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ROLLACITY

ROCHFORD

ACOUSTIC STUDY

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FEBRUARY 2011

SUMMARY

Acoustic transmission tests and a subjective appraisal of music transmission between the intended Rollacity section of the building and the adjacent occupiers, Thermofisher, have been carried out. From these tests it has been concluded that :

1 A number of measures are proposed to improve the sound attenuation and control the sound levels within the Rollacity venue.

2 A music sound level of approximately 75 dBA within the venue was subjectively found to correspond to the level that is anticipated to occur during normal operating hours. At this level the music was just audible within the ThermoFisher offices. Measurements of the sound attenuation currently existing between the premises show that an improvement of at least 5 to 10 dB will be required.

3 Measures are proposed for the sound system design and for additional sound insulation / isolation that will achieve this target.

4 It is recommended that a number of electronic measures to limit and control the maximum sound pressure levels are incorporated into the sound system design & installation.

1 INTRODUCTION

It is intended to convert an existing commercial building in Purdey's Way Rochford into a roller-skate rink facility. It is intended to play music for the skaters and an associated DJ booth and sound system are to be installed. The venue shares a party wall with ThermoFisher Scientific, a specialist, light assembly manufacturer. Concern has been raised regarding the likely sound transmission from the roller-rink to the offices and assembly area of ThermoFisher. Tests were carried out to assess both the objective sound transmission that is currently occurring and also to gain a subjective impression of the sound levels and transmission. This initial discussion report summaries the results of the measurements undertaken and the results of a computer modelling study undertaken to investigate the sound transmission and coverage within the intended RollaCity space.

Figure 1 shows an image of the initial computer model which helps to describe the space. The party wall is the wall to the left of the figure (Red & Green sections).

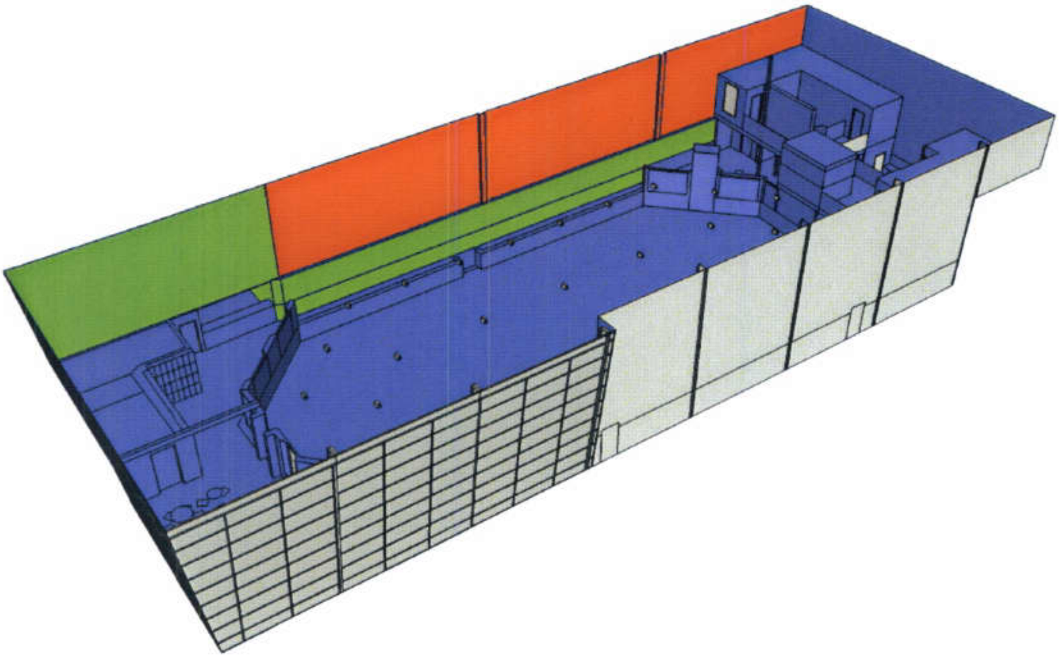


Figure 1- Rendered image from acoustic computer model

2 SOUND TRANSMISSION TESTS

In order to simulate the effect of the venue playing music, two PA speakers were set up on the floor of the Rollacity side of the building and set to play the level of music anticipated to be used during the skating sessions. (Approximately 75 dBA). With the cooperation of ThermoFisher, measurements were then taken in their adjoining premises of the ambient background noise and sound breakout from the Rollacity side of the building. The output from the loudspeakers was then increased (to approximately 90 dBA so that accurate transmission loss measurements of the party wall could be made. (It should be noted that this sound level was only for measurement purposes and not meant to reflect the actual sound levels anticipated). Rollacity advise that they intend to use approximately 75dBA (* see section 3 comments) as their sound level for the music to accompany skating.

Figure 2 below shows the results of the measurements of the intended music scenario.

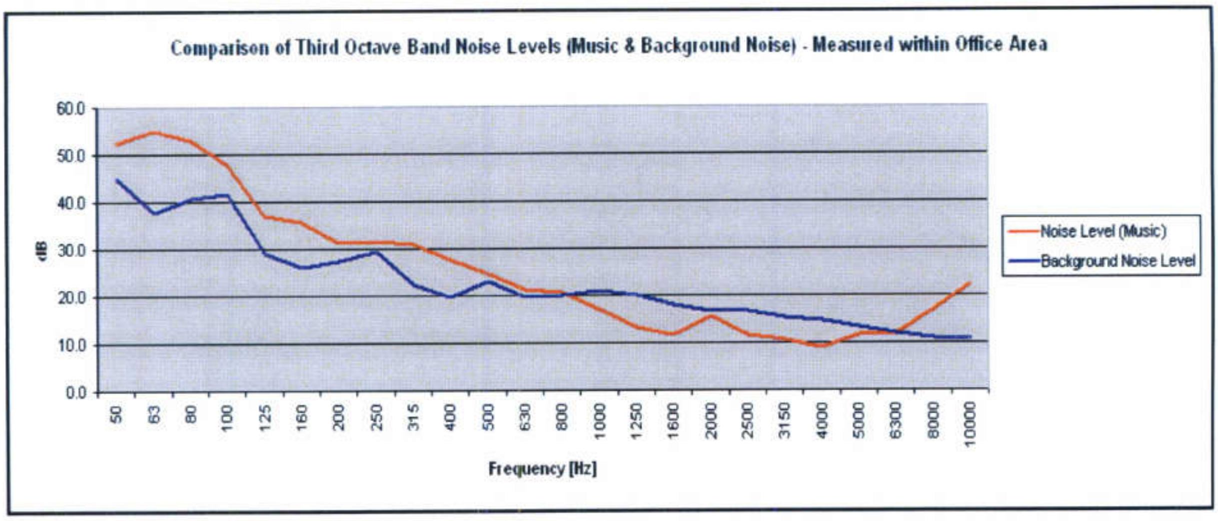


Figure 2 - Comparison of background noise and sound transmitted to Thermo Scientific

The blue curve in Figure 2 shows the normal background noise in the ThermoFisher office that abuts the party wall and the red curve shows the derived level of the music that is transmitted via the wall into the office for the maximum level of music anticipated during normal operation. From the data it can be see that the background noise level in the offices was lower than might normally be expected (31dBA as opposed to 35 to 40 dBA for typical offices - as per BS 8223). At mid to high frequencies (i.e. above approximately 800Hz) the music is below the level of the background noise - (i.e. the red curve is below the blue curve). An exception to this is at the very high frequency region (8 and 10kHz) where, unusually, the music was found to be just above the background noise. At the lower frequencies, the wall does not provide as much sound insulation and the music is above the background noise and is audible in the office. It should be noted that the above results were based on a slightly false situation, as the loudspeakers were deliberately directed at the wall to create a 'worst case' scenario. In reality therefore, it can be expected that a rather better situation would result – though this is unlikely to change the outcome of the low frequency transmission at frequencies of 250 Hz and below. In overall terms the average music level in the office was 36.6 dBA whereas the normal background noise level was 31.4 dBA – i.e. the music produced an overall increase of 5.2 dBA. The bass frequencies were subjectively noticeable and the overall effect was determined to be unacceptable by ThermoFisher.

Figure 3 shows the measured sound transmission characteristics of the party wall. Whilst the overall shape of the curve is in general agreement with what might be expected, the drop at high frequencies (at 6,300Hz and above) is unusual and immediately explains the unexpected high frequency levels that were measured during the music test. As the exact construction of the wall is not known, it is difficult to particularly comment on the sound reduction performance – as it is what it is.

From the above sets of measurements, it is clear that an improvement in sound reduction performance of around 5 to 10 dBA is required. Whilst this is a significant increase in sound insulation performance it is achievable by means of careful sound system design and additional physical measures.

