



WWW.L-ACOUSTICS.COM

Tel: +33 (0)1 69 63 69 63 - Fax: +33 (0)1 69 63 69 64 - 13, rue Levacher Cintrat - Parc de la Fontaine de Jouvence - 91460 Marcoussis - France

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SCOTT WILLSALLEN

Auditoria Pty Ltd, London 2012 Ceremonies Audio Systems Designer



1 - Paralympics Opening Ceremony

LONDON 2012 OLYMPIC GAMES CEREMONIES AUDIO SYSTEM CASE STUDY

Once L-ACOUSTICS were selected as the brand of choice for the sound system at the Olympic Stadium for the Olympics and Paralympics at London 2012, the collective team faced a gargantuan task. Exceptional sound was required to electrify a brand new stadium with a capacity of 80,000 for the Opening and Closing ceremonies of the Olympics and Paralympics as well as for every single athletic event held within the Olympic Stadium over a 29 day period in total.

TOTAL QUANTITIES	PRODUCTS		
220	V-DOSC	8	SB18
100	KUDO	8	I2XT
88	SB28	2	I08P, SB18 and LA8 for nearfield monitoring at the rehearsal venue
51	ARCS II	22	RCF ART322i
70	LA-RAKS		
18	8XT		

The amount of kit required to meet these diverse needs was exceptional. Most large-capacity touring gigs do not usually require more than 100 large format line source cabinets, but the Olympic Stadium hosted over double that figure. Scott Willsallen Audio Systems Designer at London 2012 Ceremonies Limited, who was responsible for the design and implementation of the technology at the Olympic Stadium says that, "I've never put that much power in the air with a sound system before." As far as L-ACOUSTICS is aware, no one has ever assembled together so many amplifiers to one network before either.

The total inventory comprised 220 V-DOSC line source cabinets, plus 51 ARCS II downfill cabs spread out across 22 arrays, suspended from a custom tension ring made especially for the event. An additional two arrays were suspended from the roof with 6 KUDO in each. On the ground, a further 88 SB28 subs and 88 KUDO were provided as additional sound reinforcement for the opening and closing ceremonies. The equipment was supplied by Delta Sound, Norwest Productions, Autograph and Britannia Row Productions.



2- Bobby Aitken and Scott Willsallen

“OBVIOUSLY THE SCALE OF THE PA SYSTEM IS NOT SOMETHING YOU COME ACROSS VERY OFTEN, BUT WITH SCOTT AND BOBBY’S EXPERT NURTURING IT WORKED ADMIRABLY...WORKING WITH SUCH A GREAT, FRIENDLY AND COMPETENT CREW DRAWN FROM MANY PLACES WAS A GREAT PRIVILEGE.”

Richard Sharratt
FOH Mix, Olympic and Paralympic Opening Ceremonies

SCOTT WILLSALLEN

from Auditoria Pty Ltd, London 2012 Ceremonies Audio Systems Designer.

Scott is a leading expert in audio systems design for major international events and performance venues with design credits including multiple Olympic, Asian and Commonwealth Games Ceremonies since 2003.

Scott Willsallen writes about his experience as Audio Systems Designer at the London 2012 Olympic Stadium

I began using groundstacked L-ACOUSTICS KUDO systems at the Melbourne 2006 Commonwealth Games Ceremonies. Since then I have used them at the Doha



3- Opening Ceremony rings

“THE ATMOSPHERE IN THE STADIUM WAS ELECTRIC. HOWEVER, AMONGST THE CREW THE FEELING WAS ONE OF NERVOUS EXCITEMENT. HAVING HAD VERY LITTLE REHEARSAL ON SITE, THE POSSIBILITY FOR THINGS TO GO WRONG WAS LOOMING LARGE IN PEOPLE’S MINDS. THE AUDIENCE ON THE OTHER HAND WERE CLEARLY UP FOR JOINING IN THE GREAT PARTY ATMOSPHERE...IT WAS AN HONOR TO BE INVOLVED IN SUCH A GREAT EVENT.”

