



Guidelines for video conferencing room acoustics

D14377.01 – September 2010

Video conferencing room acoustics

- Does the audio quality fail to meet your expectations?
- Do you feel tired when spending longer hours in video conference meetings?
- Is it hard to catch what people say in these meetings?
- Too much noise in your meeting room?
- Does the far end tell you that your audio is bad?

Have no fear, all this may just be another case of bad acoustics—luckily there is a cure!

The cure may require you to pay a visit to a specialist—in this case an acoustic consultant—but you should consider self-medication as well. Self-medication can save you some time and money, even though you sometimes end up seeking professional advice in the end anyway.

I. Check for symptoms of bad acoustics

The natural starting point will be to check for symptoms of bad acoustics. Try clapping your hands in your meeting room and listen to the sound you produce.

Does this produce an industrial-like sound, as in an empty basement, a garage or a bathroom? Or, does it sound more intimate, as in a bedroom or in a walk-in closet? Industrial sound is not good—intimate sound on the other hand tends to be perceived as more cozy and inviting and are therefore more suited for audio/videoconferences.

If you are not sure what to listen for, try clapping your hands in the bathroom and in the bedroom before you go to bed tonight and listen to the sound you produce in the two rooms (you may want to exercise this with caution, typically when you are on your own or before your partner is asleep).

The next step will be to take a look at your meeting room. Are there a lot of hard, impenetrable, flat surfaces like polished floors, concrete or plaster walls and windows with no curtains? Such rooms typically produce industrial-like sound, which tend to obstruct the feeling of natural communication.

As a non-acoustician you will probably not be able to change the acoustics of the room from not so very good all the way up to excellent just on your own, but there are things everybody can do that may make the acoustic conditions end up as fairly good.

The secret lies in the introduction of soft penetrable surfaces, simply because they absorb sound. Examples of objects having such surfaces will be carpets, upholstered sofas and chairs, pillows and curtains (the heavier the better).

Allow us to demystify the noble art of finding out if a material or object has the acoustic properties required. For the tasks described in this section you won't need access to advanced and expensive equipment to do that. All it takes is to give things a little blow of your breath. To some it may make your behavior look a little strange, but there is an explanation behind it.

The quickest way to check the absorption properties of an object is to place your mouth at its surface and blow. If the resistance is perceived as similar to that of a bed pillow, the surface is a good absorber. As simple as that!

To achieve this effect in a room, the surfaces should be covered with absorptive material. One of several solutions is to use acoustic panels.

There are special acoustic panels commercially available. These include mineral wool panels designed to be mounted in the ceiling and on the walls. Such panels come in almost any flavor—you can even get them with print!

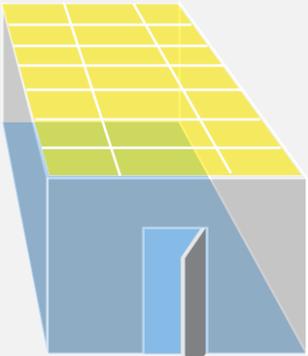
To obtain a list of recommended products contact your local Cisco representative.

Your solution

- In general, introduce things that absorb sound into the room. If possible, cover hard surfaces with absorption, as this will improve the sound absorption further.
- The ceiling is the best place to start putting absorption as large areas easily can be covered.
- Never let two opposing, parallel walls remain without absorption. This means that absorption must be placed on at least two adjacent walls in addition to the ceiling.
- The best result is obtained if absorption is spread out on all walls in addition to the ceiling.
- Putting a large object such as a white board, smart board or a large picture in a frame on the wall. is beneficial if the surface of this object is not parallel to the wall. This can easily be done with a spacer—see the Fig. below.

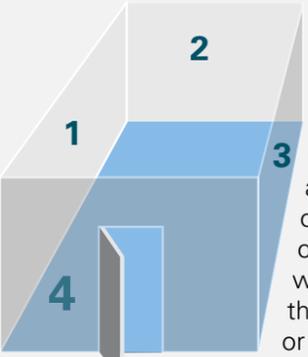
Applying absorption

The ceiling is the best place to start putting absorption, as large areas easily can be covered.



If you cannot put absorption on all walls, put it on adjacent walls, which will be either:

- On the walls 1 & 2
- On the walls 2 & 3
- On the walls 3 & 4
- On the walls 4 & 1



Do not put absorption on opposing walls only—in other words: not on the walls 1 & 3 or 2 & 4.

Mounting a large surface, such as a white board, smart board or a large picture in frame is beneficial if the surface is not parallel to the wall. This can easily be done with a spacer.



