Sound masking design and specification

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Abstract - Every sound masking system requires a design customised to the space. However, without an understanding of good system design, specifications may be difficult to implement, and the installation may be unsuccessful. This paper introduces the basics of sound masking technology, identifies common misconceptions about the technology, and shares some simple rules to apply when specifying a sound masking system. The paper covers the importance of end user experience and offers the theory of sound mask system design along with practical examples and case studies of successful designs and installations. Applying this knowledge to each specification will give each installation the best chance of sound masking success.

1 INTRODUCTION

Every sound masking system requires a design customised to the space. But specifying a sound masking system can be a daunting task for anyone who has not worked with the technology. Sometimes this can result in underspecified or over-specified designs, and unnecessary costs to the client. Fortunately, it is not difficult to prepare the correct specification for each project. It simply requires some knowledge of sound masking technology and design principles, and the humility ask for help, if needed.

In this paper, I use practical examples and case studies to show how to best use the technology, how to factor in end user experience, and the practicalities of good design. Using this information, acoustic consultants should be equipped to specify an acoustic sound masking system that will meet the needs of a range of client requirements.

2 WHAT IS SOUND MASKING?

2.1 Defining the problem

Before we dive into the nuts and bolts of sound masking, it's useful to first define what we are talking about. Australian/New Zealand Standard AS/NZS 2007:2016 section 5.3 provides a description of the problem:

> In spaces where acoustic isolation and speech privacy are important and the sound levels are below the lower level of the recommended design range, there is an increased risk of inadequate acoustic masking. Where this occurs, the loss of acoustic and speech privacy can be a significant concern. In these situations acoustic masking can be introduced into the space to raise the sound level to within the recommended design sound range level in Table 1. (Standards Australia, 2016)

In other words, sound masking is the introduction of a sound into a space that increases the background level of the space to reduce either or both the impact of intrusive noise and the intelligibility of speech. This can include natural sounds like water flowing or bird song, or digital sounds like white or pink noise.

2.2 Sound masking hardware

For the purposes of this paper, “sound masking technology” refers to purpose-built hardware, including loudspeakers and a sound generator, installed into a space to produce a randomised digital sound capable of masking noise like human speech.

A range of sound masking systems are commercially available, with various functions. As well as being randomised, the system output should be capable of being shaped between 20Hz and 20kHz (eg, using an equaliser) and zoned (eg, using a zone distributor). The loudspeakers should be specifically built for sound masking service—that is, not public address system speakers, which are built for a different purpose.

If all of these requirements are included in the specification, then you should have a perfectly workable sound masking system, regardless of the brand.

3 UNDERSTAND THE TECHNOLOGY

Sound masking technology has many applications. However, as with all acoustic technologies, there are limitations. A good understanding of both the applications and the limitations is critical to a successful installation.

3.1 Optimal conditions

An open plan office space furnished with pop-in ceiling tiles and carpet is the perfect candidate for a sound masking system. Generally, the low background noise levels are causing the problem.

Examples shown in *Figure 1* demonstrate a small range of these scenarios. There is an open plan office with ceiling-height meeting pods (ie, sound leakage), a regular office space with workers trying to concentrate, a yoga studio with heavy traffic noise outside, and a small call centre with workers on the phone in close proximity all day. In each scenario, sound masking offered a solution by increasing the background sound levels, which worked well to reduce disruption from intrusive noise and reduce speech intelligibility. This improved concentration and the occupants’ perceived privacy. With the correct design, these kinds of spaces will always find a solution in a sound masking system.

Figure 1 – Open plan spaces with pop-in ceiling tiles and carpet offer an optimal application for sound masking.

Similarly, medical suites, meeting rooms, and boardrooms in standard office fitouts will benefit from a sound masking system when speech privacy is required. The problem, again, is usually low background noise levels. Introducing a masking system will reduce speech intelligibility from the adjoining space and improve speech privacy. *Figure 2* provides some examples of such scenarios, including a medical suite waiting area adjacent to consulting rooms, a private meeting room adjacent to the open plan area, and a boardroom adjacent to the waiting and reception area.