*Gary Bradshaw
FOH Mix, Olympic Closing Ceremony*

2006 Asian Games Ceremonies, the 2010 Singapore Youth Olympics Games Ceremonies, and the 2011 Rugby World Cup Opening Ceremony in Auckland, New Zealand. The fact that KUDO were predictable, reliable, and produced excellent sound helped to make each event a success.

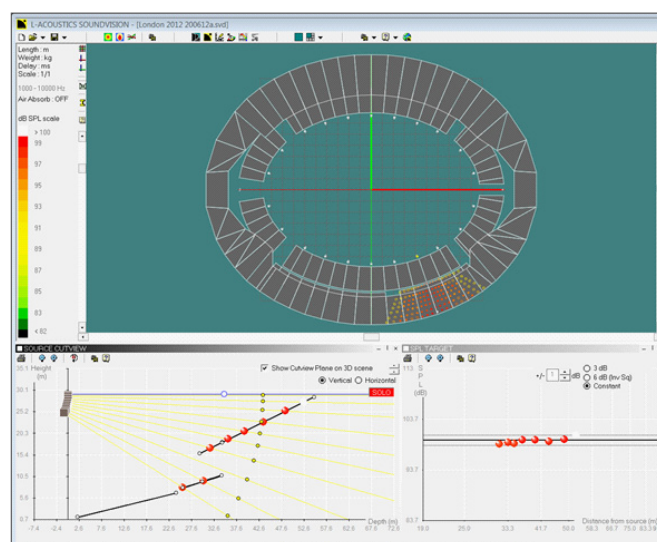
It was clear to Bobby Aitken (Ceremonies Sound Designer) and I from the outset that London 2012 Olympic Opening and Closing Ceremonies would feature some of the world’s greatest musical talent. Both Ceremonies relied heavily on the soundtrack to engage the audience and drive the excitement. The design had to exceed the expectations of the musical directors, performers, live audience and the world’s media.

Aside from the planning for the sound systems for the Ceremonies, we also providing sound for all the athletic events held at the Olympic Stadium (this is often considered as a separate project). As Roland Hemming, LOCOG Venue Technical Manager - Audio, points out, ‘The sports presentation programme was much more comprehensive than any previous Olympics. This needed a more enhanced PA system than previous Games to deal with that requirement.’

To create the best sound possible for these Games, we had to use a lot of resources, the best companies and equipment and many talented people working together over several months and even years in some cases. We also needed a great sound system with minimal visual impact that could provide the best possible performance for the Ceremonies and the track and field events throughout both Games. What set the London 2012 Olympic Stadium apart, visually and acoustically at least, was the spectacular ring of flown arrays for the upper bowl, suspended above the audience and athletes for almost four months against the elements. For a sound systems designer, the primary area of concern is the geometry of the space to work within. London 2012 offered some special challenges which will be discussed in further detail in this case study.

I would like to think that the amazing performances from the athletes were due to the brilliant sound system, but perhaps it was also due to their years of training and commitment! The atmosphere was incredible. Take any one element away and it would have suffered. The presentation of sport is becoming a strong focus for all disciplines and every element of the presentation has to keep up. I’m very proud that London 2012 was the best sounding Olympics ever.

In the case study that follows, I describe in detail the design decision-making process as Audio Systems Designer for London 2012.



4- L-ACOUSTICS SOUNDVISION

DESIGN OBJECTIVES FOR LONDON 2012

Design Principle

Most of my previous designs have used a distributed ground based source to localise the lower bowl audience to the performance area. In my experience there is a perceived improvement as a result of dividing coverage between the upper and lower bowl areas. So the design process for London 2012 began based around a ring of flown arrays for the upper bowl and a ring of ground stacked arrays for the lower bowl.

My design process worked to achieve the best possible vertical coverage with the minimum quantity of elements, and then to use the minimum quantity of arrays to deliver the best possible horizontal coverage. Achieving the minimum power requirements is addressed from the outset by selecting the appropriate line source product.

A large area in the stadium was devoted to the world's media. The TV media were located in a section of the lower bowl. The press were in the same section of the stadium but in the upper bowl. Each rights' holding broadcaster from around the world had a commentary position in the lower bowl media tribune where they could watch the Ceremonies and comment on the show.

