Birmingham City University

Live Sound Reinforcement 2

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Abstract

In this comprehensive report, the planning and design of a large-scale outdoor music event is detailed. The project involves utilising tools such as ArrayCalc to create a bespoke speaker system tailored to the specific needs of a specified band. The careful selection of equipment is justified through thorough research, considering technical specifications and industry standards. The system integration is outlined with a focus on advanced audio networking protocols. Power requirements are calculated using excel, and environmentally friendly solutions and provided. The report culminates in a thorough risk assessment using Microsoft Word, ensuring all potential hazards are identified and addressed. Overall, this project not only delves into the technical intricacies of event planning but also prioritises a seamless and optimal experience for both performers and audiences.

Contents

List of Figures

List of Tables

Acronyms

CPL Coupling

DSP Digital Signal Processing

FOH Front of House

HFA High Frequency Attenuation

IEM In-Ear Monitors

ISL Inverse Square Law

PAP Pedestrian Access Point

SL Stage Left

SPL Sound Pressure Level

SR Stage Right

THD Total Harmonic Distortion

UHF Ultra High Frequency

VAP Vehicle Access Point

VHF Very High Frequency

WAP Wireless Access Point

1 Introduction

This report demonstrates the planning of a hypothetical large-scale (50,000 - 100,000 people) outdoor music event, including the entire event setup and system design for a specified band. Utilizing ArrayCalc to design a speaker system for the event. Equipment will be carefully chosen based on the band's requirements and comparative research. Excel will be employed to create a comprehensive patch sheet, outline the system integration and calculate power requirements. Finally, a risk assessment will be formulated using Microsoft Word to identify necessary precautions.

1.1 Aims

The aim of this report is to plan and design various aspects of a large-scale outdoor music festival. This report will explain the rationale behind the selection of specific equipment and decisions over alternatives, aiming to craft a detailed design that ensures an optimal experience.

1.2 Objectives

- Specify technical requirements for the event (such as microphones, desks, stage boxes, amplifiers and loudspeakers), tailoring the equipment for a specified band and venue.
- Design a bespoke speaker system for an outdoor venue and calculate the Sound Pressure Level (SPL), taking health and safety requirements into consideration.
- Justify equipment choices through meticulous research and evaluation of technical specifications, bearing in mind the band's equipment specifications.
- Identify and compare suitable audio networking solutions and protocols, while integrating redundancy within the system integration plan.
- Calculate power requirements, choose appropriate generators, and explore eco-friendly options.

2 Event Planning

2.1 Venue

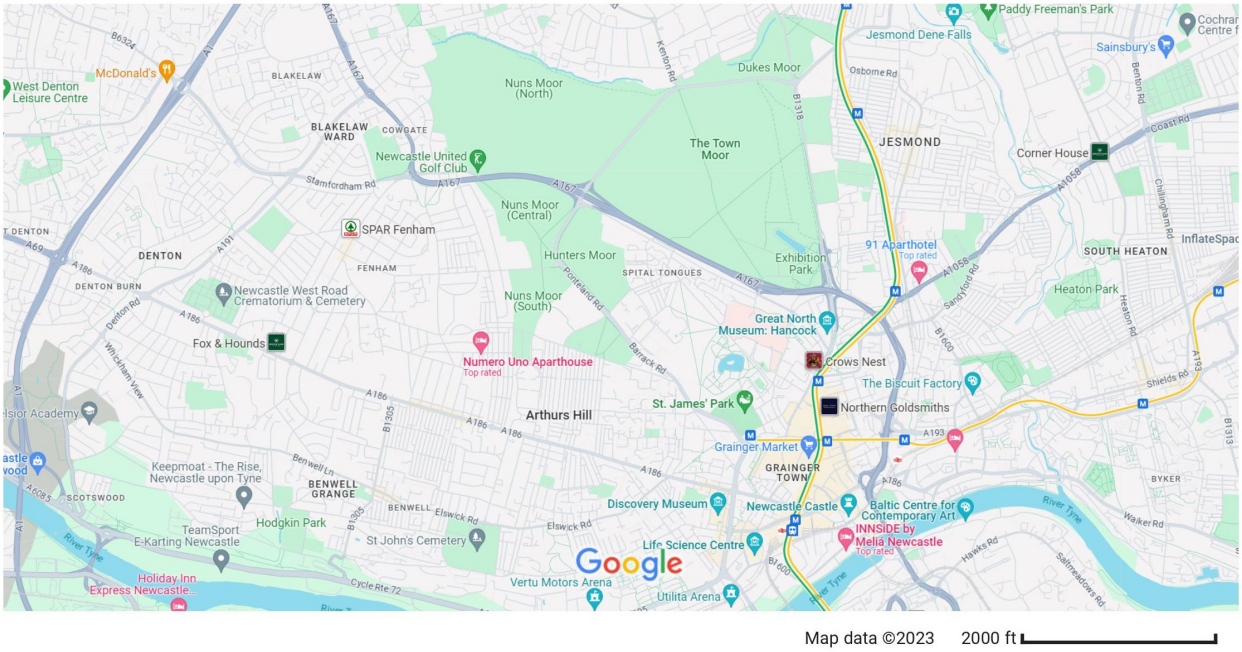


Figure 1: Map of the surrounding area

The Town Moor in Newcastle Upon Tyne was selected for its UK city setting, offering approximately 1,000 acres of open space to accommodate a crowd of 50,000 to 100,000 people. Situated near a well-known brewery and various amenities, this centrally located area, which has previously hosted one of Europe's largest travelling fairs, fulfils the project requirements.

Figure 2: Satellite image with city centre (purple), and festival location (green)

Given the proximity to busy A roads and motorways, sound pollution is anticipated to be partially masked in this area. The vast size of the park should contain most of the pollution. Strategies, including minimizing rear-firing through techniques like end-fire for a cardioid sub frequency response, will be explored. The festival's location and direction are expected to aid in dissipating audio across extended sections of the moor.

Figure 3: Festival VAP [small (yellow) medium (orange) and large (red)] and PAP (black)

Figure 3 shows the VAP with large, medium and small sized vehicle routes for setup and staff access. PAP indicates the access routes for pedestrians entering the festival area.

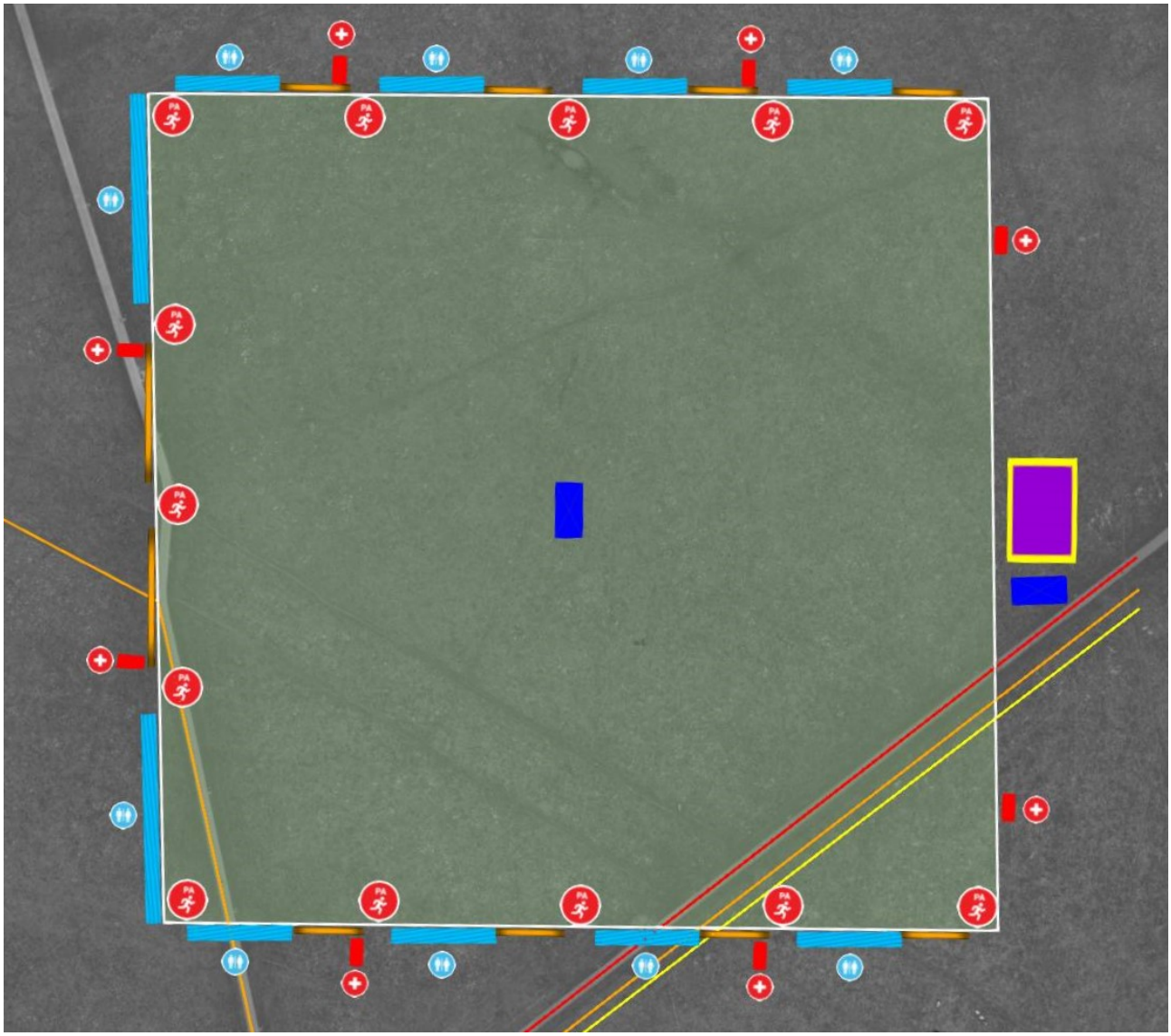


Figure 4: Festival layout with toilets (light blue strips), vendor booths (orange strips), medical tents (red), entrance/exit (red PA / running man), staff tents (dark blue), stage (purple)

Figure 4 shows a rough guide of various amenities, with measurements calculated as shown in Table 1 (some measurements have been rounded up for simplicity in calculations and to give room for error).

Item	Calculations
Total Area	To comply with fire and safety regulations, the festival's total area must be carefully allocated. According to Montgomery et al. (2018), the following considerations should be taken into account: ▪ At least 200 square meters must be set aside for the staging area. The requested area is $20\,\mathrm{m} \times 30\,\mathrm{m}$, which equals $600\,\mathrm{m}^2$. ▪ At least $500\,\mathrm{m}^2$ should be reserved for vendor booths, staff, security, and medical personnel. Scaling this by the same factor as the staging area, we get $3 \times 500\,\mathrm{m}^2 \approx 1500\,\mathrm{m}^2$, divided into approximately $500\,\mathrm{m}^2$ each for vendor booths, staff & security, and medical personnel. ▪ Under fire and health safety regulations, the remaining area should provide 2 people per square meter. For the main festival standing audience (at full capacity), an area of $50\,000\,\mathrm{m}^2$ will be required. ▪ For a moving queuing system, the guidance suggests 4 people per square meter. Therefore, an area of $25\,000\,\mathrm{m}^2$ will be allocated for the queuing audience (at full capacity).

Item	Calculations
Exits	HM Government (2007) states that the risk of outdoor fires is typically considered lower than indoor fires due to reduced susceptibility to smoke and heat, and outdoor escape routes are less likely to be obstructed. **Risk to Exit Time:** $$\begin{aligned} \text{High:} \quad & <5\,\text{min} \\ \text{Normal: } 5 \quad & <10\,\text{min} \\ \text{Low:} \quad & >10\,\text{min} \end{aligned}$$ **Appropriate Flow Rate for Outdoor Standing Events:** 109 people per meter of escape width, per minute. **Total Exit Width Calculation:** $$\text{Total Exit Width} = \frac{\text{Number of People}}{\text{Flow Rate} \times \text{Escape Time}} \approx 92\,\text{m}$$ **Minimum Exit Size:** 1.09 meters, adjustable for larger venues. To determine the required exit width for a venue, the formula considers both the nominal exits needed and an additional exit to account for potential blockages during a fire event: $$\text{Total Exits} = \text{Nominal Exits} + 1$$ For a given exit width of 7 meters, the nominal exits required can be calculated using the formula: $$\begin{aligned} \text{Nominal Exits} &= \frac{\text{Total Exit Width}}{\text{Exit Width per Exit}} \\ &\approx 12 \text{ nominal exits} \end{aligned}$$ Additionally, the total capacity of the exits can be determined by multiplying the flow rate of 109 persons per minute by the total escape width of 92 meters: $$\begin{aligned} \text{Total Capacity} &= \text{Flow Rate} \times \text{Total Escape Width} \\ &\approx 10,000 \text{ persons per minute} \end{aligned}$$ To estimate the number of people leaving within a given time frame (e.g., 10 minutes), the total capacity is further multiplied by the time: $$\begin{aligned} \text{Number of People Leaving} &= \text{Total Capacity} \times \text{Time} \\ &\approx 100,000 \text{ people for 10 minutes} \end{aligned}$$ Therefore, a total of 13 exits with a width of 7 meters will be required.

Item	Calculations
Vendor Booths	According to information from Jones (2023), food trucks are typically $5\,\mathrm{m}$ long by $2\,\mathrm{m}$ wide, but can range from $3\,\mathrm{m}$ to $8\,\mathrm{m}$ long by $2\,\mathrm{m}$ to $3\,\mathrm{m}$ wide. Let's assume we have $5\,\mathrm{m} \times 2\,\mathrm{m}$ trucks, which equals $10\,\mathrm{m}^2$. With the available area of $500\,\mathrm{m}^2$, we can accommodate 50 vendor booths $(500\,\mathrm{m}^2 \div 10\,\mathrm{m}^2)$.
Medical Regulations	Based on first aid cover guidelines from St John Ambulance (2023) and ambulance size specifications from National Health Service (NHS) (2021), the medical regulations can be calculated as follows: First aid cover: ▪ 2 first aiders per 1,000 people $=$ 200 first aiders – 152 first aiders in and around the crowd – 48 in tents (6 per tent for 8 tents) ▪ Standard first aid tent size $= 8\,\mathrm{m} \times 4\,\mathrm{m} = 32\,\mathrm{m}^2$ Ambulance size $= 2.45\,\mathrm{metre} \times 6.95\,\mathrm{m} \approx 18\,\mathrm{m}^2$. According to Hardcore Medical and Ambulance Services (HMAS) (2023), for festivals with 4,000 people, 1 ambulance or response vehicle is recommended, therefore 100,000 people require 25 ambulances or response vehicles.

Item	**Calculations**
Toilets	For a large music events featuring alcohol, food, and drinks, the required toilets can be calculated using the following guidelines from Sharp (2023) and AndyLoos (2015): ▪ Women: 1 portaloo per 75 people ▪ Men: 1 portaloo per 400 people ▪ Men: 1 urinal per 100 people Taking into account the percentage split of men to women at festivals (e.g., at Latitude Festival, the split was 40% women and 60% men (Awbi, 2019)), therefore, considering an example with 100,000 attendees, the minimum required toilets would be: ▪ Total minimum: 1000 ▪ Women's toilets: 534 ▪ Men's toilets: 150 ▪ Urinals: 600 Therefore, based on standard portaloo sizes of $1.1\,\mathrm{m} \times 1.2\,\mathrm{m}$, arranged in rows of 42 toilets per row, with pairs of rows back to back, this requires 12 pairs of rows. Taking up a total of $1320\,\mathrm{m}^2$: $1.1\,\mathrm{m} \times 1.2\,\mathrm{m} = 1.32\,\mathrm{m}^2$ for 1 portaloo $1.32\,\mathrm{m}^2 \times 1000 = 1320\,\mathrm{m}^2$ for 1000 portaloos
Front of House (FOH) and Back-stage Areas	Tents with the dimensions of $20\,\mathrm{m} \times 10\,\mathrm{m}$ will be provided for each: FOH ($\approx 120\,\mathrm{m}$ away from stage), stage left and stage right. A backstage truck provides a $50\,\mathrm{m} \times 10\,\mathrm{m}$ area for artists and backline tech.
Security	Security barriers will be setup $1.2\,\mathrm{m}$ high, with a minimum of $1.8\,\mathrm{m}$ from the stage, running entire length of the stage and wings. A non-transparent barricade will be erected to isolate back stage areas from audience. A Mojo barrier will be place around the FOH location within the audience. Westminster Security (2023) suggests 1 security staff to every 100 attendees will be required, totalling 1,000 staff for the event.

Table 1: Calculation of all amenities

2.2 Regulations and Guidance

During indoor rock concerts, sound levels typically surpass 100 dBs for extended periods, with peaks reaching 130 dB. However, there's limited data on sound exposure at outdoor music festivals, particularly those spanning multiple stages across several days (Brecht, 2023).

As the LAeq will exceed $96\,\mathrm{dB}$, tickets, advertising and notices at entry points will advise the audience of the risk to their hearing in advance (Health and Safety Executive (HSE), 2023). Hearing protection will be provided to all staff and audience members on the door as The Control of Noise at Work Regulations (2005) state that any prolonged exposure to noise of over $85\,\mathrm{dB}$ in the workplace requires ear protection. Additionally, younger kids who may attend have sensitive hearing and anything over $85\,\mathrm{dB}$, even for a short exposure time, can cause damage (Brecht, 2023).

Health and Safety Executive (HSE) (2023) states that the continuous A-weighted SPL over an event should not exceed $107\,\mathrm{dB}$ and the C-weighted peak SPL should not exceed $130\,\mathrm{dB}$ within the audience. Therefore, during soundcheck and at intervals throughout the festival, the FOH will perform regular SPL checks using a 10Easy system with Rational Acoustics's software 'Smaart'. The audience to loudspeaker separation distance should also exceed $1\,\mathrm{m}$ to help reduce the peak levels within the area.

