which the flying lines with attached “bob” weights can be fully retracted. This is a modification from the current practice of leaving unused “bob” weights and flying lines suspended below the ceiling (this can be seen in Figure 68 above), and this will lead to a cleaner and less obstructed volume above the audience. .

1.5 Introduction of the Creative Learning Centre

The main strategic imperatives for the Creative Learning Centre (CLC) are to improve visitor experiences and expand the delivery of the Opera House's learning programs by:

- Enriching the community's accessibility to the creative arts and artists;
- Establishing a centre-of-excellence for creative learning at the Opera House;
- Supporting 21st Century learning pedagogies through an arts-rich cross-curriculum learning program; and
- Connecting digitally with students, teachers and families nationally and internationally in the delivery of a digital, multi-media learning program.

The CLC space currently accommodates offices and meeting rooms; it was originally envisioned by Utzon as the main entry to the Opera House's administration and reception. The area will be repurposed into two learning spaces with adjoining kitchenette, children's toilet facilities and storage.

1.5.1 Do nothing option

The SOH Children, Families & Education (CFE) department present a range of Creative Learning (CL) programs that currently have no "permanent" presentation spaces at the Sydney Opera House. The CL programs currently use foyers and other public spaces on an itinerant basis. The lack of a permanent home is restrictive on the capacity of the SOH to offer these programs effectively.

Currently the Creative Learning program provides performances, digital live and interactive workshops plus a free creative play program in the public foyers on-site at Sydney Opera House.

The CL program competes with internal and external hirers to access the theatres and broadcast studio and despite lower ticket prices within a family and educational context, it also pays the standard internal charges.

At present the CL program is unable to offer a cost effective workshop space for deep and long term engagement due to the nature of the heavily used building.

The free creative play program operated in the western foyers places a heavy strain on the space with our catering and tourism operators as well as private hirers using the foyers. The organisation is currently struggling to meet the competing needs of these diverse internal business groups at peak operating periods such as the summer school holiday period.

As the program has no dedicated workshop space it is unable to provide cost effective, interactive and innovative cultural and creative learning programs.

The space proposed for the Creative Learning Centre is currently used as administrative offices, and would remain as back of house spaces. The alternative of opening these spaces to become front of house and publicly accessible has been discussed as an "Opportunity for Change" in the Conservation Management Plan Fourth Edition.

1.5.2 Concept Design

Multiple options were explored during Concept Design Phase, principally designed to address:

- Flexibility for different collaborative learning environments adaptable for:
    - Change throughout the day
    - Day/night
    - School holidays/term-time
- Ease of re-configuration of the spaces for varied uses and client groups

- ‘Theatre’ lighting and rigging points and services to contribute to the learning experience
- In-ground data and power services
- Re-use of existing wobbly panels
- Accessibility and multiple entries (from Western Foyer, Western Broadwalk and Northern Broadwalk)
- Exhibitions and displays

Initially three concepts were developed. Each option had different imperatives and/or opportunities for programming, access and amenities.

- Option 1 with amenities to north and south of the front western entry and a larger store room
- Option 2 with amenities to south of the front western entry and a smaller store room
- Option 3 with three lifting platforms to facilitate a quick changeover for displays and usage (vertical programming).

These options are depicted in the following diagrams:

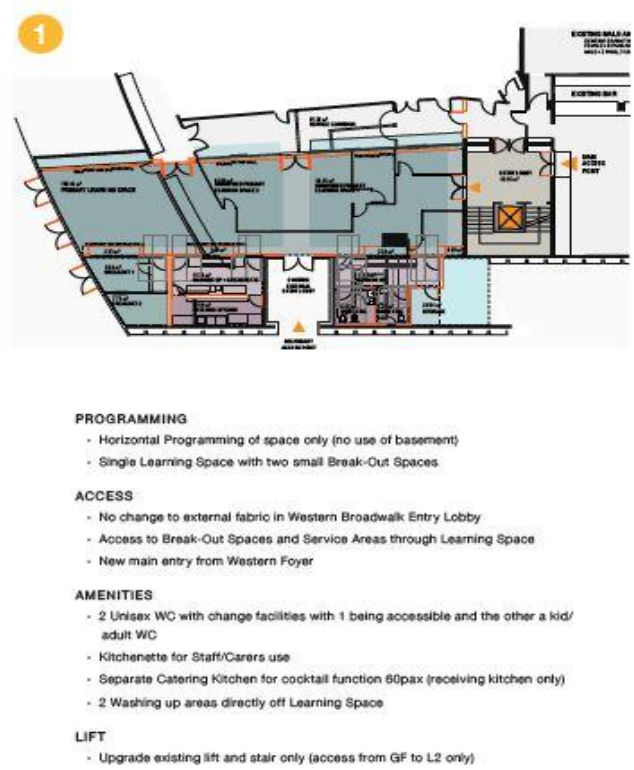
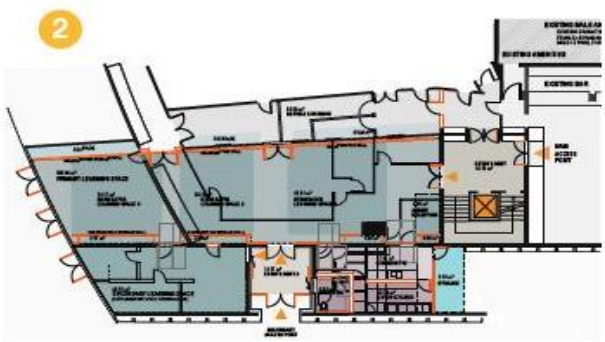


