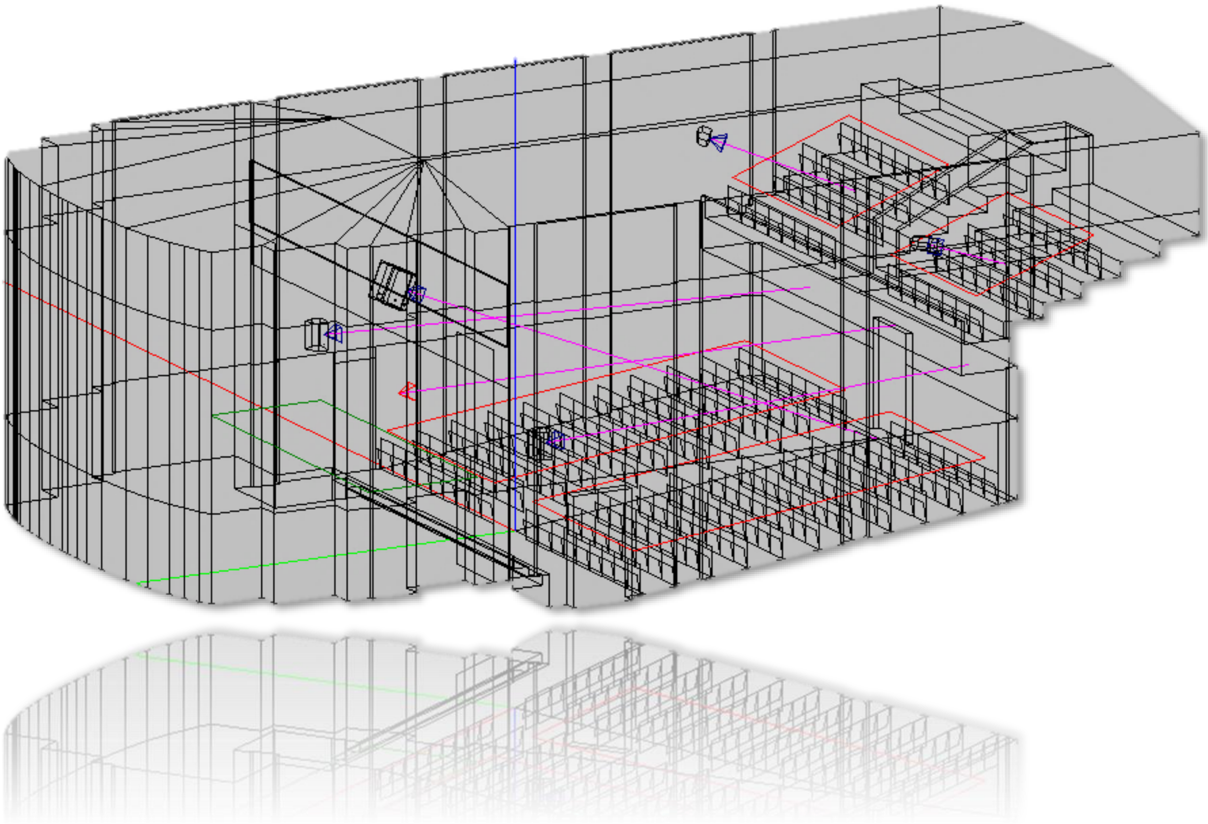
DERBY GUILDHALL THEATRE

Live Sound System Design and Optimization



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Venue Analysis (Peter Jones)

Derby guildhall is a grade 2 listed building with an audience capacity of 182 (122 Main, 60 on Balcony). The venue itself was originally used as a town hall, requiring reinforcement of natural sound from the room itself. This most likely using early reflections to reinforce the direct sound (Stark, 1996). The venue is now used to house many different events. Some of these requiring sound reinforcement. The introduction of a sound reinforcement system within the venue will require careful consideration. Current restrictions do not allow the application of any new fixtures to walls/ceilings within the venue. The inability to add absorption/diffusion to compensate high reflection rates will be an issue during the design of this system.

Current events held within the venue include, but are not restricted to:

- Small Theatre Productions
- Comedy Shows
- Dance Recitals
- Small Live Music Events (Jazz Bands)

The range of event styles will require a system providing good clarity for spoken word productions, stereo imaging for theatre performances & a frequency range of 20hz –20Khz for musical performances (Stark, 1996).