3 Band Planning

3.1 General Information

The band and relevant staff consists of 10 musicians, 12 crew, 1 photographer, and 3 drivers. They've requested 6 hours from load in to the end of sound check for their setup time requirements. A PA with $115\,\mathrm{dB\,A}$ SPL full range with even coverage was requested. A separate control over the L/R matrix, front fills and subs will be provided. Another consideration is that the monitor engineer requested access to waves soundgrid plugins.

3.2 Staffing Requirements

The band specified that all staff should be experienced, professional and speak good English. Table 2 shows the staff required.

Quantity	**Staff**
8	Stage hands for load in/out and changeover
1	Rigger
2	Lighting engineers
2	Audio engineers
1	Electrician
1	House spot
1	Runner with good knowledge of the area

Table 2: Staffing Requirements

3.3 Patch Sheet

Patch sheet located at Appendix (C).

3.4 Area and Riser Requirements

For the main stage, the roof, sides and back wall will have black weather proof covers installed. On both the stage and wings, the area will be well lit with handrails. The band requested minimum requirements for each area however, larger areas are specified above in Table 1.

Area	Length	Width	Height
Main Stage	$12\,\mathrm{m}$	$10\,\mathrm{m}$	$1.5\,\mathrm{m}$
Wing Stage Right (SR)	$4.5\,\mathrm{m}$	$3\,\mathrm{m}$	-
Wing Stage Left (SL)	$5\,\mathrm{m}$	$3\,\mathrm{m}$	-
FOH (Audio)	$5\,\mathrm{m}$	$3\,\mathrm{m}$	-
FOH (Lighting)	$5\,\mathrm{m}$	$2\,\mathrm{m}$	$1\,\mathrm{m}$

Table 3: Minimum Area Requirements

Quantity	Length	Width	Height
2	8ft	8ft	1ft
2	8ft	8ft	2ft
1	8ft	12ft	2ft
2	8ft	4ft	2ft
2	Small 2ft treads/steps		

Table 4: Riser Requirements

3.5 Monitor Requirements

The band specified In-Ear Monitors (IEM) with 10 stereo mixes over 2 bands minimum. No wedges will be required however, they do specify 2 sub sidefills. These are placed at the sides of the stage, facing the performers which creates a more natural on-stage experience and provides the physical sensation of bass frequencies.

4 System Design

The festival prioritises a minimum SPL of $96\,\mathrm{dB}$ at FOH for optimal mixing while actively addressing noise pollution concerns in nearby areas. Ensuring even coverage across the venue is essential, and strict adherence to regulations is maintained.

The design incorporates specified d&b Audiotechnik products, covering calculations for delay times, rigging, power requirements, amp configurations, and routing. Relevant SPL maps for the festival area are also provided, utilising software such as d&b ArrayCalc, d&b NoizCalc, and d&b R1. Additionally, SubAligner and Excel were employed for calculating delay compensations and power consumption.

4.1 System Overview

The Inverse Square Law (ISL) (1) can be used to estimate the SPL by considering the uniform emission of sound from a point source in all directions (WKC, 2023).

$$Lp(R2) = Lp(R1) - 20 \cdot \log_{10}\left(\frac{R2}{R1}\right) \tag{1}$$

Where:

- $Lp(R1)$ is the known sound pressure level at the first location (typically measured data or equipment vendor data).
- $Lp(R2)$ is the unknown sound pressure level at the second location.
- $R1$ is the distance from the noise source to the location of the known sound pressure level.
- $R2$ is the distance from the noise source to the second location.

However, line arrays defeat the ISL with a $-3\,\mathrm{dB}$ drop per distance doubling (Brenda Brown, 2010) (2) however, in a practical scenario this is not always the case, and only continues up to a certain distance (Stewart, 2016). A line array directs constructive interference to the center and induces destructive interference at the sides, enhancing projection towards the audience while minimising reflection from the floor and ceiling (Mellor, 2006).

$$Lp(R2) = Lp(R1) - 10 \cdot \log_{10}\left(\frac{R2}{R1}\right) \tag{2}$$

From this the number of speakers needed in a line array can be calculated by considering the superposition principle of sound waves (3). Where the power of two sources are the same, when stacked adds approximately $3.01\,\mathrm{dB}$.

$$\text{Total dB} = 10 \cdot \log_{10}\left(\sum_{i=1}^{n} 10^{(a_i/10)}\right) \tag{3}$$

Using this, 22 flown GSL12 speakers was calculated for the main array and 18 KSL12 speakers for the delay per side. As well as 12 SL-Subs on the ground for FOH and 4 flown KSL-Subs for the delay.

ArrayCalc simplifies system optimisation by including a CUT button to eliminate lower frequencies, reducing interference with subs and improving amplifier efficiency. The tool also features High Frequency Attenuation (HFA) for natural frequency response, 'line' and 'arc' options for speaker settings, and a Coupling (CPL) attenuation function to address near field effects in straight array sections and Array Processing for advanced system tuning. All of which are explored in the system design.

Subwoofers have cardioid and omni-directional patterns for directing low frequencies. Passive systems are suitable for larger venues, offering greater power and easy amplifier access when flown, unlike active subs which lack power. Therefore, passive systems are used in this design.

The directivity rule is crucial in subwoofer arrays. Lower frequencies are omni-directional, so array layouts focus on efficient sound direction. Techniques include beam-forming for polar pattern shaping, gain shading for regular coverage (Berryman, 2010), and three main subwoofer array types:

- **Broadside** common and versatile, with variations like straight, curved, or stair-cased rows affecting polar patterns.
- **Gradient** uses amplitude and phase variations for even lower frequency distribution, common in outdoor venues for maintaining sound levels over long distances.
- **End-fire** lines of speakers pointing in the desired direction with set delay times, effective with a larger number of speakers.

The main array will be flown as this improves energy distribution and reduces SPL excess in the front. However, the sub array will be ground stacked as they offer an extra 6dB in sub frequencies through coupling with the ground. A gradient array with broadside characteristics will be used to create a cardioid pattern.The J series was not chosen as they are now discontinued.

Series	Description	Advantages
GSL	Large scale applications.	Precision and power for large events. Exceptional directivity and coverage control. Optimized for stadium and festival environments.
KSL	Medium to large scale applications.	High-performance system with extended low-frequency response. Versatile rigging options for easy integration into various venues.
J-Series	Versatile for both small and large-scale applications.	Exceptional audio quality with flexible configurations. Versatility in system design, suitable for both permanent installations and touring applications.

Table 5: Comparison of d&b line array series

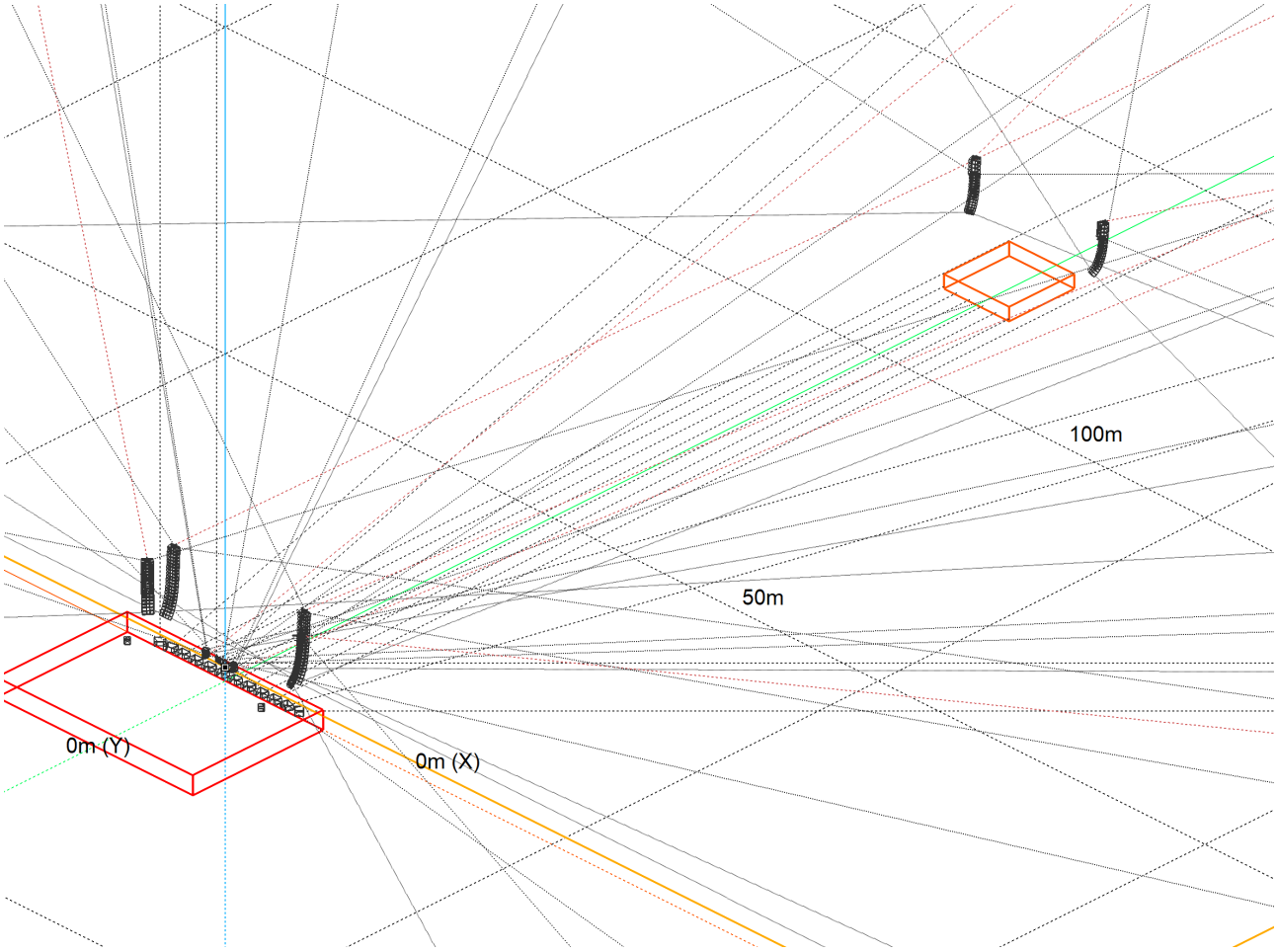


Figure 5: Full System

4.1.1 Parts List

The complete parts list is located at A.5.

4.1.2 Rigging Requirements

The full rigging requirements are provided at A.3 with the required pick points, loads and dimensions specified.

4.1.3 Delay Times

Delays are crucial to ensure proper alignment of multiple audio sources. Especially when arrays are distributed across different locations and distances from the audience. To calculate the necessary delay times for each speaker array, trigonometry is employed to account for the varying distances between the individual speaker hangs.

The time delay (t) needed to time-align two speaker systems with positions (x_1, y_1, z_1) and (x_2, y_2, z_2) can be calculated using the formula (4):

$$t = \frac{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}}{v} \tag{4}$$

where (v) is the speed of sound in air.

To calculate the speed of sound (v), the following formula is used (5):

$$v = 331.4\sqrt{1 + \frac{T}{273.15}} + 0.6 \times H \tag{5}$$

where (T) is the temperature in degrees Celsius, and (H) is the relative humidity.

Cramer (1993) demonstrates equations that includes the altitude (7). Using the altitude value, the air pressure is calculated with the barometric formula (6):

$$P = P_0 e^{-\frac{gM(h-h_0)}{RT}} \tag{6}$$

Where:

- h is the altitude at which we want to calculate the pressure, expressed in meters.
- P is the air pressure at altitude h.

- P_0 is the pressure at the reference level h_0. In our pressure calculator, it is assumed that the reference level is located as sea level, so $h_0 = 0$.
- T is the temperature at altitude h, expressed in Kelvins. The temperature at altitude calculator may help you find it.
- g is the acceleration due to the gravitational force. For Earth, $g = 9.806\,65\,\mathrm{m/s^2}$.
- M is the molar mass of air. For Earthly air, $M = 0.028\,964\,4\,\mathrm{kg\,mol}$.
- R is the universal gas constant. Its value is equal to $R = 8.314\,32\,\mathrm{N \cdot m/(mol \cdot K)}$.

This is then applied to Cramer's formula (7):

$$
\begin{aligned}
ENH &= \pi \cdot 10^{-8} P + 1.00062 + T^2 \cdot 5.6 \cdot 10^{-7} \\
PSV_1 &= T_k^2 \cdot 1.2378847 \cdot 10^{-5} - 1.9121316 \cdot 10^{-2} \cdot T_k \\
PSV_2 &= 33.93711047 - 6.3431645 \cdot 10^3 / T_k \\
PSV &= e^{PSV_1} \cdot e^{PSV_2} \\
H &= Rh \cdot ENH \cdot \frac{PSV}{P} \\
X_w &= \frac{H}{100} \\
X_c &= 400 \cdot 10^{-6} \\
C_1 &= 0.603055T + 331.5024 - T^2 \cdot 5.28 \cdot 10^{-4} + \\
&\quad \ldots (0.1495874T + 51.471935 - T^2 \cdot 7.82 \cdot 10^{-4}) \cdot X_w \\
C_2 &= (-1.82 \cdot 10^{-7} + 3.73 \cdot 10^{-8} T - T^2 \cdot 2.93 \cdot 10^{-10}) P + \\
&\quad \ldots (-85.20931 - 0.228525T + T^2 \cdot 5.91 \cdot 10^{-5}) X_c \\
C_3 &= X_w^2 \cdot 2.835149 + P^2 \cdot 2.15 \cdot 10^{-13} - X_c^2 \cdot 29.179762 - 4.86 \cdot 10^{-4} X_w P X_c \\
C &= C_1 + C_2 - C_3
\end{aligned}
\tag{7}
$$

Where:

- Rh: is the relative humidity.
- Tk: is the measured ambient temperature in kelvins.
- ENH: is the molecular concentration of water vapour calculated from Rh. Using Giacomo's methods as demonstrated by Rasmussen.
- PSV values: are constants taken from Cramer's equations.

- H: is the molecular concentration of water vapour.
- Xw: is the mole fraction of carbon dioxide and water vapour, respectively.
- C values: are the speed calculated using the method of Cramer from JASA vol 93 page 2510

Referring to weather averages for Newcastle in July, the temperature typically ranges between 19°C and 13°C, with humidity averaging around 75% (WorldWeatherOnline, 2023).

Table 6 displays the approximate delay compensations for each source, where the delay reference point is at $X = 150\,\mathrm{m}, Y = 0\,\mathrm{m}$. These may differ to the ArrayCalc times as phase is also considered to closely align with the subs at specific frequencies as shown in Figure 6. The supporting calculations are provided in the 'DelayAlignTimes' excel file.

Temperature $= 16\,^{\circ}\mathrm{C}$, Humidity $= 75\%$, Altitude $= 64\,\mathrm{m}$				
Source	**X**	**Y**	**Z**	**Total Delay**
Delay	$125\,\mathrm{m}$	$10\,\mathrm{m}$	$10.5\,\mathrm{m}$	$364.39\,\mathrm{ms}$
Main	$2.4\,\mathrm{m}$	$10\,\mathrm{m}$	$12\,\mathrm{m}$	$13.34\,\mathrm{ms}$
Outfill	$0\,\mathrm{m}$	$12\,\mathrm{m}$	$10.5\,\mathrm{m}$	$6.20\,\mathrm{ms}$
Sub	$0\,\mathrm{m}$	$0\,\mathrm{m}$	$0\,\mathrm{m}$	$8.33\,\mathrm{ms}$
Nearfill	$-0.6\,\mathrm{m}$	$2.20\,\mathrm{m}$	$2.5\,\mathrm{m}$	$6.55\,\mathrm{ms}$
Frontfill	$0\,\mathrm{m}$	$0\,\mathrm{m}$	$0\,\mathrm{m}$	$8.33\,\mathrm{ms}$

