SMALL ROOM ACOUSTICS

THE DISCOVERY OF FALSE MYTHS
AND RELEVANT GUIDELINES FOR A PROPER DESIGN.

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Donato Masci
Acoustic Designer & Consultant donatomasci@gmail.com
Studio Sound Service s.a.s. www.studiosoundservice.com

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ACOUSTIC DESIGN BY DONATO MASCI – WEBSITE

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Among the most important projects:

- Barys Arena (ice hockey) @ Astana, Kazakhstan;
- FOX International Channels @ Hammersmith, London (UK) – a/v post-production studios
- Mulinetti Studio (Alberto Parodi) @ Genova (**Resolution Award 2015 – Best Audio Facility**, Nomination)
- The Garage @ Civitella v.d.C. (AR) (**Resolution Award 2014 – Best Audio Facility**, Nomination)
- House of Glass @ Viareggio (LU) (**Resolution Award 2013 – Best Audio Facility**, Nomination)
- PPG Studios (Andrea Bocelli) @ Santo Pietro Belvedere (PI)
- In House @ Roma - Dolby® approved cinema mixing theatre, color correction
  (sound design for “La Grande Bellezza” di Sorrentino, 2014 Oscar)
- George Lucas Home Theater, Italy
- Santa Maria Nuova Church (Arch. Mario Botta) @ Terranuova Bracciolini (AR)
- Prada @ via Orobia, Milano - Auditorium and Conference Room
- Ferrari @ Maranello - Projection room of the Ferrari Museum

MYTHS AND FACTS ABOUT STUDIO ACOUSTICS

… IS THE SAME FOR ALL SMALL ROOMS! (PHYSICS IS FORTUNATELY THE SAME)

Three articles: “Myths and facts about studio acoustics”
Resolution Magazine 2014 (March, April, May/June)

MYTHS AND FACTS ABOUT STUDIO ACOUSTICS

… IS THE SAME FOR ALL SMALL ROOMS! (PHYSICS IS FORTUNATELY THE SAME)

In my three-articles series, by using scientific criteria <u>I will try to prove the following frequently encountered statements to be right or wrong</u>:

1. You can't mix in rooms that are too big, too small, with a high ceiling, with a low ceiling.
2. Panels or tube-traps are enough to make a room a good mixing room.
3. I do not like to listen with the subwoofer.
4. Some monitors sound too good to be used for mixing.
5. Big monitors are good for clients but not for mixing. They're just too big for that, they lack "definition".
6. I don't want my monitors in the wall, it's not necessary and I can change them easily if I ever want to. Furthermore, they can be moved about in case I need to perform a "fine tuning".
7. Nearfield monitors have much more "definition" than far-field ones.
8. Auto-calibration is useless if a room has good acoustic treatment.
9. I don't need acoustic treatment if I have auto-calibration.

1. PRELIMINARY OBSERVATIONS

ABOUT RECORDING STUDIO ACOUSTICS

In the audio community is now considered indisputable fact (even if some pros are still not aware of it!) that the control room has to "sound" as neutral as possible.
To be more specific, AESTD1001.1.01-10 specifications represent a good guide line:

1. the optimal reverberation time from 200Hz up is around 0.25s in 100m^3 rooms and at lower frequencies can go up to 0.75s; for smaller rooms (or bigger) these optimal values are lower (or higher);
2. frequency response has to be as flat as possible, better if within ±3dB range (even if many probably don't know that most "professional" monitors have a ±5dB range measured in an anechoic chamber);
3. first reflections should be 15dB lower than direct sound.

STANDARDS AND OBJECTIVES

REVERBERATION TIME

1. the optimal reverberation time from 200Hz up is around 0.25s in 100m³ rooms and at lower frequencies can go up to 0.75s; for smaller rooms (or bigger) these optimal values are lower (or higher);

$$T_m[s] \approx 0.25\left(\frac{V}{V_0}\right)^{1/3}$$

Reverberation time	T_m [s] = nominal value in region of 200 Hz to 4 kHz; V = listening room volume; V_0 = reference room volume (100 m^3)	$\approx 0.25\,(V/V_0)^{1/3}$ (Reverberation time decay and tolerance borders are shown in Figure 3.)

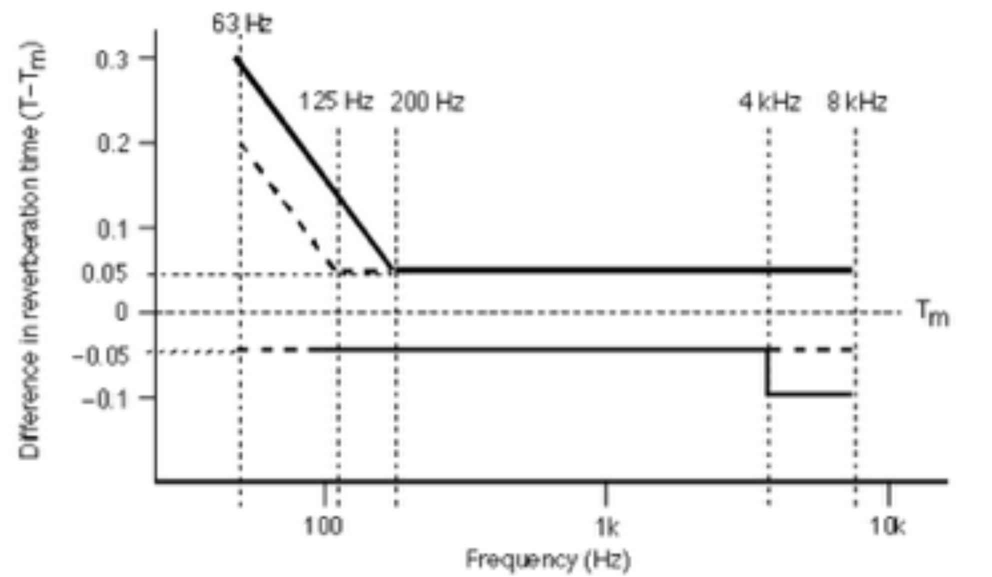


Figure 3. Tolerance mask for reverberation time, relative to arithmetic average value T_m. (Based on international recommendations, but extended to lower frequencies, with smaller tolerances in the range of 63–125/200 Hz.)

STANDARDS AND OBJECTIVES

FREQUENCY RESPONSE

2. frequency response has to be as flat as possible, better if within ±3dB range (even if many probably don't know that most “professional” monitors have a ±5dB range measured in an anechoic chamber);

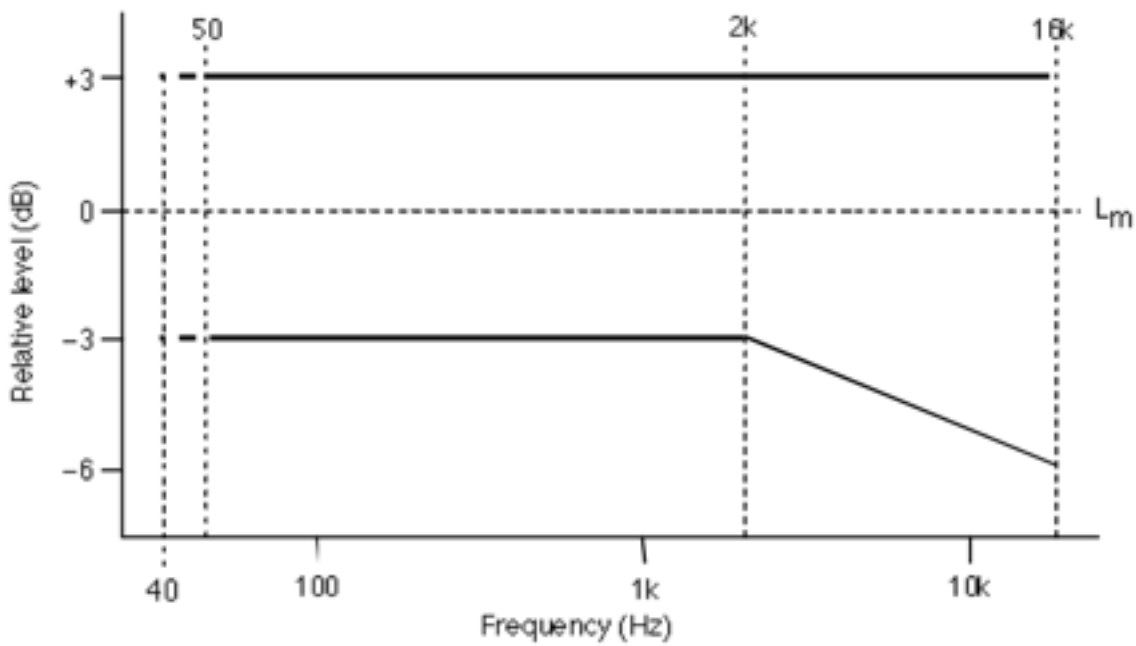


Figure 4. Tolerance limits of operational room response curve, relative level. (Based on international recommendations but extended to lower frequencies.)

Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

PRELIMINARY OBSERVATIONS

WHAT DO THE ENGINEERS LOOK AT?

The first thing sound engineers take a look at, maybe because the chart is easily understandable, is the **frequency response**.

Unfortunately, <u>many engineers actually only stick to these parameters</u>, not knowing that, for non-treated rooms, frequency response is often quite flat (setting aside a physiological enhancement of lower frequencies, that can be easily corrected with the roll-off filter that is common to most monitors).

In this case, the issue is that **the room has not sufficient sound definition to a mix, especially at low frequencies, even with a "quite flat" response!**

You need to have a look at other parameters… (RT, early reflections etc.)

The reason is that the monitor's direct sound as it reaches the listening spot is coloured by the reflected and reverberated sound that comes from the room. Reverberation time is a key factor. On the other hand, if this were particularly low it would make listening quite uncomfortable and quite different from the same sound reproduced in another more "normal" environment.

PRE TREATMENT

WHAT I FOUND ON PRELIMINARY BASIS, PRE TREATMENT

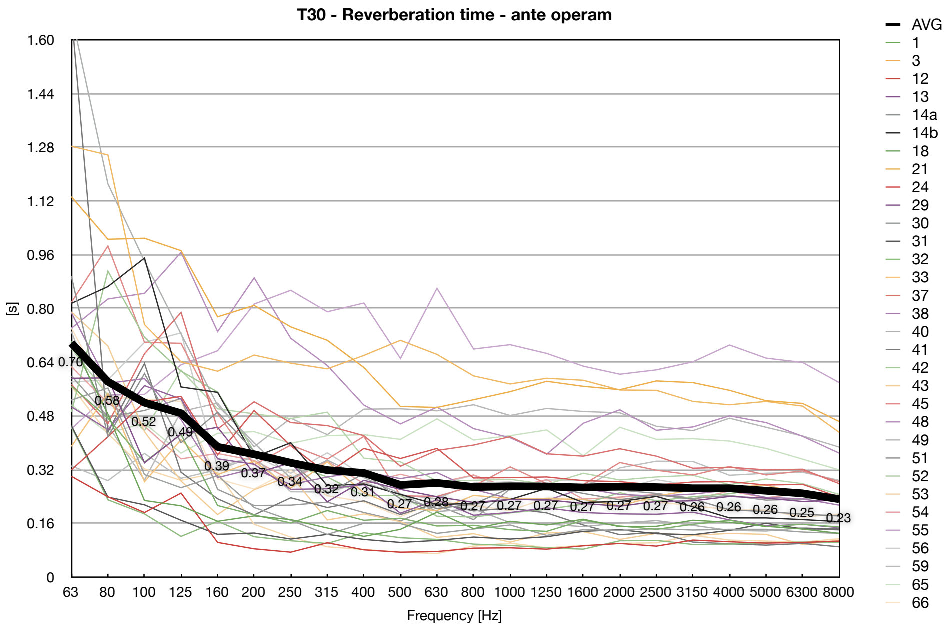
On average, among studios I visit on a preliminary basis before any drawings or treatment is done:

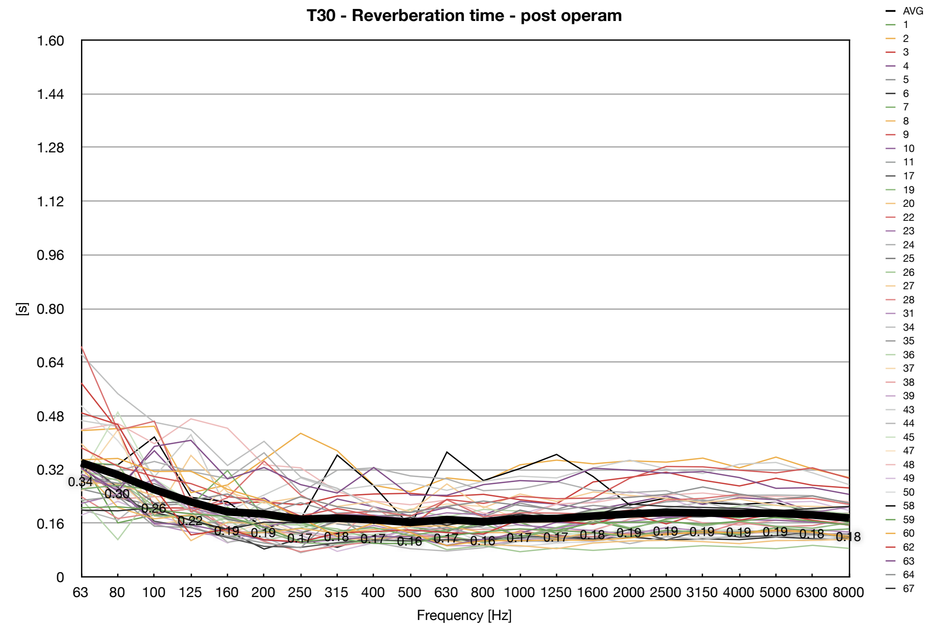
- only a small portion have absolutely no treatment to begin with;
- the majority have self-made treatment solutions, based on what the Internet has to say on the subject (and most of the times these do not manage low frequencies correctly!);
- most clients treat their rooms with absorbent pyramidal panels et similar.