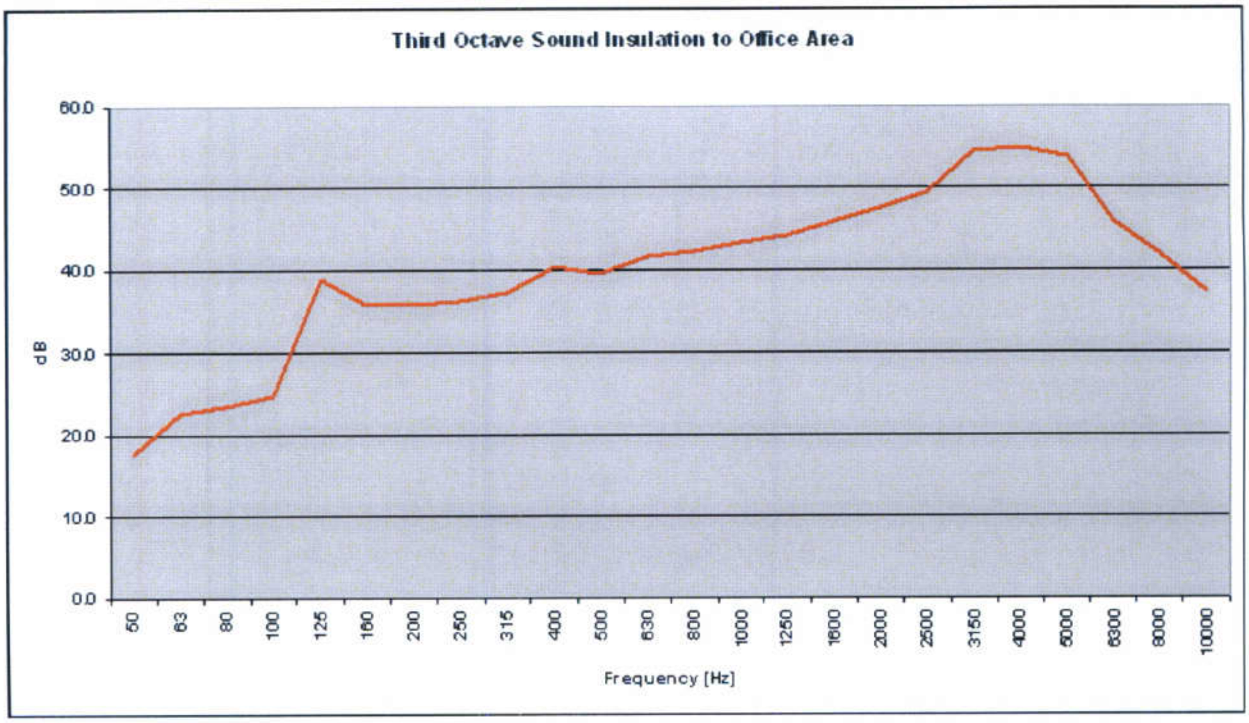


Figure 3 - Sound Insulation provided by the existing party wall

3 MEASURES TO REDUCE THE SOUND TRANSMISSION VIA PARTY WALL

There are essentially two strategies available to reduce the sound transmission to the adjoining premises. (1) Reduce the sound level at source and (2) improve the insulation of the wall - or employ a combination of the two.

Having set a nominal level of 75 dBA as the operating requirement for the music level in the roller rink, the only means of reducing the sound level from the loudspeakers is either to reduce the distance between the loudspeakers and the listeners or to use highly directional loudspeakers. In order to improve the performance of the party wall, a second skin would need to be introduced – on the Rollacity side. A further, small, but worthwhile improvement can be achieved by reducing the reverberation time or sound reflectance within the Rollacity side of the building – particularly within the rink area.

3.1 Reduction of reverberation time

It is understood that the internal surface of the rink barrier wall is to be treated with carpet or a similar, hard wearing, material. Sound absorbing material (such as carpet) in this location will help to locally reduce noise build up and provide useful general absorption and provide a 'padded' impact surface for customers. Treating the ceiling over the rink would also help to significantly reduce the reverberation time. This does not need to be a sophisticated treatment, for example, 40mm tissue faced mineral wool / glass fibre applied directly to the ceiling would be adequate (This might also provide useful thermal insulation). Treating the party wall along the side of the rink would also help (and also help reduce impact sound). Introducing the above measures will reduce the reverberation time down to approximately 1 second at mid frequencies – which will also help to significantly control general occupancy noise.

3.2 Loudspeaker System

As noted above, there are two basic methods of controlling and reducing the sound transmission from the loudspeakers. (1) Reduce the distance between the loudspeakers and the listeners and (2) use directional loudspeakers or a combination of the two approaches may be used. The acoustic computer model was used to simulate a number of scenarios for sound transmission and coverage within the Rink area of the building. Examples of this are shown in figures 4, 5 & 6 which show the sound level contour patterns for a directional loudspeaker array and overhead distributed loudspeaker system. (When reviewing the data, it has to be realised that there are two components to the sound field produced by a loudspeaker. (1) The 'Direct Sound' – that sound which arrives directly from the loudspeaker and (2) the reverberant or reflected sound. This is sound from the loudspeaker that undergoes a series of reflections (i.e. impacts with room boundaries or surfaces) before arriving at the listener. (The introduction of sound absorption into the space helps absorb this component of the sound – which is generally unwanted / deleterious). The Direct and Reverberant Sound combine to provide the Total Sound Field – which correlates more closely with how we perceive the overall sound in a space. Plots of Direct and the Total sound are presented in order to provide an overview of the situation).

3.2.1 Overhead Distributed Loudspeaker System

Some experimentation with the computer model showed a distributed loudspeaker system employing 25, compact, full range 'medium power' (100watt) loudspeakers suspended over the rink at height of 3.5m gave a very even distribution and minimised the amount of sound falling on the party wall (and external side wall). It should be noted that the sound radiation is frequency dependent. Most loudspeakers are very much less directional at low frequencies than at medium and high frequencies. This can be seen in the following figures. Figure 4 shows the sound distribution for the overhead loudspeaker system.

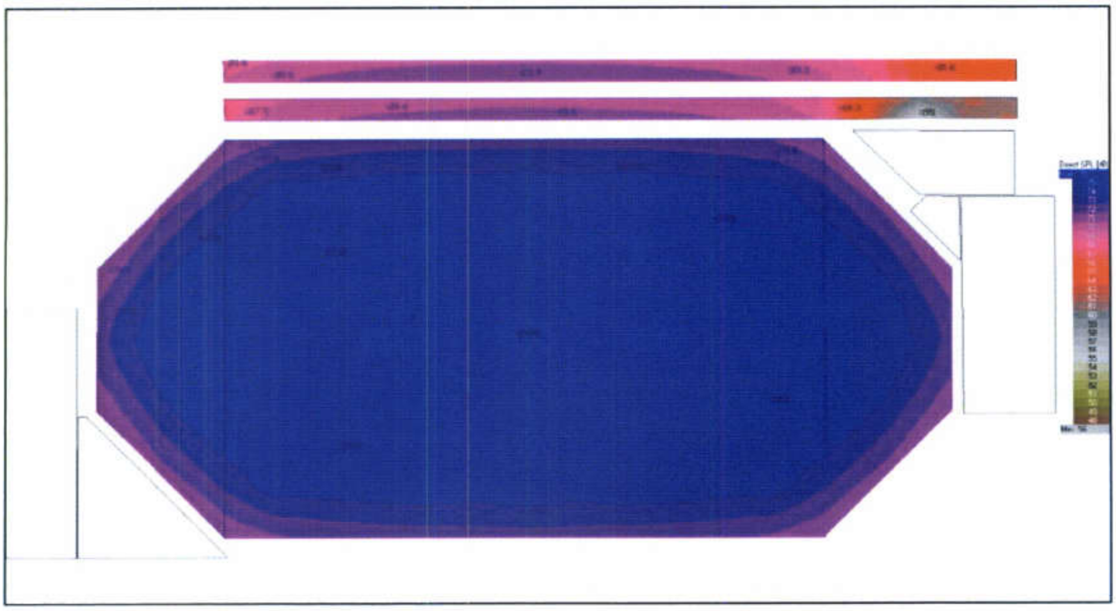


Figure 4 (a) – Direct Sound distribution from overhead loudspeakers at 125Hz

The central area of the figure represents the rink whereas the two strips above show the sound that is impacting the party wall at 1.5 and 2.8 metres. As can be seen from the figure, there is very even sound coverage over the rink and the direct sound at the wall is approximately 4 dB lower. A similar result occurs at 250 Hz – as shown in figure 4(b).

