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The noises of the Textile Industry: Sound of space and creation of hexagonal sonic enclosure for museum rooms

FERHAT DURAL

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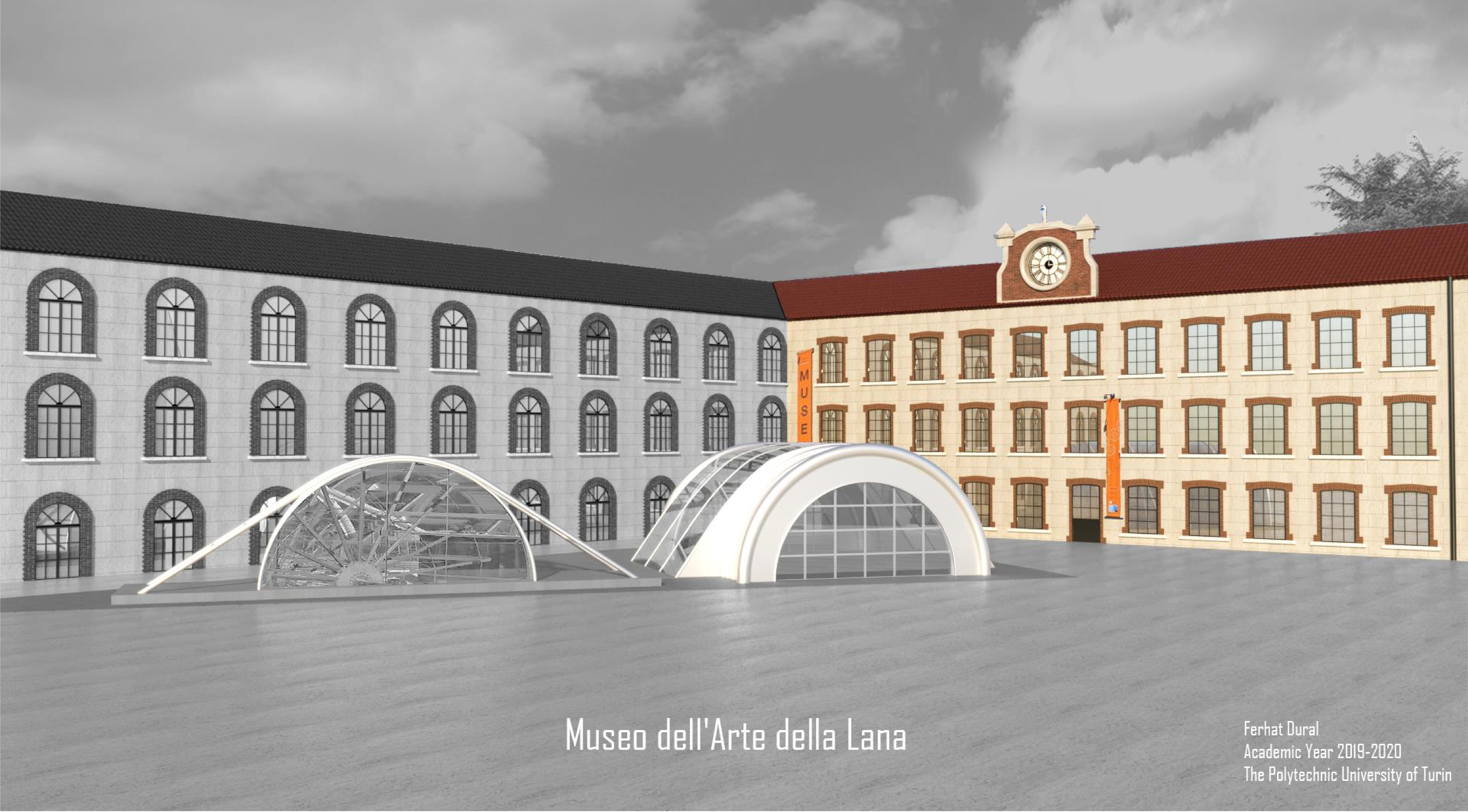
Reviewed and approved* by the following:

Thesis Supervisor

Prof. Marco Carlo Masoero
Prof. Carlo Deregıbus
Prof.Emma Angelini
Prof.Louena Shtrepı

The Polytechnic Unıversty of Turin

* Signatures are on file in the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1.0 ABSTRACT

How does our perception of sound affect our perception of space? How does our auditory experience affect our spatial experience?
Hearing is an integral aspect of spatial perception, arguably even more important than sight. Sound is immersive and perceptible to everyone.Unfortunately, sound is often overlooked or ignored during the design process. The immersive aspect of the sound was the driving force of most of the thought that underpins the thesis. The work of artists and architects, both humans and works, find themselves side by side, sometimes strange, sometimes pleasant, but never unpredictable.
This thesis places sound at the center of architectural research and enhances the use of electroacoustic techniques to create intangible sonic enclosures that block sound in a harsh environment while allowing light and matter to penetrate unimpeded.Sound is being explored as a material for building interconnected areas without physical boundaries.

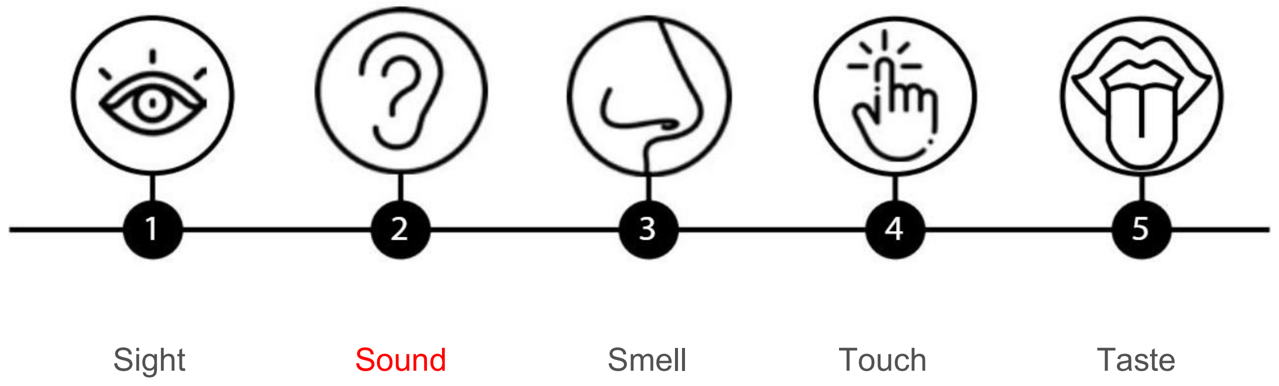
2.0 THESIS STATEMENT

Thesis title — **The noises of the Textile Industry: Sound of space and creation of hexagonal sonic enclosure for museum rooms**

Statement — While most of the functions of architecture not the material but the social ones can be fulfilled by sound, and sound as a supplement or complement to conventional architecture, sound has a great potential yet to be discovered partially. Sound offers the possibility of an architecture that can produce and outperform interactions and activities in contemporary urban conditions.

Perception and senses for architecture

For architecture, the experience of the senses is an integral part, and these experiences make the space more than the meaning of "housing". Due to the presence of perception, space has a greater importance. In architectural design, although there is no specific theory of awareness architecture, there are many architectural typologies that successfully implement the design using the five senses. These buildings enable people to gain awareness through sensory experience.



The awareness experience focuses on how people experience the space. In this way, it simulates the impact of awareness, thus helping people actively join the building to experience the meaning of being. Experience supports everyone's opportunity to learn, explores the world and experiences joy, miracles and social relationships (Lupton, 2019)

By guiding the five senses, the frame can come alive so that people can keep their enthusiasm for something.

‘’Architecture is essentially an extension of nature into the man-made realm, providing the ground for perception and the horizon to experience and understand the world. It is not an isolated and self-sufficient artifact. It directs our attention and existential experience to wider horizons.’’ (Pallasmaa 2005,p.41)

Sense	sight	hearing	smell	touch	taste
Percentage share	83%	11%	3.5%	1.5%	1%

Table**:**Comparison of the perception of the environment by individual human senses

(Skaza,Maciej,2019,p.3)

Although the above table shows overwhelming superiority of sight over the other senses, they should not be ignored. As one can notice: “it is surprising how strange coffee can taste when we drink it convinced that it is tea. One needs to see a lot more than what our eyes encounter. One should hear and feel a lot more than the receptors of our nervous system register. The beginning of creativity is the intelligence of perception”
(Sensation and Perception, 2002, p.11)

Architectural experience is the concept between mind, body and built environment.The body can feel the warmth, texture, smell and sound of the environment. The inclusion of the whole body allows the inclusion of all senses, not just the sense of sight.

Architecture and sight

The relationship between seeing and architecture (in relation to other visual arts) is obvious and architecture is considered a visual phenomenon.The buildings are designed to satisfy the eyes. When architects design visual environments regardless of their functionality, multiple sensibilities and user friendliness, they result in distorted areas with no mental or physical accessibility.

According to Maurice Merlau-Ponty, who is one of the important names in phenomenology, Eyesight is an embodied vision and an embodied part of the fabric of world.
Pallasmaa states that the sight separates us from the world, while the rest of the senses joins him (Pallasmaa 2005,p 25)

This sense has something in common with other senses.
“The eye takes its effects by watching the image. Elements with similar or repeated distances are known by the eyes as rhythms or rhythms similar to receiving the sound from the ear with music; Architecture is cold music. " (Neufert 2010, p 31)

As a result, architectural design is to please the sense of sight. This should not mean that architects only focus on beautiful pictures of their designs, but some are not balanced in terms of flashy possibilities. Shadows and darkness are necessary for the sense of vision to determine depth and distance.

Smell

Scent is necessary to capture the memory of the space. The nose reminds eyes. For blind people, the sense of smell can help to be aware of one's position. The fragrance may also be related to hunger and a desire to consume. If it is a new fragrance, it is possible to remember and then redefine the fragrance. Spatial qualities are related, as it is not possible to name all odors.

Peter Zumthor explains the sense of smell in a building in his book "Thinking Architecture":
“... (in the kitchen) Small hexagonal tiles of the floor, dark red and fitted so tightly together that the cracks between them were almost imperceptible, were hard and unyielding ,and a smell of oil paint issued from the kitchen cupboard”
(Zumthor 1999,p.7)

Pallasma says, “A particular smell makes us unknowingly re-enter a space completely forgotten by the retinal memory; the nostrils awaken a forgotten image,and we are enticed to enter a vivid daydream. The nose makes the eyes remember.”
(Pallasmaa 2005, p.54)

A special smell can identify places with specific intensity. A material can also reveal odors that can help blind people define what the material is. For example, timber, varnish, wax, polish has a recognizable odor.By changing these surfaces, it will be an interesting experience for blind people when defining various odors.
Smell is the sensation most associated with reminiscence, and each of the invisible works of art is aimed at evoking memories and influencing visitors' thinking patterns.

Touch

Since tactility emphasizes the lack of language to define visual sense and touch, it is not usually combined in design.It is difficult to draw the temperature of a room or photograph the raw feel of a wall. However, tactility plays a crucial role in the experience of a space and should therefore be considered in the design process. The sense of touch has the ability to save us from the digital world, tell time and age, and ground our environment.

According to Zumthor "(…) While the tactile space separates the observer from the objects, the visual space separates the objects from each other (…) the perceptual world is guided by the touch, being more immediate and welcoming than the world guided by sight"
(Zumthor 1999,p.57)

Tactility can reveal the history and structure of the material and play an important role in the sensory perception of a space.

"A pebble polished with waves is pleasant not only because of its shape, but also because it expresses the slow process of its formation; The palm realizes a perfect gravel time, time turns into shape. " (Pallasmaa 2005,p 25)

While tactile sense includes affection, intimacy and closeness, the distance sense organ is the eye. The sense of sight feels and approaches the tactile sense while observing and researching. The tactile sense gives us information about weight, texture, temperature and density.

Taste

Although the human tongue can only distinguish 7-8 different types of flavors, the nose can distinguish hundreds of ingredients, even in small quantities. The fragrance increases the sense of taste. This rule also applies to taste in architecture.
It is clear that architecture has not had any real taste since the ferry tale of Hansel and Gretel. And it can still stimulate the sense of architectural taste.

Seeing turns into taste. A building should act like a fine tuned vehicle that interacts with the senses of the passenger at the right moments.

"Some colors and delicate details create an oral feel. A fine, polished stone surface is perceived by the tongue as subconscious."
(Pallasmaa 2005,p.69)

" The sensuous materials and skilfully crafted details of Carlo Scarpa's architecture as well as the sensuous colours of Luis Barragan's houses frequently evoke oral experiences. Deliciously coloured surfaces of stucco lustro, a highly polished colour or wood surfaces also present themselves to the appreciation of the tongue."
(Pallasmaa 2005, p.39)

In other words, the taste of architecture does not mean kneeling and trying to eat stone bricks, but it means that architecture can only make mouth water by seeing attractive materials.

Area of Focus Summary

Sound n.

1. Sound is vibration in air and water that stimulate the nerves inside the ears to create the sensation of hearing.

2. Mechanical vibrations transmitted through an elastic medium, traveling in air at a speed of approximately 1087 feet (331 meters) per second at sea level.

3.In geography, a sound is a large sea or ocean inlet, deeper than a bight and wider than a fjord; or a narrow sea or ocean channel between two bodies of land.

4. Auditory effect caused by a specific reason: the sound of the music.

5.Noise, vocal expression, tone of music or the like: sounds from the next room.

6. The sensation perceived by the sense of hearing.

7. Transmitted vibrations of any frequency.

8. Meaningless noise

After harmonizing the interests of this thesis with the Sensation & Perception system of inquiry, it would be useful to further define such studies in a more focused research area. Here, we will focus on the sonic nature of the environment in which we focus. Although the visual experience of architecture is arguably dominated by all sensual interactions, the audio experience offers some particularly rich qualities that can inform such an initiative.

First, the sound is spatial by nature and therefore characteristically depends on our architectural interests. Sound moves from its source in all directions and is completely affected by the size, shape and material composition of its surroundings.This relationship between sound and container is so intrinsic to our sonic perception that it is almost identical.

“Listen! Interiors are like large instruments, collecting sound, amplifying it, transmitting it elsewhere.”
(Zumthor 2006,p.7)

Second, the sonic environment is the most natural interactive perceptual quality of the architecture.Despite the dominant role of visual perception,it remains a uni-directional process Light is produced from a external source, travels across an architectural form,and is consumed by the eye.This intense engagement is so often ignored in our built forms that we predominantly fail to even take notice of the relationship between sound and space within our daily move - ments.

"…[the] interconnection between humans and space is a dialogue that enables us to experience ourselves in the sound of the room."
(Martin 1996,p.27)

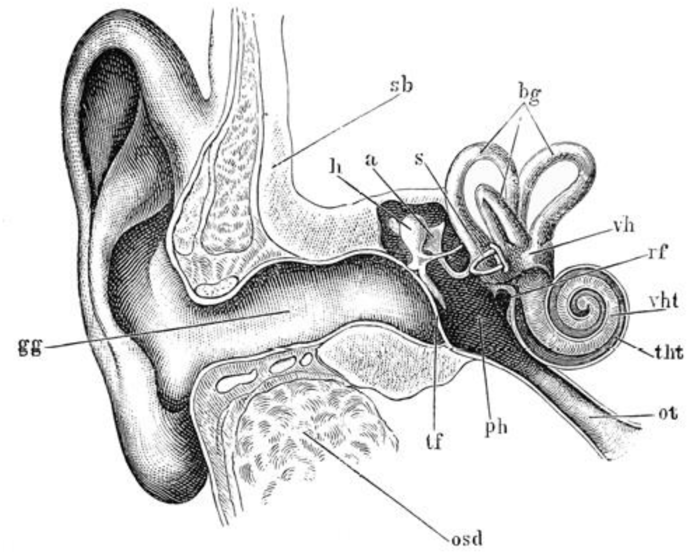
The sounds in architecture increase the perception intensity.A building usually works for sound absorption, sound insulation, and reduction, but areas prepared for acoustics act as an instrument and lead to a very sensory experience.These different sounds can be developed when there are volume, form and material differences in a volume, providing sound absorption and reverberation times.The sound of a building is the result of volume and form, surface material and applications.

Juhani Pallasmaa who has argued that the power of sound as an illumination of architecture it demands a revision of the quality and importance of hearing in design.

"The sense of sight implies exteriority, but sound creates an experience of interiority. I regard an object, but sound approaches me; the eye reaches, but the ear receives. Buildings do not react to our gaze, but they do return sounds back to our ears." (Pallasmaa 2005, p. 49)

The role of sound in spatial perception is really powerful, it may not always be obvious, but the sonic environment has a serious impact on human well-being. This is partly because the human brain is wired to navigate the auditory landscape.

The ear has three times more nerve connections to the brain than that of the eye, and it can decipher a range of sounds from 20 Hz to 20,000 Hz. The brain is filtered through a continuous world of sound order to give the conscious mind an accurate understanding of its environment. (Eberhard 2008,p.197)
In fact, if removed from the sonic landscape (as in an anechoic chamber), the brain struggles to adapt to the missing sensory input.