What follows is that **all such rooms are quite colored in frequency** and fail to achieve what is required – a **neutral sound**.

REVERBERATION TIMES

PRE TREATMENT VS POST TREATMENT





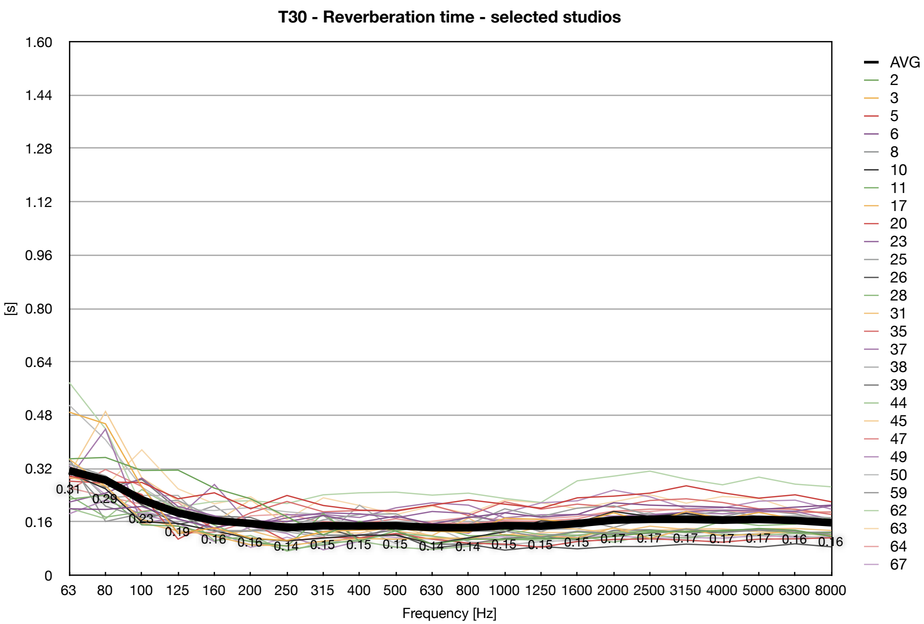
- As shown in the pretreatment reverberation times charts from my measurement of various rooms (Figure 1), the average is above the optimal value, considering that the rooms’ mean volume is 60 m^3 – but the most important element is the variance: it's very high, mostly at low frequencies.

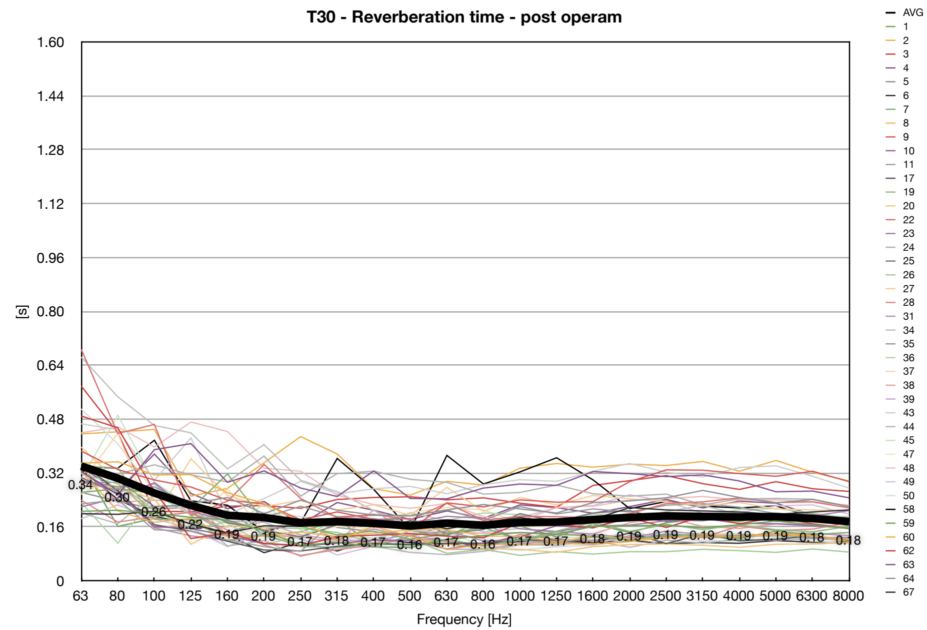
Donato Masci

Acoustic Designer & Consultant

www.studiosoundservice.com

POST TREATMENT (BEST) VS POST TREATMENT





In the post-treatment RT chart (Figure 2) of the same rooms, we see that:

- there is a substantial reduction in RT values, especially at low frequencies;
- the average value @ 63Hz is twice the value @ 500Hz – it was three times higher pre-treatment;
- variance is very reduced, although physiological discrepancies remain among rooms with different volumes;
- there are no rooms with RTs higher than 0.65s @ 63Hz.

For rooms I selected on the basis of a better subjective quality of listening experience (Figure LEFT) this trend is even more noticeable.

Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

As it shines through the AES guidelines and as shown on these charts:

optimal RTs depend on the room's volume.

Therefore, there's no answer to the question:

“what is a control room's ideal RT?”

if its volume is not known **because the factor that is most related to sound definition is the ratio between direct vs. reverberated sound energy that reaches the listener.**

For all reasons given above, I found it interesting to examine control room acoustics through “energy” parameters, usually common in architectural acoustics (theaters, auditoria, etc.) and defined by **ISO3382** standards. Unfortunately, in the literature there is no way to find (*or at least, I have not found yet!*) their optimal values for recording studios.

other parameters:

C50 - C80 - D50 - **Ts**

Instead, I found the analysis of the Center Time or Barycentric Time as particularly interesting.

BARYCENTRIC TIME
DEFINITION

Barycentric Time (Ts) quantifies:

the time required for energy to reach the measuring spot as if this energy were "packed" in a single reflection.

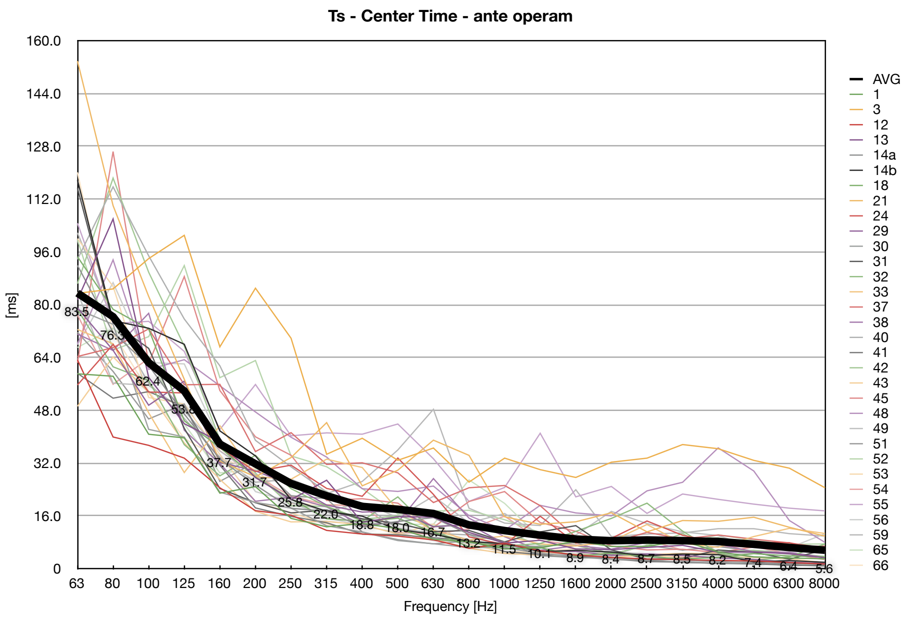
What is remarkable is that Ts **assumes very similar values for treated rooms** and is even more similar for quality selected rooms.

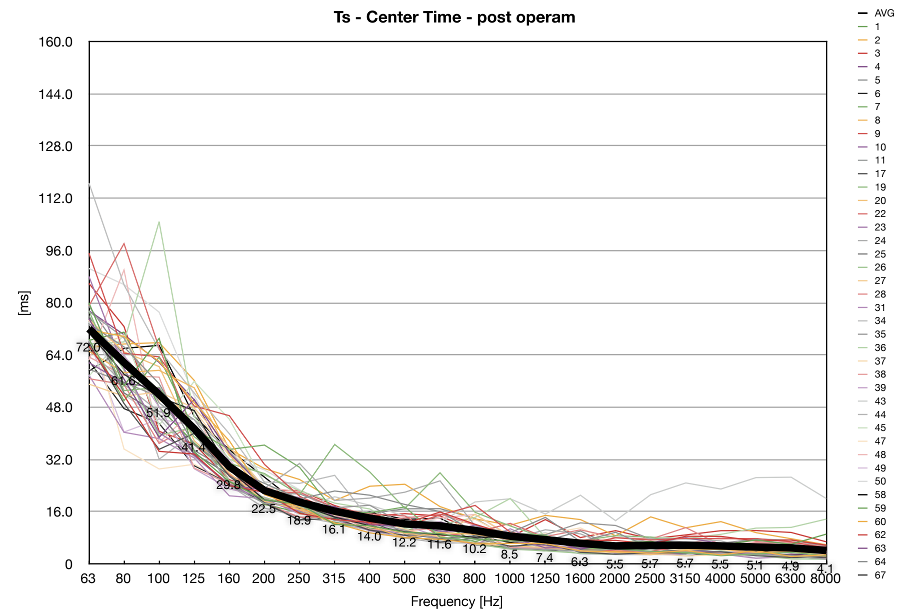
There is no substantial variation based on a room's volume, therefore it is, in my opinion, an absolute parameter that defines after how much time you achieve the average sound energy at different frequencies.

In next Figures we will show, it's clear that this parameter, for quality selected rooms, tends to an average value independently from the single room's volume.

BARYCENTRIC TIME

PRE TREATMENT VS POST TREATMENT





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Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

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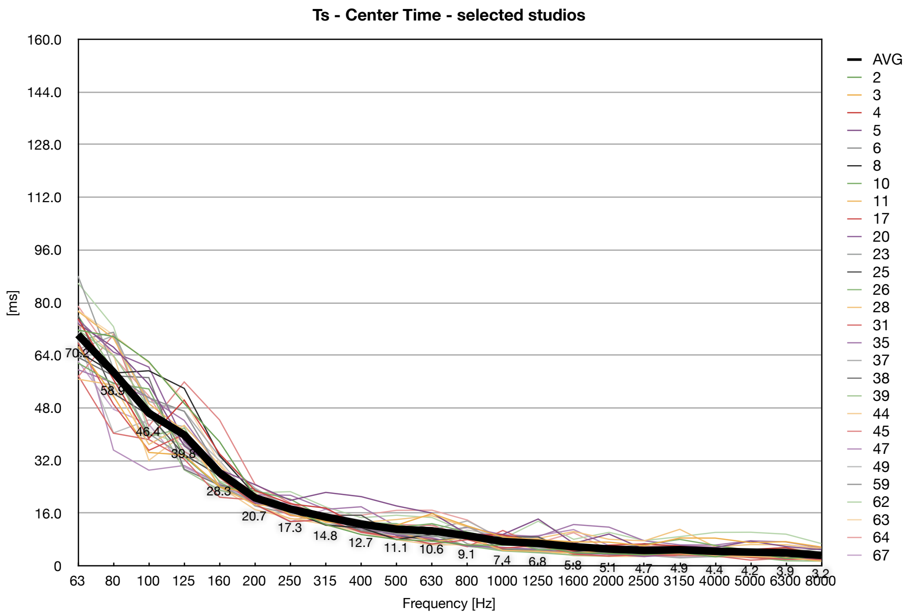

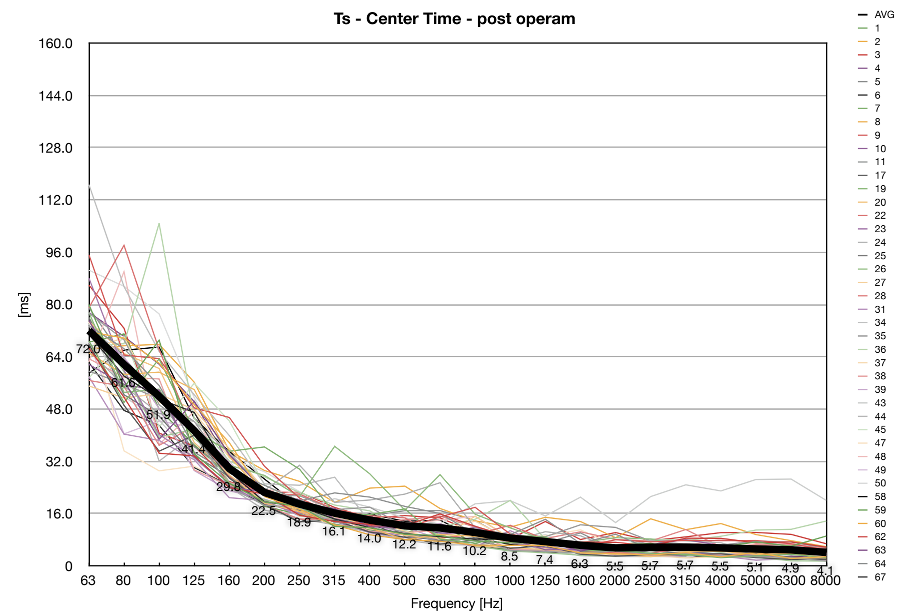

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FIRST DISPELLED MYTHS

1-4: THE GREAT ISSUE IN NON-TREATED (OR BADLY TREATED) ROOMS, ARE LOW FREQUENCIES.