Figure 91: Creative Learning Centre Concept Design Option 1



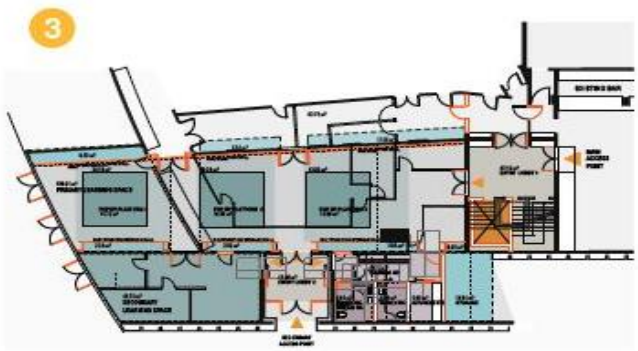
PROGRAMMING
- Horizontal Programming of space only (no use of basement)
- 2 Learning Spaces with separate access

ACCESS
- Western Broadwalk Entry Lobby enclosed with new openings in wall panels allowing separate access to Secondary Learning Space and WC

AMENITIES
- Single Unisex WC (accessible) with change facilitiesKitchenette for Staff/Carers use
- Kitchenette for Staff/Carers use
- Separate Catering Kitchen for cocktail function 60pax (receiving kitchen only)
- Single Washing up area directly off Primary Learning Space

LIFT
- Upgrade existing lift and stair only (access from GF to L2 only)

Figure 92: : Creative Learning Centre Concept Design Option 2



PROGRAMMING
- Horizontal and Vertical Programming of space allowed with use of 3 stage lift platforms into basement
- 2 Learning Spaces with separate access

ACCESS
- Western Broadwalk Entry Lobby enclosed with new openings in wall panels allowing separate access to all spaced

AMENITIES
- 2 Unisex WC with change facilities with 1 being accessible and the other a kid/adult WC
- Kitchenette for Staff/Carers use
- Single Washing up area directly off Learning Space

LIFT
- Existing lift and stairs reconfigured and replaced with new fully accessible lift and stairs providing access from B1 to L3

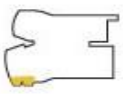


Figure 93: : Creative Learning Centre Concept Design Option 3

1.5.3 Schematic Design

Option 2 was chosen for further development during the Schematic Design Phase when various user configurations were determined.

Primarily, two learning spaces were maintained:

- Primary Learning Space
- Digital Learning Space

Felt walls were added to enable subdivision of the Primary Learning Space.

Room layout options were explored to accommodate various event types as shown in the following images.

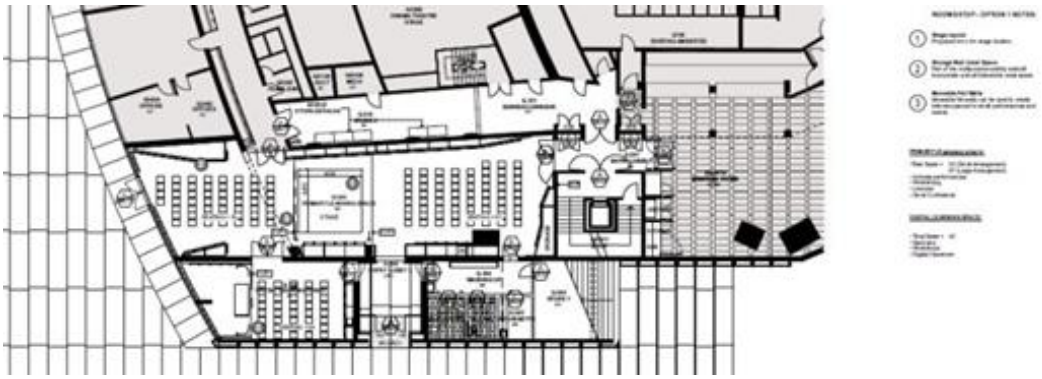


Figure 94: Creative Learning Centre Schematic Design

In this configuration, there would be:

1. Stage
2. Storage wall /crawl space
3. Moveable felt walls

Primary Learning Space

- Seats 53 – 67
- 4m x 4m stage
- Intimate performances
- Workshops
- Small conferences

Digital Learning Space

- Seats 40
- Seminars
- Workshops
- Digital classroom

An alternative configuration as in the following image was also considered:

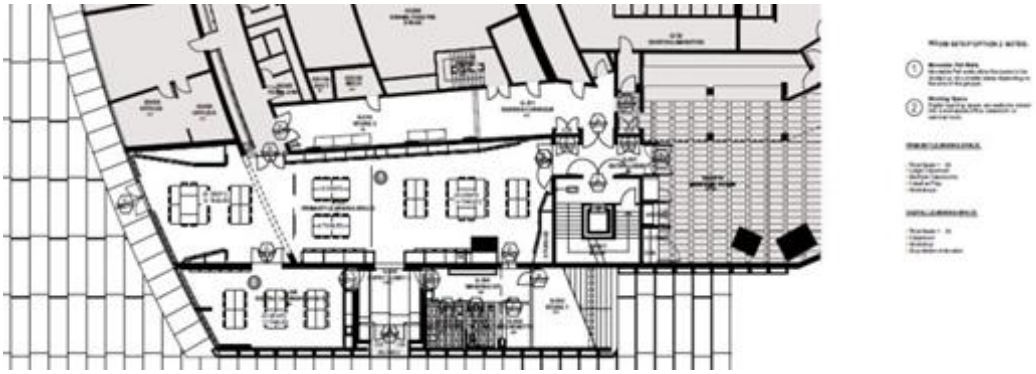


Figure 95: Creative Learning Centre Schematic Design Alternative Option

In this configuration, there would be:

1. Moveable felt walls
2. Working space

Primary Learning Space

- Seats 64
- Large classroom
- 2 classrooms
- Workshops
- Creative play

Digital Learning Space

- Seats 24
- Classroom
- Workshops
- Stop motion animation

Flexibility of using the “wobblies” as joinery cupboards for exploration and display was devised. This was the primary device to transform the space whereby the wobbly doors opened through 180 degrees to reveal interior spaces for activity and opportunities for display and interaction. This transformation is shown in the following images:

Figure 96: CLC “Wobbly” Cupboards Closed

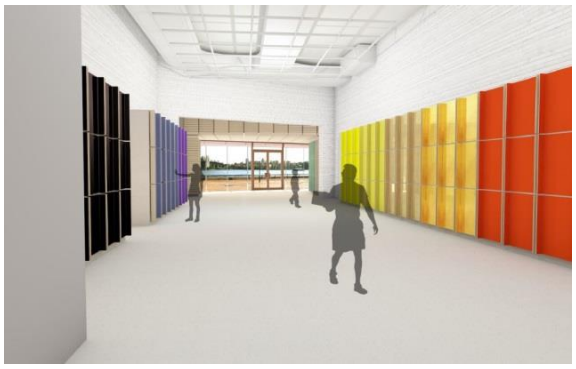


Figure 97: CLC “Wobbly” Cupboards Open

The harbour side portion of the Digital Learning Space was also developed as a useful flexible space where the opportunities for display and exhibition - as well as a night-time presence for the CLC - could be accommodated. This is shown in the following images.