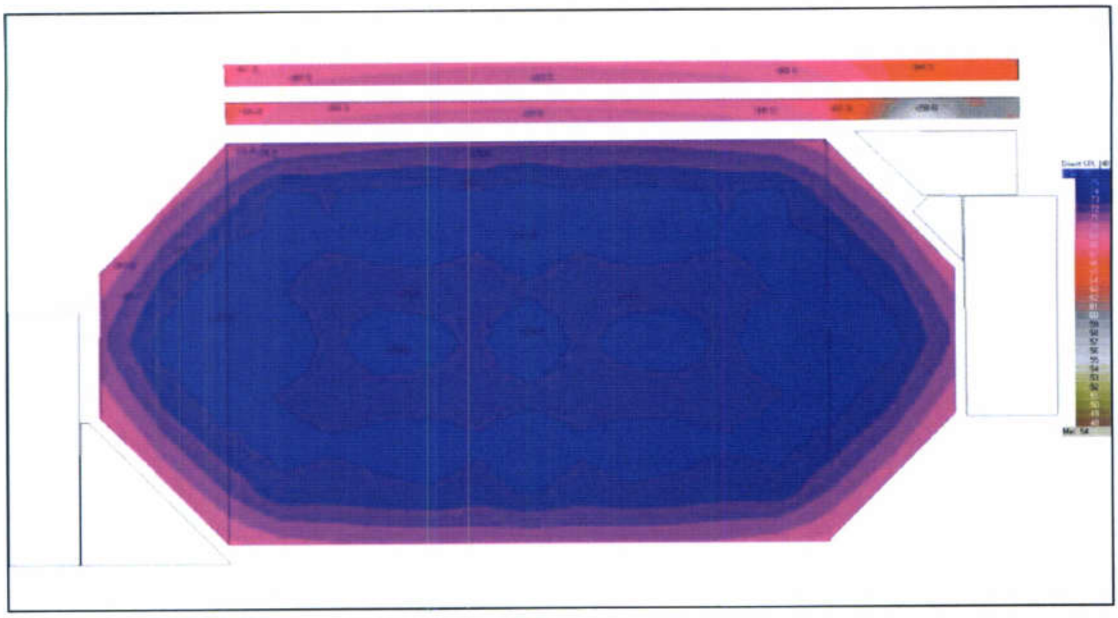


Figure 4 (b) – Direct Sound distribution from overhead loudspeakers at 250Hz

At 500Hz the pattern is similar with a 5 dB reduction in level as shown in figure 4(b).

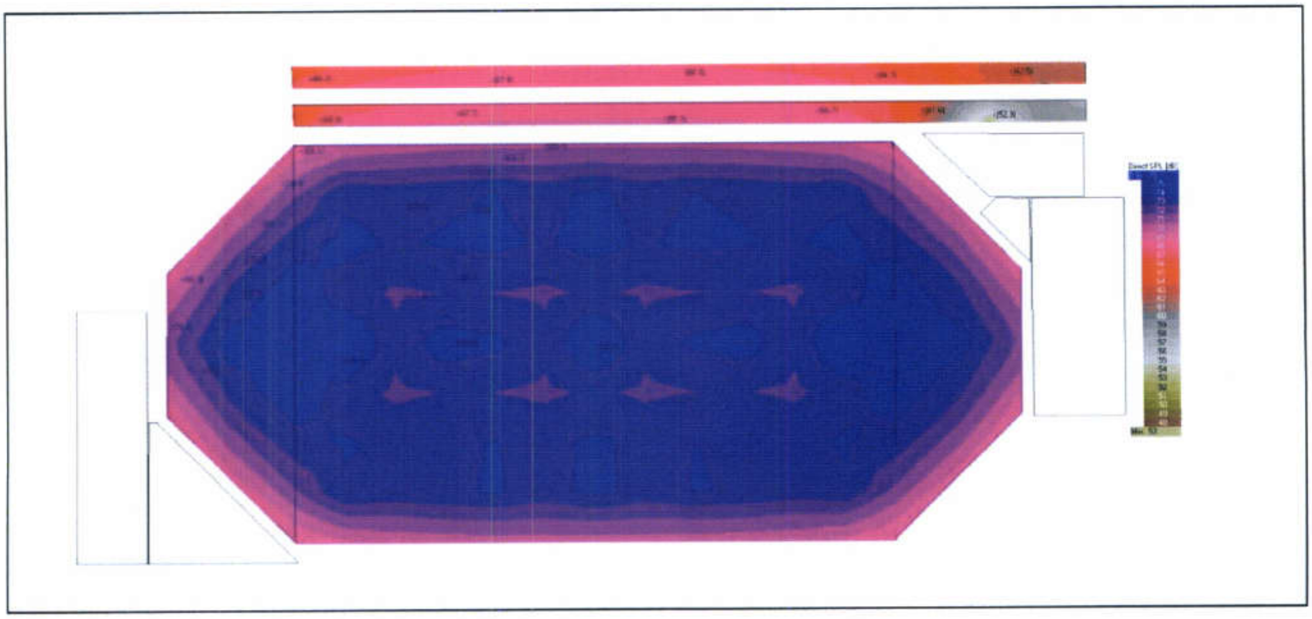


Figure 4 (b) – Direct Sound distribution from overhead loudspeakers at 500Hz

At 1 kHz, the sound distribution over the rink is still very even and the reduction at the wall is 6 to 7 dB as shown in figure 4(c).

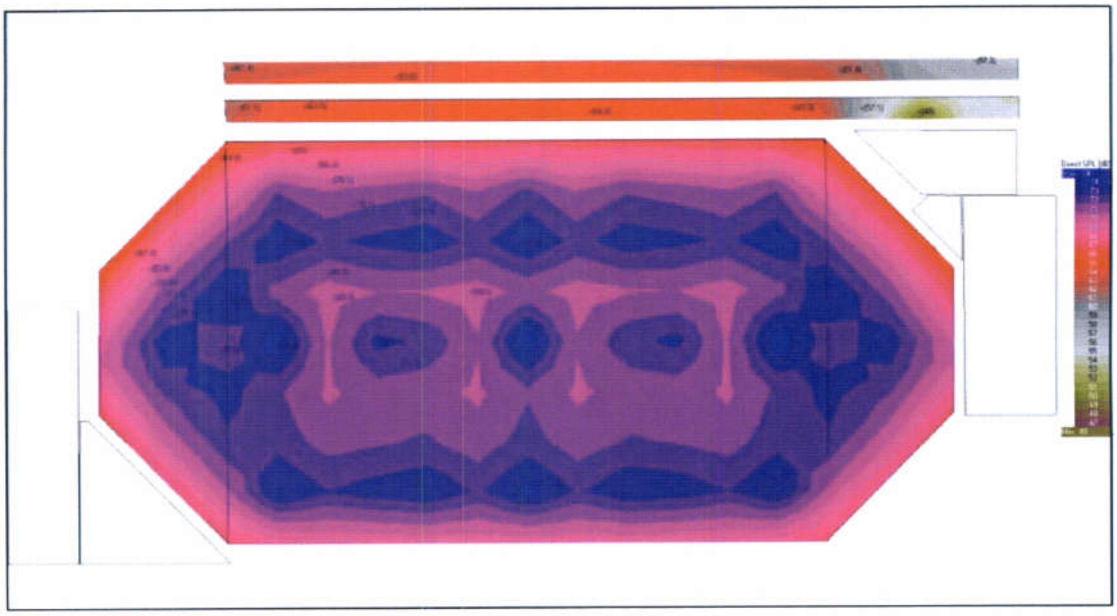


Figure 4 (c) – Direct Sound distribution from overhead loudspeakers at 1kHz

The above plots show that a useful reduction in the level of the sound directly impacting the sound can be achieved using the overhead system. However, when the reflected component is also taken into account the improvement is not so marked – as shown in figures 5(a) – 5(d).

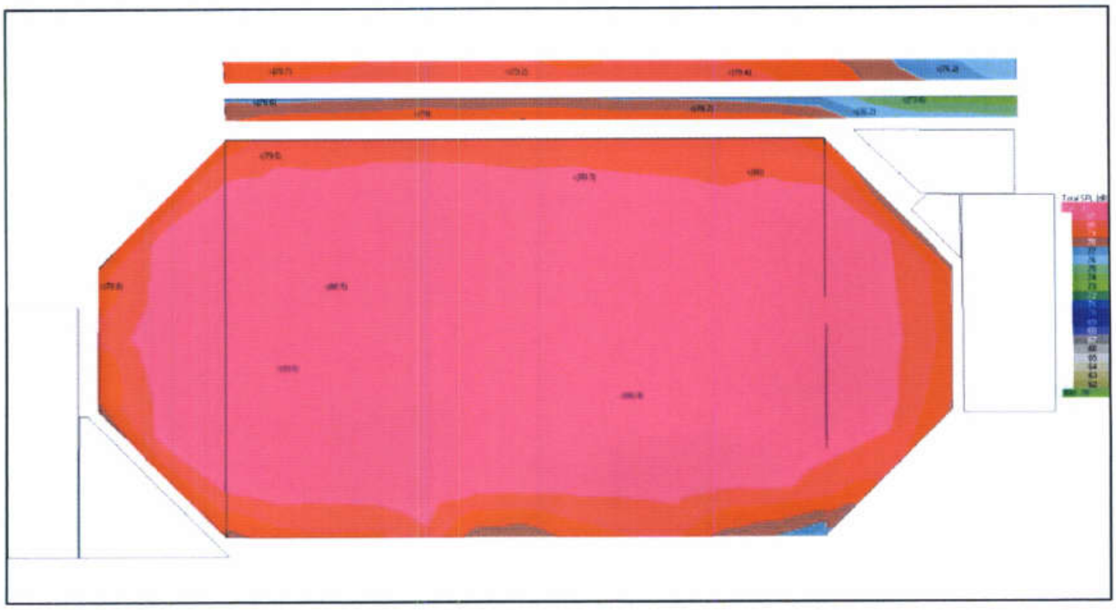


Figure 5 (a) – Total Sound distribution from overhead loudspeakers at 125Hz

At the party wall the sound level at 125 Hz (bass region) is approximately 2 dB lower than in the Rink. At 250Hz the reduction of the Total Sound is 1-2 dB.

