Escola Universitària Politècnica de Mataró

**Graduat en Mitjans Audiovisuals**

# MOVIE THEATER RENOVATION

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## Abstract

This project aims to show the main points and issues to consider when making the complete renovation of a 20's cinema theater. In this particular case, due to the project will not be made in a nearby future, has been tried to reform the local with the purpose that the result will give us the best acoustics conditions, even with the room conditioning and also in its design. Also looking for the best audio and projection equipment which will have a perfect adaptation to nowadays cinematographic projections that can be found, and also bearing in mind where the cinema projection is going to during next years, in a coming future, basically with the 3D cinema projections.

## Resum

En aquest projecte es volen mostrar els principals punts i aspectes a tenir en compte a la hora de fer la reforma total de una sala de cine dels anys 20. En aquest cas en concret, y degut a que el projecte no es durà a terme en un futur pròxim, s'ha volgut fer una reforma del respectiu local per a que els resultats proporcionin las millors condicions acústiques, tant en la part del acondicionament acústic i disseny de la sala com a la hora de buscar tots els equipaments, d'àudio i de projecció que millor es puguin adaptar ales projeccions cinematogràfiques que trobem a l'actualitat, també valorant cap a on es dirigirà el sector en un futur, principalment, amb el cinema en 3D.

## Resumen

Este proyecto quiere mostrar los principales puntos y aspectos a tener en cuenta a la hora de hacer la reforma total de una sala de cine de los años 20. En este caso en concreto, y debido a que el proyecto no será realizado en un futuro próximo se ha querido hacer una reforma de dicho local para que el resultado nos proporcione las mejores condiciones acústicas tanto en la parte de acondicionamiento acústico y diseño de la sala como a la hora de buscar todo los equipamientos, de audio y de proyección que mejor se puedan adaptar a las proyecciones cinematográficas que se encuentran en la actualidad y también valorando hacia donde se dirigirá el sector en un futuro, principalmente, con el cine en 3D.

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# 1. Introduction

This project consists of a reforming plan for the possible conversion of an old cinema theatre into a modern cinema with the current facilities equipment required for proper operation. The hall which this project consist in is an old movie theatre build in 1921, located in the town of Vilassar de Dalt (SPA). This room is currently used as a dancing school. Because of this, the project itself is unlikely to be carried out, but if it were possible in the future, could be done following some of the guidelines, specifications and sections of this reforming plan.

The main aim of the project will be to make the corresponding acoustic design of the room. For this it should be necessary to bear in mind several points, from knowing how the current status of the building structure is, to analyzing the different acoustic theories considered for the reforming. For the previous point we will consider the main acoustics theories for the sound insulation and sound transmission. Some of these theories will be the reverberation of sound theory, reflection of sound, absorption of sound, among others. After bearing in mind all these theories (along with the current legislation), will proceed to chose all the different acoustic materials to be used.

When all the different acoustic materials to condition the room has been chosen, will proceed to carry out an acoustic analysis with the CARA (Computer Aided Room Acoustics) software. This will be done to check if all the acoustic conditioning characteristics of the room are suitable for a cinema.

When the fictional renewal of isolation and acoustic conditioning of the room has been done, it's time to choose the video projection and audio systems to use in our new cinema theatre. For this will be needed to start knowing the history and evolution of systems and equipments, both the video projection and audio systems. Performing this step and with a thorough analysis of the different audio playback equipment and projection, it will be possible to make a better comparison between the existing systems, therefore it will be easier to choose the systems that are best suited for this room. Then, once the video projection and audio systems are selected, there will be a scheme of the steps to follow for proper installation of the equipment.

After the above points are completed it is time to make a budget specifying the cost of all steps previously mentioned. Due to the reforms of structure and design of the room has been made to get the most optimal, acoustically speaking, this reform has been impossible to make and easy calculation of the budget for these changes because it is very difficult to calculate just with the overdesign that has been done with the CARA software. In other hand a budget of the equipments has been elaborated including, the audio systems (the price of the amplifiers, speakers, ...) and video projection systems (projector, screen, ...) cost.

Finally, the conclusions will contain a small conducting feasibility analysis, to check the feasibility of carrying out the project, both financially and with the unexpected problems encountered during the fulfillment. Then will be included a personal analysis about to carrying on the project.

# 2. Acoustic design of the theatre

This first section contains the information for necessary acoustic conditioning of the cinema. It has been thought necessary to make this point first because it is perhaps, the most complex part and is imperative to continue with the next steps of reform.

Logically, before installing any equipment in our room, both video projection and audio, an acoustic reform of the room have to be made. This is because the results obtained in this section greatly affect the acoustic quality of the building with respect to both a good hearing in the room and the insulation that should be created with respect to the noise acoustic legislation for the corresponding country (Spain) and the acoustic regulations of the area.

The first section of this block consists in an analysis of the building structure isolation conditions and the acoustic characteristics of the current room. Once analyzed the building conditions the appropriate choice of acoustic materials will be done bearing in mind the main theories and acoustic factors that should be taken into account cases like this.

Once the corresponding calculations and deductions are done, the choice of materials will be much easier to perform thanks to knowing the suitable results to obtain the room acoustic conditioning needed for a movie theater.

# 3. Building conditions

First of all you should know that this theater was built in 1965 and in at that time there was no access to most audio equipment that currently exist and acoustic materials were available only for the largest budgets of that time. This results in that the room was built without acoustical materials in its floor, walls and ceiling, and with very similar to a "shoebox” design.

Its current dimensions are 27 meters long and 15 meters wide, and a height of 7.5 meters. These are measures much larger than a current cinema. Nowadays the cinemas theaters are built with forms mostly avoiding finding plans and walls completely parallel to each other.

The actual room has been build in CARA software to be able to make the acoustic analysis of this room, choosing the most similar preset materials, or creating them with their correct specifications and absorptions coefficients, making them as real as possible. The actual materials found on the walls, floor and ceiling are:

- **Walls:** Al the walls of the room are made of heavy concrete with rough unplastered surface, and simply painted with blue paint to give more visual comfort to de audience. As it’s shown in *Figure 1,* its absorption coefficient level is very low at all frequencies, and it goes approximately from a 2 or 3% of absorption for the low and mid frequencies, and it rises up to an 7 or 8% for the high frequencies. On the side walls and the back one (opposite wall to the screen) of the room are timber panels that reach a height of 3 meters of the wall. Those timber panels have more absorption than the concrete one but as you can see in the *Figure 2*, still not being so much and the covered area is not large. It goes from a 15 % for the low frequencies and decreases to a 8 or 9 % in higher ones.

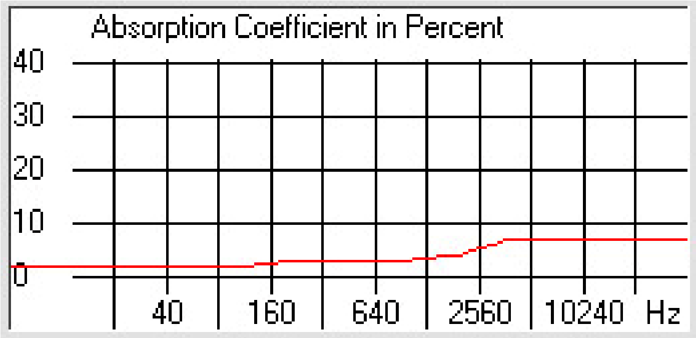



**Figure 19 -** Absorption coefficient in % of heavy concreted of the walls.

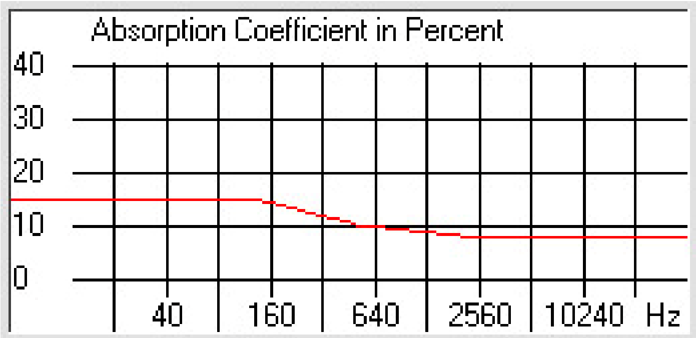



**Figure 20 -** Absorption coefficient in % of timber panels.

- **Floor:** The current room floor is made of heavy concrete with fine blue painted surface. This kind of floor has an almost zero absorption coefficient for all along the spectrum frequency, as is shown in the next figure, *Figure 3*. The floor is not completely flat and approximately at 12 meters from the screen wall has a slight slope that raises the floor 70 cm when it arrives at the back wall of the room (see *Appendix 1*). Obviously, on the ground, are all the seats of the room. These seats are upholstered and covered by fabric and it provides a quite high absorption coefficient, which appears in *Figure 4*, compared with the rest of the room materials.

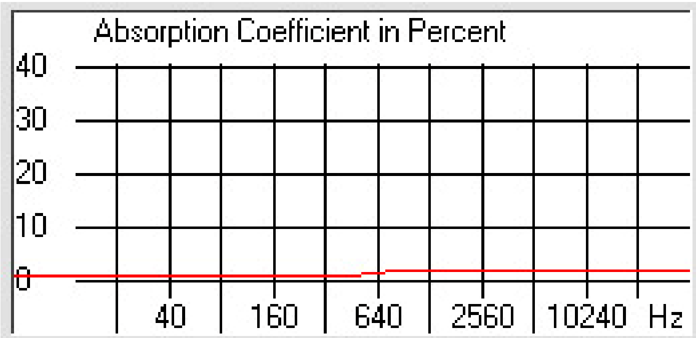



**Figure 21 -** Absorption coefficient in % of fine painted concrete.

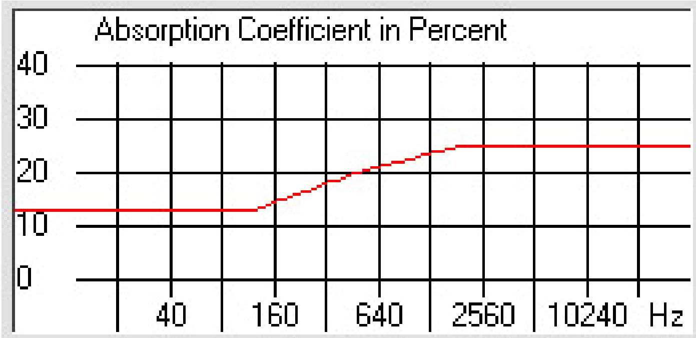



**Figure 22 -** Absorption coefficient in % of the seats.

- **Ceiling:** The ceiling of the actual theater is completely flat and it is made of 10 mm thick gypsum plasterboards, with a 50 mm cavity behind filled by mineral fiber. Behind these boards there is a 50 cm of empty space which separates the boards from the original ceiling. In *Figure 5* it is possible to see that this material has a relatively big absorption coefficient for the frequencies below 160 Hz and nearly 10 % for the medium and high frequencies.

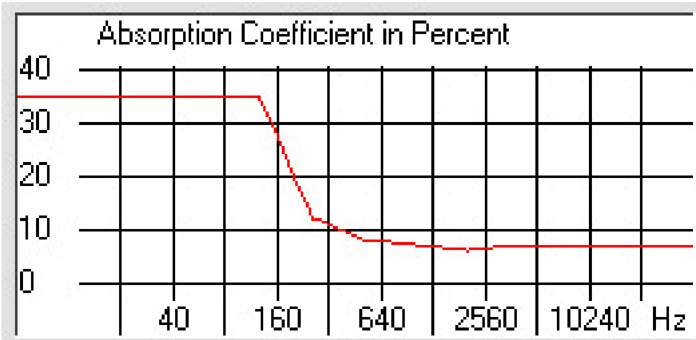



**Figure 23 -** Absorption coefficient in % of the actual plasterboards.

Once the materials that cover every part of the room are known, an equal replica to the actual theater with the CARA software has been made.