Due to the box nature of the room, line of sight is of much importance to ensure all audience members have a clear view of the stage. This box shape will also cause audience members towards the edges of the room to be prone to strong reflections from side-walls (Stark, 1996). The venue has an overall SPL restriction of 115dB which must be upheld, with possible effects to surrounding areas due to being located within a city centre. The average temperature within the room is 20 degrees Celsius, which will be accounted for in simulations within the report. Current systems are being powered through a 32amp single phase connection which will also be accounted for.

During a brief walkthrough of the venue, audience & performance areas were noted and outlined below in fig 1.1. The audience areas span over two levels, first being the main listening area (A,B) with an central aisle and small incline. The second being a balcony approximately 3meters above (C,D), the small depth underneath the balcony not requiring infill systems (McCarthy, 2010). Performance areas are comprised of the main stage and a small musical pit to the left (E,F). The main stage surrounded by thick drapes to control possible room modes and deaden reflections on stage for musical performance (McCarthy, 2010).

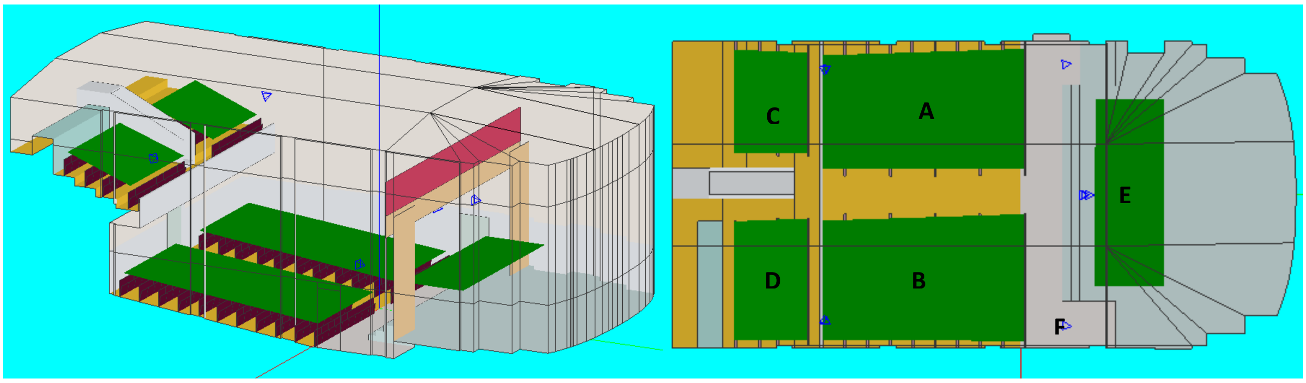


FIGURE 1.1 – OUTLINE OF LISTENING / PERFORMANCE AREAS

A key feature of the room is a convex ceiling, this being prone to concentrating strong reflections back down towards the audience areas. The edges of the ceiling pictured below (Fig 1.2) act as a form of natural diffusion, eliminating some strong reflections. Although the centre of the ceiling contains glass, due to the absorption from the carpeted aisle below; it will be of less concern.

FIGURE 1.2 – CEILING WITHIN VENUE

Lastly, the venue uses a compression grid system to fly its lighting systems above the stage, this used to push against interior walls rather than be fixed to it. Allowing up to 1 ton of weight to be applied. If used, this rigging system must be able to account for the weight of the new system as well as existing fixtures.

Model Creation

Drawings provided by the venue were used to aid the creation of an acoustic model. From basic dimensions it was concluded that the room is modal in nature below approximately 50hz (Davis, 1990). The semi-diffuse nature within the room will require small and large room acoustic techniques according to the Schroeder frequency (Davis, 2013). Small room techniques being dependant on absorption and diffusion, room modes in the low frequency bands cannot be controlled due to building restrictions. Although non-invasive absorption could be added. To amend these issues, location/directivity of the sound system will be of upmost importance (Davis, 1990)

To begin, the Computer aided drawings were inspected and due to being created in 2009 some changes were made in comparison to pictures taken on the site visit. These were then drawn up in Google Sketch-Up. Once completed each panel in the model was allocated to specified layers corresponding to the materials list previously created. This was then converted into a Soundvision file for testing of proposed sound systems with LA-coustics software. The same model was then also imported into EASE for acoustical analysis of the room. (Fig 2.2)

