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Flexibility through Complexity: Black Box Theater Solution using Computational Design for the UDLAP Community

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Abstract

The UDLAP is a university characterized by its cultural programs. One of the projects taken to future development inside the campus is a cultural complex where one of the spaces would be a Blackbox theater. This performance spaces are flexible and adaptative according to the needs of each artistical experience it might be inside. A place with these characteristics should be solved with technological tools that can have the same adaptability. This thesis will develop a proposal for the Blackbox theater using a computational design process, applying tools like Grasshopper for Rhinoceros and other plugins, and Rhino inside Revit. The solution will explore the advantages of applying a computational design process using BIM and visual script tools to give a complex multidimensional solution to a flexible space. The proposal will be tested acoustically and by fluxes, so the pertinent actions can be taken to improve the project. A structural test is also applied to the skin of the project, a complex geometry reflection of the tools used in the design process. Finally, the result will be shown using the practical tools of visualization of Revit and Enscape to render the model in real time.

Key words: Blackbox theater, computational design, transformable spaces, Rhino inside Revit.

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Introduction

A university is a space where students have the possibility to learn, experiment and explore new dimensions of all disciplines. Talking about arts, the UDLAP have a cultural program known by its prestige. However, right now, inside the campus, there is no space that allows the performative arts students to explore beyond the endstage scenario. Even if transformable spaces for art is a tendency that have decades happening all around the globe (Quesada, 2018). This tendency of flexibility has taken the technology as the main ally, and the computational capacity of our nowadays machines is a powerful tool to explore this adaptative spaces. Inside the architecture, the computational design had gain terrain in the last decades in the way we develop complex solutions through great amounts of data (Caetano, et al., 2020). Even if this is not new and Sabine and his reverberation formula can be taken as example, the artistical spaces have a lot of unexplored horizons that this kind of projects can take advantage of. This thesis looks forward to demonstrating that small simple spaces should not be designed like four walls for an empty box, and the many advantages of using the computational capacity of the today software to resolve a flexible space that is not so simple in its core, to solve, in an architectural design, the complex multiple dimensions that can form the artistic space beyond the black emptiness.

Justification

In 2020 the University of las Americas Puebla celebrated its 80th anniversary. The construction of a cultural center was desired to be the emblem of the celebration. However, because the pandemic of COVID 19 the project got frozen for a not so nearby future. This thesis, look forward to rescuing the design of one of the three buildings inside the cultural complex, a Black Box Theater, that responds to the community need of a transformable space for art, that the Performing Arts Halls used to satisfice until it became an endstage space. For The Black Box Theater designed in this thesis will use computational tools to explore the flexible nature of the space through a complex definition and design process, to increase the adaptative capacity of the building and the dimensions taken in count in the design. The scope is a conceptual architectural project that could be used as base for the real project of the cultural complex. As limitations are the unknow factors such as the masterplan of the complex making difficult the transition to an executive project, and the technical capacity of the computer used for designing since technology can become obsolete in few years.

General Objective

To design a Black Box Theater for the UDLAP community through a computational design process that will allow flexibility, adaptability, and complexity, in the multidimensional solution design process.

Specific Objectives

To understand the nature and current need of flexible spaces for art and the relevance of technology in the solution development.

To define a methodology that reflects the relevance of the computational design usage for the generated solution.

To design a Black Box Theater for the UDLAP community according with the site, needs, and applicable dimensions, to present a conceptual architectural project.

Theorical Framework

Section 1. Transformable Spaces For Art

Humans make art. That is a fact. In the discussion about what is art and when it started to happen, all the definitions come to the common of being human related. Even if there is a possibility that some artistical expressions "might conceivably be produced by non-human species" (Adajian, 2018), is uncontroversial that, by human hand, those

> entities (artifacts or performances) intentionally endowed by their makers with a significant degree of aesthetic interest, often greatly surpassing that of most everyday objects, first appeared hundreds of thousands of years ago and exist in virtually every known human culture. (Davis, 2012, as cited in Adajian, 2018, para. 3)

This affirmation defends that art is a common denominator in human history from society to society and it has an aesthetic interest, but it could "sometimes have non-aesthetic – ceremonial or religious or propagandistic – functions" (Adajian, 2018). However, the concept of art is always influenced by its context, the "cultural and historical features", if a classic or contemporary tag is in use, if is a philosophical position or and aesthetic one (Adajian, 2018); so is impossible to have a definitive definition for the term art, because is directly dependent on the historical moment, cultural context and social reality where is placed. Today's concept of art responses to today's society, as an evolving term for an evolving group of forms of expression, being not unique even less absolute.

Another flaw of art is the way it comes from. Tracing physical art, like artifacts and crafts, is easier than the performative art, object of interest in this thesis. Adajian's definition (2018) refers to "performances", and according to the Encyclopedia Britannica "knowledge of prehistoric performing arts is necessarily slight" (Brandon, Glass, Aung, Maceda, & Rawson, 2020), but is known. Asia, for example, have an ancestral history of “simple dances” and “rhythmic percussion sounds” performed by tribes, evidenced by bronze drums and ritual masks found in the mainland, islands and remote areas, that happened to be “folk performances, in part religious rites connected with seasonal festivals and in part joyful entertainment” (Brandon, et al., 2020). Performative arts don’t leave a clear clue like artifacts, are harder to trace, place and understand. However, the evidence of music and dances since the first civilizations exists and demonstrates its social function, ludic or religious. Such as art in general, the term evolved, just like humanity, and gave performance another range of meanings. Since the 1970s, performance art arose as a term that englobe cultural tendences of Futurism and Dadaism, the interdisciplinary quality of Happenings and Fluxus, activism, the body ritual, and other expressions “characterized by improvisation, spontaneity, audience interaction, and political agitation”, always keeping the constant of being “an event rather than an artifact, by nature ephemeral” (Wainwright, 2011). Performative arts today have a complex meaning and range of expressions that go beyond the ludic or ritual of the first civilizations, given by the even more complex social dynamics of nowadays societies.

The performative arts, for its ephemeral event nature, need a place to happen, and the space have a direct relationship with the performance impact. Is not the same to see a classical play on an Opera House than in the streets, neither to see a mime face to face in a random encounter than on stage. The space needs to fulfill the necessities of the performance intentions, in every sense. As Blazekovic (2017) says “the importance of the original space for which a work of art had been intended could be extremely important, regardless of whether we talk about a musical composition or a work of visual art”. Architecture, according to the last, when is related to a performance or exposition space, needs to have a deep connection with what is happening, the meaning of the artistical expression, and the artist's original intentions. The place could be also inspiring, and combine the artistic sensibility with functionality, like Leitermann (2017) expresses about Theater planning:

> Fortunately, most architects share this view of the theater building as a functional response to a need. Architects also view theater buildings as aesthetic objects in their own right. Since architecture and theater are both arts, then theater buildings are works of art that serve as vessels for art. […] Emphasizing only art may result in a stunning architectural achievement that is unworkable as a theater. Emphasizing function and craft without art may result in a serviceable but utterly uninspired and uninspiring theater. Striving for this balance is one reason why theater design and construction is such an interesting and challenging endeavor. (p. 3-4)

This duality helps both interests, the architect's one that looks to make a beautiful functional building, and the artist's one that looks for an inspiring place that meets their performance needs.

After understanding the deep relationship between performance and architecture, and the historical tendency of art to evolve like the society that produces it, the architectural changes in time of performing spaces are logic. Humans appropriate of natural places and build their own to cover certain necessities, and art is not unlike. From the cave to contemporary transformable spaces, as seen in Figure 1, performative arts have been a reason for the design of certain typologies of buildings or public spaces. Changing and innovating themselves to the artist's benefit, focusing in sight and hearing to better experiences, architectural spaces are witnesses of the sociocultural dynamics over time, and it will be a huge mistake to think that todays arts can be satisficed by the same typologies of the last centuries.

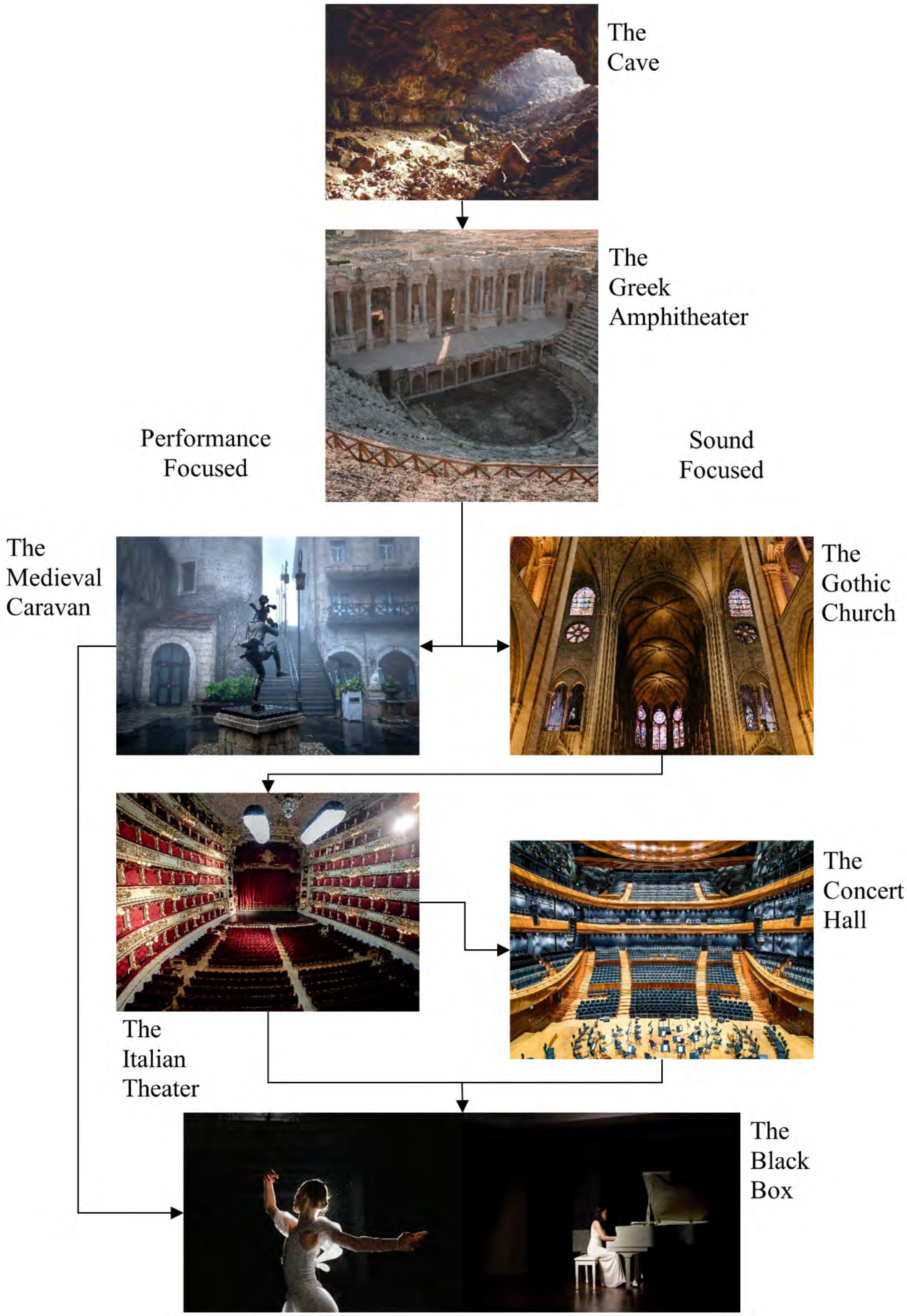

Figure 1. Illustrated evolution of performative spaces (own illustration using CC images).

Performing Spaces: Historical Overview

The first space that human beings used to make a performance was the cave. When a musician first entered a cave, and played -probably- a wind instrument, he found out that the rock walls returned the sound of his notes, prolonging the time they could be heard cause reverberation, making harmonies, and giving a richer and strong sound back (Bagenal, 1951). From that moment, musicians and singers started to experiment within diverse caves to realize that the sound of their instruments and voices sounded different in each one. A small one could cause unwanted increase of the bass, a moderate one could give a wider compass, while a "large *grotte* with recesses and stalactites, and fringed with creepers" was capable to empower the sound of the seven notes, making the sound nicer; as a disadvantage, inside the cave a slower tempo is needed, but if musicians played quicker rhythms for dancing using the rock walls just as a reflector, playing in front rather than inside, it will "make themselves heard to a good distance and, […] carrying power would be more noticeable to listeners" (Bagenal, 1951). This discovery about solid objects and the way they affected sound, inside or in front of them, is the basic principle of proportions, chosen materials and diffusers shapes still used in today's constructions.

The Greeks developed the first typology to imitate the natural cave effects on sound: the amphitheater. This open-air spaces for performance stablished their basic acoustic principles: "good reflection from rear wall and paved floor, to avoidance of echo, and to the absence, in an open-air auditorium, of reverberation" (Bagenal, 1951). Reflection was the most relevant aspect for Greeks, leaving the capacity of the inner cave aside to focus only on the acoustic shell power of walls, floor, and vases. They put efforts on the acoustical optimization for music and voices, while the cultural ritual of the performance was present. Both, sound and the body presence, were equally desirable. Further typologies of performative spaces will take back the inner cave capacity but, in the other hand, will also break the correlation between sight and hearing, choosing only one above the other.

After the Greeks and Romans, approaching the Middle Ages, there is a gap for performance spaces talking about the socio-cultural rite of dramatic arts. The amphitheater had a numerous type of plays that deeply reflected the society feelings on the audience. But during this period the theater was banned precisely for that. The body presence or sight were not desirable as hearing, and hearing became a religious focused practice, so "public theater moved to the streets. The structure was a wagon or a simple platform, perhaps raised, a canvas backdrop —all utterly temporary and moveable" were political and social themes gain importance (Rawn in Leitermann, 2017). This tendency of making performing art as a social critique in a non-perfectly defined space will disappear with the great Theaters of the Renaissance and the lift of the ban and be taken back in the XX century until today.

Parallel to this ban of theater, music played an important role for performative arts in religion, as commented above, during the Middle Ages. The Gothic Cathedrals took the place of the most relevant spaces to perform. The acoustics of the cave, but now the inside ones that the Greeks once forgotten, were replicated in an architectural room with concave top that allow the "art of sustained notes, of choral tone, and of the open vowels", that were the sacred music, to use "the church as an instrument" because the acoustics benefit and fulfill the bass tone and slow tempo (Bagenal, 1951). The properties of the cave that weren't desirable for quick tempos favor the choral music, making the place relevant for the right interpretation of this kind of art. Later, with the Lutheran churches, dimensions were reduced and the reverberation too, allowing faster tempos and strig music to sound good indoors, "there was a more rapid music flow, and true tempo effects in church music were now possible" (Bagenal, 1951). The architectural characteristics of the space in churches determined if the sacred music would be choral -using an organ- if it could be or accompanied by strings. The physical space had direct influence in the performance nature because the acoustics.

Back to theaters, in the Renaissance born the called Italian theaters, opera houses, and other configurations exclusively for Fine Arts, especially dramatic and musical. Bagenal (1951) consider the first step to this typology when Palladio in the XVI century decided to put a roof at the theatre of Vicenza, benefiting the sound of pipes and strings inside the classic amphitheater. Even if the first characteristics were totally focused on music, the performing arts gained terrain as a respected form of expression, the ban of the Middle Ages was gone. Quesada (2018) denominated these buildings as theater-temple, where the architectural piece was an urban symbol of politic and civil power given by the new laic tendency of society. The theater was not only a place to perform but a landmark inside cities and a monument to the new era, where social dynamics got more complex and so the artistic reflections of critique, status and power. As dramatic arts evolved, the theater did it so an gave a step forward to the theater-machine. Quesada (2018) explains that this change was a Baroque tendency for experimenting the relations between stage and orchestra by using mechanic systems to give more flexibility to this relationship, through visual effects and dynamic objects. The rigid temple-theater slightly started to change to versatility using technology on its favor, and given the body presence, the sight, renewed importance aside the hearing.

Theaters, according to Bagenal (1951), made people get used to a specific kind of sound, the hearing of the audience was educated, and the acoustics were replicated empirically to one to another space. In 1900 Sabine determines the reverberation formula and the Concert Hall as a typology started to glance. Sabine, according to Carl Gayley (as cited in Hagler, 2006), gave a cooking recipe to the design, “is a shoebox […] It's a long, relatively narrow hall with a tall ceiling. The intent of this design is to maximize the sound quality and reverberation in the volume of the room”. This recipe isn’t necessary good. Beranek (2015) defends that “the highest-rated halls acoustically were built before 1901”, before Sabine, and the cooking recipe transformed acoustics to a check mark, so now “architects and owners have often placed beauty and novelty of architecture above acoustics”. Is not that the architectural piece doesn’t need to be beautiful, but what happens inside must be as important as the building. The Concert Hall of the XX century suffered a lack of balance between the space aesthetic and the inside behavior. Equally seen in other typologies, hearing -acoustics-, sight -body presence regarding the audience-, and beauty -of the building itself-, are the three main desirable characteristics of a performative space, but the social tendencies and architectonic solutions made balance between them a hard task to achieve.