# 4. Acoustic problems and solutions

With the process mentioned above we were able to calculate the reverberation time of the current room. For this, the program creates a graph where you can see two green lines that mark the boundaries of the optimal reverberation time for our room.

## 4.1. Problems

The reverberation time is the first problem we found in our theater. Reverberation time is defined as the time required for the sound in a room to decay 60 dB (RT60). In very rough human terms, it is the time required for  sound that is very loud to decay to inaudibility [1]. As you can see in *Figure 6* according to the optimal reverberation time  which there is usually great disagreement with it as to just what it is because it is a subjective problem and some differences in opinions must be expected. For this reason, the use of the room has to be considered [2]. For this theater room, as we have created it on CARA, its optimal reverberation time has been used. It is shown in *Figure 6* graphic, marked by darker green color marks, and the reverberation time in the current room is quite superior, especially in higher frequency to 200Hz. The following higher frequencies the RT60 is declining but still above the limits.

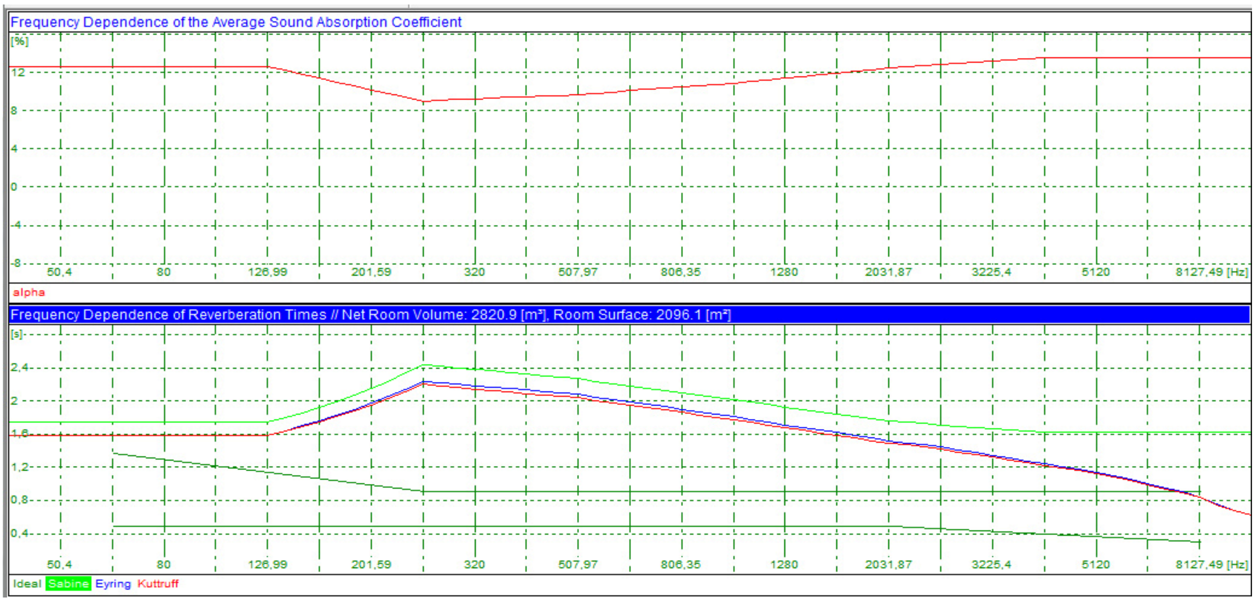



**Figure 24** – Average Sound Absorption Coefficient (up)

Sabine, Eyring and Kuttruf reverberation time of the actual room (down)

This is mainly due to four reasons:

- The first refers to the absorption coefficient of the room: as we saw in the previous point of the project, the materials which are mounted on the floor, the walls and ceiling have not enough absorption coefficients to reduce the sound faster.
- The second refers to the reflection of sound in flat surfaces [3]: as its shown in the plans and pictures (see Appendix 1 and 2) of the actual room it has a flat concrete walls with a bit of roughness, and a very smooth painted floor. All this creates more reverberation time.
- Thirdly, all the walls are parallels between each other, it means that there is a full-frontal reflection, as is the case with the side speakers that send sound directly to the front wall would cause the sound wave was bouncing between a wall and the other in the same area producing feed back at some frequencies or attenuation in some other parts of the room [4]. It makes a continuous reflection that can make a longer RT60.
- Another possible problem is the echo: Large enclose spaces are potential producers of discrete echoes. Reverberation time affects the audibility of echoes [5].

## 4.2. Solutions

Once the problems are known it is time to solving them. First thing to do is to make a new design of the room shape. In the reforming process are going to be in mind all structure influence. To begin the new room is not going to be as rectangular in its section. A sloping floor with a grandstand will be build, not just for a better screen point of view for everyone in the cinema, this way also an irregular shape of the building is being made being able a irregular reflections in the room that will decrease the RT60. In this reforming the walls of the theater are going be build without plain plans (see building plans). In the case of a movie theater like this one, is not necessary to get a perfect and homogeneous sound pressure at each point of the room, due to this type of defects can easily be compensated in the theater, by providing lately more gain to the volume of the room. Even though this room has been designed trying to design the walls as the sound has to be easily transmitted from the screen to the backside of the room and the reflections in the opposite direction have to find more difficulties (see building plans). That is why the shape of the sidewalls produce that the sound reflections from the main sound source in the large sections of the wall, go to the backside audience, but the reflections that occurs in the rear wall are tried to be absorbed or reflected back again by the shorter wall sections.

Next step to do is to mount more suitable materials with more absorption coefficient for a more considerably reduction of the reverberation time. Here we show the characteristics of the chosen materials. All this materials are of CARA software.

- **Walls:** a 9.5 mm of thick gypsum plasterboard with a 50 mm cavity behind, filled by mineral fiber. This material has a quit big absorption in low frequencies (see *Figure 7*).

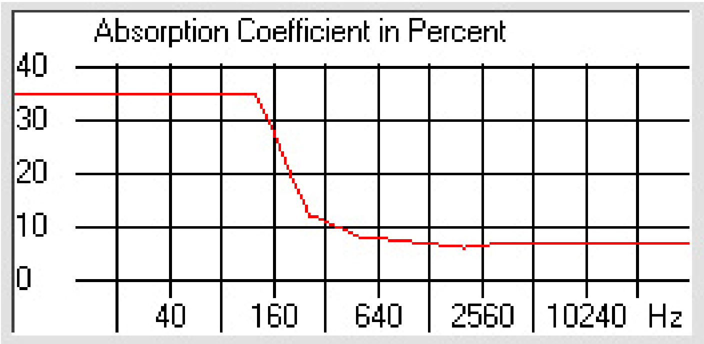



**Figure 25** – plasterboard from the walls

- **Floor:** a looped soft carpet with foam pad has been used to cover the zones of the floor which forming the grandstands. Also a thick luxurious carpet has been mounted with massive foam pad in the plan zones between groups of seats even in the access to the room. Both materials have a good absorption coefficient at high frequencies (see Figure). The second one has also a good coefficient at the frequencies between 400Hz and 550Hz. As in the actual room, in we find the seats that are large easy chairs (see *Figures 8, 9, 10*).

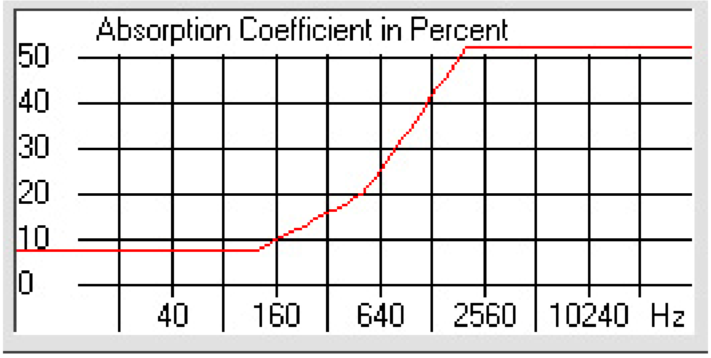



**Figure 26** – Carpet of the grandstands

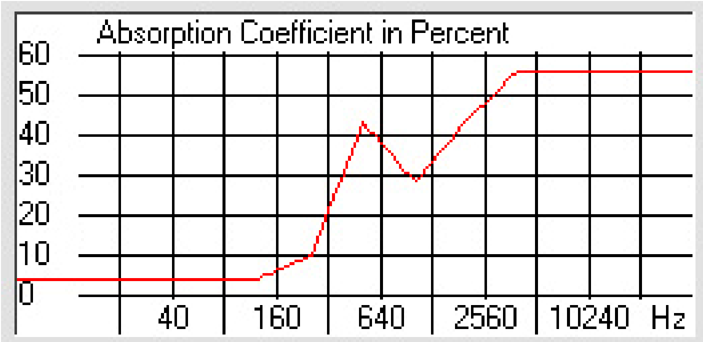



**Figure 27** – Carpet from the flat areas of the floor

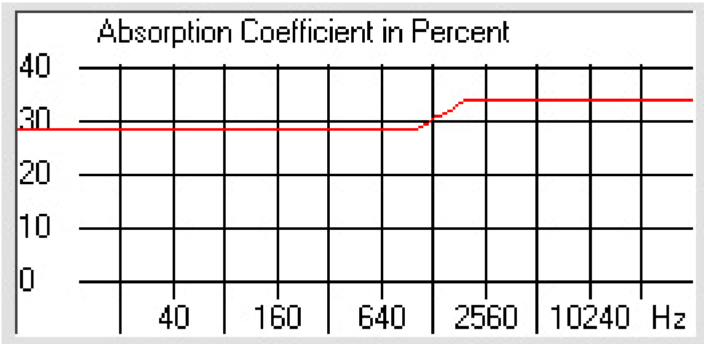



**Figure 28** – Material from the seats

- **Ceiling:** The most part of the ceiling material is the same as in the walls (see *Figure 7*). Also in the ceiling there is a part which is sloped and is a 0.5 inch thick gypsum plaster board, with 65 mm distance to the wall and with behind it an empty space (see *Figure 11*).

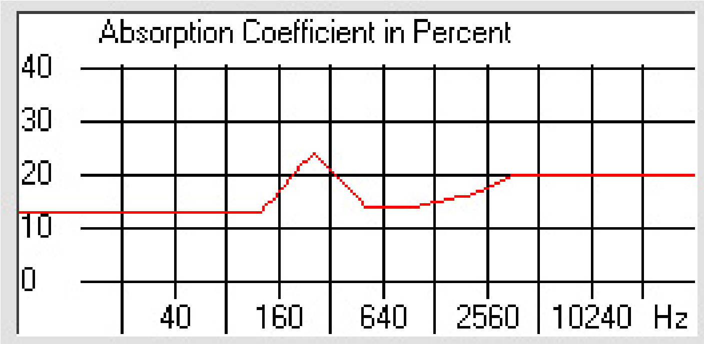



**Figure 29** – Material of the sloping ceiling

- **Sides and behind the screen:** At every side of the screen and under the same there are some heavy curtains which help quite alot with the absorption at high frequencies (see *Figure 12*). Behind the screen there is a structure to hold the screen speakers and subwoofers made of unplastered painted plasterboard (see *Figure 13*)

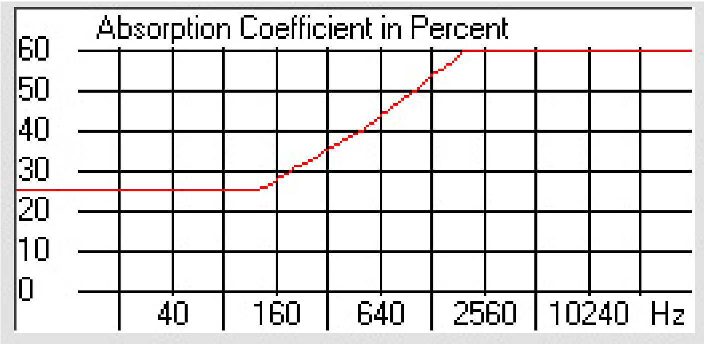



**Figure 30** – Materila screen courtains

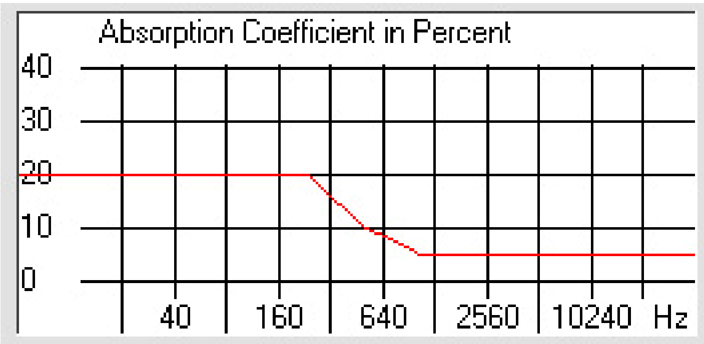



**Figure 31** – Unplastered painted plasterboard

After all this structure and material reforming and once simulated with CARA software the RT60 obtained are correct enough for our cinema theater (see Figure 14).