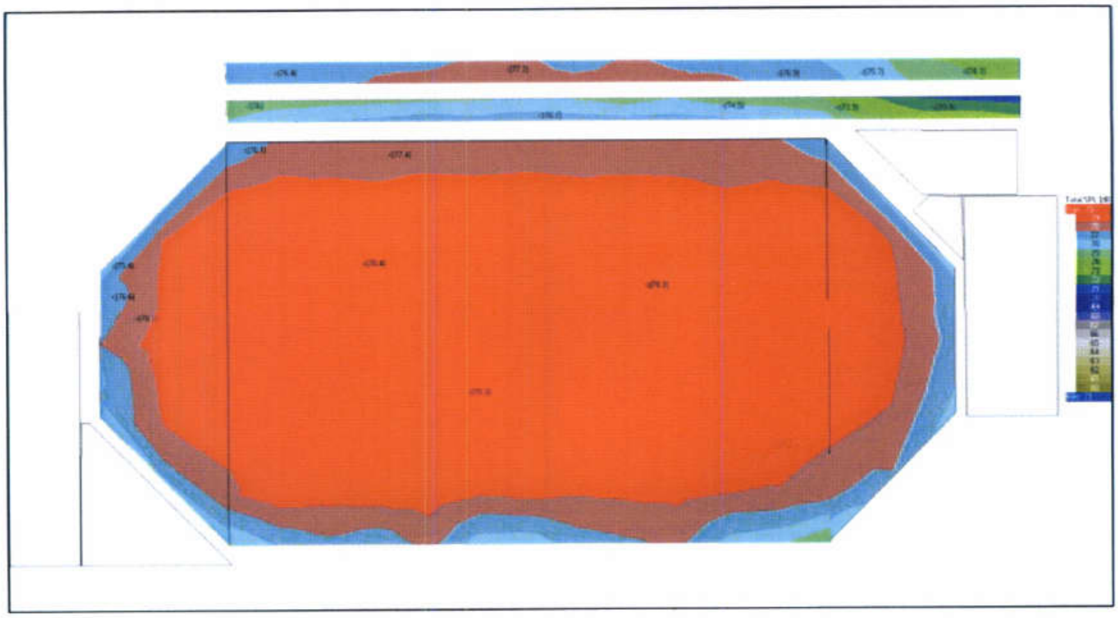


Figure 5 (b) – Total Sound distribution from overhead loudspeakers at 250Hz

At 500Hz the reduction of the Total Sound at the wall is 2-3 dB

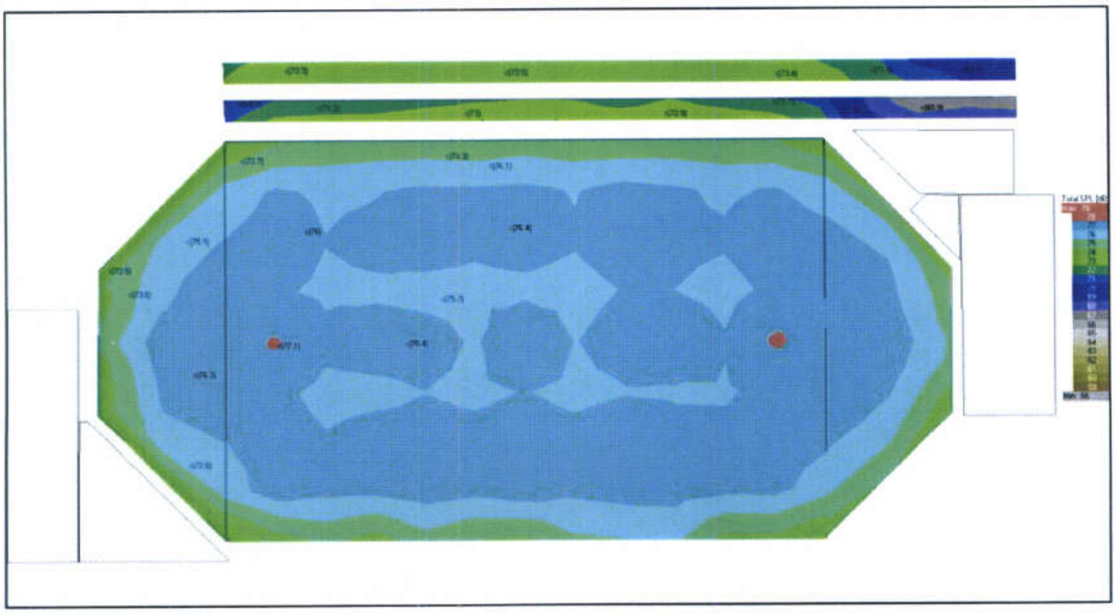


Figure 5 (c) – Total Sound distribution from overhead loudspeakers at 500Hz

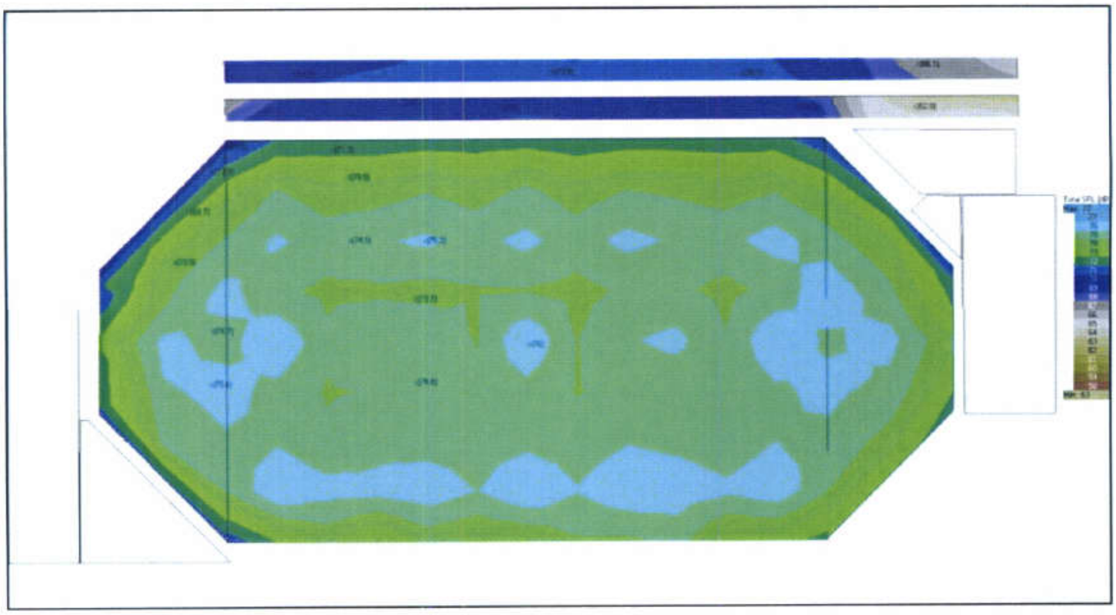


Figure 5 (d) – Total Sound distribution from overhead loudspeakers at 1000Hz

At 1000Hz the reduction of the Total Sound at the wall is approximately 4 dB

As can be seen from the above sound level plots, it is essential to minimise the reverberant sound component – which can be achieved with directional loudspeakers and by reducing the reverberation time of the space by introducing a sound absorption into the space – particularly above the rink.

3.2.2 Directional Loudspeakers

The use of a more directional speaker was also tried within the computer model. Two different formats were tried. Firstly a cardioid (directional) compact speaker was used to replace the conventional overhead compact enclosure. A 16 element line array approach was also tried (Martin Audio Omniline 1.9 metre array) together with a Renkus Heinz 'Live' dual array system (2.5m).

