# Revisiting the Performance Sound System

by Alan Hardiman

The refinement of the performance sound system in the Walt Disney Concert Hall in Los Angeles over the past two years is an instructive exercise in harmonizing a number of implicit values to engineering design. The evolution of the sound system reveals a subtle shift in the weighting of four key values: the landmark status of the hall, the incorporation of fixed, rather than variable, acoustics into its design, aesthetics, and appearance, and the ascendancy of audiophile values over those associated with installed sound systems.

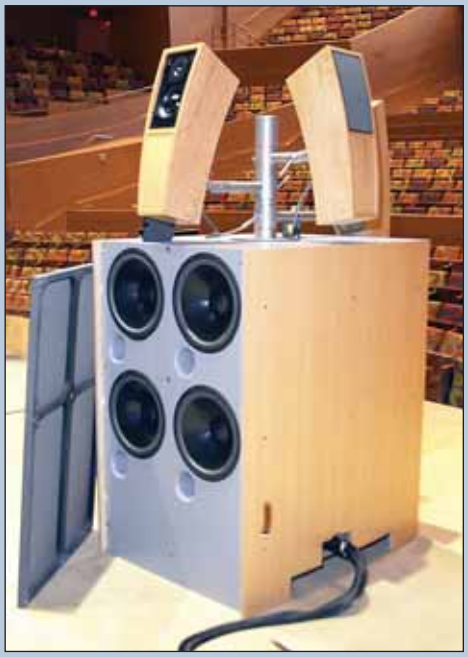
Perhaps the hall's most obvious value is that it was built to be a landmark. Asserting itself unmistakably on the Los Angeles cityscape, the $274-million structure was designed by Frank Gehry as an arabesque of swooping forms and angles wrapped in gleaming stainless steel panels.

A second value is that, as the new home of the Los Angeles Philharmonic Orchestra, the hall was designed for symphonic music, with fixed acoustics by acoustician Yasuhisa Toyota of Tokyo-based Nagata Acoustics. There are more than 38,000 reflective surfaces in his design. However, this led to a major complication in designing a performance sound system. The sonic reflections and reverberations that enhance symphonic music work against intelligibility and upset the spectral balance of music played at higher sound pressure levels. A loud orchestra can produce a sound pressure level of about 95 dB, while an amplified system can become about four times louder, with a sound pressure level of 115 dB which, untamed by absorption, can quickly build into a cacophony.

While the most common solution is to build a hall with variable acoustics—incorporating architectural mechanisms for adjusting the hall's acoustics—the approach taken at Disney was not to change the architecture but to design a performance sound system with directional characteristics that minimize the number and degree of potential problems created by over-reflectivity and high sound-pressure levels. The 2,265-seat hall opened in October 2003 with a performance sound system centered on four JBL line arrays, custom-designed to provide good coverage to every seat in the auditorium, yet keep the sound focused in the audience with minimal scatter.

## Creating visual appeal

Initially, the most important criterion for the sound system's visual appearance was to preserve the view of the concert platform, the beauty of its glowing wood enhanced by the multitude of theatrical lights embedded behind glass portals in the pillowed ceiling, and the "bellies" above the terrace seats beside the stage. Therefore, suspended arrays were specified to eliminate visual and



**These ATC speakers are made of Douglas fir, to blend into the Disney Concert Hall interior.**

acoustical obstruction of the stage. Left and right arrays were chosen to minimize the interference with a view of the beautiful organ from the seats in front of the stage and to provide a familiar left/right mixing situation to visiting mix engineers. The 27' height of the arrays was necessary to maximize direct-to-reverberant energy in the audience, steer cross-stage reflections above seats, match acoustic centers of front and side arrays to eliminate broadband phase cancellations in overlap areas left and right, and provide unobstructed sightlines for the audience and followspots to all locations on the stage and lift platforms. Front-fill loudspeakers were embedded in the stage lip to bring the aural image down from the suspended arrays to the stage level for the front seats and the orchestra level in general. The design of the sound system was modeled, rendered in 3D CAD drawings, and reviewed and approved by the architectural team. Later, the moving doors and rigging that were intended to hoist the loudspeakers out of sight for symphonic and other acoustical concerts were deleted for budget reasons.

This system performed well for the series that played after the inaugural gala; however, the visual presence of the multiple line arrays were unpalatable to some.

It soon became apparent that while the static acoustics were overwhelmingly successful for the acoustic concerts, the amplified concerts were suffering from untamed reverberation of sound emanating directly from the stage, regardless of the sound system configuration. A variable acoustic draping system was developed and installed to mitigate this problem.

The original performance sound system has since been reconfigured into a center cluster flown above the stage to provide adequate coverage to the balconies and upper terrace. It consists of 29 JBL Vertec VT4887 units: "a forward facing element of 11 units, a rear element, which has six, and six facing to each side," explains Fred Vogler, Los Angeles Philharmonic's sound designer. The original subwoofers remain built into the stage. Vogler notes that the hall performs best with an average sound pressure level of 96-97 dB. "If you exceed that level, it gets a little overwhelming, and it's not a pleasant overwhelming," Vogler says.