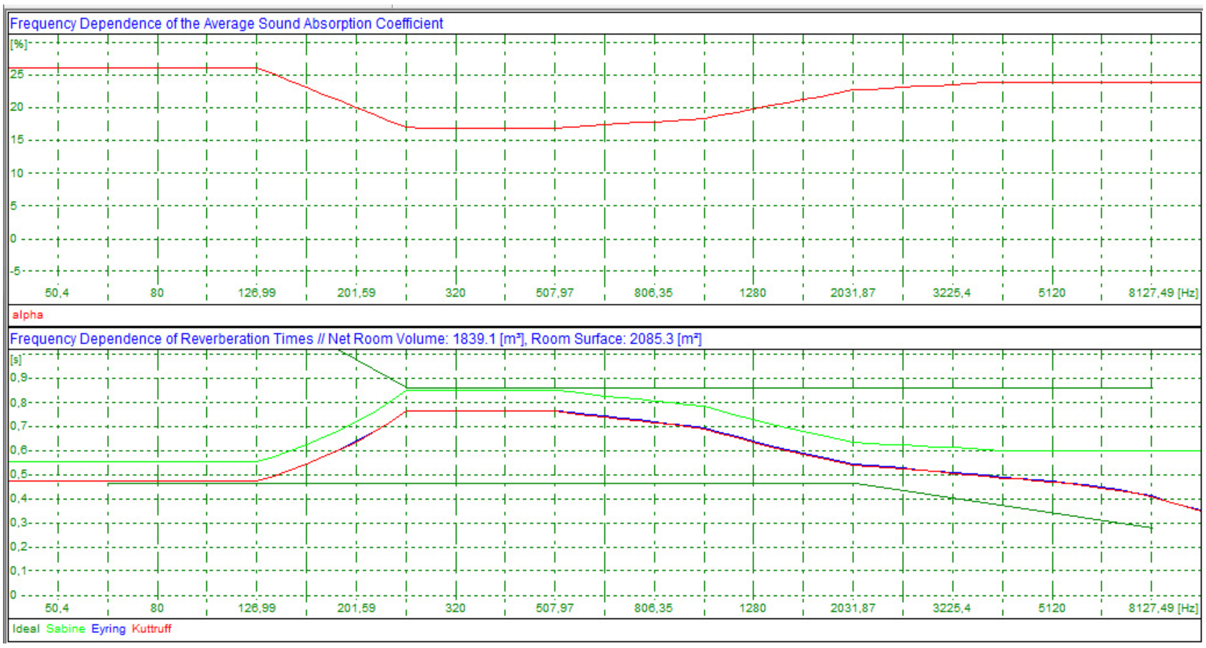



**Figure 32** – New RT60 with the new average absorption coefficient

# 5. Cinema audio systems

This part of the project consists in making the choice of the best audio system for our cinema. For a good result, is important to begin to know a little bit, the history and evolution of cinema audio systems and cinema audio standards. Once knowing and being aware of which has been the path that audio systems an standards have followed in the cinema's world, it will be more clear where it is headed and therefore what kind of standard would be the most appropriate for a new cinema theatre building.

In this section we also analyze the different systems and standards that exist nowadays to make a little comparison between them. This way also bears in mind  the best available options the market offers.

Once the previous steps have been done, to proceed with the election of the audio system that will be used in the theatre will be much easier. The choice of audio standard will be done based on the results and information obtained from the previous two steps, taking into account either the most commonly used systems today or the systems are expected to be used during next years.

## 5.1. Evolution of audio standards in cinema

The cinema is one of the most influenced by technological advances art form, as they have given freedom and the creative possibilities for filmmakers. In addition, in the cinema there are two very differenced technologies: the image and sound. In the history of image technical developments, the most important moments could be the invention of cinema itself, as a moving-picture, and the appearance of colour, along with other less significant innovations such as widescreen or three dimensions. In the field of sound has been a similar trend, although not parallel in time, with the creation of talkies (was the nickname given to movies with sound when they first debuted) and then the emergence of Dolby stereo and its very rapid development in recent times. For this project is important to know the evolution of cinema sound from its origins to the present.

**Analog mono sound**

The first movies with sound are from the late twenties. Recording system used are mono and analog using two different technologies: sync disks and optical sound. The synchronized disk system, used in “The Jazz Singer” (Alan Crosland, 1927), was quickly rejected for the technical difficulties it had, and the optical sound was quickly imposed. The development of optical sound will be essential in the technical development of cinema throughout the thirties. At the beginning of the decade, the difficulties of recording sound are overwhelming: the absence of directional microphones, the high level of noise produced by the cameras and the inability to mix several sound sources made the film sound recording a difficult task, ungrateful, and above all very costly both in money and time. For its part, the film “Singing in the Rain” (Stanley Donen and Gene Kelly, 1952) shows in some of its sequences (in a comedy way), the difficulties of sound recording the beginning of the talkies. Having overcome the early setbacks, with the emergence of post-production sound mixing, or the invention of the shaft to the microphone, there were still many problems that would solve over time.

Later Magnetic sound appears, which will become the main mastering system in the 40s, although the commercial copies for cinemas will continue to have optical sound (first distributed with magnetic sound film was "The Robe" in 1953). The characteristics of optical and magnetic sound as printed in the motion picture are:

a) Optical Audio: the soundtrack is printed on the film between frames and drilling. A light beam is filtered by the optical track and is read by a photocell, and later became electrical impulses and these turn into sound.

b) Magnetic Sound: prints a magnetic strip in the movie red by some heads (the same way as home videos or cassettes). The magnetic sound has higher quality than optical and a narrower track width. One drawback of the magnet is the higher cost for maintenance of equipment and the film handling, and the ease which you can erase the tracks by exposure to magnetic fields, scratches, etc.

The magnetic sound, despite its higher quality, has never unseated the optical one. In one side by the above drawbacks, but mostly by the cost involved in the cinemas magnetic sound installation, this meant the continued opposition of the exhibitors. So the optical sound has remained until today, reaching such high quality, the last decades of the twentieth century, that equates with the magnet one.

**Analog Stereo Sound**

In stereo, the situation can be manipulated to make sound coming from any point in the full width of the screen, which represents a substantial improvement not only in the film show but also in the narrative of the medium. With the use of stereo recorded natural reverberations or reverb effects with this feature becomes more evident and gives more realism to the illusion of depth.

In the early fifties appeared the first stereo systems for both optical sound to magnetic. During this period the magnetic sound awakened the industry interest, as the experiments in optical systems did not have much significance. The fifties magnetic stereo sound was normally working with four channels: three along the screen (left, right and center) and a fourth one as surround that created a sound field behind the viewer. This was the distribution of Cinemascope (it will be explained in the 3.1 section), the most popular system, introduced in “The Robe” (Henry Koster, 1953), although there were others such as Todd-AO, with a six-channel configuration, used for example in “Around the World in 80 Days” (Michael Anderson, 1956). Though, even if a film was carried out and mastered with magnetic sound a large number of copies were distributed with the old optical sound, because this technology was held by the projectors of most of the cinema theatres. The magnetic playback equipment high cost attached to technological advances in recording and playback systems caused the magnetic sound disappeared in the early sixties from the rooms, but survived as a recording system.

**The analog Dolby Stereo**

This system, developed by Dolby Laboratories throughout the seventies, was the starting point for a improve process of movie sound quality that has brought us to today's high quality standards. This allows highly spectacular sound treatments, thus increasing the sound importance in cinema.

The Dolby system includes two major innovations for the sound in cinema, comparable with the passage of black and white to colour: the Dolby background noise reduction and multichannel audio system.

What happened before the appearance of Dolby background noise reducer was, if there is a mixture of several audio tracks, the background noise of each is added up to the previous ones. On the other hand, the noise was very annoying at high frequencies and in the lower was masked by useful sound. The solution the film industry had found to this problem, before the advent of Dolby reducer, was to limit the frequencies of the soundtrack of the films. In 1938 the Hollywood Academy of Motion Picture Arts and Sciences issued a standard used until the seventies: Was the "Academy curve“. It consists of applying a high-pass filter (it starts falling at 3.000Hz with a very low volume at 8.000Hz) to the cinematic sound. In the films sound recording was avoided to exceed beyond the limits of this curve, while cinemas had their sound systems equalizers in the same way, so the background noise of high frequencies was not perceived simply because these frequencies did not exist. This solved the noise problem but created another. If high frequency harmonics are eliminate sound is lost, becomes poor and opaque sound, which is, in fact, what it’s heard in all films until the mid-seventies.

The basis of the Dolby noise reduction process lies in the sound recording itself. In the Dolby system a recording with a “natural” EQ sound is not made, instead of it, the high frequencies volume is increased getting, this way, an uncompensated recording, rich in high frequencies, which retains its inevitable background noise. When this recorded sound is played, introduces a filter to lower these high frequencies to normal, restoring the sound so close to the original, but removing background noise from high frequency.

The other innovation of Dolby System is the use multichannel system. In the early seventies, the only useful stereo playback method was the magnetic sound, with minimum number of rooms equipped for it. The optical sound has a poor quality in a stereo system. However, Dolby Labs found that using the sound reducer was possible to get optical stereo sound tracks with higher quality than existing. So, Dolby Stereo is simply an optical sound stereo system with background noise reduction. Apart from left and right chanels, a rear channel is introduced behind the audience, and a central one in front of the audience, in the screen centre. This system was used for the first time in “A star is born” (Frank Pierson, 1976), and consolidates with "Star Wars" (George Lucas, 1977). With that film, Dolby launches its optical sound processor CP-50, and it is imposed in most rooms in the early eighties. The system is a variation on the stereo, so make able to use the stereo standard track from the tape: the four original channels - L (left), R (right), C (center channel) and S (Surround) - are reduced into two stereo channels with a matrix, being this information printed on the film. In the room, a decoder is used to restore the four channels. Combining the L, R and S, the “super field” is created (the feeling that an effect played by S and L will come from back-left, and an effect played by S and R, from back-right). The system also has the advantage of its adaptability: if the room does not have a decoder, just a simple stereo system, playback can be performed on this system without any problem, furthermore is adaptable to a monaural sound.

The two channels added to the two stereo advantages are that surround channel enables to extend sound field to the entire space surrounding the viewer. These artificial spatial locations possibilities of sound have led to the concept of super fields. In Michel Chion definition “*is the field designed in the multitrack cinema by the environmental sounds of nature, from the city noise, music, rumors, etc., surrounding visual space and can come from outside the limits of the screen points*”. In any case, coupled with improved quality of sound in cinema, Supercamp alters our perception of the film space, and sounds become perfectly located in that space.