"Ear in a vertical position, gg: The ear canal; tf: Tympanic Membrane; ph: Tympanic Cavity;
h: Malleus; a: Incus; s: Stapes; bg: Semi-circular Canals; vh: Organ of Corti; tht: Vestibules; vht: Cochlea;
ot: Eustachian Tube; osd: Temporal bone; sb: Mastoid bone; rf: Round Window."
(Fowler 2017,p.24)

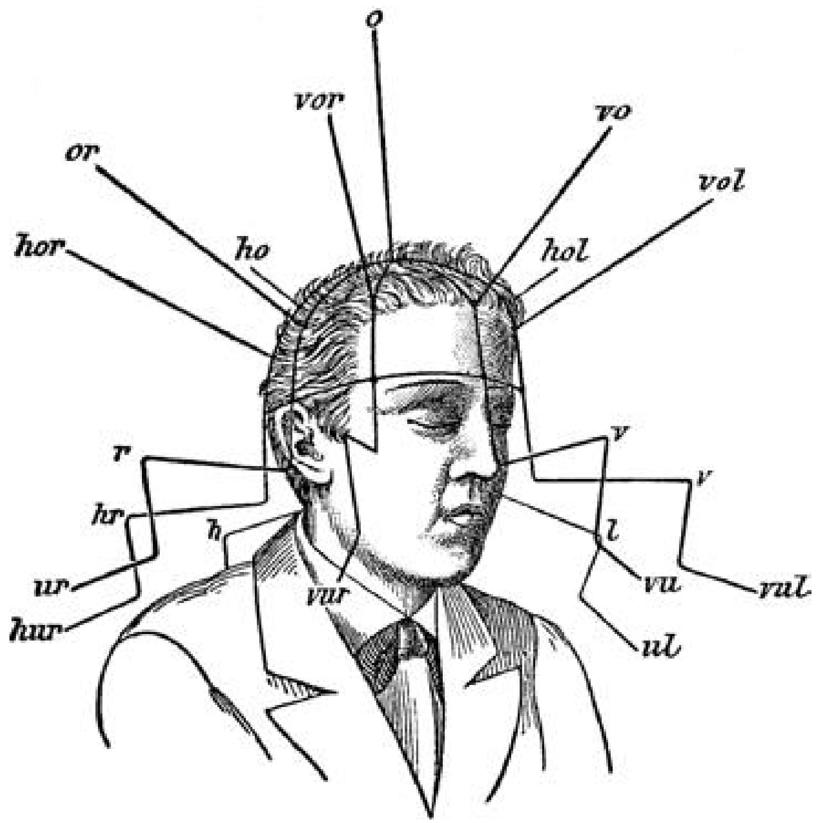
The ear becomes hyper-sensitive, low body sounds like blood circulation and lung movement become audible, and mental well-being begins to decrease within a few minutes.

The sonic quality of the built environment affects not only the research of such a thesis proposal, but also our daily life.Weak acoustics in the classrooms have been associated with a 50% reduction in vocal clarity from teacher to student. Many hospitals combat internal noise levels that prohibit healthy rest due to medical machine noise. The urban sound environment has become a disaster zone of auditory aesthetics. (Treasure, 2012)

Although it is based on theory and experiments, the results of this body of thought reach the structured environment of our daily experiences.

According to Ponty,
[…] To listen is to be straining toward a possible meaning, and consequently one that is not immediately accessible. (Ponty 2007, p.6)

However, the main way of how we perceive the auditory dimensions of the architectural space is the sum of the vibrations, each of which approaches the ear in slightly different time distributions, as a neurological calculation from the auditory channel. According to William T. Preyer's 1886 study, it comes from twenty-six noticeable aspects.



Preyer's twenty-six detectable diagram sound directions

(Fowler 2017,p.44)

Perception and the place

As place is sensed, senses are placed;
as places make sense, senses make place. (Feld 1996,91)

In addition to being an epistemological structure related to the place of knowledge, meaning and experience, space is seen as an ontological concept with close relationships with human subjectivity.The understanding of place by a certain philosophical tradition is inherently connected to how that philosophy explains the condition of being. In turn, the condition of being is determined by the state of being in or situated in a place. While subjectivity informs the perception of place, place acts as a conditional, formation agent for the emergence of subjectivity. To understand how a philosophical tradition predicts subjective experience, one can look at how the place is construed within that framework of thought.

Contemporary phenomenology, for example, describes the feeling of being embedded and molded in place, to the extent that the two are virtually inseparable from each other. For example, in The Poetics of Space, the French philosopher Gaston Bachelard offers a close examination of the domestic place, one’s childhood home.

Considering the home as a special shelter, a “cocoon” grown in the subconscious.
(Bachelard 1994,p.,13)
Bachelard’s psychoanalytic observations on domestic space can also translate to place and its experience in general. The places that we live in, our house, street, neighborhood, city, are also the places we deeply identify with. According to this view, functions act as an ontological starting point, a deep-seated anchor securing one’s sense of self, in other words the“psyche.”

Another philosopher of place Jeff Malpas says: “Place is not based on subjectivity, but is rather that on which subjectivity is founded. Therefore, there is no subject that comprehends certain features of the world in terms of the idea of place; instead, the structure of subjectivity is given in and through the structure of place”
(Malpas 1999, p.35).

As a result facilities of the mind get to be separated from and valued above the flesh of the human body. It is presumed that the perceiving subject is prone to error unless the information obtained through the senses is constantly scrutinized, the mind is rationally analyzed and verified, the mind is brought to mind by subtracting a scientific thought process.

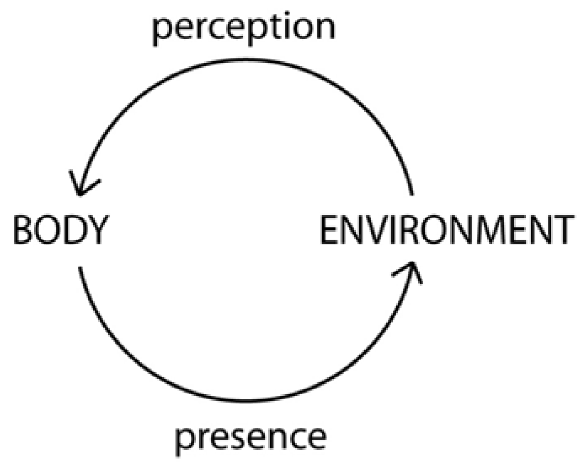
One of the ways to define the perception of the place is a feature related to the environment. The Romans believed that the places had natural spiritual properties that gave them a special feeling and personality. These were linked to physical, topological, architectural, and metaphysical attributes of a particular location. This was called "the soul of the place" (Norberg-Schulz, 2000)

The sense of place is then a human experience, shaped by the "spiritual" qualities of a physical space provided by its core nature, and supported by architecture and human activities as the manifestation of the dwelling.

The place acquires the soul as the space that creates this being, so it is different from the space that is uniform and depicted without human existence.Another issue to consider is the necessity of mobility and intentionality for the experience of the sense of place.
According to the phenomenological approach to human perception, movement is considered necessary for sensory experience to occur.

Sensory modalities function as frameworks of interaction between human beings and the environment. Place perception is intersubjective. One perceives place in a similar fashion to others perceiving the same place. And as one perceives place, he or she is also perceived in place. The sensory perception area is the human body; therefore, it must first be in the environment in order to perceive.
Perception and presence operate in opposite directions to each other, making place experience a complete circle between the body and the social and physical environment. Senses operate in each direction as conduits between the two.

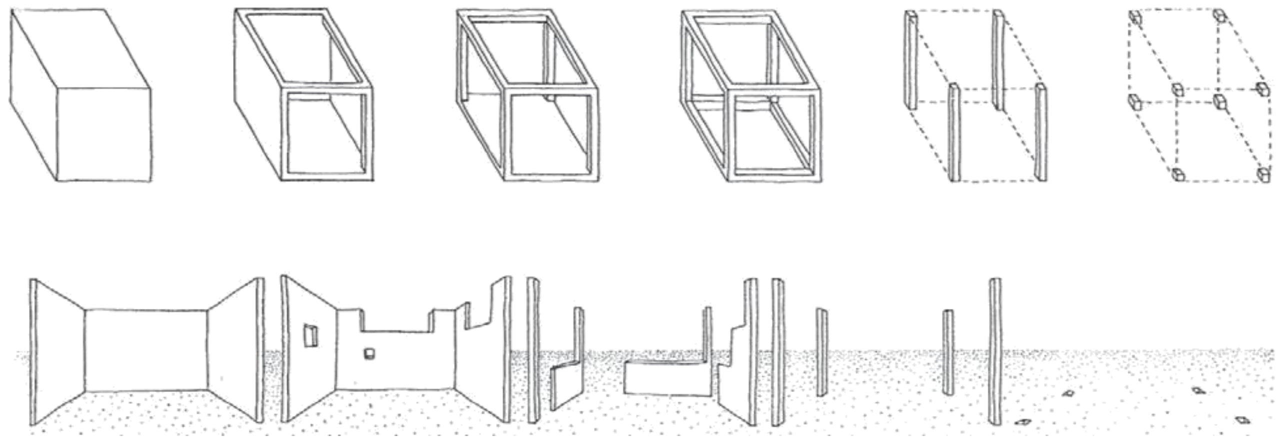
According to Merleau Ponty, every perceiving subject possesses a “body schema” (Merleau-Ponty 2002,p.113)
Indeed according to the phenomenological view, it is argued that perception is impossible without embodied intentionality.The body schema also serves as the most important point of reference in describing one’s relationship to place.



Body, environment (physical+social), perception and presence

Sensory modalities function as frameworks of interaction between human beings and the environment. They also form the channels of communication through which human beings interact with each other. Each sensory modality simultaneously operates in active or passive dimensions.

Sensory methods function as phenomenological and social channels between body and environmental-social context. The two-way channel theory of sensory interaction requires that the "sense of place" be reorganized to accept not only the perception of the environment but also its presence within it.



From explicit to implicit space defined by various spatial cues

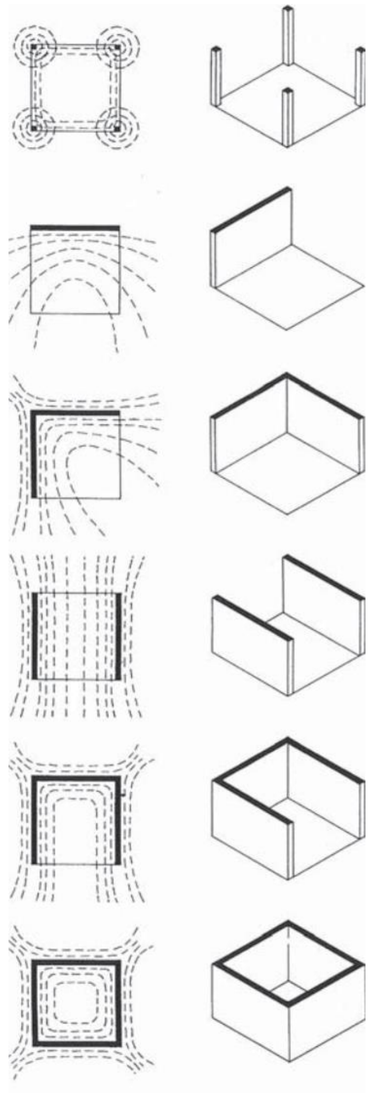
The existence of place is held to be obvious from the fact of mutual replacement. Where water now is, there in turn, when the water has gone out as from a vessel, air is present. When therefore another body occupies this same place, the place is thought to be different from all the bodies which come to be in it and replace one another. What now contains air formerly contained water, so that clearly the place or space into which and out of which they passed was something different from both.
(Aristotle,1991,p.208b1-208b8)

Aristotle describes the area as an empty container. The architectural statement is based on designing this hollow container space. The utility of the architecture allows the creation of space defined by walls and partitions (not limited).

While ensuring the cube's dematerialization, it still preserves the clues that strategically identify the cubes. He senses these clues, consciously or unconsciously, as perceptual beings, based on the sensory stimulation of vision, touch and sound. This allows the space to communicate with implicit or open roads.When boundaries are discussed with auditory spatial perception, this situation can also be defined by sound.

Along with the phenomenological understanding of the space, sound walls that clearly define the space can be built. Spaces have a basic condition to provide a variety of closeness depending on the function of the room.This proximity can be achieved by blocking various stimuli used to detect the wall area.

The wall creates spatial boundaries, the dematerialization of the walls to permeable thresholds (sonic walls) can reach a state of restraint in which the expression of different characteristics and space can occur. Define the spatial properties of layering, thawing, blurring and uncertainty that transforms the user experience as the walls move.



Different spatial areas in the same square plan with changing vertical elements

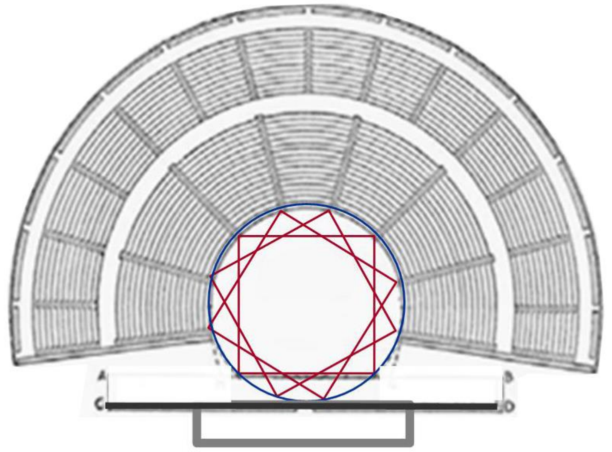
Historical sensory projects

Ancient Greek and Roman Theatres

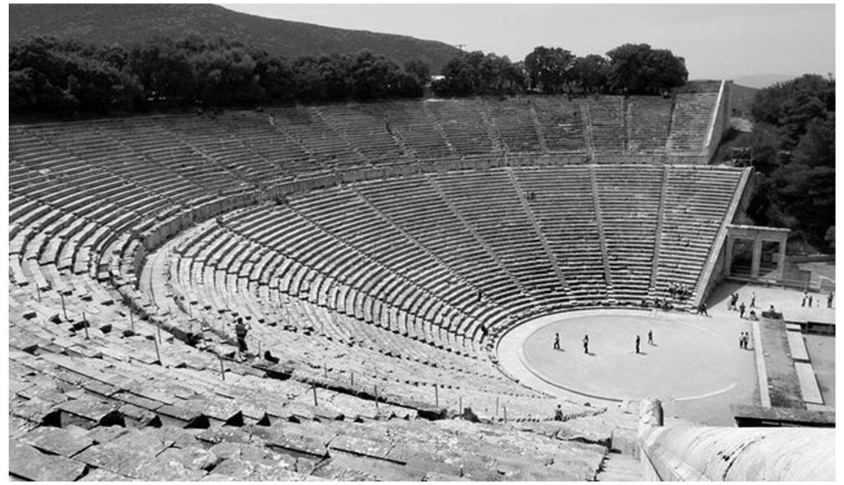
Ancient Greek and Roman theaters are the first examples of trying to apply the acoustic intention to architecture. The reason why Greek theaters had semi-circular or semi-elliptical forms with raking seating was that the actors were placed closer to the stage and the stage so that the movement and dialogue of the actors were clearly visible and heard. A theater arrangement is typically a natural covering of the ground, where the hillside would permit natural raking of seating rows.

On the other hand, the Romans took an ambitious approach and a building behind the stage to sit more upright on the wall instead of a slope. This type of design was useful for sound reflections from the scene that could produce audible sound. Such reflections had only a short delay time when compared to the direct sound when heard in the auditorium, and therefore helped rather than preventing speech articulation. Then, with the development of the elliptical amphitheater, a magnificent perspective to the arena can be appreciated.
(Lord,Templeton,1986, p.7)

The Greeks used certain materials and sound physics to ensure that the sensors in the amphitheater can hear even a whisper from the lower level of the skene, regardless of where they sit.(Bomgardner,2000, p.28)



Classical Greek Amphitheatric
Circa 450 BC



Ancient Greek Theatre,Epidaurus,Greece

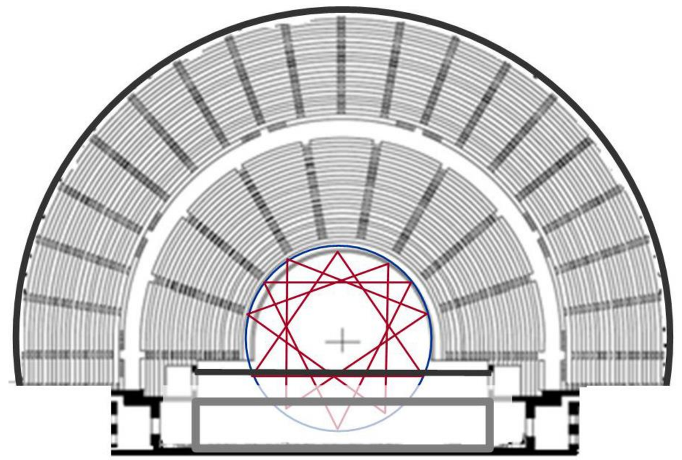
https://acoustics.org/the-origins-of-building-acoustics-for-theatre-and-music-performances-john-mourjopoulos/

The ancient Greeks and Romans were not concerned with the conservation of their amphitheatres, but with the acoustics produced in the space.The structure was used not for the resonance and reverberation of the sound and the iconic representation of the built environment, but for the perception of the receiver. (Chase,2002 p.25)

The acoustic qualities included in the Epidaurus theater have not been used in other Greek amphitheatres. Materials and layout were also changed. Epidaurus is the only area built using limestone for the seats and with the slope of the rows.