Table 6: Delay Times

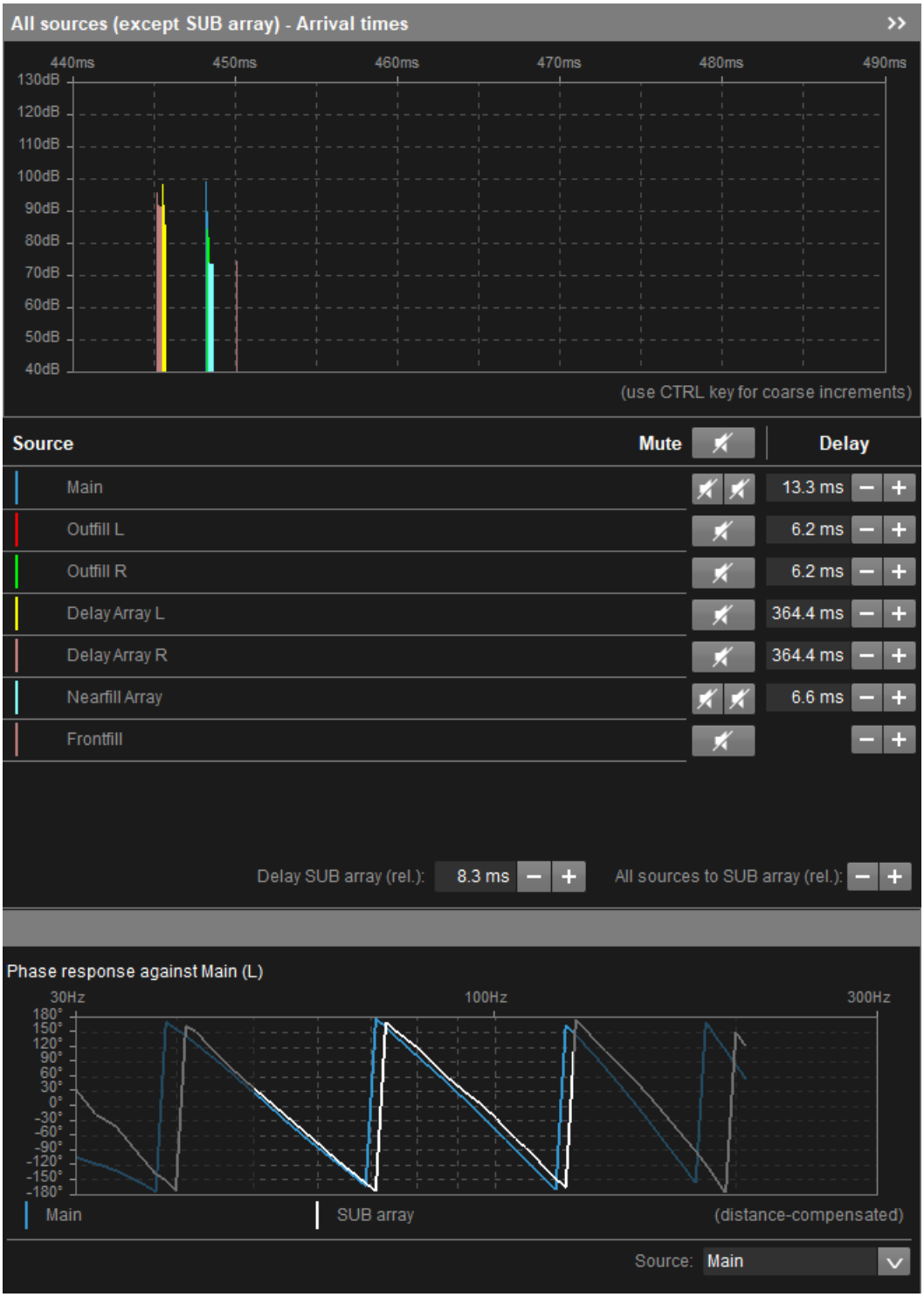
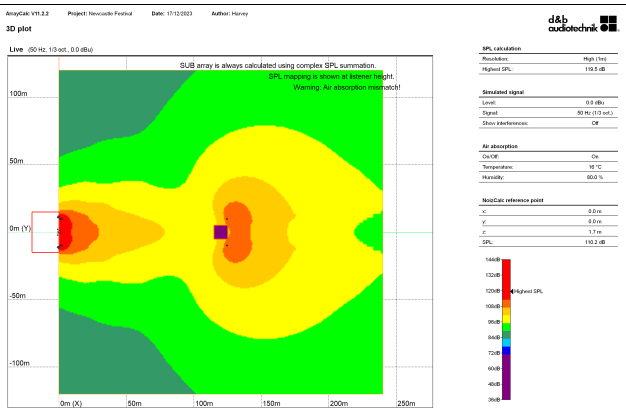
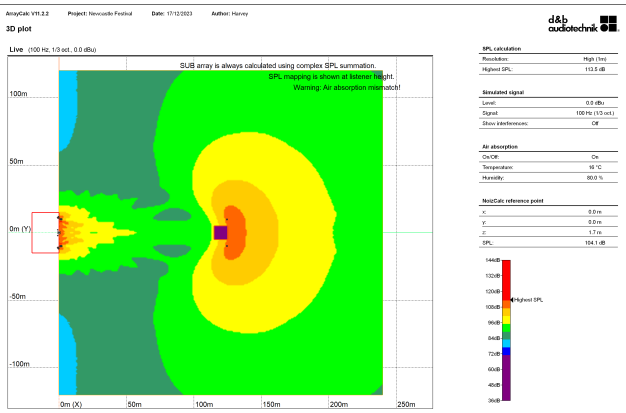
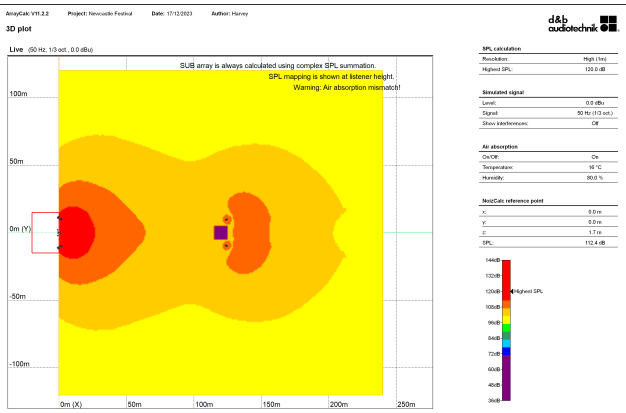


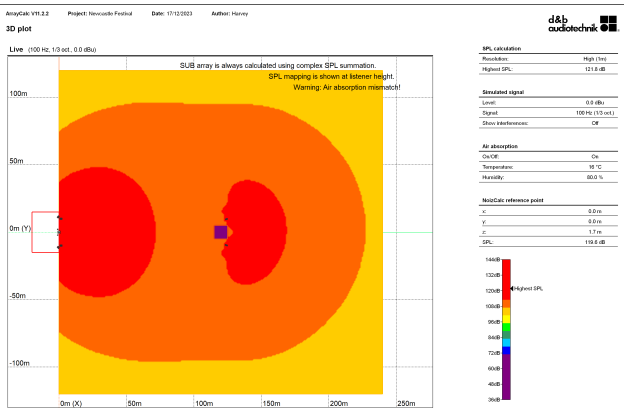
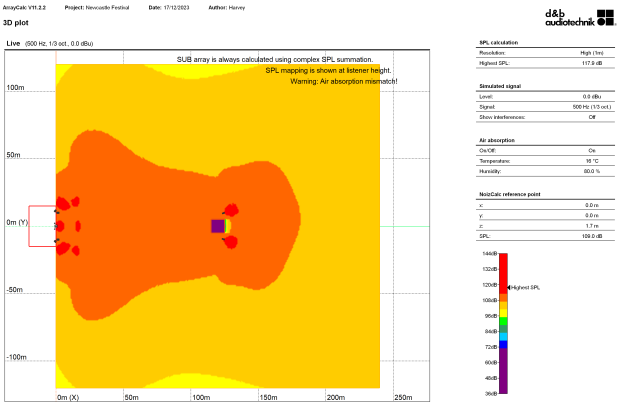
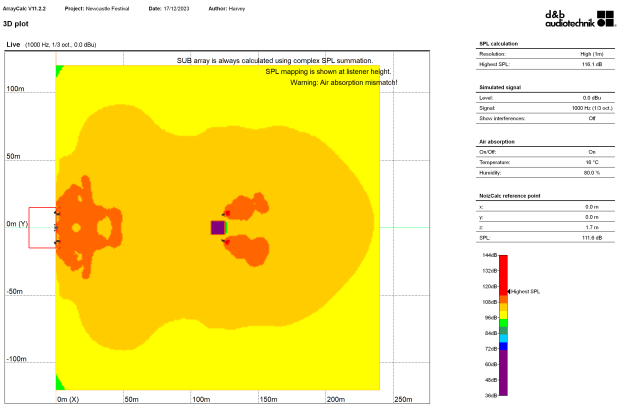
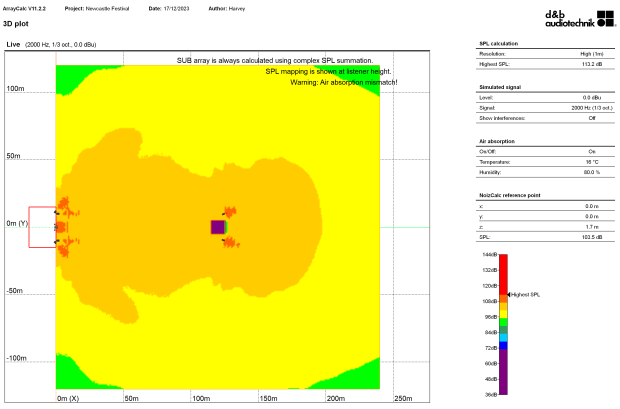
Figure 6: Time and phase alignment of sources

All delay times are written in full at A.4.

4.1.4 SPL Mapping

The SPL mapping of the system can be seen in Table 7; showing the highest, lowest, standard deviation and average SPL.

Freq	Screenshot	High SPL	Low SPL	Std Dev	Avg. SPL
Sub Array Only (all other sources muted)					
50 Hz		119.5 dB	84 dB	25.1 dB	101.8 dB
100 Hz		113.5 dB	78 dB	25.1 dB	95.8 dB
Full System					
50 Hz		120.0 dB	96 dB	17.0 dB	108.0 dB

100 Hz		121.8 dB	102 dB	14.0 dB	111.9 dB
500 Hz		117.9 dB	96 dB	15.5 dB	107.0 dB
1 kHz		116.1 dB	90 dB	18.5 dB	103.1 dB
2 kHz		116.1 dB	90 dB	18.5 dB	103.1 dB

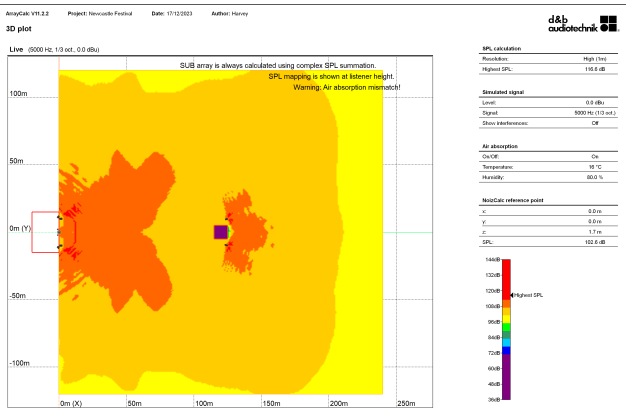
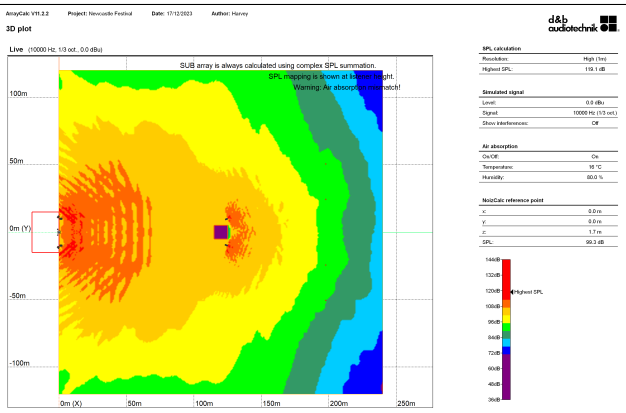
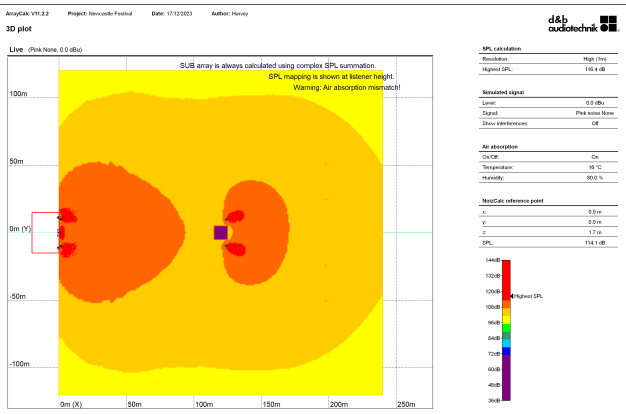
5 kHz		116.6 dB	96 dB	14.6 dB	106.3 dB
10 kHz		119.1 dB	72 dB	33.3 dB	95.6 dB
Pink		116.4 dB	96 dB	14.4 dB	106.2 dB

Table 7: SPL Mapping

4.1.5 Monitors

As regards to monitors, the band will use IEMs, however the requested sub side fills will require an additional 2 d&b V-GSubs and a d&b D20 Amplifier.

4.1.6 Design Considerations

NoizCalc was used to calculate the noise pollution (Figure 7). This takes into account the temperature, humidity, altitude and obstacles such as greenery or structures. Although this may not be fully accurate and is variable depending upon meteorological conditions, it gives a good approximation.

Westbury (2016) also stated that some events offer to pay for temporary relocation of residents in the immediate locality if needed or even provide free and discounted tickets to residents within a certain radius of the event.

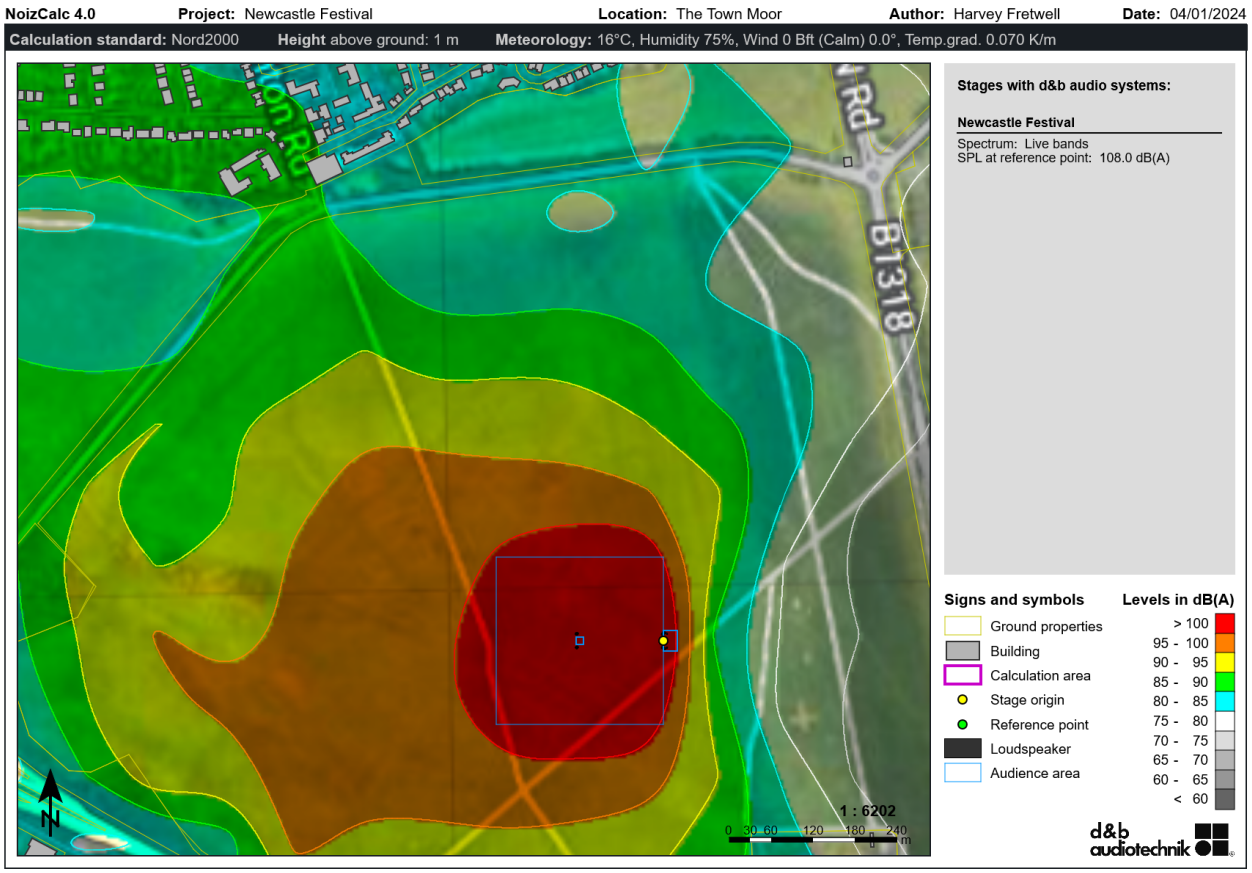


Figure 7: Noise pollution for the surrounding area

4.2 System Selection

4.2.1 Console

Various consoles were explored and after comparing the tech specs against the price ranges, the following consoles came out as the most appropriate for the festival at an affordable price range (baring in mind these prices are for buying outright, not hiring) 8. Other consoles such as the Yamaha

Rivage PM series and the DiGiCo Quantum series had more features but drastically increased in price.

The final console chosen was the DiGiCo SD12 for both FOH and Monitors as although the band specified DiGiCo SD10's, the SD12 is more expandable when using Dante and Waves, and the usability will be analogous. Features such as the extensive Digital Signal Processing (DSP), high channel count, busses/matrices provides optimal flexibility for the engineers. 2 large touchscreens with 26 touch sensitive and motorised faders will increase usability. These desks also provide high quality audio with less than $0.05\,\%$ Total Harmonic Distortion (THD) and up to 40-bit floating point processing. Having the expandability of Waves on the monitors will provide even extra DSP.

	DiGiCo SD12	**Yamaha CL3**	**Midas HD 96**	**Soundcraft Vi5000**
Channels	64 I/O over Dante (+8 I/O on the desk)	64 I/O over Dante (8 I/O on the desk)	64 I/O over Dante (+8 I/O on the desk)	64 I/O over Dante
Buses	36 mix, 12 Matrix	24 mix, 8 matrix	96 mix, 24 matrix	32 mix, 8 matrix
Touchscreen Control	2x 15 inch	10 inch	21 inch	4x 10 inch
Faders	26 Touch-Sensitive, Motorised	26 Motorised	28 Touch-Sensitive, Motorised	32 Touch-Sensitive, Motorised
Sample Rate	$96\,\mathrm{kHz}$ with Dante	$48\,\mathrm{kHz}$	$96\,\mathrm{kHz}$	$96\,\mathrm{kHz}$
Effects	119 Dynamic EQs, 119 DigiTubes, 12 Digital Effects	8 GEQ Racks, 8 Effect Racks, 8 Premium Racks	24 Effects Slots, 84 Ultima Dynamic EQs	8 Stereo Lexicon multi-effects units, UAD powered plugin platform
Existing Connectivity	MADI	Dante	AES50	MADI
Expansion Cards Needed	DMI-DANTE64@96, DMI-WAVES	WSG-Y16 V3 mini-YGDAI I/O	KT-DANTE64, Soundgrid not supported	VI-DANTE, Soundgrid not supported
Price (Approx.)	£20,500	£20,000	£30,000	£30,000
Card Price (Approx.)	£1,586 + £931	£549	£677	£1,444

Table 8: Console Comparison (Green: 1st, Orange 2nd, Red 3rd)

4.2.2 Stage Box

Various stage boxes were compared (as shown in Table 9) including the Yamaha Pio series, however these were only compatible with Rivage consoles. As both consoles are DiGiCo, the SD-Rack will be used for the stage box as this allows for gain and phantom control via the desk. To make this Dante compatible, an Orange Box will be needed to convert from Dante to OPTO or an OPTO card can be added onto the SD12 console.