During the last century, the theater-caravan reborn form the Middle Ages and came to fit a new necessity, one that a fixed space couldn’t solve completely. Quesada (2018) explains the renewal caravan as a response for a cultural and social change that the avant-garde brought. The transformable spaces are now a reality and a social need for arts. Static buildings cannot contain the variety of delivery ways that experimental art have, including the huge range of themes that critique can aboard, and mixed types of representation. Also, Bagenal (1951) had already pointed out this need of adaptable spaces when he refers to Beethoven and Mozart as two musicians that can’t be played in the same scenario, the music of both is different and require specific reverberation times, so the space should be different in each scenario, like what happened with gothic or Lutheran churches. Having one transformable stage could be easier than having two with specific fixed conditions, that are not limitative to the acoustics behavior, but can be translated to shape, volume, seats arrangement, and even location. The artifices needed to achieve this characteristic will make the theater-caravan have a special bound to the theater-machine of the Baroque and the technology advances of its time.

Some performances require special needs, and there is where the relevance of the transformable space lays. Moving forward, the Black Box Theater would be the contemporary response of this need of dynamic spaces, that will present the void of the blank room as an opportunity to be fulfill with the artist imagination. As first approaches, Quesada (2018) writes about the Lyric Theater of Cagliari that gave the possibility of change the inside configuration of the place -Figure 2- through floor and ceiling mechanic systems -Figure 3-. Arrangement will be the first characteristic that architects and artist will try to make a variable in new performative spaces typologies. Other example is the New Theater of Udine (Quesada, 2018), other proposal of the XX century that plays with the idea of a movable space where the system of blocks is able to dismantle and ensemble in another site, in different arrangement, in a plaza -Figure 4- or along the street -Figure 5-. Modularity and ephemeral spaces will be other options in contemporary architecture to explore with, not only in performative arts but even in housing. In conclusion, for more than seven decades the flexible spaces have been in the mind of architectures and in the needs of performers. Acoustics, physical arrangement, and beauty are only the three main of multiple desirable characteristics that these multidimensional spaces can have, and the more complex the need to satisfice, the more complex the way the solution comes should be.

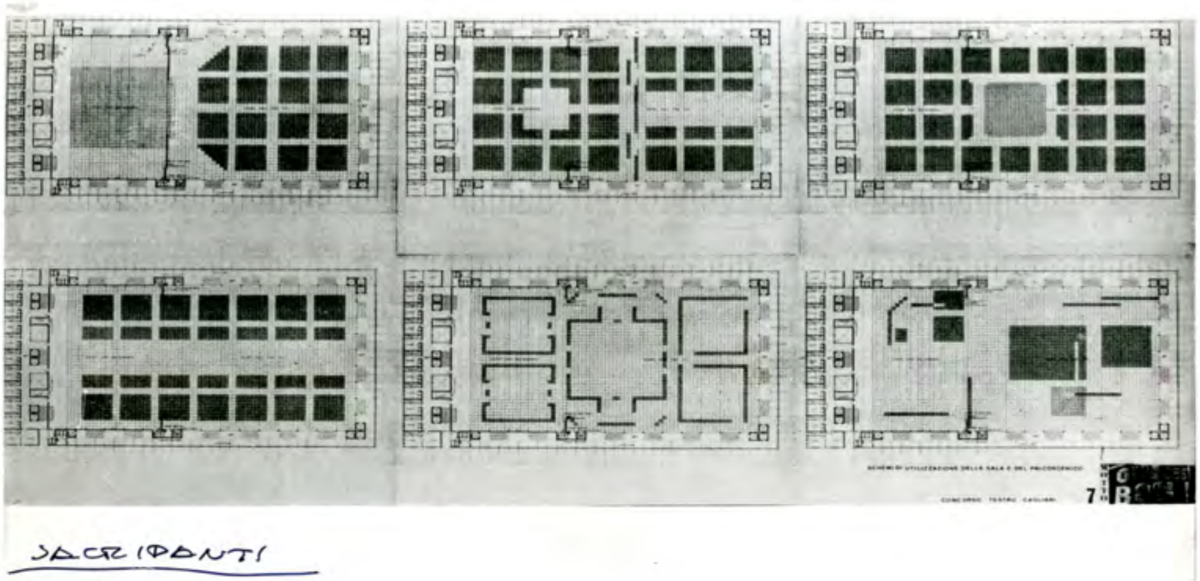

Figure 2. Plan Configurations of the Lyric Theater of Cagliari, Maurizio Scripanti, 1965 (Quesada, 2018).

Figure 3. Model of the Lyric Theater of Cagliari, Maurizio Sacripanti, 1965 (Quesada, 2018).

Figure 4. Configuration A of the New Theater of Udine of Nino Dardi y Mario Ricci, 1974 (Quesada, 2018).

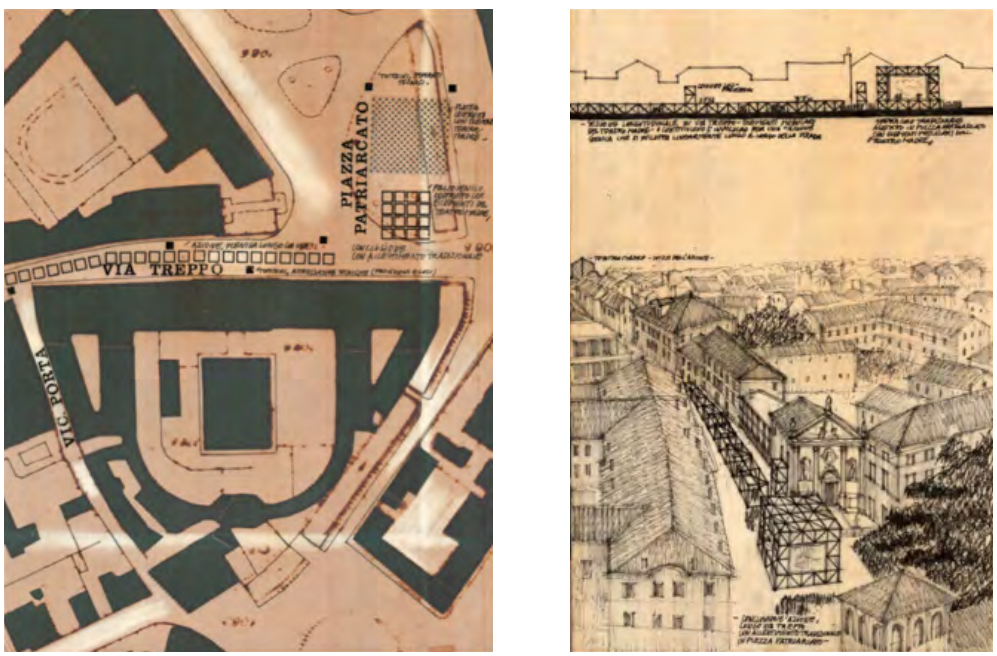

Figure 5. Configuration B of the New Theater of Udine of Nino Dardi y Mario Ricci, 1974 (Quesada, 2018).

The Space Needed For Today's Performance

Since the last century, adaptability, versatility, and flexibility, have been desirable characteristics for performance spaces. No matter if is the acoustical behavior or the configuration between stage and orchestra, transformable spaces are the response for a changing society that use art as an expression form adaptable to its time. An example of this is the work of Marcela Sánchez Mota and Octavio Zeivy, dancers that have diffuse the line between dance and theater to make a performative art that fits body, sound, image and technology, everything in one stage or video. In a conference given to the UDLAP community (Sánchez Mota and Zeivy, 2021) they exposed pieces such as *Idea de una pasión*, that plays with a static place with changing noises, colors and the video edition like the conditioner tools, one of their most traditional works taking about performativity. But they also exposed *Mar Dulce*, a performative piece that proactively uses technology as part of the narrative, using screens and video fragments to change the space and time perception of the spectator, making harder to understand where the stage ends, and the video begins. *La Muerte* is other piece literally taken place in a Zoom video call, so no stage is needed. Their art reflects the reality of their society in their point of view. According to them, arts shouldn't be enclosed to the traditional standards anymore, even our language referred to art should change, and need to choose multidisciplinary to look forward to new perspectives inside this ever-changing society (Sánchez Mota and Zeivy, 2021).

As Graells said (1994), the todays theater needs to change to give multiple points of view, so the space -the theater as an architectural piece- and the performance -the theater as a dramatic art- complement each other to create new relations between artist and spectator and the surrounding environment, new ways of making art. The today's performance space needs to be different for giving live to new expressions of performative art, avoiding to the most being a limit to the artist but a possibility. Even considering that the physical space is not the only one that could be used, like Sánchez Mota and Zeivy work exemplifies, and that the rest of our senses need to be extimulated in different ways. If multidimensional and experimental architecture is required in ways never explored before, is a key point to known new ways for designing architecture, using technology as the number one ally to achieve a non-traditional workflow and design.

Section 2. Computational Design In Architecture

Nowadays humanity is living the fourth industrial revolution. It was said in the first section that society evolves, and art and architecture do it so. Another thing that is in continuous innovation is technology, and the relationship of architecture with the industrial production processes make it close dependent on scientific and technological realities. Parametric Design [PD] is the most popular term in architectural tendencies, but is Computational Design [CD] the term of interest for this thesis, which exists before the computer and goes beyond PD.

The term CD can be traced before the use of a computer for design. The most famous examples are the bubbles experiments of Frey Otto for his tensed structures, or the geodesic domes of Buckminster Fuller. They were applying the term compute, that means "reckon or calculate (a figure or amount)" (Oxford, n.d.) making physical experiments that gave them a certain amount of data to make predictions. As key word of investigation inside the architectonic field, the CD appeared for the first time in the 60s, focused on futurist theories of artificial intelligence and cybernetics; but in the 80s CD was consolidated as an important field for architecture, hand to hand with the boom of the first CAD tools (Caetano, Santos, & Leitao, 2020). Today, in words of Terzidis "CD techniques applied in architectural design surpassed the automation of drafting tasks" (2004, as cited in Caetano, et al., 2020). It has reached such amplitude of realities in architecture that goes from the capacity of having real time data like in BIM projects, to digital fabrication and machine learning, inviting the today's architects to also became programmers.

Computational is no for computer but for compute, to analyze big amounts of data, something that architects already did. The computer, as a tool and a machine, have the potential of making this calculation processes faster and accessible for every user. In consequence, CD gain terrain with the digital evolution of technology. Like previously mentioned, these technological advances should be used in favor of architecture to do more complex spaces that could satisfice complex needs, like performative arts. The possibility of taking big amounts of data to an architectural design implies the capacity of analyze the design in multiple ways, to achieve the multidisciplinary factor needed to the desirable new space of art. It would be possible to evaluate multiple arrangements of stage-seats, analyze the acoustics, simulate different mechanic objects, and decide the aesthetics of the building, everything in a digital environment, one hundred possible to take to reality.

Clarification Of Terms And The Solution Problem Relevance

The computer came with the first CAD programs and a process of digitalization. A lot of analogue activities started to be done in a computer: write, make counts, draw; an architectural design wasn't the exception. Even if some authors link CD with the use of digital tools for design solutions, is not, that definition fits the Digital Design [DD] concept (Caetano, et al., 2020). DD, then, needs a computer to work, CD doesn't, but the machine helps the processes of design related to data. Inside CD -as shown on Figure 6- are more terms that refers to certain computational approaches. Even if PD is the most popular and the one that makes Google deliver hundreds of images of crazy organic forms, PD is not about complexity and complexity is not parametric always. Other terms are Generative Design [GD] and Algorithmic Design [AD], linked with form finding and script development. Is easy to confuse these terms and necessary to clarify them for the development of this thesis.

Using the Vern diagram -Figure 6- and definitions of Caetano et al. (2020) as guideline, the terminology would be the next way:

- CD is the design based in the manage of data to take decisions, doesn't matter if they are focused in optimization, generation, or evaluation of forms. Uses the computational advantages of machines to look for solutions faster. PD, GD, and AD are part of CD and DD mix.
- PD involves the use of parameters in the design process. This goes from the BIM tools that calculate and give information per object or project, or the input data for an algorithmic process. PD can be applied even in an analogue way if, for example, the parameters are proportions or geometric conditions.
- GD depends on the use of algorithms for the design. The result can be controllable or not and is linked to the creative capacity of the machine.
- AD is necessarily inside the GD, but it can be or not inside PD, the only condition for AD is that the result needs to be traceable inside the algorithm to know why the computer took the decision it took. One example is the evolutive algorithms that show the properties of every element and generation individually.

Taking these definitions in count, this thesis would use the CD design approach inside the DD, making the whole process digital, while using AD inside PD for control of the final product properties. So, it is in the black section of Figure 6.

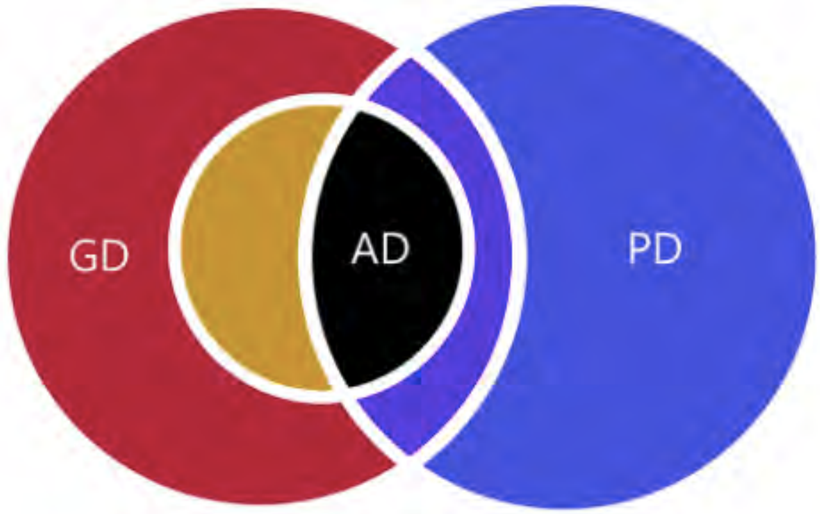

Figure 6. Vern diagram of Parametric, Generative and Algorithmic Design inside the Computational Design (Caetano, et al., 2020).

CD had been used in the last decades for every type, size, and complexity of projects. When the Parametricism of Zaha Hadid and Patrick Schumacher gain popularity because the complex forms they created, PD started to be wrongly confused as a synonym of Parametricism. The architectural projects of Zaha Hadid uses the people's perception as her parameter, so her buildings can give different perspectives for most point of views; the complex forms she created are parametric, that's true, but only the use of this parameter in specific is Parametricism (Lee, 2015). The real power of CD is not only in the creation and fabrication of complex forms but in the analysis of complex problems to give solution to. As Navarrete (2014) explains, PD -extended the term she uses to CD- is the key to resolve architectural pieces of multidimensional purposes in an era -XXI century- caring for social and ecological responsibility and interdisciplinarity. So, CD becomes a necessity to satisfy the design of a piece of architecture that should respond to an environment that is not only urban, but human, cultural, social, ecological, artistical, and the list can go on and on. That is why is relevant its use in this thesis, not only to achieve the three desirable dimensions for artistic spaces -hearing, sight, and beauty- but for the interdisciplinary and variability of the building and the complexity of the need it looks forward to giving solution to.

Section 3. Relevant Concepts For The Proposal Design

Knowing that CD have multiple subcategories suggest that the opportunities for selecting one design process are infinite. Because the complexity of this workflows and the great variety of tools for disposition, is not a surprise that Parametricism caught the attention of many eyes, being the complex geometries the most obvious product of a complex process. However, CD and the degree of complexity of the workflow is not defined by shape itself, but for the desirable results. The tools to use and the steeps to follow will be notable different from a quick environment analysis to a deep geometry-structure optimization. According to Giancarlo Di Marco (2021) the workflow, no matter the nature of the project, should be divided in 8 points: 1. Defining the design problem 2. Stablishing the goal to achieve 3. Pre-thinking the system or how the solution will be offered 4. Delimiting the parameters 5. Defining the system -script- and the limits -parameters in processable data- 6. Evaluating the results 7. Experimenting with the definition 8. And pushing further the model. These eight steps will rule the process using CD and determine the best path to follow.