“Now, researchers at the Georgia Institute of Technology have discovered that the limestone material of the seats provide a fi ltering effect, suppressing low frequencies of voices, thus minimizing background crowd noise. Further, the rows of limestone seats refl ect high-frequencies back towards the audience, enhancing the effect.” (Chao,2017)

The Greeks used the sense of audibility and did not rely solely on visual aspects in the construction of this area. Sound conveys sound through the elements of architecture and nature throughout the field, with emphasis on audibility..Sound is in this case the main producer of space, so the sound is allowed to settle from a spatial composition.



Roman-Semi Amphitheatric
Circa 100 BC

Ancient Roman Theatre, Aspendos,Turkey

https://acoustics.org/the-origins-of-building-acoustics-for-theatre-and-music-performances-john-mourjopoulos/
https://www.flickr.com/photos/fengwei888/36904866665

In the 17th century, speaking statues by Kircher were designed. These sculptures will carry sounds from a particular room using a resonance tube hidden on the walls of the building and place it in its mouth as a surprise statue among its audience.

Kircher analyzed the echo phenomenon and other effects of sound architecture, and ultimately planned the construction of a moving eye and mouth-speaking sculpture. It is connected to a spiral tube placed in a building that gives it to a public space. Acting as conductive, deforming and amplifying, the tube transforms the wind into breath, the sounds of the public sphere into human or animal sounds. Kirchner has begun to consider noise - its propagation and gain - possibly for the production of music and works, with sound being understood as an amplificable signal..

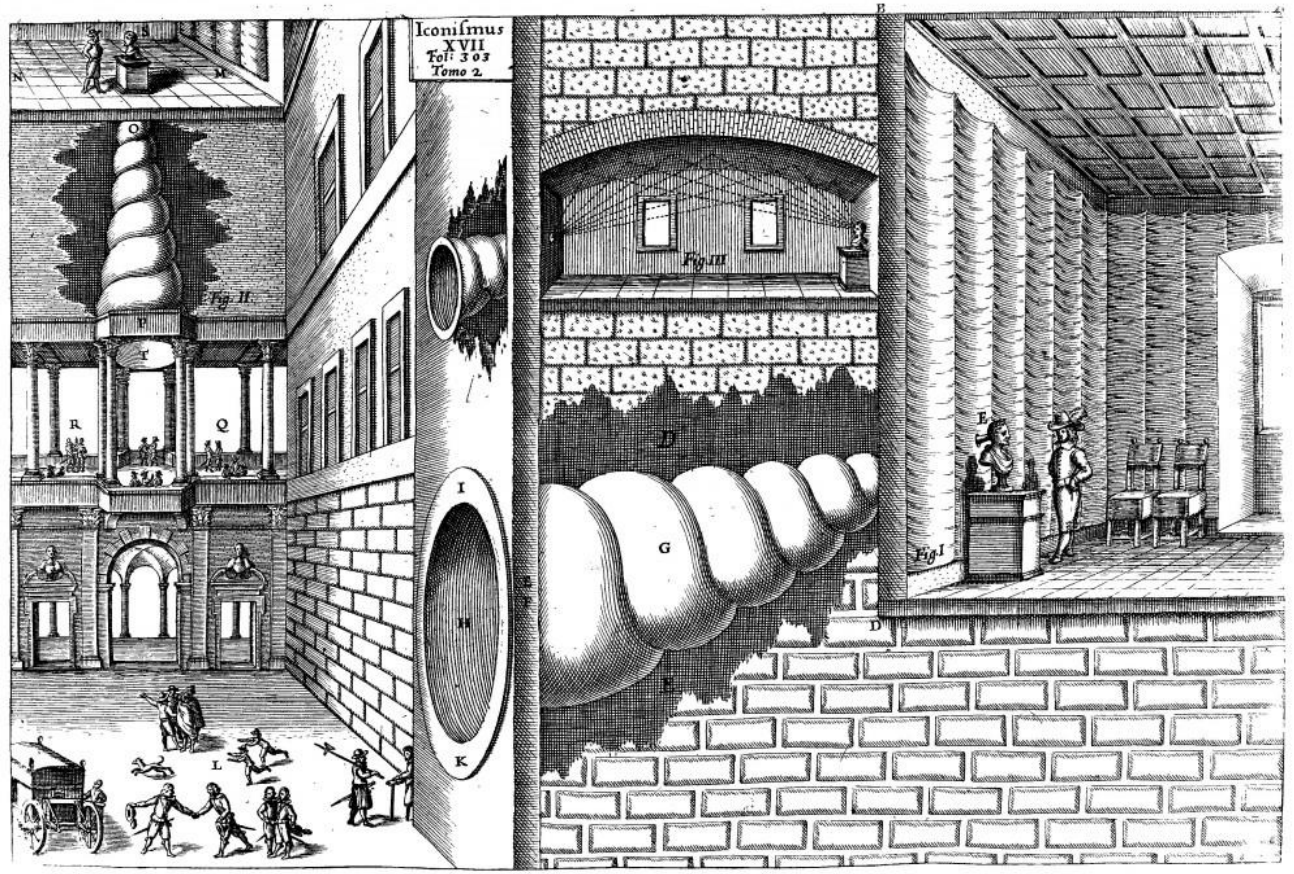
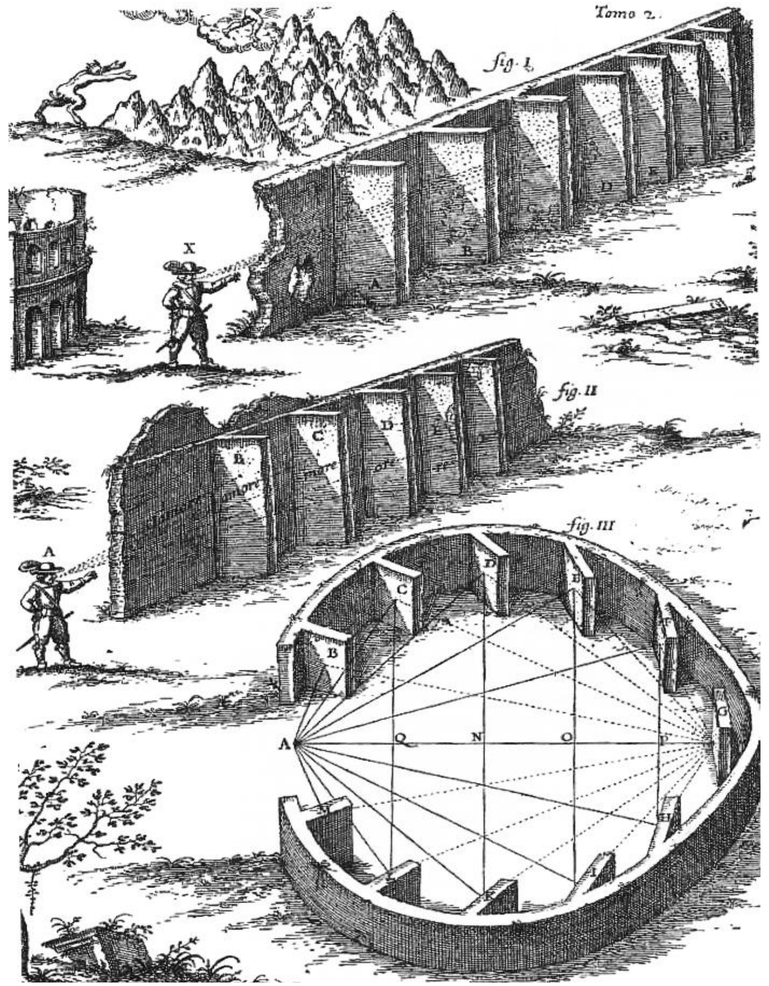


Illustration by Athanasius Kircher of the construction of a statue able to emit both articulated and inarticulated sounds.

https://web.stanford.edu/group/kircher/cgi-bin/site/?attachment_id=677.

Materiality and form are an important part of architecture and acoustics. Since Vitruvius' writings are discussed as a tool to formulate materiality and create spatial acoustics. At the Renaissance, Athanasius Kircher was one of the first to try sonic faculties of importance and form, as discussed in the "Phonurgia Nova" (Magical Place of Sound and Silence) debate in 1673.

One of Kitcher's interesting experiments is regarding the obiectum phonocampticum, which refers to all the objects where the sound or the voice could be reflected, not only from walls and buildings, but also including trees, rivers, and metallic surfaces. During the explanation of his Echosophia (the “science of echoes”), Kircher found that air movement causes sound propagation, and wind propagation can influence echo effects as well as weather conditions. This could beconsidered as one of the most relevant results Kircher achieved in the field of acoustics. (Tronchin,2009,p.12)

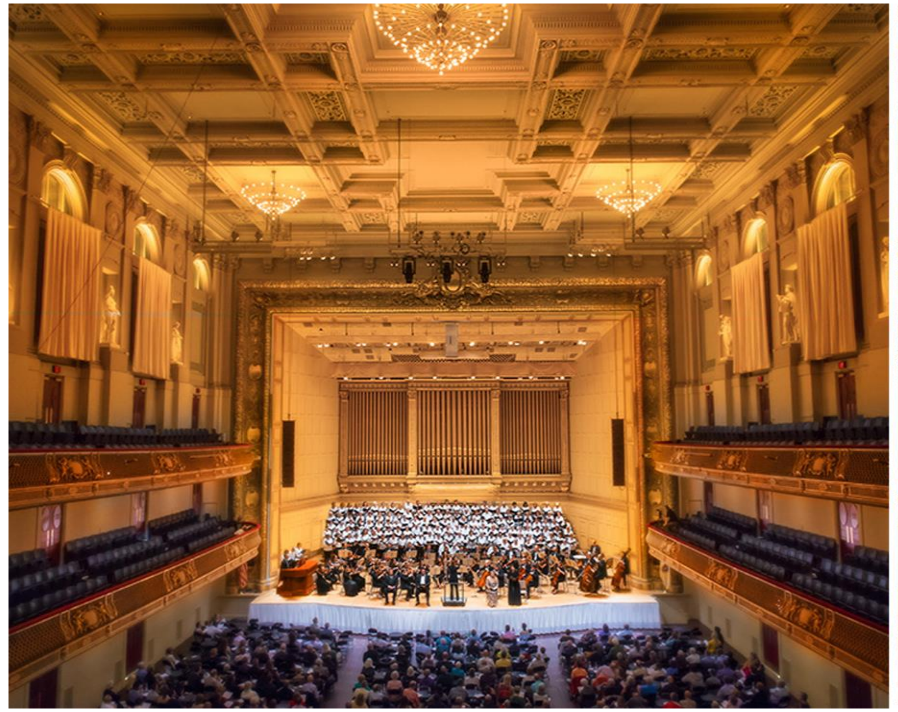


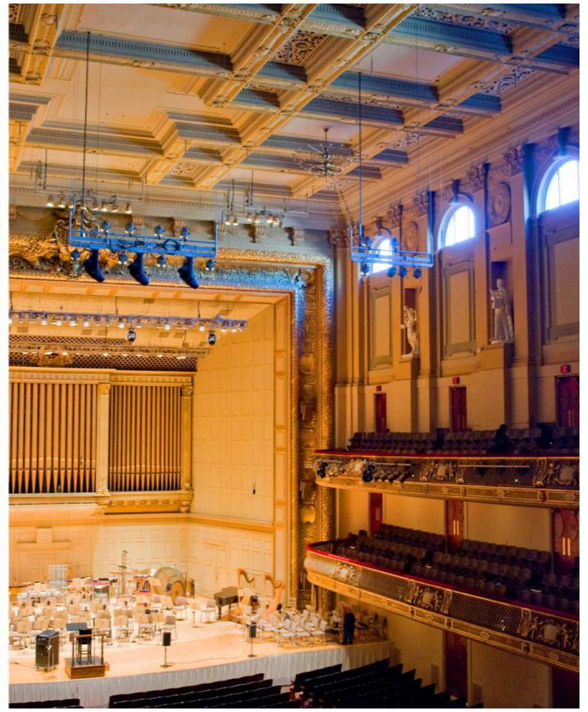
Experiments with echoes

(Tronchin,2009,p.13)

After that, as modern sciences proliferated, a scientific understanding of spatial acoustics reported by importance and form launched the designs of acoustic rooms calculated in 1890 to accommodate performance areas such as the Boston Symphony Hall designed by acoustic expert Wallace Sabine.The correct positioning of the materials allowed the desired spatial acoustic properties to emerge. Through the use of materials, full control of the sound is provided, as can be seen in an anechoic chamber design where the sound-absorbing material brings all sonic energy to complete silence.

Finally, an acoustically ideal stage was built for the orchestra. The walls, ceiling and floor of the stage bend inward to reflect the sound to the audience. Narrow side balconies prevent sound from jamming, while the pillars of the stage bend inward to properly orient the sound. The niches on the walls and the cassette on the ceiling provide a maximum aural sound experience for every seat in the room.





Boston Symphony Hall, 1890

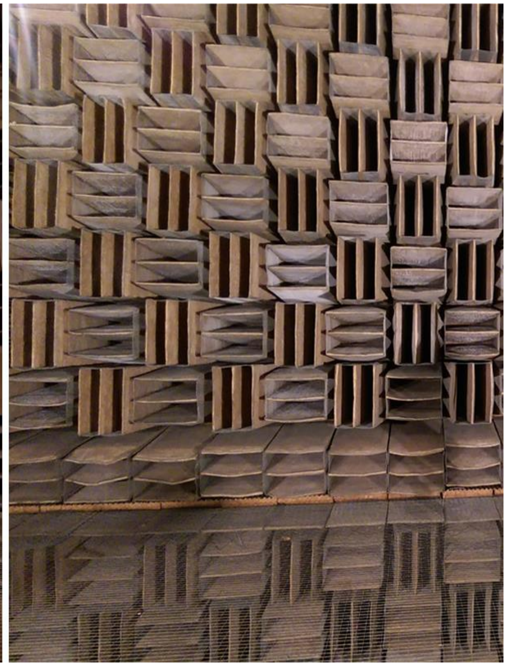
https://www.berkshirechoral.org/programs/boston

Through the use of materials, full control of the sound is provided, as can be seen in an anechoic chamber design where the sound-absorbing material brings all the sound energy to a complete silence state. The name "anechoic" literally means "without echo". Built in 1940, Murray Hill reverberant chamber is the oldest wedge-based reverberant chamber in the world.

This room may resemble a modern art installation, but the only purpose of this striking design is to actually block as much sound as possible. Built by Bell Laboratories in Murray Hill, New Jersey in 1940, this room was later considered the quietest room in the world.

The chamber absorbing over 99.995% of the incident acoustic energy above 200 Hz. Large fiberglass wedges were mounted on the walls absorbed sound reflections. Thick cement and brick walls surrounded the exterior, blocking out outside noises. The room floated above a sunken pit, resting on a shock absorbing wire grid to negate any external vibrations.
(Nova Newsletter, 2018)

The Murray Hill wedge design, the first of its kind, is still used today in anechoic chambers all over the world. The materials also absorb different amounts of sound at different frequencies. An anechoic chamber is a strange experience, both acoustically and visually, because the ceiling is made up of deep, absorbent wedges everywhere. Form and depth help capture energy that loses energy because it is not a reflective surface.



Anechoic Chamber in Murray Hill

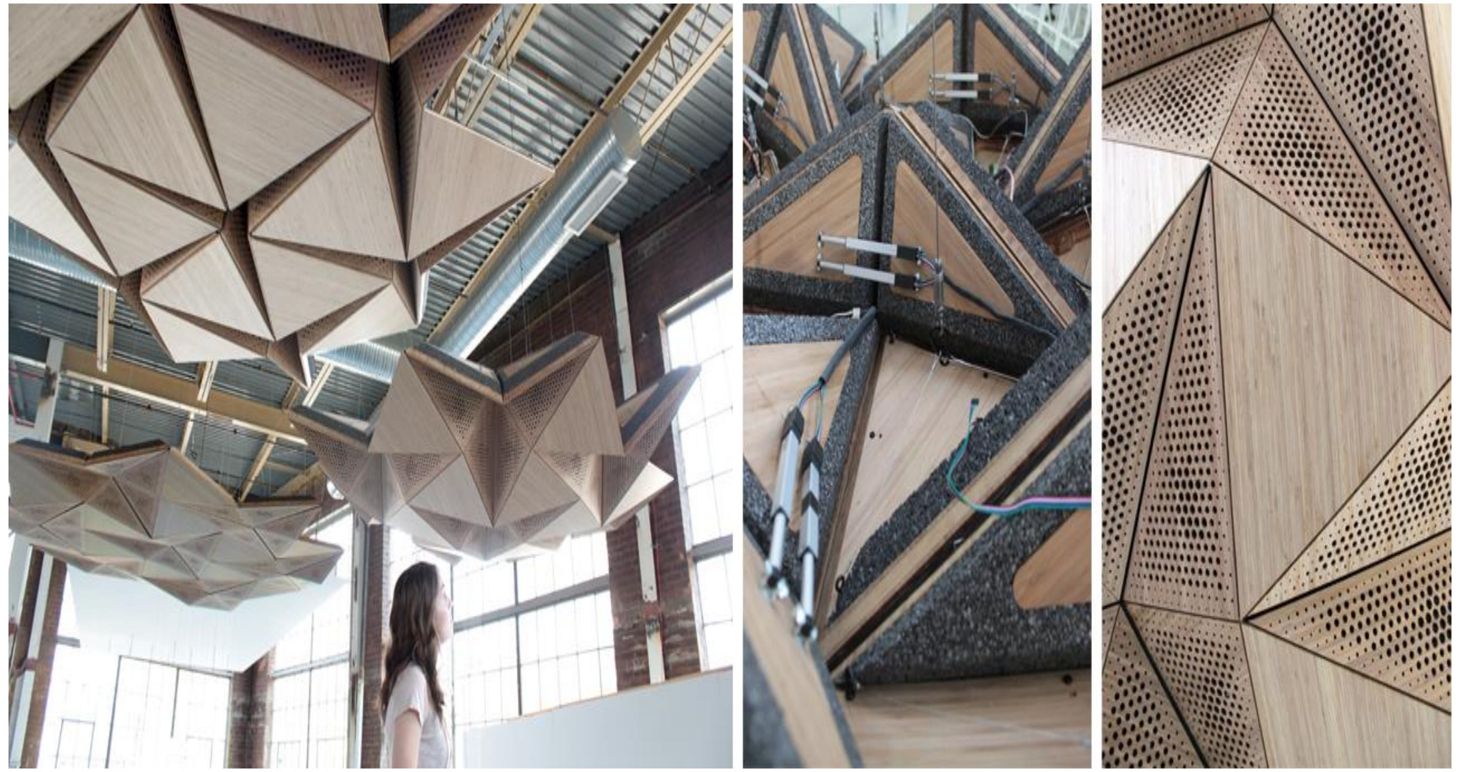
https://www.youtube.com/watch?v=wqCjE2WzhBk

The Resonant Chamber research project by Ann Arbor and the Toronto based design firm RVTR in 2011, is an inner envelope system that uses origami principles to transform acoustic environment through dynamic spatial, material and electro-acoustic technologies. The aim is to develop a sound field that can adjust its characteristics in response to changing sound conditions, change the sound of an area during performance, and create an instrument that is flexible enough to be played on an architectural scale.

