Professional but practical P.A. A thoroughly researched guide for performers who provide and operate their own sound systems; describing methods for improving the quality of sound reinforcement in venues under a capacity of 400 seated

This document reviews which resources best inform which of the project's objectives. It evaluates which of the conclusions made in previous studies, are most relevant to the project's intended readership. It validates the need to undertake the project and identifies key research themes from previous studies. It concludes how the project seeks to bring clarity to discord between resources and add value with further investigation.

As a matter of first priority, a framework to create definition of the term professional and practical P.A, is needed within the scope of the project. In the pursuit of professional P.A., *Sound Systems For Worship* (Eiche, 1990) and *Introduction To Live Sound Reinforcement* (Boyce, 2014) both give intelligibility page one priority. Achieving intelligibility (or clarity) is a theme common to all resources considered. In *Sound System Design & Optimization* (2014, location 1425), McCarthy details key specifications for professional loudspeaker system components. McCarthy (2014) mostly informs the project of the best-case scenario however, which restricts his relevance to performers who operate their own P.A. systems for smaller scale events. A number of other sources offer a more practical, purpose and venue specific approach. *Basic Live Sound Reinforcement* (Biederman and Pattison, 2014, p.31) acknowledges that 'good sound is tailored to the application'. Davis and Jones (1990, p.347) agree by first considering programme material. Astralsound (2016) describes how aspects of professional P.A., such as pattern control, must be considered with venue dimensions in mind. Pragmatic considerations of P.A. are strong in (White, 2012) and Stark (2004, p.207). They highlight aesthetic considerations linked to occasion types, which are very relevant to project's focus group. Stark (2004, p.207) informs the project that compromise from the highest specifications, perhaps including some of those made by McCarthy (2014, location 1425), may be required. Along with intelligibility, the more application specific characteristics identified within the later part of this paragraph, will be used by the project as a starting point when defining professional and practical P.A. A more complete definition will be developed as an outcome to further research and experimentation during the project.

Acoustic environment has a ‘drastic impact on perceived sound quality' (Stark, 2004, p.47). It is essential therefore that analysis be made of various P.A.'s performance in a range of spaces. White (2015) lacks context, making no reference to acoustic environment in his chapter on Practical P.A. Several sources provided at Astralsound (2016) are better contextualised. The guide produced by this project will develop the resources presented by Astralsound (2016), to be even more applicable. This project will add measured results, in a range of real venues and for several types of P.A. system.

Sound Reproduction: Loudspeakers And Rooms (2008) is well informed by multiple earlier published studies. Toole discloses that the majority of scientific research into sound fields has been conducted in large auditoriums. In a broad sense, Toole’s aim and the overall aim of this project are closely aligned. Larger venues are not where ‘most of us spend most of our [sound reinforced] listening time’ (Toole, 2008, p.41). In 2008, Toole believed continued research into the acoustics of modern venues was required. This project will undertake some of that study, adding to its validity.

McCarthy (2014, location 4271) and Toole (2008, p.44) discuss distinctions between spaces which sound good acoustically and those which suit sound reinforcement; a likely source of confusion to some readers in the focus group. Toole (2008, p.39) explains how ‘humans like reflections’. It is for this reason, and as a power transmission aid, that traditional concert halls feature strong early reflections. McCarthy (2014, location 4387) goes on to explain how when multiple loudspeakers are brought in, the influence of the room must be decreased in order to manage sound reinforced summation. Toole (2008) however takes a more prescriptive approach, showing that reflections which arrive within an ‘integration interval’ (Toole, 2008, p.162), actually support speech intelligibility. Additionally, within music reinforcement Toole (2008, p.39 & p.51), Eiche (1990, p.32), and Biederman & Pattison (2014, p.135-136) state that reverberation is important for a sense of envelopment and liveliness. The literature identifies that an acoustically dead room is therefore not required; an important conclusion for operators of mobile P.A., who typically have limited influence on architectural acoustics.

Toole (2008, p.43) and Stark (2004, p.214) make an important distinction; different challenges are faced in halls with high-ceilings, to those spaces with lower ceilings, (that often have a greater relative volume of absorptive material). Initial primary research suggests the focus group is familiar with this broad distinction. Within the project, these two environmental challenges will therefore be treated distinctly, with separate electroacoustic analysis.

In high-ceiling halls, Toole (2008, p.44) cites reverberation time as 'the paramount acoustical measure'. McCarthy (2014, location 4420) and Amundson (2007, p.113) agree over the critical role that reflections, (the earlier portion of reverberation) play in this type of environment. In smaller venues, Stark (2004, p.214) makes the case that resonance related to room dimensions is a greater obstacle than diffusion, (the later portion of reverberation). By selecting a range of room sizes for the experiments, this project will test the conclusion which can be drawn from the literature; that reverberation is the most critical factor in higher ceiling halls, while standing waves typically play a more decisive role in rooms with lower ceilings and of less capacity.