The central channel plays the two side channels sound with lower intensity, usually at -15dB . This produces an impoverishment of the stereo, but allows what has come to call “sociabilization” it. This is because the normal stereo enables the correct perception of sound directivity only to the center of the room viewers regard to the screen placement. Both sides viewers suffers a deformation of sounds spatial location perception, hearing them closer to the place where they are located. With the central channel system achieve that sounds are similarly perceived in all parts of the room, with the cost of decreased stereo viewers in the center, so sacrifices the centred viewers ideal hearing to have a everyone proper hearing in the room regarding the sound source.

**The Dolby Digital (or Dolby 5.1 Or AC3)**

It was first used in 1992 in Batman Returns (Tim Burton, 1992). It's a radically different format from Dolby Stereo as it is a digital optical audio consists of six separate channels, not reduced into two stereos, and therefore does not need decoder to be read in the room. Obviously, it can present problems in stereo only equipped rooms. Digital sound is printed on the film, in the space between the holes that allow the tape hiss. The film also sets an optical audio band, for the rooms that do not have digital technology, and when errors occur in digital reading of the track, which tend to be quite frequent due to small cracks or scratches on support. It must bearded in mind that analog reading errors normally produce unwanted noise, but digital readout errors produce periods of absolute silence. For this, when system detects errors in the digital readout goes immediately to use the analog track.

Dolby Digital uses 6 real audio channels: 5 full-range (20 Hz to 20,000 Hz) and additional channel for low frequency effects (from 3 Hz to 120 Hz). Each audio track has a 16 bits and 48KHz resolution. The reason for using a 48KHz sampling 44'1KHz and not the standard in the audio cd is because it is a multiple of 24, which are the frames per second film has, so the audio is synchronized with image (although the 48KHz is used for other audiovisual formats such as digital video with 25 frames per second). All six channels are central, left, right, surround left, surround right and subwoofer.

**The Dolby Digital Surround-Ex**

The first film that used this sound format was "Star Wars Episode I: The Phantom Menace" (George Lucas, 1999). It is a similar system to Dolby Digital with the addition of a seventh central surround channel. That is, if the Dolby Digital had two rear channels (rear-lateral-left and rear-lateral-right), the Dolby Digital Surround-Ex has three: lateral-left, lateral-right and rear-side.

**The DTS (Digital Theater System)**

There are two other systems used in theaters, the DTS and SDDS. Each has its advantages and disadvantages, and is in clear conflict with the Dolby Digital, which is currently dominating the market.

The DTS appears for the first time in 1993, with the movie “Jurassic Park” (Steven Spielberg, 1993). It is identical to Dolby Digital in their configuration. However, its sound quality is higher, because it uses 20 bits (compared to 16 of Dolby Digital) and a lower signal compression. The main difference is that the sound is recorded on compact discs, thus playing in another device different than the projector. In the film only a sync track is printed that ensures the simultaneous playback of both devices. This DTS feature provides a freedom that other systems do not have, because they are limited in the number of channels and audio information due to limited space available on tape film. Besides avoiding the digital track printed reading errors on the tape because of the increased reading effectiveness of the compact-disk systems, and facilitates the screening of the film in different languages: only will be necessary to change the cd and not the coil to change the language. Despite this, is less widespread than Dolby Digital.

**The SDDS (Sony Dynamic Digital Sound)**

This system was introduced by Sony in 1993 with the movie "Last Action Hero" (John McTiernan, 1993). It provides 8 independent channels with the following configuration: two rear surround channels (left and right) and 6 channels behind the screen, which achieved a much more integrated sound with the image and best audio effects. These six channels are L, R, C and subwoofer (such as Dolby Digital), plus two additional channels of effects, located between LC and RC. Sony does not provide information about the type of compression or digital sound features, but based on the used film area, it is similar to other systems, with a higher compression than Dolby Digital but less than DTS.

As this is the last system has been built, they found the problem that the entire space of the film was taken, except for the outer margins, which was the used area. As is hard hit tape part, the information is duplicated on both margins, this way when there is one damaged margin, information is read from the other. This makes it possible to include in the film all systems: the optical analog, Dolby Digital, DTS and SDDS, so whatever the system installed in a specific room, the audio can be read without problems.

**THX**

The THX was designed in 1982 during the production of “The Return of the Jedi” (Richard Marquand, 1983). It's not really a sound system itself. Is a set of standards devised by the company Lucasfilm for movie theaters. THX is a system that tries to make the movie sound reaches the audience with optimal quality levels, as designed and recorded by the films creators. The halls that wish to operate under this format should install concrete sound equipment under strict instructions, also requires contracting an annual maintenance of the system. Lucasfilm requires that used devices have to be chosen from an approved by them list, and rent a specific processors for audio treatment. A THX engineer equalizes the room and sealed the whole equipment.

The goal of THX is, first, set a minimum standard of quality and technology needed to play movies, and second, to create a similar environment in all cinemas in the world, so that filmmakers can control exactly how the film will listen to the audience. The THX rule primarily affects acoustic aspects (level of noise generated inside and outside the room, room acoustics properties, sound system used, etc..), but also image (quality and color) and even the comfort of the rooms.

## 5.2. Different audio systems and standards in cinema

Having seen the evolution of audio systems in the cinema over the story, is time to analyze the different offers that are currently on the market for movie theatre sound systems. This way, will be possible to know which brands and equipment manufacturers are most used, being able to decide which is in terms of quality, the most indicated sound system for our room.

**Brands and manufacturers**

Nowadays it’s possible to highlight four different brands of standard and audio systems for cinema. These are, as it’s shown in the previous section, ***Dolby, DTS, SDDS***. In addition to these three brands of sound systems will also have regard to the ***THX*** standard.

## 5.2.1. Dolby

Dolby deliver a wide range of comprehensive and reliable technologies that ensure the director's sound will be reproduced in the theater precisely as it was intended. This brand offers several audio systems for movie theaters and then presents the most important and most widely Dolby systems used nowadays which are the Dolby Digital and the Dolby Digital Surround EX.

**Dolby Digital**

Dolby® Digital, also referred to as AC-3, is an advanced audio encoding/decoding technology that efficiently delivers up to 5.1 discrete channels of vibrant surround sound. Dolby Digital is already found in thousands of cinemas.

Its main characteristics are:

- Enables the efficient storage and transmission of high-quality 5.1 digital surround sound.
- Immerses audiences in the on-screen action.
- Provides compatibility with millions of existing playback units Dolby Digital technology ensures that your audience enjoys a rich, enveloping surround sound experience by delivering up to 5.1 discrete audio channels.

Three front channels (Left, Center, and Right) provide crisp (good sound, with no interference and no buzzing noise in the background), clean dialogue and accurate placement of on-screen sounds, while two surround channels (Left Surround and Right Surround) immerse the audience in the action.

The Low-Frequency Effects (LFE) channel delivers deep, powerful bass effects that can be felt as well as heard. As it needs only about one-tenth the bandwidth of the other channels, the LFE channel is referred to as a “.1” channel.

Dolby Digital audio technology puts a six-channel digital optical soundtrack on 35 mm prints. The digital information is on the space between the film sprocket holes, next to the analog soundtrack. The Dolby Digital soundtrack is encoded onto the filmstrip in addition to the analog track, so all films will play back satisfactorily in nearly every cinema.

**Dolby Digital Surround EX**

By introducing an additional rear surround audio channel, Dolby® Digital Surround EX™ takes the Dolby Digital 5.1-channel setup one step further, clarifying audio effects that pan from front to back, and creating a more enveloping surround sound experience.

Its main characteristics are:

- Adds a center rear channel to the Dolby Digital 5.1 system for increased cinema realism.
- Supports 6.1-channel home audio playback.
- Enables Dolby Digital Surround EX soundtracks on DVDs to automatically activate EX decoding in a compatibly equipped EX receiver or preamp/processor via a digital flag contained in the bit stream.
- Includes backward compatibility with any Dolby Digital 5.1 cinema installation.

Dolby Digital Surround EX uses the same digital data blocks positioned between the sprocket holes as Dolby Digital, and remains fully compatible with the Dolby Digital 5.1-channel system. Because optical transfer and laboratory printing processes remain identical, using this format doesn’t add any extra cost. Dolby Digital Surround EX seems the most indicated audio system for our cinema theatre because its good sound quality adding the center rear channel to our room.

## 5.2.2. DTS (Digital Theater System)

DTS (Digital Theater System / Sound / Surround) is a digital audio encoding that allows the existence of six discrete channels of audio in a single compressed signal. Apart from being used for the cinema, DTS is also used in "special places" such as theme parks or simulators, in which case can accommodate up to 8 independent channels into one signal, and can synchronize multiple signals to get an unlimited number of fully independent channels.

The 6 channels offered correspond in name and locations with Dolby Digital, with a frequency of 20 Hz to 20 kHz in all channels (left, right, central and surrounds) and 20 Hz to 120 Hz LFE. It has a sampling frequency of 48 kHz to 96 kHz. Compared to Dolby Digital, DTS uses a higher bitrates speeds (768 or 1536 Kb/s in its simpler variants), which makes it a system of higher quality.

The DTS does not incorporate the data on the tape to project, but are recorded on a separate CD-ROM. What the tape has included is a synchronization signal "time code" printed which enables to reproduce the image and sound simultaneously, even when a tape of 24 frames per second is projected at 25 f/s, for example, it supports variations of ± 10% speed, thanks to the versatility of this time code, DTS is the only digital system used in 70 mm.

### 5.2.3. SDDS (Sony Dinamic Digital Sound)

SDDS is a digital film sound format comprised of the SDDS soundtrack, optically printed on both edges of 35mm film, and it is read by a SDDS playback hardware. Sony designed this sound standard exclusively for motion picture theatres, there is no consumer equivalent. Is the only motion picture sound format to offer up to 8 channels of discrete, clear, crisp, vibrant digital sound.

The soundtrack consists of an array of microscopic dots (or pixels) much like those recorded on a CD. With SDDS, both edges are used to provide two continuous streams of data interleaved using a cross-redundant error correction technique to further prevent drop-outs from film damage or scratches.

The SDDS reader is mounted on top of a 35mm projector. The film is threaded through the reader before it passes through the picture aperture. As the film runs, red LEDs are used to illuminate the SDDS soundtrack. Special integrated circuits called CCDs (Charge Coupled Devices), read the SDDS data and convert the stream of dots on the film into digital information. This information is pre-processed in the reader and passed on to the SDDS decoder.

The SDDS decoder is installed in the sound equipment rack. The decoder receives the information from the reader and translates it into audio signals routed to the cinema's power amplifiers. The decoder is responsible for a series of processes that must be performed before the audio is recovered. Next, errors caused by scratches or damage to the film are corrected using redundant error recovery data. Since SDDS is read at the top of the projector, the data is delayed slightly to restore synchronization with the picture. And finally, adjustments in balance and playback level are made to match the specific auditorium's sound system and acoustics. SDDS is designed to process sound entirely in the digital domain, bypassing any existing analog processor, preserving clarity and providing full dynamic range.

This system consist in 6 or 8 channels of discrete digital sound through 5 screen loudspeakers, 2 stereo surround channels and a full-frequency sub-woofer channel. The usual gaps between the Left, Centre and Right speakers are filled, creating a far more uniform sound field for all patrons in the cinema, regardless of cinema size.

### 5.2.4. THX (cinema certification)

THX is a high-fidelity standard sound used in movies, movie playback professionals in video and audio systems in cars. THX was developed by Tomlinson Holman, the company Lucas film in 1983 to ensure that the soundtrack for the sixth film of the Star Wars saga (The Return of the Jedi), could be heard in the best condition.

The THX system is not a recording technology, and is not an audio format, all digital audio systems (Dolby Digital, SDDS, DTS) and analog (Dolby SR, Ultra-Stereo) can be heard in THX. THX is a quality control system. If a sound producer says his film is THX, means that the soundtrack of the film will be heard exactly as in its creation and like the director intended. THX Certified Cinemas provide standards and best practices for architectural design, acoustics, sound isolation and audio-visual equipment performance.