Distributing the absorption works better than absorption clusters.



II. Further reading: Why is acoustic treatment of the room important for video conference?

It is all about perceived audio quality

Perceived high audio quality is a prerequisite for natural communication and high speech intelligibility. Low audio quality leads to communication quality impairments.

Human speech normally has a high degree of redundancy. This means that we are able to work out the missing information even when the audio suffers from being of less than optimal quality.

Not always, though. There are cases where ambiguity due to low audio quality may emerge. A classic example to some could be whether Jimmy Hendrix actually sings “Excuse me while I kiss the sky” or maybe he just sings “Excuse me while I kiss this guy”. Low audio quality may lead to misunderstandings and wrong decisions during a meeting.

Lowered speech intelligibility will inevitably obscure natural communication, take focus away from important aspects of the meeting and lead to fatigue.

This will be further accentuated in meetings where people use a non-native language and/or suffer from hearing impairment.

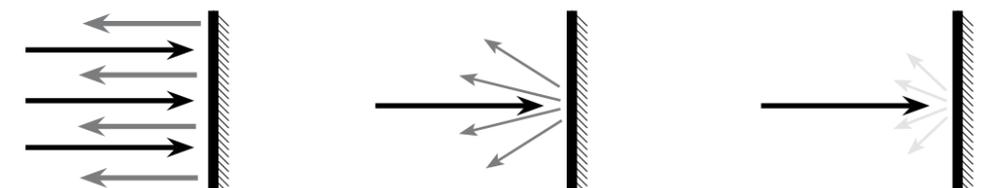
The main contributor to reduced audio quality is suboptimal acoustical conditions in the meeting room—typically when sound is reflected too much by the walls, ceiling and floor. This condition is perceived as having too much *reverberation* in the room. A sound receiver picks up the sound coming directly from the sound source as well as the reverberation. The sound source is either a person talking or a loudspeaker; while the sound receiver is either a person listening or it is a microphone.

The reverberation is characterized by its length and its diffuseness. The amount of sound reflected by the surfaces determines the length. The reflections that the reverberation consists of can either be specular, diffuse or a mix somewhere in-between, which in turn also will characterize the degree of diffuseness. Specular reflections of sound waves are analogous to light rays being reflected by a mirror while diffuse reflections are analogous to reflections by a frosted window or blurred mirror. Specular reflections occur from plane hard surfaces, while diffuse reflections occur from irregularly shaped objects.



Above: Sound reflected off a wall resembles very much reflections of light. Specular reflections, as shown to the left, are similar to reflections seen in a regular mirror, while diffuse reflections, as shown in the middle, resembles a blurring mirror. Diffuse reflections *with* absorption provides a blurred “washed-out” reflection as shown to the right.

In rooms with specular reflections and parallel opposing walls, the sound will bounce back and forth between the parallel walls, creating highly unwanted effects.



Above: Specular reflection with little or no absorption (left), diffuse reflection with little or no absorption (middle) and diffuse reflection with absorption (right).

For the early part of the reverberation—typically within 80–120ms after the arrival of the direct sound—specular reflections are more disturbing than diffuse reflections. Specular reflections can lead to echoes if the room is very large (not a problem in meeting rooms of regular size), flutter echoes, and comb filtering.

Flutter echo is caused by sound bouncing between two parallel surfaces and it sounds like a “rough” reverberation.

Comb filtering is caused by delayed copies of the direct sound interfering with the direct sound. The effect is that the signal will be attenuated at some frequencies and magnified at others. It goes without saying that this will have a huge influence on the audio quality and speech intelligibility.

Diffuse reflections will reduce the magnitude of distinct early reflections and thereby reduce the flutter echoes and comb filtering effects. Diffuse early reflections can even be positive since they perceptually fuse together with the direct sound thus creating higher speech intelligibility.

When the sound has been bouncing back and forth in the room for a while—typically for 80 to 120ms—the reverberation will consist of a chaotic mix of reflections. Among acousticians this is referred to as “the late diffuse part of the reverberation.”

Whether the reflections are diffuse or specular will no longer matter due to this chaotic state. This is the part of the reverberation that is responsible for smearing the speech. This late part has the same effect on speech as rubbing your finger on a crayon drawing will have: The harder you press and the longer you do it, the more blurry the drawing becomes. For speech, what happens is that the phonemes tend to float into each other. The speech blurriness is determined by the amount of sound reflected by the walls quantified by the reverberation time (RT). RT is defined as the time it takes from you stop speaking to the reverberation sound level has fallen below the threshold of hearing.

