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# THE ELECTRO-ACOUSTIC ENHANCEMENT OF THE ADELAIDE FESTIVAL THEATRE – A RE-SOUNDING SUCCESS?

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## 1 INTRODUCTION

In the late 60's, Adelaide was developing its biennial Adelaide Festival of Arts with some success. It was obvious that Adelaide required a major arts venue to provide a focus for the festival and to provide enhanced performance venues for Adelaide. The city could not justify separate orchestral, opera and general purpose venues of the size envisaged and decided on the development of a 2000 seat multi-purpose venue, suitable for staging major touring events from musicals to symphony. When it opened in 1973, it was regarded as an acoustically innovative design for its system of retractable acoustic curtains along the rear walls and above a false ceiling. After being in operation for some time, the theatre came to be regarded as having less than satisfactory acoustics for symphony orchestras, and to a lessor extent opera, primarily because of its excessively short middle and high frequency reverberation time, perceived lack of envelopment, and little support from the auditorium back to the stage.

A decision by the state government and the State Opera of South Australia to mount a full production of Wagner's Ring Cycle in late 1998 and the need for a general upgrade to the Adelaide Festival Centre resulted in a master-planning study in late 1996 to early 1997. The study parameters included a required outcome of improving the acoustics of the theatre suitable for the staging of The Ring to an international audience. This paper briefly reviews the acoustical shortcomings of the theatre, the range of architectural changes considered and the decision making process leading to the installation of a LARES electro-acoustic enhancement system for the theatre. The paper addresses the question of whether the treatment was successful with a review of published or broadcast comments.

## 2 ACOUSTIC STUDY AND OUTCOMES

### 2.1 Existing Theatre

The Adelaide Festival Theatre was designed in the early 70's and opened in 1973. It seats a nominal 2000, and comprises stage and flytower, stalls, two balconies and side boxes with increasingly limited views to the near side stage. The basic plan shape (Fig 1) is a fan at the stage end and closer to parallel sides towards the rear. The side walls however comprise a series of octagon shapes, a recurring theme in the Festival Centre complex. The section view (Fig 2) shows the two balconies, the lower one in particular being quite extensive and a significant volume above the visual ceiling containing air-conditioning ducts, lighting bridges and retractable absorbers to assist in achieving variable reverberation.

The design of the ceiling was intended to promote reflections back to the auditorium, whilst still being open enough to allow the above-ceiling space to be considered as part of the auditorium volume.

## 2.2 Acoustic Assessment

### 2.2.1 The Task

The theatre is widely used for a large range of events, from university graduation ceremonies and school based events through to major amplified musical presentations. The general criticism of the space acoustics revolved around the theatre's use for orchestral concert and for opera, in particular under the balconies, with the following quote being typical of the criticism.

> "Just as well that some people are easily pleased, because the sound – particularly the orchestral sound – in the back rows of the stalls is curiously muted and lacking in quality. I wouldn't pay good money for those seats. What will the interstate and overseas customers coming for next year's Ring make of it."
>
> (From Roger Knight's review of *The Marriage of Figaro* in The Adelaide Review, September 1997.)

The following objectives and constraints facing the acoustical consultants were:

- Those that would improve the theatre's performance as an opera house.
- Any additional measures which would improve the theatre's performance as a concert hall, without diminishing its performance as an opera house.
- Those that would improve the natural acoustic fold-back to on-stage performers.
- Those that would improve some low frequency problems affecting strongly sound reinforced productions.

### 2.2.2 Existing Conditions

The Festival Theatre auditorium had an acoustic that provided good, even coverage for speech, contemporary music concerts and musicals. Its reverberation time was long at low frequencies, short at middle frequencies and very short at high frequencies for its size. The relatively long low frequency reverberation sometimes caused problems for sound engineers in highly amplified performances.

An auditorium the size of the Festival Theatre with no additional absorption other than its audience would be expected to have a mid band reverberation time of about 1.8 seconds, much longer than the measured 1.3 - 1.4 seconds. The significantly lower reverberation at higher frequencies and lack of early energy to the central seating areas and under the balconies added to the impression of a dry acoustic.

The excess absorption in the Festival Theatre was often attributed to its carpet floor covering and fully upholstered seating. This led to a pool of opinion that removing the carpet would dramatically improve the acoustics. Even allowing for carpet and fully upholstered seating, the high frequency absorption was still excessive, and the mid-frequency absorption should not have been significantly affected.