The design problem of this thesis is a Black Box Theatre [BBT] for the UDLAP community and will be explained further in the Design Process chapter. The current section and the next one -sections 3 and 4- will present the parameters or dimensions to take in count in the design solution, using as a starting point, and as explained above, the desirable characteristics for a contemporary performing space. This kind of buildings are determined by the relationship that exists “between the performance, the spectators, and the theatrical space: performers need to have their audience, the audience owes its presence to performers, and their communication occurs within the performance space" (Blazekovic, 2017). The qualities of the space then get more subjective and use the human factor -artist or spectator point of view- as a key point to evaluate if the architectural site -the physical space- responses correctly to the performance needs, beyond the more objective and measurable ones mentioned in Section 1, like the acoustics or the stage-seats arrangement. About this more human and subjective relation between performers, audience, and space, Leitermann (2017) writes:

> The overlapping of real and mythic space within a theater can be expanded upon: the theater building exists, in physical space, in relationship to a city or landscape. The stage (or performance area) is a physical space in which the actors move; it exists within the theater building and in relationship to the audience area. The scenographic space occupies the physical stage space and suggests a fictional space in which the characters of the play live. Layered on the scenographic space is the dramatic space created by language and theater craft. This dramatic space encompasses both the space in view of the audience and the fictional world "off stage.". (p. 4)

Leitermann is conceiving all the layers of the performance space from the most technical and functional to the most artistic, almost metaphysic, one that create the whole view of the building and performance in a continuous dialogue, where the audience and the artist go from one layer to another without breaking this communion. The quality of the space, then, is subjective inside the relation artist-spectator-space and the performance itself. But to qualify this subjectiveness to give a north to architectural design is necessary to have some measurements, or parameters, as standards. These ones will have a close relationship with human senses but can be translated to data, information that can be processed by a computer.

The first parameter will be acoustics, as one of the main topics for performative spaces discussion, and for being the closest to hearing, the sense that first attracted the attention of humans into caves. Following with the next one mentioned, the sight would be translated into isoptic, as the measurable way to evaluate if the spectator has a free sight line with the artist. Also referred to the sight, illumination is other aspect that can be measured and is relevant to the performative arts. Finally, the body space experience, that could be linked with touch, can be analyzed by pedestrian fluxes. These four parameters will be the subjective elements of the human aspect for the performance space, capable of being evaluated in every configuration the BBT may have.

Acoustics

From the cave and the Greek amphitheater to the Theaters and Concert Halls, the main topics of acoustics in performance spaces are reflection, echo, reverberation, and absorption. About reflections, Morales Alanis (2012) recommends that the space needs to have folds on walls and ceiling -Figure 7- to avoid parallelism in sound, help diffusion, and eradicate echo; about absorption, is recommendable to have an absorbent material in the opposite wall of the stage, to avoid unwanted reflections back. Is important to consider that these two aspects -reflection and absorption- are for endstage theaters, and it could be not necessarily favorable to other configurations the BBT may have, like the ones in Figure 16. About reverberation, Morales Alanis (2012) provides a graph -Figure 8- to know the range of seconds admissible for intelligible sound according to the volume of the room and the nature of the building. Reverberation, however, should be a parameter capable of change for the specific performance requirements, as discussed in Section 1.

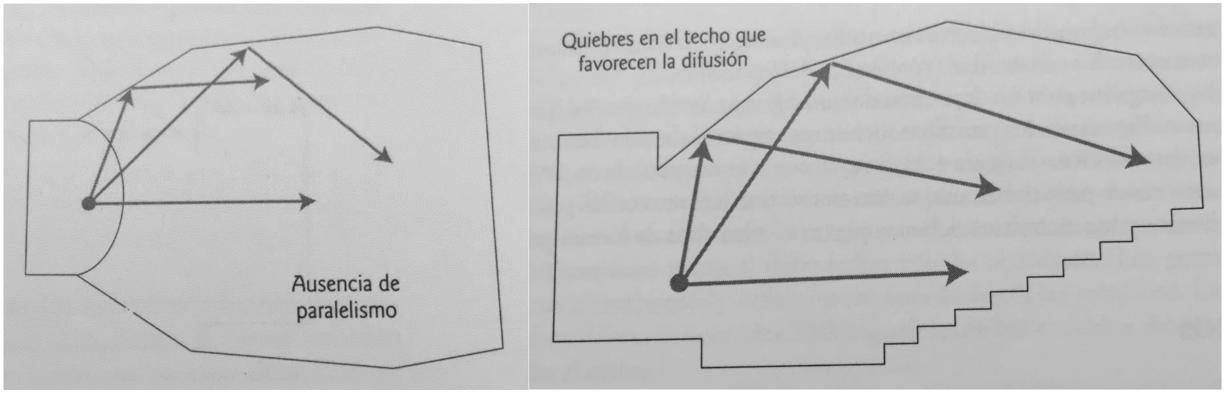

Figure 7. Reflection behavior in folded ceiling and walls to avoid parallelism of sound and help diffusion (Morales Alanis, 2012).

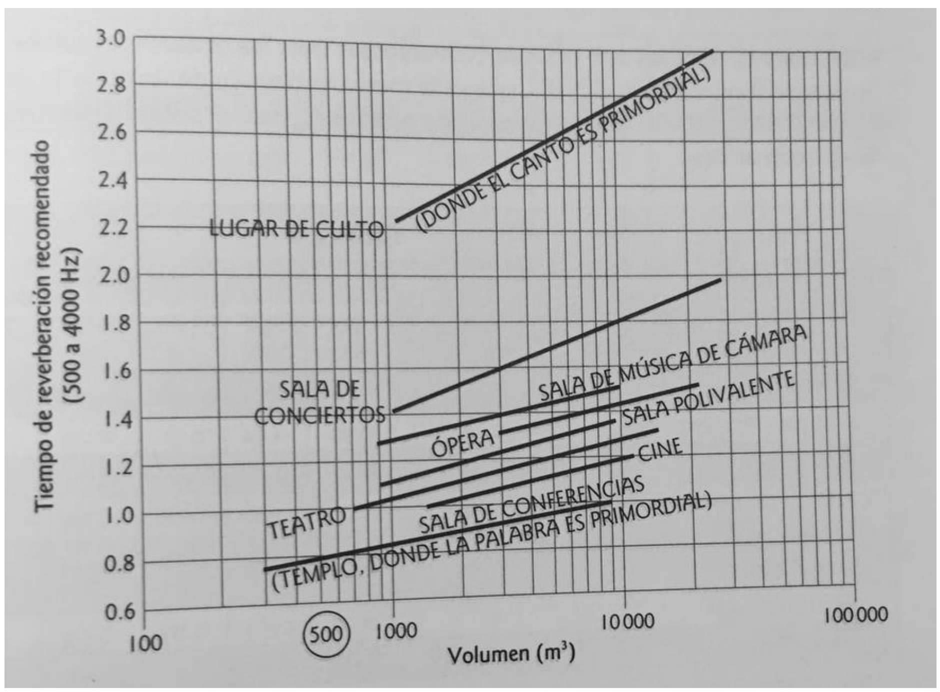

Figure 8. Reverberation time against volume of the room according to the type of building (Morales Alanis, 2012).

Isoptic

The performing space, for its natural relation between artist and spectator, needs to cover the necessity of having a good and comfortable view from every seat to the stage. The calculation of the isoptic curves, vertical and horizontal, allows all the audience to have total view of the performance, taking in count that the human eye have a sight of 180º (Iñiguez, 2021). The vertical isoptic -Figure 9- determines the steps height and is calculable with the next formula:

$$h' = (d'(h+k)) / d$$

where h' is the height to the eye -h for the row behind-, d' is the distance between the spectator and the base point -d from the row behind-, and k is the distance from the eyes to the forehead (Iñiguez, 2021). This simple calculation allows the spectator sight to be blocked by the head of the person seated in front. For the horizontal isoptic, that determines the radial distribution, the diagram of Figure 10 shows the maximum angle of vision of the first and last central spectator - 110º and 30º- (Iñiguez, 2021). Even if the complete sight is of 180º, using the hole range or leaving it to narrow will be uncomfortable for a long-time lapse. These calculations could be done in any configuration the space may have, taking in count that the seats will not change height or separation between them -Figure 35-, only the block or rack position around the room.

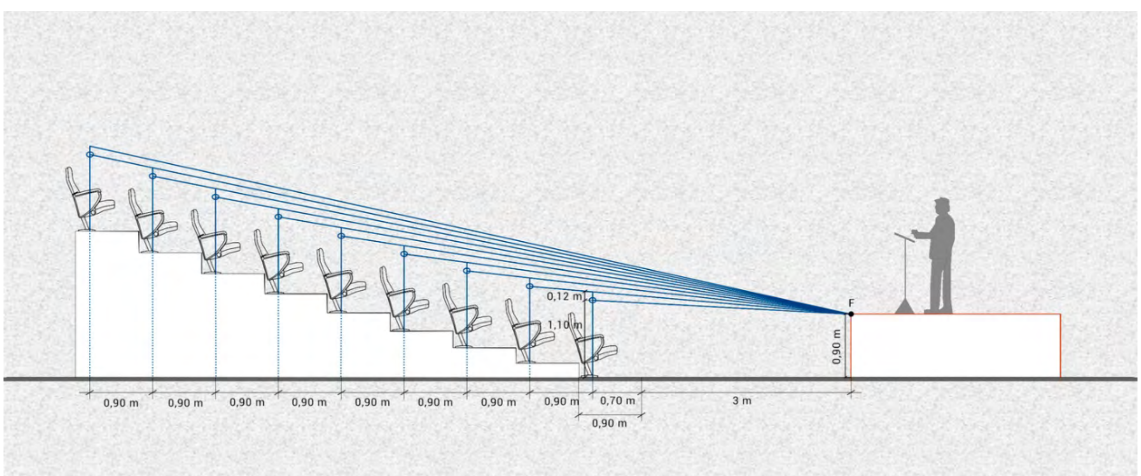

Figure 9. Vertical isoptic calculation diagram (Iñiguez, 2021).

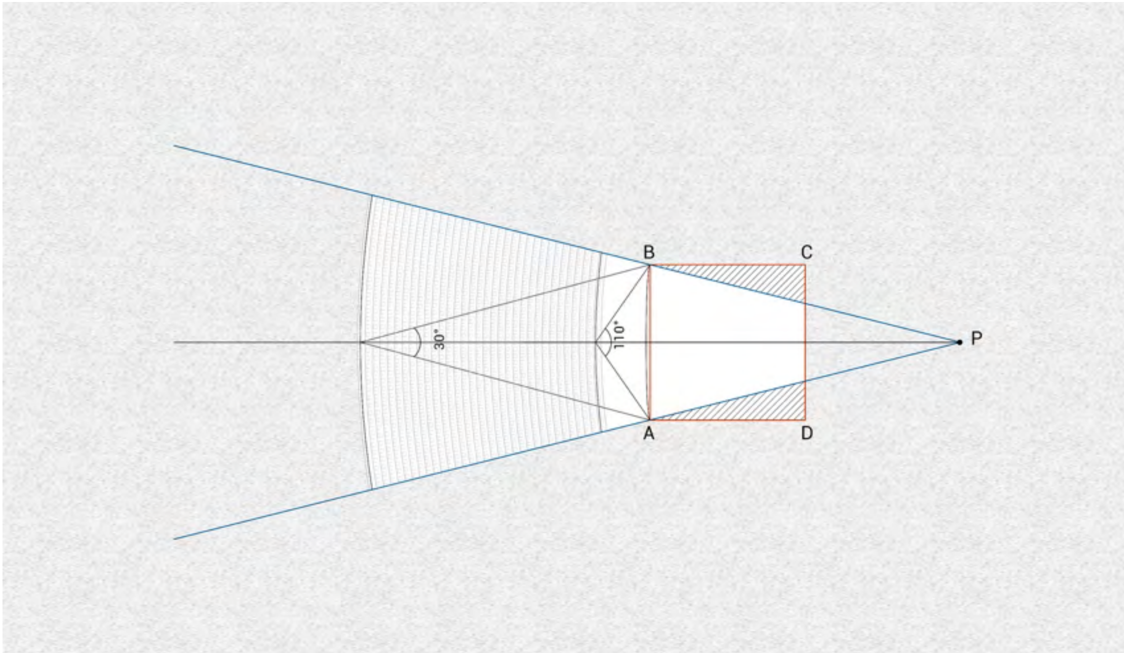

Figure 10. Horizontal isoptic calculation diagram (Iñiguez, 2021).

Illumination

Lighting plays an important role inside the performance space. It fulfills the basic need of light so the human eye is capable of see and users can move with security around the place, but it also can be used for the performance benefit in a dramatic way. Reid (2001), in his *Stage Lighting Handbook*, writes that "light quantity is only the very beginning of the stage lighting story. After (but only after) basic illumination has been provided, light can start to fulfil a more exciting role as a dramatic tool", and that "balance is the key to the amount of light required; brightness is relative rather than absolute". He talks about the light needed to move through the space while nothing is happening in stage, and how the effects, objects and level of lighting could affect the performance perception in the audience; is very important to consider that the iris is susceptible to previous amount of light to receive a new level, so changes in lighting need to be able to be gentle with the human eye. Lights, as equipment and physical objects in the building's installations, need to be taken in count in design according to the wanted possibilities of the space illumination. For example, the BBC (n.d.) have an article referred to light types, where spot, Fresnel, flood, and strobe are compared according to the dramatic effects that produce each one of them. Having a variety of lighting opportunities makes the performance space capable to support more performing art forms and expand the experimentation options.

Fluxes

At least four types of fluxes exist within a performing space. Three because its users, artist and spectators that converge in the stage but from different positions, and the staff that serves the performance form outside the stage; and the fourth is in case of emergency, when everyone needs to leave the building. Leitermann (2017) says that the program of a theater -or any other performing space- is a challenge because the multiple entrance for the different users and the quantity of rooms, where "each individual room […] has critical relationships to other unique rooms", so "accommodating the optimal locations and adjacencies of these rooms is a challenging task". If is already a challenge to define the logic of how every user gets to every room, exit, seat, or stage, in a static building, is even more in a flexible one like the BBT, where there is more than one possible configuration. The stage, as the heart of the performing space, determines the behavior of the rest of the building, so the whole architectural building needs to be prepared for, at least, four types of fluxes multiplied for n number of configurations that the artist imagination may proposed.

These four main topics are the standard starting point of the parameters of the design for the BBT for the UDLAP community. In the Design Process chapter, the definition will be explained along the specific decisions taken from each parameter and the way the free configuration of the space got measurable as well to the algorithm to work in analysis and optimization of the dimensions design.

Section 4. State Of Art: Black Box Theaters

Transformable spaces for art are a necessity today. Section 1 lead to that conclusion ending the historical review in the first attempts of the theater-caravan, and Section 2 and 3 set the bases for accomplish its design through technology. However, for the design of a BBT is necessary to get deeper to the modern and contemporary successors of this experimental spaces, as a formal typology, and the moment a computer meets its versality. The concept is born in the XX century, as a response for the XIX century rigid proscenium theaters, so the avant-garde groups started to use wherever space they could to make flexible presentations, and two thinker's postures, Craig and Appia, that looked for a mostly empty space where everything that really matters is the experimentation of modern performance (Kerem Özel, 2017, Hannah, 2003). Architecture of classical theaters no longer fitted the possibilities of performative arts, so it was necessary to look for typologies that free the space in benefit of the performance. A BBT first definition is a type of theatrical space

> […] which is also be called as "experimental", "flexible" or "adaptable" theatre […] is a rectangular, flat and all-sides black space, where the relationship between the acting and spectating areas is not fixed in advance and could be defined over and over again in each new production. (Kerem Özel, 2017, p. 66)

BBT is understand as a container, without personality or intention, just to delimit the space where performance can happen; all the attention is on what's happening in stage.

The BBT needs to be reformed to match its essence of versatility -coming for Modernity- in a contemporary approach, is impossible to build a BBT for Modern tendencies when performative art keeps evolving. Some theories, as the one of emptiness and performativity presented by Hannah (2003) and Kerem Özel (2017), are different approaches to re-interpretate the BBT. The first one talks about the void, the abyss that is "permeable and infinitely transformable" to the service of performance; but is also a material space that needs "to be re-configured as an essential and active space of theatrical production, a "space that breathes, swells, sweats, bleeds and breaks", that lives like the art that contain, is not only a vessel but a complement (Hannah, 2003). The second one is closed related to the network created by artist, spectator, and space explained above. This one explains that performativity is "the interrelation between moving bodies and the spaces which determine and manipulate these movements, in other words, between the act and the architectural environment of its context is inherently bounded", making the performance capable to use the space to interact with it, not only to fill it; and the space have its own identity while "unfolds in indeterminate ways, in contrast to the fixity of predetermined, programmed actions, events and effects", the space serves what happens inside it but its flexibility is its own identity (Kerem Özel, 2017). The contemporary BBT is not the black flatted box that provides a stage, but a complex building that gives a void to fill and is flexible and capable to have live itself and within it, is an architectural piece and the performance is the complement that serves. The object of this thesis, then, looks to avoid the neutrality of the traditional BBT and give the architectural space a capacity to evolve with the art that frames, using the human senses as qualifiers of the space, and return to the desirable factor of beauty, as the architectonical character of a building, without matters its own nature, as part of the urban landscape.