As spatial properties and functions increase over time, interest in the acoustically sensitive application of materials and forms has developed.

Positioning of materials as a result of calculations allows the desired acoustic properties to emerge. With the use of these materials, full control of the sound has been achieved, as can be seen in an anechoic chamber design where the sound absorbing material brings all the sound energy to a complete silence state.

What is unique about this project is that both sound and shape can be changed dynamically. Layered pieces reveal and hide their shape by adjusting their faces and changing the sound conditions.



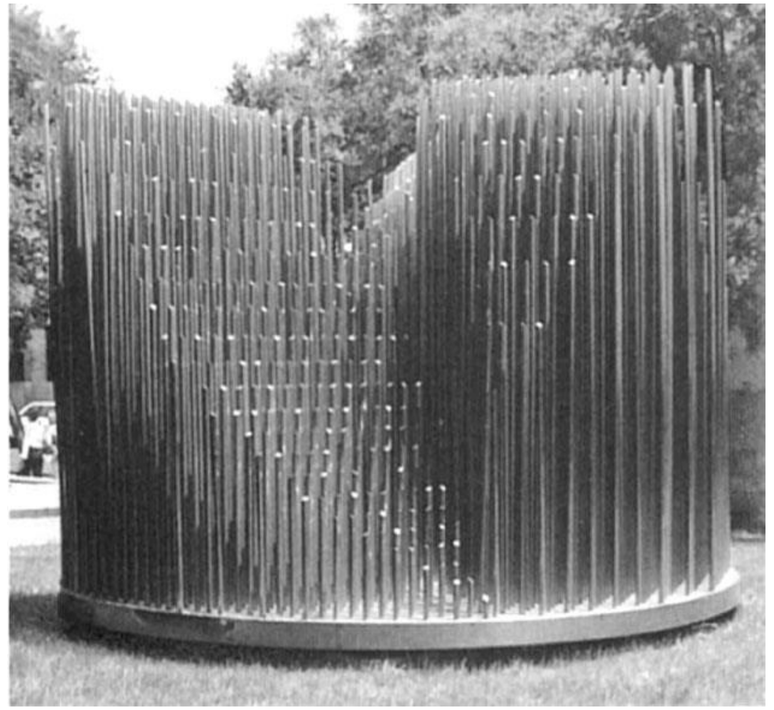
Resonant Chamber, RVTR, 2011 is responsive acoustic installation.
Popular Winner,2013 A+Awards,Architecture and Sound

https://architizer.com/idea/344993/

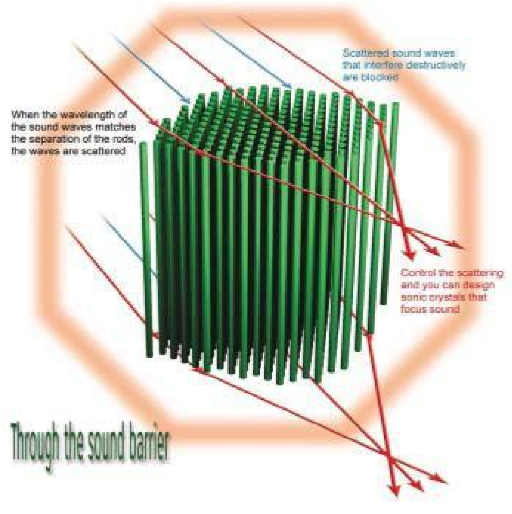
Significance and form revealed the development of metamaterials. Like the sonic sculpture designed by the 20th century Spanish minimalist artist Eusebio Sempere, he created a sculpture of three-dimensional polished stainless steel pipes rotating at the base.

It is a sonic filter that prevents the transmission of certain frequencies in addition to its provocative visual effect as moving surfaces are reflected in sunlight.A listener on one side can hear a visual equivalent of a tonal modification of these sound sources on the other. This sculpture is an auditory decoration because it changes the sounds emitted from it.

The statue features a series of wavy spotless steel tubes that change the sound frequencies as sound passes through it. As a result of tests conducted by acoustic scientists Francisco Meseguer, it was revealed that steel tubes created a "sonic band gap structure" Meseguer changed the spacing and diameter of the rods to weaken all of the specific frequencies and change their acoustic properties.



Sonic sculpture by Eusebio Sempere



Sonic metamaterial also known as sonic crystals.

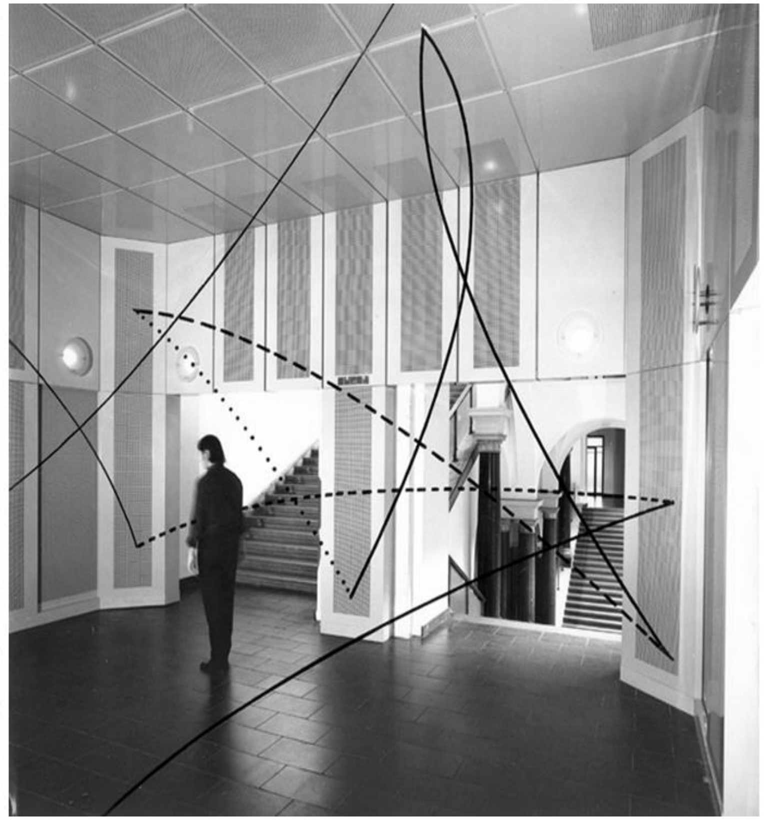
https://www.nialldebuitlear.com/blog/436

An explanation of using sound as material to create temporary voids is the work of composer / architect Bernhard Leitner, whom he describes sound as the "plastic sculpture medium".

The resulting works are defined as sound architecture, sound / space-sculpture, -installation or - objects. His early research began with the assumption that sound can create an interior space that can be acoustically experienced by both the ears and the whole body. His brochure, Sound Architecture, published in New York in 1971, presents the results of his research in a very formal way.

“I can hear with my knee better than with my calves.” This statement made by Bernhard Leitner, which initially seems absurd, can be explained in light of an interest that he still pursues today with unbroken passion and meticulousness: the study of the relationship between sound, space, and body.(Lopez,2011)

Atelier Leitner - Sound Tube 1971



Atelier Leitner - Sound Space Tu Berlin 1984

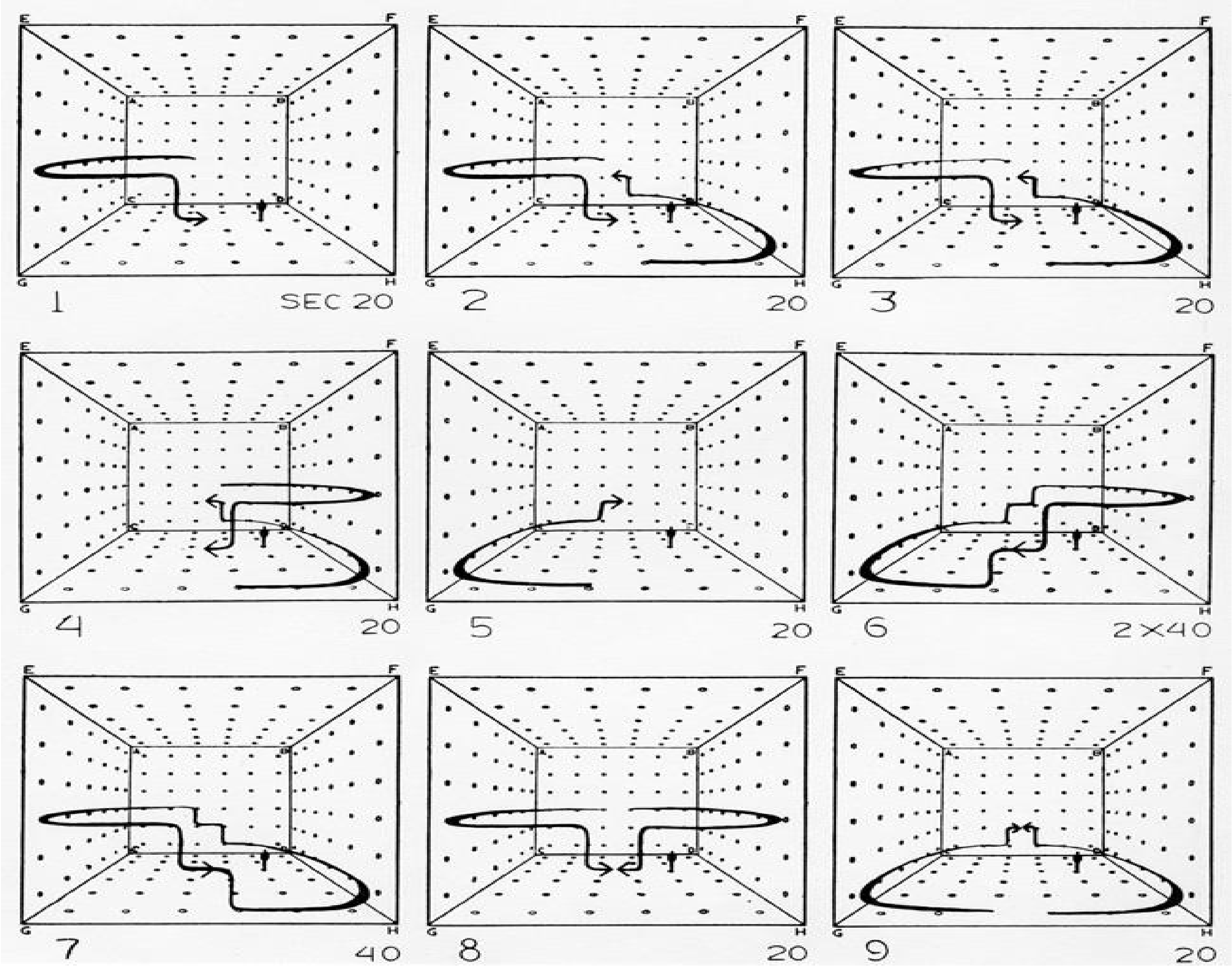
https://www.archdaily.com/168979/bernhard-leitner-sound-spaces/1265545139
https://www.archdaily.com/168979/bernhard-leitner-sound-spaces/1263320024

Bernard Leitner began his research on sound defined space in 1969. As a result of these researches, he created the Soundcube, a room with 64 speakers, which allowed the sounds to go from one side to the other, changing the circle, spiral, step and direction.

Leitner's work has been a process using electroacoustic techniques that move sound through a range of speakers to make room for sound. "Sound Cube" uses the sensory power of the mind to create space and to perceive the movement of sound around a body.

“Leitner speaks of “corporeal” hearing, whereby acoustic perception not only takes place by way of the ears, but through the entire body, and each part of the body can hear differently.”
(Lopez,2011)

According to Lopez's work on this, the visitor inevitably becomes aware of his own body as part of the combined area of sound installation. First, a specific spatial position or even pose is determined for his body. Secondly, the visitor in the sound installation is given the feeling that the tone that fills the installation area flows from his own body. The boundaries of his own body are ultimately questioned and become relative and begin to perceive themselves as part of the installation site as a whole.



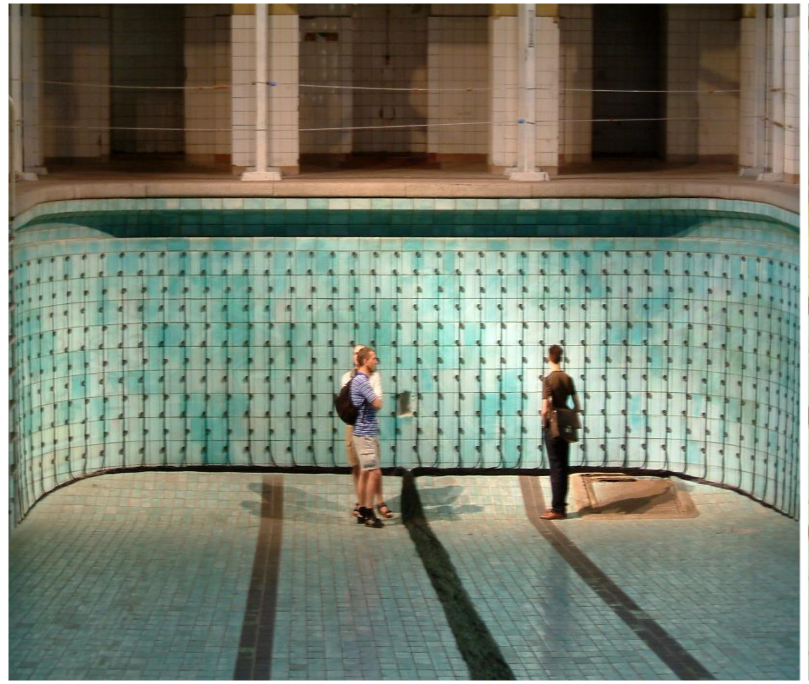
Atelier Leitner - Sound Cube 1970- The movement of sound around a body and the areas defined by the sound are shown.

https://www.archdaily.com/168979/bernhard-leitner-sound-spaces

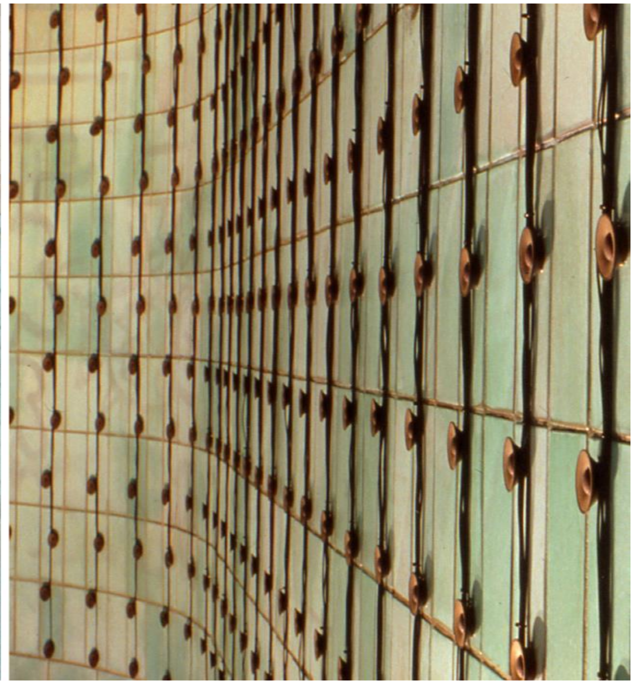
The applications of composer and sound installation artist Robin Minard is another example. As a composer, Robin Minard's work explores the spatial properties of sound as he composes the sound from space. In sound installation, Minard investigates the quality of the relationships between sound, visual and / or architectural elements. Defines Minard compositions as non-narrative music.