During investigations into the acoustic problems in 1978, it was noted that the reverberation time in the ceiling space was significantly longer than at any location in the auditorium, including just under the ceiling, indicating that the predominantly open ceiling was providing a significant resistance to acoustic transmission, resulting in a coupled secondary volume, rather than one larger volume. This helped to explain the reverberation results in the mid-frequency region but the higher frequency absorption was still excessive, even for the reduced volume.

The walls of the theatre are covered with decorative wooden blocks, which are a hardwood tile varying in size, but typically 200mm square and approximately 40-60mm deep with a splayed front

face. During construction, the builder incorporated a 2-3 mm gap between each tile. The gap was intended to prevent the tiles from dislodging from the wall should they expand as a result of absorbing moisture. It had previously been thought that the narrow gap, varying between 40 & 65 mm in depth, could be acting as frequency selective (quarter wave) absorbers. The investigation provided an opportunity to test the theory.

A ten square metre sample of the tiled wall treatment was measured in a reverberant chamber, as mounted in the theatre, and with all the gaps caulked, resulting in the following Sabine absorption coefficients.

Table 1: Absorption of Timber Block Wall Treatment

| | Frequency - Hz | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 |
| Original Sample | 0.10 | 0.14 | 0.26 | 0.28 | 0.37 | 0.32 | 0.42 | 0.35 | 0.32 | 0.32 |
| With Gaps Caulked | 0.08 | 0.08 | 0.07 | 0.08 | 0.08 | 0.06 | 0.06 | 0.08 | 0.07 | 0.04 |

It was obvious that any remedial architectural treatment had to address the acoustic transparence of the ceiling and the additional absorption on the walls.

The other major acoustical problems were the lack of early reflected energy to the centre stalls and circles, affecting audience, and lack of early reflected energy back to the performers on stage, affecting the performers' perception of the space acoustics and their own performance. Consideration of reflection paths from the walls, the balcony fronts and sides of the proscenium opening showed that there was little early reflected energy back to the stage and early non-frontal energy to the audience other than from some areas of the side walls. The reflected paths that did assist in early non-frontal reflection was propagating over audience heads and of course suffered the additional absorption from the wooden blocks.

Seating under the balcony overhangs in the dress circle and the rear stalls is cut off from sounds reflected down from the upper walls and ceiling, so is even more removed from the early energy, and the later energy filtering down from the above-ceiling volume. This is consistent with patron feedback of feeling more distant or removed when sitting under the balconies.

The rear walls of the auditorium were curved. In speech mode, the walls were covered with retractable curtains, but when retracted, the walls provided a perceptible echo to some on stage performers.

### 2.2.3 Architectural Acoustic Upgrade

At the conclusion of the master-planning investigations, the consultant team and the client sought a further review with two external acoustical consultants. A workshop was conducted in March 1997 comprising Bassett Acoustics (Adelaide), Peter Knowland & Associates (Sydney) and Arup Acoustics (Sydney). It considered contributions from the State Theatre of South Australia, the State Opera of South Australia, ARO Technology, the Adelaide Symphony Orchestra, the Adelaide Festival, and the Festival Centre Sound Department. This group agreed with a general characterisation of the auditorium generally as described above and that the architectural solutions would need to address the following.

- Improving the early-reflected energy to those seats not shielded under balconies by reshaping the side walls and /or providing upper side wall / ceiling reflecting panels.
- Increasing loudness by closing the horizontal sections of the ceiling.

- Replace the carpet with parquet flooring. There was some concern and comment that this would be of minor benefit, and may be less desirable given the requirement to maintain the quality of the space for major musical productions.
- Increasing the coupling between the auditorium and the above ceiling volume by removing significant areas of the non-horizontal sections of the ceiling and removing or increasing the spacing of the radial beams.
- Adding more effective variable acoustic systems above the visual ceiling.
- Increasing the reverberation time in the middle and upper frequencies by removing the wooden blocks (or caulking to overcome their existing absorptive properties).
- Increasing the support factor (to the stage) by reshaping side walls, and/or providing suitable diffusing and reflecting elements on the side walls, shaping ceiling and proscenium reflectors to suit this purpose and providing a solid reflector at the orchestra pit rail.
- Overcoming other specific problems including the provision of diffusive elements on the auditorium rear walls to reduce the echo, diffusive elements to the orchestra pit, and additional low frequency absorption to specific areas in the stage tower and above the auditorium ceiling.

The proposed changes would have taken significant time and money and required relatively long-term closure of the Theatre. In addition, the acoustic environment under the balcony would still have been less acceptable and it was agreed that some form of future electronic system would still eventually be needed to assist in improving the acoustics under the balconies.