Emptiness and performativity are qualities of a complex subjective space, there lays the relevance of using CD in the design of a BBT, to transform this subjectiveness into measurable data to work with. Transformable performing spaces need to respond to multiple factors that impact the performance and have specific solutions to do it. The most significant example of this is Octave 9, focused on musical experimentation, where the absorption of sound is the key factor; the space "can acoustically and visually disappear—an experience that responds to programming, rather than the surroundings" (ArchDaily, 2019), quality given by the curtain that optional enclose the place and the different seats arrangements - Figure 12- that the circular plan with only one column allows. The CD lays in the ceiling that is a sculptural one composed by cells -Figure 11-, rather than the hanging ceilings of a BBT, each panel for the recycled-PET made system was calculated, fabricated, and constructed using a CD logic (ArchDaily, 2019, Schuler, 2019). This space, even if focused only on music, is the example of a performing space that was design and optimized to resolve a complex problem: good acoustics in a circular space that have versatility in its arrangement. Octave 9 is a contemporary empty but not identity-less room that provides flexibility while giving a solution that can be totally measurable to work with. The place is architecture itself, not only a void, and at the same time it has this blank space to be fulfilled, to exist on its own and to serve to the art that was conceived to contain.

Figure 11. Octave 9 (Photo by Benjamin Benschneider in ArchDaily, 2019).

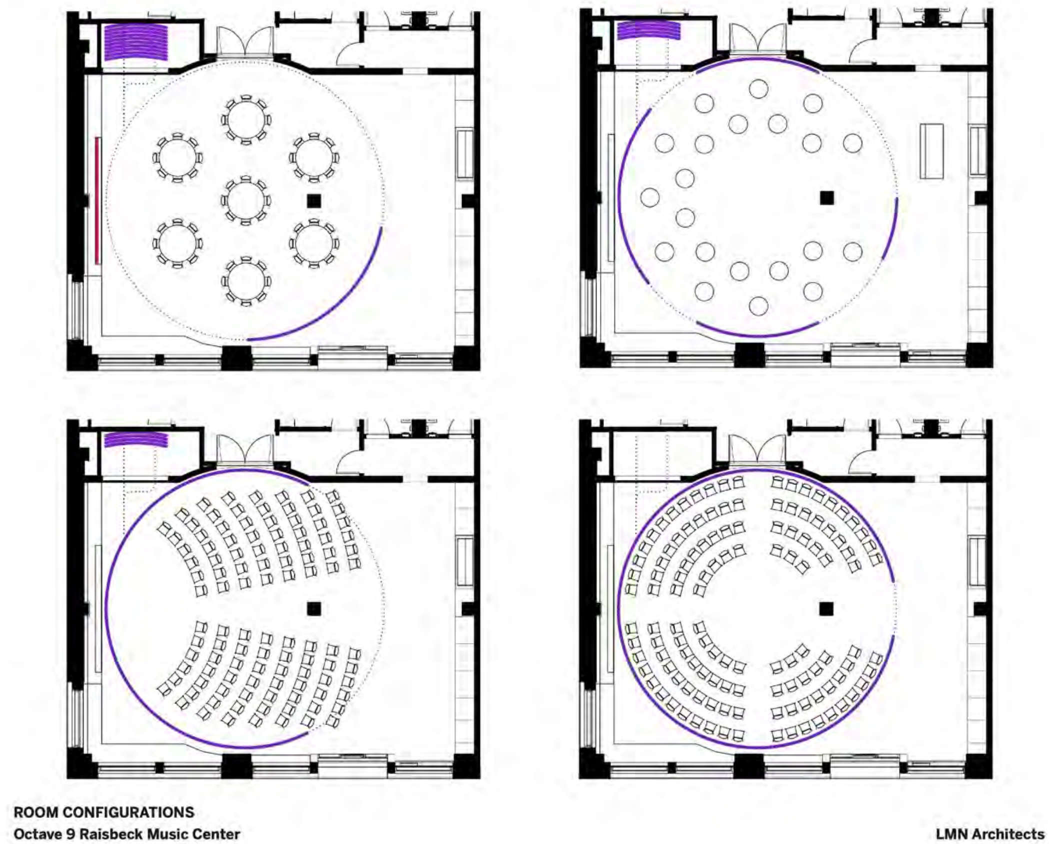

Figure 12. Octave 9, Configurations (ArchDaily, 2019).

Mexican Analogue Cases

Inside the Mexican context, there is not examples of CD applied in artistical spaces, even less in a BBT. But there are some performing spaces in the country that can help to understand the logic between the stage-seats disposition, the experimental performance, and the needs of a transformable performing space. Those are glances to the growing need of other kind of spaces in the Mexican art scene, that, as mentioned in Section 1, is also changing, and demanding not fixed stages. Diana Studio is taken as the similar version of the Performing Arts Halls of the UDLAP, Room 3 is a manually transformable space that does not use the endstage configuration, and the Polyvalent Theater the one to have mechanic systems that transform the stage directly. All of them with desirable characteristics for the design problem.

Diana Studio -Figure 13- have a capacity of 120 to 180 spectators -taking in count that people can stay on foot during some presentations-, thought as an intimate place for local art in Jalisco, is a classic BBT with folding chairs that can fill or empty the space that consist in an endstage theater in a four black walls room (Teatro Diana, s.f.). This place is like the Performing Arts Halls of the UDLAP, that just to have folding chairs until Civil Protection highlight that characteristic as dangerous, so the seats ended up being fixed; for the BBT that will be design in this thesis, the seats must be fixed as a client request (Sergio Castro, director of cultural diffusion UDLAP, personal communication, March 10, 2021). The challenge of the fixed seats in a transformable BBT is one of the main concerns of the object of this thesis. However, the client pointed out later the desire of being racks of retractile seats -Figure 33-, not necessarily fixed to the ground but to a movable structure -the rack- that could be move around the place (Sergio Castro, personal communication, March 15, 2022; Eduardo Espinosa, audiovisual technician of Cultura UDLAP, personal communication, March 17, 2022). This liberty of movement allows multiple configurations inside the BBT, only conditioned by the number of independent racks.

Figure 13. Diana Studio (Teatro Diana, s.f.).

Room 3 -Figure 14- is part of the Conjunto Santander in Guadalajara. This space was conceived to respond to the local necessities of experimental production of art, with a capacity of 430 people and a variable stage that goes from arena to traverse using the basic principle of hiding one side of seats with a curtain, allowing the presentation of any kind of performance that needs spectators in more than one point of view (Conjunto Santander, s.f.). Even if there is not clear information about the acoustics of the place, analyzing the room is relevant the presence of folded walls for reflections, the ceiling gives place to spot and flood lighting systems, and the fluxes clearly go between the four blocks of seats. For the proposal, the manual principle to hide some seats will be taken back by taking away the racks. About acoustics, the ceiling will play the main object of analysis, and the walls will not be considered but will leave a future path of investigation. The grid for illumination will be present as well as the multiple doors to go in and out the stage for performance purposes.

Figure 14. Room 3 (Conjunto Santander, s.f.).

Polyvalent Theater -Figure 15- is part of the Art Centre of San Luis Potosi, with a capacity of 400 people, it was thought as a transformable space from the beginning, reason of the retractile mechanic seats that allows the stage to gain deep, going from a classical endstage to a thrust like without lateral seats, because the stepped out stage -as can be seen in Figure 16- for plays of bigger format in a moderate size architectural piece (Secretaría de Cultura de San Luis Potosí, 2019). This place is the example of classical Italian theaters logic applied to a new transformable space, where the mechanical systems -inspired by the Baroque- allow the performance needs to make an important decision: the size of the stage it needs to happen. That decision power will be explored in the BBT proposal by the rack arrangement, where the balance of the decision lays in sacrifice performance space to have more spectators, or vice versa, leaving less spectators with a bigger stage. The minimum areas of the BBT will be one of the main conditioners, or limitations, for the artist will.

Figure 15. Polyvalent Theater while the stage is stepped out (Secretaría de Cultura de San Luis Potosí, 2019).

As conclusion, the BBT for the UDLAP community should be a place that allows the community of artist to experiment and expresses through new ways of art, an intimate space. The flexibility, as seen in the analogue cases, will come from the configuration capacity and the relation stage-seats that will flow free thanks to the rack solution, giving the artist the opportunity to work with classical scenarios as the ones of Figure 16, or explore new and diverse relations of space-artist-spectator. Thanks to the use of CD, the architectural piece will not only be a container of art but a live space that responses to technical as artistical needs, such are acoustics, isoptic, illumination, and fluxes, cause the capacity of the model of being analyzed in each aspect in every desired configuration. However, the arena one will be the lead configuration for base analysis and optimization. The product will be a BBT, but not a flat impersonal one, it would be a performative space that provides the performance with a void to experiment with, so the space will not be a conditioner -only in this physical size- of the creative capacity of the performer, but a support as an evolving space that will serve multiple generations of artists in their own evolving art, as the society changes, naturally, through time.

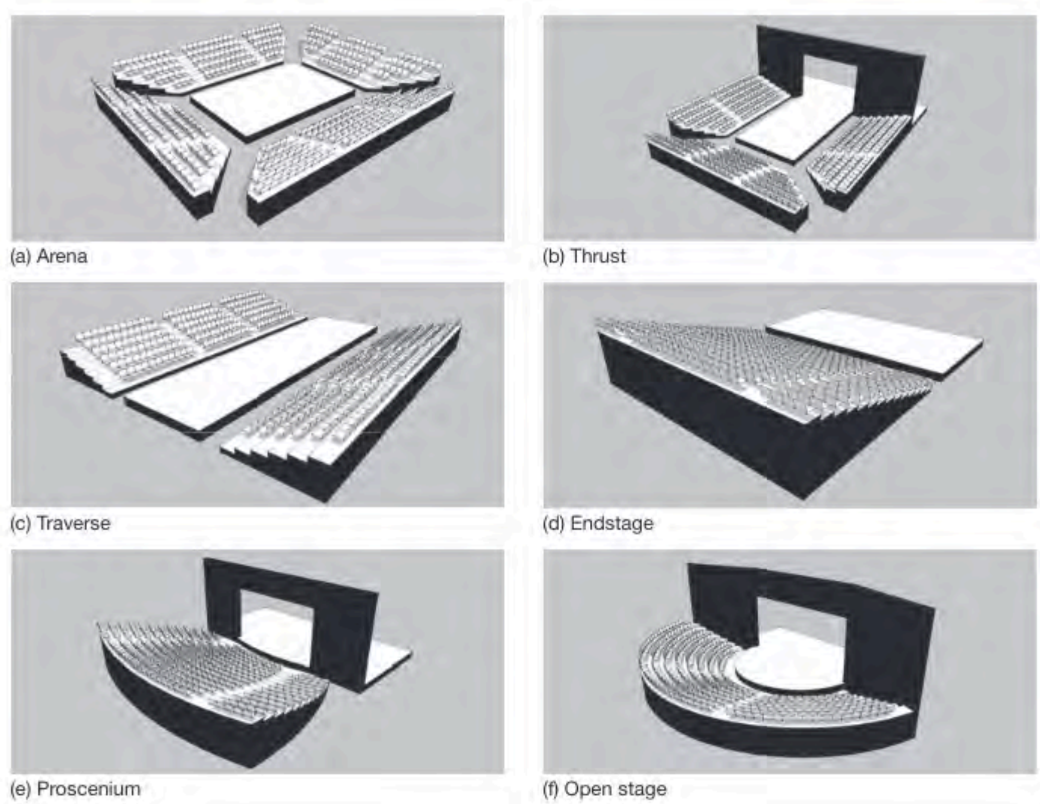

Figure 16. Drama Theater Forms (Leitermann, 2017).

Methodology

Section 5. The Workflow

The design of the BBT for the purpose of this thesis implies the application of a computational logic based on a digital environment. It mixes the traditional design process for decision making as a start up and then the inside-outside methodology through parametric tools to evaluate the new steps of design. Many computational designers around the globe, such as Giancarlo Di Marco, César Saldivar, and Alicia Nahmad, had rescued the idea that technology does not takes away the analogic tools, such as drawing, form the architectural practice, but complements it. As explained in Section 2, Di Marco (2021) highlights inside his eight steps the process of drawing and thinking before starting with the algorithm. Nahmad (2020) defends that technology and machines makes smarter architecture, more efficient with better possibilities, but always taking in count the social dimension, that would be always human. According to her, is necessary to mix the human-social thinking with the technological logics of new materials, machines, and platforms, even changing the architectural language, as part of this never-ending evolution that had been previously mentioned (Nahmad, 2020). The architectural object, then, should obey in its solution decisions that were made on paper by the architect, for volume and configuration expectations, site response, the architectural program, and other base decisions that would be the equivalent of the design problem inside the Di Marco steps. Before the first line of code, the outcome is already known.

The base is decided by the architect, but the machine, the algorithm, will make further decisions. The inside-outside methodology that will be used implies that some aspects to analyze for the decision-making process, are going to happen from the inside of the building to the outside, for a coherent design that shows from the outside what is really happening in the inside.

Saldivar (2020) explains this as the associative logic of CD, where all the parameters respond to each other and changing one variable will recompute the possible solutions, without breaking the stablished relationships. He also talks about the use of the form making [FM] and form finding [FF] processes, where the first one is a series of parameters that would give the expected geometry, and the second is the solutions that the computer will offer to accomplish the given parameters (Saldivar de Lira, 2020). Both would be used in the design process of the BBT, and both need to be controllable by the architect, even if the creativity of the computer or algorithm is applied. Di Marco (2021) mentions about this that the error in the algorithm could case beautiful outputs, interesting geometries, but the control above everything is the key to make smart CD. The ceiling and the outside structure of the BBT will be the FF aspects of the project, while the rest will be FM, everything resolved through parameters given by the architect and interpretated by the machine.

Even if the eight steps of Di Marco are applied, the sequence of decision leads the model to jump from one software to another and to be manipulated with different tools, complements and plugins, as seen in the workflow -Figure 17-. The process is by steps but not linear, and the way is explained in the next chapter will not be chronological. The starting point are the paper decisions of the architect and the rest the action field of technology taking advantage of computational capacity. Going from the Grasshopper [GH] and Rhinoceros [Rhino] environment to the Revit one, according to needs of the next step of design.