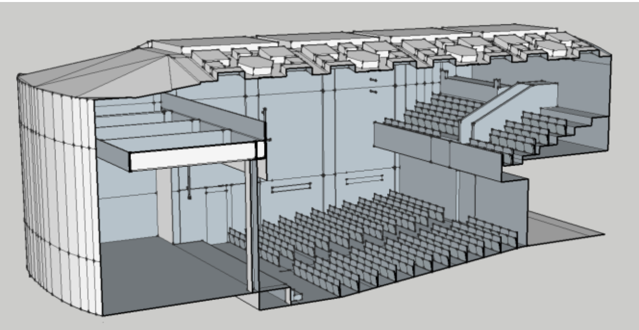


FIGURE 2.1 SKETCHUP MODEL

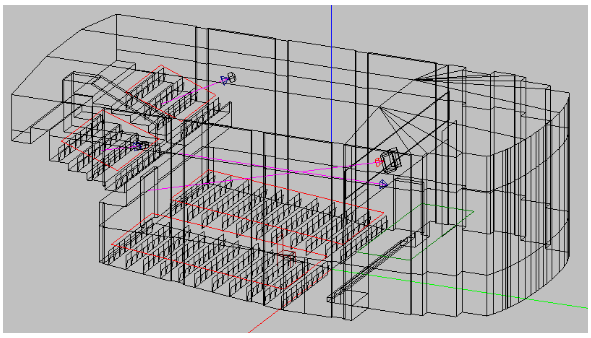


FIGURE 2.2 EASE MODEL

The materials within the model utilised the 'General' library, due to no further details given about specific room materials. With further visits, detailed analysis of the venue would allow more accurate implementation of each surface. Each material contains different absorption coefficients to allow the room to behave as expected. In conjunction, scattering coefficients were used to represent the effect of the ceiling and balcony front found in the venue. These applied to the mimic the behaviour of the afore mentioned ceiling diffusion, and a wooden balcony front that may cause a strong reflection back on stage. The addition of these were used to keep the model simple during design but also ensure validity.

Details of these materials can be found in appendix A.

Acoustic Analysis

Once the model was checked for holes to ensure proper testing of the venue, general measurements were taken.

Total Volume – 1384.18 m3

Total Surface Area – 1257.63 m2

Average Absorption Coefficient – 0.22 (With Audience)

Mean Free Path (MFP) – 4.40m

The average distance travelled by sound before hitting the noise floor (40dB) is 271m, using this value with the MFP, the average number of reflections in the venue = 61.59. Due to the average absorption coefficient being above 0.1 Eyrings formula was used rather than Sabine equations. Resulting in an RT60 of 0.8.

When analysing the room with and without and audience it is visible that the presence of an audience will play a vital role in absorption of almost 1 second of low frequency decay time (Fig 3.1) (Davis, 1990).