	DiGiCo SD-Rack	**Yamaha RIO3224**	**Soundcraft Vi 6432**	**Allen & Heath dLive CDM64**
Channels	56 Analogue Inputs, 56 Analogue Outputs	32 Analog Inputs, 16 Outputs, 8 Digital Outputs, Would require 2x	64 Analogue Inputs, 32 Analogue Outputs	64 Analogue Inputs, 32 Analogue Outputs
Sample Rate	96 kHz	96 kHz	96 kHz	96 kHz
Existing Connectivity	MADI, Opto	Dante	MADI	DX
Expansion Cards Needed	Orange Box	-	VI-DANTE	M-DANTE A
Price (Approx.)	£10,011	£9,280 x2	£11,981	£9,272
Card Price	£1,188	-	£1,444	£990

Table 9: Stagebox Comparison (Green: 1st, Orange 2nd, Red 3rd)

4.2.3 Monitors

The band has requested L'acoustics SB28JKS28 as sub sidefills however, our system is using a d&b audiotechnik system, therefore V-GSUBs have been substituted. A buttkicker will be provided for the drummer as it is a common preference to help feel the bass when using IEMs. All other monitors will be IEMs.

4.2.4 IEM

Wireless microphones and IEMs, typically operate within specific radio frequency bands:

- **Very High Frequency (VHF)**: Frequencies between $30\,\mathrm{MHz}$ and $300\,\mathrm{MHz}$. While VHF was historically popular for wireless microphones, it has become less common due to its susceptibility to interference and limited available spectrum.

- **Ultra High Frequency (UHF)**: Frequencies between $300\,\mathrm{MHz}$ and $3\,\mathrm{GHz}$. UHF is widely used in the professional audio industry for wireless microphones and IEM. It offers a larger available spectrum, which allows for more channels and better resistance to interference compared to VHF.

(Shure, 2022)

Table 10 shows the frequency bands and their required licensing.

Frequency Ranges	**Licensing Information**
$470 - 550\,\mathrm{MHz}$	Mandates licensing and is exclusively sanctioned for use in installations, major events, and specialised applications.
$550 - 558\,\mathrm{MHz}$	Needs a license that lasts for 6 months (renewable), commonly set aside for LTE, and is contingent upon individual local authorisation verifications.
$566 - 606\,\mathrm{MHz}$	Needs a license that lasts for 6 months (renewable), commonly set aside for LTE, and is contingent upon individual local authorisation verifications.
$606 - 614\,\mathrm{MHz}$	Primary band, necessitates an annual license fee of £85.
$614 - 630\,\mathrm{MHz}$	Secondary band, necessitates an annual license fee of £85.
$630 - 670\,\mathrm{MHz}$	Mandates licensing and is exclusively sanctioned for use in installations, major events, and specialised applications.
$734 - 782\,\mathrm{MHz}$	Mandates licensing and is exclusively sanctioned for use in installations, major events, and specialised applications.
$823 - 832\,\mathrm{MHz}$	Mandatory licensing, requiring registration and associated with fees since 2015.
$838 - 862\,\mathrm{MHz}$	Unauthorized for wireless system usage.
$863 - 865\,\mathrm{MHz}$	No licensing is necessary throughout Europe; however, the maximum transmitted power is restricted to 10 mW.
Free Band	Unlicensed
Requires License	Legal requirement for operation
Requires Temporary License	Legal requirement for a limited duration
Illegal	Operation without proper authorisation is prohibited

Table 10: Frequency range licensing

These are then put into standard frequency band classes (Table 10).

Bands	Frequency Ranges
A1	$470 - 516\,\mathrm{MHz}$
A	$516 - 558\,\mathrm{MHz}$
G	$566 - 608\,\mathrm{MHz}$
GB	$606 - 648\,\mathrm{MHz}$
B	$626 - 668\,\mathrm{MHz}$
C	$734 - 776\,\mathrm{MHz}$
E	$823 - 865\,\mathrm{MHz}$

Table 11: Standard Frequency bands

After reviewing specifications and various online reviews, the top professional IEM transmitters were Shure P10T/PSM1000 and Sennheiser SR2050.

The SR2050 was chosen as it provides wide tuning bandwidths, touring-grade features, and wireless remote control via the WSM software (Table 12). Table 13 shows the various models and which frequency ranges they span. To provide minimal interference, the transmitters will span over a minimum of 2 bands i.e. Bw providing 10 channels with 72 different frequencies, spanning over GB and B bands.

The Sennheiser A5000 antenna will be used on either side of the stage, as the circular polarisation minimises variations in signal strength and almost eliminates multi-path problems (Sennheiser, 2022).

Feature	Shure PSM900	Shure PSM1000	Sennheiser EW G4	Sennheiser SR2050
Frequency Range	470 - 952 MHz	470 - 952 MHz	470 - 865 MHz	470 - 865 MHz
Compatible Frequencies	20 per band	39 per band	20 per band	20 per band
Tuning Bandwidth	39 - 40 MHz	72 - 80 MHz	42 MHz	75 MHz
Audio Frequency Response	38 Hz - 15 kHz	35 Hz - 15 kHz	25 Hz - 15 kHz	25 Hz - 15 kHz
THD	$< 0.5\,\%$	$< 0.5\,\%$	$< 0.9\,\%$	$< 0.9\,\%$
SNR	$> 90\,\mathrm{dB}$	$> 90\,\mathrm{dB}$	$> 90\,\mathrm{dB}$	$> 90\,\mathrm{dB}$

Networking / Remote Control	No	Yes	No	Yes
Rack Mountable	No	Yes	Yes	Yes
Price	£1,169	£4,674	£1,199	£3,499

Table 12: IEM Comparisons

Chan	From MHz	To MHz	Sennheiser SR2050		Shure P10T	
70	862	870	DW			
69	854	862	790 - 865 MHz			
68	846	854	75 MHz			
67	838	846				
66	830	838				
65	822	830				
64	814	822				
63	806	814				
62	798	806				
61	790	798				
60	782	790	Cw			
59	774	782	718 - 790 MHz			
58	766	774	72 MHz			
57	758	766				
56	750	758				
55	742	750				
54	734	742				
53	726	734				
52	718	726				
51	710	718				
50	702	710				
49	694	702	Bw		L8E	
48	686	694	626 - 698 MHz		626 - 698 MHz	
47	678	686	72 MHz		72 MHz	
46	670	678		GBw		

45	662	670		606 - 678 MHz 72 MHz		K10E 596 - 668 MHz 72 MHz
44	654	662				
43	646	654				
42	638	646				
41	630	638				
40	622	630				
39	614	622	Gw 558 - 626 MHz 68 MHz		J8E 554 - 626 MHz 72 MHz	
38	606	614				
37	598	606				
36	590	598				
35	582	590				
34	574	582				
33	566	574				
32	558	566				
31	550	558	Aw 516 - 558 MHz 42 MHz			
30	542	550				
29	534	542			G10E 470 - 542 MHz 72 MHz	
28	526	534				
27	518	526				
26	510	518				
25	502	510				
24	494	502				
23	486	494				
22	478	486				
21	470	478				

Table 13: IEM Transmitter Frequency Ranges (for each model)

Headphones: Shure SE846 Pro

4.2.5 Microphones

The following tables show comparisons of equipment. The chosen equipment is then highlighted in green and that'll be used for the event. The choices were made based upon price, industry preferences and product specifications / features.

Kick	**Shure Beta 91A (Used for Kick In)**	**Shure Beta 52A (Used for Kick Out)**	**Audix D6**
Key Features	It's uniform half-cardioid polar pattern, ensures maximum gain-before-feedback and effective rejection of off-axis sounds. Tailored for kick drum and low-frequency applications, it boasts a wide dynamic range, suitable for high SPL environments. The two-position contour switch allows users to optimise attack and clarity. (Shure, 2024c)	Tailored frequency response designed specifically for kick drums and bass instruments. Its supercardioid pickup pattern ensures high gain before feedback and superior rejection of unwanted noise, making it ideal for capturing the deep and impactful sound of a kick drum. (Shure, 2024a)	The cardioid pickup pattern provides effective isolation and feedback control. Its VLM diaphragm ensures natural and accurate sound reproduction, making it ideal for miking instruments with extended low-frequency needs, such as kick drums, large toms, and bass cabinets. The transformerless design and low impedance will contribute to less interference. (Audix, 2024b)
Approx. Price	£279	£165	£189
Snare	**Sennheiser e904 (Used for Snare Top)**	**Beyerdynamic M201TG (Used for Snare Bottom)**	**Shure SM57**
Key Features	Crafted specifically for drums and percussion. Its compact design, equipped with a universal rim clip, makes it ideal for mounting on toms and snares. A full, impressive, and lively sound with a very fast attack. Excellent sound profiling, adapting seamlessly to various percussive styles. (Sennheiser, 2024c)	Hypercardioid polar pattern that efficiently eliminates unwanted noise and feedback. Its slim design allows for easy positioning. Known for its clear and detailed sound reproduction. A universal instrument mic which provides a linear frequency response making it a popular choice for drums and acoustic guitars. (Beyerdynamic, 2024)	Its uniform cardioid pickup pattern isolates the primary sound source, reducing background noise. Provides a contoured frequency response great for snares. The pneumatic shock-mount system minimizes handling noise. Is well known for its durability and versatility among musicians. (Shure, 2024f)
Approx. Price	£155	£303	£104

Toms	**Sennheiser e604 (Used for Rack Tom)**	**Audix D4 (Used for Floor Tom)**	**Shure PGA56**
Key Features	Its optimized frequency response and cardioid pickup pattern make it ideal for drum sets and percussion instruments. A high sound pressure level handling exceeding 160 dB. Produces a balanced, clear, and low-distortion signal. The lightweight voice coil ensures extended high-frequency response and rapid transient response. It's clip on mount provides further versatility and suitability. (Sennheiser, 2024a)	Well suited for large rack toms and floor toms with a wide frequency response of 40 Hz – 18 kHz. Able to handle SPLs exceeding 144 dB while delivering precise low-frequency reproduction. Its hypercardioid pickup pattern ensures effective isolation and feedback control. Equipped with a VLM diaphragm for natural and accurate sound reproduction. (Audix, 2024a)	Provides a flat-response, ensuring clear reproduction. Its cardioid polar pattern efficiently rejects unwanted noise. The drum mount allows for quick attachment to drum rims. (Shure, 2024e)
Approx. Price	£114	£152	£72
Cymbals	**Shure SM81 (Used for Hi-Hats and Ride)**	**Shure KSM141 (Used for Overheads)**	**Audio Technica AT4041**

Key Features	20 Hz to 20 kHz frequency response and a flat response curve for precise reproduction. Low noise, high output clipping level, and low distortion across various load impedances. The cardioid polar pattern provides maximum rejection of off-axis sounds. A lockable attenuator switch offer flexibility in adjusting the mic's characteristics. (Shure, 2024g)	A mechanical polar pattern switch offering cardioid and omnidirectional patterns. Ultra-thin, 24 karat gold-layered Mylar diaphragm ensures superior transient response. Class A, discrete, transformerless preamplifier maintains transparency and minimal distortion. With a subsonic filter, switchable pad, and low-frequency filter, it effectively eliminates unwanted noise and handles high SPLs which is ideal for overheads. (Shure, 2024d)	Remarkable clarity and sensitivity in a compact cardioid condenser. Smooth, extended frequency response with a slight rise in the higher frequencies. Also ideal for drum overheads, acoustic guitar, banjo, piano, horns, and placement under a snare. Enhances transient response and reduces handling noise. Transformerless circuitry virtually eliminates low-frequency distortion. 80Hz low-cut filter and a switchable -10dB attenuator pad for added versatility. (Audio Technica, 2024)
Approx. Price	£338	£341	£305

Table 14: Drum Microphone Comparisons

Piano	**SE8 (Used for Piano and other L/R spots)**	**Rode M5**	**Rode NT5**
Key Features	A high-performance small-diaphragm condenser with high durability. Excels in capturing sources like pianos, woodwind, drums and choirs. High dynamic range and SPL handling. Integrated attenuation pads and low-cut filters enhance its versatility. Can come as a matched pair providing stereo configurations. (SE, 2024)	Provides good results on acoustic instruments and choirs. Can come as a matched pair allowing for stereo recording. Features a sensitivity variation of no more than 1dB. (Rode, 2024a)	A small-diaphragm condenser with a 1/2-inch gold-sputtered cardioid capsule ensures a smooth and balanced sound with minimal self-noise. The wide frequency response will make it well suited for piano performances. Its versatility is enhanced by the option of an interchangeable omnidirectional capsule (NT45-O), providing further flexibility can can come as a matched pair. (Rode, 2024b)
Approx. Price	£151	£78	£164
Guitar & Spots	**Sennheiser e609 (Used for Guitar Cabs)**	**Shure SM57 (Used for other spot micing)**	**Sennheiser MD421**

Key Features	Super-cardioid pick-up pattern and a durable design. Specifically designed to be placed in close proximity to the source, providing exceptional isolation. Its advanced shock-mount design and hum compensating coil further contribute to its reliability. (Sennheiser, 2024b)	A contoured frequency response that ensures clean reproduction. A versatile microphone that can be used in many scenarios. The uniform cardioid pickup pattern isolates and effectively minimises background noise. Its contoured frequency response, features a distinguishable presence. A durable design built to withstand heavy use and a go to micorphone for many musicians. (Shure, 2024f)	Cardioid microphone renowned for its clear sound reproduction and rugged build. Dynamic Large diaphragm design excels in handling high sound pressure levels. The microphone's five-position bass control and effective feedback rejection enhance its versatility. (Sennheiser, 2024e)
Approx. Price	£96	£104	£336
Wired Vocals	**Sennheiser e945 (Used for Wired Vocal Mics)**	**Shure Beta 58A**	**Telefunken M80**

Key Features	A dynamic super-cardioid vocal microphone known for its narrower pick-up pattern, providing exceptional detail and isolation with great feedback rejection. Delivers a smooth response and is a reliable choice for most musicians. Ensures durability, while the shock-mounted capsule minimizes sensitivity to impact and handling noise. The hum compensating coil reduces electrical interference, and the neodymium ferrous magnet with boron keeps the microphone stable in varying climates. (Sennheiser, 2024d)	Meticulously designed for professional lead and backup vocals. Its tailored frequency response emphasizes vocals with a brightened midrange and controlled proximity effect through bass rolloff. The uniform supercardioid pattern ensures high gain before feedback and superior rejection of off-axis noise. (Shure, 2024b)	Provides a wide frequency response, condenser-like performance, and impressive SPL capabilities. Typically used for lead vocals and snare drums. Its low-mass capsule and thin yet robust membrane, provide an intimate, studio-quality feel.
Approx. Price	£163	£159	£277

Table 15: Microphone Comparisons

The brass section will use DPA4090 as they are highly popular in both live sound and studio applications. Plus due to it being a clip on mic, it provides better flexibility for the musicians.

The shotgun microphone used will be a Sennheiser MKH 416-P48U3 as these are high quality microphones that are quite standard in film and broadcasting scenarios.

A simple DI was chosen as the quality is still high however, it was a fraction of the price of the high-end DI. Mackie also provide stereo versions of this DI which will also be used.

DI	Mackie MDB-1P	RADIAL PRODI	Behringer Ultra DI400P
Key Features	Provides a 1/4" high-impedance input and thru with -15db pad and a balanced XLR output with ground lift.	High quality 1 channel passive DI box with -15dB pad and a ground lift	Very basic 1 channel passive DI box with no extra features.
Approx. Price	£43	£129	£25

Table 16: DI Comparisons

Wireless Vocal Microphone	GLXD24+/B87A	Sennheiser Digital 9000	Sennheiser EW 500 G4
Key Features	Lower range reciever. Fixed antenna. License free frequency zone (meaning more interference). 12 hours of usage.	Covers the ranges 470 – 798 MHz. 80 - 20,000 Hz audio frequency response. 5.5 hour usage.	Up to 88 MHz bandwidth and 32 channels and 3520 selectable frequencies. Wireless control with WSM software. 80 - 18,000 Hz frequency response. 8 Hours of use.
Approx. Price	£759	£2068	£892

Table 17: Wireless Microphone Comparisons

4.2.6 Signal Engine

Using a signal engine such as the DN100 enables compatibility with dante and d&b's en-space software. En-space can be used to enhance the auditory experience through boundary plane emulation technology (dbaudio, 2023) used to emulate other outdoor venues. This unit can also be configured in redundancy mode within the Dante network.

4.2.7 Waves SoundGrid

As the band specified they wanted to use Waves Soundgrid for DSP on the monitors, a DMI-WAVES card will be provided for the desk along with a One-C Server to run SuperRack.

4.3 System Integration

As all of the equipment selected is Dante compatible, and includes redundancy with power and networking, the system should be highly reliable. To further enhance this, a redundant star network will be integrated (Figure 9) as other typologies can cause drastic disruptions if a device fails within the network (Figure 8).