Figure 2 – Medical suite, meeting room and boardroom where speech privacy required sound masking.

In each of these cases, the sensitive speech was intelligible in the adjoining area prior to the introduction of sound masking, and unintelligible after the introduction of sound masking.

Architectural trends are moving towards open ceilings with exposed services. Sound masking can also offer a solution in these spaces, and wherever the background noise levels are too low.

3.2 Unexpected applications

Sound masking also has some surprising applications that, depending on the space, can offer a solution. This is especially true where aesthetics are important to the client. The reverberance in warehouses and atriums offer two examples of this. In these scenarios, adding physical acoustic treatments may "ruin" the aesthetic of the space. This is particularly problematic when the client has spent a lot of money to achieve a minimalist aesthetic.

Figure 3 shows three such scenarios, including a warehouse which had open ceilings (but required speech privacy), an office atrium with significant reverberation, and a library atrium where sound transference was a problem. As can be seen, adding physical acoustic treatments would ruin the "look", but sound masking, even when exposed, is unobtrusive.

Figure 3 – Atriums and warehouses are two surprising spaces where sound masking can improve the acoustic environment.

3.3 Limitations

The main limitations of a sound masking system's success are client expectations, and the proximity and loudness of the intrusive noise.

If a client's expectations of sound masking include "sound proofing", then they will be disappointed. Sound proofing is a different technology. Sound masking is capable of reducing the speech intelligibility and intruding noise to the point that the speech is unintelligible, however it is incapable of rendering speech inaudible without other acoustic treatments. Sound masking is also capable of improving a space so that intrusive noise is less obvious, but it is incapable of cancelling noise.

Sound masking is also incapable of masking loud noises. For example, it is impossible to mask a barking dog unless the masking is set to hearing loss levels, around 90-100dBA (Sakamoto, 2014).

Further, sound masking cannot create speech privacy in every circumstance. For example, it cannot comfortably mask a private conversation in an open plan office if the conversation is happening in half a metre away. There are other acoustic solutions to these problems.

Sometimes these limitations can be overcome by including additional acoustic treatments (eg, door seals), but sometimes they cannot. One of the scenarios, where additional acoustic treatments created an optimal outcome, is provided in *Figure 4*, where door seals were added after the sound masking didn't reach the required level of speech privacy. This was an expected outcome, and we were able to advise the client of the likelihood door seals would be needed. This small, inexpensive, adjustment created speech privacy without compromising the vintage aesthetic.

Figure 4 – Door seals were needed where sound masking alone was not enough to provide complete speech privacy.

4 KEY DESIGN PRINCIPLES

Now that we've covered what the technology can and cannot achieve, it's time to consider how to specify a sound masking system. As a general rule, simplicity is the key to success.

4.1 Designing a sound masking system

Successfully designing and specifying a sound masking system requires a floor plan and ideally a reflected ceiling plan. A basic specification should include the required sound generator (including equaliser, distributor etc) and the loudspeakers. The sound generator is generally located in a rack with other audiovisual and information technology equipment.

The key design consideration is the placement of the speakers. Often this is best left to the manufacturer, but if you want to design the system yourself, keep in mind that most sound masking systems on the market work on around 4 - 5 metre centres for speaker placement. It is wise to be flexible with this aspect of the design unless there is one specific brand you are specifying. The final design can be guided by the manufacturer depending on the specific requirements of the chosen system.

This is also the time to consider your zoning. If there are meeting rooms or consulting suites that require a different sound level, you might zone those differently from the open plan office or reception areas, but not always. *Figure 5* provides an example of a floorplan with speakers laid out in two zones with the office areas, including the reception desk and a meeting room, in one zone and the board room in another.