Sitting near a wall will improve the speech quality. Reflections from the wall will tend to reinforce your voice.

It is not the acoustical conditions in terms of reverberation, flutter echo and comb filter effects alone that may lead to reduced perceived audio quality. Noise sources present will lead to higher background noise, which in turn may mask the audio and disturb the communication. Traffic noise heard in the meeting room, due to poor sound insulation, can be surprisingly disturbing. Noisy HVAC (heating ventilation and air conditioning) installations may also make natural communication difficult.

The effects of noise present will be magnified by poor acoustical conditions. The reason why is that even the noise will be subject to the same reverberation, flutter echo and comb filter effects as the speech will.

Ease of speech

Based on the above, one may conclude that the shorter the reverberation time is, the better. However, communication is not only about listening, even talking is involved. In order to turn a room into a place where it is pleasant to talk, the room must provide you with some feedback, in other words reverberation is not all bad. Luckily, diffuse early reflections are preferable even here, as they provide the best support for speech.

A side effect of background noise is that if the background noise is too high, most people tend to talk louder. Researchers tend to believe that this occurs because speakers unconsciously feel that they do not hear themselves sufficiently and therefore feel that they cannot communicate adequately with the others.

In this respect reverberation should be considered as noise. Consequently, the amount of reverberation heard by the speaker may also have the above effect. This reverberation stems from noise sources present, but also the voices of the persons speaking.

The amount of reverberation is therefore a tradeoff. It should be low enough to avoid raised voices, while at the same time offer some diffuse support to ease the speaking process.

The raised voice is known as Lombard speech. The speech’s pitch and level increases leading to voice stress and fatigue. It is assumed to start at a speech level of 55dB(A) SPL and a background noise level of 45 dB(A).

Solving the problem

The destructive effect of the reverberation can be reduced by increasing the level of the sound received directly from the source relative to the reverberation.

This can be realized in two ways:

- By decreasing the distance between the sound source and the sound receiver
- By attenuating the reflected sound.

Decreasing the distance between the sound source and the receiver imposes restrictions on the meeting setting:

Microphone: If you consider placing microphone(s) close to the participants without having them wear the microphone(s), this will impose severe restrictions on the freedom of seating. This is highly undesirable in situations with a multitude of speaking participants.

Loudspeakers: You may reduce the distance between the loudspeakers and the listeners. However, even this will impose severe restrictions on the freedom of seating.

Room: The conference situation within the room requires further restrictions in where people can be seated since everyone should be within ears reach of each other in order to be able to communicate.

These three restrictions show that acoustical treatment of the room is the only viable solution.

Acoustical treatment attenuates the reflected sound and increases the usable distance between sound sources and receivers. This will in turn increase the audio quality over a wider seating area, thus enabling higher flexibility in seating for the people attending the video conference. Furthermore, it allows the customer to get value for the money invested in high quality video conference equipment since acoustical treatments increases the quality of the recorded and reproduced sound.

The sound is attenuated by absorbers which turn sound waves into heat through friction. The travelling sound waves move the air in the absorber back and forth creating friction between the air and the absorption material. Close to walls, ceiling and floor, the movement of air is very small since the surfaces are hard.

The definition of “close” depends on the wavelength, typically a fraction of a quarter wave length. The further away from the surfaces there are absorption, the further down in frequency sound is absorbed. We therefore recommend a mounting distance of about 10–20cm (4”–8”) in most cases, which will lead to good absorption for the frequency range of speech. This can be obtained by means of curtains.

A consequence of hard surfaces in a room is that specular reflections occur between parallel walls. This will lead to very noticeable comb filtering, flutter echoes and reduced ease of speech. These highly unwanted effects can be reduced by treating at least one of the walls in each pair of opposing, parallel walls. Further improvements will emerge if you introduce irregularly shaped objects to the room. This will lead to a higher degree of diffusion. Other ways of getting diffuse reflections include breaking up plane hard surfaces with “islands” of absorption. For more on this see *C.L.S.Gilford. The acoustic design of talk studios and listening rooms. J.Audio.Eng.Soc. 27. 17–31. (1979)*. This is often considered to be one of the best solutions for smaller meeting rooms—see Fig on page 4.

The background noise level will also be reduced by increased absorption. However, increasing the sound insulation and choosing HVAC solutions less noisy should also be considered.

For the best result we do recommend that the room fulfills the recommendations in EBU Tech. 3276 (<http://tech.ebu.ch/docs/tech/tech3276.pdf>).

This will in practice require the use of an acoustic consultant.