It became obvious that the architectural options were not practical given the cost constraints imposed by the government, and the time constraint imposed by The Ring, for which tickets had already been sold. In addition, the Festival Theatre itself was reluctant to close its doors for any longer than necessary and had bookings for the coming year. At this time, the Festival Theatre and Bassett Acoustics began to consider that a full rather than partial electro-acoustic system was potentially the best option. The use of a fully developed electro-acoustical system appeared not only to be able to significantly improve the sound fields under the balconies, but also had the ability to provide an appropriate sound field that emulated the acoustical effects that were being sought by the various architectural changes. It was important that such a system be transparent in its operation.

The benefits of implementing a suitable electro-acoustical system were:

- The architectural changes required to increase the early non-frontal energy required to the majority of the seats were eliminated and the amount of diffusive elements significantly reduced.
- The acoustical deficiencies under the balconies were addressed affording improvements to the sound field. This is not practical using a purely architectural solution.
- The provision of early energy “foldback” to the stage (increasing the Support factor) eliminated the need for architectural work around the proscenium and for diffusing elements on the side walls and ceiling.

The decision was made to investigate if a suitable system existed.

# 3 ELECTRO-ACOUSTIC ENHANCEMENT SYSTEM

## 3.1 The Decision Process

The development of an existing electro-acoustical enhancement system during the late 1980's by Festival Theatre Sound Department staff had established the potential for electronic architecture in the Festival Theatre. This experimental system, designed to extend high frequency reverberation time, was a primitive third generation design. Its development ceased when the Adelaide Symphony Orchestra moved its base to the Adelaide Town Hall in 1991. None the less, the significance of this experimentation is that there was some existing understanding of the applied technology by Festival Theatre staff and Bassett Acoustics.

It was noted that reports in professional literature pointed to recent developments in the technology and its increasing application in the United States and Europe for either improving poor acoustics in existing auditoria or providing adjustable acoustics for new auditoria. A search of the professional literature and internet sites for references to electro-acoustics indicated that two companies, LARES and SIAP, were actively involved in installing new electro-acoustic systems.

It was realised early that the best system was of no use if the main end-users would not accept the concept of electro-acoustic enhancement. There was qualified acceptance of the concept by both State Opera and the Adelaide Symphony Orchestra. It was clear that both parties required that the system must be transparent in operation, and provided that it sounded natural, there was no philosophical objection to the concept.

A subjective comparison of the two systems was undertaken by visiting a number of venues in the United States, Canada, England and Europe. Mr Stephen Phillips (General Director, State Opera of SA), John Matheson (Logistics Manager, Festival Theatre) and the author formed the evaluation team. The method of evaluation was subjective and consisted of visiting and auditioning venues with systems installed using live performances by singers and musicians as the test signal, and talking to the music industry professionals who use these venues. The LARES system was chosen because it gave, in the evaluation team's opinion, a superior musical experience, and its relatively open design using readily available equipment appealed to the Festival Theatre.

The recommendations were made to government and the decision was made to proceed with the design and installation of a LARES system on 30 April 1998. The system was to be substantially complete by October that year for the early rehearsals of The Ring.

Some passive acoustic changes were also to be incorporated. These included replacement of the carpet with parquet to increase the high frequency reverberation time, and absorptive treatment to the fly tower and the ceiling space above the auditorium to reduce the low frequency reverberation time, giving more even reverberation times across the frequency spectrum. A modified pit rail was constructed to enhance reflections to the stage and reduce the orchestral sound level at the front rows of the stalls. Fixed rear wall absorption was installed to reduce the echo problem.

## 3.2 The Installed System

LARES Associates do not provide “turn key” installations, or generally even complete system designs. Whilst they manufacture and supply key components, such as the acoustic processors, and provide design criteria such as loudspeaker placement recommendations, they work in partnership with acoustic consultants and specialist sound designers on each project. The system design became a collaboration between Mr Steve Barbar (Principal, LARES Associates), John Matheson, and the author.

LARES Associates allow considerable freedom in the specification of the system peripheral equipment. The design team chose to implement the system using Peavey Media Matrix, which is a PC based virtual sound system. The advantage of this approach was a great reduction in the amount of physical equipment that needed to be installed, and complete flexibility to redesign the

system without a physical re-wire. The system for the Festival Theatre included 172 delay lines, 121 mixers, 128 equalisers and 12 high pass filters, which required a Media Matrix computer fully loaded with eight digital signal processing (DSP) cards.