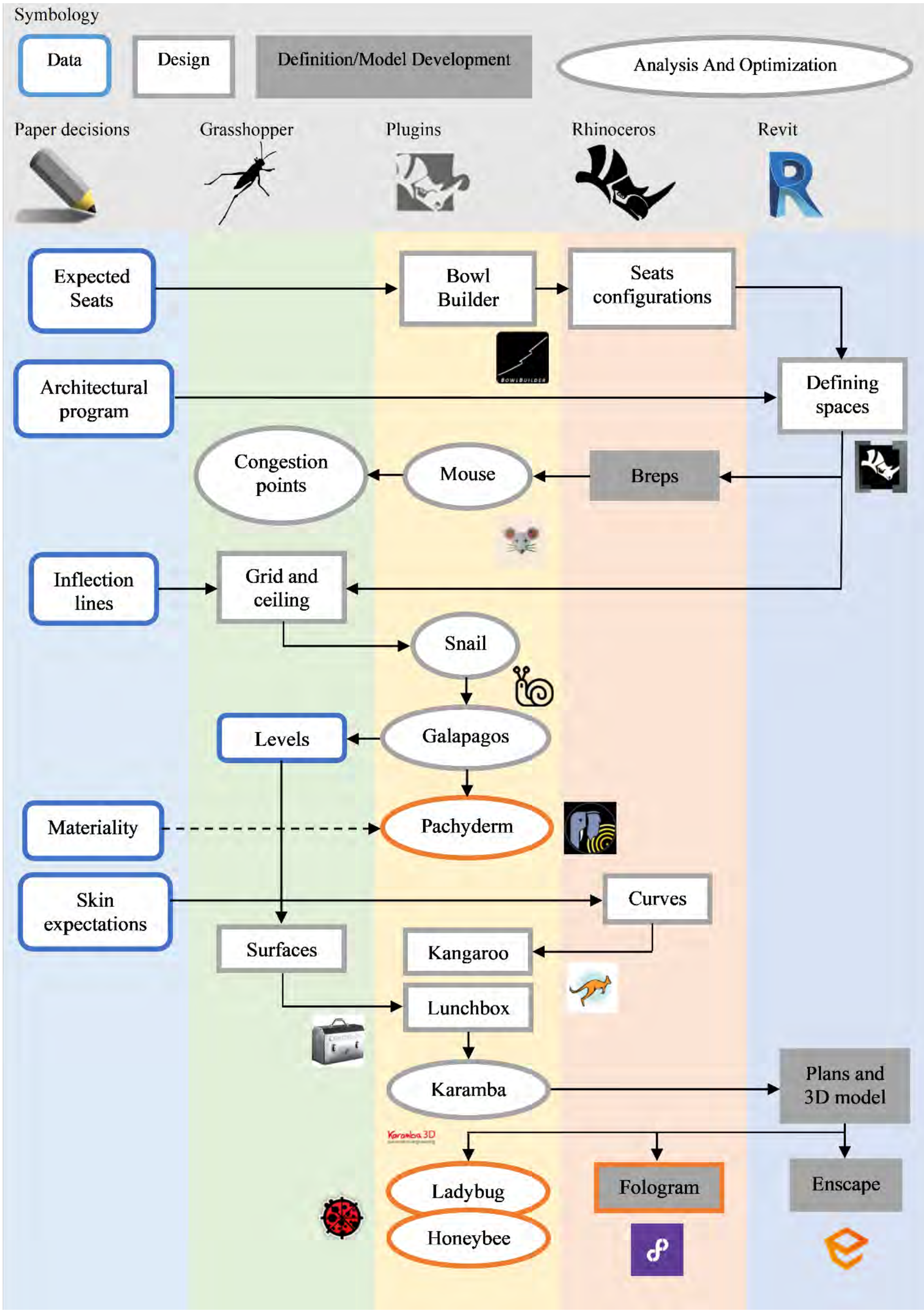

Figure 17. Workflow (own illustration).

Section 6. The Definition

Everything in the CD process needs to be organized and structured. Following the recommendation of the computational designer César Saldivar (2020), the definition -also known as script- needs to be clear in its organization and easy to read. Table 1 shows the color code of the definition of GH, used to locate the type of decision or data that each part of the algorithm works for. The steps with an orange contour where not executed in this thesis, are only a suggestion for further investigation. Figure 18 is the definition itself, where the color code can be observed. The parameters or inputs for each block are at the left side, form where the definition is started to read, and then spreads like a tree.

Table 1. Color code for the GH definition

Color name	**Color sample**	**Definition code**
Yellow		Use of a plugin
Green		Support definitions that give important information for the plugin usage
Red		Normative or parameter check
Purple		Geometry generation inside GH or Rhino
Blue		Geometry import/export to Revit

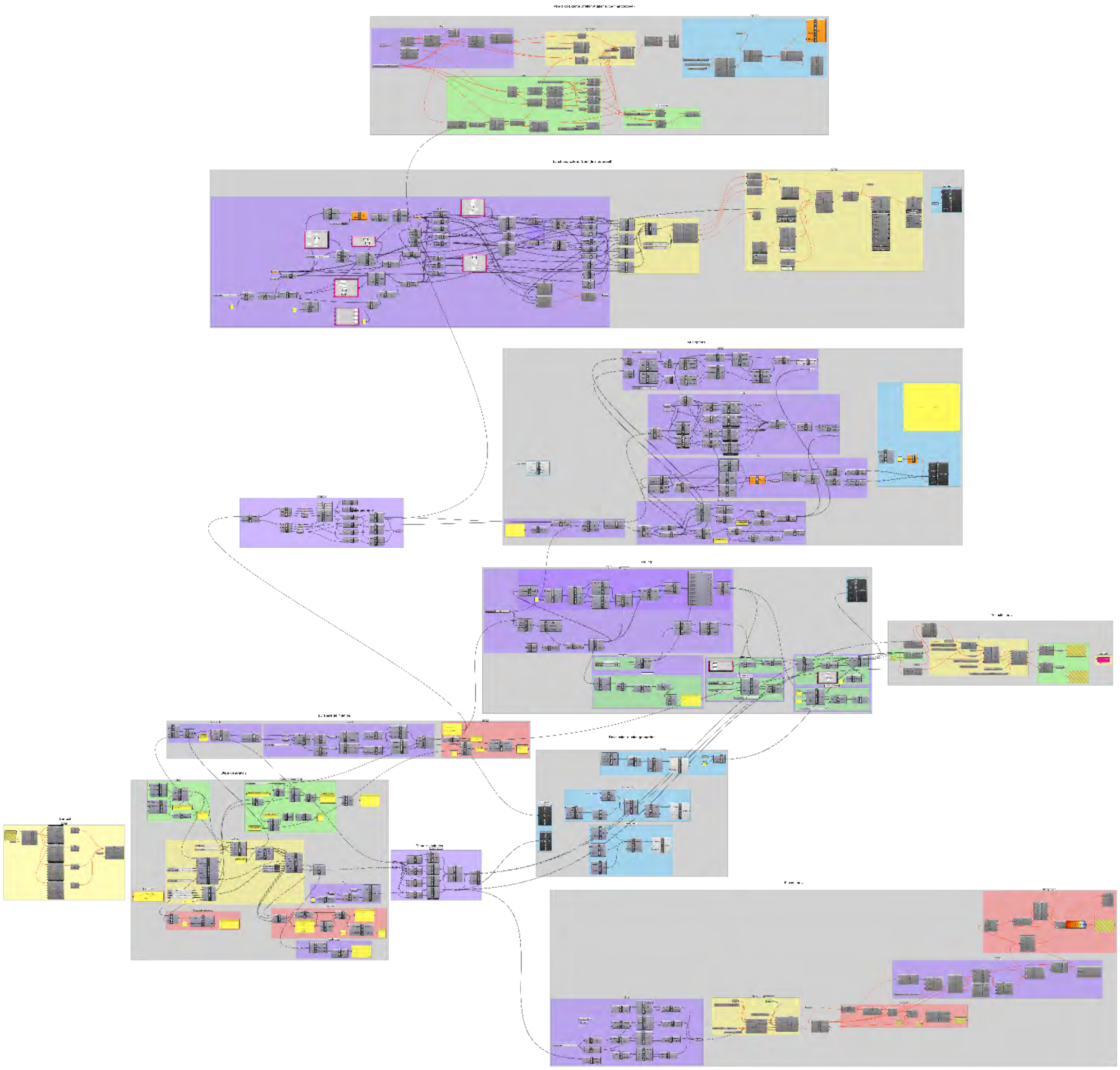

Figure 18. The definition (own image from GH).

Design Process

As explain in the chapter above, the design process is not linear, so the next sections are not necessarily consecutive. Section 7 and 8 would present the steps 1 and 2 in the CD process: Defining the design problem and stablishing the goal to achieve. Sections 9 and 10 would make steps 3 to 5: Pre-thinking the system or how the solution will be offered, delimiting the parameters, and defining the system -script- and the limits -parameters in processable data-. Finally, Section 11 would follow steps 6 to 8: Evaluating the results, experimenting with the definition, and pushing further the model. Going from the site analysis to the result of the conceptual project and following the inside-outside thinking, the design process will be explained within its jumps in the workflow but following those steps.

Section 7. Site And Context

Architecture should be thought from where is going to be. The architectural design of any building needs to consider the site geographic, social, and urban conditions, with all its dimensions, to project a piece that will only fit perfectly there, nowhere else. However, sometimes is possible or necessary to design with some flexible conditions. For the BBT, object of this thesis, some conditions were speculative, giving the possibility to adapt the project according to the official master plan of the complex or a new location if the analysis below is taken in consideration for future decisions made by the institution.

The BBT for the UDLAP was conceived as one of three buildings that would conform a cultural complex inside the campus. These three would be an expositions center for 3,000 people, a traditional Italian theater for 900, and the BBT for 400. No further information, but the site analyzed in the next section, was given to the development of the proposal, so the first speculative condition is the surface needed for each building. The square meters required for each one, in order of mention, are 4,000 up to 5,000, 1,500 up to 1,800, and minimum 1,000, according to the comparison of similar built spaces inside the country broken down in Table 2 for the first two, and the key point in the *Construction Regulations for the Municipality of San Andrés Cholula* (Gobierno del Estado de Puebla, 2017) about the minimum of 2.5 sqm per spectator in show areas for the BBT.

Table 2. Comparisons between capacity and square meters of similar spaces.

Theater	Capacity	Square meters	Conventions Center	Capacity	Square meters
Julio Castillo Theater	1,000	1,500	Campeche XXI	1,500	1,639
Theater of the Insurgents	959	1,800	Cancún International Convention Center	3,000 up to 5,000	4,700
Aldama Theater	849	1,000	International Congress Center of Yucatán	6,000	5,450
Hidalgo Ignacio Retes Theater	816	1,300	Expo Chihuahua Full -and Sala A-	4,720 -2,700-	6,363 -2,106-
			Convention Center William O. Jenkins	3,500	5,489

Note: some surfaces calculations were made by satellite maps applications and correspond to the exhibition/convention area only, most information was taken from Top Adventure (2020) and the Mexican Government (n.d.).

The site destinated for this complex is located at the east side of the main entrance of the campus and have an approximate area of 12,500 sqm, leaving almost 5,000 sqm of free space between buildings. However, as seen in Figure 19, the site has a high density of woods and an irregular form, making problematic to fit the three elements, in addition to the preexisting buildings to the south of the site -administrative area- that limits the access to that specific piece of land. Two different configurations of arrangement for the three buildings where made -Figure 20-, but to fit all the program wanted for the complex, the woods would need to be totally eradicated -red spots-, going against the ideal of green campus held by the UDLAP. Also, the service access -straight arrows- would need to be from two different sides of the site to reach all buildings, being complicated the access through the administrative area. Then, the complex, projected as 3 separated buildings, doesn't fit in the proposed terrain, and further options need to be explored.

Figure 19. Site location -blue shadow- and its immediate context (own illustration).

Figure 20. Two different configurations of the cultural complex based on the square meters pre calculated, where the wood would be totally eradicated (own illustrations).

Since the site have such limitative conditions, two different explorations of arrangements were made by reducing the area of the biggest building, the exposition center, and eliminated it completely. The first -Figure 21- one take in consideration the creation of the complex as a single building with 3 main areas, having a plaza -blue circle- for main access, and still using two sides for service access. This option would cut the area of the exposition center to half, and the lilac zone would be a unifying element that could be sacrificed to gain the independence of the 3 elements, however, this would mean the exposition center to be even smaller. This option keeps the greatest wood zone but eradicates the little ones of the east side. The second option explores the solution giving away the less trees possible -Figure 22-. The configuration eliminates the totally of the exposition center to have a performance area only with the BBT and the Italian theater, each one with an access plaza surrounded by trees. Also, this condition allows the service access to be one sided, by the Eucalipto Street, avoiding the administrative area. A minor adequation of the junction of the UDLAP distributor with the Eucalipto Street is proposed -black arc- to better access of big transportation vehicles.

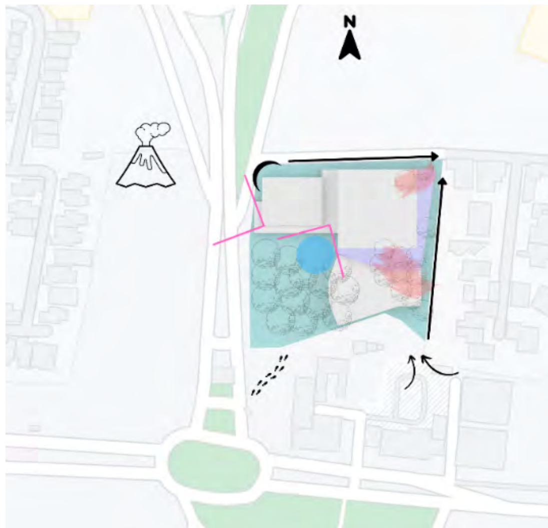

Figure 21. Less invasive alternative for the complex composition by giving less relevance to the exposition center and making one of three buildings (own illustration).

Figure 22. Option with only two of the three buildings that will allow to keep most of the woods and only one service access (own illustration).

In both options, the BBT is in the northwest corner of the site. This specific location allows the building to take advantage of a terrace with views to the woods and complex and the volcanos -pink V shape-. The skin of the architectural piece would open to those views, hiding a deeper meaning of being opening the campus to the outside world, without the traditional barrier of trees, breaking physically the 'bubble' that socially had already be broken by the legal and political situation lived by the community form July 2021 until March 2022. This disruptive building, that looks forward to stablishing an experimental space for evolving art, will be also a symbol of this cultural and social changes that the institution could live. This location and correlation with the context are the conditions for the outside behavior of the BBT.

For the design and algorithm development, is a comfortable starting point to have right oriented in Rhinoceros and Revit the model with the global north of the working planes. For this reason, the plugin Urbano was used to contextualize the site, attaching the street map of the UDLAP campus and its surroundings into the digital environment -Figure 23-. This action had no further impact in the design process but the correlation of norths in Rhino and Revit.

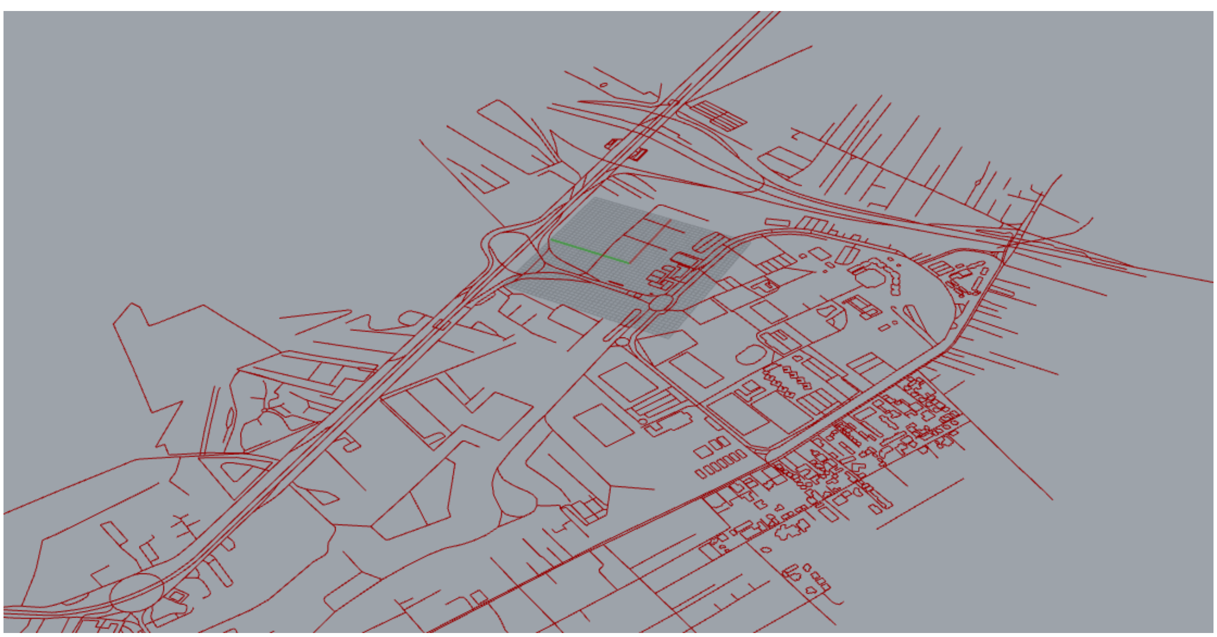

Figure 23. Urbano map from GH showing the UDLAP campus terrain (own image from Rhino).

Section 8. Plan, Section, And Volume

The BBT, independent of its role inside the complex and outside correlation with the site, has spatial needs that the architecture should satisficed, to accomplish the function of being a performance space for a university community. This section will explain the plan solution and section and volume expectations for the project, starting with the architectural program presented in Table 3, that takes in count the fact that the performing space is transformable, so the whole project needs to work ignoring the interior distribution of the Blackbox itself. The building is fixed, and the variability lays only inside the performance space.

Table 3. Architectural program.