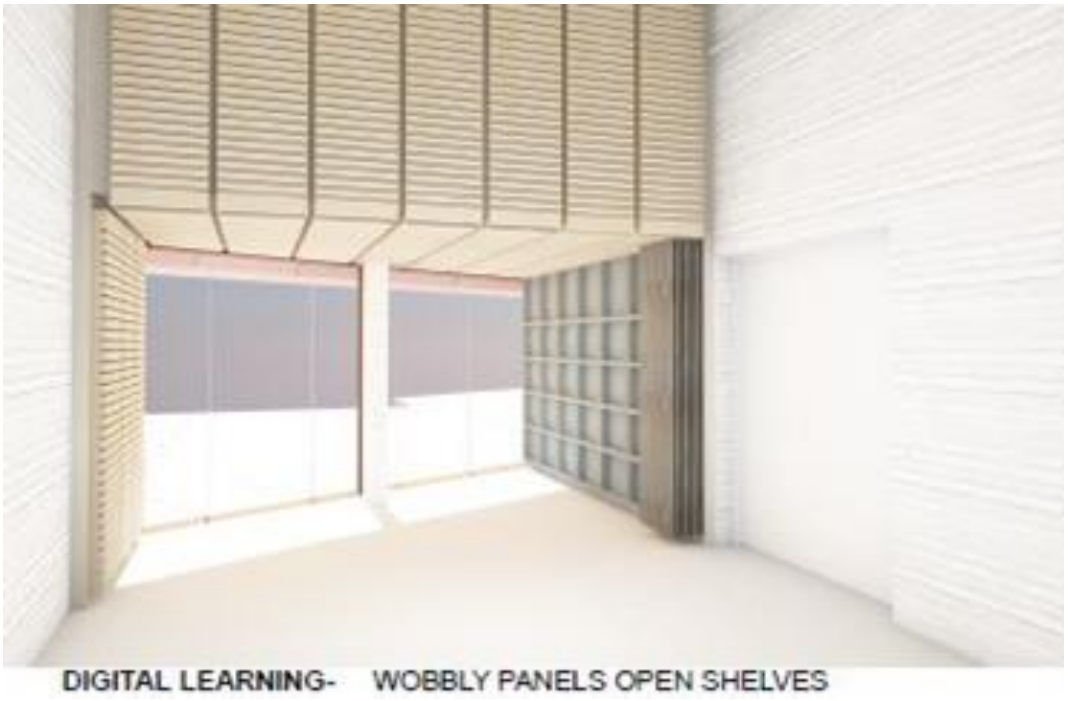


Figure 98: CLC Northern Window Space – Wobbly Panels Open

Figure 99: CLC Northern "Display" Window Space Closed Off (looking from inside)

Figure 100: CLC Northern "Display" Window Space (looking from outside)

1.5.4 Detailed Design

The Detailed Design Phase firmed up details of Option 2 with a focus on elements such as:

- High-level services
- Sprung floor, floor services boxes and ferrules
- Floor finishes
- Barisol membrane ceiling in the corridor to the Western Foyer
- Wobbly joinery
- Felt curtain dividers
- Door and façade details
- Green screen deployment
- Storage corridor at rear

A number of simplifications were made:

- Deletion of motorised lighting bars in favour of all fixed bars
- Reduced number of wobbly joinery cupboards
- A single position for the green screen
- Reduced numbers of dimmers and dimmer sockets

Final adjustments were made as part of the value engineering process, principally the deletion of the external door onto the Northern Broadwalk. The final floor plan is shown in the following image:

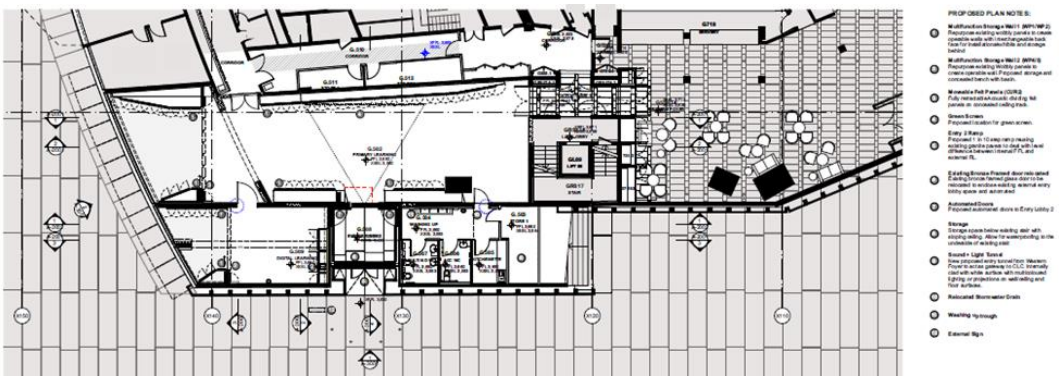


Figure 101: Final Floor Plan for Creative Learning Centre