1. You can't mix in rooms that are too big, too small, with a high ceiling, with a low ceiling:

Small variations in the size of mixing rooms can be accepted. What matters is that the Ts complies with average values observed in quality selected studios.

However, **smaller rooms will be problematic** because of stationary waves that concentrate in a short range of frequencies. Very large rooms might suffer a loss in definition, caused by the distance between the monitors and the listening spot.

2. Panels or tube-traps are enough to make a room, a good mixing room:

False. To make efficient full range acoustic correction a large quantity of absorption is required to handle low frequencies; the depth of premade mobile acoustic panels is simply not sufficient.

3. I do not like to listen with the sub and,

4. Some monitors sound too good to be used for mixing:

To me, such claims derive from the fact that **some rooms are often so "colored" that the listener prefers monitors that do not go too low**. For the same reason many do not like listening with the sub, along with the fact that the sub's release time is in some cases too long and may easily effect Ts values (making them longer on low frequencies).

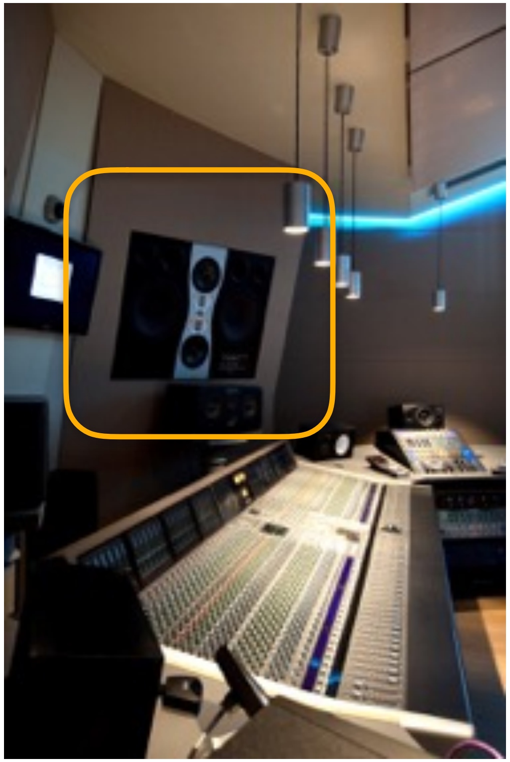
2. LOUDSPEAKERS IN A ROOM

DAMNED FLUSH-MOUNTED MAIN MONITORS!

Are flush-mounted main monitors really better than others?

From a technical point of view, most popular recording studio designs (Non-Environment, LEDE, RFZ) base their entire theory on these on big monitors and especially on their in-wall mounting. For nearfield and free-standing monitors you generally accept various reproduction compromises.

From my research many engineers are **unhappy** with the big monitors either because the are accustomed to working only with nearfield monitoring positioned a maximum 1.70 m from the listening position or because they have been "burned" by the incorrect positioning and mounting of big monitors, which, unfortunately, happens more often than you might think.



Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

WHY PEOPLE HATES BIG MONITORS

DAMNED FLUSH-MOUNTED MAIN MONITORS!

1. historic or generational reasons?
   - it is common for younger engineers who debuted in their home studio (with a compromised listening environment) to not feel the need to change.
   - in the 70s and 80s, big monitors struggled to provide good reproduction quality at low SPLs so many engineers preferred small monitors for working at lower levels for many hours without fatigue. This could be one of the reasons why nearfields got a foothold together with the fact that rooms have got smaller and nearfields are the only possible solution.

Nowadays big monitors (or at least the best ones) sound very good at low SPLs too.

or not? so … Full range system = Near Field + Subwoofer.

Do you like it?

WHY PEOPLE HATES BIG MONITORS

DAMNED FLUSH-MOUNTED MAIN MONITORS!

2. technical aspect?
    - difficulty in installing a monitor that could reproduce lower frequencies.

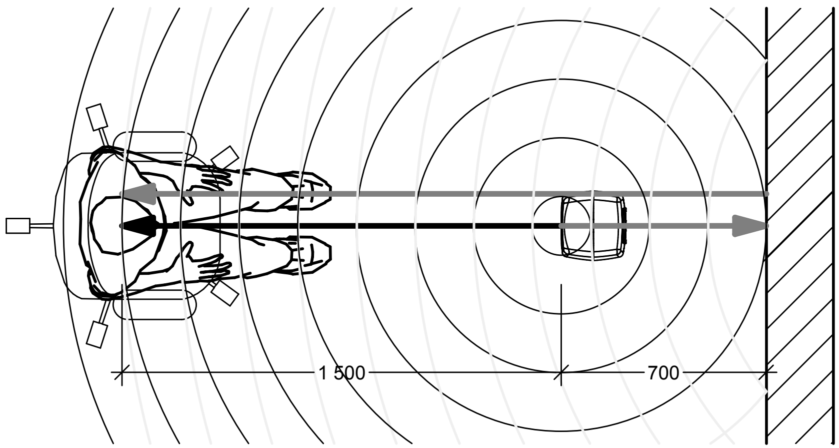
From me it is hard, if not impossible, to have a satisfying listening experience with big monitors if they are not flush-mounted into a wall.

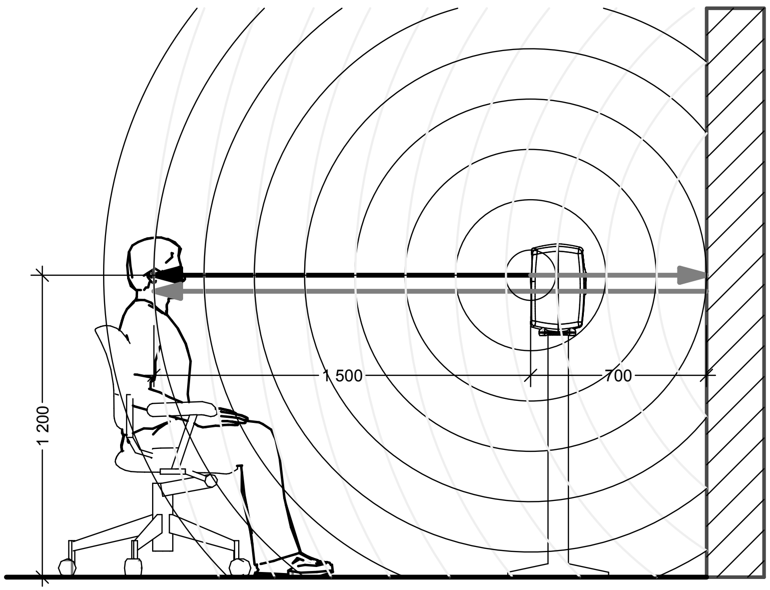
Heavier materials are better than lighter ones.

- Phantom centre image problems
- resonances of layers
- interaction with other walls far from the source (non minimum phase problems)

Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

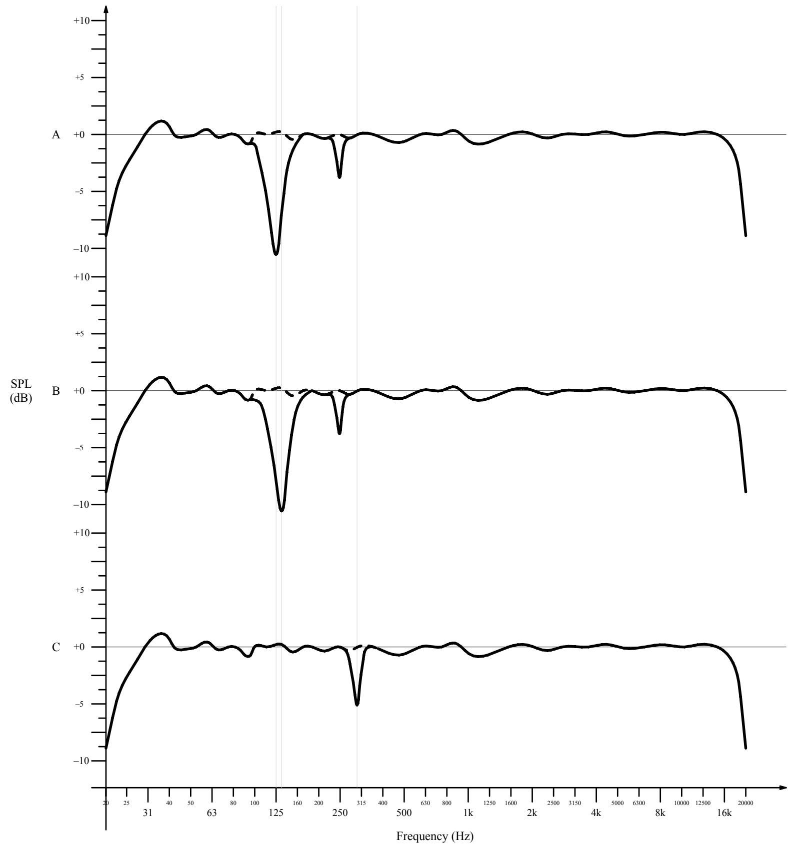
MINIMUM AND NON-MINIMUM PHASE EFFECTS

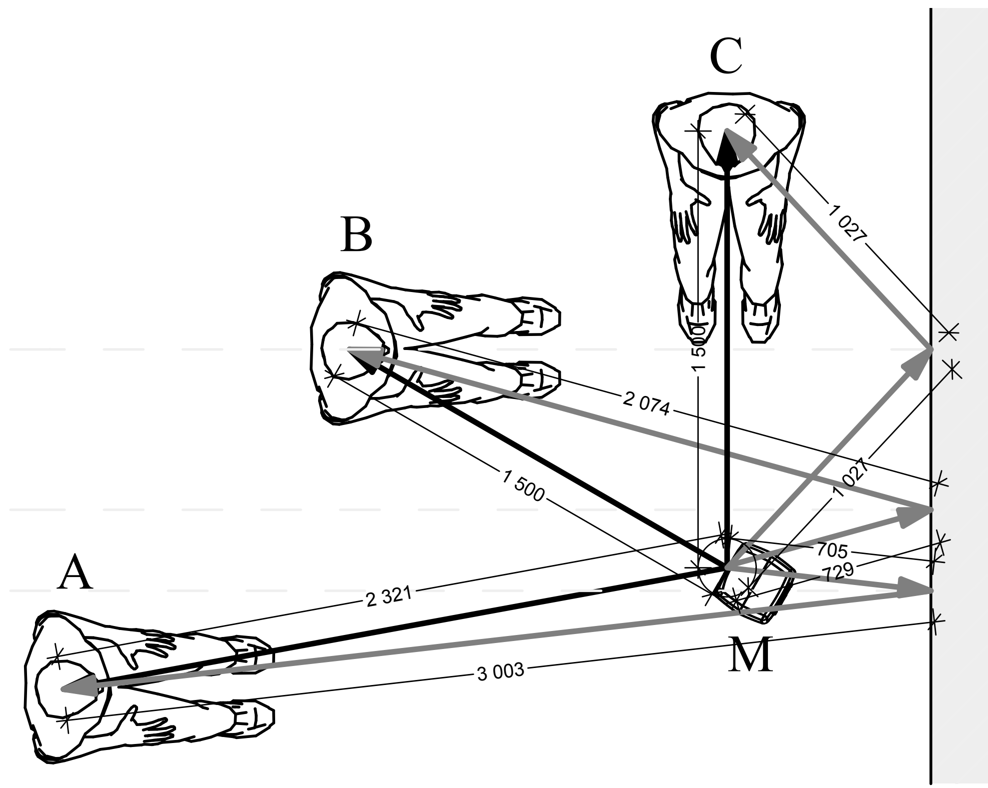




Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

NON-MINIMUM PHASE EFFECTS





Donato Masci
Acoustic Designer & Consultant
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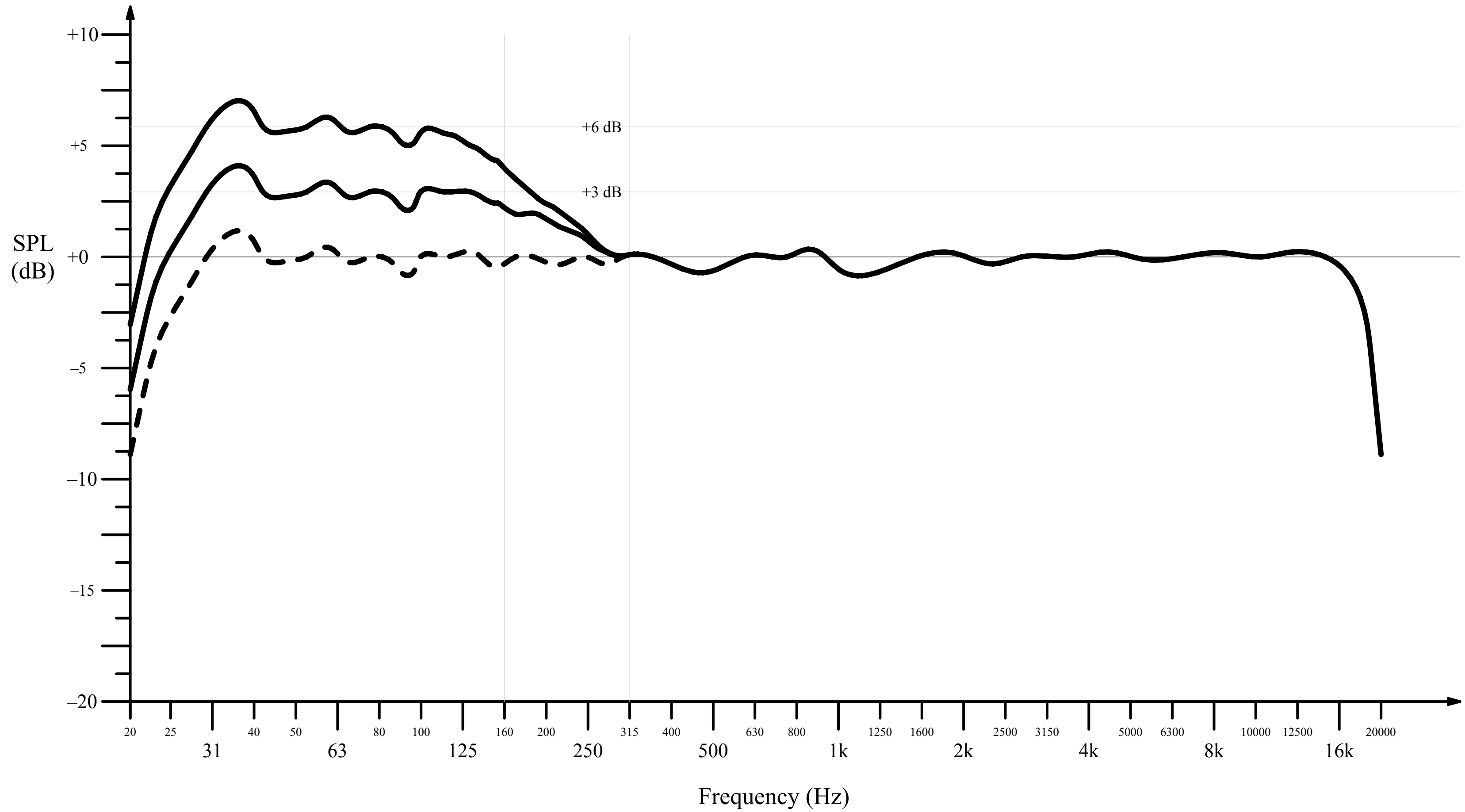
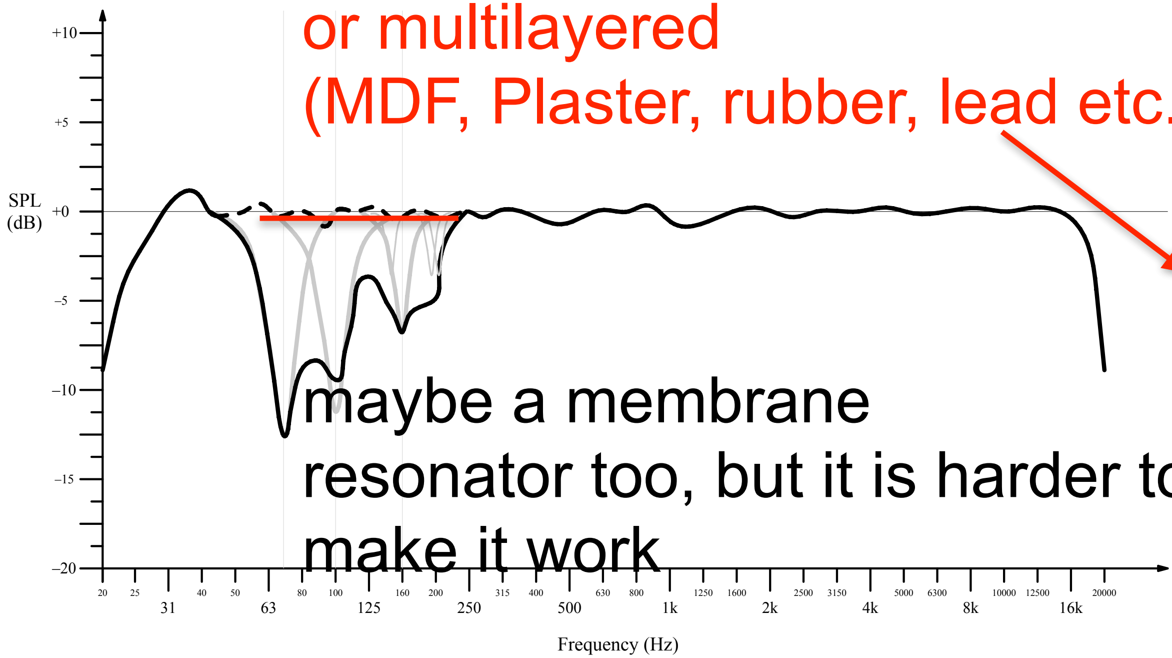
MINIMUM PHASE LOW FREQUENCY BOOST

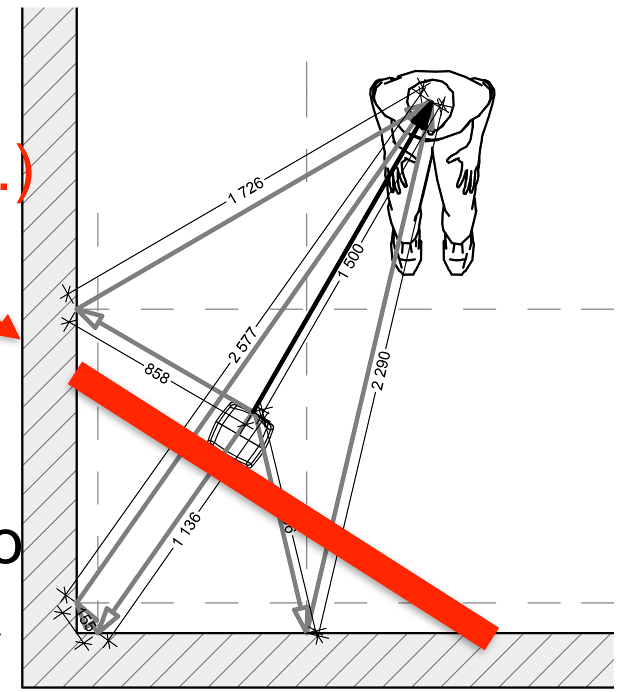


CORNERS

Solid (concrete, masonry)
or multilayered
(MDF, Plaster, rubber, lead etc.)



maybe a membrane
resonator too, but it is harder to
make it work



Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

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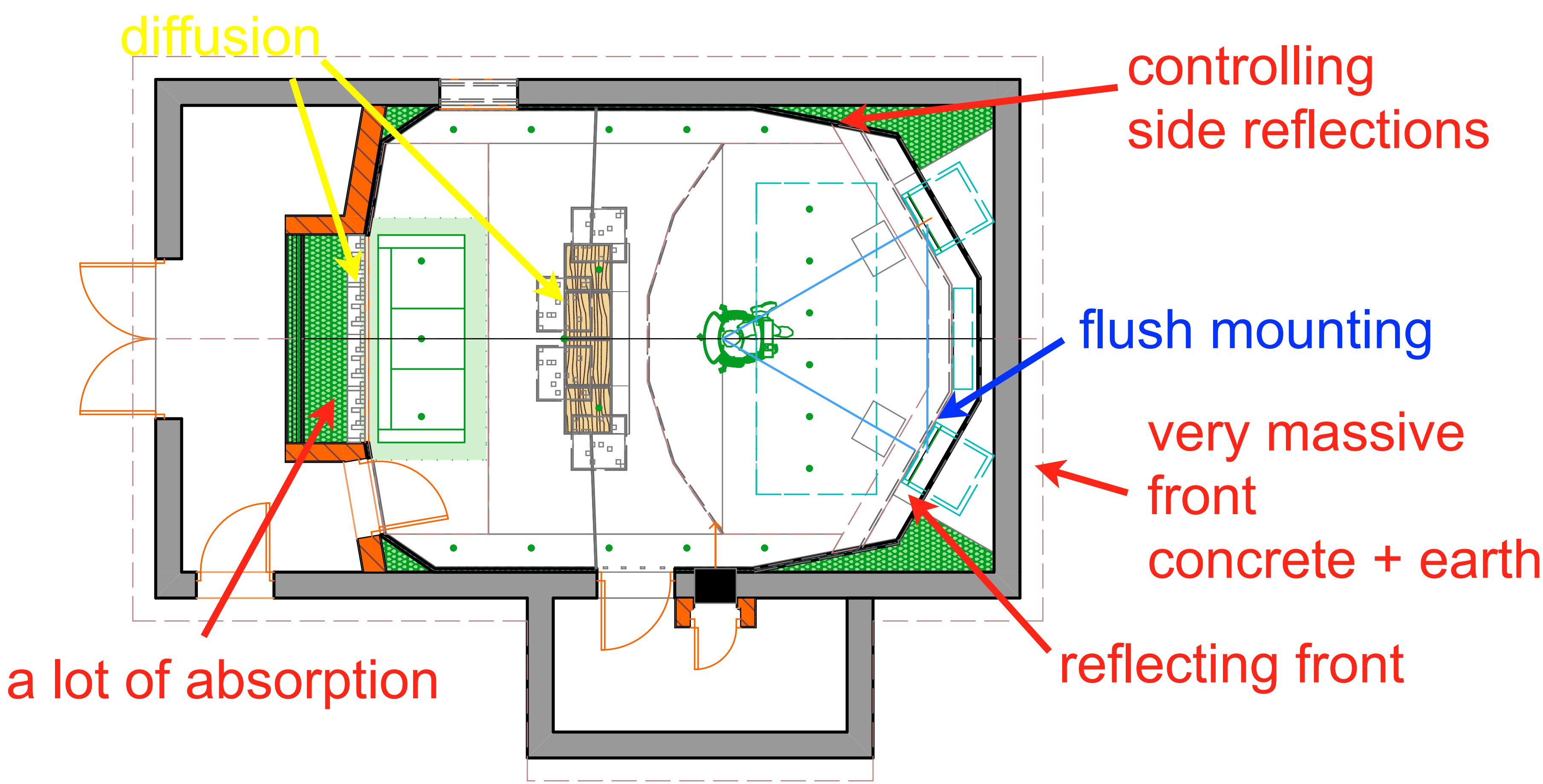
STARTING FROM SCRATCH

THE GARAGE STUDIO



STARTING FROM SCRATCH

THE GARAGE STUDIO

Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

The Garage Studio (Fabrizio Simoncioni)
@ Civitella val di Chiana (AR)
nominated for Best Audio Facility 2014 Resolution Awards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Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