The commissioning process specifications set out that we were to attenuate the lower bowl media tribune. This allowed the commentary to be as clean as possible whilst still providing the commentators with an enveloping and exciting experience. Ultimately the lower bowl media area was 6 dB down on the rest of the stadium and the upper bowl did not require any attenuation.



5- London 2012 Olympics Athletics with arrays



6- Full array suspended against sky

Alternative Left/Right

We attempted to deliver some kind of stereophonic experience to as many listeners as possible. Though it is often very difficult to perceive in distributed designs, the signal path to the flown and ground stacked arrays was configured for an alternating left/right layout.

Athletics

It was decided early on that the flown Ceremonies loudspeaker system would also be used for athletics. This required the flown arrays to be augmented with additional product to extend coverage to the lower bowl. This additional coverage was switched off for the Ceremonies.

Loudspeakers locations

A continuous rigging beam or fixing edge was installed following the oval shape of the field of play perimeter. It was designed to place the fixing edge approximately 30 metres on-field of the existing roof edge, at a trim height of approximately 30 meters from the field. Geometrically, this is the ideal location for the flown arrays.

The fixing edge itself was simply a 48mm flexible steel wire rope ring supported by 56 smaller diameter radial wire ropes which tied into the roof support system. Each flown array had to be located on a junction between the tension ring and a radial rope to provide stabilisation. The flown positions also had to consider the location of the Olympic caldron and other significant set pieces.

The design process itself

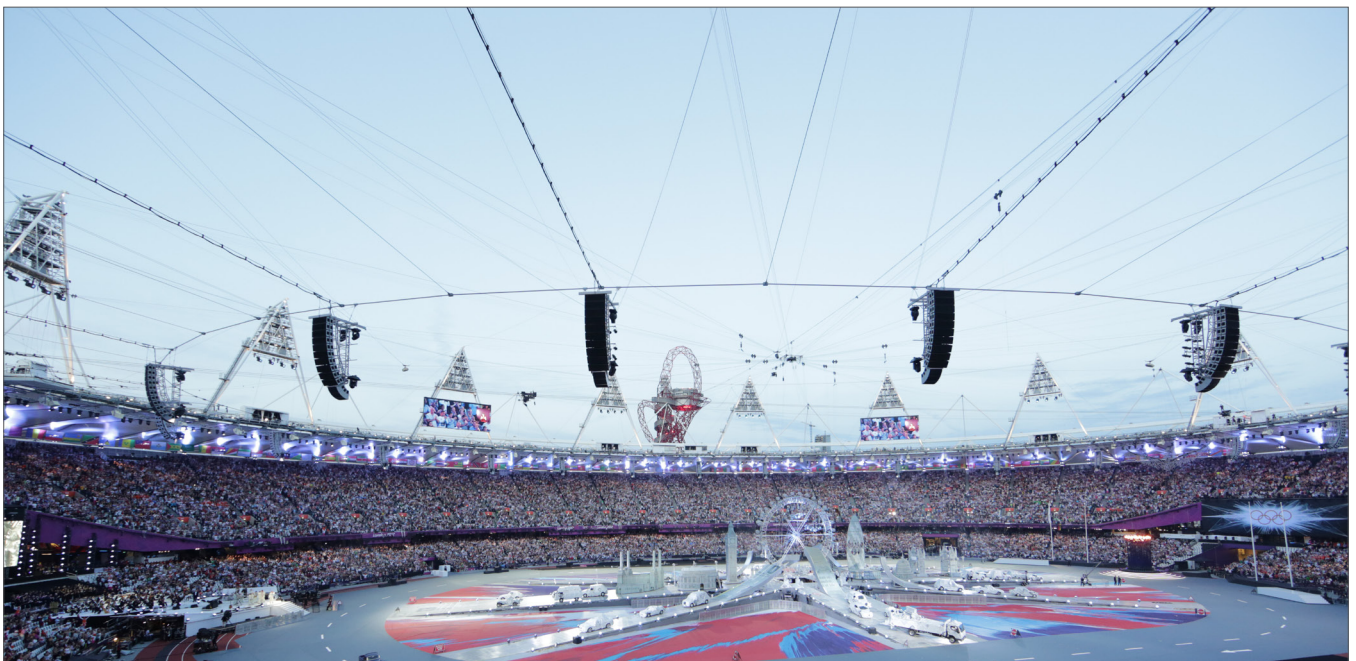
This stadium was an unusual case for me as it was already built, so not only did I have accurate CAD files, but I could also walk around the venue to develop a more realistic sense of how the design would fit into the building. The design

process began with creating an EASE model from the CAD files. This model was used to audition alternative products to arrive at the final five design alternatives, which included the L-ACOUSTICS option. Once we had determined the final five alternatives the detailed design phase began.

