Grand Intelligibility

Until recently, the Grand Concourse at Sydney's Central railway station was the epitome of an acoustically hostile environment. **Alice Gustafson** learns how Acoustic Directions changed this perception

PICTURE THE SCENE: YOU'RE IN a large train terminal filled with jostling commuters, hoards of chattering students and tourists, people shouting importantly into their smartphones, all the while of course, surrounded by a never ending influx of arriving and departing trains. Now imagine trying to hear the announcements over the din.

Unfortunately for Sydney's Central Station and its Grand Concourse terminal, this was an all too familiar scenario. Built in 1906, today the late Victorian-style building is the main entry for the 25 platforms that service Sydney and much of Australia. Needless to say, it is cited to be the largest train station in the country, and receives a high percentage of the many tourists that visit the city to catch a glimpse of a certain opera house.

However, due to very high reverberation times (ranging from 5s at 500Hz to 3s at 4kHz), caused by a combination of terrazzo floors, sandstone walls and a 20m high arched steel roof, the station became notorious for its acoustically hostile environment – leaving passengers struggling to understand announcements.

Over the years, various sound system designers had tried and failed to overcome the Concourse's seemingly insurmountable acoustic problems, leading Rail Corporation NSW to contact Glenn Leembruggen, principal of Acoustic Directions, to determine if a solution might exist for the challenging space.

No stranger to designing sound systems for difficult acoustic environments, Acoustic Directions and its sister company ICE Design Australia have a history of tackling similarly tricky acoustic projects, including the parliamentary chambers of Australia and New Zealand, St Marys and St Pauls Cathedrals in Sydney and Melbourne, the New Zealand Supreme Court, High Court of Australia and the Melbourne Cricket Ground.

'With a proven track record of designing sound systems for difficult spaces, and our membership of the panel of acoustic consultants RailCorp can call upon, we were well placed to assist RailCorp,' explains Mr Leembruggen.

'There were at least four legacy systems still visible in the roof of the concourse when we started the project,' he reflects. 'There were old column speakers, speakers installed "temporarily" for the Olympic Games and others scattered about the roof. These legacy systems are testament to the difficulty of achieving intelligibility in the space.'

Working closely with Acoustic Directions' senior team members David Gilfillan and David Connor, Mr Leembruggen proposed a solution involving acoustic absorption treatment for the concourse roof and multiple overhead, bespoke beam-steered loudspeaker arrays implemented in a Victorian architectural style. However, after some consideration, RailCorp elected to not proceed with the acoustic treatment and asked Acoustic Directions to develop an alternative solution.

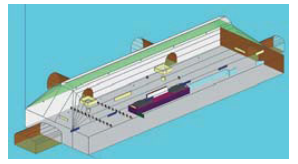
Glenn Leembruggen, principal of Acoustic Directions

Acoustic Directions' David Connor

Without acoustic treatment, an overhead loudspeaker system would not work due to the amount of sound reflected from the floor back into the roof space, which would then reverberate, so the team set about exploring other solutions.

'One idea was to aim ultra-directional speakers in an east-west direction from the centre, but this would direct sound towards articulated sandstone walls,' admits Mr Leembruggen. 'In response to the difficulty of predicting the severity of echoes from these walls with acoustic modelling software, RailCorp suggested we measure that severity rather than predict it, and to do this we used a 5m long test loudspeaker,' he furthered. The test confirmed the echo problem, so another design approach was required.'

The team concluded that the solution was to locate loudspeakers on the north wall and direct the sound towards the semi-open southern side of the Concourse. For heritage reasons, the loudspeakers were to be located above the sandstone at a height of 9m. The solution had to deliver a flat frequency response over the entire concourse floor, radiate a minimum amount of sound towards the high ceiling, and limit the amount of sound striking some high glass barriers that directly and unavoidably face the loudspeakers.



A 3D representation of the virtual acoustic model that was used to predict the impulse responses and STI performance

Acoustic Directions ultimately concluded these requirements would be best fulfilled by a number of Martin Audio Omniline loudspeaker arrays employing the manufacturer's ASP optimised beam-forming algorithm.

'Of all the beam-steered loudspeaker systems we modelled, the Omniline system produced the best results,' he asserts. 'With the Omniline system, the STIs and consistency of frequency responses over the listening area were substantially better, and the amount

of sound striking the ceiling and glass barriers was substantially lower. This is due to a combination of the Omniline box design, array shape and the mathematics of the ASP process.

'The ASP optimisation process is unique as it allows the designer to tailor frequency response and level targets for the entire coverage area, and those areas which must be hard-avoided with sound radiation,' furthers Mr Leembruggen. 'It is substantially more sophisticated than other manufacturers' algorithms as the frequency response of sound reaching any part of the room can be examined and tailored.'