Through its standards for acoustic performance, background noise, sound isolation and image quality, THX Certified Cinemas promise every seat in the house is a good one. During the certification process, THX offers the following services to its cinema partners:

- **Feasibility Study**: Analysis of THX design integration into cinema architectural plans.
- **Speaker Layout and Baffle Wall**: Detailed architectural drawings for speaker positioning and baffle wall (behind the screen) design.
- **Auditorium Isolation**: Review of exterior noise sources, such as adjacent auditoriums, street traffic and concessions, to ensure nothing distracts audiences from the feature presentation.
- **Reverberation Control**: Specifications for the installation of acoustic absorption material.
- **Measurement of Background Noise**: Confirm background noise meets NC30 at all octave bands; this ensures noise from air conditioning units and projection equipment does not mask the subtle effects in a movie's soundtrack.
- **Screen Placement**: Evaluation of cinema visual performance, including luminance, resolution, color, jitter and weave, as well as audience viewing angles in every seating position. THX recommends having a 36 degree viewing angle from the farthest seat in the auditorium.
- **Projected Image**: Analysis of the projected image to verify that the entire image size is projected on the screen.
- **Calibration**: Calibration of the sound and projection system to industry and THX standards.
- **Final Testing**: Ensure equipment and auditorium is performing to THX performance specifications.

## 5.3 Choice of audio system

Once seen the evolution of audio formats and different options to choose from nowadays existing audio systems, it's time to make the choice of which will be used in our cinema. This includes, besides the standard type to use, choose all necessary or advisable for the sound equipment as the processor, frequency dividers, amplifiers and speakers that will be installed in the theater. This has been made by following the guidelines installation of one of the largest distribution and projection sound equipment in Spain. This company is called Kelonik and the part of the company dedicate to sound is K.C.S. (Kelonik Cinema Sound) and its headquarters is located in Barcelona.

The acoustic system configuration used in our theater will be the Dolby Surround EX and bearing in mind that our auditoria is a large sized one (according to the Kelonik company, it is considered a large room, those with a capacity greater than 250 people) it will be reproduced by a 7 channels configuration with tri-amplified system (3 ways) in the screen which includes the following equipment and devices:

**- Dolby CP650 Digital cinema processor:**

Is the only all-digital cinema processor, capable of reproducing Dolby soundtrack formats, whether analog or digital. Its high quality, reliability, versatility and the simplicity of its configuration explains their presence in the best cinemas in the world. It also supports new technologies like digital cinema, ensuring a long product life.

The configuration CP650, processes Dolby SR and A-type analog, Dolby Digital, and Dolby Digital Surround EX soundtracks. It also provides four AES3 inputs for digital cinema audio.

**- K.C.S Frequency divider (crossover):**

The KCS multi-channel electronic crossover with time corrector has been specifically designed for cinemas use.

**Features:** Active 3-way splitter with tri-amplifier for three channel behind screen system with:

- Predetermined stop frequencies, depending on model.
- High frequency compensation curve.
- Time delay system with 180, 270, 360, 450 and 540 degree delay, to balance the distance between high frequency units and bass speakers.
- By-pass system in case of emergency with the active dividers, allowing the 3 bass screen speakers to work as a complete sound system.

**- QSC ISA 1350 Amplifiers:**

The ISA Installed System Amplifiers are designed to meet the needs of sound system designers and contractors worldwide. Three models feature isolated 25-, 70-, and 100- volt outputs for distributed sound systems, while for low impedance modes are rated for 2-ohm operation. The ISA 1350 drivers 70V lines directly with 1500 watts per channel. Versatile loading options and comprehensive set features make the ISA Series a rugged, cost-effective power solution for any permanently installed sound systems.

The equipment will be composed by 10 amplifiers which will distribute the sound signal to different speakers with the following configuration:

| | **Output 1** | **Output 2** |
|---|---|---|
| **Amplifier 1** | L channel High freq. speaker | L channel Mid freq. speaker |
| **Amplifier 2** | L channel Low freq. speaker 1 | L channel Low freq. speaker 2 |
| **Amplifier 3** | C channel High freq. speaker | C channel Mid freq. speaker |
| **Amplifier 4** | C channel Low freq. speaker 1 | C channel Low freq. speaker 2 |
| **Amplifier 5** | R channel High freq. speaker | R channel Mid freq. speaker |
| **Amplifier 6** | R channel Low freq. speaker 1 | R channel Low freq. speaker 2 |
| **Amplifier 7** | Subwoofer 1 | Subwoofer 2 |
| **Amplifier 8** | Subwoofer 3 | Subwoofer 4 |
| **Amplifier 9** | L-side speakers (x6) | R-side speakers (x6) |
| **Amplifier 10** | Backside L speakers (x3) | Backside L speakers (x3) |

Table 2 – Amplifier output direction

**- Speakers:**

All the speakers have been selected from the K.C.S. catalogue and its possible configurations and have been appropriately distributed in the theater as follows:

- Behind the screen:

  - L, C, and R channels: Each of those channels needs a three way speakers. The model S-8500, from the K.C.S. Company, has been selected each one. The S-8500 speaker system is especially designed for high quality and spectacular cinema installations with large capacity theaters.

- Subwoofers: The subwoofers section which is behind the screen is composed by four speakers. The model of those speakers will be C-218-A from the K.C.S. Company as well.

- Surround channels speakers:

    - LS and RS: The L-side and R-side speakers section is composed by 6 speakers in each side. The model of those speakers will be SR-12 from the K.C.S. Company.

    - Backside-L and Backside-R: This will be a group of 3 speakers in each side of the end wall. The chosen speaker's model is the same as in the LS and RS, the SR-12.

# 6. Cinema projection systems

As has been done with the audio equipment, now it’s time to choose the projection system. This part of the project consists in to make the choice of the best projection system for our cinema theatre. For it, is important to know the history and evolution of cinema projection systems and cinema projection standards. Once knowing and being aware of which has been the path that projection systems an standards have followed in the cinema’s world, will be more clearly where it is headed and therefore what kind of standard would be the most appropriate for the projection system of a new cinema theatre building.

In this part will also being analyzed the different projection systems and devices that exist nowadays to make a little comparison between them. This way also bears in mind which is the best available projection system offered in the market.

Once the previous steps have been done, to proceed with the election of the projection system that will be used in the theatre will be easier. The choice of projection standards will be done based on the results and information obtained from the previous two steps, taking into account either the most commonly used systems nowadays or the systems are expected to be used during next years.

## 6.1. Evolution of projection standards in cinema

The evolution of projection systems based its beginnings to the first projector of the history that has been documented. This is the Kinetoscope and Thomas Edison patents it in 1888, but the concept of moving images as entertainment was not new in the late 19th century. Magic lanterns and other devices had been used in popular entertainment along generations. Magic lanterns used glass slides with images that were projected. The use of levers and other contrivances made these images "move."

Another mechanism called phenakistiscope consisted of a disk with images of the successive phases of the movement of it which could be rotated to simulate the movement.

And then there was Zoopraxiscope, developed by the photographer Eadweard Muybridge in 1879, projecting the image series in the successive phases of movement. These images were obtained by using multiple cameras. The invention of a camera in the Edison laboratories capable of recording successive images in just one camera was only a practice more profitable advancement influence all subsequent motion imaging devices.

Muybridge proposed Edison, collaborate and combine Muybridge Zoopraxiscope with Edison's phonograph (sound recording and player device). Although apparently intrigued, Edison decided not to participate in this partnership, perhaps realizing that the Zoopraxiscope was not a very practical way for effective movement registration.

In an attempt to protect their future inventions, Edison filed a registration with the Patent Office on October 17, 1888, describing their ideas for a device that "does for the eye what the phonograph does for the ears" record and reproduce objects in motion. Edison called the invention a Kinetoscope, using the Greek words "Kineto" which means "movement" and "scopos" which means "to see." For some years the films were exhibited in the United States using the Kinetoscope. This way the film could only be seen by one person at the same time in a peep-show box. It was not ready for large audiences. Later in 1896, Edison showed his improved Vitascope projector and it was the first commercially, successful, projector in the U.S..

Over a century there have been many inventions and innovations as respects the projection systems. Most of projector models were invented and created by different companies over the first half of the 20th century. These included many formatting changes so that it respects the width of the film, or celluloid. The most common sizes of films at the time were the 16 mm and 35 mm 8 mm. But there were more unknown formats like 9.5 mm, 17.5 mm, 22 mm, 28 mm, even including widescreen formats ranging from 56 mm of Magnafilm (Paramount) to the Widefilm (Lumiere) 75 mm, going through the 65 mm Vitascope (Warner Bros). With so many changes can be considered as a miracle that 35 mm films, invented at the beginning of the history of Edison projection (in fact it was called Edison size), have become the standard format currently used by all modern cinema theaters for the analog film projection.

**Development of colour in cinema**

In the cinema world, the apparition of the color films (as the apparition of talkies respects to sound) it's a very important improvement. The color is clearly a phenomenon of post-war. However, prior Hollywood studies already performed with a variety of experimental techniques of color. This produced a lot of interest of filmmakers from all over Europe and America.

The black and white films still predominating the market during the late twenties, thirties or forties due to the implementation of color increase so much the budget movies. The black and white film was simply cheaper. For many studios, the use of color was too expensive for film screenings.

*Stenciling techniques, pioneered by Pathé - thus known as Pathécolor – and later improved upon by the Handschiegel process thanks to a St Louis engraver of the same name, allowed for a more industrialized production of colour films. The technique reached its peak in the nineteen teens but still remained in use into the early 1930s*. (Steve Neale, p116, Cinema and Technology: Image, Sound, Colour 1985).

With the improvement of processes to get the color in the movies, it was possible to get the color with a similar cost to the black and white films. After the end of 2nd World War, many more films were filmed in color as the industry saw that the color was essential to attract people and apart them from the competition offered by television, which remained half-white black and until the mid-1960s. In the late 1960s, color had become the norm for film makers.

**Digital Projectors**

The Society of Motion Picture and Television Engineers began to work on standards for digital cinema in 2001. Digital Cinema is a new technology that is poised to spread in popularity in the movie industry. "**Star Wars Episode II: Attack of the Clones**" was the first all-digital live action feature, no film was used in the creation of that movie until film copies had to be made for theaters without Digital Cinema projectors. It is future-proofing, though, as technology always progresses and studios will most certainly invest in higher resolution equipment as time goes on.

## 6.2. Different projection standards in cinema

At this point the two major projection systems currently used are presented even some of its major manufacturers. These two systems are 35 mm projectors and digital projectors. Furthermore, the last evolution for cinema projection technology will also be analyzed, 3D cinema which its popularity is growing up in recent years between the audiovisual producers and cinemas exhibitors.

### 6.2.1. 35 mm projectors

This projection system is virtually used from the beginnings of the film projection. As seen in the history of projection systems section, 35 mm format film was created by Edison when the cinema's world began to develop. Despite the many changes in formats and different projectors that have been throughout history, the 35 mm film is the analog standard used nowadays in all the theaters that have analog format. For a better comprehension about how a 35 mm projector works, a summary of its operation system has been done in the following paragraphs.

A projector moves 24 frames per second in front of the lens. In a film, those 24 frames measure up to 1.5 meters of tape. With the quickly respective mathematical calculations tells you that one minute frames is equal to 90 feet of film, while the roll of typical a two-hour movie can be measured around 2.13 miles.

To hold all this amount of film, a projector is installed next to platters. As a minimum, you need two platters, one to feed and one to accept the film that has already been projected. The beauty of the platters is that when a film roll is over, the take up platter switches rolls to become the feed platter and the projection can continue. Nowadays most cinemas use these platters, however old art houses and independent theaters continue using reels. In a reel projection system a second projectors per screen is required. The film moved through the projector on a reel and when it was close to the end of the reel, a symbol or small cigarette burn appear at the top right of the screen. This will alert the projectionist to start the second projector. These kind of projectors are the ones that are currently in the theater which this project is based in. The second projector starts when the first reel reaches the end.