Toole (2008, p.63) warns of the limitations to studying RT60 times alone. Accurate RT60 measurements involve using an omnidirectional speaker for 'random incidence' Toole (2008, p.63). All loudspeakers used by the project will have directional characteristics. This limits the relevance of RT60 in the context of the project. Furthermore, both Eiche (1990, p.31) and McCarthy (2014, location 4711) remind the project that the spectral character of the diffuse tail has an equally important influence on the quality of sound. For this reason, off axis frequency analysis will be made for each test loudspeaker in the project.

Variation exists in recommended RT60 times for sound reinforced events with combined speech and music. Eiche (1990, p.32) suggests 1.5 – 2 seconds. This however this takes account of longer RT60 times required to blend a choir. Toole's more conservative 1 – 1.5 seconds (2008, p.29) is therefore more relevant for the project.

The literature agrees that noise floor is an obstacle to speech intelligibility. However through previous psychoacoustic study, Toole (2008, p.163) proves that the ear brain system has a remarkable ability to depict the message from speech, even with a signal to noise difference of just 5dB. M^C Squared System Design (n.d.) however state a signal to noise requirement of 25dB. This is more pertinent to the project than Toole's suggestion. Other challenges to intelligibly, including late reflections, render 5dB more academic theory than practically useful in the context of the project.

There is agreement in the literature on two possible solutions for reducing front to back sound pressure variation. Either the loudspeakers must be moved further back from the front of the audience and higher in elevation, or a distributed system of multiple loudspeakers positioned closer to the audience, but at lower level, should be used. Reviewing these options, the project aims to contextualise circumstances in which either loudspeaker elevation, or distribution is the best practice.

Stark (2004, p.214) corroborates the belief of this project that feedback is more difficult to avoid in smaller rooms. Davis and Jones (1990, p.47) verify this challenge, specifying an equation to approximate maximum acoustic gain before feedback. Applying the equation, this project hypothesises that a small room with strong early reflections permits the lowest gain before feedback. This investigate will be continued by an experiment in the project.

In order to combat destructive interference, several sources discuss minimising dispersion overlap of mid and high frequencies. *Sound System Design & Optimization* (2014, Location 2187) concludes that SPL gains due to dispersion overlap should be reserved to low frequencies only. As Director of System Optimization at Meyer Sound (2013), the project considers McCarthy an expert in his field. His in depth electroacoustic study provides an important underpinning for the project. However, performers without a technical background will be put off by such detail. The project must find a more concise way to explain only the most crucial facts of complex summation.

There is a lack of firm conclusion from the literature as to whether a mono system would be appropriate in the context of the project. For avoiding destructive phase interference, Stark (2004, p.210) and (Eiche 1990, p.101) suggest using a central single cluster, especially for speech-based reinforcement. In *Sound System: Mono versus Stereo,* M^c Squared (n.d.) makes the much bolder claim that two channel systems are 'especially ineffectual' for speech reinforcement. Although this opinion is the most extreme found, there is a theme of favouring mono systems for speech running through the resources. However in regards to a multipurpose system, Toole (2008, p.51 & p.101) and Stark (2004, p.212) make the case that human enjoyment in listening to music is increased when sound arrives from a reasonably wide horizontal plane. On the other hand, Graham (2013) explains that stereo 'loudspeakers are [typically] too far apart to allow similar arrival times for every audience member'. Both Graham (2013) and McCarthy (2014, location 7280) agree that this leads to a collapsing of the stereo image to the loudspeaker closest to a particular audience area; nullifying the left right mix balance popular with bands. With differing perspectives in the literature, the use of a wide dispersion but mono source warrants further investigation. This will be carried out using the Bose test loudspeaker.

There is also a lack of literary discussion into the relevance of having a sense of front orientation to sound reinforcement while playing recorded music to dance floors. A source trend is to emphasise the importance of sound emanating from the stage, maintaining the audio-visual relationship with the talent. Further investigation into how pertinent this approach is for a dance floor, where patrons have no fixed orientation, will be undertaken by this project.

Amundson (2007, p.108) and White (2015, location 615) offer the most relevant practical advice towards ensuring reliability in sound reinforcement; chiefly, bringing carefully selected backup components. However the literature does not consider the use of an uninterruptable power supply. The importance of this fail-safe device will be introduced by the project.

Boyce (2014 p.52) believes that sensitivity is an important measurement 'because in combination with the dispersion specification, it tell us how well a speaker system will cover a given audience area'. McCarthy (2014, location 1854) completely disagrees; making the case that dBSPL per Volt is the only accurate measure of loudspeaker output which correlates well to the room. In order to investigate this further, the project will undertake an additional investigation. dBSPL / Volt measurements will be taken for each test P.A. system. These will be compared to the standard 1 Watt at 1-meter ratings and other output performance statistics of each system, within the test environments. The project will therefore seek to advise its focus group which method is best suited to their purpose.