The L-ACOUSTICS design was created in SOUNDVISION 3D SIMULATION with some reverberant field analysis in EASE.

Venue geometry

The venue is relatively simple in its shape and remains consistent. There are three design features which interrupt the consistent upper and lower bowl profile; the north and south video screen locations and the west side middle bowl. The basic approach was to use consistent flown and stacked arrays throughout the design to avoid variations in vertical pattern control. This approach suited two thirds of the stadium perfectly, however I expected that the west middle bowl would require unique processing to deal with change in the profile. This would be dealt with during the tuning and commissioning process.



7 - London 2012 Olympic Closing shot in daylight

Flown line length

To achieve a consistent listening experience throughout the upper bowl each array required 10 V-DOSC elements. At over 4.5 metres long, this quantity of V-DOSC also provided the line array length required for useful low frequency pattern control.

The angles between elements in the V-DOSC array were manipulated to deliver a predicted flat power response within +/- 1dB.

Selecting 22 arrays allowed us to provide the best balance between providing a stereo listening environment and avoiding too much overlap and damaging intelligibility. 22 arrays also worked with the geometry of the tension ring system.

With all 22 V-DOSC arrays designed the athletics requirements needed to be addressed. The V-DOSC provided excellent coverage for the upper bowl and for the upper and middle bowl on the west. The flown arrays required extending to provide lower bowl coverage.

We had planned to run the V-DOSC with a more full range preset for the athletics given the lack of subs, and perhaps change the system EQ to extend the frequency response. This approach provided plenty of 40 Hz to 80 Hz for the lower bowl so the downfill could be a two-way product which helps in terms of amplifier count and total system weight. Conveniently, at approximately the same time L-ACOUSTICS launched the ARCS II CONSTANT CURVATURE LINE SOURCE which both had the power we needed and provided the coverage required with only a pair of cabinets. The addition of a pair of ARCS II cabinets to the flown systems provided excellent downfill coverage for the entire lower bowl.

Stacked Arrays

The ground stacked arrays, pictured below, consisted of four KUDO and four SB28 each. KUDO is low profile enough to fit four elements in an acceptable vertical height.



8- Stacked Arrays London 2012

The design intent behind the long horizontal line of SB28's was to create an array with horizontal pattern control. Controlling the vertical pattern was not of interest, the goal was to minimise the number of sub-bass sources audible at any listening location to improve the impact and clarity of the system. The approach was very successful and one that I will definitely be using again.

Filling the gaps

The loudspeaker system is designed around the venue geometry, yet inevitably there are parts of the overlay such as staging, camera platforms and scenery that creates acoustically shadowed audience areas. The original design predicted this, and eight 12XT loudspeakers were available to be deployed as required for each Ceremony.

System Installation

The rigging method and suspension concept for the system was devised by Jeremy Lloyd (Technical Manager, Staging and Design). All 22 arrays were installed over a four day period. The custom rigging for the V-DOSC and the ARCS II downfill consisted of a bumper, a vertical spine, lighting ladder and ARCS attachment. All parts locked together to form a rigid structure which supported the V-DOSC from top to bottom.

Amplifier Installation

The London Olympic Stadium has a catwalk just above the edge of the roof which runs the full circumference of the roof. Various rooms were built over the catwalk to house technical facilities such as automation control, power distribution and audio network nodes.

The placement of the amplifiers was loosely based around the network node layout, but the most important factors were minimising the speaker cable lengths whilst ensuring weather protection of the amplifier racks. Ultimately all speaker cable lengths for the flown arrays were 50 meters and all amplifiers were well protected from the daily London downpour.