“The important concept related to sound installation is that of a non-narrative musical expression.Guidelines within this mode of expression place emphasis on musical concepts.Musical parameters such as register,timbre and rhythm take on new meanings as work is guided by the influence of sound elements on spatial perception rather than on the listener's interpretation of a musical narrative or a particular musical syntax.” (Minard, 1999,p.75)

Based on these examples, HSE will investigate a design idea and use similar techniques in which auditory architecture can be adjusted to play a more prominent and useful role in our daily spatial experiences.



"SoundBits" By Robin Minard



SoundBits" Placement of speakers that add to the "spatial timbre"

http://robinminard.com/data/images/SoundBits_3_Web.jpg

Site Analysis

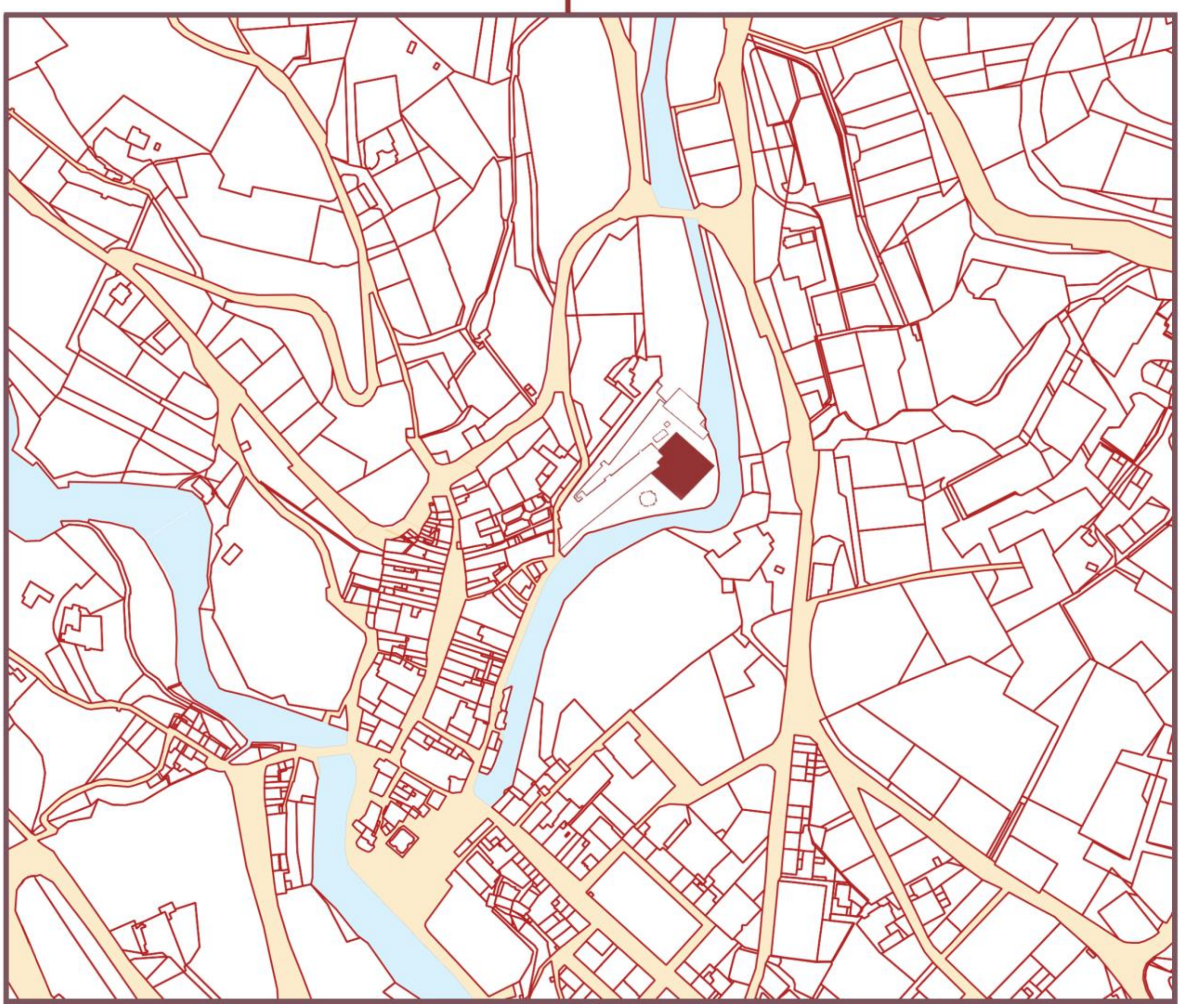
Museo dell'Arte della Lana

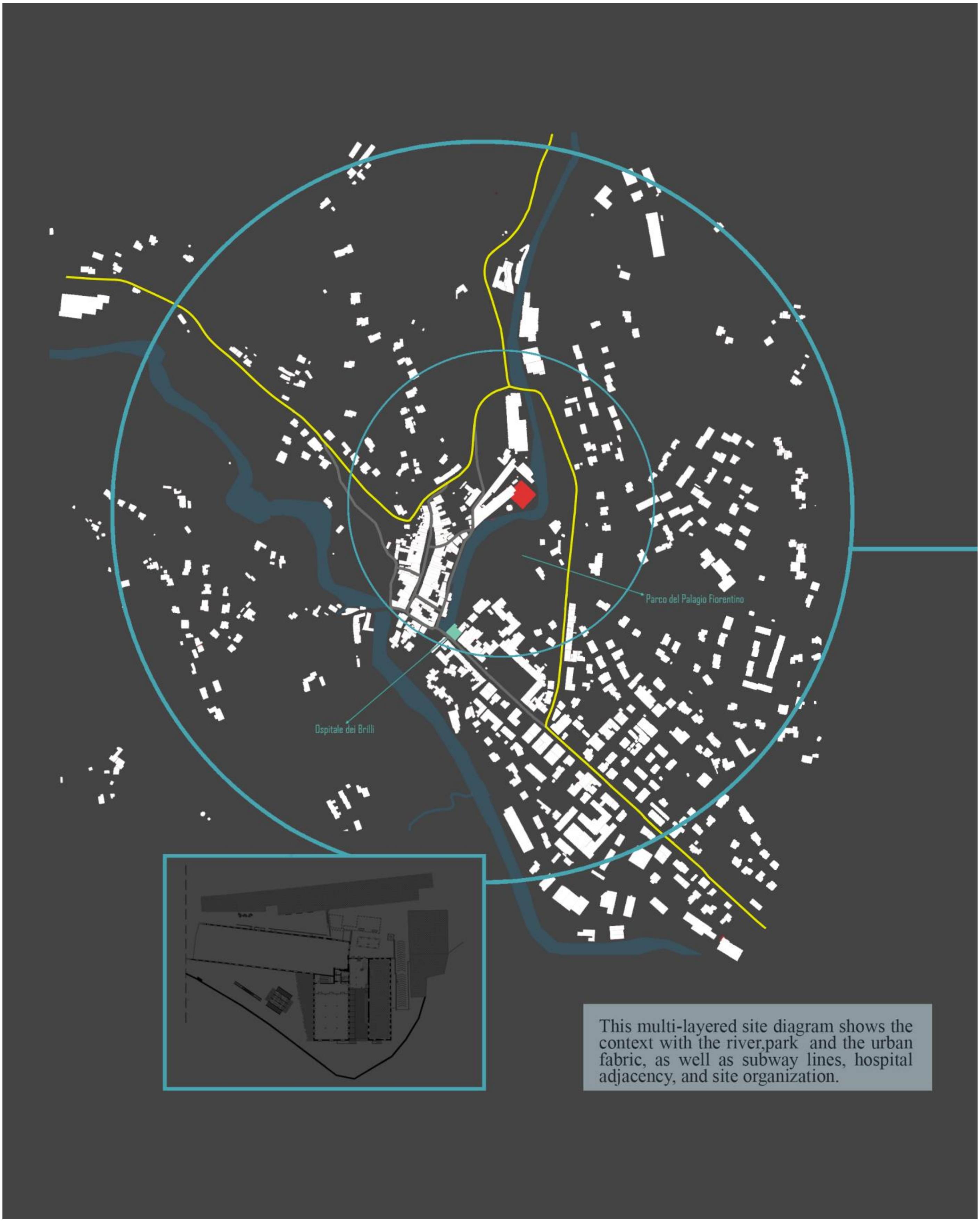
43°48'20.29"N
11°42'45.25"E

Description

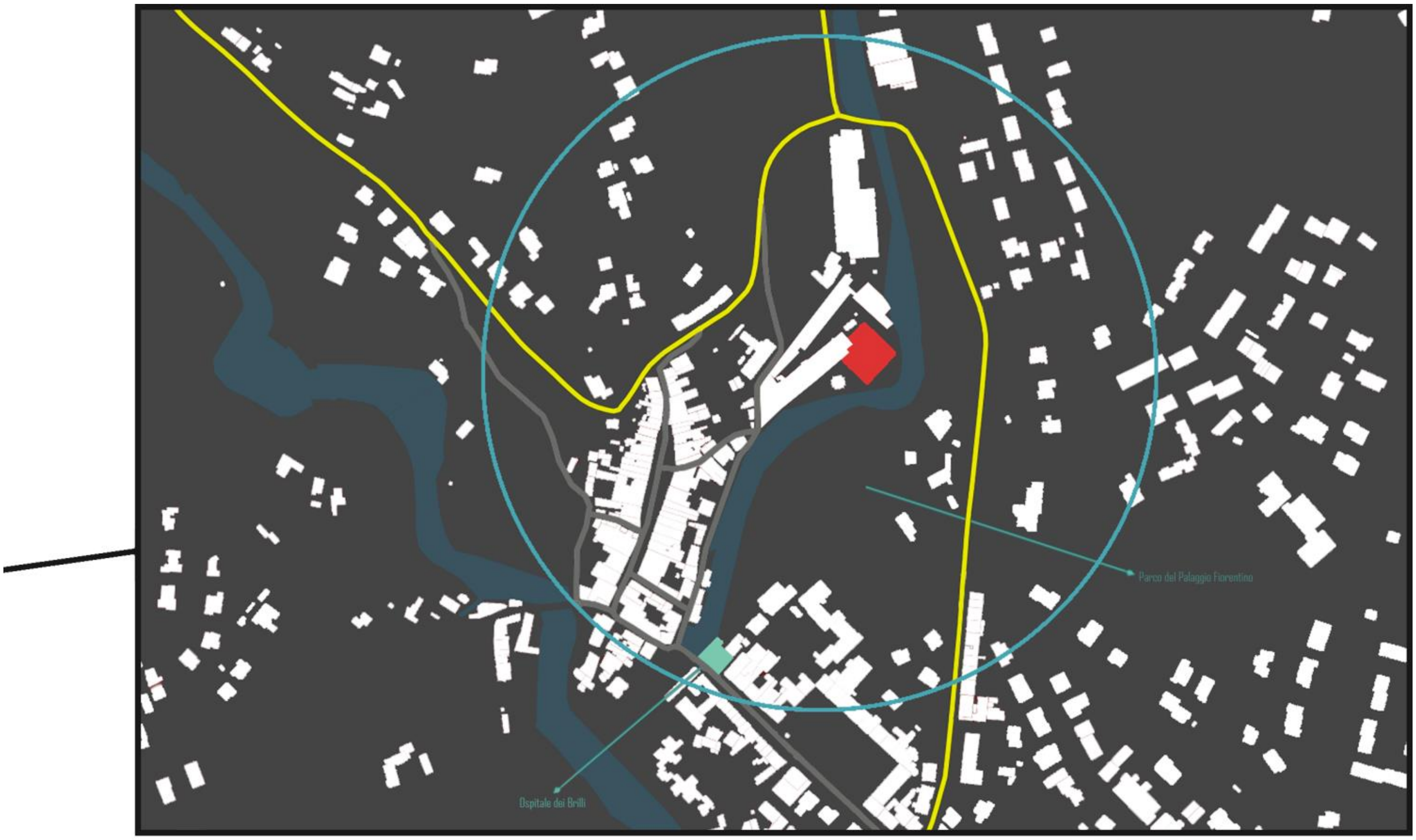
The Art Museum of Lana is located in the complex of the former woolen mill of Stia (Arezzo), in Casentino, restored after decades of neglect .From the mid-nineteenth century to the fifties of the twentieth century, the Stia Wool Mill was a pivot that turned the local economy; It was one of the main Italian wool factories in the first decades of the twentieth century.Today is a wonderful example of industrial archeology, the recovery of which has been made possible by the "Fondazione Luigi and Simonetta Lombard", the owner of the entire work area and lender, and engineering companies and architecture Comes srl who designed and directed the restoration work.

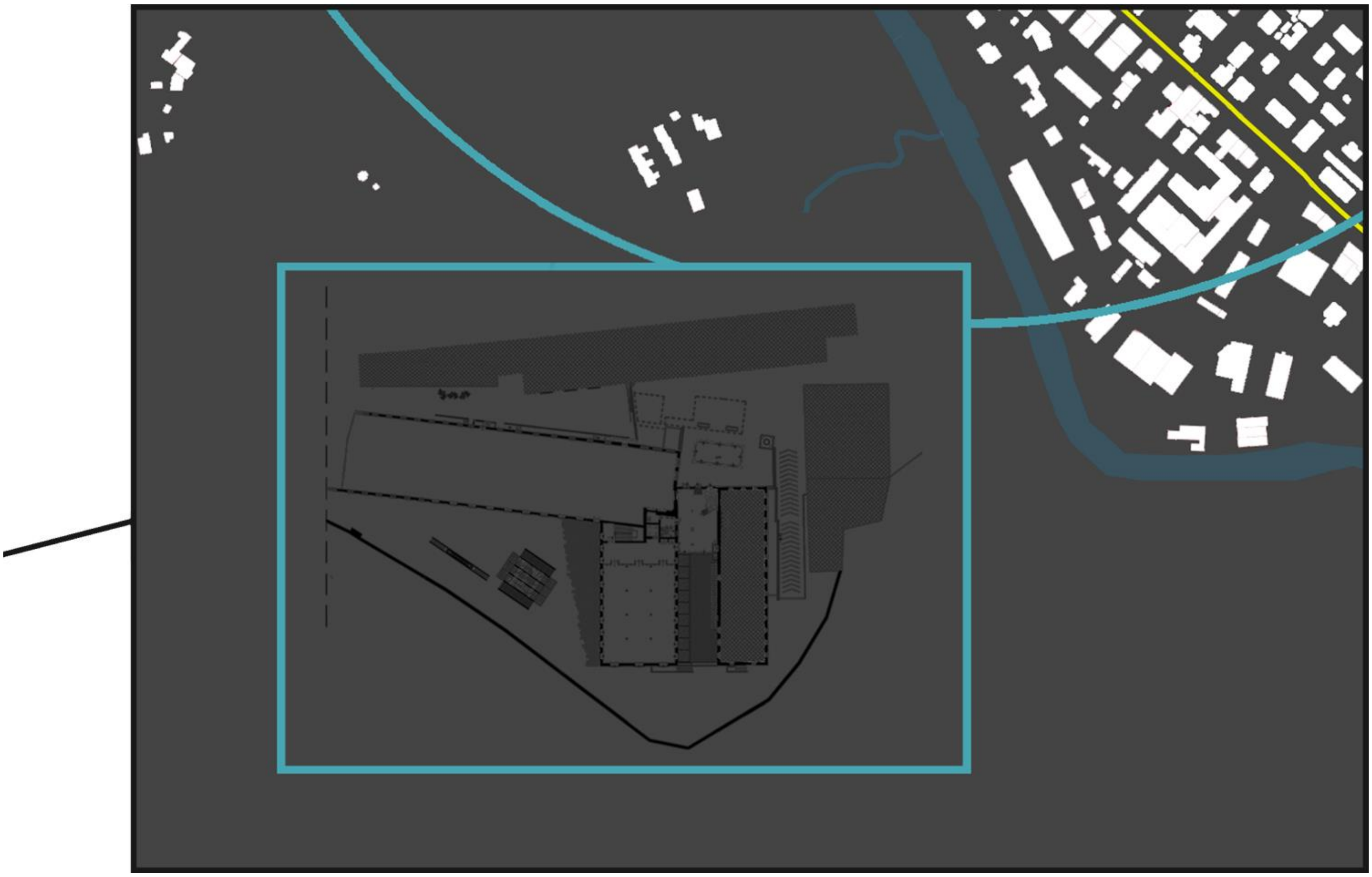
Via Sartori, 2 - 52015 Pratovecchio Stia (AR)