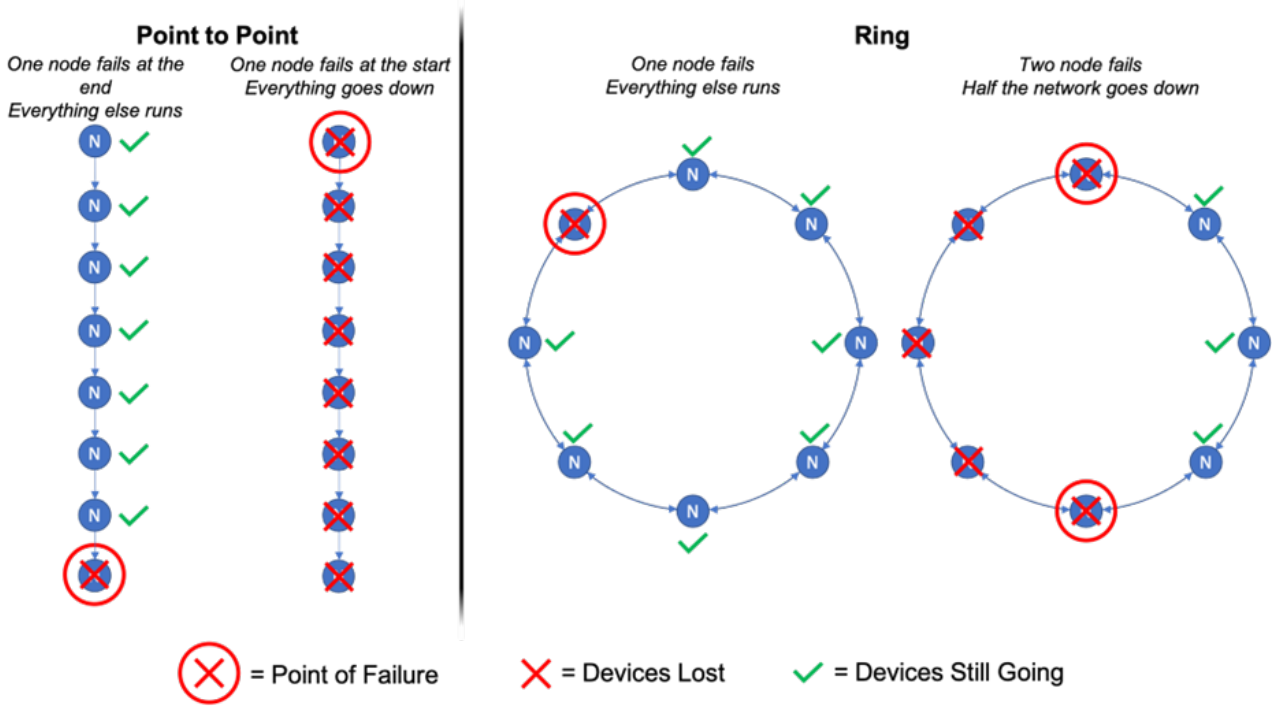


Figure 8: Point-to-Point and Ring Topology

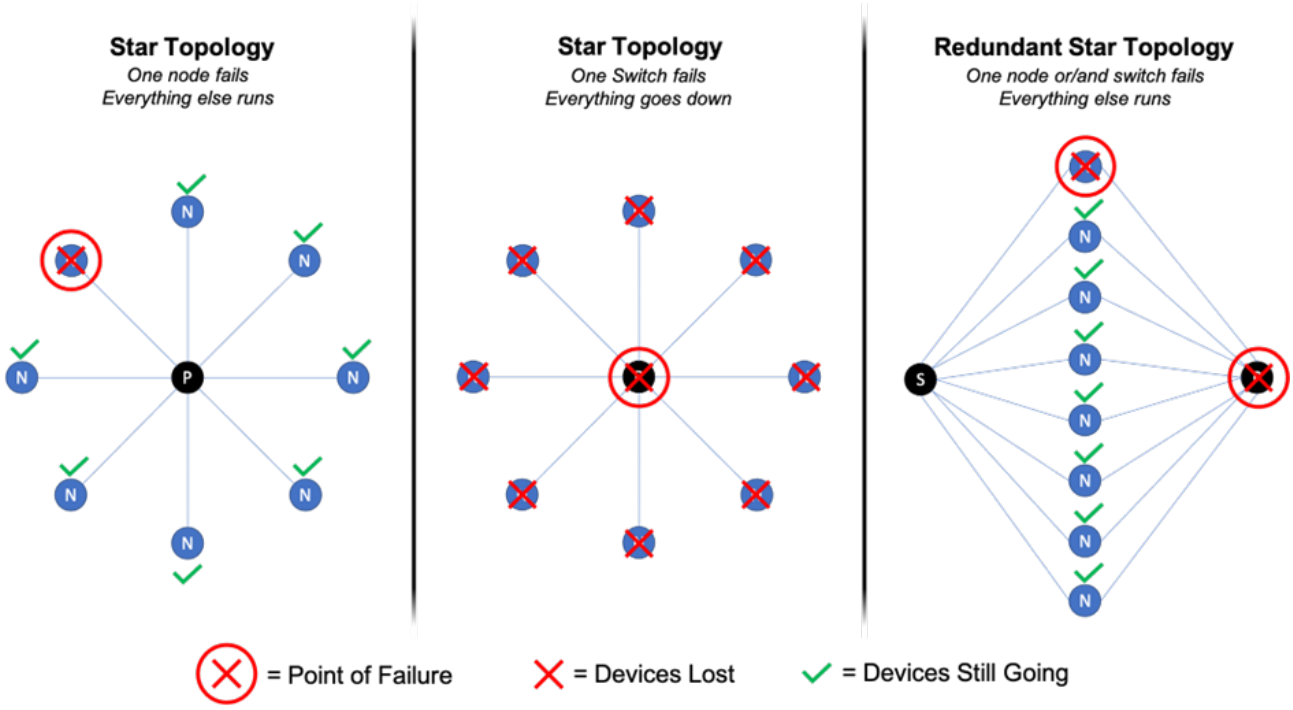


Figure 9: Start and Redundant Star Topology

The system integration plan below shows the FOH connections on the left and the stage connections on the right (Figure 10). iPads can also be used with a Wireless Access Point (WAP) to control either console remotely using the SD-Core 2 app.

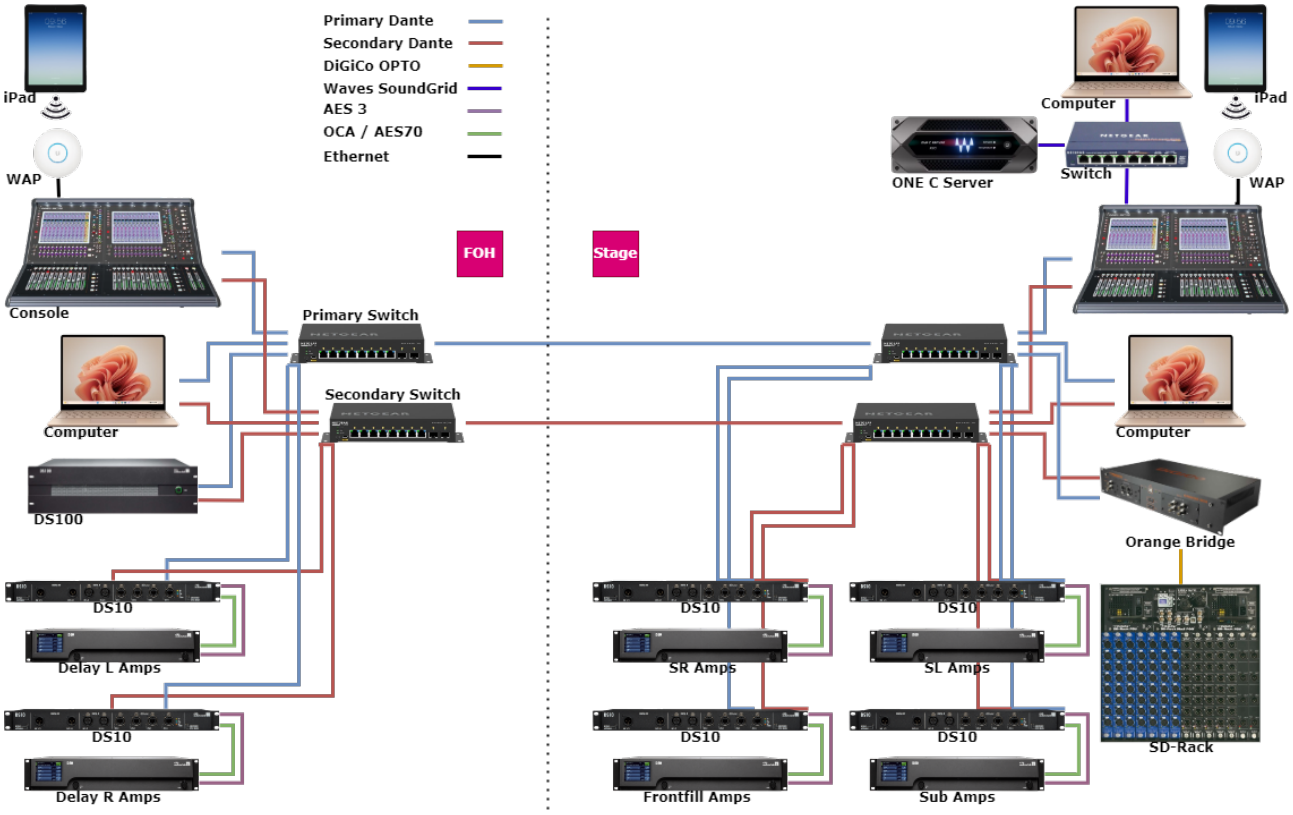


Figure 10: System Integration Plan (Light Blue: Primary Dante, Red: Secondary Dante, Yellow: OPTO, Dark Blue: SoundGrid, Purple: AES3, Green: AES80/OCA, Black: Standard Ethernet)

The amplifier configurations are provided at A.1 and the full patch sheet for the sound system is displayed at A.2; showing the routing between the network bridges, signal engine, amplifiers, and speakers.

4.3.1 Audio Networking

The choice of the audio networking protocol for this event is primarily influenced by its popularity and compatibility with an extensive list of products (Figure 11).

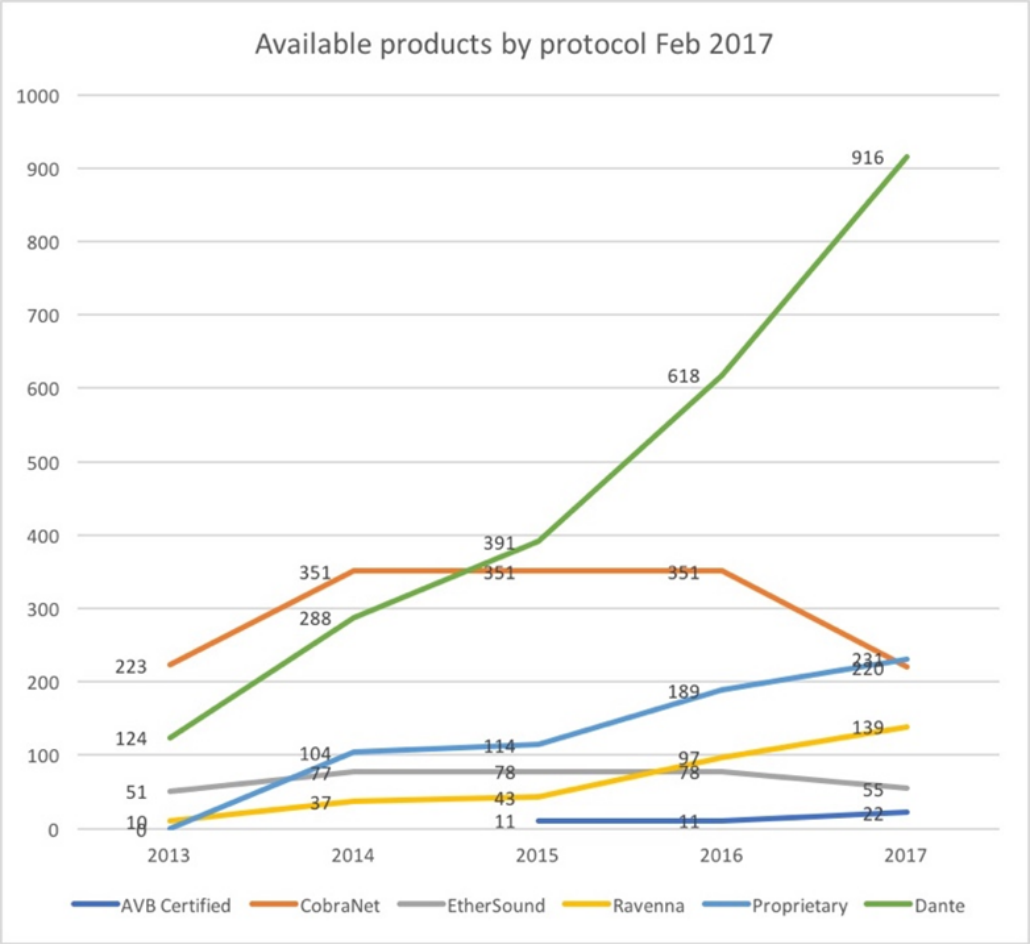


Figure 11: Popularity of Audio Networking Protocols

Dante enables Audio over IP, allowing seamless communication among compatible devices without requiring specific switches or cables—just a standard Ethernet (CAT5 or higher). Dante is an industry standard, offering expandability for audio, video, and lighting with many topology options such as the redundant star. It has user-friendly 'plug and play' features (making implementation easier) such as automatic device discovery and IP assignment through DHCP in Dante Controller, and automatic master clock assignment. Table 18 shows comparisons of other networks that were also explored.

	Pros	Cons
Dante	One of the most popular protocols in the industry with low latency and high quality audio. Requires standard Ethernet cables. Integrates with AES67. Scalable for all applications with a complete networking solution. 'Plug and play' with automatic device discovery and master clock assignment. Provides audio, video and lighting / DMX control. Any L2 or IP network topology can be used. Integrates well with many products including d7b audiotechnik.	Proprietary software which is expensive due to licensing and requires a few hours of training to understand the technology. Requires dedicated Dante enabled devices.
SoundGrid	Provides plugin processing, offload DSP to remote servers. Integration with waves plugins. Compatible with most of the DiGiCo SD range.	Proprietary software and hardware which is expensive as licensing is required for each server. Waves hardware is quite costly and not many companies provide waves as a standard networking protocol by default. Only allows for Star and daisy chain topologies. Only allows for 3 hops until higher latency starts to occur.
MADI	Easy to setup and quite reliable and robust. Allows for long cable runs with little signal loss. Cost-effective and is used widely on various Soundcraft and DiGiCo products.	Limited bandwidth for high channel counts. Requires Point-to-point connections with no redundancy. Lack of advanced features compared to IP protocols.
AES50	Part of the AES standard and is widely used on various Midas and Behringer products. Provides better channel count capability than AES3, ADAT and TDIF with low latency. Reliable with support for long cable runs and well suited for medium sized applications. Easy to install and understand	Only allows for Point-to-Point topology and limited interoperability with other protocols

AVB	IEEE standard for audio and video. Quality of Service (QoS) support and great with time sensitive applications. Scalable for various network sizes and low latency. Integrates well with L'Acoustics products. Open Source format so a lower cost.	Not as popular as Dante in the industry and requires proprietary networking equipment. Only allows spanning tree topology

Table 18: Networking Protocol Comparison

4.3.2 Full Equipment List

Type	Item	Price (inc VAT)	Quantity	Total Price
FOH & MON Console	SD12	£300*	2	£600
Stagebox	SD-Rack	£80*	1	£80
License	SuperRack License	£471	1 (optional)	£471
License	Dante License	£15	2	£30
License	G and GB RF License	£85	1	£85
Expansion Card	DMI-DANTE64@96	£1586	3	£4758
Expansion Card	DMI-WAVES	£931	1 (optional)	£931
DSP Server	ONE-C Server	£200*	1 (optional)	£200
Bridge	Orange Box	£1188	1	£1188
Bridge	DS10	£30*	6	£180
DSP Engine	DS100	£196*	1 (optional)	£196
Amplifier	D80	£70*	44	£3080
Amplifier	D40	£60*	12	£720
Amplifier	D20	£50*	5	£250
Speaker	GSL12	£70*	76	£5320
Speaker	KSL-SUB	£75*	8	£600
Speaker	KSL12	£65*	28	£1820
Speaker	SL-SUB	£80*	12	£960
Speaker	V8	£40*	6	£240
Speaker	V-SUB	£30*	2	£60
Speaker	Y10P	£35*	4	£140

Rigging	GSL Compression set	£15*	2	£30
Rigging	Hoist chain 4t	£15*	12 (only 10 if using aiming plate)	£180
Rigging	SL Aiming plate	£15*	6 (optional)	£90
Rigging	GSL Flying frame set	£15*	4	£60
Rigging	KSL Flying frame set	£15*	2	£30
Rigging	KSL Compression set	£15*	2	£30
Rigging	KSL-SUB Adapter frame	£15*	2	£30
Rigging	V Flying frame	£15*	2	£30
IEM Transmitter Set	Sennheiser SR2050	£3499	5	£17495
IEM pack	Sennheiser EM2050	-	20 (4 per bundle)	-
IEM battery charger	Sennheiser BA 2-way Charger	£182	2	£364
IEM spare batteries	Sennheiser BA 2015	£50	8	£400
IEM Antenna Combiner	Shure PA821B	£3110	2	£6220
IEM Antenna	Sennheiser A5000	£829	2	£1658
IEM Antenna Cable	$5\,\mathrm{m}$ N-Type Cable	£20	2	£40
IEM Antenna Cable	$10\,\mathrm{m}$ N-Type Cable	£50	2	£100
Hardware	Limiter Empirical Labs EL7X Fatso	£2449	2	£4898
Hardware	TC Electronic Reverb 4000	£764	2	£1528
Hardware	Waves Maxx BCL Digital Compressor	£1883	1	£1883
Switch	Cisco SG350-10MP	£250	4	£1000
Switch	Cisco SG250-08	£108	1	£108
WAP	Cisco Catalyst 9100 WAP	£300	2 (optional)	£600
Tablet	iPad	£326	2 (optional)	£652

Computer	MacBook Pro	£1699	2 (+1 optional)	£5097
Microphone	Sennheiser MKH 416-P48U3	£695	2	£1390
Microphone	DPA4090	£899	2	£1798
Microphone	Shure Beta 91A	£279	1	£279
Microphone	Shure Beta 52A	£165	1	£165
Microphone	Sennheiser e904	£155	2	£310
Microphone	Beyerdynamic M201TG	£303	2	£606
Microphone	Sennheiser e604	£144	1	£144
Microphone	Audix D4	£152	2	£304
Microphone	Shure SM81	£338	2	£676
Microphone	Shure KSM141	£341	2	£682
Microphone	Sennheiser e609	£96	3	£288
Microphone	SE8	£151	4	£604
Microphone	Sennheiser e945	£163	2	£326
DI	Mackie MDB-1P	£43	10	£430
DI	Mackie MDB-2P	£63	2	£126
Microphone	Shure SM57	£104	8	£832
Wireless Microphone Set	Sennheiser ew 500 G4	£892	4	£3568
Wireless Microphone	Sennheiser SKM 500 G4	-	4 (1 per bundle)	
Tall Stand	K&M 20800	£77	2	£154
Standard Stand	K&M 2102	£63	23	£1449
Short Stand	K&M 25905	£33	5	£165
Generator (1250 kVA)		£1750	1	£1750

Table 19: Full Equipment List (*day rental)

5 Power Requirements

It's important to calculate the correct generator size needed as it can pose risks if done incorrectly. Oversized generators can lead to potential damage to electrical systems, unnecessary operational costs, and inefficient power production. However, undersized generators may result in generator damage, overheating, insufficient or unreliable power, and failures in critical facilities. Optimal generator sizing is crucial to avoid these issues and ensure reliable and efficient power supply.