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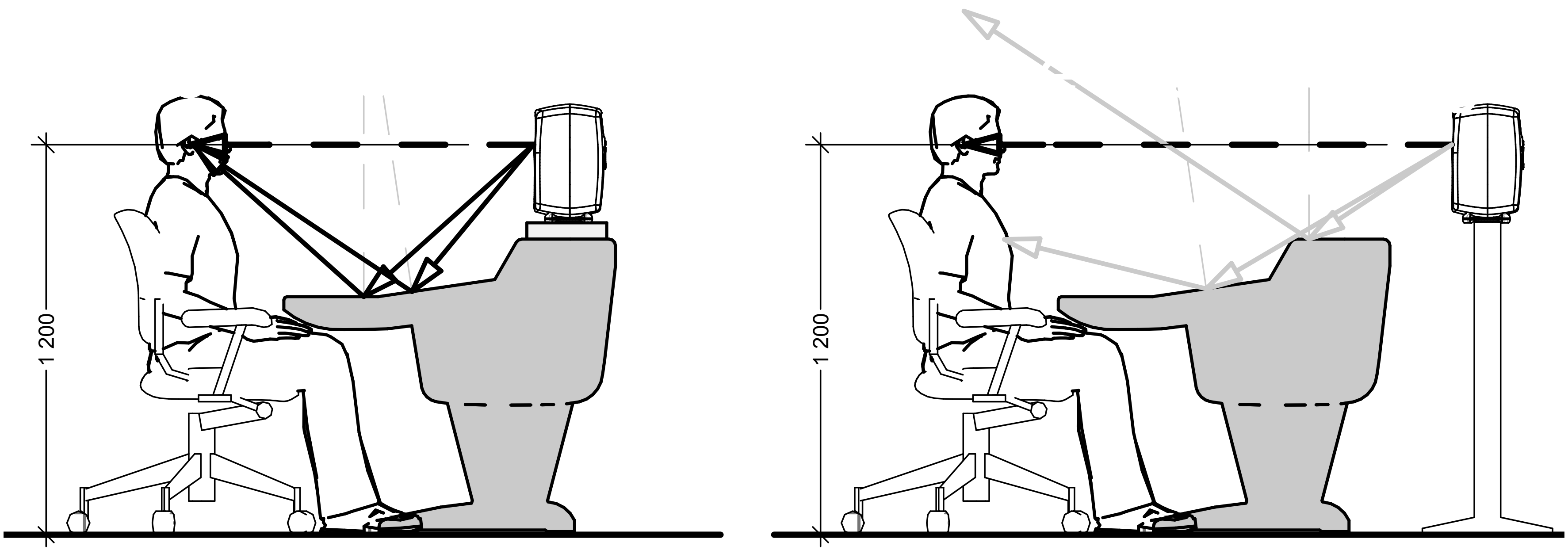
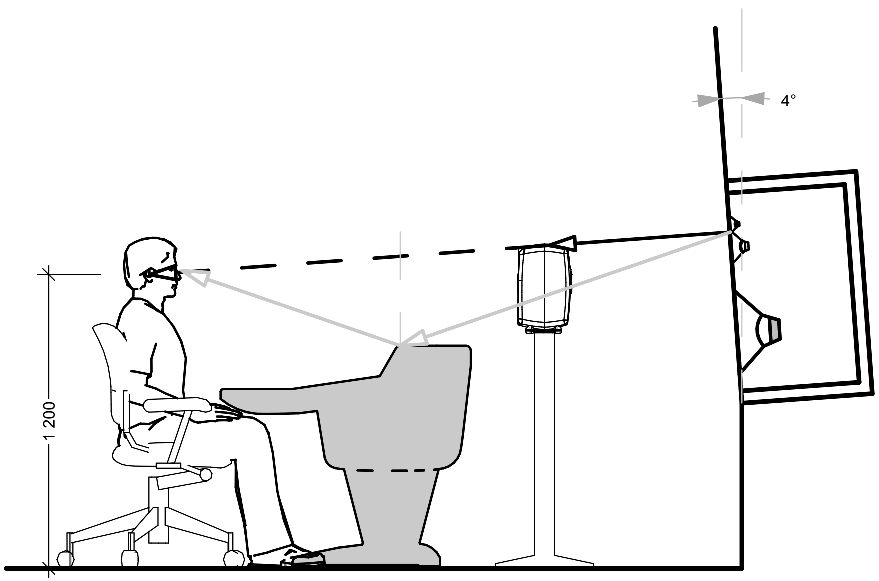
The Garage Studio (Fabrizio Simoncioni) nominated for Best Audio Facility 2014 Resolution Awards

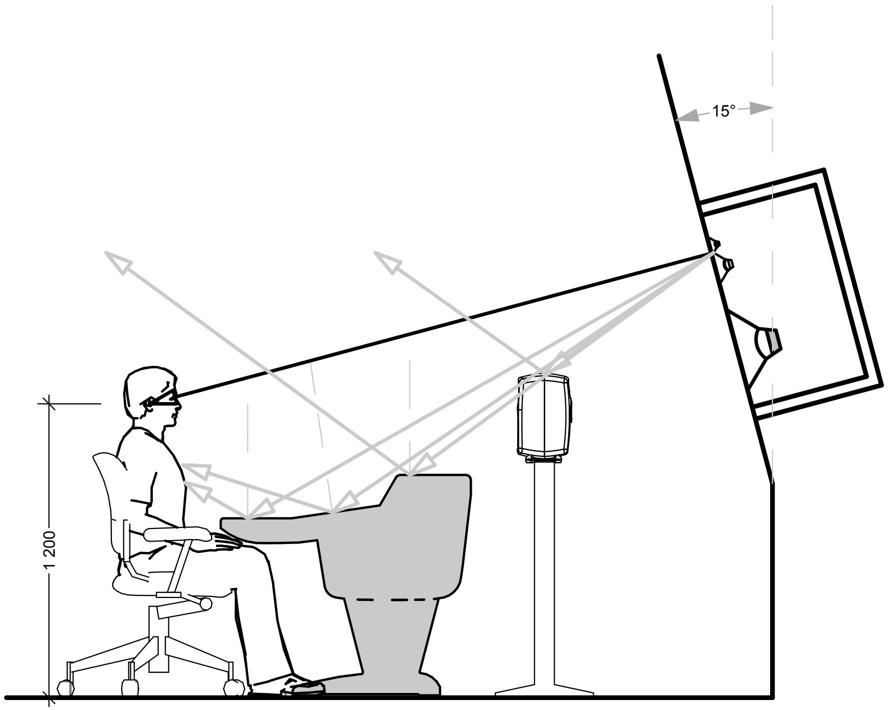
CONTROLLING THE REFLECTIONS FROM THE CONSOLE



CONTROLLING THE REFLECTIONS FROM THE CONSOLE

BIG MONITORS AND NEARFIELDS





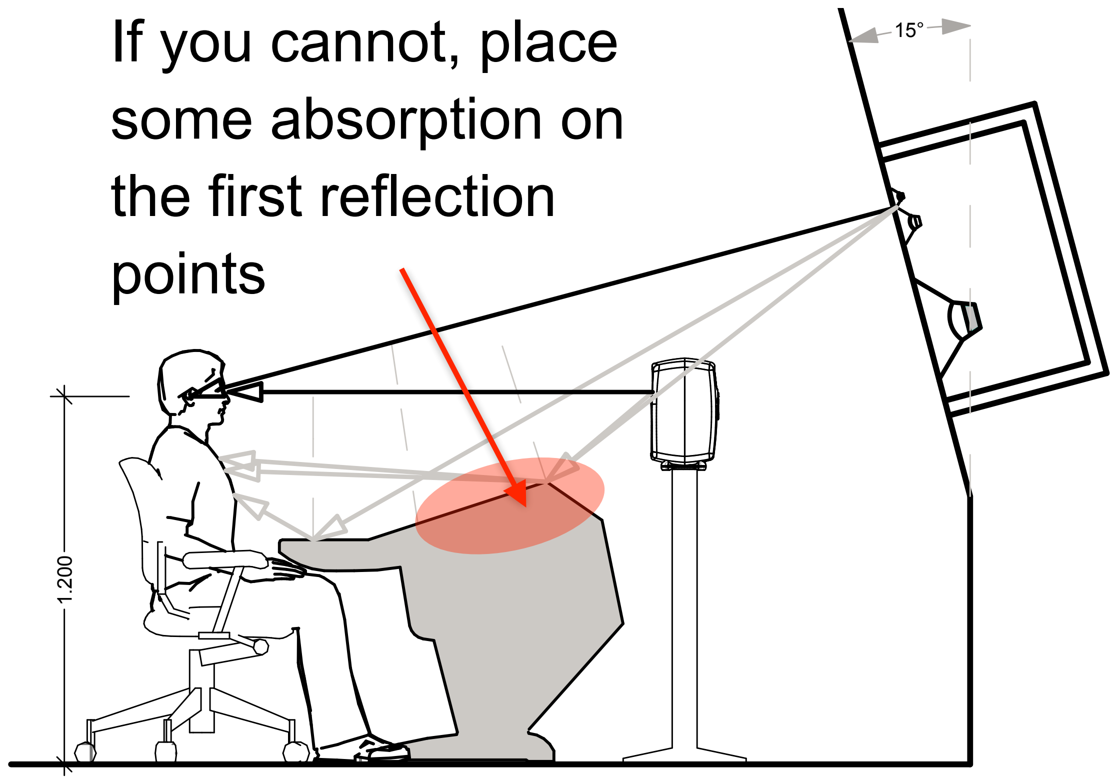
Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

CONTROLLING THE REFLECTIONS FROM THE CONSOLE

TILTING THE CONSOLE

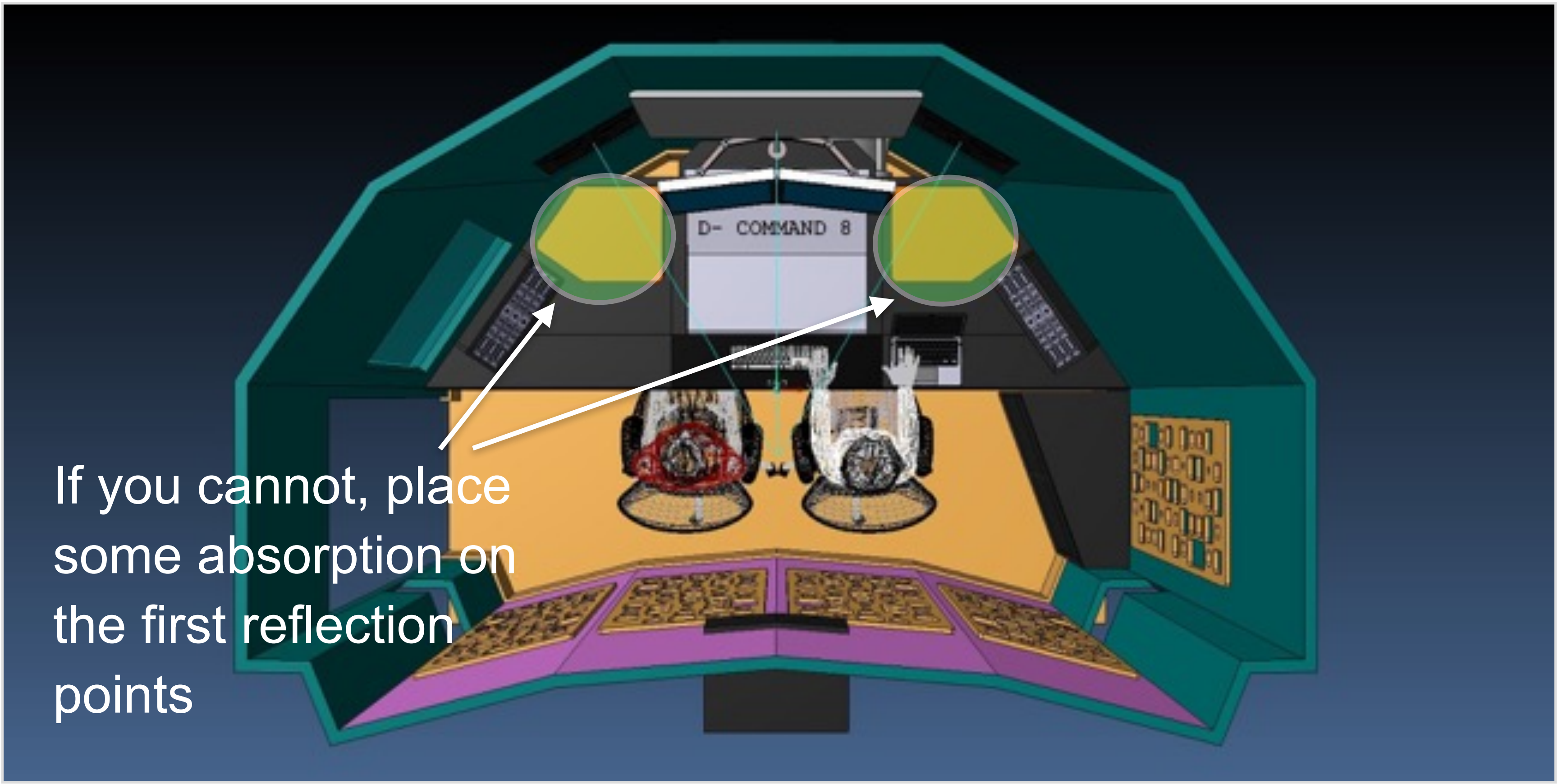
Tilting the angle of the console, it would be better for the ergonomics and the acoustics too