Loudspeakers were positioned in a matrix over walls and ceiling to provide a broad field of “reflected” energy providing good coverage to each listening position, including those of the performers and players. The usual conflicts arising between speaker locations and structural impediments in an existing venue resulted in an iterative design process between LARES and Bassett. The locations were further adjusted on site to allow for physical obstructions such as air conditioning ducts, etc, before being rechecked for power response by LARES.

It was noted during the evaluation tour of electro-acoustical installations that the quality of the loudspeakers is a crucial component in the success of any electronic architecture system. At the same time, neither LARES nor SIAP engineers were particularly satisfied with the performance of existing commercially available loudspeakers. In particular, suitable existing designs typically exhibited a power response "hole" in the 1kHz to 3kHz frequency region, which unfortunately coincided with the peak absorption of the wall block gaps in the Festival Theatre. By arrangement with LARES two local loudspeaker manufacturers were invited to develop a suitable loudspeaker for electro-acoustic electronic architecture systems.

The LARES system uses microphones to collect sound from the stage, orchestra pit and auditorium for processing before being returned to the auditorium via loudspeakers. Six gain matched DPA (formerly Brüel & Kjær) 4022 microphones are positioned high in the air, one pair on the boundary between the large orchestra pit and auditorium row A, one pair downstage in front of the proscenium and one pair mid-stage. All of the microphones are in view, but not in sightlines. Under theatre lighting conditions, the microphones are difficult to see, due to their small size and matt black colouring.

Signals from the microphones feed five LARES Digital Processing Mainframes, which run specially developed room acoustic simulation software.

Media Matrix is used to pre-condition and mix the six microphone inputs into ten signals for the five LARES frames. These in turn produce twenty outputs, which are further processed in Media Matrix to product a total of 120 discrete equalised outputs for the 204 channels of amplification feeding 287 loudspeakers (See Fig 1 – 4). The stage is covered from overhead by twenty-four plus an additional eight for lateral energy mounted four a side at fly gallery level. Twenty-four loudspeakers are mounted around the proscenium, made up of six in a concealed column each side and twelve across the top in two rows of six. A further eighty loudspeakers are located in the ceiling proper, and twenty-eight flushed into each of the tiled auditorium side walls. Thirty-seven loudspeakers are flushed into the underside of the second balcony and forty-two into the underside of the first balcony. Sixteen loudspeakers are concealed in the fronts of the lower seating boxes to add additional lateral energy to the stalls. In all, there were 85 speaker penetrations in 200mm poured concrete wall or ceiling slabs and 56 in 100mm concrete.

Each loudspeaker is individually connected to the racks of power amplifiers mounted with the LARES equipment in a room at the rear of the second balcony. This location was chosen to minimise the length of loudspeaker cabling, which still runs to nearly 20 kilometres.

A Crestron control system is used to adjust each piece of equipment according to the room setting chosen. The heart of the Crestron controller is a touch screen panel. On this panel the appropriate setting for the LARES system is selected for each performance. The panel incorporates password security to prevent tampering and limit control options. Because of the Crestron control system no special skills are required to operate the LARES system. (See Fig 5)

The settings for The Ring provided a mid frequency reverberation of 1.5 to 1.6 seconds, only marginally above the system off condition. However, the main benefit is the increase in early non-frontal energy to all seats and to the stage. The setting for general orchestral work (Fig 6) results in mid frequency reverberation of 2 seconds.

# 4 WAS IT A SUCCESS?

Overall, the answer is a very strong Yes. There was broad acclaim for the acoustics of the production of The Ring and for orchestral concerts held later the next year. During the initial set up during rehearsal for the ring, performers commented that they had heard reports regarding the poor acoustic of the theatre. They commented that they thought that it was very good did not know why we trying to improve the space. At this time, there was only the early energy systems operating with no additional reverberation, confirming that a major part of the poor theatre acoustic was a lack of early non-frontal energy. It also indicated that the system was transparent in its operation.

The following is a selection of comments from critical reviews.