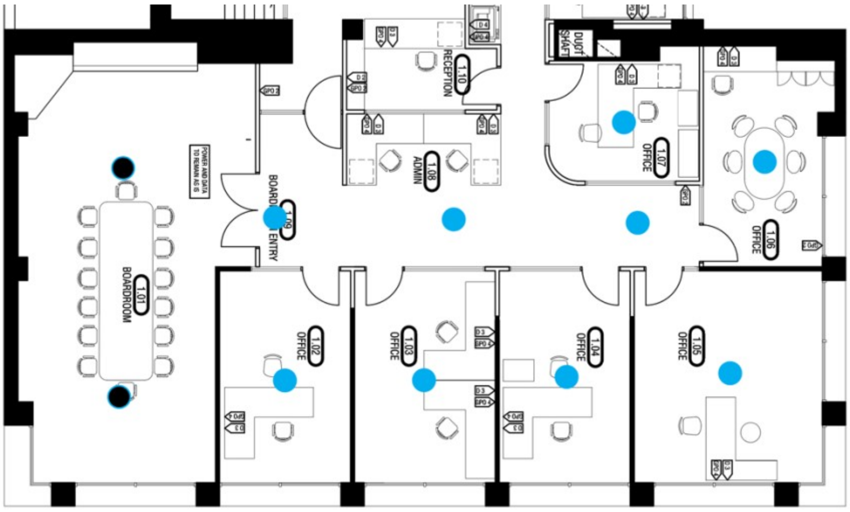

Figure 5 - The design layout features two speaker zones – one for the board room, one for the other areas.

The reason for this particular design was to avoid the perception of different sound levels within the office. Lower sound levels were necessary in the boardroom to allow meetings to take place without attendees having to raise their voices to be heard.

Sometimes, the second design consideration is the sound shape. If the space is being retrofitted (ie, you have been able to measure the background levels in an existing space) and you have a specific sound shape in mind, you could include that in the specification. However, most commercially available sound masking systems will have standard sounds preset that have been designed and fine-tuned over many years to be just right for their system. If that is the case, it is usually best to apply the manufacturer's recommended shape first, and then if you're not satisfied, shape it from there.

Another design consideration might include particular target sound levels. However, as I will describe in section 5 below, flexibility within the specification is key to a comfortable user experience, and the success of the system.

4.2 Masking one room only

Frequently, the client just wants the CEO's office masked. That's where the private conversations are happening, and everyone can hear them! To mask that one office, you cannot simply hang a speaker in the office and hope for the best. The area around the office also needs to be masked. This is because the masking sound must be where the eavesdropper is located. However, you cannot just mask around the CEO's office and leave the CEO's office unmasked either. This is because the CEO and his or her guest will be able to hear conversations from the surrounding area, and therefore feel psychologically that they can be heard too. *Figure 6* below shows an example of such an instance.

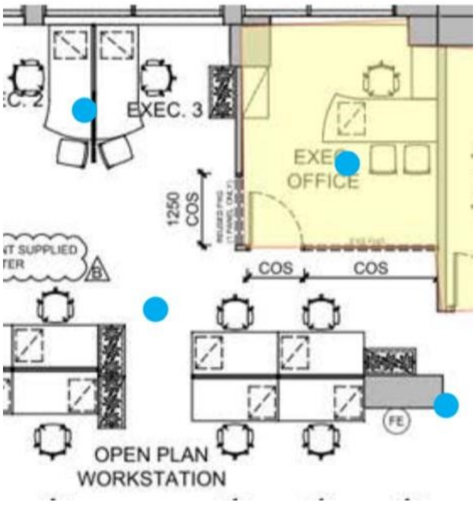

Figure 6 – Masking one room requires masking around the room as well. Blue dots indicate speaker placement.

This can sometimes create the problem of "walking into a wall of sound", where the ambient background noise levels are low, and then the masking is set relatively high to achieve privacy. There are several solutions to this. One instance of this occurred when a boardroom needed completely confidential speech but was located at the end of a very quiet and expansive open plan office. Ideally the whole open plan office would be masked, but that is not always practical from a cost point of view. In this scenario, we scattered some speakers "leading up" to the installed speakers which created a more "graduated" sound.