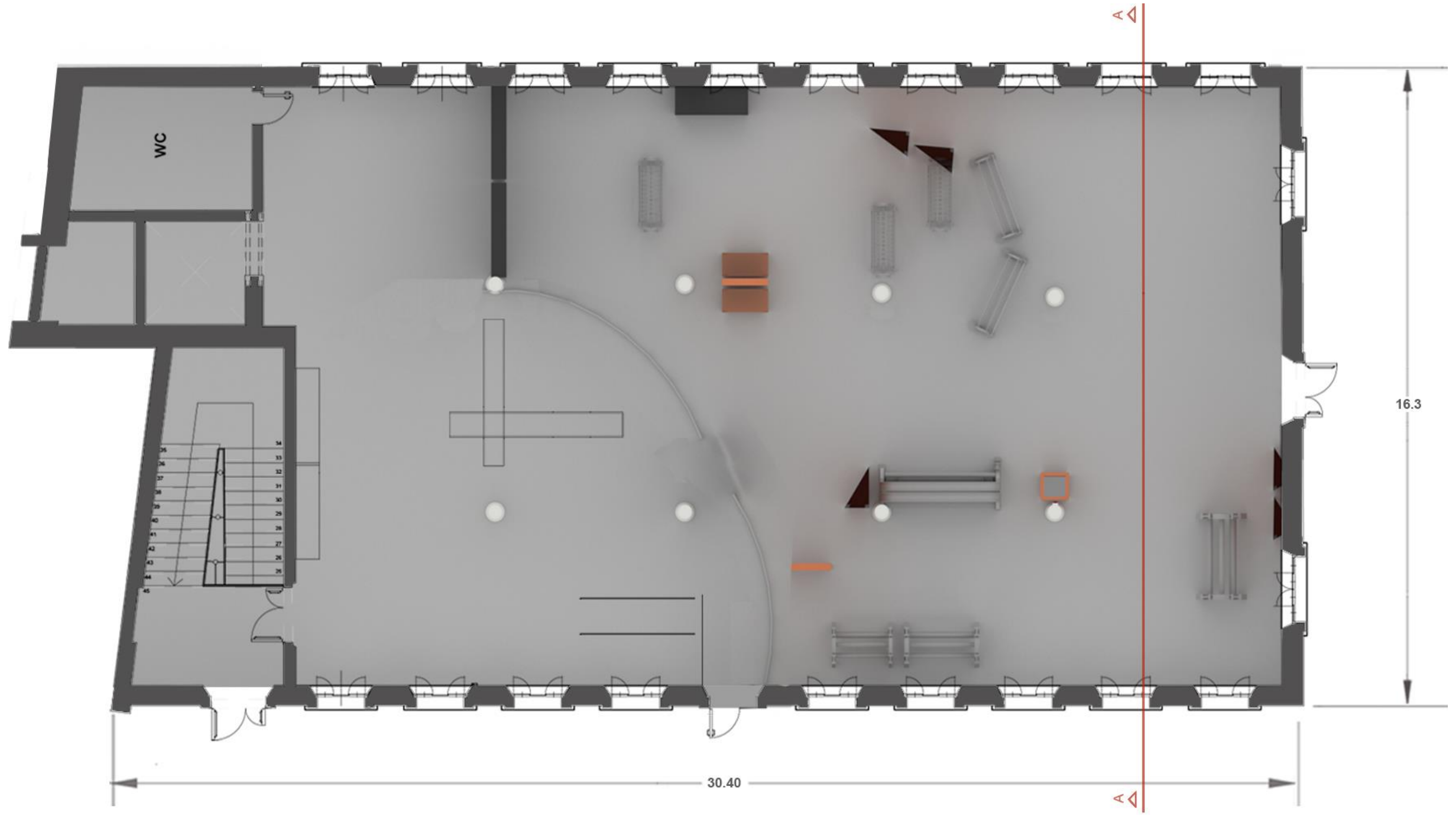


This multi-layered site diagram shows the context with the river,park and the urban fabric, as well as subway lines, hospital adjacency, and site organization.

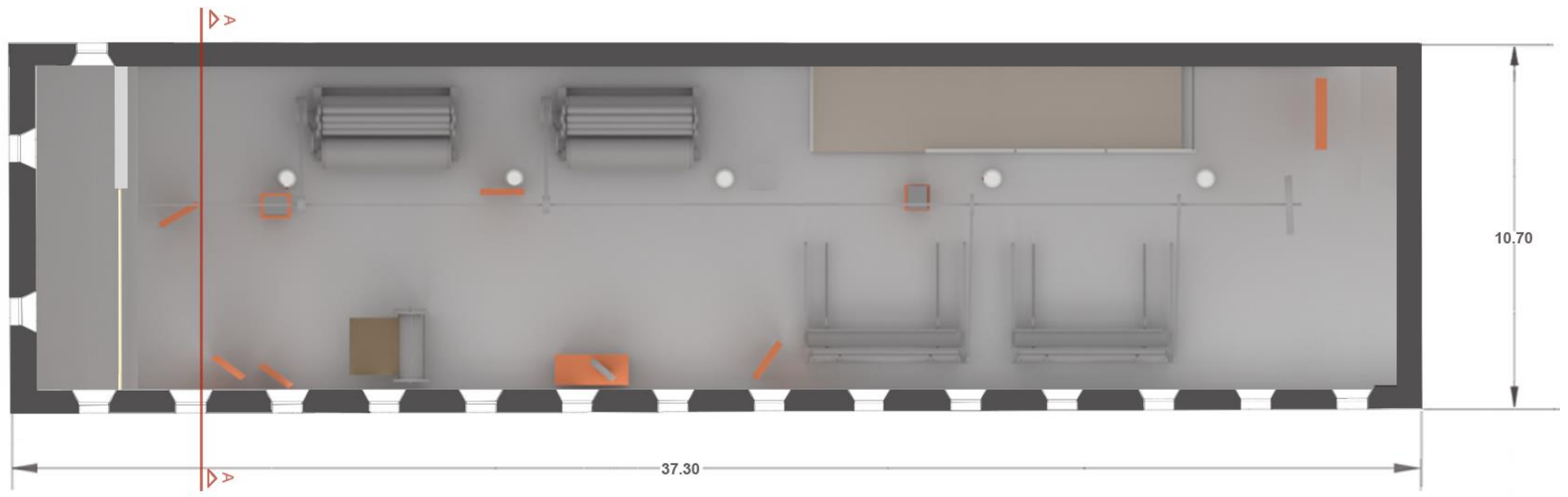

Parco del Palaggio Fiorentino
Ospitale dei Brilli



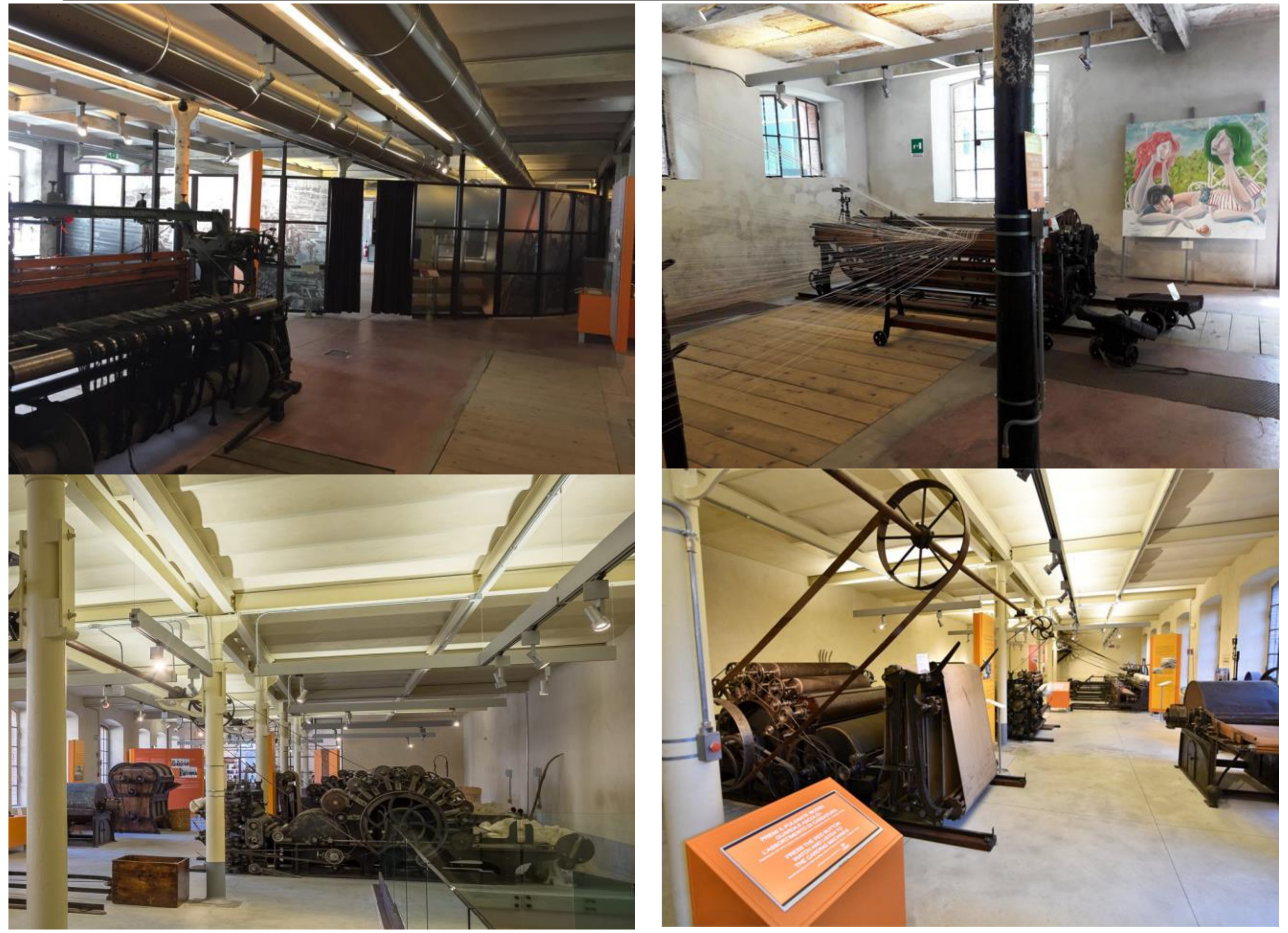
The Museum of Wool Art



Ground Floor Plan



First Floor Plan



In the museum, no materials and applications on the ceiling, floor and walls that filtering, diffuse and absorb sound.On the floors of the museum specified in the project, there are boxes where the sound of the machines can be listened with the help of a button. There is no application to filter the sounds of the machines coming out of these boxes and to create a quiet area around the visitors.

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Project Strategy

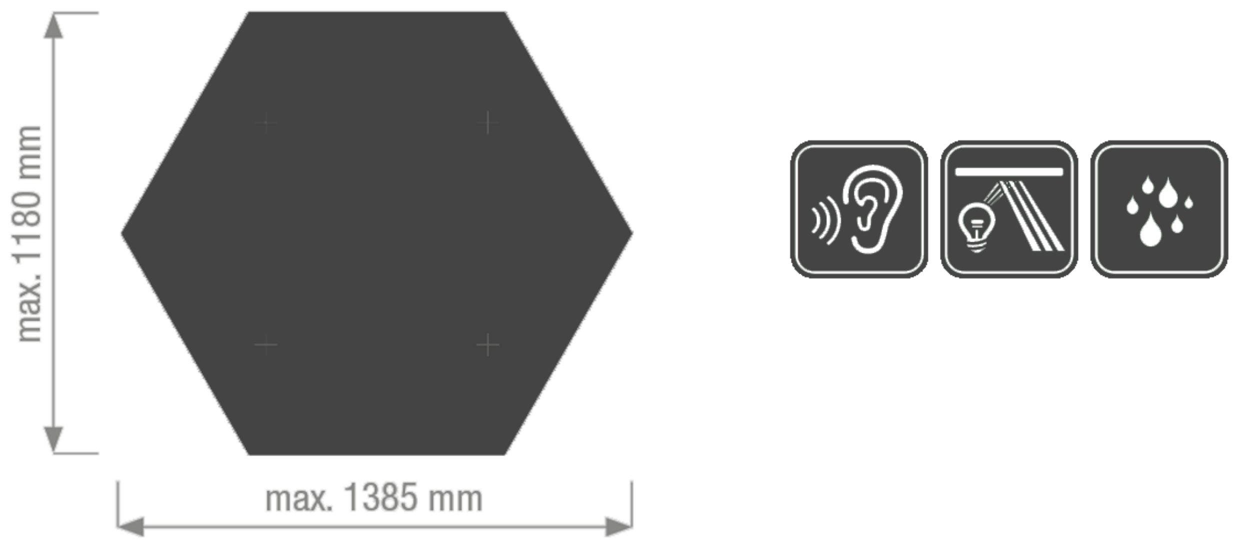
This thesis started in the beginning by questioning how the sound and auditory qualities of our architectural spaces can affect people and their experiences in this space. The understanding the relationship between sound and space has two aspects to be covered in this thesis.

The succeeding chapters describe ways in which sound can identify gaps and stimulate reactions. Historical examples, precedent studies gave insight into how we designed our auditory spaces and soundscapes.Finally, this chapter will explore a design idea in which aural architecture can be adjusted to play a more prominent and useful role in our daily spatial experiences. The 'HSE' design expresses the desire to fully utilize our understanding of sound by listening with both ears instead of seeing the sound as background noise. For this reason, the wool art museum serves as a retreat from the results of noisy, unhealthy and faint auditory environments in our cities, where visitors can appreciate changing auditory spaces throughout.

Hexagonal sonic enclosure

The Hexagonal Sonic Enclosure (HSE) is an immaterial enclosure constructed purely out of sound. HSE allows vision and physical movement to penetrate unobstructedly while filtering sound. This envelope is based on active noise cancellation principles to create an invisible area of silence around the user.

Panels



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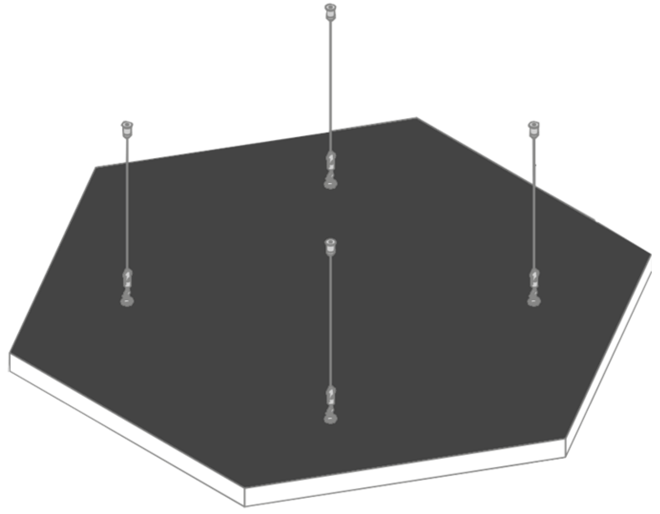
Technical Performance
Sound absorption EN ISO 354
Humidity resistance up to 95% relative humidity
Hexagonal up to max. 1180 mm x 1385 mm
Thickness approx. 40 mm
Weight /raft approx. 6.0 kg/m² (including suspension)
Knauf Company



Surface and construction design
Fleece and colour coated on face and reverse side
Frameless, joint-free
Wide range of forms
Floating effect due to set-back fixing points
Flexible, adjustable suspension

Sound absorption

Sound absorption refers to the reduction of sound energy in a room through a sound wave losing energy through component surfaces. Thus, it determines the acoustic well-being of a user in a room as it shortens the reverberation time, reduces noise levels and increases speech intelligibility.

Sound absorption values according to EN ISO 354

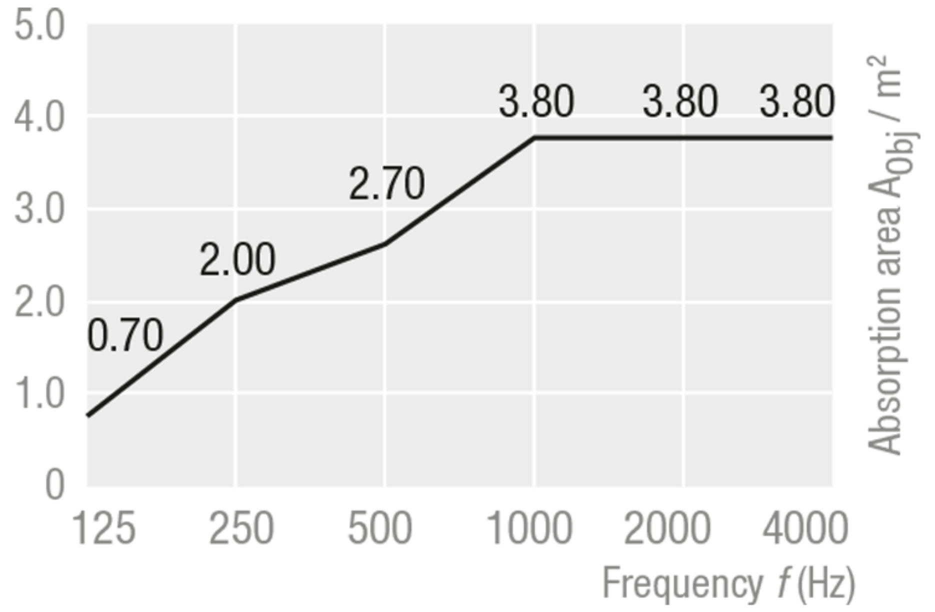
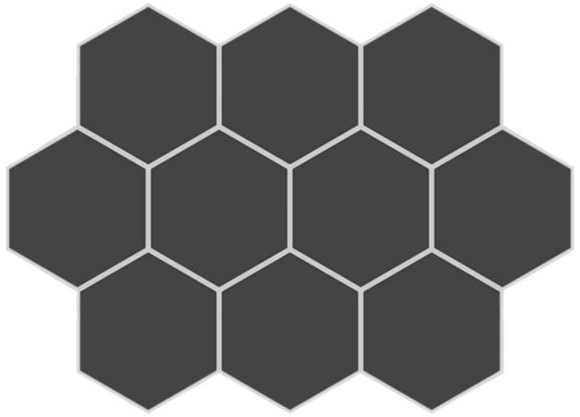
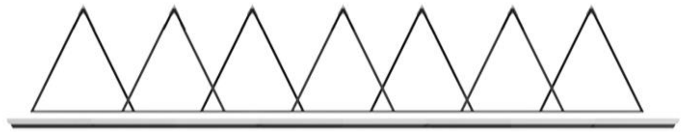


Fig:Knauf C.