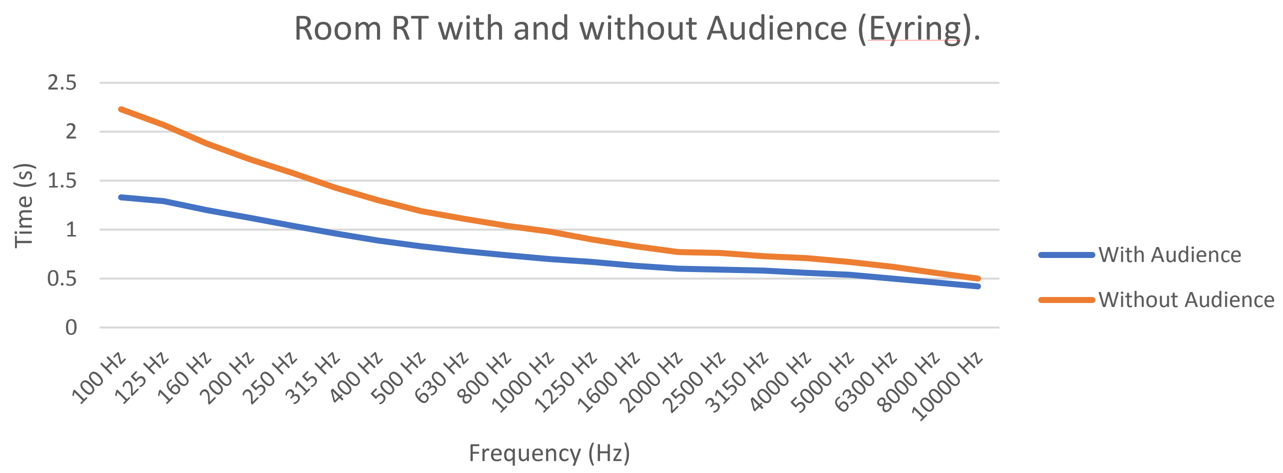


FIGURE 3.1 – RT AUDIENCE COMPARISON

Due to the number of reflections being lower than 108, the validity of just these equations would not be adequate (Davis, 2013). Instead, local decay rate modelling was completed showing a model RT60 of 1.4, similar to that of theatre venues for speech and musical performance which can range from 1-1.5 (Toole, 2013). This was then tested using Aura modelling for T30 mapping, showing the time taken to drop by 30dB then doubled to get the RT60, results supporting the local decay rate of the model (Fig 3.2)

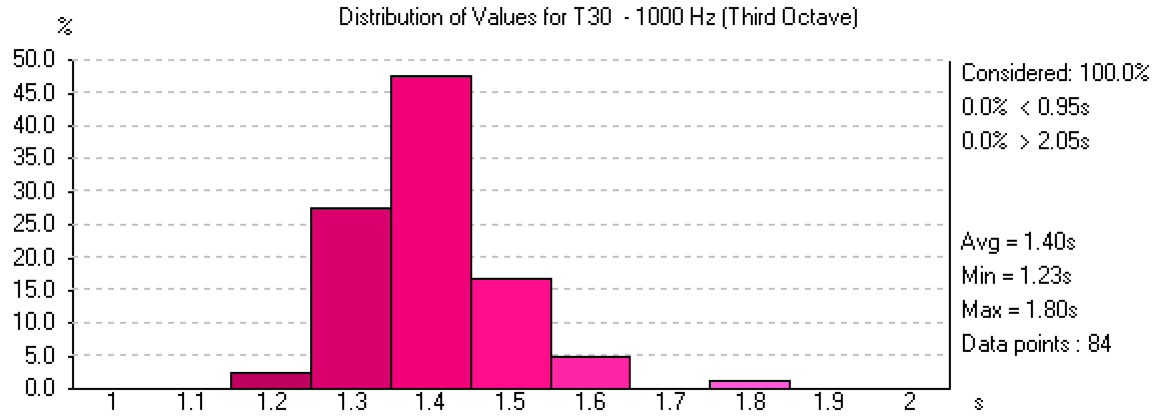


FIGURE 3.2 – T30 MEASUREMENTS

For analysis of the room, acoustical measurements were taken with an omnidirectional source placed approximately 2m above the stage floor. This to resemble the nature of a spoken word performance on stage and an average sound systems propagation path during use. This source was then use to complete standard mapping of the room for multiple tests (40dB noise floor to account for a quiet audience and air conditioning units).

Speech intelligibility within the room was mapped to assess the clarity of male & female voices & how they would be perceived within the space.