Overhead, compact directional loudspeakers

An exact substitution of the conventional overhead loudspeakers with compact directional units was implemented in the model. Whereas a benefit in the direct sound was found to occur, there was little advantage when the complex (Total) soundfield was investigated. Figure 6 shows a sample result for the 250Hz octave scenario.

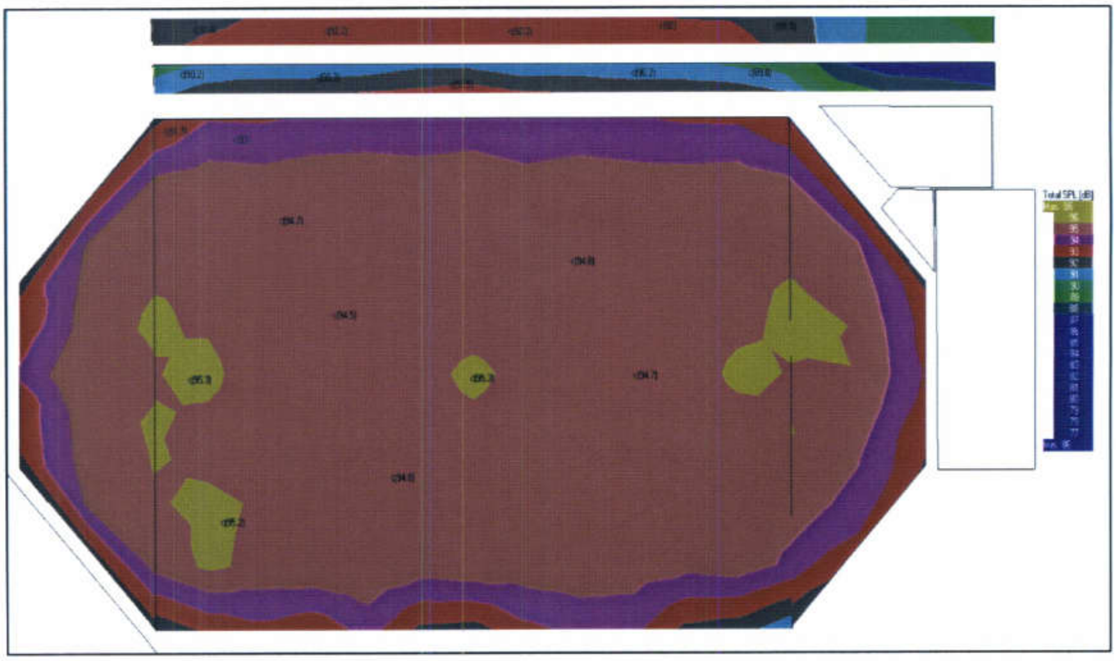


Figure 6 (a) – Total Sound distribution from overhead directional loudspeakers at 250 Hz

At 250 Hz, the reduction in the Total Sound is 2 dB which is the same as the conventional unit. Whereas the Direct Sound attenuation is 4-5 dB which is slightly better than the conventional unit – but only by 1 to 1.5dB.

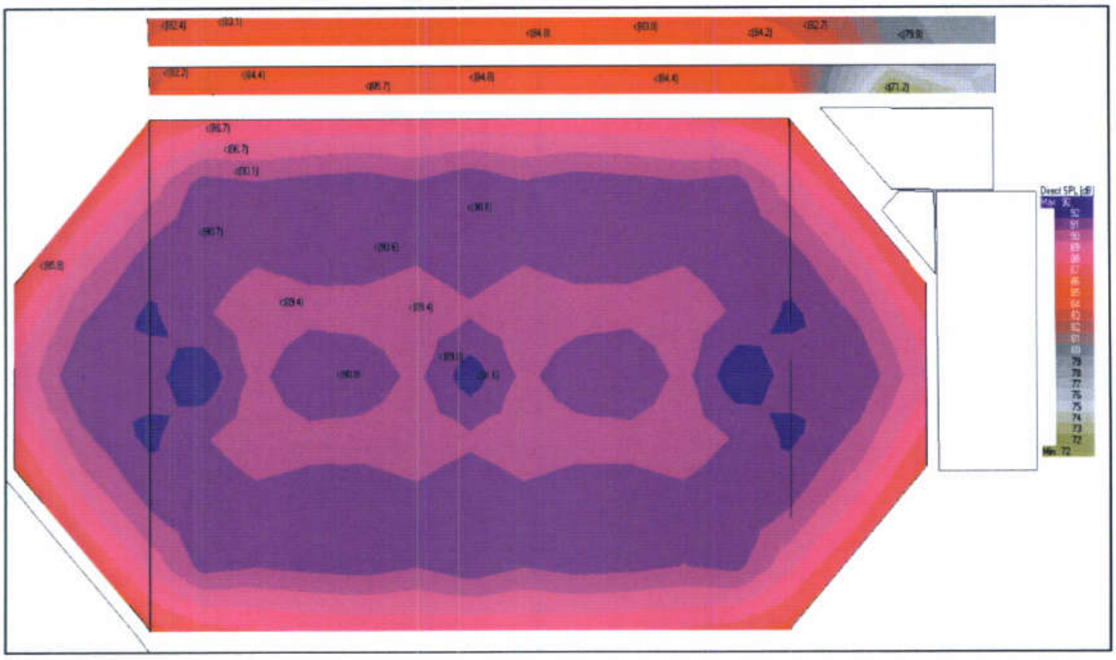


Figure 6 (b) – Direct Sound distribution from overhead directional loudspeakers at 250 Hz

At 500Hz and above, comparison of the loudspeaker radiation patterns showed the conventional unit in fact to be more directional and therefore better able to control the sound. As the cost of the directional units is more than double the price of the conventional loudspeakers, the additional cost versus the benefit gained is not considered worthwhile.

An alternative approach using a 'line array' loudspeaker was also tried out in the model. The array was located on the short side of the rink away from the entrance. In summary, the result was that the distribution of the sound was not as even as with the overhead system (it would subjectively appear to be twice as loud near the loudspeaker as at the far end of the rink) and effectively as much sound was directed towards the party wall as occurred on the rink – though the large differential in levels could perhaps be used to advantage. However, this effect essentially disappears when the Total Soundfield is considered. Figures 7 (a) & 7(b) show some sample results but is it clear that the overhead distributed system is the better solution.