According to Eiche (1990, p.97), directivity factor is used by 'consultants in specifying speech reinforcement systems'. A more modern text, McCarthy (2014, location 2018), explains how a single number pertaining to both vertical and horizontal coverage is too limited. A more practical word intelligibility test for this project is described by Astralsound (2016). The measure is made from the proportion of words which listeners can identify when a series of random words are played through a loudspeaker in a venue. This is a feasible experiment for the project. McCarthy

(2014, location 3584) specifies the percentage loss of consonants to speech (%ALCONS) as the ‘foremost means of measuring speech intelligibility’. Both M[c] Squared (2016) and AFMG (2015) endorse %ALCONS. It is worth noting their vested interests however; the calculation involves products which they offer. Nevertheless based on McCarthy’s experience, %ALCONS is considered suitable, and will be measured by the project in addition to the word illegibility test detailed in this paragraph.

The value of line array in small venues is an area of disagreement within the literature. Astralsound (2016) and Amundson (2003, p.15) both dismiss the opinion of White (2012), who believes that compact line array ‘is the future’. The difference in opinion is likely to be the result of ambiguity in the definition of line array. This project will present a clearer understanding of the extent to which certain systems match their line source marketing claims.

To conclude, there’s a trend in the sources to focus towards concert systems, or for occasions where the on stage performance is the main event. Primary and empirical research will show that this is often not the nature of functions involving this project’s focus group.

Different emphasis exist between writers on the objectives of professional P.A. McCarthy specifies minimal level and frequency variance across the audience. Davis & Jones (1990, p.354) take a more tolerant approach; ‘a lower level at the rear… will usually be perceived as natural’. Amundsen (2005, p.36) agrees; at certain events, some audience members may wish to be seated in a quieter zone so they can socialise, but still feel a part of the event. This project will evaluate advantages to be had by embracing two naturally level variation zones.

Bibliography

AFMG, 2015. *Ease 4.3 Tutorial English.* [online] Available at: < http://www.afmgsupport.eu/SoftwareDownloadBase/EASE/EASE_4.3_Tutorial_English.pdf > [Accessed 24.12.15]

Amundson, M., 2007. *Live Sound Theory & Practice.* Las Vegas, NV: Timeless Communications, Corp.

Astral Sound, 2016. *Loudspeaker Horizontal Pattern.* [online] Available at: < http://www.astralsound.com/horizontal_pattern.htm > [Accessed 24.12.15]

Astral Sound, 2016. *Loudspeaker Vertical Pattern.* [online] Available at: < http://www.astralsound.com/vertical_pattern.htm > [Accessed 24.12.15]

Biederman and Pattison. 2014. *Basic Live Sound Reinforcement. A Practical Guide For Starting Live Audio.* Burlington, MA: Focal Press

Boyce, T., 2014. *Introduction To Live Sound Reinforcement: The Science, the art, and the Practice.* Victoria, BC: Friesen Press

Davis, G. and Jones, R., 1990. *Sound Reinforcement Handbook.* Second Edition. Milwaukee, WI: Hal Leonard Corporation.

Eiche, J. F., 1990. *Sound Systems For Worship.* Milwaukee: Hal Leonard Publishing Corporation

Graham, P., 2013. *Stereo: Localization, Imaging And Live Sound.* [online] Available at: < http://www.fohonline.com/current-issue/74-tech-feature/8508-stereo-localization-imaging-and-live-sound.html > [Accessed on 12.12.15]

McCarthy, B. 2014. *Sound Systems: Design & Optimization*. Modern techniques and tools for sound system design and alignment. [e-book] Abingdon, Oxon: Routledge.

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M^{c} Squared System Design Group, Inc, (n.d.) *% ALCONS Calculator. .* [online] Available at: < http://www.mcsquared.com/alcons.htm >

M^{c} Squared System Design Group, Inc, (n.d.) *Sound Systems: Mono versus Stereo.* [online] Available at: < http://www.mcsquared.com/mono-stereo.htm#demo > [Accessed 24.12.15]

Stark, S. H., 2004. *Live Sound Reinforcement: A Comprehensive Guide To P.A. And Music Reinforcement Systems And Technology.* Vallejo, CA: Artist Pro Publishing.

Toole, F. E., 2008. *Sound Reproduction: Loudspeakers And Rooms.* Oxford: Focal Press.

White, P., 2012. *Finding The Right P.A. System For You.* [online] Available at: < http://www.soundonsound.com/sos/jun12/articles/choosing-pa-systems.htm > [Accessed 05.01.16].

White, P., 2015. *The SOS Guide To live Sound: Optimising Your Band's Live Performance.* [e-book] Abingdon, Oxon: Focal Press.