> "By the time the first of this year's three cycles had finished, it was clear that the exercise had been a qualified triumph – a nearly unmitigated one for the enlarged Adelaide Symphony Orchestra and conductor Jeffrey Tate…the general full-throated quality of the ASO playing was most impressive…
>
> "…badly needed improvements were made to the aging Festival Theatre. …the notoriously quirky acoustic of the Festival Theatre has been improved permanently by the installation of Lares audio system… …there's no doubt it makes the Adelaide Festival Theatre a considerably more satisfying place in which to listen to opera, and presumably will make it a better concert hall as well."
>
> **David Gyger**
> **Opera~Opera, December 1998**
>
> "But the heroes were the Adelaide Symphony Orchestra which, over a four-month preparation period under Jeffrey Tate, honed its skills to world-class level.
>
> "A state-of-the-art acoustic enhancement system (LARES) delivered exceptional clarity – London's major concert halls should investigate immediately."
>
> **Barry Millington**
> **The Times, London, 24 November, 1998**
>
> "Musically, the enlarged ASO under English conductor Jeffrey Tate and the electronic enhancement of the hall (coming soon to the Sydney Opera House?) both worked their spell. It's a big sound."
>
> **Jeremy Eccles**
> **The Canberra Times, 20 November 1998**
>
> "The strings are producing a solid, burnished body of tone, the woodwinds coming over accurately and sweetly and the brass firm and resonant…
>
> "Something had to be done about the auditorium's wretched acoustics, and I think they are getting near to the answer."
>
> **Roger Knight**
> **The Adelaide Review, December 1998**
>
> "…the theatre is functioning as we had all hoped it would. After struggling with dodgy acoustics for 25 years, the $1 million Lares electro-acoustic system, first heard in public on opening night, has had a revelatory impact on the place.
>
> "It elevates the sound of classical music in the Festival Theatre from being fine and distant, to having all the richness of a great opera house."
>
> **Tim Lloyd**
> **The Advertiser, 21 November 1998**

"I do want you to know that I think the whole thing to be a triumph. It is astonishing how much warmer and more mellow the sound is and how utterly discreet the system. If anyone… turned up nursing a degree of scepticism (as I fancy some of them did) they were pretty well silenced by what they heard. Congratulations to all concerned – it was money exceptionally well spent, I am sure."

**Anthony Steel**
**Festival Direction and Arts Consultant**

"Generally the sound is a miracle, every harp glissando and thundering percussion glittering like electricity in the theatre's new acoustic."

**Noel Purdon**
**RealTime E-Zine, February - March 1999**

"No greater challenge could have been chosen for the Festival Theatre's important new LARES acoustic enhancement system's debut in a classical symphony program than an all-Mozart concert containing his last symphony and his last piano concerto.

"Thankfully, the disagreeable old acoustic has at last been banished. In its place on this occasion there was a considerably increased level of volume and resonance coupled with freshness and even some edginess to the sound."

**Rodney Smith**
**The Advertiser, 12 April 1999**

"It's state of the art. It adds reverberation, genuine life, to dead halls. It is the first system that does it for voices and orchestra without any sense of amplification.

"The system picks up sound waves and distributes them around the space more evenly. But if a singer has a small, ugly voice, it remains a small, ugly voice."

**Jeffrey Tate (Conductor for *The Ring)***
**Quoted in Opera News (New York), July 1999**

"Without a doubt, the strongest component of the cycle I saw was the playing of the Adelaide Symphony Orchestra under the inspired leadership of TATE, who led a perfectly paced performance. There was often a sensual quality to the orchestral playing, an almost tactile sense of beauty that was nothing short of astounding. I kept thinking of the Berlin Philharmonic under Karajan. The members of the orchestra all seemed to be singing through their instruments, to be totally engaged in the work at every instance, their sheer sound reflecting Wagner's drama to a degree one seldom hears. It was thrilling to encounter layer upon layer of sound, each distinct from the other, flawlessly balanced yet united into a seemingly endless flow of passionate melody.

**Paul Thomason**
**Opera News (New York), July 1999**

The main negative comments on the system have been limited to comment on variable balance between singers, between instruments or between singer and orchestra. This is generally perceived as problem with the system as there is a perception that the operators of the system are controlling relative levels during a performance.

"..singers of that calibre do not loose their voices. …(a particular critic) would be hearing patchiness in the stage of the acoustic response

"..this new acoustic system needs some fine tuning..