If you cannot, place some absorption on the first reflection points



CONTROLLING THE REFLECTIONS FROM THE CONSOLE

CONSOLE ABSORPTION



FOX International Channels @ Hammersmith, London UK

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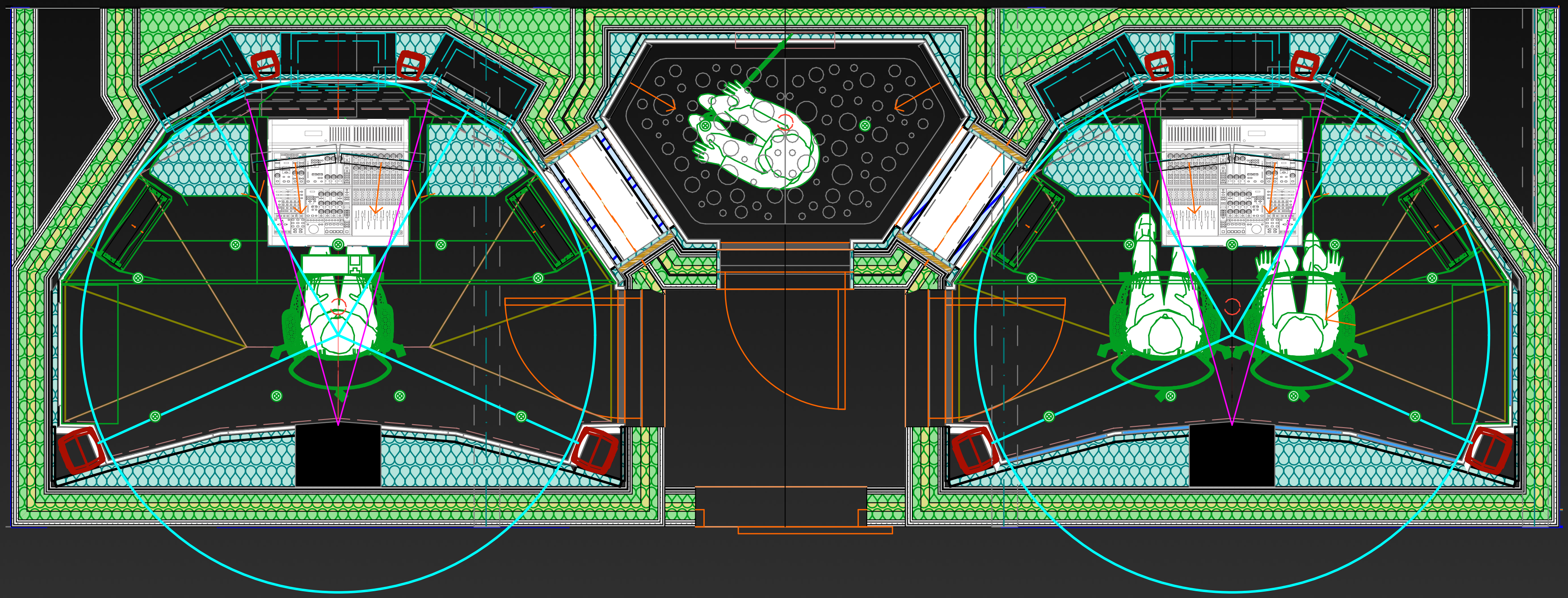

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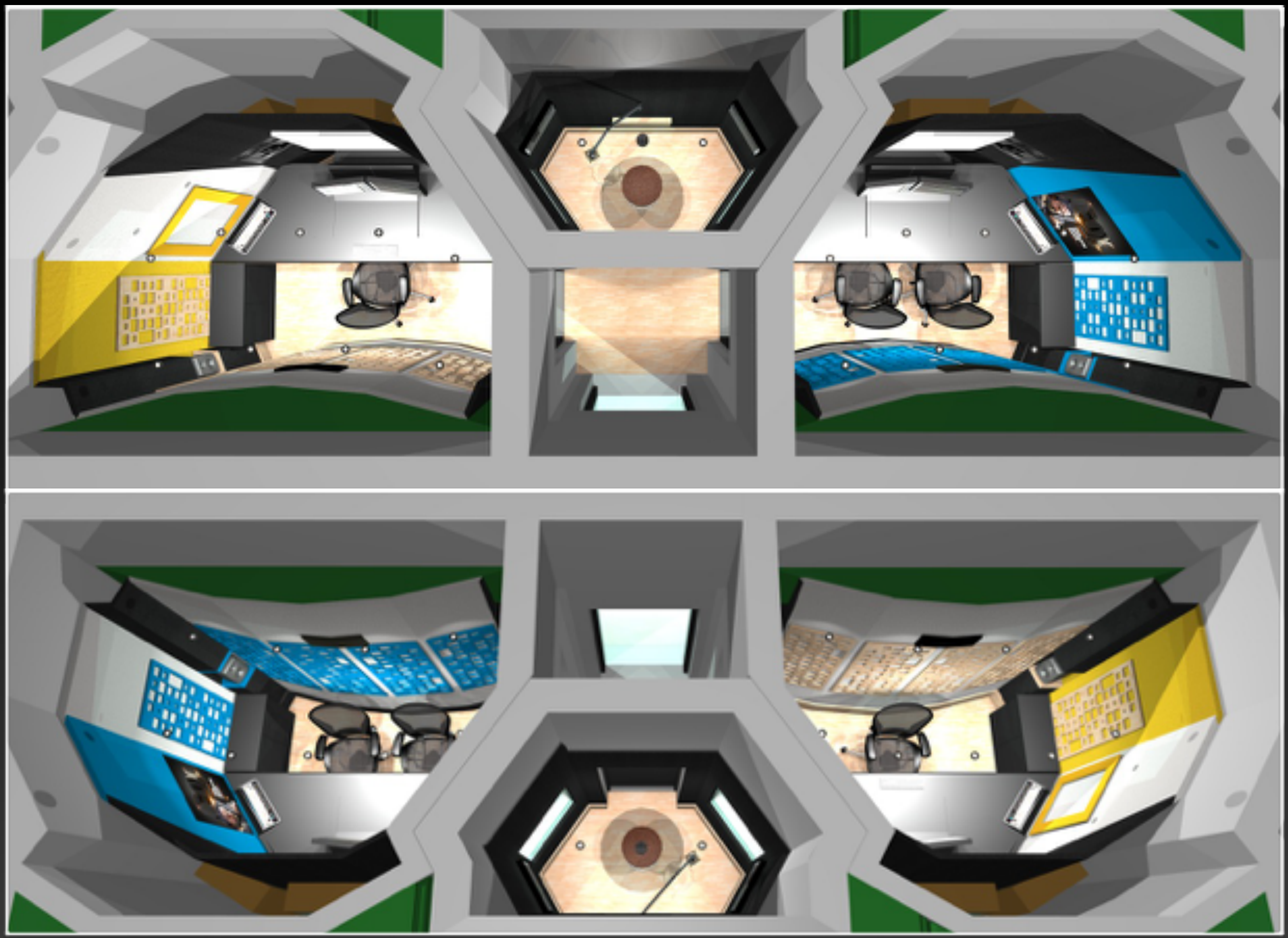

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Mulinetti Studio (Alberto Parodi) @ Genova
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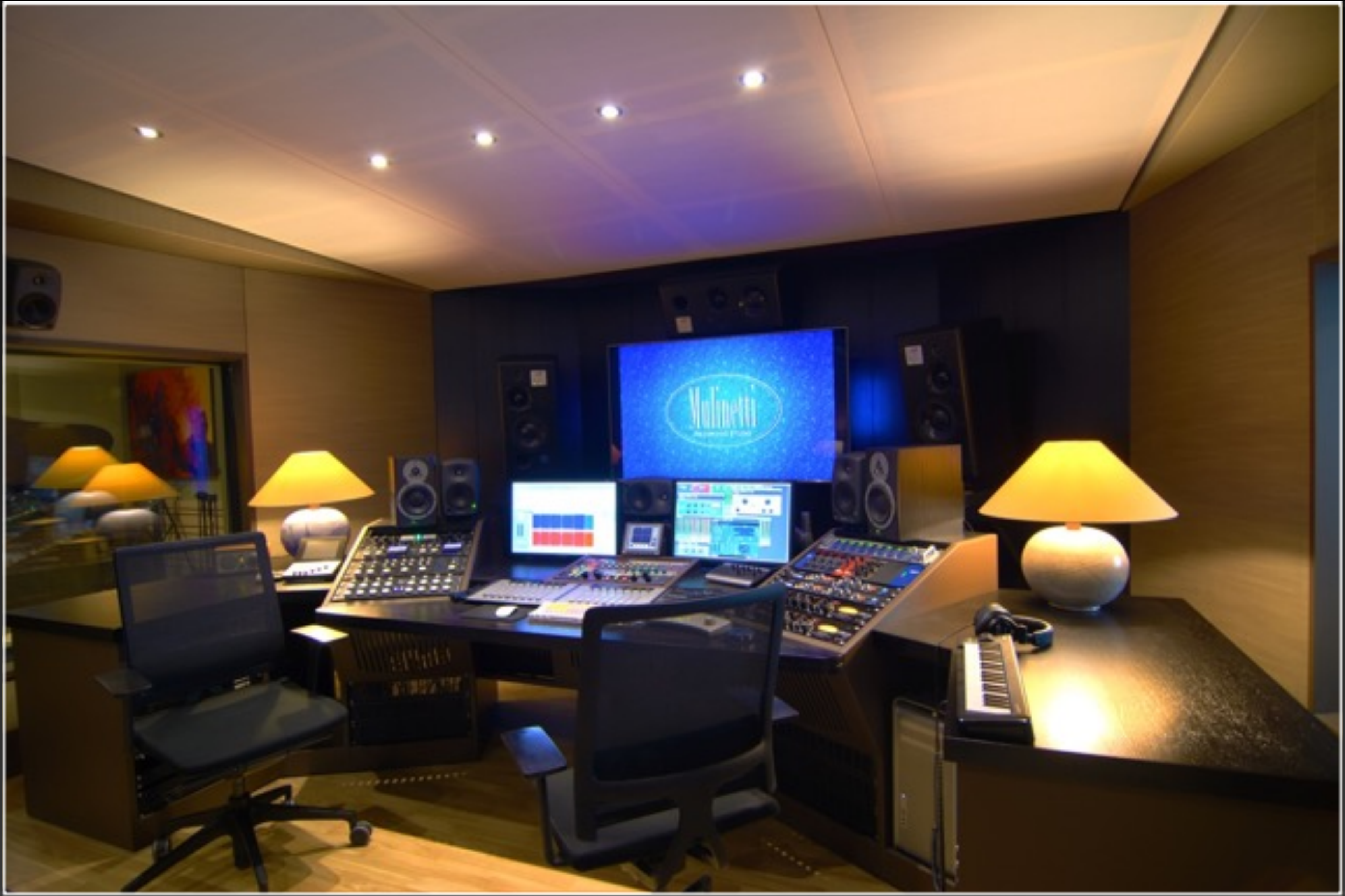

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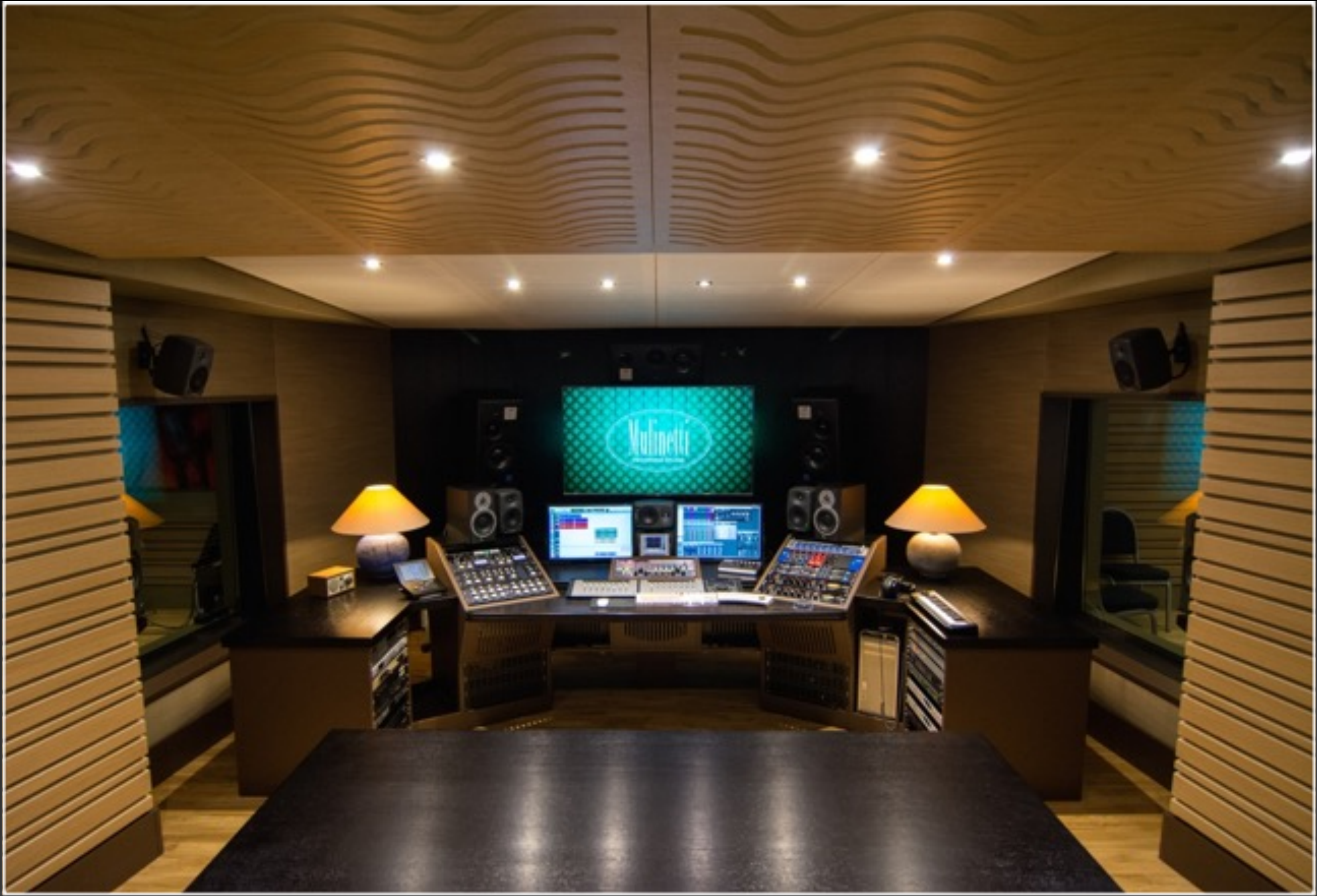