Room or area	**Square meters needed or recommended**	**Final area**
Access plaza	124 sqm recommended	42.9 sqm (between ramp and lobby)
Lobby	100 sqm recommended	134.9 sqm
Ticket office	14 sqm recommended -only one needed-	Included in lobby
Restrooms for public	48 sqm -calculated by the needed seats per each 100 spectators-	92.3 sqm (but the requirements of service numbers met)
Blackbox	2.5 sqm per spectator needed	1,117.9 sqm
Access for artists and staff	30 sqm recommended	43.1 sqm for the main one 35.1 sqm for the support one
Common area and rest area	55 sqm recommended	35.5 sqm
Restrooms for artist and staff	48 sqm recommended	40.1 sqm for the main one 12.2 sqm for the support one
Dressing rooms	96 sqm recommended	80.5 for the main one 21.2 sqm for the support one
Scenography room	60 sqm recommended	46.6 sqm
Projection room	12 sqm recommended -2.2 m per side obligatory-	12.8 sqm each (having two)
Gallery	-	+300 sqm
Terrace	-	+300 sqm

Note: The recommended spaces are larger than the final ones because the BBT necessities and minimum space condition.

The architectural program broken down in Table 3 pre-size the spaces according to the *Plazola* (n.d.) recommendations and the *Construction Regulations for the Municipality of San Andrés Cholula* (Gobierno del Estado de Puebla, 2017) specific indications for some rooms. The gallery and terrace do not have pre recommended space because are spaces that born from the intention to give a space for plastic arts and to admire the views, as explained in Section 7. The final areas are conditioned to the area of the Blackbox, the performance space, that was determined by the racks of seats dimensions and will be explained in Section 9.

To determine how the plan works, the Figure 24 explores the way the fluxes could work for spectators, artists and staff, a relevant parameter as mentioned in Section 3 and as in example with Room 3, mentioned in Section 4. Arena configuration is the base of the exploration for being the configuration that provides a four entrances arrangement and covers most of seats-stage options. The main element, the box, will be embraced by the second element, the rest of the program. The exploration goes from two volumes one in front to another, to a volume that is in-between other two, and finally, to the one that propose a U volume embracing the box one. This could help artists to access in two sides -one as the main and the other as support only if the inside configuration needs it- and leaves a 'blind' side that will be used for services and emergency exits, the partial symmetry allows to have two control rooms, and a lobby that goes all along the opposite site of the blind one. The Figure 25 explores the fluxes and sight in the section because the control rooms that will need a free sight view to the Blackbox while the spectators and artists need to go in and out from the room. A change of level between the lobby and the performance and service space is proposed to gain height in the double height Blackbox, but also to avoid that the 2-floor service area getting too high.

Figure 26 shows the first attempts of distribution with corrections applied in the final plan showed in Figure 27, where the cafeteria and the rehearsal room are eliminated from the final program and the thick side of the U is west, not east. Figure 28 shows the final sections where the changes of level can be observed, giving the lobby a good double height, a 2-floor gallery, good sight and height for control rooms, and a service access that is 1 meter tall for trailer loading and unloading.

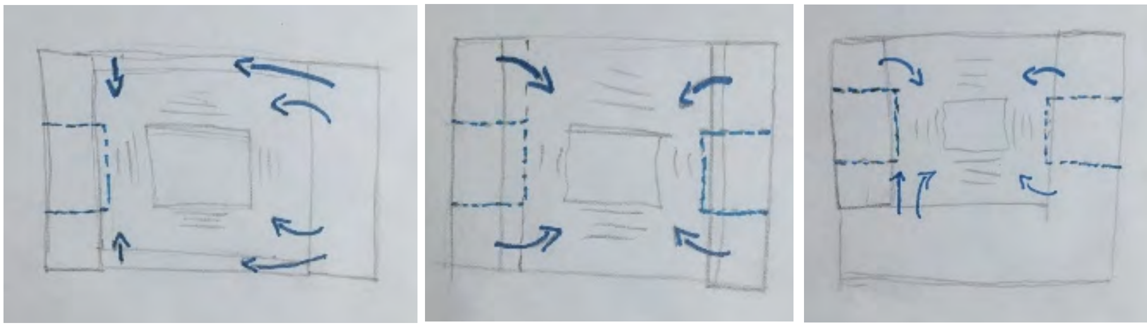

Figure 24. Plan evolution through correlation between access and performing space (own drawings)

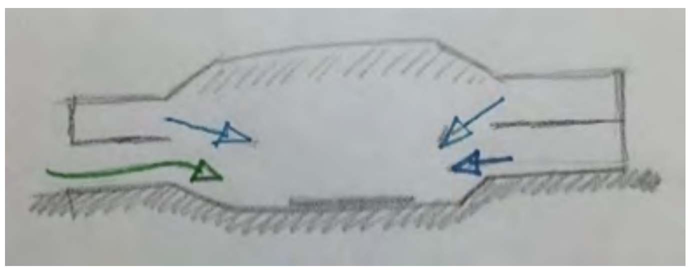

Figure 25. Section expectations

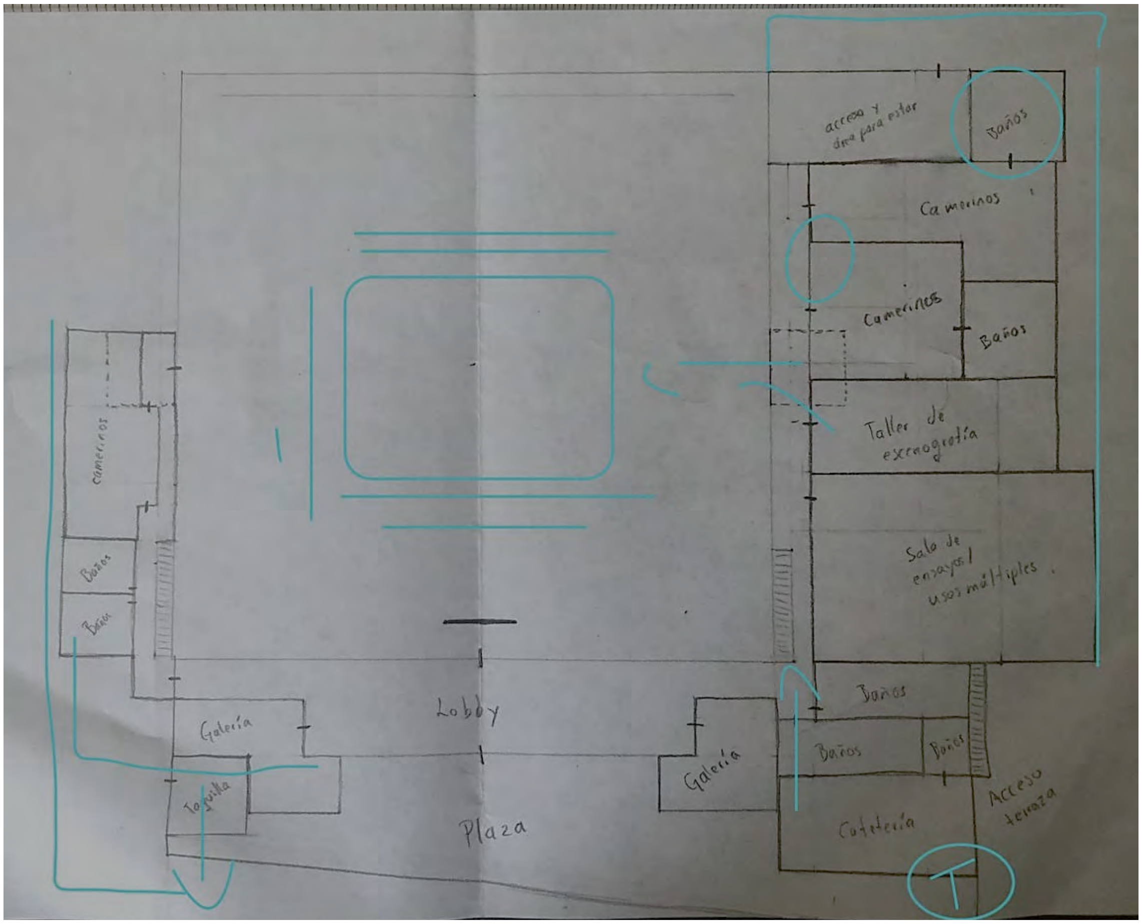

Figure 26. Plan expectations with corrections (own drawing).

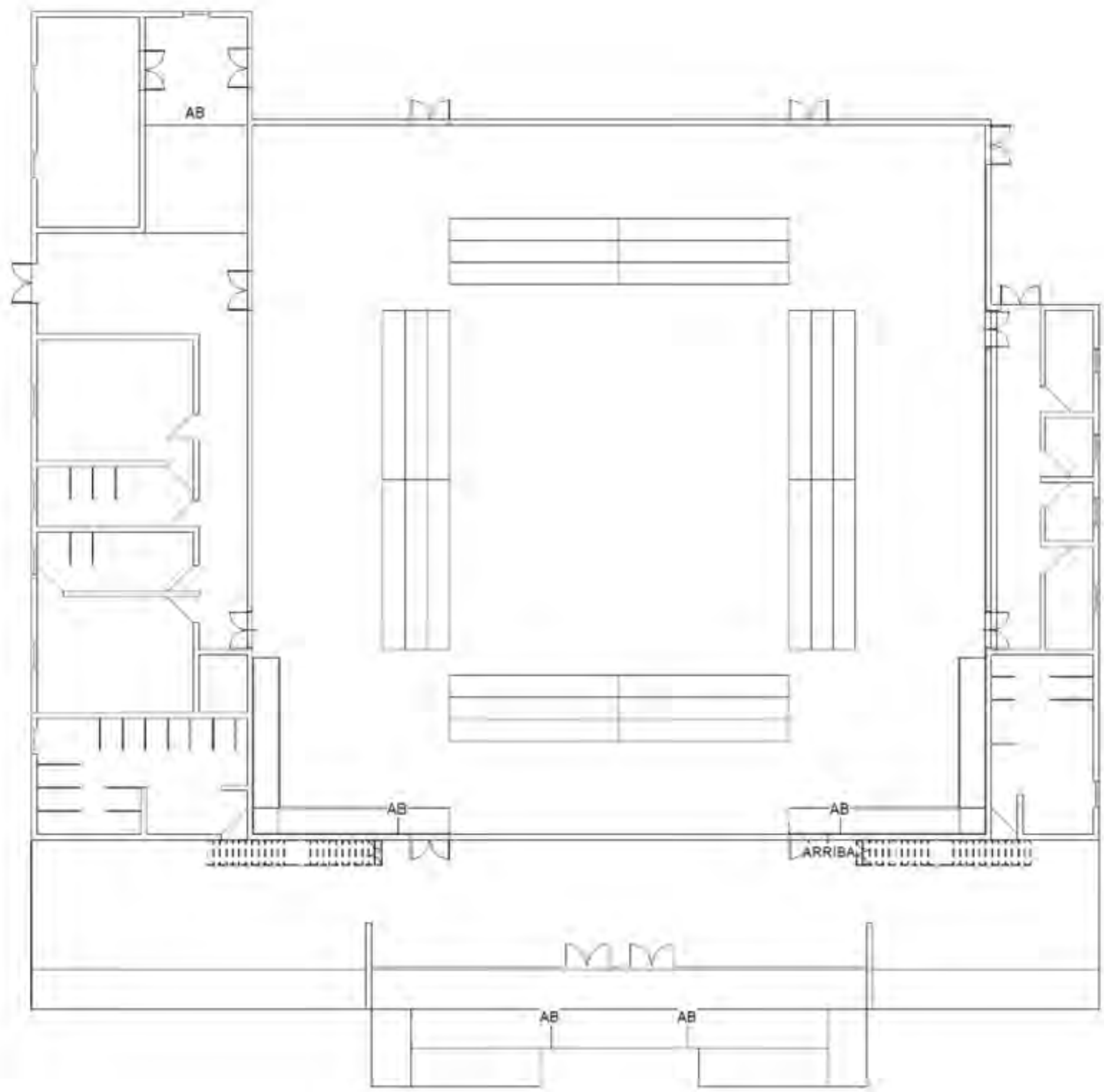

Figure 27. Final distribution plan (own image from Revit).

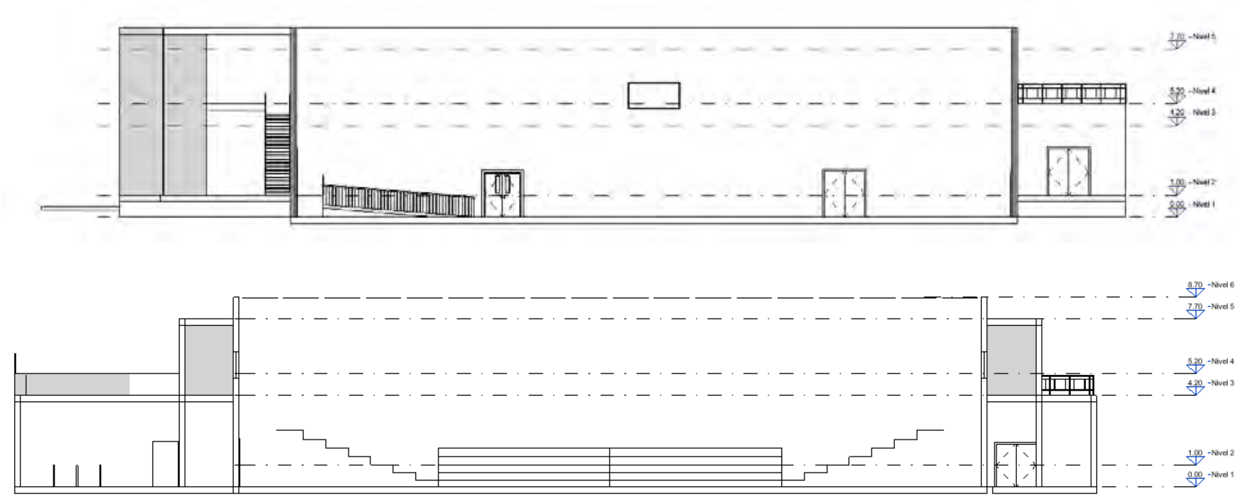

Figure 28. Sections (own images from Revit).

The project, then, follows the existence of two volumes: the Blackbox itself and the service area that embraces the box. However, if the performing area is the main element but also is a non-space because its transformable condition, the U will be embracing the nothing. The need of a third element is key for the building to be whole. The skin of the volume, derivative from the top of the Blackbox logic of inflection lines -Figure 43-, will embrace the U element as seen in Figure 30. This skin suffered an evolution in its geometric complexity -Figure 29- and will be explored as an orthogonal object, even if a first attempt to make it organic was made. Each element has a defined nature, as seen in Figure 30, where the U, the service area, holds the institutional image of the UDLAP, the Blackbox is the void, the non-place, and the skin, the disruptive shell, is the contemporary element that makes obvious the usage of new technologies in the design, that the campus with its art and architecture keeps evolving. The existence of the skin also allows more flexibility in the level arrangement of the space. The 3D volume shown in Figure 31 is the result of the process of sizing the main space -the Blackbox- according to the seats and taking this first area into Revit to model the rest of the rooms. The following sections would explain this first step of sizing the performance area and the further steps after taking the

Revit model back to the Rhino environment for the design of the illumination grid, the acoustic ceiling, and the skin.

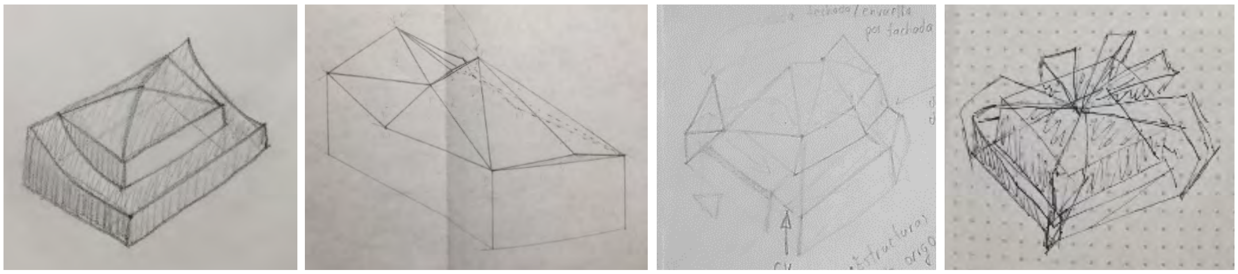

Figure 29. Volume expectations evolution (own drawings).