The final design comprised eight arrays of 12-element Omniline loudspeaker elements, with each element being individually processed with ASP filtering. The arrays are arranged in two groups of three and one group of two, resulting in a total of 96 Omniline elements which were supplied by Martin Audio's Australian distributor TAG. 'The driving system for each array group is unusual,' points out Mr Leembruggen. Sub-groups are formed by driving each element of an array in parallel with corresponding elements in the other arrays within that group.

These sub-groups are driven via a 100V distribution system by a total of 36 Biamp Fusion amplifiers and 36 MediaMatrix Nion signal processing channels, located some 150m from the loudspeakers. The 100V speaker

Martin Audio Omniline loudspeaker arrays employing ASP line the Concourse

transformers are ultra-matched bespoke types made by Harbuch Electronics in Sydney, boasting low distortion and 10-degrees of phase shift at 20kHz. 'New Era Group expertly handled the difficult and complex cabling and installation processes, paying due attention to heritage details,' Mr Leembruggen adds.

Commissioning

Mr Leembruggen notes that the commissioning stage was just as important and detailed as the design phase. During this period, every design parameter was confirmed and all adjustments carefully optimised.

'In the first stage of the process, every electronic and loudspeaker component in the signal chain was checked for connectivity, polarity and frequency response, including confirmation that the FIR filter coefficients for ASP were correctly entered,' he explains. 'The second stage of the process is equalisation and level adjustment, which involved numerous spatial measurements of frequency response using our WinMLS2007 analyser, followed by careful equalisation with our curve-fitting Excel software. Refinements were then made to the equalisation by listening to music and live and pre-recorded speech.'

Mr Leembruggen confirms that 'the new system performs very well, and better than any other solution would have'. However, a perfectionist at heart, he admits that the original solution would be been more effective at winning the reverberation war. 'The inclusion of acoustic treatment in the ceiling would have provided a better outcome in terms of speech intelligibility, but for a space that has so many constraints, the outcome has nevertheless set a benchmark for this type of space.'

At this point, *Pro Audio Asia* enquires as to why the Central Station's acoustic problems weren't solved earlier. After some thought, Mr Leembruggen offers that it comes down to a combination of technical skill, appropriate technology and client support.

'The Grand Concourse is a complex and difficult space, and the outcome is a culmination of our acoustic design skills, experience, and commissioning process,' he reflects. 'Acoustic Directions' skills are amongst the world's leading sound system design consultants and it needed that degree of expertise to develop a solution. But integral to that solution are the loudspeaker technology and the ASP optimisation, which have only recently become available,' he adds quickly. 'And unless the client is completely supportive, sophisticated problem-solving solutions cannot deliver the required outcomes.

Charles Chan, project manager and facilitator for RailCorp on the project

Acoustic Directions' David Gilfillan

RailCorp was very supportive of our approach and through their project delivery specialist Charles Chan, provided all the necessary resources for the project to be successful. This was a completely collaborative project, and it was most enjoyable.'

Perhaps most importantly, passengers have benefitted considerably, as the intelligibility is reported to be 'remarkably high' throughout the Concourse, even during rush hour. 'We understand that RailCorp is very pleased with the results,' smiles Mr Leembruggen. RailCorp wasn't the only one, as Acoustic Directions was recently awarded a Special Commendation for Engineering Excellence award at the 2012 Audio Visual Industry Awards (AVIA) in recognition of the project.

In fact, due to the success of the new system, Central Station management has suggested the Concourse be used for live music events, as it can be zoned. 'We are confident that the system offers the best clarity for size of coverage area and therefore is likely to work better than temporary systems that could be brought in for special events,' he concedes. 'The Omnilines deliver an acoustic punch that is well above their size, and this makes live music and promotional events a real possibility.

'It was a privilege to be part of this project and to have RailCorp's support to deliver this outcome, and we were thrilled to receive the AVIA commendation for this project,' he concludes. 'We pride ourselves on our engineering skill, our creativity and our approach of applying rigorous design principles to every job within a framework of originality and collaboration. This AVIA award validates our approach.'

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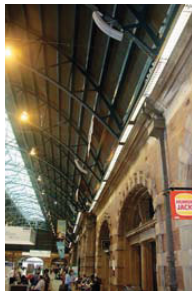
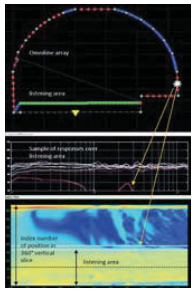
A 5m long ultra-directional test loudspeaker determines the severity of the echo



Eight arrays of 12-element Omniline loudspeaker elements cover the Concourse



Martin Audio's display prediction software was used to optimise the Omniline arrays