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REVIEWS: Audio-Technica AT5045 • Bettermaker 502P Remote & 542 Remote • JoeCo BBR1MP • Electrodyne 501 & 511 • Pete's Place BAC-500 • Meris 440

AUDIO FOR BROADCAST, POST, RECORDING AND MULTIMEDIA PRODUCTION

resolution

Small Room Acoustics Supplement • Test and measurement applied • Why it's great to make films in the UK

Postproduction mixing with Michael Narduzzo

Tim Palmer's production process

The Alberto Parodi interview

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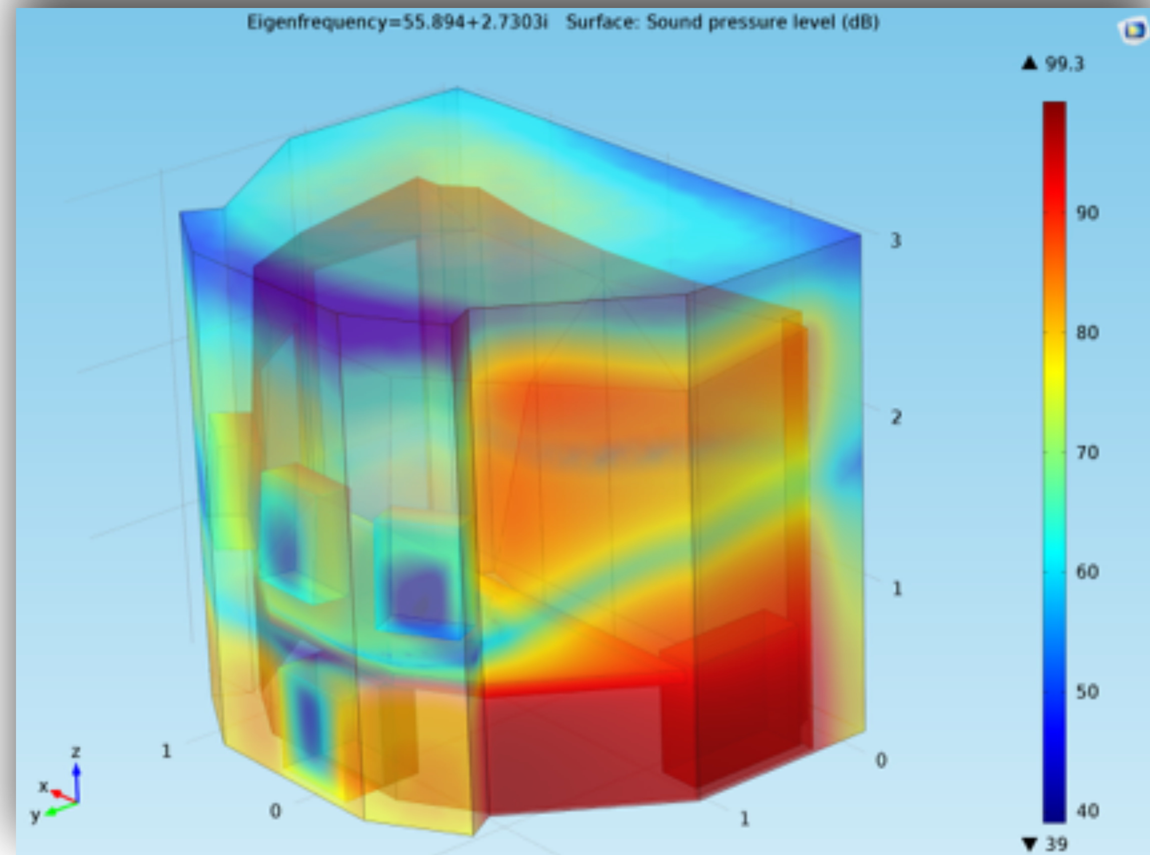
LISTENING POINT/AREA



FEM simulation (COMSOL)

FOX International Channels UK National Geographic

Thanks to B&C Speakers for the image

Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

OTHER DISPELLED MYTHS

5-7: LOUDSPEAKERS IN A ROOM

5. *Big monitors are good for clients but not for mixing. They're just too big for that, they lack “definition”:*

On the basis of the results shown and the explanations proposed, I can say that flush-mounted big monitors are truly very challenging to install in a control room, but personally give me more satisfaction, because when they sound good, it is almost as if all the acoustic design is brought to life.

6. *I don't want my monitors in the wall, it's not necessary and I can change them easily if I ever want to. Furthermore, they can be moved about in case I need to perform a “fine tuning”:*

On this point I would say that you should not think of a monitor as an object of trend to be changed on a whim but as a real part of a control room. It is good to choose it when you decide what kind of control room to build.

7. *Nearfield monitors have much more “definition” than far-field ones:*

Wrong. Far-fields introduce more energy into the room so they excite its modal resonances more than the nearfields, but the effect of the first reflections is surely worse for a free standing nearfield than for a flush-mounted big monitor.

Donato Masci
Acoustic Designer & Consultant
www.studiosoundservice.com

...IN ADDITION

SMALL VS LARGE MONITOR DIRECTIVITY

In addition, **nearfields have a lot of other problems**, such as those related to the **directivity**. Indeed, the dimensions of a monitor cabinet influence the sound radiation.

This effect exists when the wavelength that is generated by the monitor is identical (or proportional) to one of the dimension. The enclosure starts to be directive for those frequencies and the related harmonics. So, for a small monitor, the dimensions correspond to midrange which is already directive. This way it reinforces the phenomena and degrades the off-axis response. In a large enclosure the box dimensions correspond to lower frequencies where the energy is much less directive, and hence the effect becomes negligible.

This is why the same drivers in two different enclosure sizes will generate different sound characteristics.

Furthermore, a small enclosure is very affected by a large mixing desk in its radiation load at LF, by the wall behind and the induced comb filtering, and the console reflection. It is an effect of the proximity of large objects that are close to the drivers.

For a big monitor in-wall there are no objects close to the drivers in the case of the mid and tweeter at least. In a small enclosure it is often the case, and that has an effect on the response.

MONITOR RECOMMENDATION

WHAT AND HOW TO MOUNT IT?

To conclude, my advice is to think about big monitors for your control room if you have the opportunity, but bear in mind that

the minimum listening distance cannot be less than 1.7 m, **so it would definitely be useless to place them in rooms that don't have a suitable size**.

In large control rooms the common typical listening distance is about **2.5 meters**. In smaller control rooms, however, it is possible to flush-mount mid-fields with excellent results and shorter listening distance.

The mounting and positioning of a monitor is fundamental in a control room; incorrect positioning may cause dips in the frequency response of up to 15-20 dB!

3. AUTO-CALIBRATION

YES, NO...?

The most advanced auto-calibration systems record (by placing a calibrated microphone at the listening position, or at different points) an **impulse response** of the room through a test signal (typically a *sine-sweep*) for each individual monitor.

With the impulse response it is possible to obtain a lot of information (including those in the time domain as the fine **phase alignment** between the individual speakers). In particular, the system also calculates the **frequency response** at the listening point (or better to say, the measurement point – or points) and then *uses some EQ filters* trying to improve it.

WHAT CAN WE CORRECT?

FREQUENCY RESPONSE PROBLEMS

in the frequency response (FR) you can see most of the problems, but these are often overlapped with each other.

The problems in the FR may be of different nature, but can be divided into two main groups:

1. **room's acoustic field** (involving the reverberation and the wave-acoustics – room modes)
    - the reverberant field above 200 Hz "colours" the FR in a very *smooth* way, emphasising those frequencies for which it has more reflection from the walls. This effect is practically the same for every point in the room. On the other hand, the room modes (the effects of which can be seen mainly below 200 Hz) behave much more aggressively on some individual frequencies, and the result into the FR is particularly related to the source and listener position.
2. **phenomena related to the early reflections** (*or, better, the interaction between direct and reflected waves and the room surfaces and boundaries*).
    - they are much more peaked for some frequencies and depend on the position of the source and the listening point because they are based on distances between the direct and reflected paths.

STATISTICAL STUDIES
TO DETECT TYPICAL PROBLEMS AND FIGURE OUT HOW TO REMEDY

Aki V. Mäkivirta & Christopher Anet (Genelec)

“A Survey Studi Of In-Situ Stereo And Multi-Channel Monitoring Conditions”
111th AES Convention in 2001

shows the measurement data of 372 studio monitors in 164 top control rooms around the world. All the analysed rooms had big monitors.

Apart from the data of reverberation and other acoustic parameters of interest, the most striking section is about the **FR**.

STATISTICAL STUDIES
TO DETECT TYPICAL PROBLEMS AND FIGURE OUT HOW TO REMEDY

Considering the relative notch at frequencies below 1000 Hz in the third octave smoothed frequency response, the result is that:

"The median notch depth is 14.2 dB, but 30 dB notches are not uncommon" e che

"In our material the most typical notch frequency is 100 Hz, but deeper notches appear at higher frequencies".

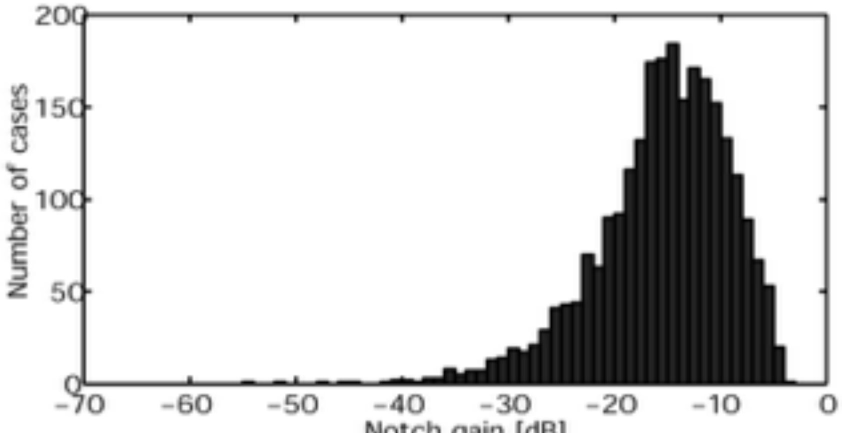


Fig. 28. Notch depth for 10 deepest notches within a frequency band 50Hz to 1kHz. Size of a bin is 1dB, median notch depth is 14.2dB ($N = 250$).

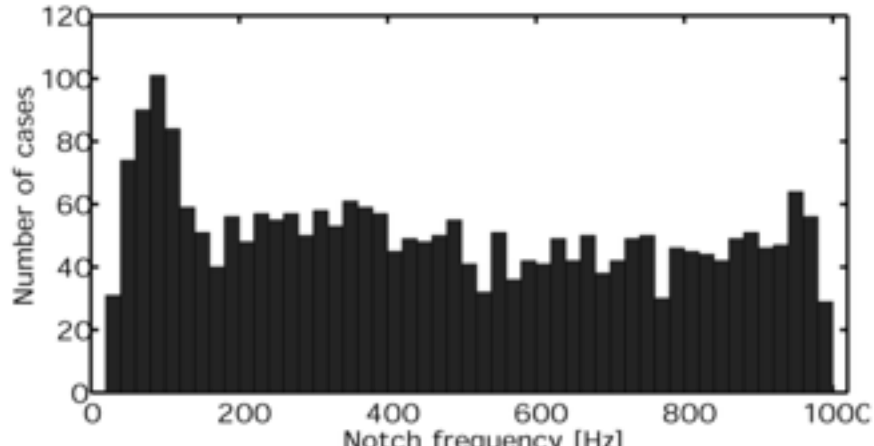
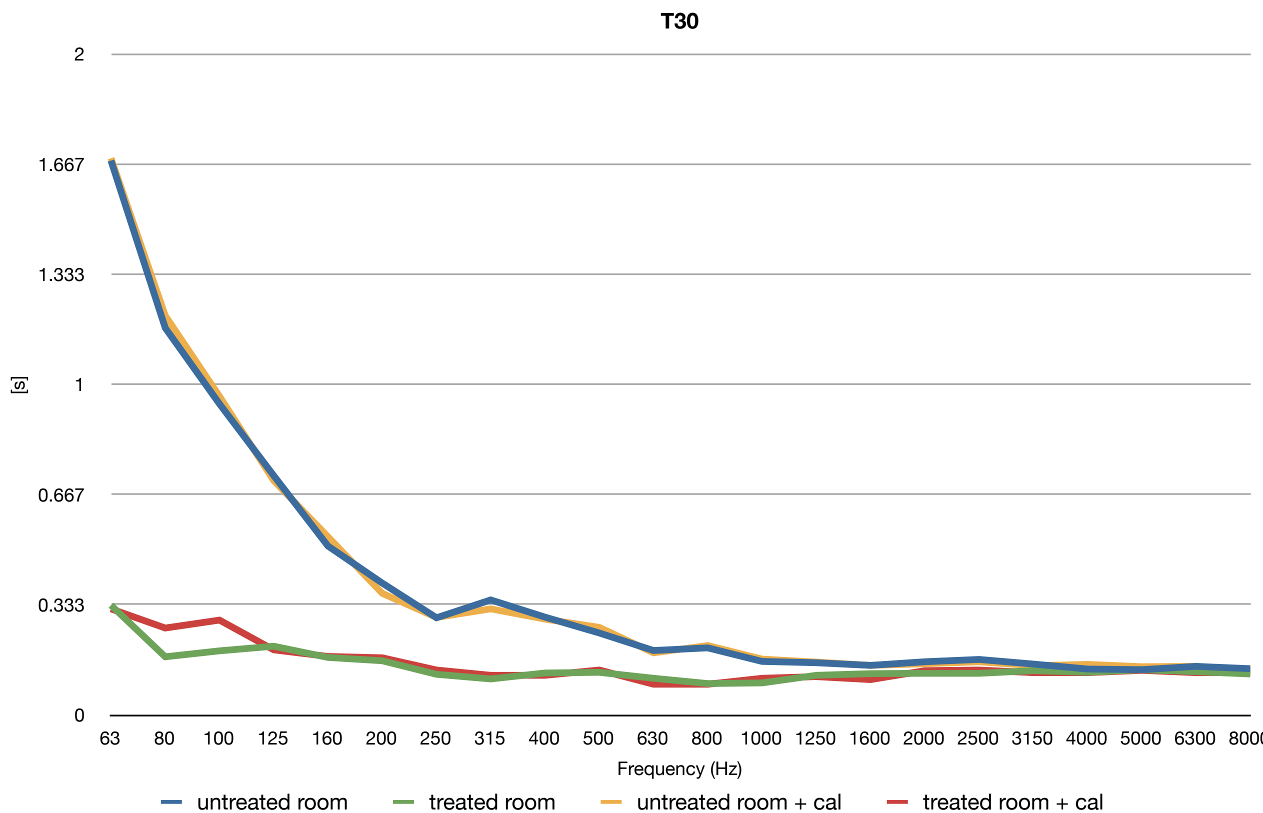