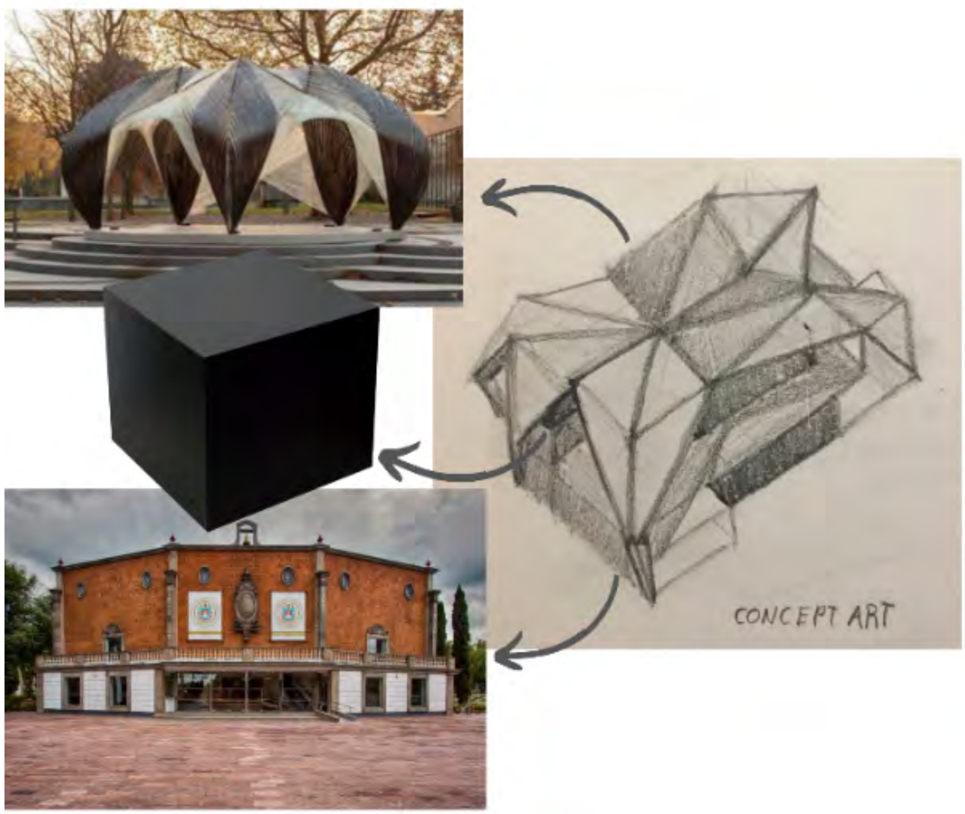

Figure 30. The three main elements expectations of the volume: void, space, and skin (own illustration using ICD/ITKE pavilion 2012 -up- and Guillermo and Sofia Jenkins Auditorium UDLAP -down-).

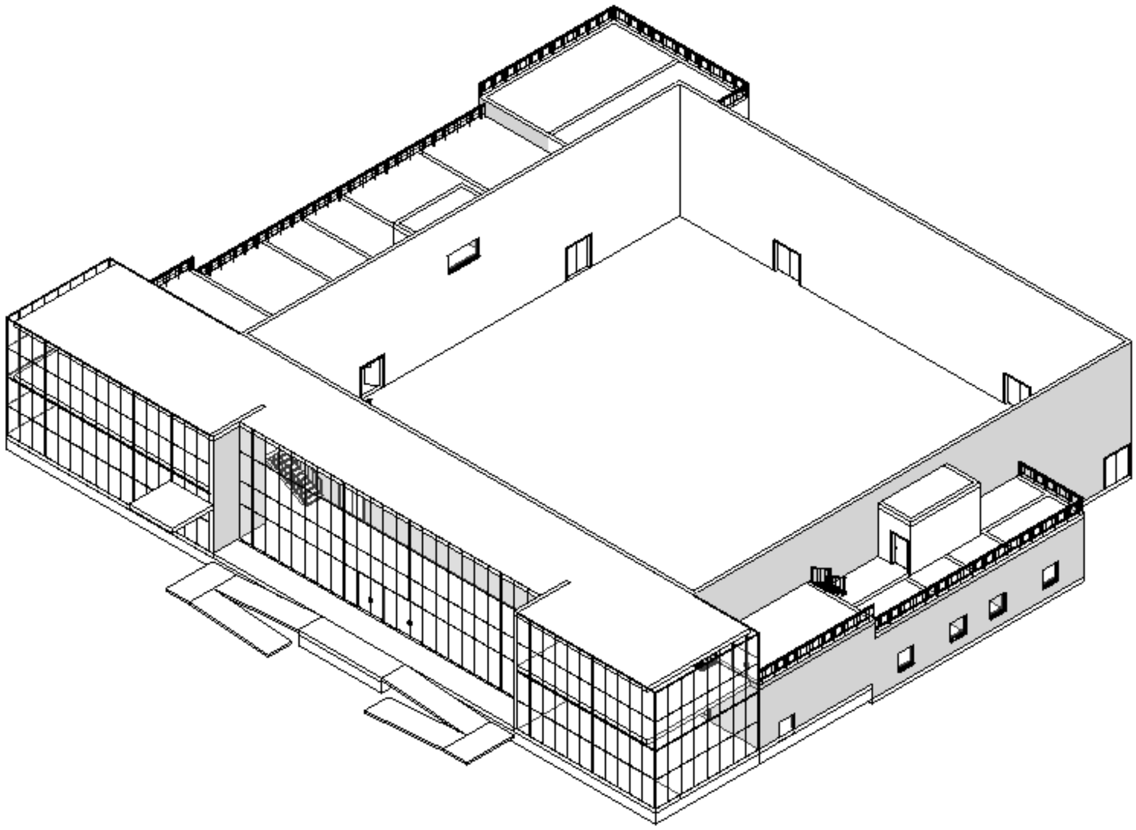

Figure 31. Partial 3D model (own image from Revit).

Section 9. BBT Inside Decisions

The core of the inside decisions is the Blackbox itself, and for the plan definition and the rest of the process is necessary to size the performing area as mentioned above. For this propose the plugin Bowl Builder was used to calculate the seats dimensions. The logic behind how many racks of seats took three points in count: the fact that the *Construction Regulations for the Municipality of San Andrés Cholula* (Gobierno del Estado de Puebla, 2017) allows only seven seats per corridor, that 400 people is the maximum capacity expected, and that the retractile system -Figure 33- needed to allow the most arrangements possible. The initial intention was to create a seats configuration that could allow the existence of the three classical theater arrangements that don't exist inside the UDLAP: traverse, thrust, and arena -Figure 16-. But the retractile system of the seats allowed more freedom. However, the logic of the traditional arrangements remained to use the arena as the most uncomfortable configuration cause its usage of four sizes, and is the perfect scenario for maximum capacity, as shown in Figure 32, using 8 racks, 2 per side. Taking in count the side note of the traverse configuration that should allow 4 racks per side, the number of seats and the size of the performance space were dimensioned by these conditions.

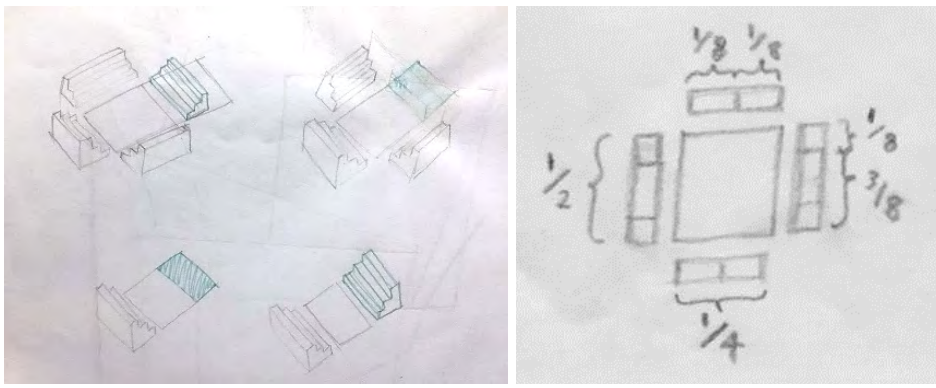

Figure 32. Seats behavior and pre-size logic to get the module dimensions (own drawings).

Figure 33. Example of the retractile seats system (Figueras, n.d.).

To run the definition, is necessary to feed the Bowl Builder plugin with the correct dimensions of the wanted seats. Figure 34 shows the used ones for reference from an online catalogue of Stage Sets (n.d.). Figure 35 illustrates the parameters being feed to Bowl Builder. The definition allowed 392 seats distributed in 8 racks of 56 seats each, 7 per row, 8 rows each as can be seen in Figure 39. The advantage of using Bowl Builder is the capacity of this plugin to calculate the isoptic, so no need to manually do the calculations of Section 3. The 0.12 m height desired for the vertical isoptic was determined to 0.13 m in this case, as can be seen in Figure 35. The vertical isoptic then is translated to the section of the rack -Figure 36-. The horizontal isoptic is calculated to the center of the stage and, as shown in Figure 37, the maximum angle is 86º, far from the 110º limit mentioned in Section 3. So, one of the main parameters is already taken in count in the definition solution.

Figure 34. Seats dimensions (Stage Sets, n.d.).

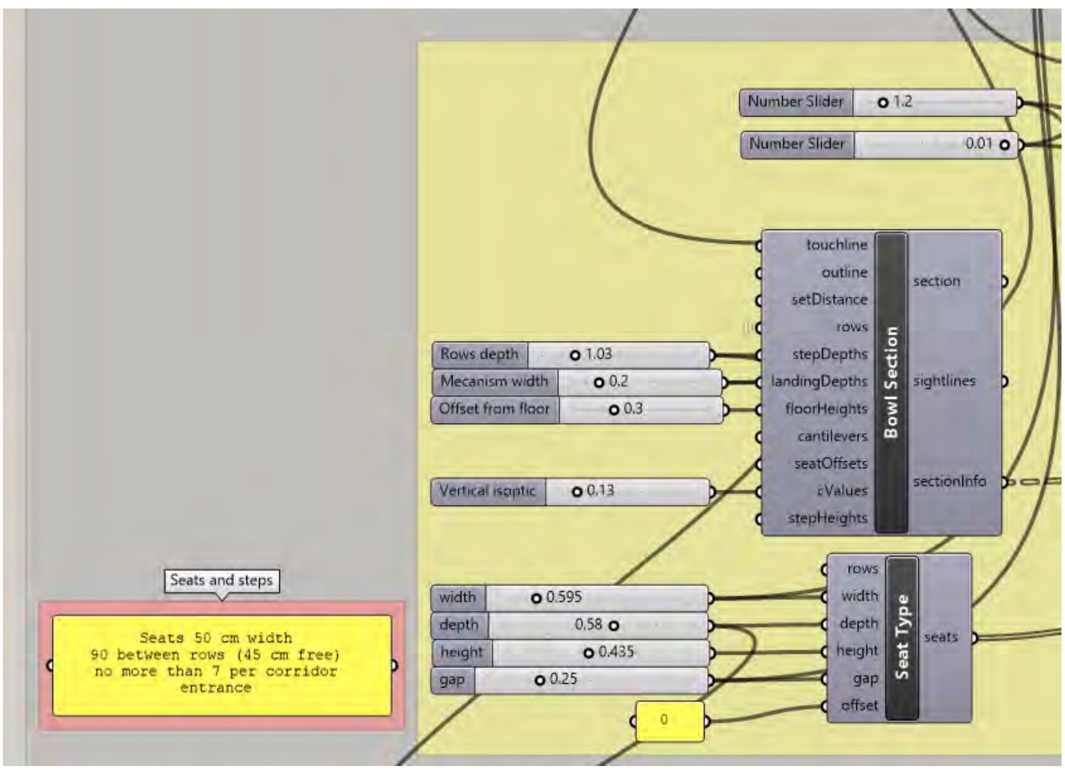

Figure 35. Seats parameters feeding the Bowl Builder definition (own image from GH).

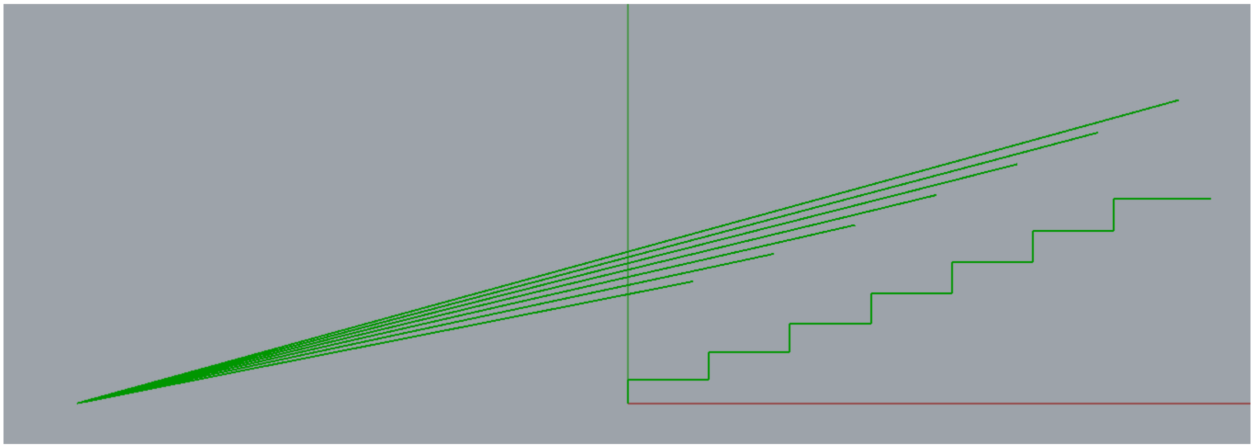

Figure 36. Vertical isoptic diagram from Bowl Builder (own image from Rhino).

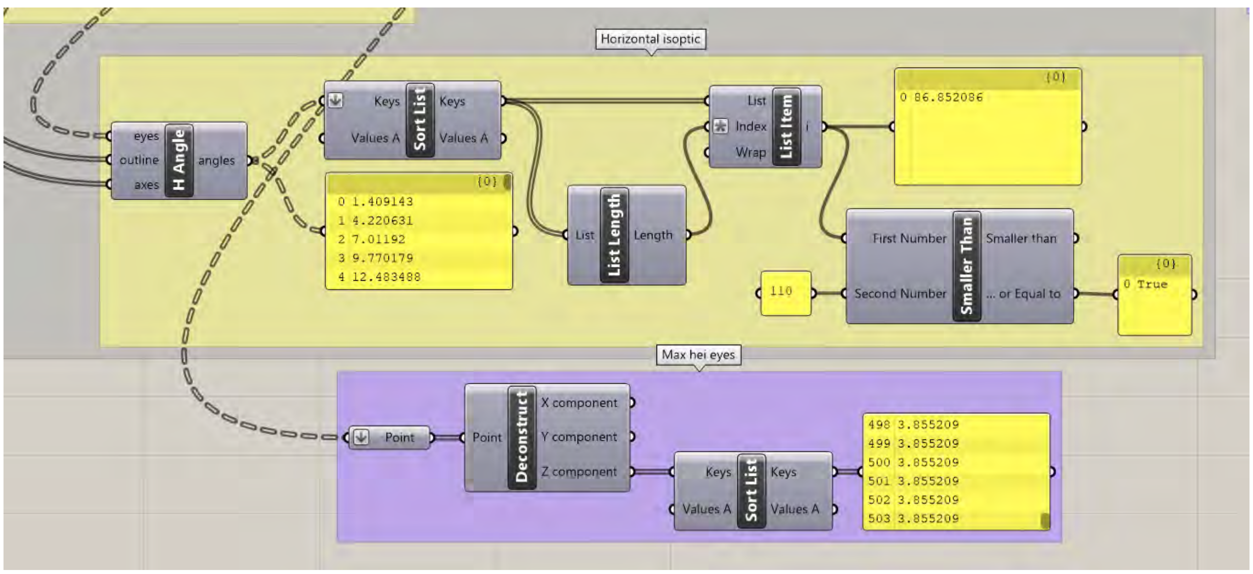

Figure 37. Horizontal isoptic angles calculation from Bowl Builder (own image from GH).

Bowl Builder gives as output the seats without corridors, as shown in Figure 38. However, the definition construction took this in count, giving two extra seats per row as the corridor width. After cleaning the geometry, the 8 racks can be easily observed in Figure 39. This basic geometries of breps for the steps and surfaces for the seats was taken to the Rhino environment to play inside the space of the Blackbox different configurations. Figure 40 shows the three classic configurations mentioned before, arena, thrust and traverse, plus the L type, where the folded racks can be observed placed in the room, without being an obstacle of view or fluxes. Finally, after the seats were calculated in the arena configuration, the area of the performance space, the Blackbox itself, could be calculated, as seen in Figure 41, were the minimum area allowed according to the Mexican laws were validated. This delimitation was the one taken as base to the Revit environment to start constructing the 3D model.