Networking and Signal Distribution

The signal transport and data backbone of the system is based on a four-core optical fibre ring. Two cores are used for a closed loop Optocore network for all audio signal transport throughout the system. The second pair of fibres connected to managed gigabit network switches. This network is referred to as the Audio LAN.

The Audio LAN is managed into four VLAN's, one of which is for the LA NETWORK. With over 200 LA8 amplifiers on the network planning and pre-programming of IP addresses is very important. Each flown array used 6 LA8 amps, 5 for the V-DOSC and 1 for the ARCS II; each FOP array used 3 LA8 amps, 2 for the KUDO and one for the SB28's. So each array needed 9 IP addresses.

Noise pollution

We did not suffer any real system performance limitation due to environmental noise limits. We used a calibrated SPL logger at FOH whenever the system was in use. We had a few complaints from nearby residents during our late night mixing sessions for the Closing Ceremonies but given the time I would have complained too.



9- Closing shot London 2012 Olympics

TESTING, TUNING AND COMMISSIONING

LA Network Manager

Once the contract had been awarded to Delta Sound with the L-ACOUSTICS design, the more detailed elements of system control were discussed.

L-ACOUSTICS were amazingly helpful. We were the first user of their updated LA Manager software (for the amplified controllers), and I really didn't want to be the first user to try 223 amplifiers on one network. They said, "Fair enough. What if we were to plug 223 amplifiers together and test it for a month?" And they did! They used exactly the same IP address that we'd already planned to use and tested it for a month. It was amazing. That level of support is pretty incredible.



10- Marcoussis testing

Marc Benard, Application Engineer, Electronics at L-ACOUSTICS explains, "Modern sound designs in arenas and stadiums commonly call for 60 to 80 LA8 amplified controllers. But for the London Olympics Stadium, these numbers were taken to a whole different level with more

than 200 LA8 units required. With thousands of spectators in the stadium and billions of people watching the event worldwide there was a bit of pressure on the tech crew."

"Part of L-ACOUSTICS commitment to this project was to undertake specific quality assurance measures by replicating the complete system at our premises in Marcoussis, France. 200 LA8 were installed in a room, connected to a redundant AES/EBU and analog audio distribution, and controlled over a fault-tolerant fiber optic ring network using exactly the same Ethernet switches running the same protocols as that of the Olympics."

"I THINK ALMOST EVERYONE COMMENTED ON THE TREMENDOUS ATMOSPHERE IN THE STADIUM AND THE AUDIO SYSTEM CERTAINLY MADE A SIGNIFICANT CONTRIBUTION TO THAT. THE PERFORMANCE OF THE L-ACOUSTICS SYSTEMS WAS "EXCELLENT." "

Roland Hemming
LOCOG Sporting Venues Audio Manager

"All were controlled from a single (and relatively basic) Windows XP computer using the recently released LA NETWORK MANAGER V2 remote control software that features a complete system event messaging system. This allowed us to challenge the resilience and responsiveness of our platform. These improvements now benefit all users worldwide whether they use a couple of amplified controllers for a local gig or they are on tour with the most popular artists around."

The software performed well and I felt confident from L-ACOUSTICS' experimentation that the software was ready for use on the project.

Using the software

Prior to London 2012 I had used L-ACOUSTICS products on many projects, but only a few with LA8 amplifiers, and fewer still where I made use of the LA NETWORK MANAGER software. Loading presets into amplifiers was very fast and the various viewing options provide great feedback during commissioning and usage.

The grouping facility of the software is excellent, allowing subtle EQ or delay changes to parts of the system very fast and reliable. The grouping also helps with muting large parts of the system very quickly for certain rehearsal situations.

Justin Arthur, the Patch Systems Engineer from Norwest Productions, spent the most time on the software and he found it easy to use, fast and reliable. Justin Arthur, "L-ACOUSTICS were a pleasure to deal with while working on the London 2012 Games. Marc Benard and his team were there right from the start testing the large network of amplifiers in their office months out from the load in of the event. Throughout the event they were always there on the phone and via e-mail to answer any questions. They even wrote a new version of the software for us when we found a bug in the previous version."

"LA NETWORK MANAGER was very simple and very easy to use. All the information you need to monitor the system is right there on one page. Grouping and monitoring has improved vastly from Version 1 of the software and it is also much more user friendly."