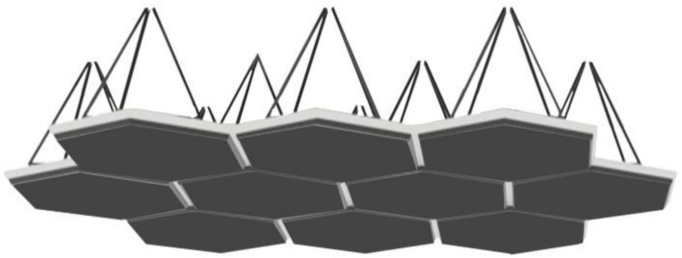
Hse Form



Plan

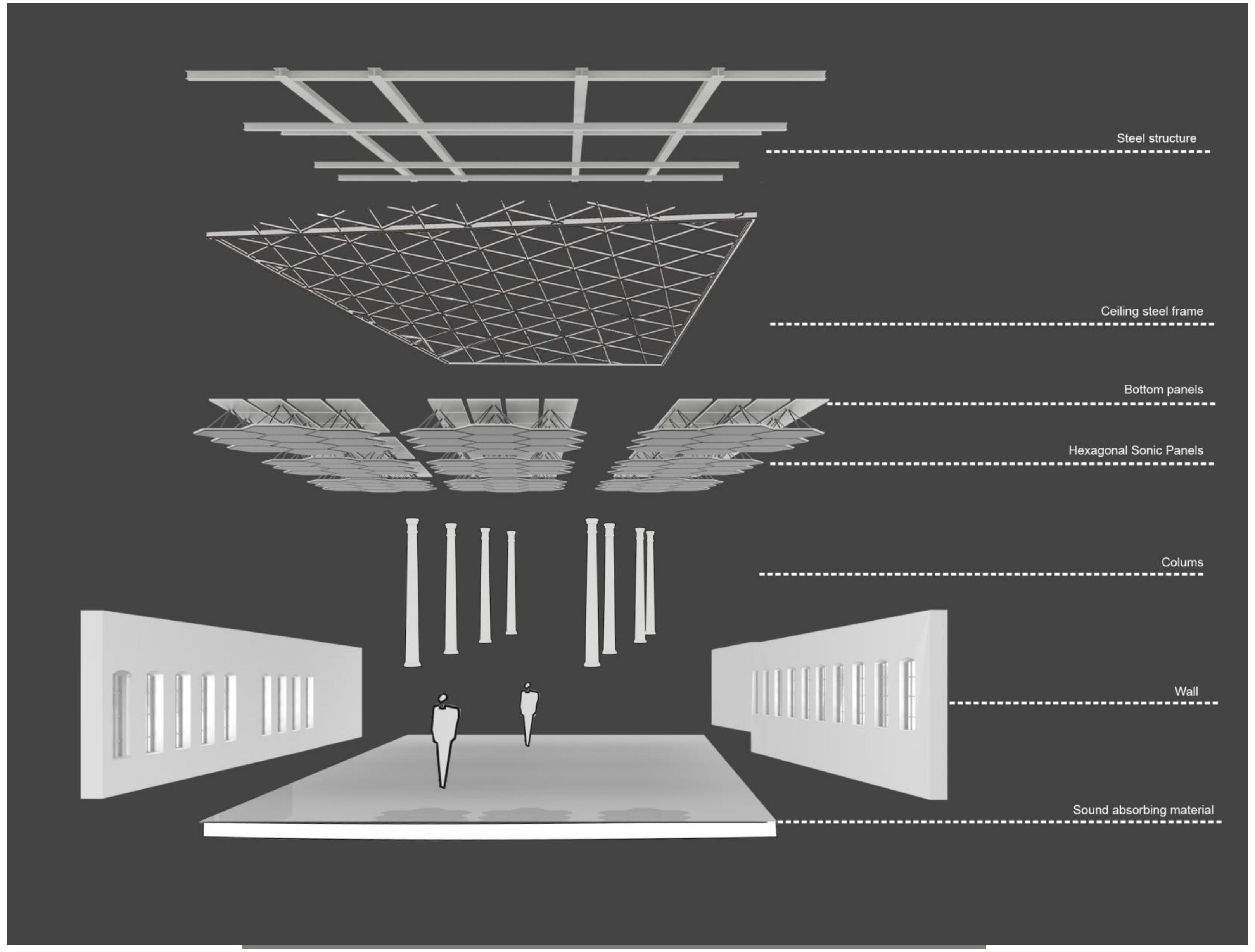


Elevation

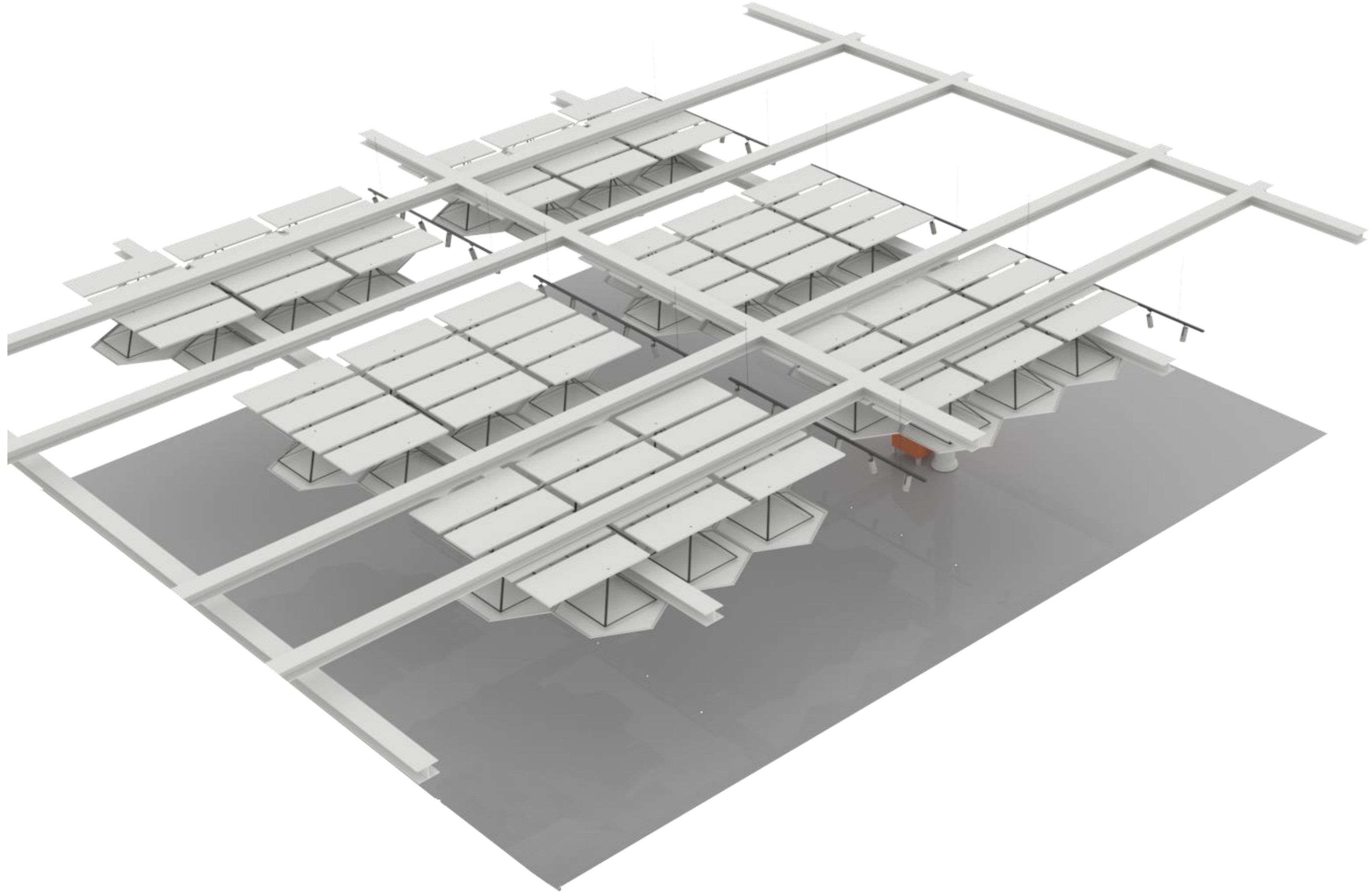


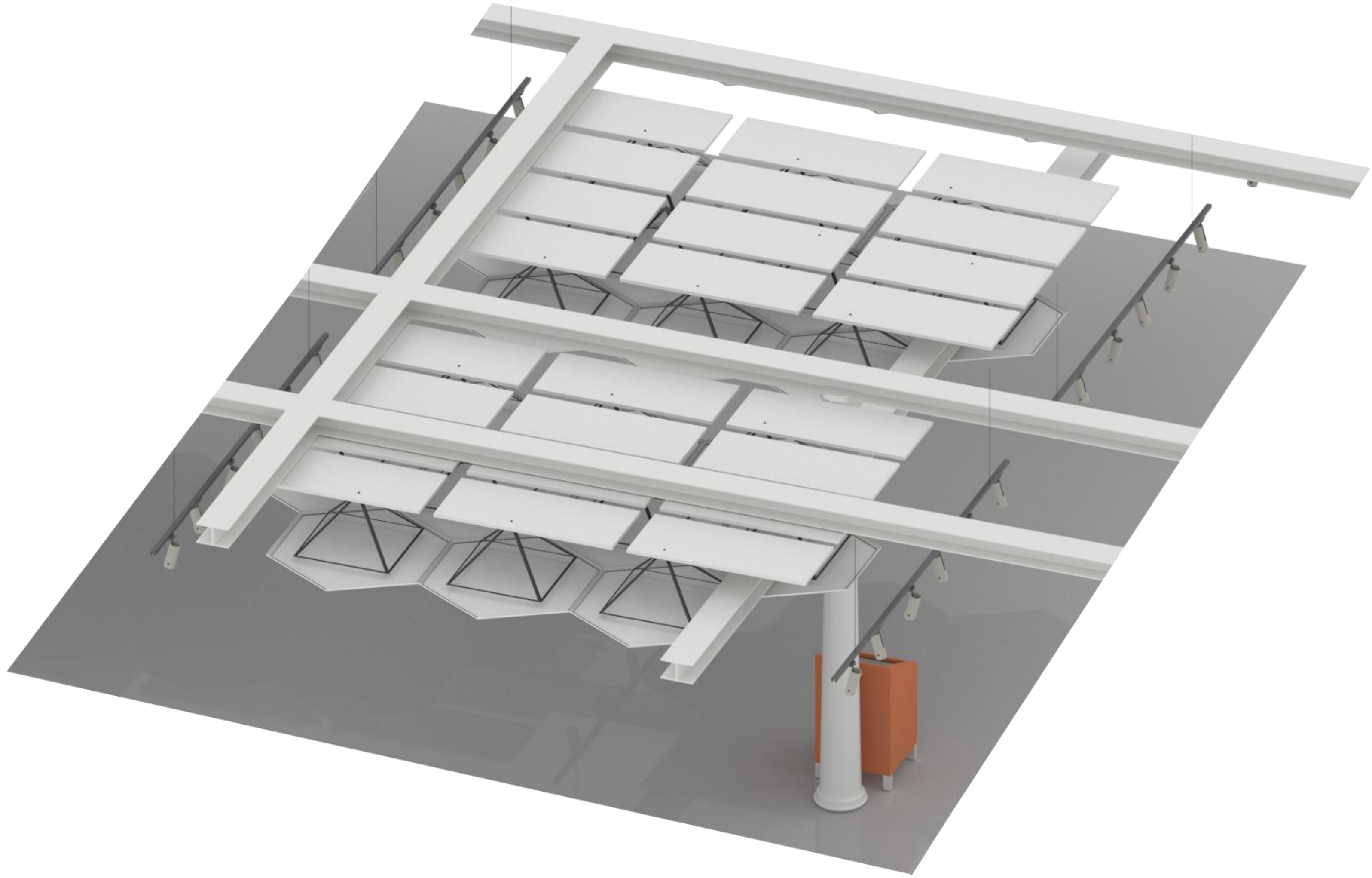
Perspective

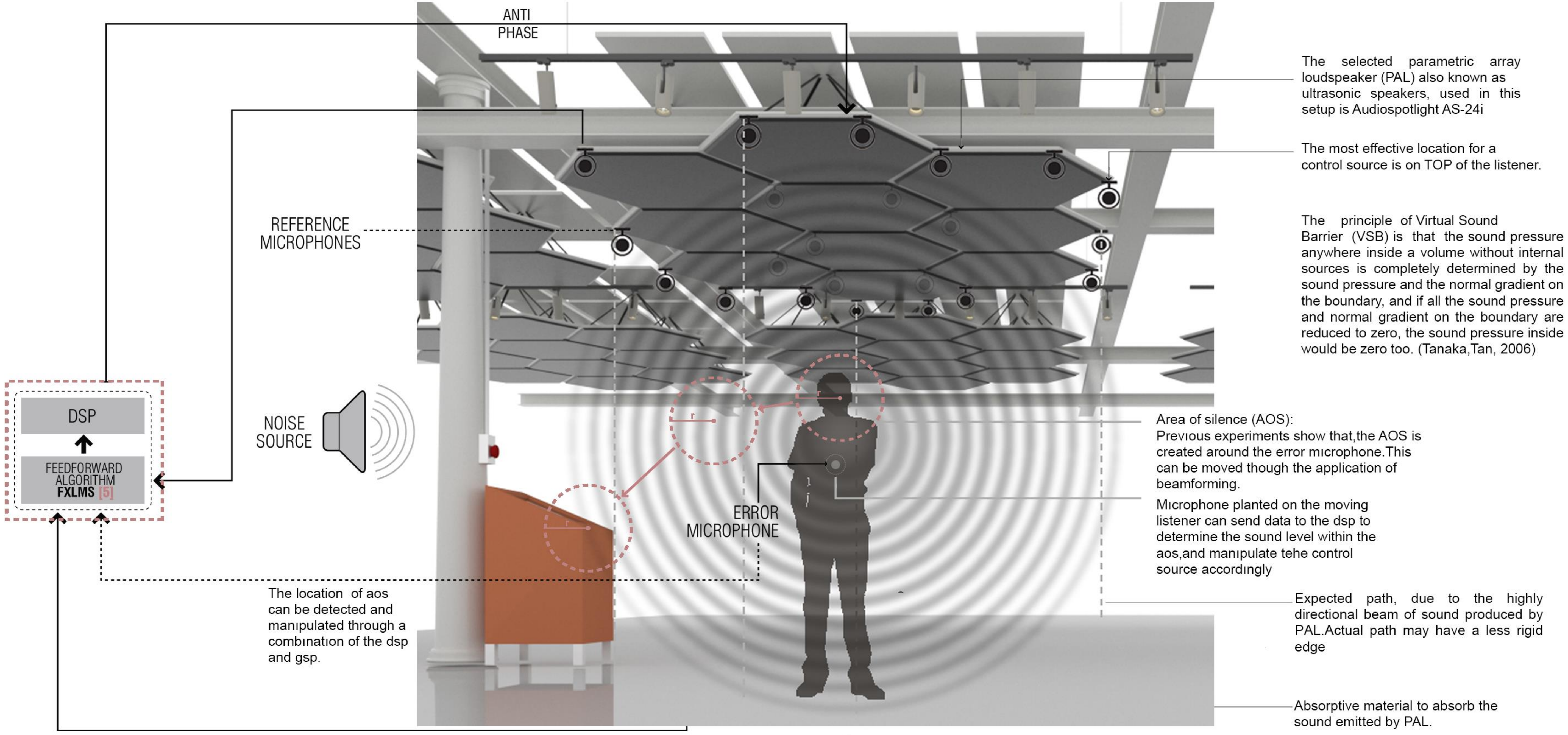
Ceiling form with HSE



Orthographic ceiling views





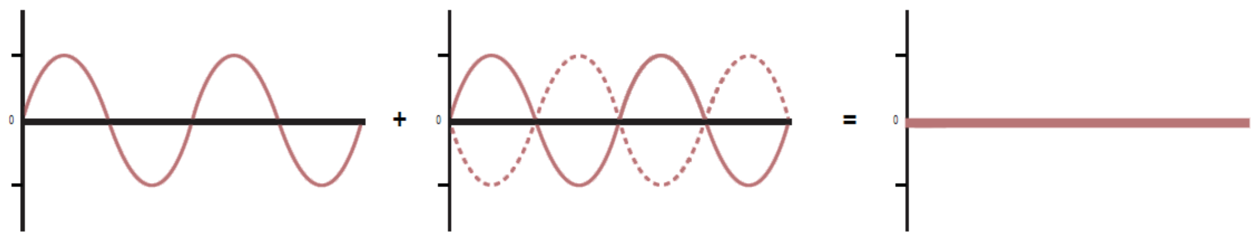


Hexagonal Sonic Enclosure Schematic

Traditionally, acoustic technologies have been based on physical materials that diffuse and absorb sound. However, this approach limits the area to physical and material limits. The main principle of HSE technology is active noise control or cancellation (ANC) sources (sound sources) are determined entirely by sound pressure, in case of sound pressure anywhere in a non-internal volume.