Figure 7 provides a sketch from the abovementioned job, with all the identifying details removed. You can see the hashed circles indicate the necessary speakers for privacy, along with black circles for the speakers that optimise user experience. The actual open plan office was much bigger than the picture. Speakers can sometimes be manually tapped down, saving on the cost of zoning for a small installation.

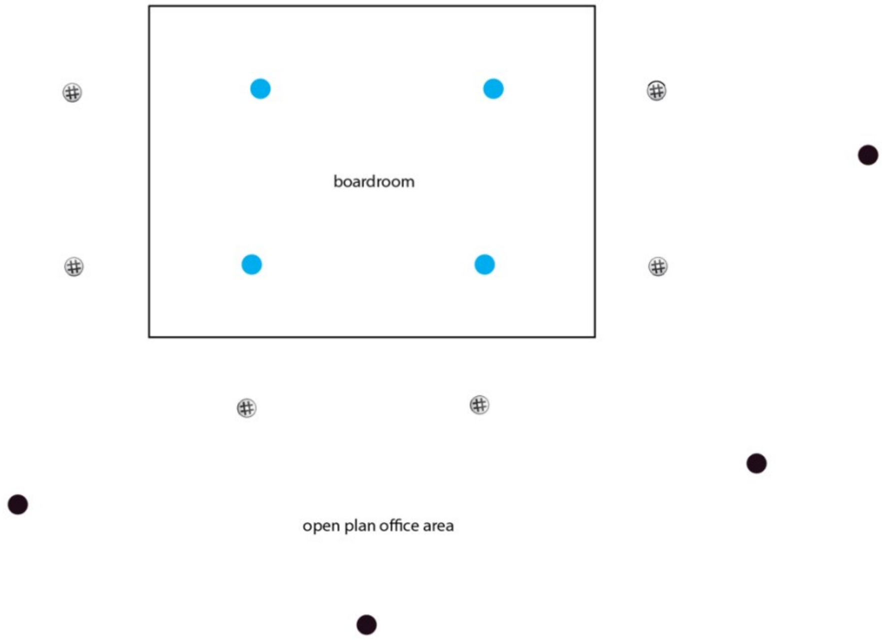

Figure 7 - An example of "graduating" sound masking to avoid a "wall of sound".

4.3 Hot spots, dead spots & obstacles

Optimising a sound masking system can present some difficulties when design specification meets practical reality. For example, it is a rare installation that doesn't run into an inconveniently placed duct or other immovable objects. This is where trained, experienced installers are critical. They know how the system *should* sound. They will know that an additional speaker needs to be added to avoid a “dead spot”, even though the design hasn’t specified it. They will also know that they should put that under floor speaker away from the vent to avoid a “hot spot”.

That said, some of these problems can be exacerbated by poor design. Not including sufficient speakers can inadvertently create “dead spots” and render the system less effective. One memorable example of this occurred when I designed a system for an architectural firm who had a Wikipedia level of knowledge on sound masking. They wanted several speakers removed from the design because they were “unnecessary”. This was a cost saving measure. After much negotiation, we installed the system *they* designed, with every written disclaimer possible. You guessed it, the system wasn’t as effective as they’d hoped. Fortunately, they relented and paid for the additional speakers. The system then worked as advertised.

Though in theory designing and implementing a sound masking system is simple, there is an art to it that can only be gained through experience. If you have not designed a sound masking system before, there is no shame in asking the manufacturer for design assistance. They should be only too happy to help.

4.4 Designing for different systems

Every sound masking system has its own benefits and limitations, some more important than others. This can significantly impact the design and the specification.

For example, if a system has 4 inch loudspeakers that need to be placed at five metre centres, the design will be quite different to a system that uses 2.5 inch loudspeakers installed at two metre centres. Sometimes acoustic consultants might have a particular manufacturer in mind when they write the specification, which is fine. But if the specification is going out to tender, a more open specification helps builders to include the opportunities for alternate designs. For example, if based on the specification the builder insists that any loudspeaker must be set 4 metres apart, it does not factor in the additional or fewer speakers needed for different systems. Further, it is not possible to fairly compare the pricing, which disadvantages the client. However, allowing opportunities within the specification to provide an alternative design optimised for a different system is allowed, the client can compare the costs of various systems on their merits. Achieving this openness can be as simple as including “alternative designs and products will be considered” or similar wording in the specification.