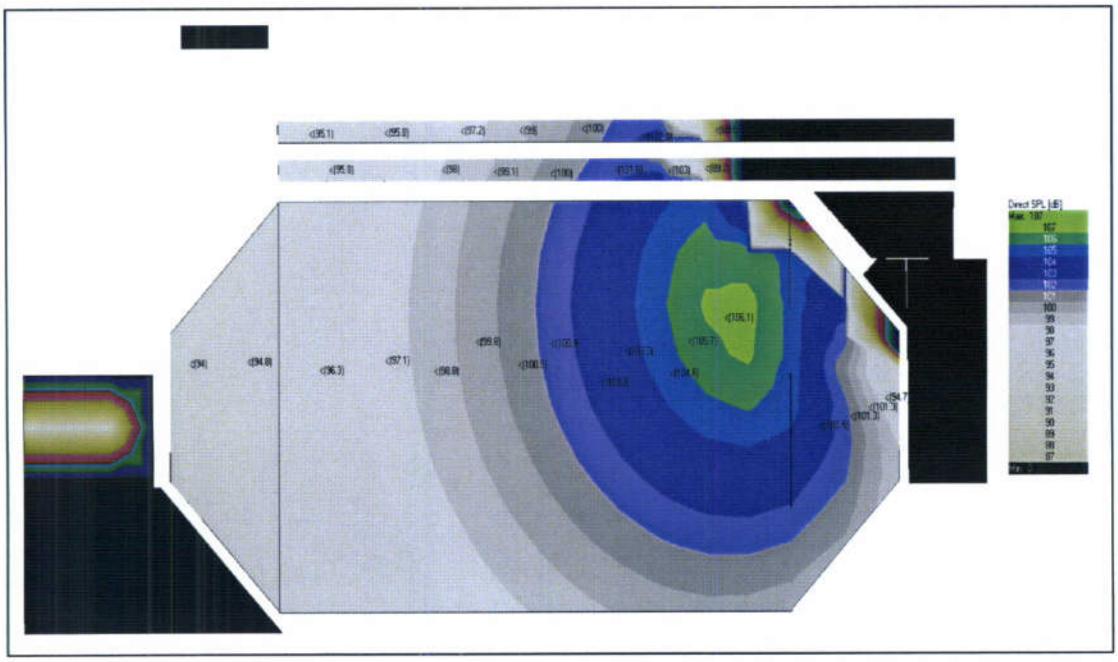


Figure 7(a) – Direct Sound coverage for line array system

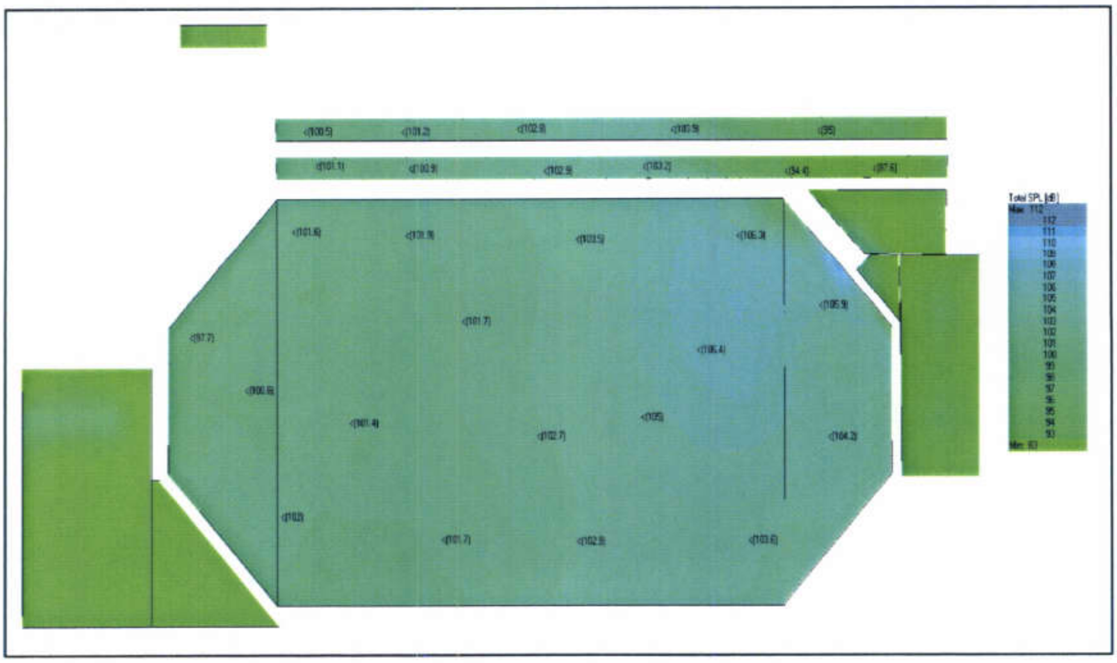


Figure 7(b) – Total Sound distribution for line array system

3.3 Electronic control measures & aspects

The loudspeaker used for the overhead unit in the computer modelling was a Martin Audio AQ6 loudspeaker. This is a two way loudspeaker, rated at 100 watts and has a frequency response extending from 80 Hz to 20 kHz +/- 3dB. It is therefore able to cover the music range apart from the lowest octave. In order to achieve a sound level of 75 dBA, the units would only need to be run at around 1 watt each. The speakers are more than capable of running at higher levels and would require approximately 30 - 50 watts each to do this. The loudspeaker layout used in the model to provide coverage of the rink is shown in figure 8 below. Ideally 25 speakers are required – though a few less could be employed if required – with some loss of some evenness of coverage. Some care needs to be taken with regards to the loudspeaker circuits as with careful wiring, some further control of the speaker levels could be obtained. (For example by turning down slightly the speakers nearest to the party wall or office area). Assuming that the loudspeaker used has a nominal impedance of 8Ω (such as the AQ6), then the loudspeakers could readily be controlled in groups of 4 with a series / parallel wiring arrangement. (Alternatively a 100 Volt distribution system with individual speaker transformers could be used, which could provide a small degree of further control and simplify the wiring).

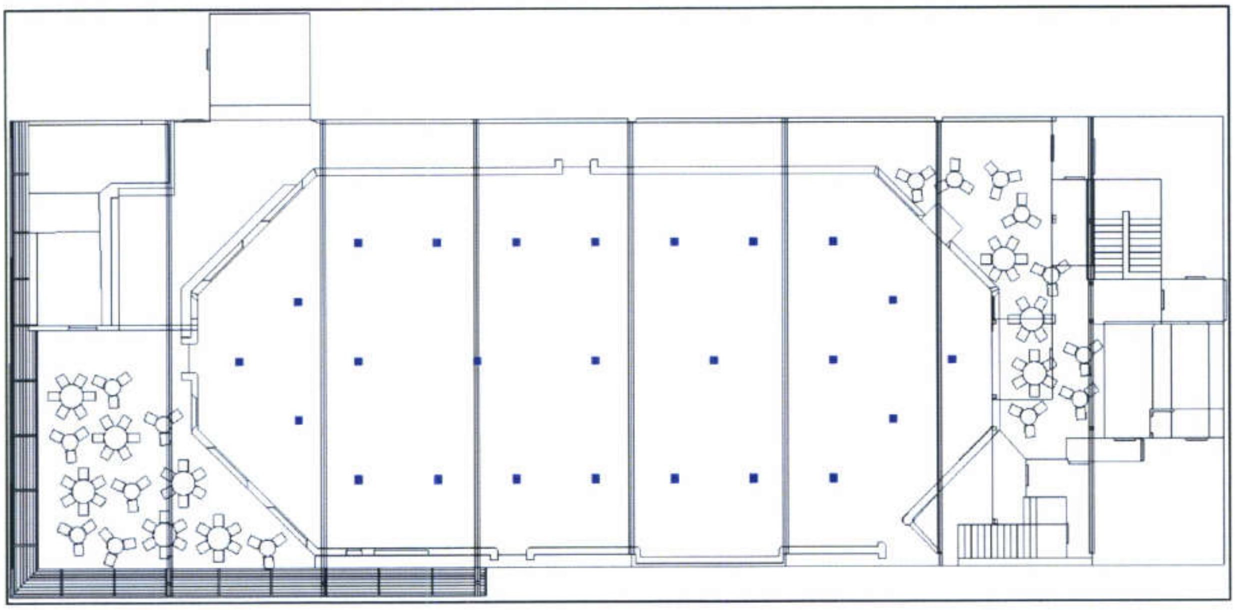


Figure 8 – Overhead distributed loudspeaker layout

If an extended bass response, outside the range of the proposed compact, overhead loudspeakers is required, an additional subwoofer will be needed. An electronically steered directional unit or array could be employed which would help control the levels – but again it is the reverberant component that dominates and effectively controls the levels that can be employed.

Figure 9 below, shows the radiation pattern of an electronically steered 3 unit subwoofer array that could be used.

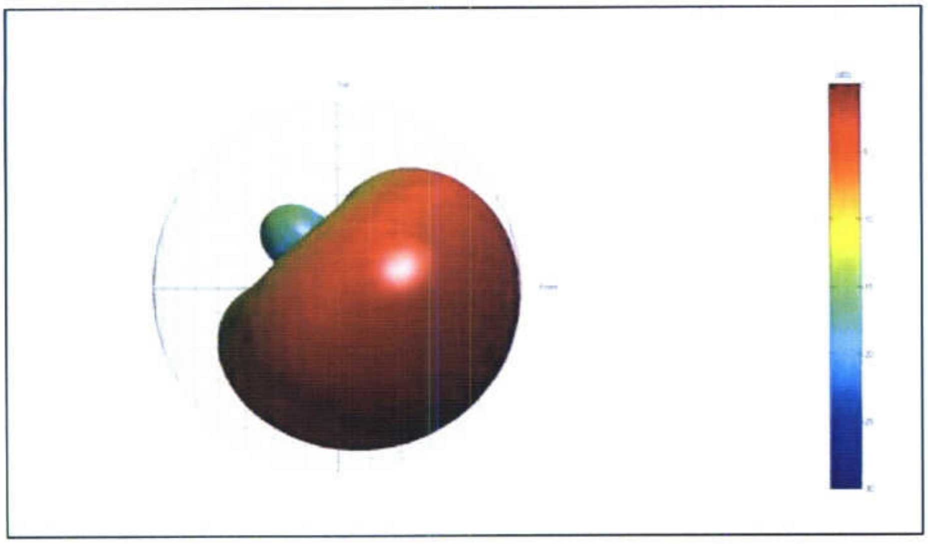


Figure 9 (a) – Polar Radiation pattern at 100Hz for 3 unit array – sound is attenuated to the side and behind the array (i.e. where the balloon decreases)