Hydrogen generators offer a sustainable and innovative solution. These generators utilize hydrogen fuel cells, producing electricity through a clean and efficient chemical reaction. Employing these would reduce the festivals carbon footprint as they produce only water vapor as a byproduct.

Generator	1250 kVA
Safe Capacity	$80\,\%$
Available kVA	1000 kVA
Amps (D80)	150.354 kVA
FOH (SD12)	0.232 kVA
MON (SD12)	0.232 kVA
Stagebox (SD RACK)	1.056 kVA
Receiver (EW 500 G4)	0.004 kVA
Transmitter (SR2050)	0.048 kVA
Bridge (Orange Box)	0.192 kVA
DSP (ONE-C Server)	0.046 kVA
Bridge (DS10)	0.01 kVA
DSP Engine (DS100)	0.4 kVA
Stage	25 kVA
Available kVA	822.426 kVA

Table 20: Power Requirements

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Appendices

A Speaker System

A.1 Amplifier Configurations

Main - Patch Total D80: 22

Cabinets		
Cab.	**Speaker**	**Link**
1	GSL12	--
2	GSL12	--
3	GSL12	--
4	GSL12	--
5	GSL12	--
6	GSL12	--
7	GSL12	--
8	GSL12	--
9	GSL12	--
10	GSL12	--
11	GSL12	--
12	GSL12	--
13	GSL12	--
14	GSL12	--
15	GSL12	--
16	GSL12	--
17	GSL12	--
18	GSL12	--
19	GSL12	--
20	GSL12	--
21	GSL12	--
22	GSL12	--

Left	Input mode: Digital / Digital		Input source: D1	
Channel name	**Amplifier**	**Output mode**	**Ch.**	**ID**
Main 01L	D80	2-Way Active / 2-Way Active	A/B	0.01
Main 02L	D80	2-Way Active / 2-Way Active	C/D	0.01
Main 03L	D80	2-Way Active / 2-Way Active	A/B	0.02
Main 04L	D80	2-Way Active / 2-Way Active	C/D	0.02
Main 05L	D80	2-Way Active / 2-Way Active	A/B	0.03
Main 06L	D80	2-Way Active / 2-Way Active	C/D	0.03
Main 07L	D80	2-Way Active / 2-Way Active	A/B	0.04
Main 08L	D80	2-Way Active / 2-Way Active	C/D	0.04
Main 09L	D80	2-Way Active / 2-Way Active	A/B	0.05
Main 10L	D80	2-Way Active / 2-Way Active	C/D	0.05
Main 11L	D80	2-Way Active / 2-Way Active	A/B	0.06
Main 12L	D80	2-Way Active / 2-Way Active	C/D	0.06
Main 13L	D80	2-Way Active / 2-Way Active	A/B	0.07
Main 14L	D80	2-Way Active / 2-Way Active	C/D	0.07
Main 15L	D80	2-Way Active / 2-Way Active	A/B	0.08
Main 16L	D80	2-Way Active / 2-Way Active	C/D	0.08
Main 17L	D80	2-Way Active / 2-Way Active	A/B	0.09
Main 18L	D80	2-Way Active / 2-Way Active	C/D	0.09
Main 19L	D80	2-Way Active / 2-Way Active	A/B	0.10
Main 20L	D80	2-Way Active / 2-Way Active	C/D	0.10
Main 21L	D80	2-Way Active / 2-Way Active	A/B	0.11
Main 22L	D80	2-Way Active / 2-Way Active	C/D	0.11

Right	Input mode: Digital / Digital		Input source: D1	
Channel name	**Amplifier**	**Output mode**	**Ch.**	**ID**
Main 01R	D80	2-Way Active / 2-Way Active	A/B	1.01
Main 02R	D80	2-Way Active / 2-Way Active	C/D	1.01
Main 03R	D80	2-Way Active / 2-Way Active	A/B	1.02
Main 04R	D80	2-Way Active / 2-Way Active	C/D	1.02
Main 05R	D80	2-Way Active / 2-Way Active	A/B	1.03
Main 06R	D80	2-Way Active / 2-Way Active	C/D	1.03
Main 07R	D80	2-Way Active / 2-Way Active	A/B	1.04
Main 08R	D80	2-Way Active / 2-Way Active	C/D	1.04
Main 09R	D80	2-Way Active / 2-Way Active	A/B	1.05
Main 10R	D80	2-Way Active / 2-Way Active	C/D	1.05
Main 11R	D80	2-Way Active / 2-Way Active	A/B	1.06
Main 12R	D80	2-Way Active / 2-Way Active	C/D	1.06
Main 13R	D80	2-Way Active / 2-Way Active	A/B	1.07
Main 14R	D80	2-Way Active / 2-Way Active	C/D	1.07
Main 15R	D80	2-Way Active / 2-Way Active	A/B	1.08
Main 16R	D80	2-Way Active / 2-Way Active	C/D	1.08
Main 17R	D80	2-Way Active / 2-Way Active	A/B	1.09
Main 18R	D80	2-Way Active / 2-Way Active	C/D	1.09
Main 19R	D80	2-Way Active / 2-Way Active	A/B	1.10
Main 20R	D80	2-Way Active / 2-Way Active	C/D	1.10
Main 21R	D80	2-Way Active / 2-Way Active	A/B	1.11
Main 22R	D80	2-Way Active / 2-Way Active	C/D	1.11

Outfill L - Patch Total D80: 8

Cabinets

Cab.	Speaker	Link
1	GSL12	--
2	GSL12	--
3	GSL12	--
4	GSL12	--
5	GSL12	--
6	GSL12	--
7	GSL12	--
8	GSL12	--
9	GSL12	--
10	GSL12	--
11	GSL12	--
12	GSL12	--
13	GSL12	--
14	GSL12	--
15	GSL12	--
16	GSL12	--

Input mode: Digital / Digital **Input source: D2**

Channel name	Amplifier	Output mode	Ch.	ID
Outfill L 01	D80	2-Way Active / 2-Way Active	A/B	2.01
Outfill L 02	D80	2-Way Active / 2-Way Active	C/D	2.01
Outfill L 03	D80	2-Way Active / 2-Way Active	A/B	2.02
Outfill L 04	D80	2-Way Active / 2-Way Active	C/D	2.02
Outfill L 05	D80	2-Way Active / 2-Way Active	A/B	2.03
Outfill L 06	D80	2-Way Active / 2-Way Active	C/D	2.03
Outfill L 07	D80	2-Way Active / 2-Way Active	A/B	2.04
Outfill L 08	D80	2-Way Active / 2-Way Active	C/D	2.04
Outfill L 09	D80	2-Way Active / 2-Way Active	A/B	2.05
Outfill L 10	D80	2-Way Active / 2-Way Active	C/D	2.05
Outfill L 11	D80	2-Way Active / 2-Way Active	A/B	2.06
Outfill L 12	D80	2-Way Active / 2-Way Active	C/D	2.06
Outfill L 13	D80	2-Way Active / 2-Way Active	A/B	2.07
Outfill L 14	D80	2-Way Active / 2-Way Active	C/D	2.07
Outfill L 15	D80	2-Way Active / 2-Way Active	A/B	2.08
Outfill L 16	D80	2-Way Active / 2-Way Active	C/D	2.08

Outfill R - Patch Total D80: 8

Cabinets

Cab.	Speaker	Link
1	GSL12	--
2	GSL12	--
3	GSL12	--
4	GSL12	--
5	GSL12	--
6	GSL12	--
7	GSL12	--
8	GSL12	--
9	GSL12	--
10	GSL12	--
11	GSL12	--
12	GSL12	--
13	GSL12	--
14	GSL12	--
15	GSL12	--
16	GSL12	--

Input mode: Digital / Digital **Input source: D2**

Channel name	Amplifier	Output mode	Ch.	ID
Outfill R 01	D80	2-Way Active / 2-Way Active	A/B	3.01
Outfill R 02	D80	2-Way Active / 2-Way Active	C/D	3.01
Outfill R 03	D80	2-Way Active / 2-Way Active	A/B	3.02
Outfill R 04	D80	2-Way Active / 2-Way Active	C/D	3.02
Outfill R 05	D80	2-Way Active / 2-Way Active	A/B	3.03
Outfill R 06	D80	2-Way Active / 2-Way Active	C/D	3.03
Outfill R 07	D80	2-Way Active / 2-Way Active	A/B	3.04
Outfill R 08	D80	2-Way Active / 2-Way Active	C/D	3.04
Outfill R 09	D80	2-Way Active / 2-Way Active	A/B	3.05
Outfill R 10	D80	2-Way Active / 2-Way Active	C/D	3.05
Outfill R 11	D80	2-Way Active / 2-Way Active	A/B	3.06
Outfill R 12	D80	2-Way Active / 2-Way Active	C/D	3.06
Outfill R 13	D80	2-Way Active / 2-Way Active	A/B	3.07
Outfill R 14	D80	2-Way Active / 2-Way Active	C/D	3.07
Outfill R 15	D80	2-Way Active / 2-Way Active	A/B	3.08
Outfill R 16	D80	2-Way Active / 2-Way Active	C/D	3.08

Delay Array L - Patch Total D40: 6

Cabinets

Cab.	Speaker	Link
1	KSL-SUB	--
2	KSL-SUB	--
3	KSL-SUB	--
4	KSL-SUB	--
5	KSL12	--
6	KSL12	5
7	KSL12	--
8	KSL12	7
9	KSL12	--
10	KSL12	9
11	KSL12	--
12	KSL12	11
13	KSL12	--
14	KSL12	13
15	KSL12	--
16	KSL12	15
17	KSL12	--
18	KSL12	17

Input mode: -- **Input source: D1**

Channel name	Amplifier	Output mode	Ch.	ID
Delay Arr... 01	D40	2-Way Active / 2-Way Active	A/B	4.01
Delay Arr... 02	D40	2-Way Active / 2-Way Active	C/D	4.01
Delay Arr... 03	D40	2-Way Active / 2-Way Active	A/B	4.02
Delay Arr... 04	D40	2-Way Active / 2-Way Active	C/D	4.02
Delay ... 05+06	D40	2-Way Active / 2-Way Active	A/B	4.03
Delay ... 07+08	D40	2-Way Active / 2-Way Active	C/D	4.03
Delay ... 09+10	D40	2-Way Active / 2-Way Active	A/B	4.04
Delay ... 11+12	D40	2-Way Active / 2-Way Active	C/D	4.04
Delay ... 13+14	D40	2-Way Active / 2-Way Active	A/B	4.05
Delay ... 15+16	D40	2-Way Active / 2-Way Active	C/D	4.05
Delay ... 17+18	D40	2-Way Active / 2-Way Active	A/B	4.06

Delay Array R - Patch Total D40: 6

Cabinets

Cab.	Speaker	Link
1	KSL-SUB	--
2	KSL-SUB	--
3	KSL-SUB	--
4	KSL-SUB	--
5	KSL12	--
6	KSL12	5
7	KSL12	--
8	KSL12	7
9	KSL12	--
10	KSL12	9
11	KSL12	--
12	KSL12	11
13	KSL12	--
14	KSL12	13
15	KSL12	--
16	KSL12	15
17	KSL12	--
18	KSL12	17

Input mode: -- **Input source: D1**

Channel name	Amplifier	Output mode	Ch.	ID
Delay Arr... 01	D40	2-Way Active / 2-Way Active	A/B	5.01
Delay Arr... 02	D40	2-Way Active / 2-Way Active	C/D	5.01
Delay Arr... 03	D40	2-Way Active / 2-Way Active	A/B	5.02
Delay Arr... 04	D40	2-Way Active / 2-Way Active	C/D	5.02
Delay ... 05+06	D40	2-Way Active / 2-Way Active	A/B	5.03
Delay ... 07+08	D40	2-Way Active / 2-Way Active	C/D	5.03
Delay ... 09+10	D40	2-Way Active / 2-Way Active	A/B	5.04
Delay ... 11+12	D40	2-Way Active / 2-Way Active	C/D	5.04
Delay ... 13+14	D40	2-Way Active / 2-Way Active	A/B	5.05
Delay ... 15+16	D40	2-Way Active / 2-Way Active	C/D	5.05
Delay ... 17+18	D40	2-Way Active / 2-Way Active	A/B	5.06

Nearfill Array - Patch Total D20: 2

Cabinets

Cab.	Speaker	Link
1	V8	--
2	V8	--
3	V8	2

Left **Input mode: Digital / Digital** **Input source: D3**

Channel name	Amplifier	Output mode	Ch.	ID
Nearfill... 01L	D20	Dual Channel / Dual Channel	A	6.01
Nearf... 02+03L	D20	Dual Channel / Dual Channel	B	6.01

Right **Input mode: Digital / Digital** **Input source: D3**

Channel name	Amplifier	Output mode	Ch.	ID
Nearfill... 01R	D20	Dual Channel / Dual Channel	A	7.01
Nearf... 02+03R	D20	Dual Channel / Dual Channel	B	7.01

Frontfill - Patch Total D20: 1

Cab.	Speaker	Link
1	Y10P-110x40	--
2	Y10P-110x40	--
3	Y10P-110x40	--
4	Y10P-110x40	--

Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
Frontfill 01	D20	Digital / Digital	D1	Dual Channel / Dual Channel	A	8.01
Frontfill 02	D20	Digital / Digital	D2	Dual Channel / Dual Channel	B	8.01
Frontfill 03	D20	Digital / Digital	D3	Dual Channel / Dual Channel	C	8.01
Frontfill 04	D20	Digital / Digital	D4	Dual Channel / Dual Channel	D	8.01

Sidefills - Patch Total D20: 2

Cab.	Speaker	Link
1	V-SUB	--
2	V-SUB	--

Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
Sidefills 01	D20	Digital / Digital	D4	Dual Channel / Dual Channel	C	6.01
Sidefills 02	D20	Digital / Digital	D4	Dual Channel / Dual Channel	C	7.01

SUB array - Patch Total D80: 6

R6

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
R6	SL-SUB	--	SUBarray R06-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	C/D	9.06

R5

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
R5	SL-SUB	--	SUBarray R05-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	A/B	9.06

R4

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
R4	SL-SUB	--	SUBarray R04-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	C/D	9.05

R3

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
R3	SL-SUB	--	SUBarray R03-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	A/B	9.05

R2

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
R2	SL-SUB	--	SUBarray R02-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	C/D	9.04

R1

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
R1	SL-SUB	--	SUBarray R01-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	A/B	9.04

L1

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
L1	SL-SUB	--	SUBarray L01-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	C/D	9.03

L2

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
L2	SL-SUB	--	SUBarray L02-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	A/B	9.03

L3

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
L3	SL-SUB	--	SUBarray L03-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	C/D	9.02

L4

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
L4	SL-SUB	--	SUBarray L04-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	A/B	9.02

L5

Cab.	Speaker	Link	Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
L5	SL-SUB	--	SUBarray L05-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	C/D	9.01

SUB array - Patch Total D80: 6

L6

Cab.	Speaker	Link
L6	SL-SUB	--

Channel name	Amplifier	Input type	src.	Output mode	Ch.	ID
SUBarray L06-01	D80	Digital / Digital	D1	2-Way Active / 2-Way Active	A/B	9.01

A.2 Patching

Source	Type	Pos	Cab	Speaker	Config	Link	Channel name	Amp	Amp. ID	In chan	Output mode	Out c	Bridge 1	B 1 Name	B 1 Ch.	Bridge 2	B 2 Name	B 2 ID	B 2 Ch.
Main	Array	L	1	GSL12			Main 01L	D80	0.01	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	2	GSL12			Main 02L	D80	0.01	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	3	GSL12			Main 03L	D80	0.02	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	4	GSL12			Main 04L	D80	0.02	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	5	GSL12			Main 05L	D80	0.03	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	6	GSL12			Main 06L	D80	0.03	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	7	GSL12			Main 07L	D80	0.04	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	8	GSL12			Main 08L	D80	0.04	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	9	GSL12			Main 09L	D80	0.05	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	10	GSL12			Main 10L	D80	0.05	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	11	GSL12			Main 11L	D80	0.06	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	12	GSL12			Main 12L	D80	0.06	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	13	GSL12			Main 13L	D80	0.07	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	14	GSL12			Main 14L	D80	0.07	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	15	GSL12			Main 15L	D80	0.08	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	16	GSL12			Main 16L	D80	0.08	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	17	GSL12			Main 17L	D80	0.09	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	18	GSL12			Main 18L	D80	0.09	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	19	GSL12			Main 19L	D80	0.1	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	20	GSL12			Main 20L	D80	0.1	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	21	GSL12			Main 21L	D80	0.11	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	1	DS100	DS100	0.12	1
	Array	L	22	GSL12			Main 22L	D80	0.11	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	1	DS100	DS100	0.12	1
Main	Array	R	1	GSL12			Main 01R	D80	1.01	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	2	GSL12			Main 02R	D80	1.01	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	3	GSL12			Main 03R	D80	1.02	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	4	GSL12			Main 04R	D80	1.02	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	5	GSL12			Main 05R	D80	1.03	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	6	GSL12			Main 06R	D80	1.03	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	7	GSL12			Main 07R	D80	1.04	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	8	GSL12			Main 08R	D80	1.04	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	9	GSL12			Main 09R	D80	1.05	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	10	GSL12			Main 10R	D80	1.05	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	11	GSL12			Main 11R	D80	1.06	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	12	GSL12			Main 12R	D80	1.06	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	13	GSL12			Main 13R	D80	1.07	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	14	GSL12			Main 14R	D80	1.07	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	15	GSL12			Main 15R	D80	1.08	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	16	GSL12			Main 16R	D80	1.08	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	17	GSL12			Main 17R	D80	1.09	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	18	GSL12			Main 18R	D80	1.09	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	19	GSL12			Main 19R	D80	1.1	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	20	GSL12			Main 20R	D80	1.1	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	21	GSL12			Main 21R	D80	1.11	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	1	DS100	DS100	0.12	2
	Array	R	22	GSL12			Main 22R	D80	1.11	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	1	DS100	DS100	0.12	2
Outfill L	Array	L	1	GSL12			Outfill L 01	D80	2.01	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	2	GSL12			Outfill L 02	D80	2.01	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	3	GSL12			Outfill L 03	D80	2.02	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	2	DS100	DS100	0.12	3