This is one of many examples of allowing flexibility in the specification allows for the best client outcome, especially when cost is an important consideration.

5 USER EXPERIENCE

The experience of the end user is one of the most critical elements of a sound masking system’s success. It is also one of the commonly overlooked elements of the design. For example, setting the volume levels incorrectly is a recipe for failure. Fortunately, it is simple to ensure the end user’s experience is a happy one.

5.1 Creating an environment

When designing a sound masking system, it is easy to lose sight of the purpose: to create a comfortable acoustic environment. When I say “end user”, I really mean “human being”. The human beings who work in the office or other space being masked will be living with the masking sound for upward of eight hours per day—double that for professions like lawyers. To be comfortable, the sound masking system needs to become part of the environment. It should be static, not changing, so that it can fade into the background and quietly do its job.

To do this job, the sound must be randomised so that the ear doesn’t become tuned to it. Aside from the randomisation, it should not bounce up and down depending on the ambient noise levels. If the sound changes, the system leaves its job of being part the environment and becomes noticeable. And once it becomes noticeable, it can become annoying. Imagine working for one hundred hours a week in an unpredictable, annoying acoustic environment. That’s the problem sound masking should be solving, not exacerbating.

5.2 Volume

One key to creating a comfortable acoustic environment is setting the volume of the sound masking system to a comfortable level. In section 2.1 above, I quoted the relevant standard, AS/NZS 2007:2016. If you refer back to that, you will see that these are the *recommended* levels only. Often, we will set levels below these recommendations—for example, some of the open plan office spaces in *Figure 1* were set as low as 35dBA to achieve the optimal outcome. This is a full 5dBA below the lower recommended levels but should not matter if it works for the space.

To ensure the user experience is optimised, it is best to avoid blindly specifying and insisting upon the recommended levels. Where sign off depends on the levels being increased to "meet the standard", despite our recommendations, this can result (and has resulted) in the system being turned off because the users find it intrusively loud. This is a waste of time and money for everyone involved, especially when the solution was so simple: to set the volume at a lower, more comfortable level.

How, then, to set the correct level? The most successful levels are generally achieved by first measuring the unoccupied ambient background sound levels, and then setting the levels around 2-3dBA higher than that. For example, if the ambient background levels are measured at 35dBA, the initial masking level is set at 37-38dbA. The wood panelled board room, pictured far-right in *Figure 2*, is an example of such levels. The levels can be adjusted upwards later, if necessary. When levels are set too high, it occasionally poses a risk to user acceptance. This is because it can be difficult for some users to accept a system they have noticed. Fortunately, that is a small cohort. We have retrofitted hundreds of systems during business hours where users know exactly what's being installed, and they are generally grateful that it solved the problem. Still, the risk remains and is easily mitigated by following the above recommendations.

Levels should be set and adjusted to the purpose, using common sense. For example, meeting rooms are typically set at a lower level than an open plan office, because meeting rooms are quieter. A call centre where people are talking 24/7 will be set at a higher level than a boardroom. It would be rare occasion when levels are set at or above 45dBA. I have personally sat in a "quiet room"—in a Boroondara Council Library—where the levels were set at 48dBA, and it was so uncomfortable I had to leave. Experiencing a sound masking system set at different volumes is generally the best way to understand the user experience.

5.3 Zoning

A "zone", in respect of a sound masking system, is the division of areas within a space to accommodate either or both different sound levels and shapes. Regardless of the sound masking system chosen, it should have the ability to create zones. Making good use of zoning can be critical in installations where there are a variety of ceiling surfaces, user requirements, and other factors.