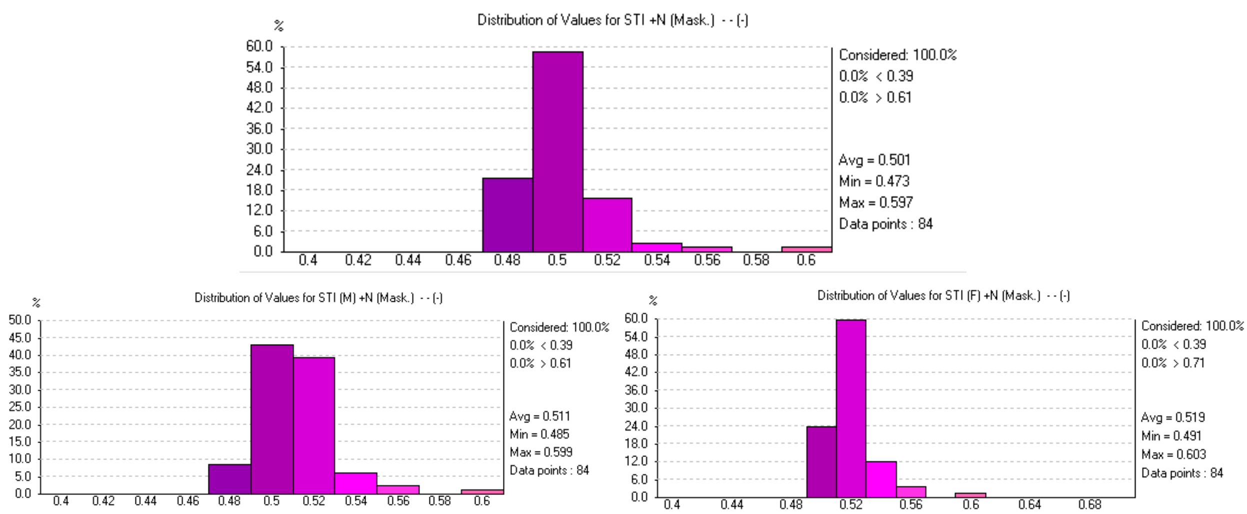
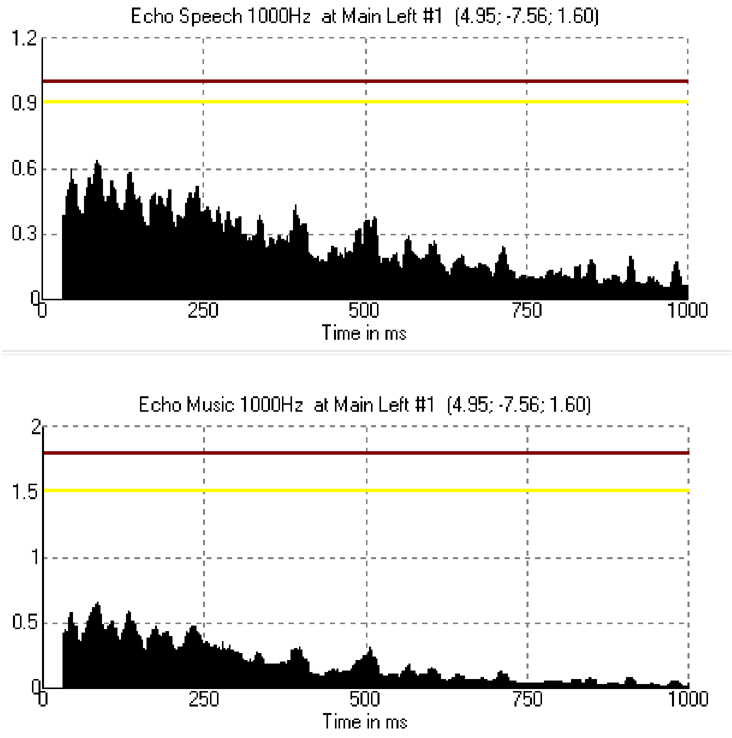


FIGURE 3.3 – STI MEASUREMENTS (STANDARD/MALE/FEMALE)

Results showed levels suitable for voice and alarm systems (Average of 0.5). A key aim will be to raise this to a level suitable for small theatre venues (0.6). From previously mentioned reasons, the system will be best aimed downward to avoid the ceiling and be directed off axis from the main balcony front (McCarthy, 2010). The influence of early reflections (<30ms) and a signal to noise ratio of 15-20dB will aid speech intelligibility within the venue (Toole, 2013)



Echograms were also derived from aura response mapping within ease to assess the extent to which delayed energy spikes within the rooms response will affect the overall quality of speech and music. This plotted as a function of time, show marginal issues above the yellow line and serious issues above the red line. These were tested over different locations/frequencies throughout the room and showed no significant issues. This being representative of spoken word and live music performance within the room without the sound system.

FIGURE 3.4 – ECHOGRAMS (MUSIC/SPEECH)

From these results it's clear that the room is heavily influenced by early reflections that may cause masking when a sound reinforcement system is implemented. One key issue outlined by the venue, was the loss of the front 4 rows due to the placement of the current systems being located on the sidewalls. Due to these issues, its clear that an alternate placement of the system may be needed, possibly making use of the compression grid above the stage.

Overall, the venue benefits from strong early reflections to reinforce natural sound. This should be handled with care when implementing a sound reinforcement system by careful placement and directionality of the loudspeakers. This to avoid directing sound towards the ceiling and on the sidewalls. The speech intelligibility within the room is of an adequate level already but should be maintained, if not improved slightly according to the British standards (<0.6) (British Standards STI, 2012). Care should be taken to provide consistent level variance across listening areas (Within 6dB) with low spectral variance for all audience members. This ensuring a clear and enjoyable experience for all event types within the venue.