In projector, which is really important is not the actual image on the film, instead the sprockets which line the side because the projector is using these gears to pull the film through itself. The film is inserted through the sprockets which adhere to a series of spring rolls that provide the needed tension to maintain the uniform sliding of the film. The projectors use a claw or intermittent sprocket to perform this task. Once the film reaches the lens, it gets the image on the screen thanks to the powerful light of the xenon lamps. Xenon is a gas that provides incredible lighting for long periods of time. The bulb is in the middle of the lamp may also known as "The House of Mirrors" because of the mirrors inside which helps to focus the spotlight.

This light passes through the shutter. This is a "small plate" which revolves around 24 times per second. Allow the light reaches the film moving so that eliminates the jerky motion and flashing on the screen. It uses a small frame that makes the light only affects the needed areas of the film to be seen on the screen.

**35mm Projectors Manufacturers**

Below there are some of the most popular 35 mm projectors manufacturers existing nowadays:

- Cinemeccanica
- Christie
- Kinoton
- Pre Vost

### 6.2.2. Digital Projector

The digital cinema projection has supposed a big evolution respects to the different movies' storage systems. In digital cinema, the tape containing traditional film is replaced by an electronic storage device, such as a high-capacity hard disk and server. This way, instead of projecting the light through each frame of the tape film, digital cinema uses technologies such as DLP (Digital Light Processing) and LCOS (Liquid Cristal on Silicon) to perform the same projection task.

This technology, which appeared at the beginnings of the 21st century, has being gained much popularity in the film industry's world.  Although, at the beginnings, the resolution capability of a digital movies is not the same as that in a film, when comparing a digital cinema presentation with a film, its possible to see that digital gives greater image stability. While film gives problems when is being transported or stored, because it can be easily scratched, is highly flammable or have any other problems after it has been projected many times, digital sound and digital image does not suffer any damage. Even after having been played a hundred times will remain as the first day.

In the digital projectors there is two important kinds of resolution, 2K and 4K. 2K refers to images with 2048 horizontal pixels by 1080 pixels resolution which is more common, and Sony Electronics makes what they call CineAlta, a 4K digital cinema system which is 4096 pixels by 2160 pixels.
In digital cinema most films have a 2K resolution and are also rendered with the same resolution. There is not very common to find 4K productions so in a simply view these features projector does not provide many benefits but it is possible to use a 4K projector for a 2K productions.

Another advantage between digital projector and 35 mm projector is that the projectionists don't have to worry about change the film reel in every projection. That is because a digital systems work "similar to and MP3" and the shows can be queued up, along with the trailer to be shown. The equipment also allows theaters to deliver other entertainment, such as concerts or sports events.

### 6.2.3. 3D Digital Cinema

The apparition of digital cinema projection systems has brought a rebirth of the 3D technology. Previously, 3D using 35 mm film was a difficult process to project and you were limited to wearing red and blue 3D glasses.

Today 3D projections have attracted much attention of the cinema industry. For the exhibitors, 3D represents premium entertainment with a premium ticket prices and higher revenue per screen. For film makers, this format represents a new set of storytelling tools and hundred of new creative possibilities and if the audience is bearded in mind this system can offers a lot of new options like giving availability to watch live sports in 3D, live concerts and 3D videogame experiences.

3D projection works by presenting separate information to the left eye and the right one. When this information is seen trough special glasses, this two images come together to form the 3D image. Current 3D presentation on DLP projectors requires the “Triple-flash” method in which a single projector is used to rapidly flash the left eye image an then the right. Each image is flashed 3 times for a total of six flashes per frame (see *Figure 15*). Triple-flash DLP is compatible with existing 3D content and uses a single projector but there are some limitations such as that it can’t presents to both eyes simultaneous image which can produce unwanted visible flash artifacts reaching to cause eye fatigue. Now is when the 4K projectors are really useful: a 4K projector can project and image to both eyes at the same time (see *Figure 16*). The 4K projectors star with the same practical benefits of the Triple-flash DLP like the use of a single projector and offers all the compatibility with the 3D content but showing both images simultaneously avoiding flash artifacts. Its 4K configuration works because it has 4 times as many pixels than conventional projectors an there are enough pixels to project simultaneously the images from the both eyes with a 2K resolution (see *Figure 17*).


**Figure 33** – Triple-flash 3D projection

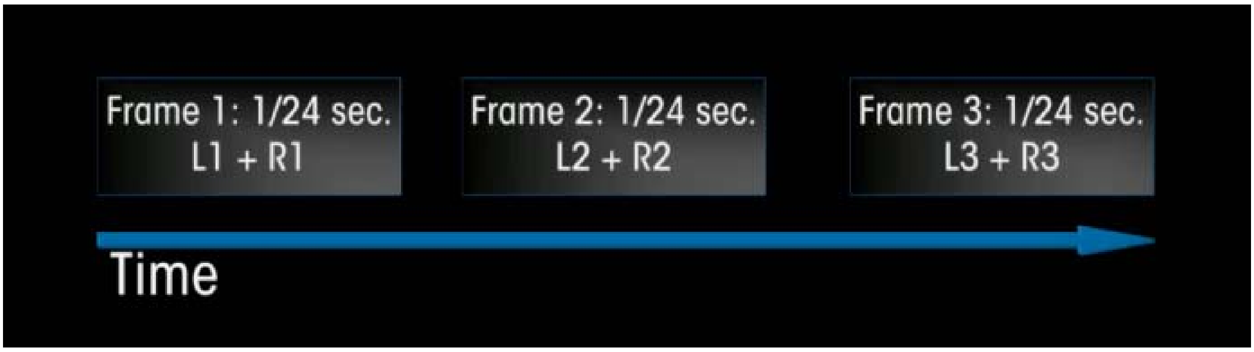



**Figure 34** – 4K projection, with both images at the same time

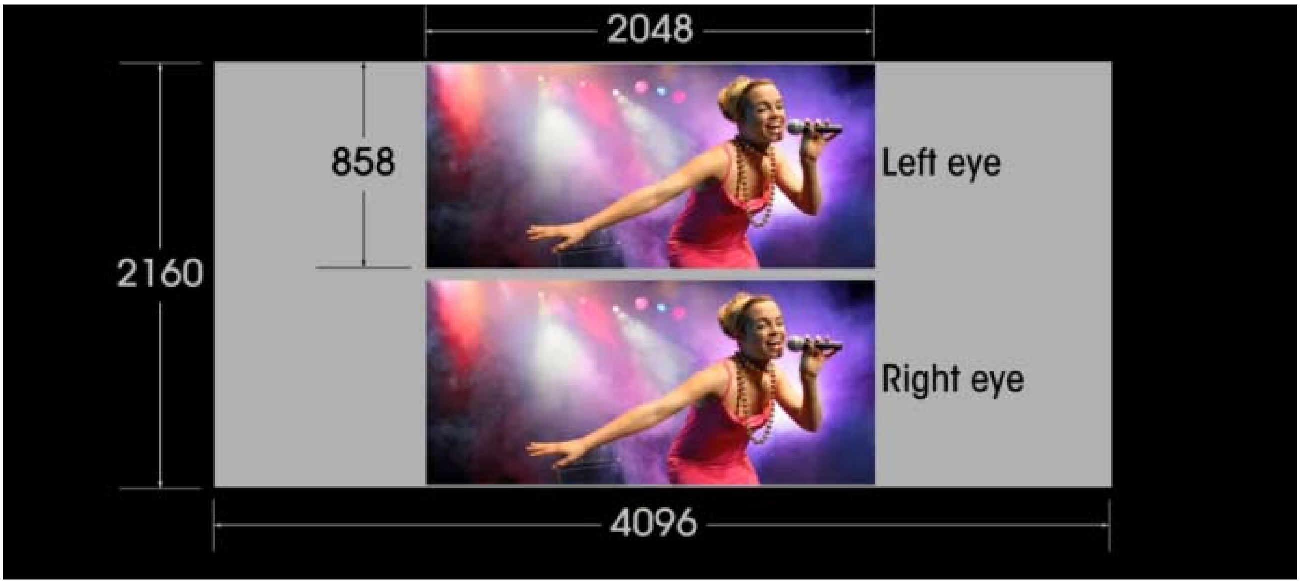



**Figure 35** – Images from both eyes at 2K resolution

**Digital Projectors Manufacturers**

Below there are some of the most popular 35 mm projectors manufacturers existing nowadays:

- Christie (2K resolution with DLP technology)
- Cinemeccanica (2K resolution with DLP technology)
- Barco (2K resolution with DLP technology)
- Sony (4K resolution)
- Nec

## 6.3. Choice of projection system

Once seen the evolution of projection formats an systems and which are the nowadays existing options to choose, it's time to make the choice of which will be used in our cinema. This will include two projectors systems, 35 mm projector and a digital projector and the processor server for the digital projector. Like happens with the choice of the audio system this part has been made by following the guidelines installation of one of the largest distribution and projection sound equipment in Spain. This company is called Kelonik and the part of the company dedicate to sound is K.C.S. (Kelonik Cinema Sound) and its headquarters is located in Barcelona.

**- Cinemeccanica VICTORIA 5B/5000 35 mm Projector:**

This model of Victoria 5B projectors includes 5000 meters (16,500 feet) film capacity that can take two whole pictures of normal length. On top of the Victoria 5 mechanism can be mounted an arm with a roller and no clutch as standard equipment or either one arm and clutch for 1 800 m (6,000 feet) of film, or a V with two auxiliary arms and clutches for 1 800 m (6,000 feet) to show trailers and commercials during the rewind time of the main picture. These projectors are supplied only with the long lamphouse beam. The most commonly ordered option is the on machine variable speed rewind, with or without auto shut off.

**- Sony SRXR220 Digital Cinema Projector:**

The SRX R220 system is a floor standing 4K (4096 x 2160 pixel) projection system intended for theater exhibition. This includes SRX R220 Projector Head, LMT 100 Media Block, R Screen Management System, Projectionist Terminal, and Enclosure Security System. For further information see *Appendix 4*.

**- Dolby Screen Server SS200:**

It is an all-in-one platform to store, decode, and deliver the movies to the digital projector. It offers outstanding performance and easy serviceability. The DSS200 decrypts the movie data and decodes the image. It outputs link-encrypted image data to the digital cinema projector and audio data to the cinema’s sound processor. It has and a RAID 5 hard-disk array with more than 1300GB which can hold 10 typical feature presentations (130 GB each) for playback.

All the audio equipment has been approved by THX ®. As it has been said before, THX is a registered trademark of LucasFilm LTD.

# 7. Equipment connections diagrams

In this section is shown how all the equipments are connected between them. It has been taking into account that there are two different configurations. In the first one all computers are connected to operate with the 35 mm projector system (see *Figure18*). Secondly is shown the connections for digital projector operation. This configuration adds a further step, because the digital video processor sends the video signal to the projector and its corresponding audio signals to the audio processor (see *Figure 19*).