While the suspended design provided good coverage in many parts of the hall, particularly the balconies and upper terrace, it proved somewhat disconcerting for concert-goers "in the more expensive seats closer to the stage," explains Vogler. "The sound that was coming out of the speakers that were suspended high above the stage was not matching the sound that was emanating from the stage." Given that the acoustic design of the hall was based on

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the acoustic source being positioned onstage, Billy Woodman, founder and technical director of British loudspeaker manufacturer ATC, recommended that an onstage, high-quality loudspeaker system be used to address the issue of imaging. ATC was chosen based on the high regard Vogler has for ATC studio monitor systems.

"We wanted to design a system that would blend as seamlessly as possible with the performers," explains Ben Lilly, ATC's R&D/transducer engineer. "The only way to do this is to have the electro-acoustic and the acoustic sources in the same place."

Aesthetic values came into play in the specification of the two onstage ATC loudspeaker systems. According to Vogler, the appearance of the sound system was very important. "We had this perfect acoustic and we didn't want to clutter it up with a bunch of technology. We had to have a specific aesthetic appeal that people would sit in there and not feel that they were being bombarded with big drivers. ATC came up with the look and the way that their components were arrayed. When I first saw the images I was just so happy. We showed it to our bosses and various administrative folks and everyone said, 'When can we get them?'" Vogler recalls.

Constructed of Douglas fir to blend with the interior of the hall and with a visual design inspired by the venue's imposing pipe organ, each system provides coverage in three directions: front, back, and to the side away from the stage. The supporting assembly for the mid/high cabinets was constructed from stainless steel and bead-blasted to give a finish that would not glare in the stage lighting. The units can be easily moved and set up by two people in about 10 minutes.

The entire system is fully active, powered by ATC P4 studio monitor amplifiers, and driven by six sends from the front-of-house console—left and right front, side, and rear—an arrangement that provides the hall's audio team the flexibility to balance levels in all seating areas. The mid/high cabinets can be angled vertically and horizontally, allowing for further optimization of audience coverage for different events.

## Qualities of sound

In terms of audio values, the choice of components of the ATC system was dictated by values more usually associated with audiophiles than with people in the installed-sound industry. "When you get into PA it's about distance and directivity, and when you get into studio monitors you want a lot of fidelity in both dynamic range and frequency response," Vogler says. "The ATCs do not compromise frequency response and dynamic range for throw and directivity. If we need more directivity and throw of specific elements or instruments,

we drive them up into the center cluster a little harder. The ATCs don't spike the sound out the same, which is good and bad. I think it's very good for the people in the expensive, closer seats," he says.

The SL drive units found in ATC's studio monitors were utilized throughout. Lilly explains, "There is no room here for PA drivers, due to their inherent distortion. Because the hall has such good acoustics, the quality of the components is vital, as there are very few room anomalies to mask deficiencies of the individual components. The hall actually amplifies problems within the loudspeaker." He adds that it was essential that the system have a very flat on- and off-axis frequency response; that is, wide dispersion.

"This goes against most ideas for amplified sound in a reverberant space but because the hall has been very well designed it is essential to make sure the direct and reverberant sound is correct for the natural timbre of instruments to be preserved. The use of our 3" soft dome midrange unit for the critical mid-band ensures this criterion is met due to its very wide dispersion pattern. We also made use of the best possible drive units available to keep distortion at an absolute minimum. After measuring the acoustics of the hall we found it to have an extremely flat magnitude response and even reverberation time versus frequency," Lilly says.

"The revised approach to the performance sound system is certainly different from the approach taken at other great concert venues, such as Boston Symphony Hall and Carnegie Hall, where suspended clusters are employed as the primary house system," says Dave Clark, director of engineering at Engineering Harmonics, the design firm of the original sound system. "The approach of using primary sound sources at the stage level will make better use of the hall's natural first and second reflections. In the case of Dr. Toyota's hall design, this seems particularly important. The imaging may be improved vertically but degraded horizontally. The coverage of the direct field sound energy will be less even and there will be no benefit from the directional control provided by large suspended line arrays. As a result, the ratio of the direct to reverberant level may not be as favorable for intelligibility.

"However, there are many design considerations at play here. The final solution will be a gentle melding of the numerous loudspeaker systems carefully calibrated with regard to location, aiming, balancing, equalization, and delay, and these presets may vary with event types. A gentle hand at the front of house and monitor consoles will be needed and the addition of acoustically absorbent material will benefit all amplified events. We are following this evolution closely," Clark says.

The revised system had its inaugural performance on November 2nd, when Brian Wilson brought his *Smile* tour to the Walt Disney Concert Hall. "There were 19 performers on stage," Vogler recalls. "We had amplifiers, monitors, and a couple of performers had in-ear monitoring. The volume was good in the house and we had a lot of happy audience members. I was impressed, I felt we had succeeded," he says. "But I don't think tweaking will end for a while."