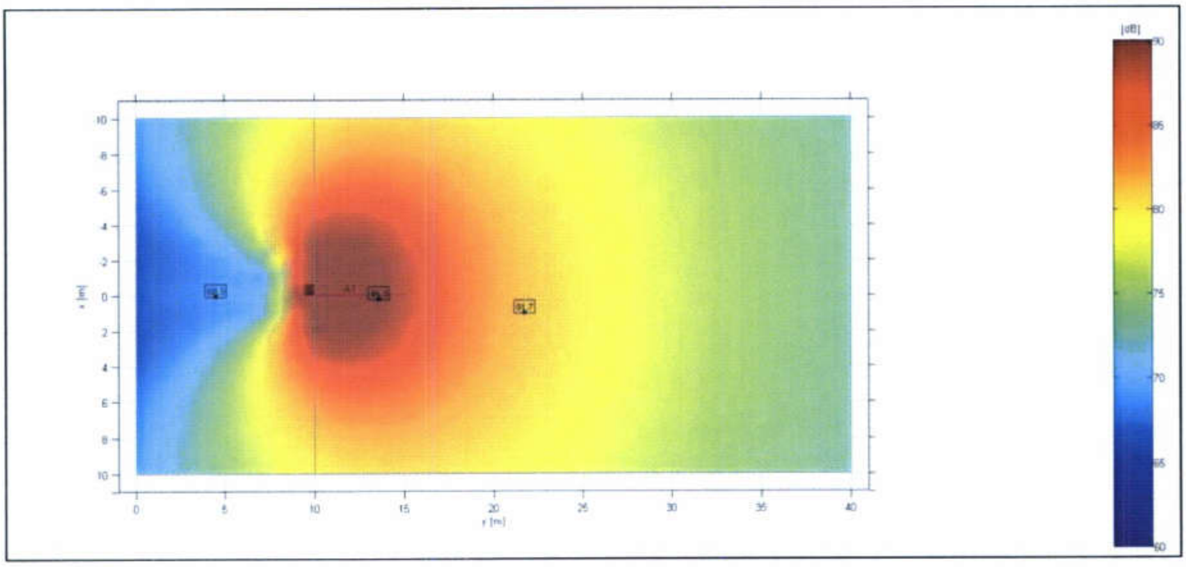


Figure 9 (b) – Direct Sound Radiation pattern for array at 100Hz

Several additional measures can be introduced into the sound system design to help control the sound levels. These include a noise monitor 'traffic light' system that provides a continuous visual indication of the sound level. (If necessary this could be linked into a limiter which would then control the maximum level that the sound system can achieve). The traffic light monitor would be a useful management tool – for both the DJ and Rink Management. In addition it is recommended that a signal leveller and limiter device is incorporated into the sound system. This device will ensure that a consistent level of sound is achieved (without annoying peaks) and that the maximum levels are again controlled). In order to assist with bass sound management, a psycho acoustic bass sound enhancer can be installed. This device effectively creates the impression of there being more bass sound present than is physically the case, thereby effectively reducing the bass sound transmission.

Whereas, the above measures can all assist, it is clear that additional acoustic measures will also be required.

3.4 Sound Insulation & Improvement

As was shown in figure 2, it is the bass and midrange music frequencies up to around 600Hz that are likely to be problematic and exceed the normal ambient background noise levels in the ThermoFisher offices. In order to improve the performance of the existing sound separation that is occurring, it will be necessary to improve the sound insulation performance to the most sensitive sections of the of the party wall.

Figures 10 -12 show the measures that will be required in order to improve the insulation / sound attenuation between the adjacent areas of the building(s).