> "..at the same time that it was disadvantaging the singers, it was giving an enormous advantage to the orchestra, and there has been a great deal of nonsense… talked about how brilliant and wonderful and marvelous this orchestra has been.
>
> "I have heard the Adelaide Symphony Orchestra play just as well in the Adelaide Town Hall making just as much noise in the Mahler 6th for instance in a natural acoustic. What we have in the Festival Centre with this new system is a greatly enhanced, quote unquote, acoustic. I wouldn't dream of using the dread word amplification, only in private, of course."
>
> **Elizabeth Silsbury**
> **Radio Interview on Adelaide Station 5AN 25 November 1998**
>
> "The critic was positively fulsome in his accolades for Jeffrey Tate's "inspired leadership' and the 'almost tactile sense of beauty' in the playing of the Adelaide Symphony Orchestra. Thomason makes some reference to the LARES but apparently did not appreciate that two microphones above the pit and four above the stage plus 257 speakers around the stage and auditorium had a considerable effect on the orchestra's volume and resonance as well as on the clarity of individual instruments."
>
> **Elizabeth Silsbury**
> **State of Opera, Wakefield Press P 174**

Although the last two paragraphs above were meant to be critical of the system, they could be interpreted as positive comment for the LARES system. The purpose of the system is to provide an acoustic similar to an orchestral performance space (such as the Adelaide Town Hall) and it is designed to have an effect on the resonance (reverberation?) and clarity.

In general, the response has been very positive from performers, critics and the public. Initial criticism from performers has mainly been with respect to the expectation that the system can act as a discreet fold back system with the ability to increase the volume of specific instruments at different locations on stage. Criticisms from the public and reviewers have mainly arisen in response to perceived poor balance between performers. In a concert hall with a "natural acoustic", the criticism would be aimed at performers or directors, but when there is an electro-acoustic enhancement system, then the imbalance or inconsistent performance can be attributed to the system. If there is a view that 'amplification" systems should not be part of concert hall or opera house, then it is difficult to overcome the philosophical objections. There has been no comment that the system is obvious; quite the reverse. Even though the Festival Theatre advertised that the LARES system was being installed, there has been no comment at all regarding the location or operation of the speakers.

If the presence of the system in the Festival Theatre had not been public knowledge, then it is likely that the improvements would have been attributed to the obvious changes in the hall and the small amount of negative comment may have been smaller. In conclusion, it can be said that the installation was a success.

It was the most cost-effective option given all the constraints, with a high degree of acceptance by performers, public and critics. The most common negative comments revolve around mis-understanding regarding the operation of the system and an expectation that it can affect the balance between performers.

# 5 ACKNOWLEDGMENT

The author wishes to acknowledge the assistance of Mr John Matheson for his comments and in providing some of the detailed information contained in this paper.