	Array	L	4	GSL12			Outfill L 04	D80	2.02	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	5	GSL12			Outfill L 05	D80	2.03	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	6	GSL12			Outfill L 06	D80	2.03	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	7	GSL12			Outfill L 07	D80	2.04	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	8	GSL12			Outfill L 08	D80	2.04	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	9	GSL12			Outfill L 09	D80	2.05	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	10	GSL12			Outfill L 10	D80	2.05	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	11	GSL12			Outfill L 11	D80	2.06	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	12	GSL12			Outfill L 12	D80	2.06	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	13	GSL12			Outfill L 13	D80	2.07	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	14	GSL12			Outfill L 14	D80	2.07	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	15	GSL12			Outfill L 15	D80	2.08	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-L	2	DS100	DS100	0.12	3
	Array	L	16	GSL12			Outfill L 16	D80	2.08	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-L	2	DS100	DS100	0.12	3
Outfill R	Array	R	1	GSL12			Outfill R 01	D80	3.01	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	2	GSL12			Outfill R 02	D80	3.01	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	3	GSL12			Outfill R 03	D80	3.02	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	4	GSL12			Outfill R 04	D80	3.02	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	5	GSL12			Outfill R 05	D80	3.03	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	6	GSL12			Outfill R 06	D80	3.03	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	7	GSL12			Outfill R 07	D80	3.04	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	8	GSL12			Outfill R 08	D80	3.04	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	9	GSL12			Outfill R 09	D80	3.05	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	10	GSL12			Outfill R 10	D80	3.05	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	11	GSL12			Outfill R 11	D80	3.06	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	12	GSL12			Outfill R 12	D80	3.06	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	13	GSL12			Outfill R 13	D80	3.07	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	14	GSL12			Outfill R 14	D80	3.07	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	15	GSL12			Outfill R 15	D80	3.08	D2	2-Way Active / 2-Way Active	A/B	DS10	DS10-R	2	DS100	DS100	0.12	4
	Array	R	16	GSL12			Outfill R 16	D80	3.08	D2	2-Way Active / 2-Way Active	C/D	DS10	DS10-R	2	DS100	DS100	0.12	4
Delay Array L	Array	D L	1	KSL-SUB			Delay Arr... 01	D40	4.01	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	2	KSL-SUB			Delay Arr... 02	D40	4.01	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	3	KSL-SUB			Delay Arr... 03	D40	4.02	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	4	KSL-SUB			Delay Arr... 04	D40	4.02	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	5	KSL12			Delay ... 05+06	D40	4.03	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	6	KSL12	5														
	Array	D L	7	KSL12			Delay ... 07+08	D40	4.03	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	8	KSL12	7														
	Array	D L	9	KSL12			Delay ... 09+10	D40	4.04	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	10	KSL12	9														
	Array	D L	11	KSL12			Delay ... 11+12	D40	4.04	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	12	KSL12	11														
	Array	D L	13	KSL12			Delay ... 13+14	D40	4.05	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	14	KSL12	13														
	Array	D L	15	KSL12			Delay ... 15+16	D40	4.05	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	16	KSL12	15														
	Array	D L	17	KSL12			Delay ... 17+18	D40	4.06	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-L-D	1	DS100	DS100	0.12	13
	Array	D L	18	KSL12	17														
Delay Array R	Array	D R	1	KSL-SUB			Delay Arr... 01	D40	5.01	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R-D	1	DS100	DS100	0.12	14

	Array	D R	2	KSL-SUB			Delay Arr... 02	D40	5.01	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	3	KSL-SUB			Delay Arr... 03	D40	5.02	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	4	KSL-SUB			Delay Arr... 04	D40	5.02	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	5	KSL12			Delay ... 05+06	D40	5.03	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	6	KSL12		5													
	Array	D R	7	KSL12			Delay ... 07+08	D40	5.03	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	8	KSL12		7													
	Array	D R	9	KSL12			Delay ... 09+10	D40	5.04	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	10	KSL12		9													
	Array	D R	11	KSL12			Delay ... 11+12	D40	5.04	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	12	KSL12		11													
	Array	D R	13	KSL12			Delay ... 13+14	D40	5.05	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	14	KSL12		13													
	Array	D R	15	KSL12			Delay ... 15+16	D40	5.05	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	16	KSL12		15													
	Array	D R	17	KSL12			Delay ... 17+18	D40	5.06	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-R-D	1	DS100	DS100	0.12	14
	Array	D R	18	KSL12		17													
Nearfill Array	Array	C L	1	V8			Nearfill... 01L	D20	6.01	D3	Dual Channel / Dual Channel	A	DS10	DS10-L	3	DS100	DS100	0.12	5
	Array	C L	2	V8			Nearf... 02+03L	D20	6.01	D3	Dual Channel / Dual Channel	B	DS10	DS10-L	3	DS100	DS100	0.12	5
	Array	C L	3	V8		2													
Nearfill Array	Array	C R	1	V8			Nearfill... 01R	D20	7.01	D3	Dual Channel / Dual Channel	A	DS10	DS10-R	3	DS100	DS100	0.12	6
	Array	C R	2	V8			Nearf... 02+03R	D20	7.01	D3	Dual Channel / Dual Channel	B	DS10	DS10-R	3	DS100	DS100	0.12	6
	Array	C R	3	V8		2													
Frontfill	Point	C	1	Y10P	110x40		Frontfill 01	D20	8.01	D1	Dual Channel / Dual Channel	A	DS10	DS10-FF	1	DS100	DS100	0.12	7
	Point	C	2	Y10P	110x40		Frontfill 02	D20	8.01	D2	Dual Channel / Dual Channel	B	DS10	DS10-FF	2	DS100	DS100	0.12	8
	Point	C	3	Y10P	110x40		Frontfill 03	D20	8.01	D3	Dual Channel / Dual Channel	C	DS10	DS10-FF	3	DS100	DS100	0.12	9
	Point	C	4	Y10P	110x40		Frontfill 04	D20	8.01	D4	Dual Channel / Dual Channel	D	DS10	DS10-FF	4	DS100	DS100	0.12	10
Sidefills	Point	L	1	V-SUB			Sidefills 01	D20	6.01	D4	Dual Channel / Dual Channel	C	DS10	DS10-L	4				
	Point	R	2	V-SUB			Sidefills 02	D20	7.01	D4	Dual Channel / Dual Channel	C	DS10	DS10-R	4				
SUB array	Sub	R6	1	SL-SUB			SUBarray R06-01	D80	9.06	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	R5	1	SL-SUB			SUBarray R05-01	D80	9.06	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	R4	1	SL-SUB			SUBarray R04-01	D80	9.05	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	R3	1	SL-SUB			SUBarray R03-01	D80	9.05	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	R2	1	SL-SUB			SUBarray R02-01	D80	9.04	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	R1	1	SL-SUB			SUBarray R01-01	D80	9.04	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	L1	1	SL-SUB			SUBarray L01-01	D80	9.03	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	L2	1	SL-SUB			SUBarray L02-01	D80	9.03	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	L3	1	SL-SUB			SUBarray L03-01	D80	9.02	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	L4	1	SL-SUB			SUBarray L04-01	D80	9.02	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	L5	1	SL-SUB			SUBarray L05-01	D80	9.01	D1	2-Way Active / 2-Way Active	C/D	DS10	DS10-Sub	1	DS100	DS100	0.12	11
	Sub	L6	1	SL-SUB			SUBarray L06-01	D80	9.01	D1	2-Way Active / 2-Way Active	A/B	DS10	DS10-Sub	1	DS100	DS100	0.12	11

A.3 Rigging

The main line array's splay over the audience is displayed in Figure 12 showing how it performs a full coverage over the whole plane.

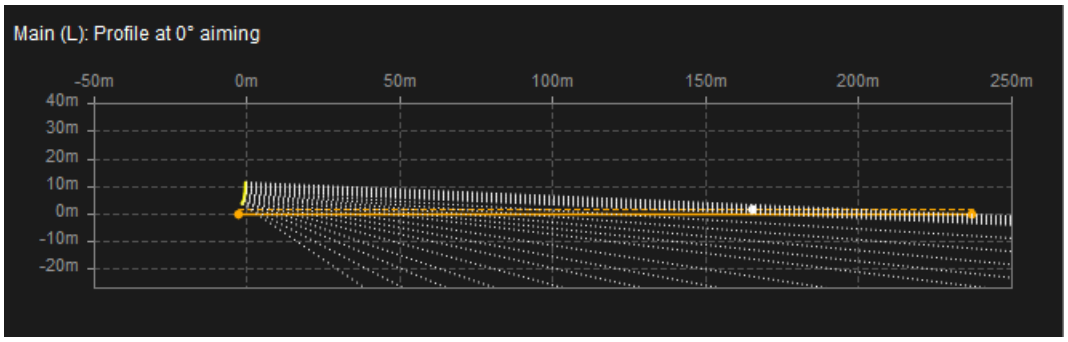

Figure 12: The splay of the main line array

Rigging plot

WARNING! Always make sure that each of your hoists is able to carry the total weight of the array.

Pick points

Main	**Rear pick**	**Front pick**	**Distance**	**Single pick**	**Height of lowest edge**
X:	1.23 m	2.51 m	1.28 m	--	
Y:	-9.96 m	-10.00 m	0.04 m	--	3.37 m
Pick point hole:	33	1		--	
Load:	1090 kg	740 kg	(Total:)	--	Load OK
Overall dimensions (depth | width | height):	2.08 m	1.30 m	8.68 m		
Outfill L	**Rear pick**	**Front pick**	**Distance**	**Single pick**	**Height of lowest edge**
X:	-0.75 m	0.07 m	0.82 m	invalid	
Y:	-11.10 m	-12.08 m	0.98 m	invalid	4.11 m
Pick point hole:	33	1		invalid	
Load:	884 kg	505 kg	(Total:)	invalid	Load OK
Overall dimensions (depth | width | height):	2.00 m	1.30 m	6.46 m		
Outfill R	**Rear pick**	**Front pick**	**Distance**	**Single pick**	**Height of lowest edge**
X:	-0.75 m	0.07 m	0.82 m	invalid	
Y:	11.10 m	12.08 m	0.98 m	invalid	4.11 m
Pick point hole:	33	1		invalid	
Load:	884 kg	505 kg	(Total:)	invalid	Load OK
Overall dimensions (depth | width | height):	2.00 m	1.30 m	6.46 m		
Delay Array L	**Rear pick**	**Front pick**	**Distance**	**Single pick**	**Height of lowest edge**
X:	124.06 m	125.01 m	0.95 m	invalid	
Y:	-9.66 m	-10.00 m	0.35 m	invalid	4.12 m
Pick point hole:	26	1		invalid	
Load:	999 kg	265 kg	(Total:)	invalid	Load OK
Overall dimensions (depth | width | height):	2.25 m	1.00 m	6.43 m		
Delay Array R	**Rear pick**	**Front pick**	**Distance**	**Single pick**	**Height of lowest edge**
X:	124.06 m	125.01 m	0.95 m	invalid	
Y:	9.66 m	10.00 m	0.35 m	invalid	4.12 m
Pick point hole:	26	1		invalid	
Load:	999 kg	265 kg	(Total:)	invalid	Load OK
Overall dimensions (depth | width | height):	2.25 m	1.00 m	6.43 m		

Notes

Rigging plot

WARNING! Always make sure that each of your hoists is able to carry the total weight of the array.

Pick points

Nearfill Array	Rear pick	Front pick	Distance	Single pick	Height of lowest edge
X:	--	--	--	--	
Y:	--	--	--	--	--
Pick point hole:	--	--		--	
Load:	--	--	(Total:)	--	
Overall dimensions (depth | width | height):		0.79 m	0.70 m	3.51 m	

Notes

Rigging plot

Cabinet layout

Frontfill

Cab.	x/m	y/m	z/m	Horizontal	Vertical	Rotation
1	-0.60	0.75	2.80	45 °	0 °	0 °
2	-0.60	0.25	2.80	15 °	0 °	0 °
3	-0.60	-0.25	2.80	-15 °	0 °	0 °
4	-0.60	-0.75	2.80	-45 °	0 °	0 °

Sidefills

Cab.	x/m	y/m	z/m	Horizontal	Vertical	Rotation
1	-5.00	10.00	2.50	225 °	0 °	0 °
2	-5.00	-10.00	2.50	-225 °	0 °	0 °

A.4 Delay Times

The delay times were calculated using a specific test position, $150\,\mathrm{m}$ away from the main stage.

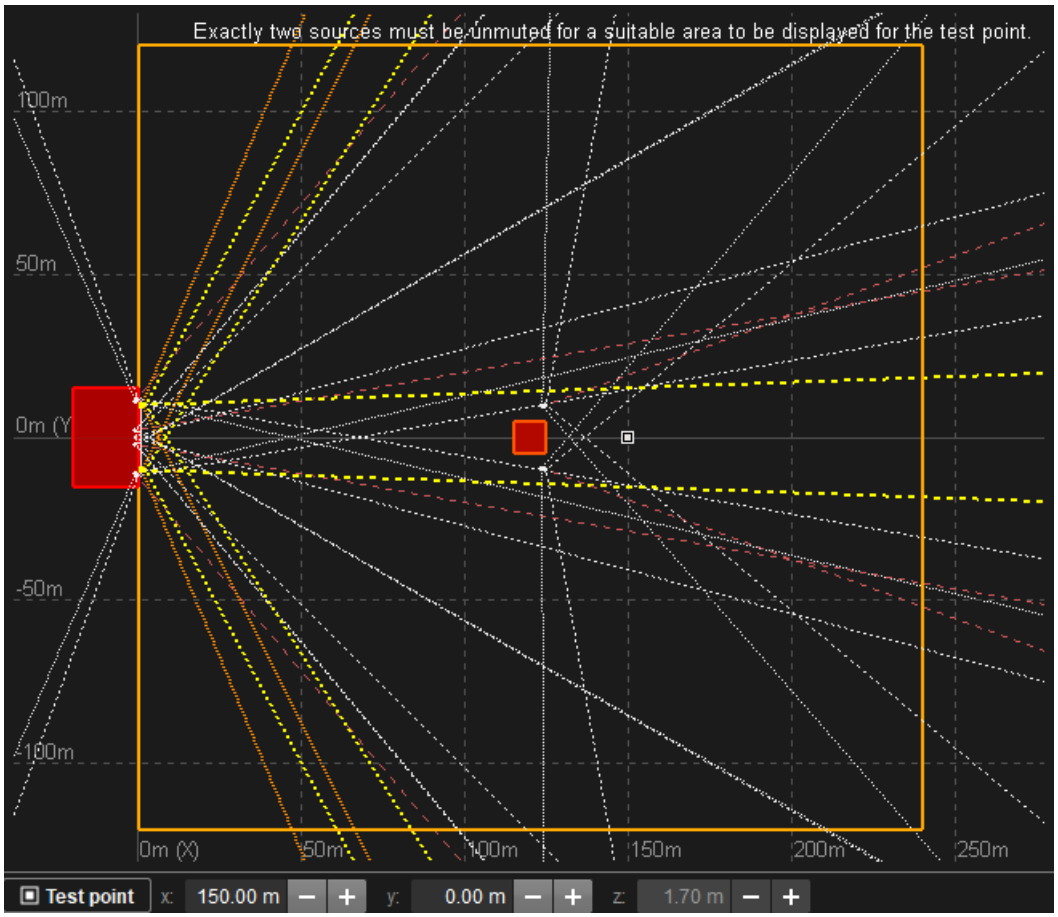

Figure 13: The splay of the main line array

Alignment

Arrays (delay times)

Main	13.3 ms	Outfill L	6.2 ms	Outfill R	6.2 ms	Delay Array L	364.4 ms	Delay Array R	364.4 ms	Nearfill Array	6.6 ms

Point sources (delay times)

Frontfill

1	8.3 ms	**2**	8.3 ms	**3**	8.3 ms	**4**	8.3 ms

Sidefills

1	4.1 ms	**2**	4.1 ms

SUB array (delay times)

L6	15.4 ms	L5	11.5 ms	L4	10.1 ms	L3	9.3 ms	L2	8.8 ms	L1	8.6 ms	R1	8.6 ms	R2	8.8 ms	R3	9.3 ms	R4	10.1 ms	R5	11.5 ms
R6	15.4 ms																				

A.5 Parts

Parts list

Arrays	d&b part no.	Array 1 Main (pair)	Array 2 Outfill L (single)	Array 3 Outfill R (single)	Array 4 Delay Array L (single)	Array 5 Delay Array R (single)	Array 6 Nearfill Array (pair)	SUB array 1 SUB array	Total
GSL									
GSL12	Z0751	44	16	16					76
Rigging parts:									
GSL Compression set	Z5704		1	1					2
Hoist chain 4t	Z5706	4	2	2					8
SL Aiming plate (optional)	Z5707	2	1	1					4
GSL Flying frame set	Z5708	2	1	1					4
Note: When using aiming plate, only 2 hoist chains are needed.									
KSL									
KSL-SUB	Z0785				4	4			8
KSL12	Z0781				14	14			28
Rigging parts:									
Hoist chain 4t	Z5706				2	2			4
SL Aiming plate (optional)	Z5707				1	1			2
KSL Flying frame set	Z5721				1	1			2
KSL Compression set	Z5724				1	1			2
KSL-SUB Adapter frame	Z5747				1	1			2
Note: When using aiming plate, only 2 hoist chains are needed.									
SL-SUB									
SL-SUB	Z0760							12	12