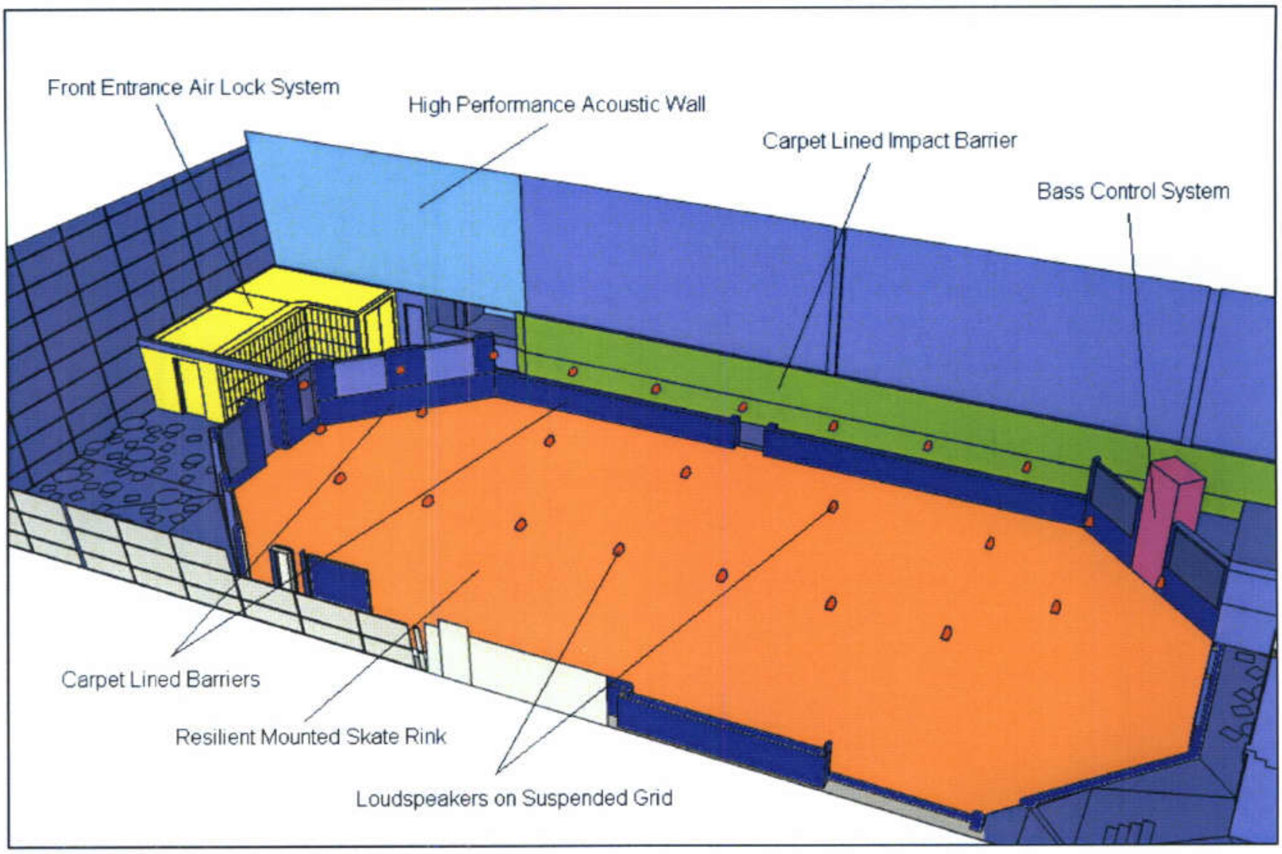


Figure 10 – Recommended Acoustic measures

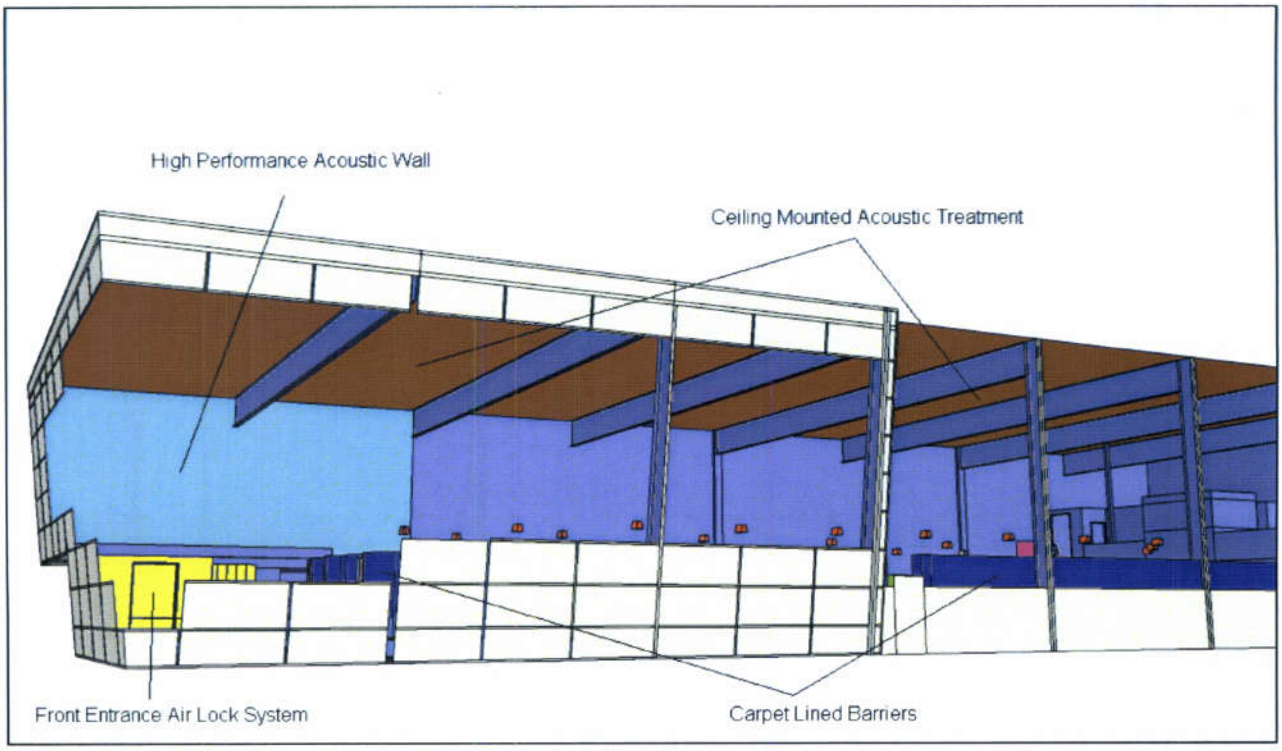
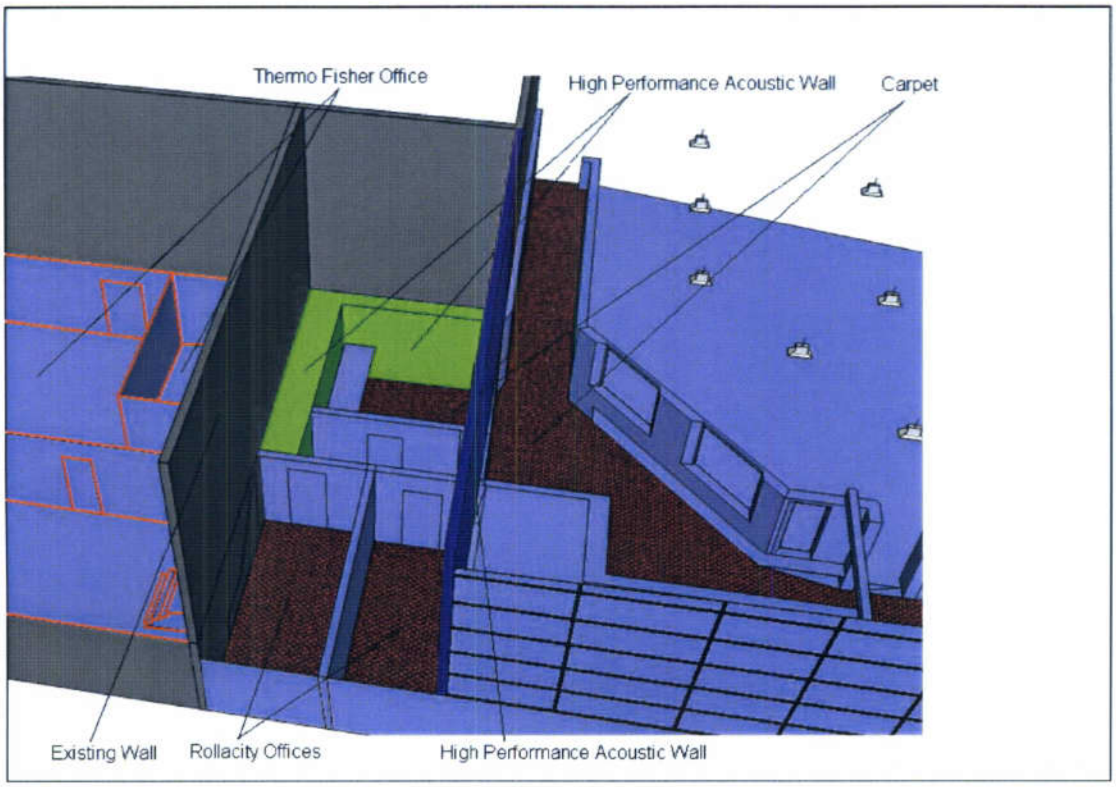


Figure 11 – Acoustic measures

It is recommended that the following acoustic measures are implemented in order to either reduce the noise levels occurring in the Rollacity side of the building or to improve the sound insulation (sound attenuation).

1. Use zoned, distributed overhead loudspeaker system
2. Resiliently mount the rink floor to reduce impact and structure borne sound
3. Extend height of rink barriers and line with carpet to help control local sound and reduce the overall reverberation time of the space.
4. Employ a bass control system (either electronic or structural container) – structurally isolate bass loudspeaker from floor (or walls)
5. Line the lower section of the party wall alongside the rink with carpet to help control local sound and stand off from existing wall by ~100mm for improved impact and sound isolation. (i.e. form second, resiliently mounted impact surface either 15mm plasterboard or 15 -18mm MDF)
6. Provide additional floor to ceiling wall / partition at the front of the rink to protect ThermoFisher Reception / Offices / Stairs.
7. Provide 'sound lobby' entrance door system to stop noise escaping via the entrance doors.
8. Provide acoustic absorption to ceiling – especially over the rink
9. Provide carpet to walkways and around seating areas to give additional sound absorption.
10. Consider lining the upper section of the party wall adjacent to ThermoFisher production area.

As the additional partition required at the front of the building will have to incorporate doors and entrances e.g. from skate hire etc, it is recommended that a second partition is provided immediately adjacent to the party wall – as illustrated in figure 12 (green section).



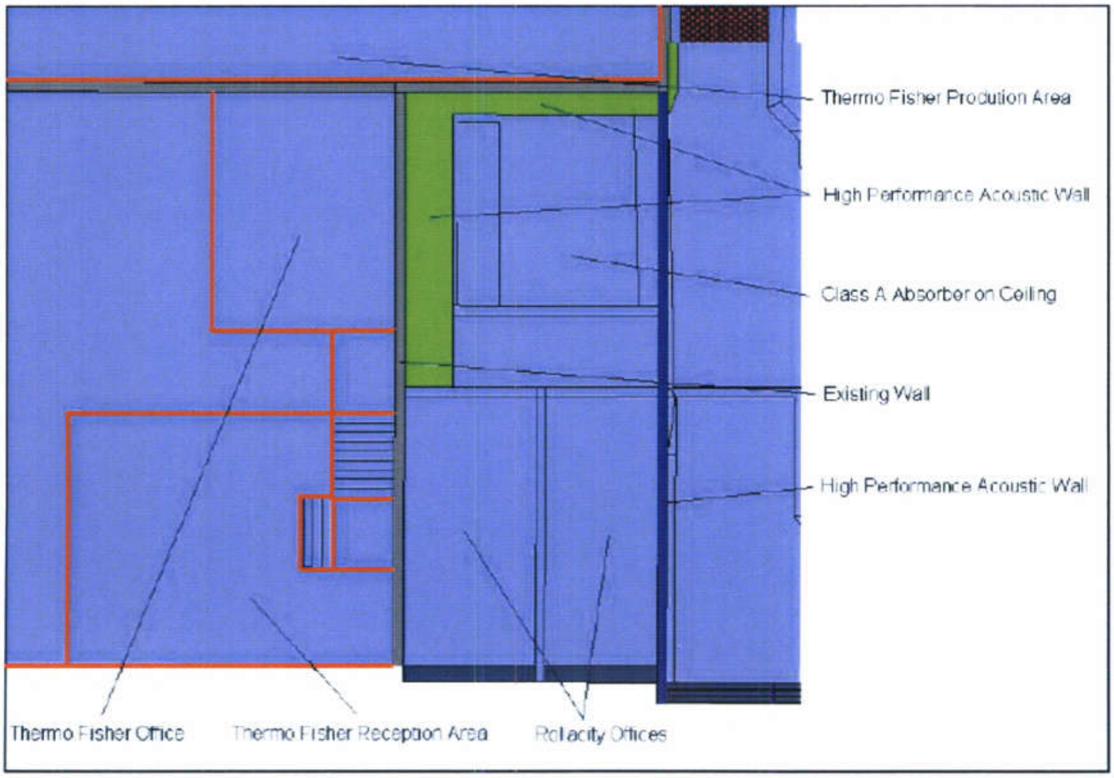


Figure 12 – Acoustic measures to protect ThermoFisher Offices & Reception areas

The exact construction of the partitions is dependent on the required layout and facilities needed for offices and skate hire within Rollacity. It is anticipated however that the full height partition would comprise 2 layers of plasterboard to each side of a stud with an acoustic blanket within the cavity. Ideally, the high performance wall (shown in green) should comprise high density blockwork or possibly of at least 2 layers of resiliently mounted 15 -18mm plasterboard with a minimum cavity of 500mm.

Structural borne sound

Apart from sound being transmitted via an airborne path, sound can also be transmitted via the structure of the building itself (e.g. via the roof structure). Little can be done to reduce this, apart from reducing the amount of direct and reflected sound that impacts on the structure. The need for sound absorption is therefore again highlighted. The overhead loudspeaker system can be supported from wires from a grid or truss or if mounted directly to a grid, then the grid itself needs to be resiliently mounted / supported so that direct coupling to the structure is avoided. As already noted, it is important that should bass speakers / subwoofers be used, that these are resiliently mounted and isolated from the building.