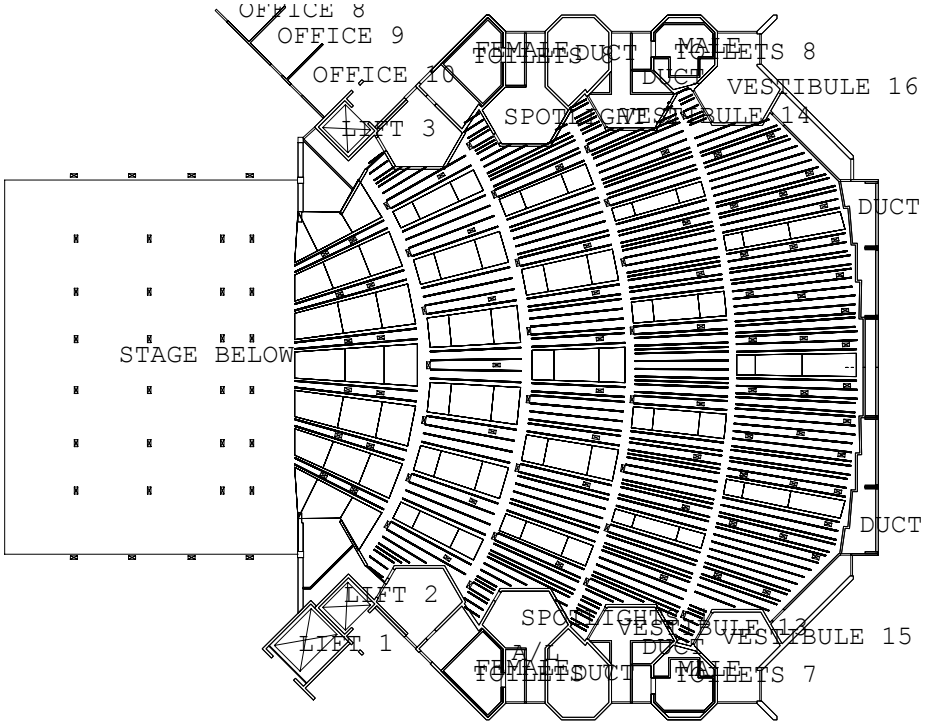


Fig 1 Auditorium and Ceiling Plan view

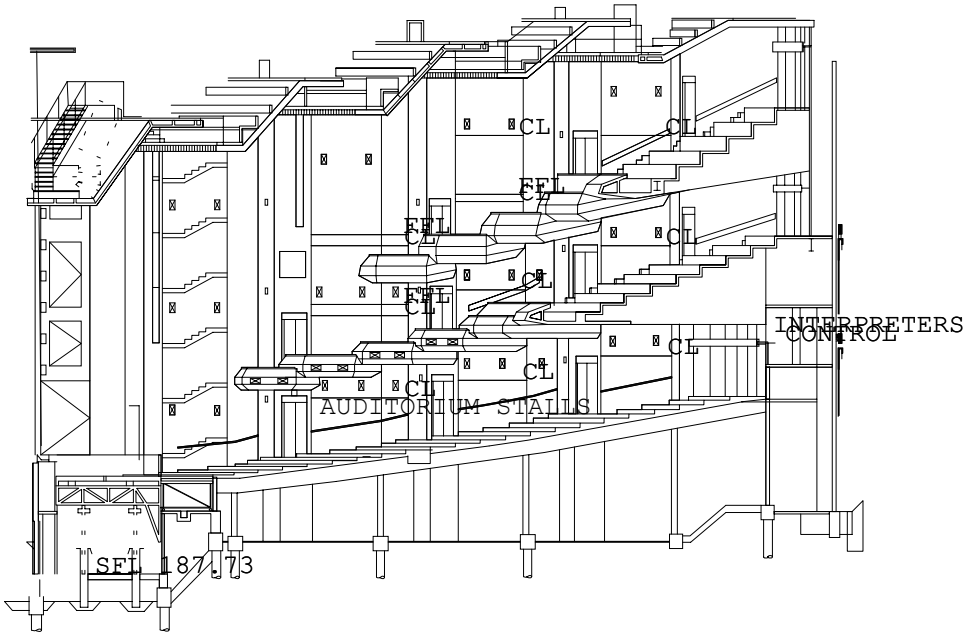


Fig 2 Longitudinal Section

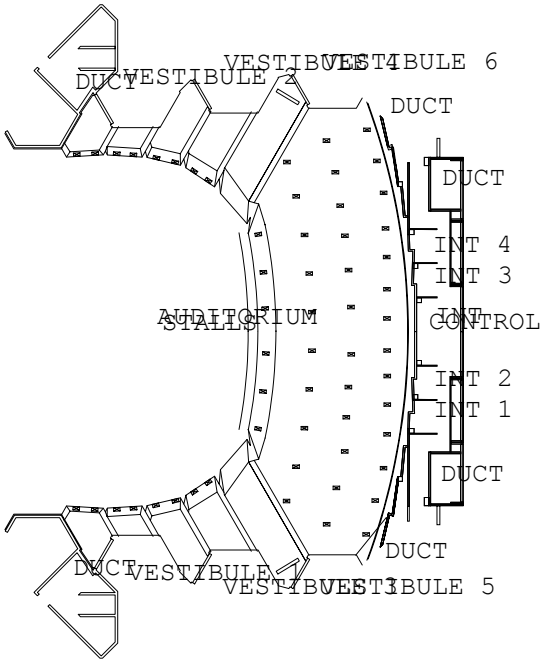


Fig 3 Reflected Ceiling Plan Under First Balcony