Zones are best used for two reasons: a) to create an even spread of sound, or b) to adjust the system to fit a specific requirement. I caution anyone attempting to create a zoned design to first consider the user. It is useful to consider what differences the human ear can discern. For example, the nuance between 41dBA, 42dBA, and 43dBA is generally lost to the human ear. I mention this because we once had an acoustic consultant specify an abundance of minizones throughout an open plan space. With specific decibel requirements ranging from 42dBA to 48dBA, this brought with it the practical difficulty of measuring discernible differences between the zones. In the end, due in part to cost considerations, the entire space was set to 44dBA.

Generally, different zones are necessary for each separate ceiling surface and purpose. A good example is Shell Australia's head office in Brisbane, where the space had four different ceiling surfaces (excluding the lift foyer), and three main purposes. The ceiling surfaces are picture below in *Figure 8.* The purposes were reducing the impact of distracting noise in open plan spaces, creating speech privacy in meeting rooms, and reducing noise transference between telephone call pods. The design only required four zones because the purposes were accommodated within the ceiling surface differences. A comfortable, even spread of sound was achieved throughout, with an average level of 39dBA.

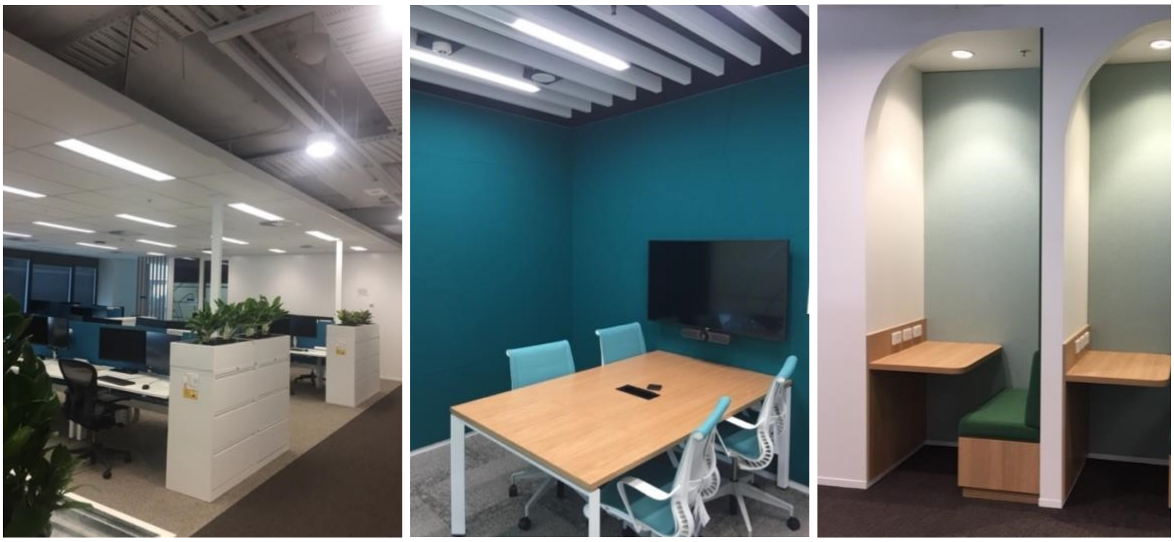

Figure 8 – Shell Australia ceiling surfaces included ceiling tiles, exposed services, absorptive panels and plasterboard.

One word of caution with zoning. Sometimes I see specifications that use zoning to manually randomise the sound generated by the system. For example, zones “A” and “B” zigzagging intermittently throughout an open plan office. This may have been necessary decades ago, but technology has moved on. If the system you want to use requires this kind of zoning, it is not a truly randomised product, and therefore does not meet the criteria for a modern sound masking system. It would be wise to consider a purpose-built sound masking system instead.

6 CONCLUSION

When specifying a sound masking system, it is important to work within the limits of the technology, prioritise user experience, and seek assistance from the manufacturer as needed. Acoustic consultants who follow these considerations have the best chance of specifying a sound masking system that offers a successful and cost effective solution to their client’s needs.

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