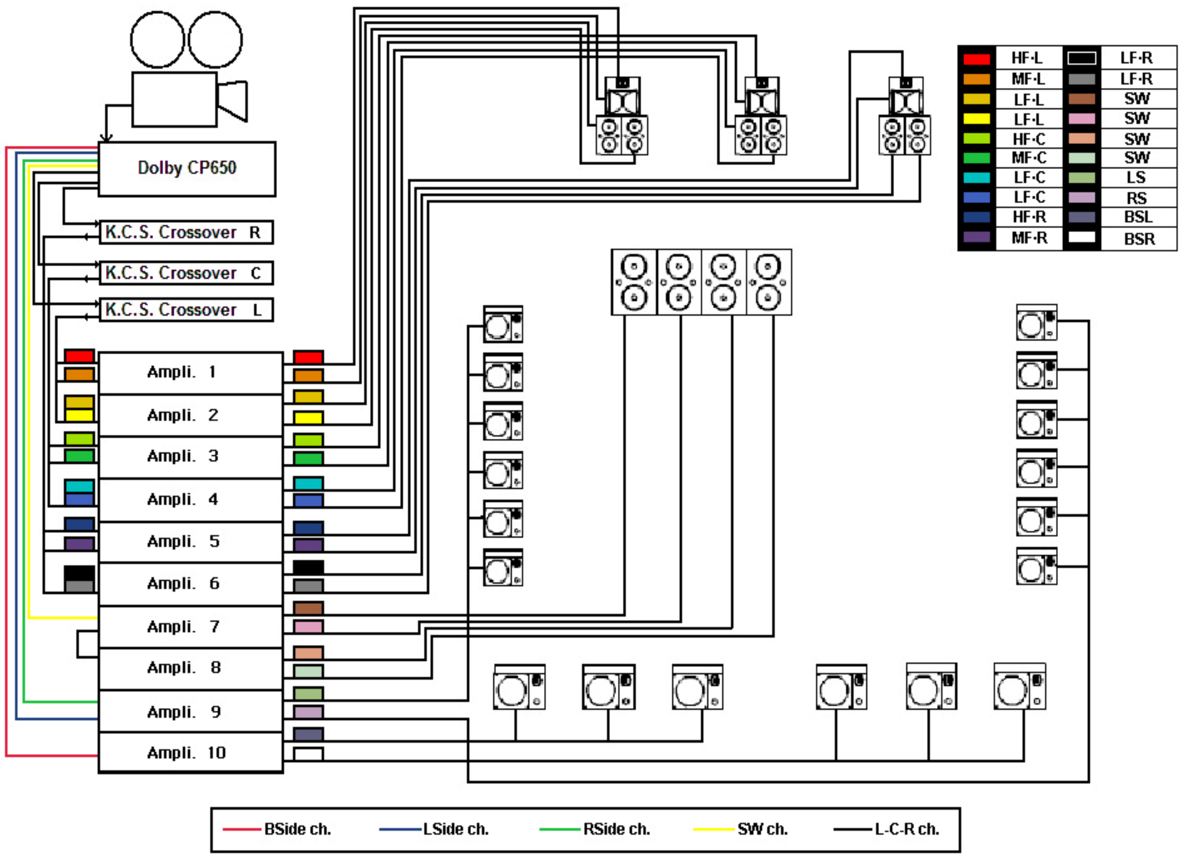



**Figure 36** – Connections diagram for 35mm projector

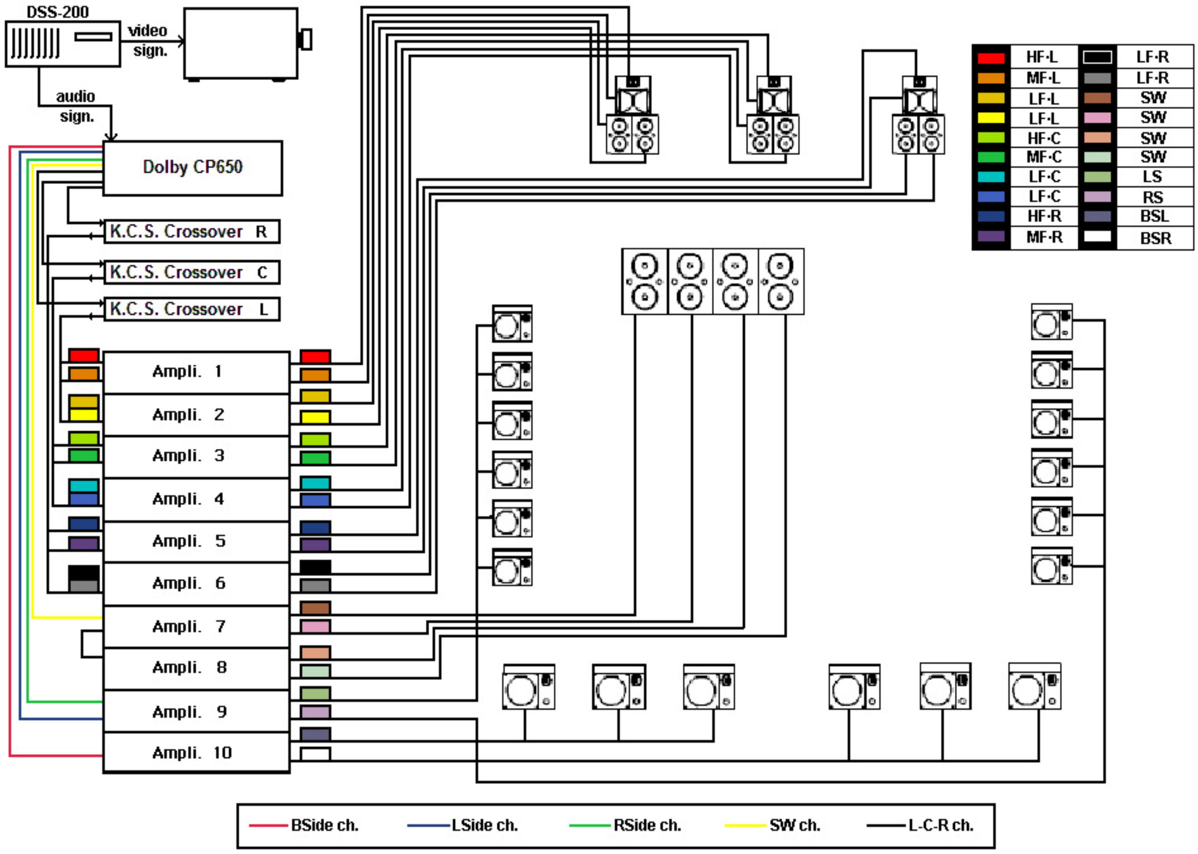



**Figure 37** – Connection diagram for digital projector

# 8. Conclusions

About my movie theater renovation project, the first thing I would say is that I have found this is a very interesting field but at the same time, involves a great deal of work and dedication to make and study in depth all issues and points that deserve to be considered.

In my case, first of all, I would and should to delve more deeply in acoustic conditioning section. I know this part of the project has a very high importance because of the many factors that influence in to the reformation or creation of a theater of such characteristics. At the beginnings I thought that it wouldn't be necessary to deep as much in theoretical acoustic issues. I had some very different intentions from what I've seen what's really needed to be addressed in this project.

In the same aspect, I also had problems in being not allowed to perform the corresponding acoustic simulations and calculations with the CARA software. Despite having been warned at the first moment, by my tutor and one of my teachers, about the high amount of time the software needed to spend performing all the calculations can be realized, once having seen CARA tutorials, I didn't expect it to be so time consuming as it was. For instance, one of the most interesting calculations which CARA software can perform was the Sound field calculation and it needed a massive period of time to calculate the entire process. I truly believe that this time was disproportionate compared with which I actually thought I really needed. As the tutorial says this process would be very useful to show the sound pressure levels divided all along the room, even respects the time and the spectrum frequency, and on it required only about 90 seconds to be completed. Then, the first thing I had in mind, was that the tutorials room size in which the calculations were carried out had at most the 15% volume of my room. So I expected it would take along time but what I did not expect was this: the tutorial warns that the Sound field Calculation process ends when a countdown reaches zero. The tutorials countdown starts at about 800 (referring to the different positions where de sound pressure is measured in the room) and recedes at constant velocity and rapidly (90 seconds). In case of my theater the countdown started with 1637 positions, and bearing in mind it would take so long I left the laptop doing the corresponding calculations while I was doing other parts of the project. My laptop spent more than twenty four hours rendering and it had made only one step, i.e., just was through the point 1636. This meant that if the process was proportional in all steps could take a very long time. Even so I decided to leave it rendering to see if the following points were fast calculated, but it was not. So was then when I decided to leave this process of my project.

Although this part of the calculations was a failure, the development and construction of the rooms with the CARA software was performed successfully and with their respective materials and shapes, which allow me to run the calculations of the reverberation time in both rooms and compare them properly. The results of the reverberation times where successfully corrected in the renovated theater.

Respected to the part of the project related with equipment and systems, I think it has been well made and have helped me to know and go so deeply into the world of film equipment industry.

Now I understand better how the different systems, both as video and projection, existing nowadays works, and which is the equipment needed to equip a current cinema theater correspondingly with the latest technologies. I could even say where this industry is headed and it is in constant development. With the advent of 3D cinema and digital sound technologies the business has a great future, especially because with this new technology (3D) is avoided, for the moment, an issue as problematic for exhibitionists as piracy, since they can provide a much more exclusive product.

Finally I just want to add that now I have much more experience in this field even in acoustics and in the equipments for cinemas.

# Budget

| | Equipment | Units | Price each unit | Total amount |
|---|---|---|---|---|
| **Audio equipment** | Dolby CP650 Digital cinema processor | 1 | 10,410.91 € | 10,410.91 € |
| | K.C.S Frequency divider (crossover) | 3 | 780.95 € | 2,342.85 € |
| | QSC ISA 1350 Amplifiers | 10 | 1,058.91 € | 10,589.1 € |
| | Left, Center, Right Speakers: S-7802 (K.C.S.) | 3 | 3,454 € | 10,362 € |
| | Subwoofers: C-218-A (K.C.S.) | 4 | 874 € | 3496 € |
| | LS and RS, Backside-L and Backside-R speakers: SR-12 (K.C.S.) | 18 | 320 € | 5760 € |
| **Projection equipment** | Cinemeccanica VICTORIA 5B/5000 35 mm Projector | 1 | 7,450 € | 7,450 € |
| | Sony SRXR220 Digital Cinema Projector | 1 | 138,100 € | 138,100 € |
| | Body | | 90,600 € | 90,600 € |
| | Lens (five types) | | 20,000 € | 20,000 € |
| | LMT-200 media block (4k DCI RAID Server) | | 27,500 € | 27,500 € |
| | Dolby Screen Server SS200 | 1 | 19,500 € | 19,500 € |
| | White screen (9m x 5m) | 1 | 8,790 € | 8,790 € |
| | | | **TOTAL** | **216,800.86** |