Also the file size for a network with over 200 amplifiers was only a couple of hundred KB so it provided very easy to manage files.

Tuning the system

The tuning phase has to take into account environmental conditions and the acoustics of the loudspeaker system. The latter have been identified and classified by L-ACOUSTICS for line source arrays in order to create the array morphing tool.



11 - London Paralympics Opening Ceremony

LA8 Filter set

Having had such experience and success with flexibility of Lake Processing over the years I was sceptical about the limited filtering offered by the LA8 amplifiers. I was even more sceptical about the concept of one set of filters that were the same for all products.

After educating myself about what they have done it makes perfect sense. Some may presume that the limited filtering is a function of DSP resources or not trusting the user to tune the system properly. This is not the case, the simplicity of the filtering indicates a level of sophistication and understanding of their products that only one or two other manufacturers can compete with.



12- Paralympics Closing Ceremony

“ALL FOUR CEREMONIES USED A WIDE VARIETY OF AUDIO SOURCES, RANGING FROM THE LONDON SYMPHONY ORCHESTRA TO COLDPLAY. THE L-ACOUSTICS SYSTEMS ALWAYS DELIVERED THIS AUDIO IN INCREDIBLY HIGH QUALITY. THE STADIUM AUDIENCE EXPERIENCED EXCELLENT AUDIO WHEREVER THEY WERE SEATED - NO DISTORTION, FANTASTIC INTELLIGIBILITY AND ACCURATE REPRODUCTION.”

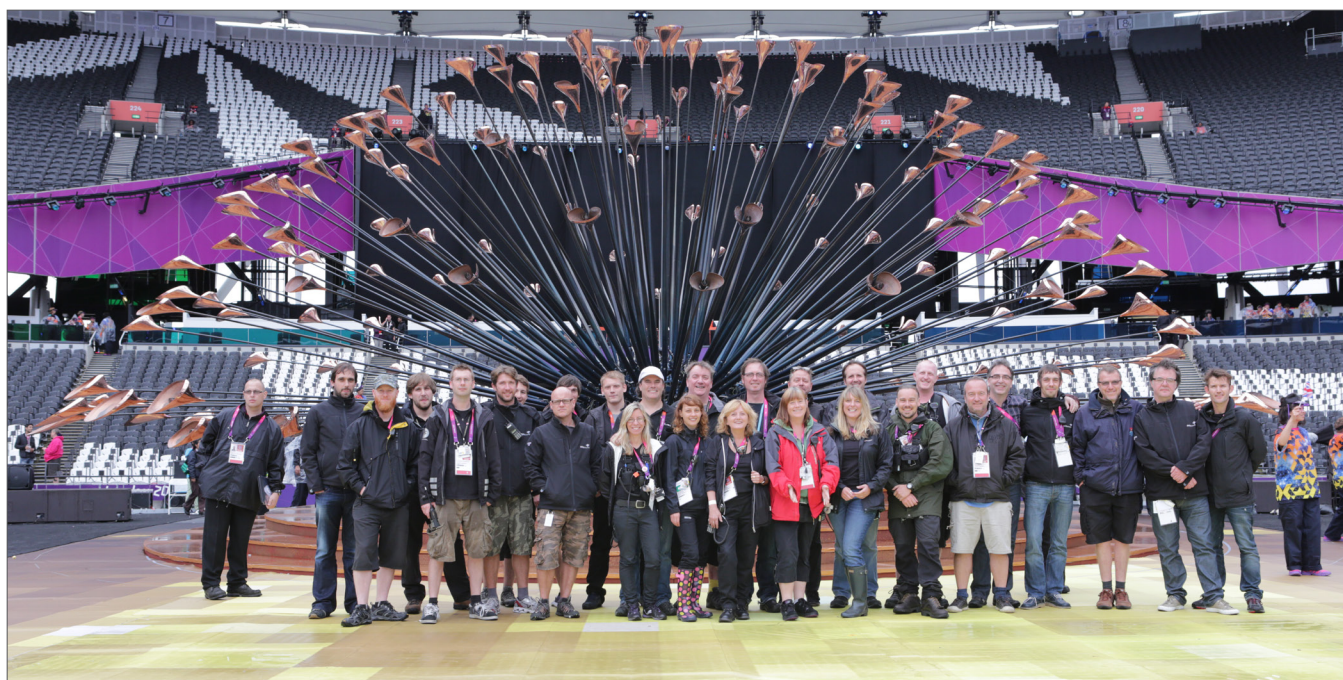
Piers Shepperd
London 2012 Ceremonies Technical Director