In the diagram above, Active noise cancellation (ANC) and (PAL) Parametric array loudspeaker used with HSE are detailed below;

Active noise cancellation



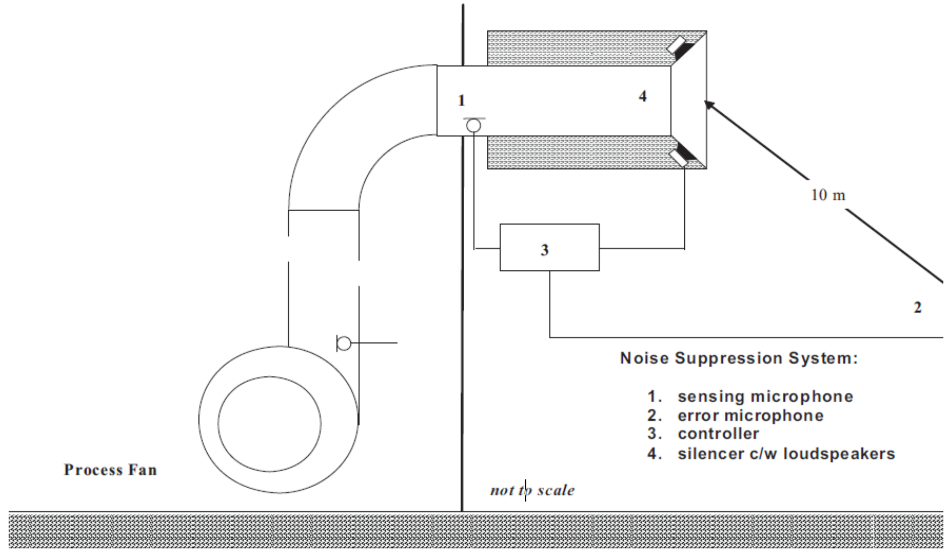
The purpose of the ANC is when the anti-noise is added to the original sound, the resulting wave becomes zero.

Active noise cancellation, also known as "anti-noise" and "active noise control" involves the electro-acoustic generation (usually with loudspeakers) of a sound field to cancel an unwanted existing sound field. (Hansen, 2011,p.1)
Purpose of ANC to reduce unwanted noise by electroacoustic manipulation of the audio signals emitted by the control source..

An ANC system is controlled by a control source that emits 180 degrees of inverted unwanted sound (anti-noise). Waves combine to form a new wave that occurs in a process called interaction. Subsequently, anti-noise cancels unwanted sound.

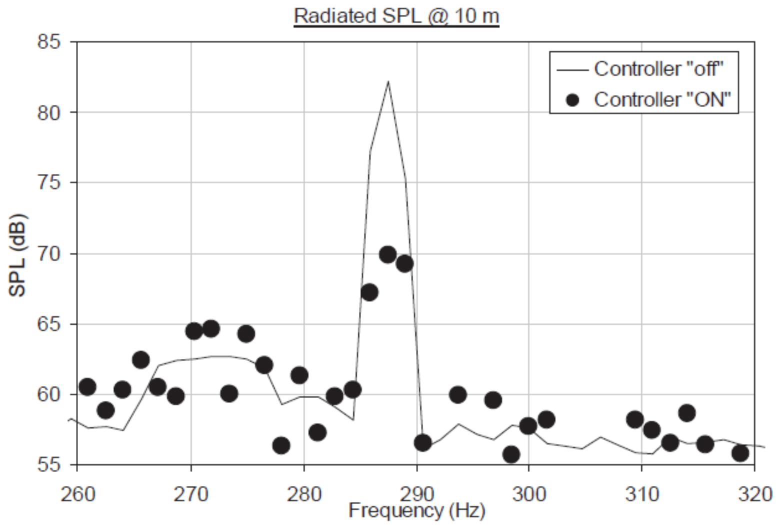
It is perceived that the resulting sound wave does not come into the human ear. For the attenuation of the noise, the control signals must be proportional to the frequencies of the unwanted sound source. The transducer that signals the cancellation can be found, for example, in the user's ear.

A typical single-channel active noise cancellation system consists of:
• a microphone reference sensor to sample the disturbance to be cancelled,
• an electronic control system to process the reference signal and generate the control signal,
• a loudspeaker driven by the control signal to generate the cancelling disturbance and
• an error microphone to provide the controller with information so that it can adjust itself to minimise the resulting sound field.
(Hansen,2001,p.1)



ANC setup at the plant.

Active noise control systems show the complete attenuation of all frequencies.
Conventional active noise control systems are ideally suited for use in the low frequency range, below approximately 500 Hz. Although higher frequency active control systems have been built, a number of technical difficulties, both structural/acoustic (for example, more complex vibration and radiated sound fields) and electronic (where higher sampling rates are required) limit their efficiency, so they are restricted to very special applications. (Hansen,2001,p.11)



Performance of the ANC system
Pompei, (1999)

In addition, traditional speaker technologies used in conjunction with control sources emit versatility. This is useful for reducing low frequencies, but because of its high versatility and shorter wavelengths, higher frequencies cannot be attenuated unless controlled by a set of control sources.
Therefore, taking into account the limitations imposed by traditional ANC methods, this thesis proposes a new modification to ensure that the higher frequencies are further weakened while producing silence zones independently of any physical boundary using the parametric array speakers .

Parametric array loudspeaker

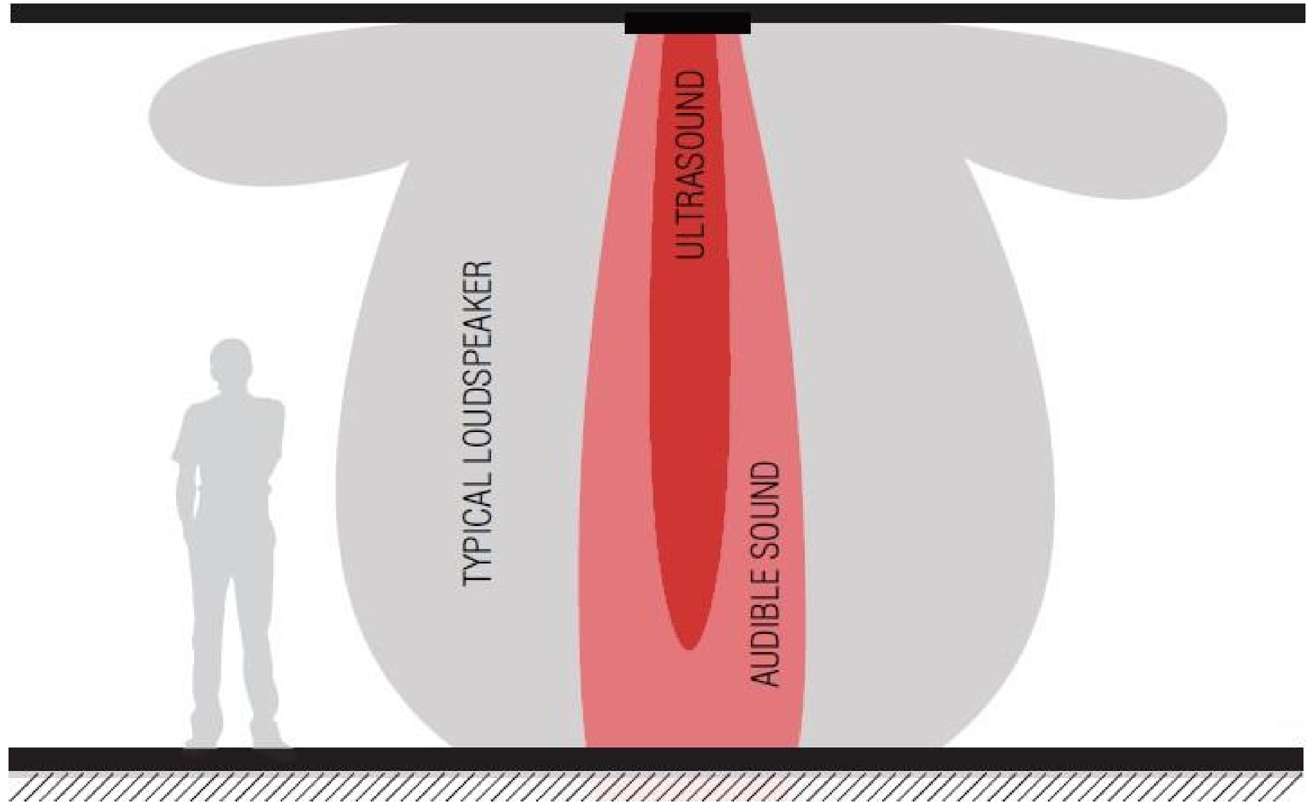
Conventional speakers are not efficient, as as they emit sound in a versatile way.This has proven that the traditional speaker is ineffective against high frequencies. This project proposes the use of parametric array speakers (PAL) developed by researcher Joseph Pompeii to alleviate this restriction.

Unlike conventional speakers, PAL does not emit versatile sound and emits laser-like sound rays. In addition, Pompeii uses ultrasonic sound carried from the air to create sound rays.
(Pompeii, 1999)

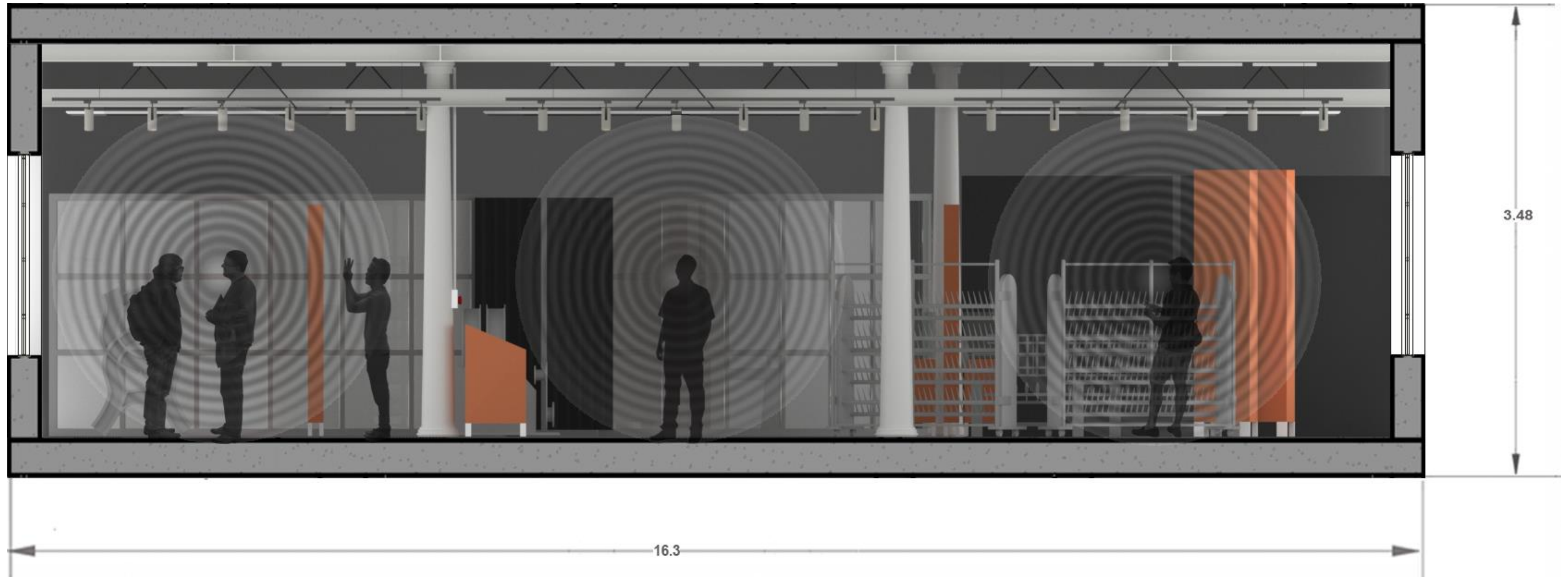
PAL uses an effect known as self-demodulation.When a compressible medium (such as air water) is not linear, it causes high frequency wave components to move.The interaction between ultrasonic frequencies produces the resulting audible frequencies.

Audio Spotlight 24i, parametric array loudspeaker

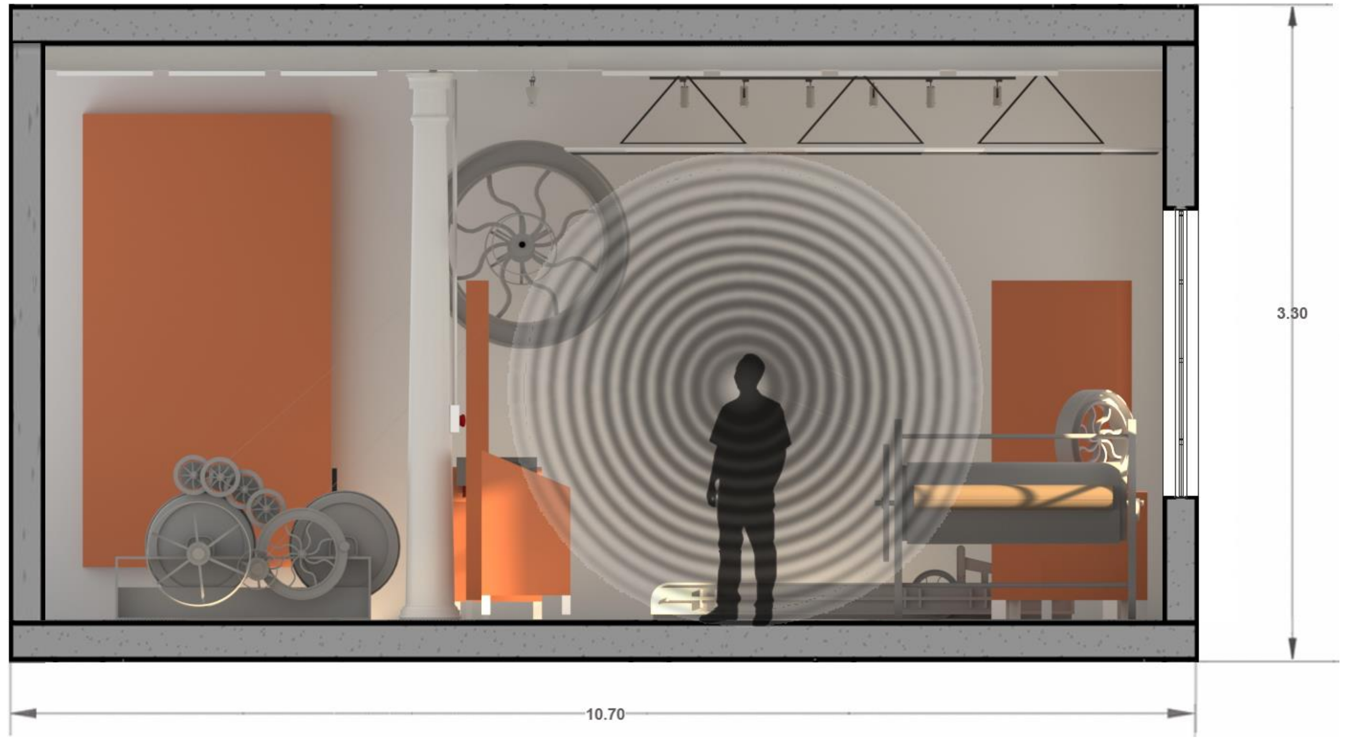
https://www.holosonics.com/audio-spotlight-24i



Comparison of PAL and traditional loudspeakers.
PAL emits high ultrasonic waves to directional sound due to the environment through which they spread and non-direct interaction.
https://www.holosonics.com/



Section AA



Section AA

CONCLUSION

This thesis built in the execution of the system in the museum, takes into account the perceptual power of mind to create deceptive areas expressed by electroacoustic methods. The thesis has investigated the importance of sound in architectural design and how the role of the aural architect can be useful in detailing our environment. Every place has auditory qualities, regardless of whether it is designed in the design.This can change a sense of space, regardless of the intent of the visual elements. In addition, sound can have an effect on the body and cause unwanted negative reactions.

This project in the museum allows a new way to build areas that require varying degrees of auditory proximity.The spatial organization of the space sound can be used as an insignificant medium for spatial definition. This is to try to grasp the architecture designed and built due to its sound and / or lack, thereby trying to produce spaces without using physical significant.

Rather than hearing sound as noise, which is often the case when spaces are too noisy or the acoustics are not suited to the program, this method of 'HSE' design attempts to entice people to fully listen to their environments with both ears.Through to the unique, interesting and adjusted aural design, architecture can better interact with our understanding of sound and positively affect our experience in the spaces.

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ACADEMIC VITA

Ferhat Dural
frhtdural@gmail.com

EDUCATION

The Polytechnic Unıversty of Turin

Dogus Unıversty

WORK EXPERIENCE

Architecture Intern

3K Construction Ltd. 2014 |

Dumankaya Construction Ltd, 2015

ARCHDESİGN-Architecture and Interıor Design office,2019-2020

SKILLS

Proficient Advanced

AutoCAD
3ds Max
SketchUp
Lumion
Vray-Corona Render

Photoshop
Illustrator
InDesign

Hand Drafting
Physical Modeling