## Bulding plans

### Current construction plans (autocad)

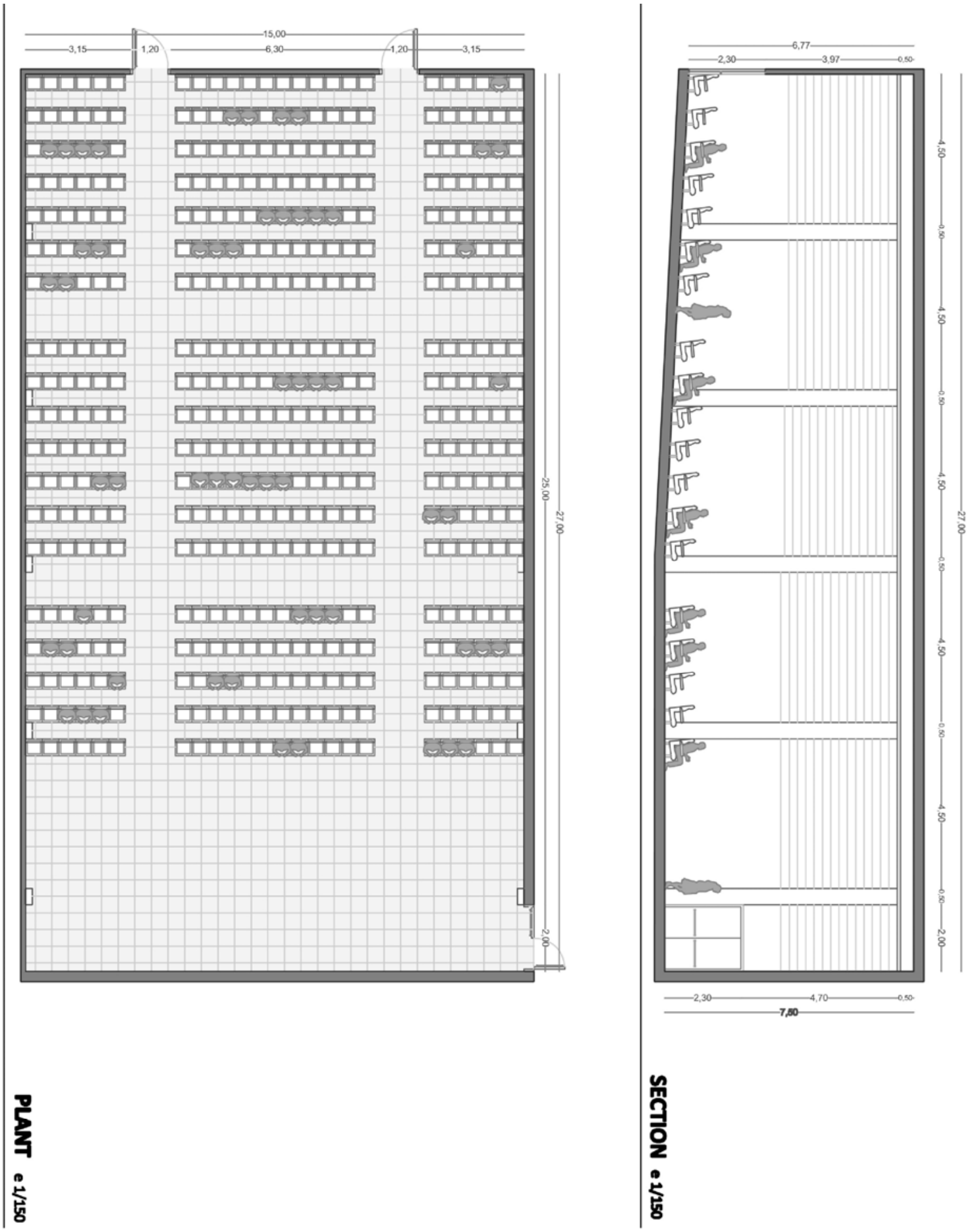



**Figure 20**

## Reformed construction Plans (CARA)

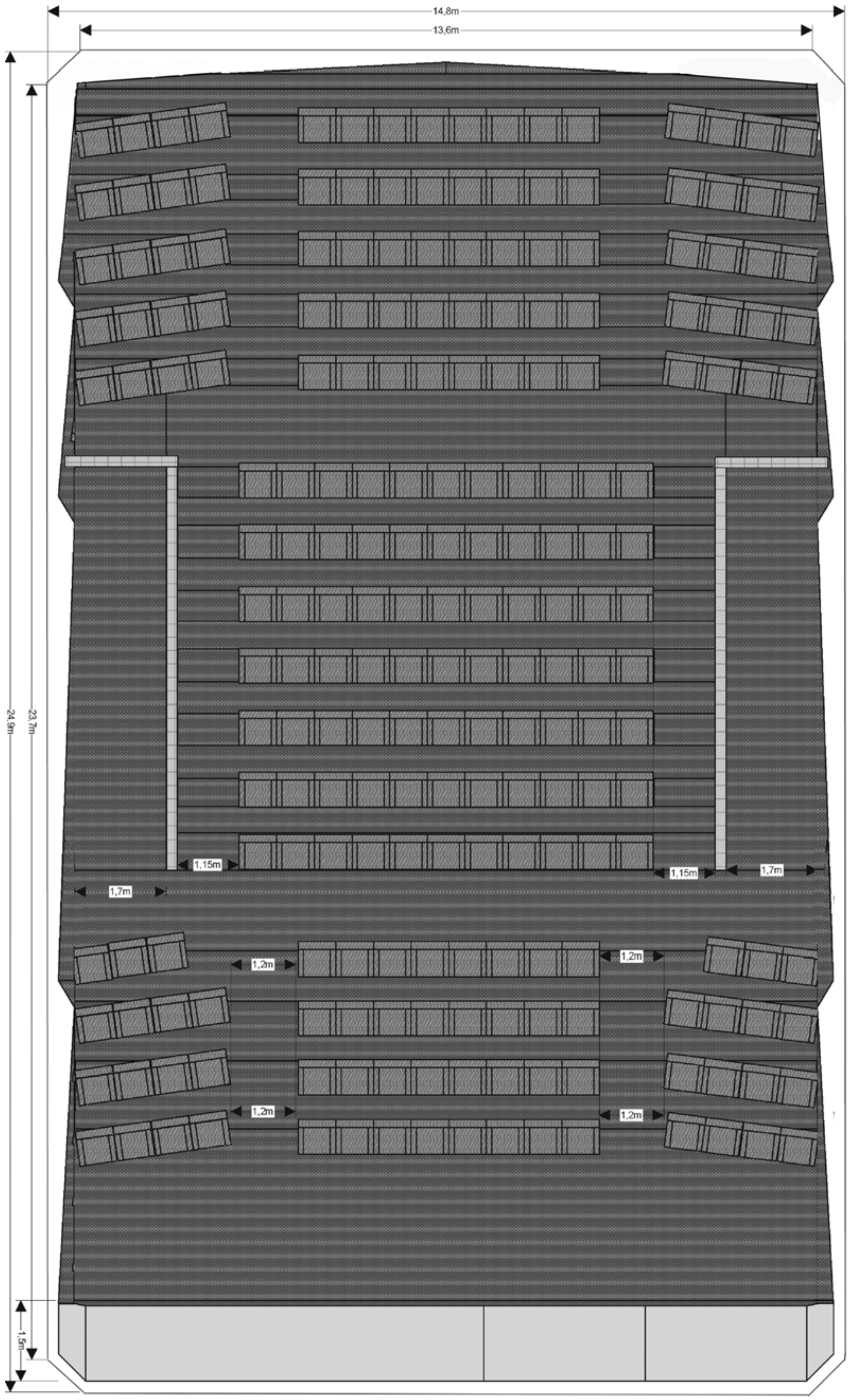
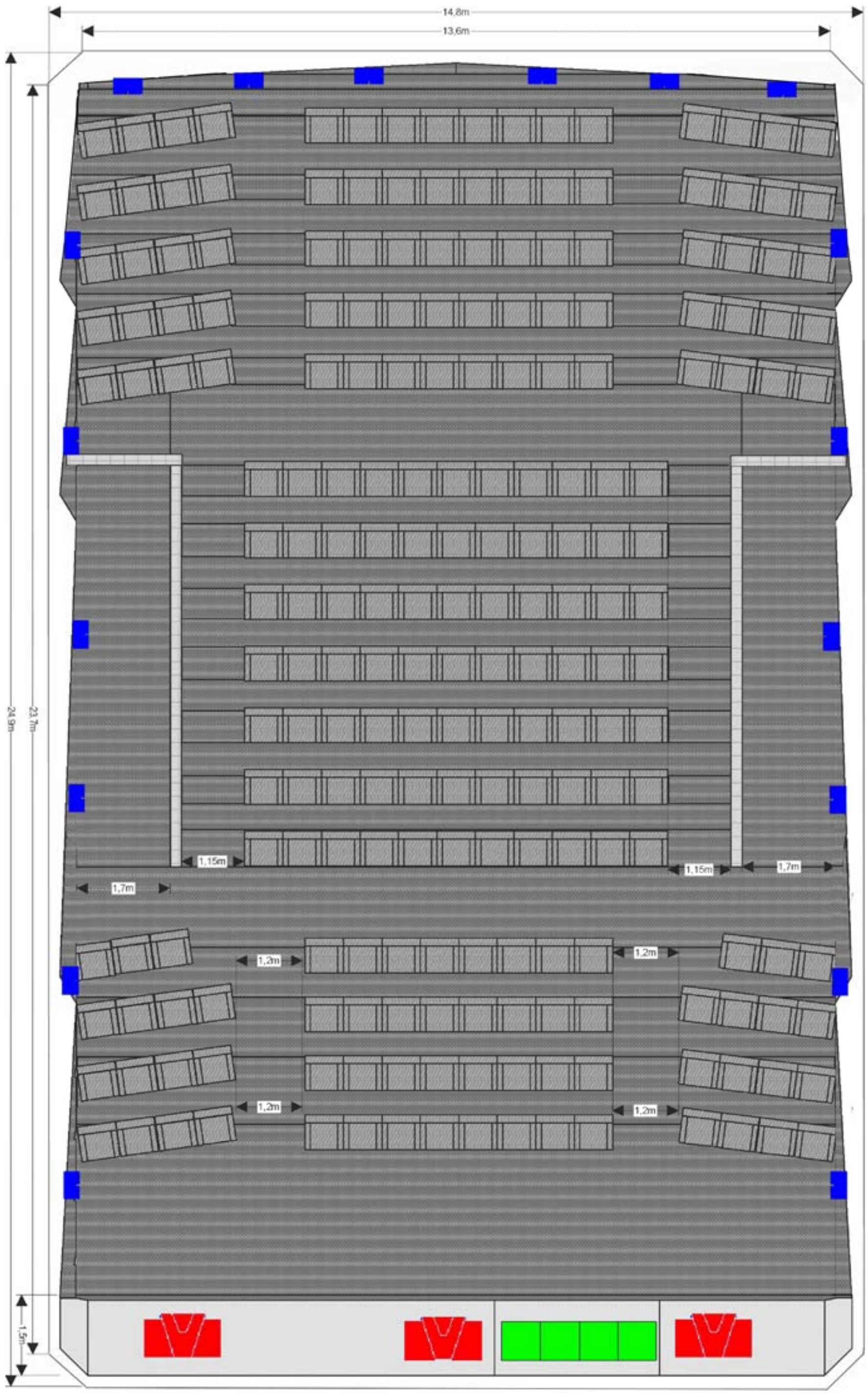



**Figure 21**

## Speakers placement plan




| | |
|---|---|
| (red) | Left, Center, Right Speakers: S-7802 (K.C.S.) |
| (green) | Subwoofers: C-218-A (K.C.S.) |
| (blue) | LS and RS, Backside-L and Backside-R speakers: SR-12 (K.C.S.) |

**Figure 22**

# <u>Specifications</u>

## Audio equipment specification and characteristics sheets

- Dolby CP650 Digital cinema processor
- QSC ISA 1350 Amplifiers
- K.C.S Frequency divider (crossover)
- K.C.S. S-8500 (Three-way screen channel system)
- K.C.S. C-218-A (Screen channel subwoofer system)
- K.C.S. S-8500 (Sorround channel system)

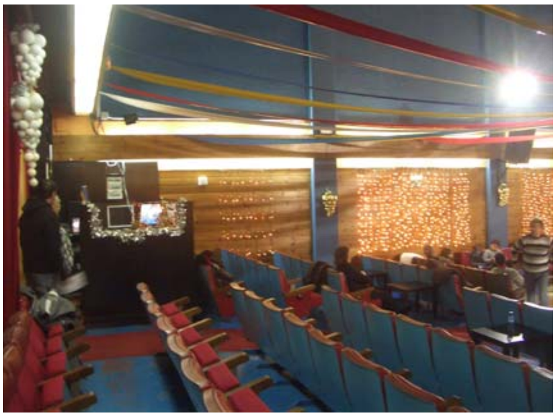
## Projection equipment specification and characteristics sheets:

- Cinemeccanica VICTORIA 5B/5000 35 mm Projector
- Sony SRXR220 Digital Cinema Projector
- Dolby Screen Server SS200

# Appendix

## Appendix I: Current room pictures

**Appen. Figure 1 -** Current room



**Appen. Figure 2 -** Seats of the current room

**Appen. Figure 3 -** View of the current room from the projection control room

**Appen. Figure 4 -** Current room ceiling

**Appen. Figure 5 -** Current room projectors

**Appen. Figure 6 -** Currrent projector lamp

## Appendix II: CD content

In the appendix CD there are four different folders containing the following material:

- **3D simulation videos:** In this folder there are the two 3D video simulations obtained from the CARA software, there is one video capture inside of the current cinema theater and another video capture of the reformed cinema theater.
- **Memory of the project:** It contains the project memory in a .PDF format. And the project abstract summary, also as a .PDF file.
- **Documentation:** It contains all the documentation which has been consulted to make the project and the memory.
- **Used software:** In this folder there are the installations files of the software that has been used to make the project (CARA software).

# Bibliography

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