Array morphing tool

The tonal balance of a line source array will vary with the array geometry (array size and array curvature) and also the listening distance. The good news is that these variations are entirely predictable and do not alter the general shape of the frequency response.

L-ACOUSTICS presets were built in such a way that these changes would have a minimum impact on sonic perception, and could be modified easily by using a specific tool in the NETWORK MANAGER called array morphing.

So with only the V-DOSC_LO preset loaded and no FIR or IIR EQ, I experimented with the zoom factor and watched the measurement of a single array change as the value was changed. It made perfect sense. In terms of the LF Contour, the same process was used and it too made perfect sense. Ultimately the tuning of the V-DOSC used a zoom factor of 0.63 for the Ceremonies and 1.0 for Athletics.



13- L2012 Ceremonies Audio Team

“I WOULD LIKE TO COMMENT ON THE 35 SOUND ENGINEERS, DESIGNERS, MANAGERS AND CREW MEMBERS THAT MADE UP OUR AUDIO TEAM. NEVER, IN MY 30 YEAR CAREER HAVE I BEEN HONOURED TO WORK WITH SUCH A TALENTED AND DEDICATED GROUP OF INDIVIDUALS. IT WAS THE TEAM, PUT TOGETHER BY PAUL KEATING [DELTA SOUND], CHRIS ETERS [SENIOR PRODUCTION MANAGER] AND SCOTT THAT MADE THE AUDIO THE SUCCESS THAT IT WAS. OF COURSE THE CHOICE OF EQUIPMENT IS IMPORTANT BUT, AS ALWAYS, THE MOST CRITICAL ASSETS ARE THE PEOPLE.”

Bobby Aitken
Ceremonies Sound Designer

System EQ and Response

On top of the Array Morphing tool L-ACOUSTICS provides a set of IIR filters and FIR filters plateau to deal with environmental factors.

The EQ of the system used all of the IIR filters to tidy up the low-mid response and FIR 2 and FIR 3 to boost the HF response. Considerable time was spent finalising the EQ between myself, Bobby Aitken, Ceremonies Sound Designer and Richard Sharratt, the FOH mix engineer for the Olympic Opening.

A wireless four channel measurement system was used to capture four locations in the vertical plane of a single array to confirm the consistency of each array. I was amazed to see and hear how precisely the actual experience matched the modelled performance.

The lower bowl is very difficult to accurately model due to the angle of incidence of the field of play arrays to the seating plane. However, this is very familiar territory for me so the KUDO performed exactly as I expected and the tuning of the array was delicate but predictable.



14- Opening Ceremony Pastoral Scene



15- Olympics Opening Ceremony

With over 450 loudspeaker products directly exposed to the elements for over four months, our total failures were just two 15" woofers. This is a testament, not only to the quality of the L-ACOUSTICS products and systems but also to the efforts Delta Sound made in preparing the systems for the event.

In the end, the system sounded excellent. I had comments from countless people, all praising the sound quality in the stadium. It was a pleasure to be surrounded by such talented people as Bobby and the whole team from Delta, Norwest and Autograph.

■ Scott Willsallen

Scott Willsallen from Auditoria Pty Ltd, London 2012
Ceremonies Audio Systems Designer

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The balance between the level of the KUDO arrays and the V-DOSC arrays was tricky. We adjusted the balance countless times to find the best result. It was surprising how noticeable balance adjustments as small as 1 dB made to the experience. We are fortunate that the rehearsal period allowed plenty of time to optimise the system. The extra time spent really does improve the audience experience.

I have to think very hard to remember the occasions where I have experienced component failure in an L-ACOUSTICS system. The reliability of the products was key for London 2012 when you consider how difficult it was to access the flown loudspeakers.