Fig. 29. Notch frequency distribution, bin size is 20Hz ($N = 250$).

CASE STUDY

AUTO-CALIBRATION OF SIMILAR MONITORS IN DIFFERENT ROOMS
THE FIRST ONE IS A TREATED ROOM AND THE SECOND IS UNTREATED



auto-calibration doesn’t change anything about reverberation (RT60, T30, Ts, etc)

CASE STUDY

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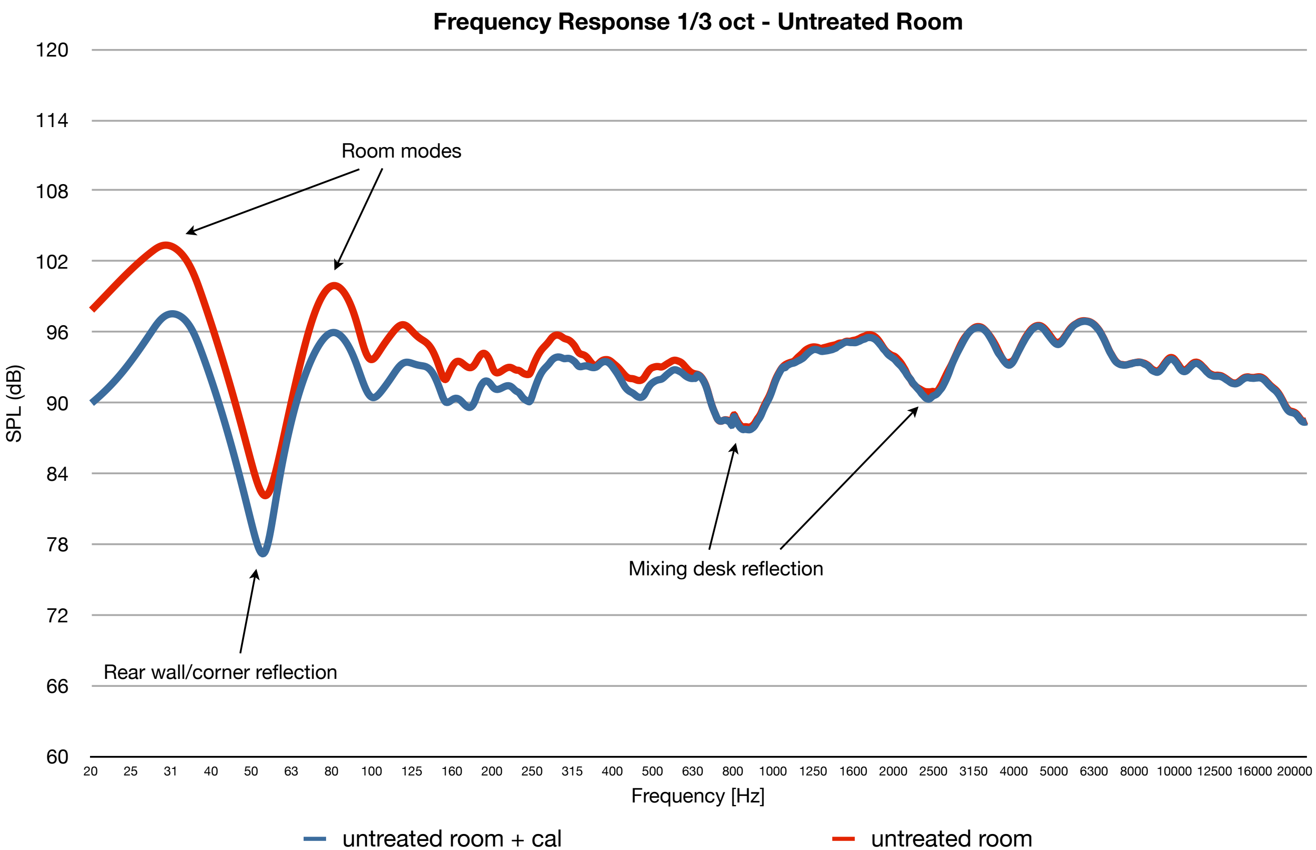

Untreated room

- a notch of about 10 dB @ 53 Hz particularly narrow due to the interaction with the corner and the rear wall.
- frequencies close to the notch were particularly emphasised (30 and 80 Hz) by the room modes.
- The rest of the FR has several comb filters – problems in the mid and mid-high frequencies that a trained eye easily notes – however it remains within ± 3-4 dB from 200 Hz to 20 kHz, confirming the fact that <u>an untreated room has often a FR that could seem good if not carefully analysed.</u>

CASE STUDY

AUTO-CALIBRATION OF SIMILAR MONITORS IN DIFFERENT ROOMS
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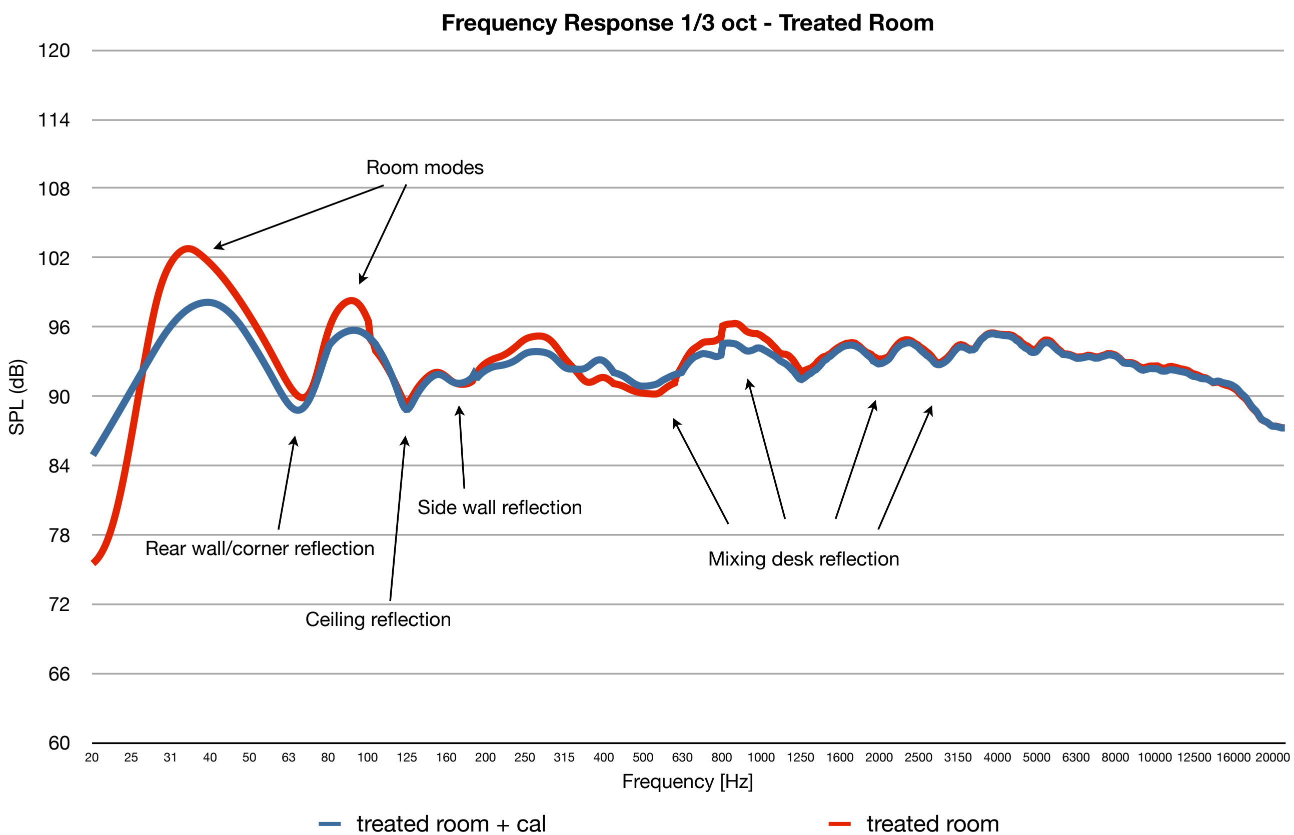

Treated Room:

- Although this is a small room, and then with room modes particularly close in the spectrum, it is equipped with some acoustic treatment to control low frequencies (especially on the ceiling, on the back and on the sides) that just leads the listening conditions at a good level.
- In this case the auto-calibration leads the room to professional levels, substantially improving the linearity of the mid frequencies, where there were reflections from the mixing desk and the outboard, and controlling all the resonances and the "minimum phase low frequency boost".

WHAT CAN IMPROVE THE AUTO-CALIBRATION?

- many auto-calibration systems work very well for mid frequencies, focusing the monitors and giving the right brightness even in listening situations where there isn't the right diffusion in the room; Genelec GLM doesn't work over 2kHz;
- They also work well for all problems related to the interaction with hard surfaces such as large consoles and racks, typical of small control room full of outboards close to the listening position. These problems are generally between 500 and 2,000 Hz;
- On the other side, at low frequencies, effectiveness is closely related to the problem. Surely a good auto-calibration system works very well in containing the low frequencies that are emphasised by the proximity of a hard surface such as when monitors are close to the wall or in-wall (in other words when you have to make an equalisation to correct a minimum phase low frequency boost). If, however, there are strong non-minimum phase effects, such as that created by boundary reflexions, auto-calibration generally has problems. In these situations, different softwares behave in different ways, and, in my opinion, the "smarter" it the one that "understands" when it is better not to intervene.

WHERE TO PAY ATTENTION WITH AUTO-CALIBRATION?

- A phenomenon that generally creates problems to auto-calibration is the modal resonance of a room, because it is **closely related to the measuring point**. In this case, the SPL at the frequency of the room mode changes from a maximum to a minimum (with easy variations of 20 dB) maybe in a few centimetres, and clearly, if the system is based on a single measurement point, it could optimise the listening in a very small area, getting it worst in the rest of the room.
- For these reasons I generally prefer to use a **multipoint system** (but it depends also about the intended use of the room).

LAST DISPELLED MYTHS

8-9: AUTO-CALIBRATION YES/NO

8. *Auto-calibration is useless if a room has good acoustic treatment;*

False. What I noticed is that auto-calibration systems give the best of themselves in situations such as home and project studios, where you have physical limitations in order to guarantee the results with the only acoustic treatment. They also work very well for a fine-tune of the “minimum phase low frequency boost” and to control reflections on the mixing desk and the outboard, which is very useful even in more professional situations with flush-mount speakers.

9. *I don't need acoustic treatment if I have auto-calibration.*

False. These days the auto-calibration systems are not able to solve all the acoustic problems of a room, because, by their very nature, they are not able to manage some of the phenomena that create the problems themselves.

As I have shown in the case study, this type of auto-calibration will not ever replace a proper acoustic treatment.

ADDITIONAL CONSIDERATIONS

SUBWOOFER

I have to spend a note on the subwoofer.

After everything I've said in previous articles, **if the phase and the level are not properly calibrated, it is better to have no subwoofer**.

The worst the room acoustic is, the more difficult it is to have proper subwoofer integration. Our ear is so imprecise at LF (remember 35 Hz sinus needs 9 dB of level change to hear and perceive a level change…) **that proper sub integration is not straightforward without measuring equipment**.

<u>Hence, most subwoofers are totally uncontrolled.</u>

In this case, the auto-calibration
(and in particular the auto-phase) **is really useful.**

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