Parts list

Arrays	d&b part no.	Array 1 Main (pair)	Array 2 Outfill L (single)	Array 3 Outfill R (single)	Array 4 Delay Array L (single)	Array 5 Delay Array R (single)	Array 6 Nearfill Array (pair)	SUB array 1 SUB array	Total
V-Series									
V8	Z0515						6		6
Rigging parts:									
V Flying frame	Z5380						2		2
Amplifiers		Chs	Chs	Chs	Chs	Chs	Chs	Chs	Amps
D80	Z2710	88	32	32				24	44
D20	Z2750						4		2
D40	Z2850				22	22			12

Parts list

Point sources	d&b part no.	PSG 1 Frontfill	PSG 2 Sidefills	Total
V-Series				
V-SUB	Z0518		2	2
Y-Series				
Y10P	Z0703	4		4
Amplifiers		Chs	Chs	Amps
D20	Z2750	4	2	3

Parts list

Audio network devices	d&b part no.	Total
DS10	Z4010	6
DS100	Z4100	2
DN1	Z4001	--
Generic	--	--

B Risk Assessment

Risk Assessment

BIRMINGHAM CITY University

Assessment Ref:	LSR2-Assessment	**Location**	The Town More Newcastle Upon Tyne, UK	**Activity**	Newcastle Festival
Date of 1st Assessment	07/01/2024		**Risk Assessor(s)** (Worker Representative)	Harvey Fretwell	

Scope of Assessment e.g. details of process or activity, what the assessment will include

Live Sound Festival

Record of Reviews		
Date Review Completed	**Reason for Review**	**Risk Assessor**

Likelihood and Severity Ratings and Guidance			
Severity Rating (SR)		**Likelihood Rating (LR)**	
1	None	1	Highly Unlikely
2	Minor Injury or illness	2	Unlikely
3	Over 7 Day Injury or illness	3	Possible
4	Major Injury or illness	4	Likely
5	Fatal	5	Highly Likely

Risk Evaluation Matrix						
P x S = Risk		**Severity (Outcome)**				
		1	**2**	**3**	**4**	**5**
Probability (Likelihood)	**5**	**5 Mod**	**10 Mod**	**15 Sig**	**20 High**	**25 High**
	4	**4 Low**	**8 Mod**	**12 Sig**	**16 high**	**20 High**
	3	**3 Low**	**6 Mod**	**9 Mod**	**12 Sig**	**15 Sig**
	2	**2 Low**	**4 Low**	**6 Mod**	**8 Mod**	**10 Mod**
	1	**1 Low**	**2 Low**	**3 Low**	**4 Low**	**5 Mod**

High 16 - 25	**High Risk - Unacceptable** Control measures must be introduced to reduce the degree of risk prior to the activity/ process proceeding.
Significant 12 - 15	**Significant Risk – Priority Action Required** Immediate review of controls must be undertaken, interim controls may be necessary in order for activity/process to continue.
Moderate 5 - 10	**Moderate Risk - Tolerable** Activity/process can continue, but additional controls may need to be introduced to further reduce the risk prior to start of task
Low 1 - 4	**Low Risk - Acceptable** Risk is being adequately controlled; but further control measures may further reduce the risk.

Risk Assessment

Hazard	Who Might Be Harmed	Existing Control Measures (if any)	Initial Risk Rating			Additional Control Measures (if required)	Final Risk Rating		
			SR	LR	Risk Level		SR	LR	Risk Level
Electrical hazards	Everyone	• **Ensure equipment is properly grounded.** • **Check for mods or damage to equipment.** • **Regularly inspect equipment via PAT tests.** • **Provide electrical safety training.** • **Don't overload extension leads by for instance daisy chaining or going over it's max capacity.** • **Keep in safe conditions away from moisture.** • **Use residual current breakers.** • **Fence off high danger areas i.e. generators.**	5 High	1 Low	5 Mod	• Remind other equipment should be PAT tested.	5 High	1 Low	5 Mod

Risk Assessment

BIRMINGHAM CITY University

Hazard	Who Might Be Harmed	Existing Control Measures (if any)	Initial Risk Rating			Additional Control Measures (if required)	Final Risk Rating		
			SR	LR	Risk Level		SR	LR	Risk Level
Trip hazards from cables (on stage)	Crew and performers	• Use cable ramps. • Secure cables with tape. • Clearly mark cable paths. • Educate performers and crew on cable safety and management i.e. how to reverse coil.	4 High	2 Low	8 Mod	• Make sure cables are under the stands. • Run cable runs under stage.	4 High	1 Low	4 Low
Trip hazards from cables (other)	Everyone	• **Secure cables with covers / ramps or tape in high traffic area.** • **Use proper cable management such as cable tidies.**	4 High	2 Low	8 Mod	• Make sure good quality tape is used and stuck properly covering the whole area and replaced when needed.	4 High	1 Low	4 Low

Risk Assessment

BIRMINGHAM CITY University

Hazard	Who Might Be Harmed	Existing Control Measures (if any)	Initial Risk Rating			Additional Control Measures (if required)	Final Risk Rating		
			SR	LR	Risk Level		SR	LR	Risk Level
Other slip trip and fall hazards	Everyone	• **Regularly inspect and maintain walkways.** • **Use nonslip mats and signage when wet or slippery.** • **Coloured tape on steps or level changes.** • **Provide lighting on potential hazards.** • **AV networking limits cable runs.**	4 High	2 Low	8 Mod	• Provide railings with good lighting	4 High	1 Low	4 Low
Noise exposure damaging ears	Everyone	• **Provide personal protective equipment.** • **Monitor sound levels don't go over 108dBA.** • **Swap staff around in high exposure areas.** • **Warn of hearing damage in advance.** • **Provide 1m distance from audience to speakers.**	3 Sig	2 Low	6 Mod	• Provide designated zones where the SPL is significantly quieter.	3 Sig	1 Low	3 Low
Structural failures	Everyone	• **Regularly inspect and maintain stage structures.** • **Have emergency evacuation plan in place.** • **Don't exceed max weight capacities when flying equipment.** • **Use safety chains.**	5 High	2 Low	10 Mod	• Make sure for flow speakers that the safety chains are secured and not too long.	5 High	1 Low	5 Mod

Risk Assessment

Hazard	Who Might Be Harmed	Existing Control Measures (if any)	Initial Risk Rating			Additional Control Measures (if required)	Final Risk Rating		
			SR	LR	Risk Level		SR	LR	Risk Level
Crowd control issues	Everyone	• **Hire trained security.** • **Manage crowd numbers in certain areas.** • **Don't serve alcohol to underaged or over the influence.** • **Implement crowd barriers.** • **No glasses allowed.** • **Have emergency evacuation plan.**	5 High	1 Low	5 Mod	• Make clear signs with prohibited items	5 High	1 Low	5 Mod
Fire hazards	Everyone	• **Conduct fire safety drills.** • **Provide fire safety training.** • **Provide fire extinguishers.** • **Clearly mark emergency exits.** • **Provide fire marshals.** • **Make sure exits are clear.**	5 High	1 Low	5 Mod		5 High	1 Low	5 Mod
Heat-related issues	Everyone	• **Provide shade.** • **Include hydration stations.** • **Monitor weather conditions.** • **Have medical teams on standby.**	5 High	1 Low	5 Mod		5 High	1 Low	5 Mod
Medical emergencies	Everyone	• **Provide adequate first aid trained staff (2 to 1000 people minimum).** • **Provide ambulances / paramedics on site.**	5 High	1 Low	5 Mod		5 High	1 Low	5 Mod
Inadequate lighting	Everyone	• **Ensure proper lighting in all areas especially walkways and emergency exits.** • **Regularly check and replace bulbs.**	4 High	1 Low	4 Low		4 High	1 Low	4 Low

Risk Assessment

Hazard	Who Might Be Harmed	Existing Control Measures (if any)	Initial Risk Rating			Additional Control Measures (if required)	Final Risk Rating		
			SR	LR	Risk Level		SR	LR	Risk Level
Equipment failure	Performers, crew	• **Regularly inspect and maintain equipment.** • **Have backup systems.** • **Provide redundancy.**	5 High	1 Low	5 Mod		5 High	1 Low	5 Mod
Manual handling injury	The engineers	• **Provide equipment such as trollies to move tech.** • **Train staff on manual handling** • **Provide easy tilt stands for consoles.** • **Make sure enough people lift equipment.**	4 High	2 Low	8 Mod	• Anyone with back issues or at higher risk should not lift.	4 High	1 Low	4 Low

Risk Assessment

BIRMINGHAM CITY University

Action Plan				
Risk or Activity	**Additional Controls and Actions required**	**Action Owner**	**Target Date**	**Completion Date**
Example	Reorganise room so cables do not trail. Monitor use of additional, unnecessary equipment. Daily visual inspection.	Department Manager	4 weeks	

C Patch Sheet

Sub Snake	Sub Snake	Stage Box Chan	IN Chan	Name	48V	Mic / DI	Type	Sends / Return	Group	Pos	Stand	Notes
1	1	A1	1	Kick In	x	Beta91A	Mic		Drums	USL		
1	2	A2	2	Kick Out		Beta52A	Mic		Drums	USL	Short	
1	3	A3	3	Snare T		e904	Mic	Send to EL76 1	Drums	USL	Short	
1	4	A4	4	Snare B		M201TG	Mic		Drums	USL	Clip	
		A5	5	Snare FATSO			Return	Return from EL76 1	Drums	-		Tape saturation / compression
1	5	A6	6	Snare 2 T		e904	Mic		Drums	USL	Short	
1	6	A7	7	Snare 2 B		M201TG	Mic		Drums	USL	Clip	
1	7	A8	8	Hats	x	SM81	Mic		Drums	USL	Standard	
1	8	B1	9	Rack		e604	Mic		Drums	USL	Clip	
1	9	B2	10	Floor 1		Audix D4	Mic	Send to EL76 1	Drums	USL	Clip	
		B3	11	Floor FATSO			Return	Return from EL76 2	Drums	-		Tape saturation / compression
1	10	B4	12	Floor 2		Audix D4	Mic		Drums	USL	Clip	
2	1	B5	13	Ride	x	SM81	Mic		Drums	USL	Standard	
2	2	B6	14	OH SR	x	KSM141	Mic		Drums	USL	Tall	
2	3	B7	15	OH SL	x	KSM141	Mic		Drums	USL	Tall	
3	9	B8	16	Bass Pre		MDB-1P	DI		Bass	USC		Dry Bass
3	10	C1	17	Bass Post			XLR		Bass	USC		Wet Bass
4	1	C2	18	Rich GTR L		e609	Mic		Guitars	C	Standard	Stereo Electric Guitar
4	2	C3	19	Rich GTR R		e609	Mic		Guitars	C	Standard	Stereo Electric Guitar
4	3	C4	20	Rich Acc		MDB-1P	DI		Acoustic Guitars	C		Acoustic Guitar
4	4	C5	21	Pete GTR		e609	Mic		Guitars	C	Standard	Electric Guitar
4	5	C6	22	Pete Acc		MDB-1P	DI		Acoustic Guitars	C		Acoustic Guitar
4	9	C7	23	Rory Acc		MDB-1P	DI		Acoustic Guitars	C		Acoustic Guitar
5	1	C8	24	Nord L		MDB-2P	DI		Keys	SR		Stereo Keys
5	2	D1	25	Nord R		-	DI		Keys	SR		Stereo Keys
5	3	D2	26	Piano L	x	SE8	Mic		Keys	SR	Standard	
5	4	D3	27	Piano R	x	SE8	Mic		Keys	SR	Standard	
6	2	D4	28	Leslie L	x	SE8	Mic		Keys	USR	Standard	Hammond Leslie
6	3	D5	29	Leslie R	x	SE8	Mic		Keys	USR	Standard	Hammond Leslie
6	4	D6	30	Leslie Sub		MDB-1P	DI		Keys	USR		
3	1	D7	31	Paul Melo		MDB-1P	DI		Keys	USC		Mono Synth
3	2	D8	32	Paul Wirly L		MDB-2P	DI		Keys	USC		Stereo Synth
3	3	E1	33	Paul Wirly R		-	DI		Keys	USC		Stereo Synth
3	4	E2	34	Prophet 5		MDB-1P	DI		Keys	USC		Mono Synth
3	5	E3	35	DX7		MDB-1P	DI		Keys	USC		Yamaha DX7 Keys
3	6	E4	36	Trumpet	x	DPA4090	Mic		Brass	USC	Clip	
3	7	E5	37	Trumpet FX		MDB-1P	DI		Brass	USC		
4	6	E6	38	Trombone	x	DPA4090	Mic		Brass	C	Clip	
	Wireless	E7	39	Rory VOX		SKM500G4	RF Mic		Vocals	DSC	Standard	
	Cable run	E8	40	Rory Spare		e945	Mic		Vocals	DSC	Standard	
	Wireless	F1	41	B Vox 1		SKM500G4	RF Mic		Vocals	SL	Standard	
	Wireless	F2	42	B Vox 2		SKM500G4	RF Mic		Vocals	SL	Standard	
	Wireless	F3	43	B Vox 3		SKM500G4	RF Mic		Vocals	SL	Standard	
4	7	F4	44	B Vox Pete		e945	Mic		Vocals	C	Standard	
6	10	F5	45	Vox FX Return			Return	FX Return	Vocals	-		
		F6	46									
		F7	47									
		F8	48									
6	3	G1	49	HD Click		MDB-1P	DI		-	SR		
	Cable run	G2	50	Ambient SL	x	MKH	Mic		Ambience	DSL	Short	Shotgun Ambient Mic
6	8	G3	51	Ambient SR	x	MKH	Mic		Ambience	DSR	Short	Shotgun Ambient Mic
2	4	G4	52	Kick Trig			XLR		Trigger	USL		Trigger
2	5	G5	53	Snare Trig			XLR		Trigger	USL		Trigger
2	6	G6	54	Rack Trig			XLR		Trigger	USL		Trigger
2	7	G7	55	Floor 1 Trig			XLR		Trigger	USL		Trigger
2	8	G8	56	Floor 2 Trig			XLR		Trigger	USL		Trigger

Stage Diagram

Leslie	Bass	Drums
Keys	Guitar	Bvs
Ambi	Lead Vox	Ambi

USR	USC	USL
SR	C	SL
DSR	DSC	DSL

Outputs

Sub Snake Num	Sub Snake Out Chan	Stage Box Chan	Out Chan	Name	Type	Group	Pos
	Wireless	A1	1	Rich	IEM	Guitars	C
	Wireless	A2	2	Pete	IEM	Guitars	C
	Wireless	A3	3	Rory	IEM	Lead Vox	DSC
	Wireless	A4	4	Paul	IEM	Keys	USC
	Wireless	A5	5	BV1	IEM	Vocals	SL
	Wireless	A6	6	BV2	IEM	Vocals	SL
	Wireless	A7	7	BV3	IEM	Vocals	SL
	Wireless	A8	8	Drums	IEM	Drums	USL
	Wireless	B1	9	Trumpet	IEM	Brass	USC
	Wireless	B2	10	Trombone	IEM	Brass	C
6	11	B3	11	Vox FX Send	Stage Returns	Lead Vox	DSC
3	12	B4	12	ShakerPlate	Stage Returns	Bass	USC
2	11	B5	13	Buttkicker	Stage Returns	Drums	USL
5	11	B6	14	Lead Vox L	Stage Returns	Lead Vox	DSC
5	12	B7	15	Lead Vox R	Stage Returns	Lead Vox	DSC
1	11	B8	16	Thimus H/WL	Stage Returns	Drums	USL
1	12	C1	17	Thimus H/WL	Stage Returns	Drums	USL

Mons Local Inputs

Chan	Type	Name	Mic	Stand	Patch	
1	Analogue	FOH TTS	SM57	Standard	FOH Multi 1	
2	Analogue	FOH SHOUT	SM57	Standard	FOH Multi 2	
3	Analogue	MONS TTS	SM57	Standard	Mons local 3	
4	Analogue	RORY SHOUT	SM57	Standard	9	>
5	Analogue	RICH SHOUT	SM57	Standard	8	>
6	Analogue	PAUL SHOUT	SM57	Standard	8	>
7	Analogue	THIMUS SHOUT	SM57	Standard	9	>
8	Analogue	BANNER SHOUT	SM57	Standard	11	>
1/2	AES	REVERB4000 1 return				
3/4	AES	REVERB4000 1 return				
5/6	AES					
7/8	AES					

Mons Local Outputs

Chan	Type	Name	Mic	Stand	Patch	
1	Analogue					
2	Analogue					
3	Analogue					
4	Analogue					
5	Analogue					
6	Analogue					
7	Analogue					
8	Analogue					
1/2	AES	REVERB4000 1 send				
3/4	AES	REVERB4000 1 send				
5/6	AES					
7/8	AES					

FOH Local Inputs

Chan	Type	Name	Mic	Stand	Patch	
1	Analogue	Distressor return				
2	Analogue	KTA D2 return				
3	Analogue	C2 L return				
4	Analogue	C2 R return				
5	Analogue					
6	Analogue					
7	Analogue	Ipod L				
8	Analogue	Ipod R				
1/2	AES	TC 4000 return				
3/4	AES	Bricasti M7 return				
5/6	AES					
7/8	AES					

FOH Local Outputs

Chan	Type	Name	Mic	Stand	Patch	
1	Analogue	Distressor send				
2	Analogue	KTA D2 send (mono)				
3	Analogue	C2 L send				
4	Analogue	C2 R send				
5	Analogue					
6	Analogue					
7	Analogue					
8	Analogue					
1/2	AES	TC 4000 send				
3/4	AES	Bricasti M7 send				
5/6	AES					
7/8	AES					