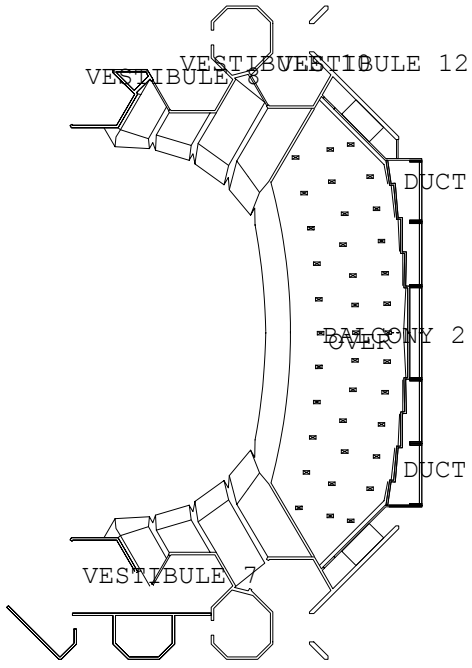


Fig 4 Reflected Ceiling Plan Under Second Balcony

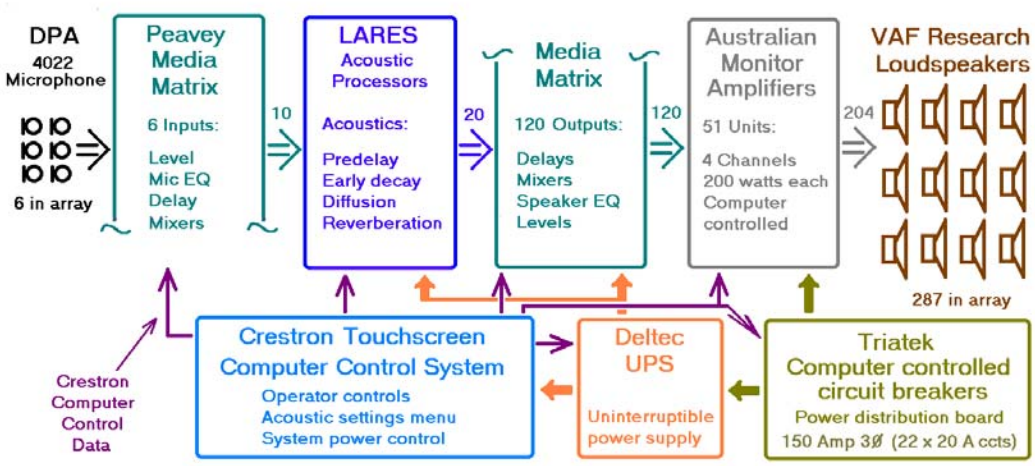


Fig 5 LARES System Schematic

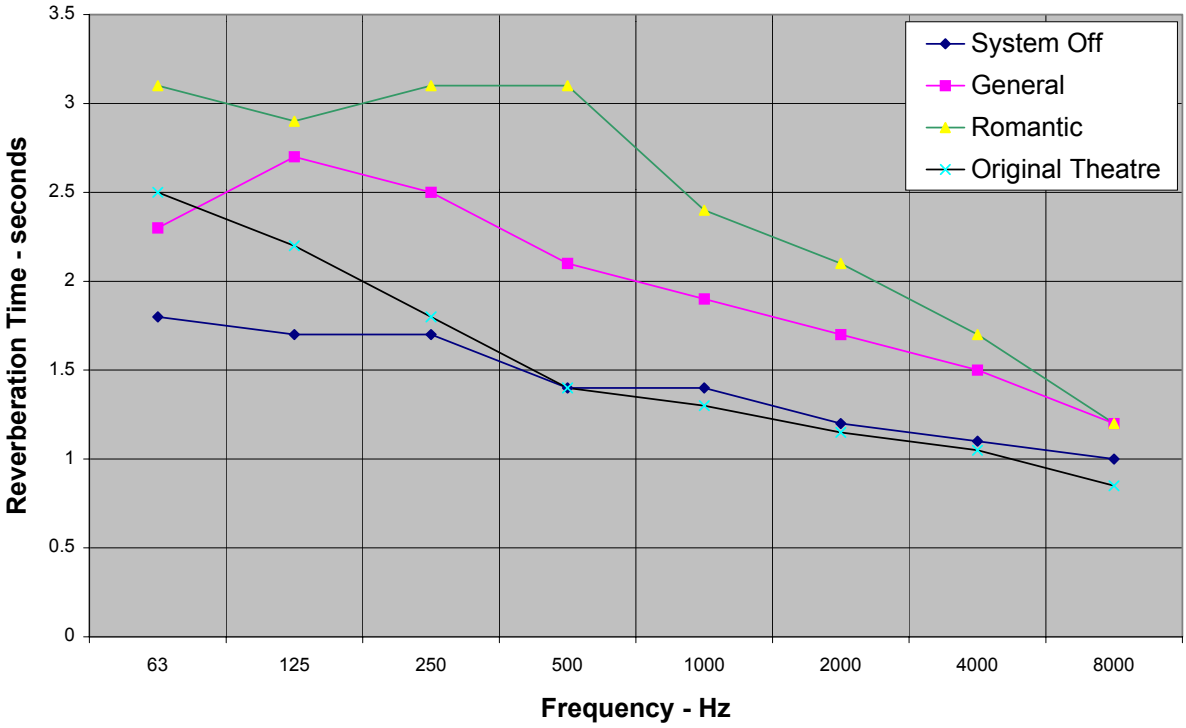


Fig 6 Reverberation Times