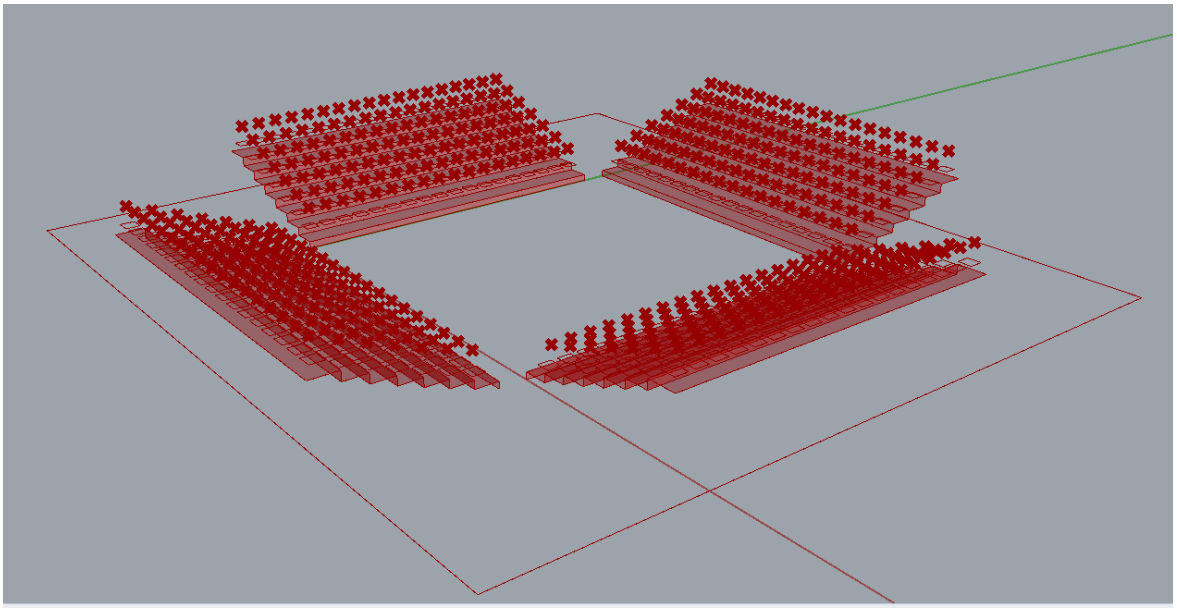

Figure 38. Seats from Bowl Builder (own image from Rhino).

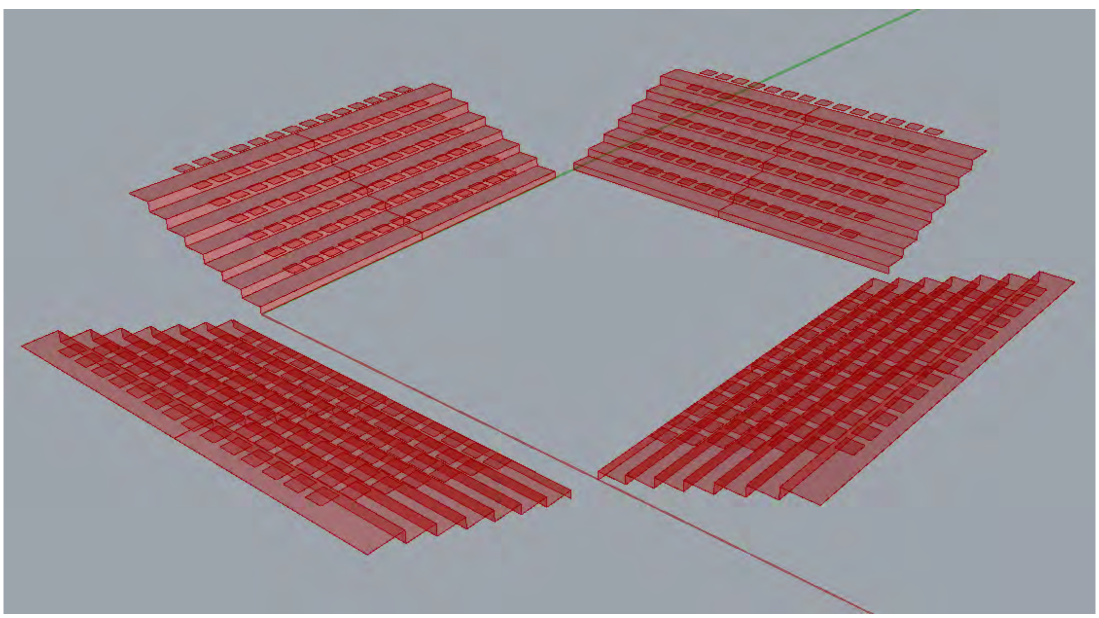

Figure 39. Clean seats dived in 8 racks (own image from Rhino).

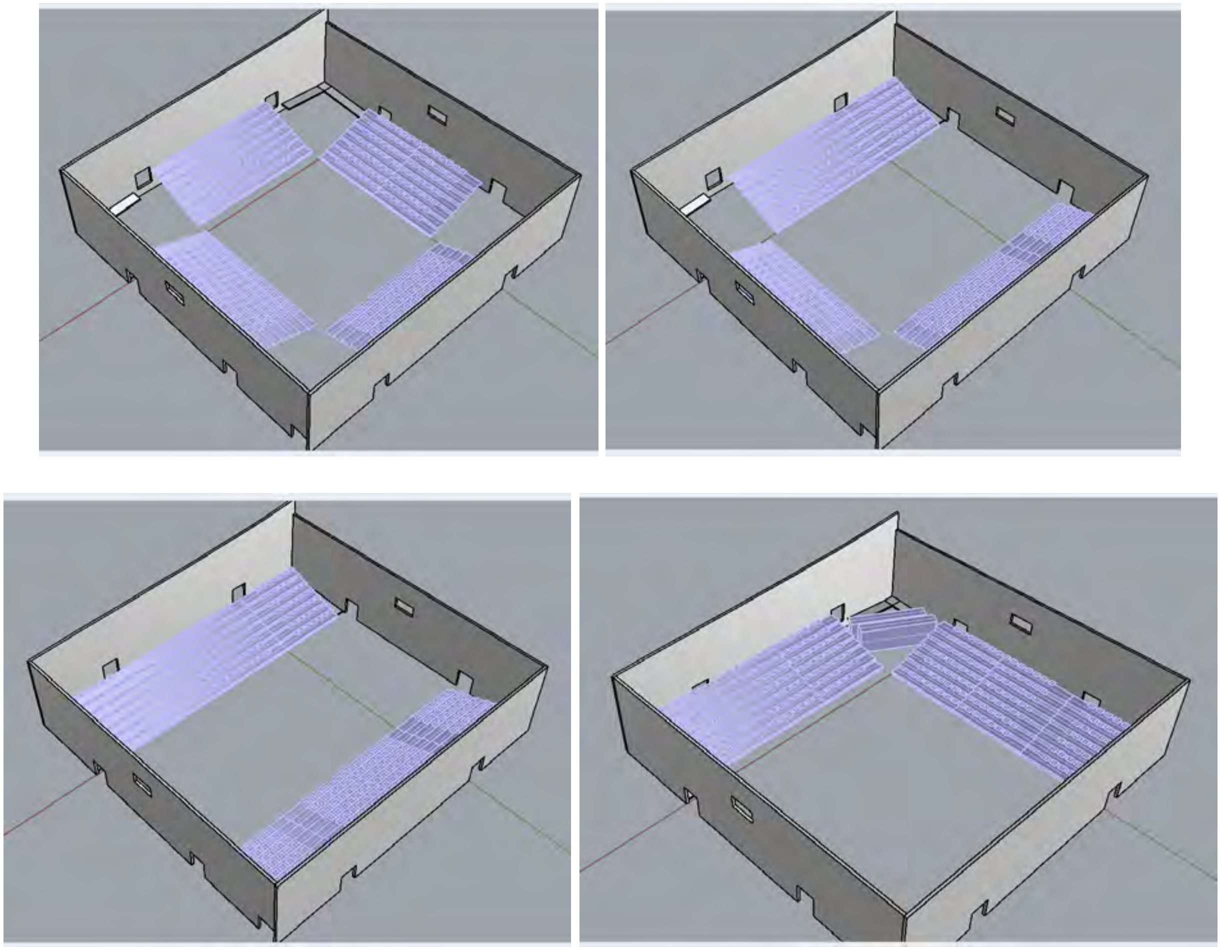

Figure 40. Seats configurations: arena, thrust, traverse, and L type (own images from Rhino).

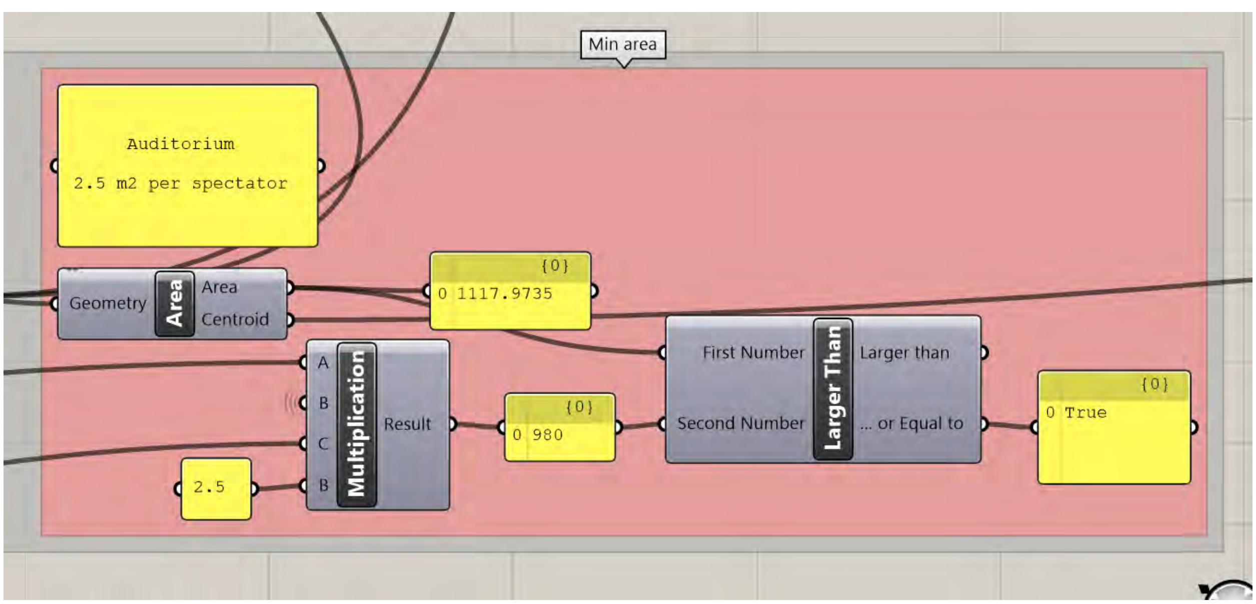

Figure 41. Area calculation (own image from GH).

Once the BBT and all its rooms were raised up on Revit, the basic geometries of the walls were taken back to Rhino to develop, using GH, the illumination grid, and the base of the acoustic ceiling. Flexibility was also the main parameter to determine the behavior of these two components. Figure 42 shows the exploration of the possible deflections in the ceiling geometry taking into consideration the three classic configurations of theater that are not endstage, understanding that the sound should travel to all seats from the center of the stage. This exploration led to the inflection lines projected in Figure 43, that were translated to the GH and Rhino environment to determine the size of the panels of the grid used as base for the acoustic ceiling and illumination grid. The acoustic ceiling will be explained later in Section 11.

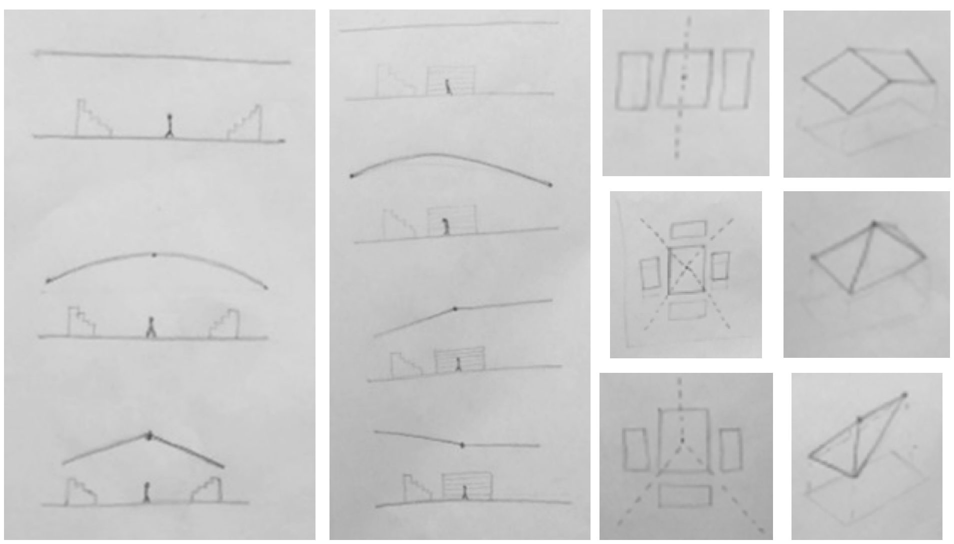

Figure 42. Ceiling behavior analysis in the three classic configurations of seats, to determine possible deflections on the geometry (own drawings).

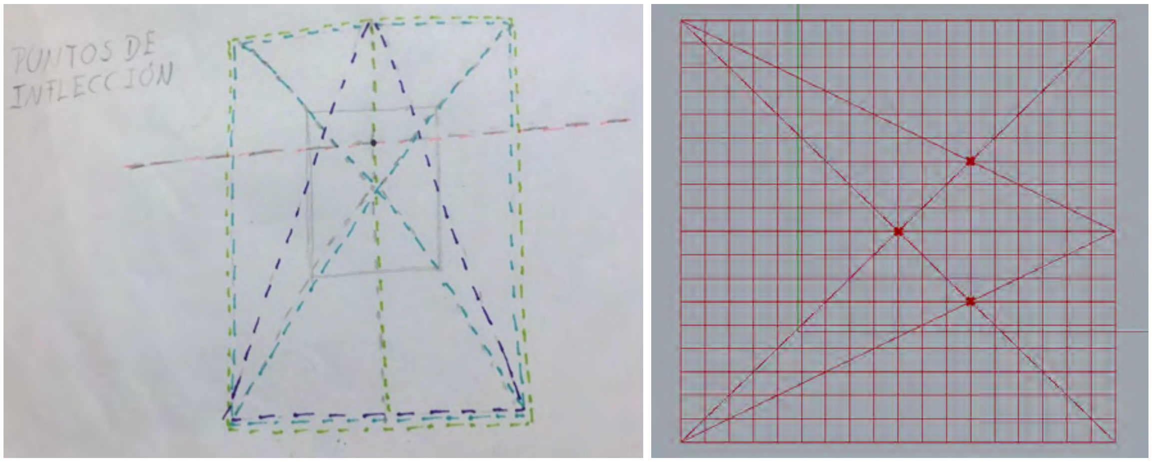

Figure 43. Inflection lines on plan (own drawing and own image from Rhino).

Once the paneling was done, the illumination grid design started by two main conditions, the fact that it should be constructed by a two layer structure of pipe over pipe -Figure 44- and that the hanging structure could not interfere with the acoustic panels, so it needed to exist within the lines of the drawn grid. The third condition was given by the client. The Performing Arts Halls of the UDLAP have a deficit in illumination because the rhombus structure the grid has, leaving the corners of the place in semi darkness (Sergio Castro, personal communication, March 15, 2022; Eduardo Espinosa, personal communication, March 17, 2022). The request was to avoid any configuration that will probably leave the corners without proper light access. The solutions explored in Figure 45 go from traditional geometries to complex and kinesthetic ones. The first one is a multiple rectangle configuration with different sizes for different purposes or presentation natures. The second is a mix of rectangles and rhombuses that will allow more flexibility with movable lighting systems -that follows the artist though the stage-. The third is an octagonal proposal that ended up being impractical. And the last one is a simple two rectangle configuration with the difference that the small one is movable. The second and fourth options are the most coherent with the space. The second does not leave dark corners and present different angles that can cover most of the light necessities of any configuration of seats that the artist may want. The fourth is more complex and require more mechanical settings, will be necessary to evaluate if it is worth the inversion. The second option, then, is the one used to present the grid solution into the final 3D model and the one taken to the Revit environment.

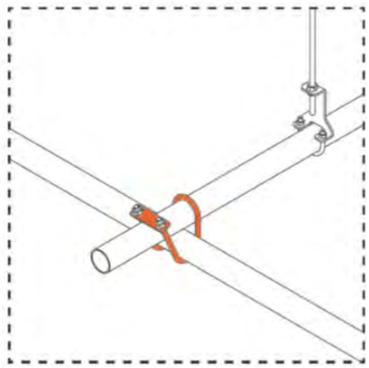

Figure 44. Grid construction detail (Siluj, 2020).

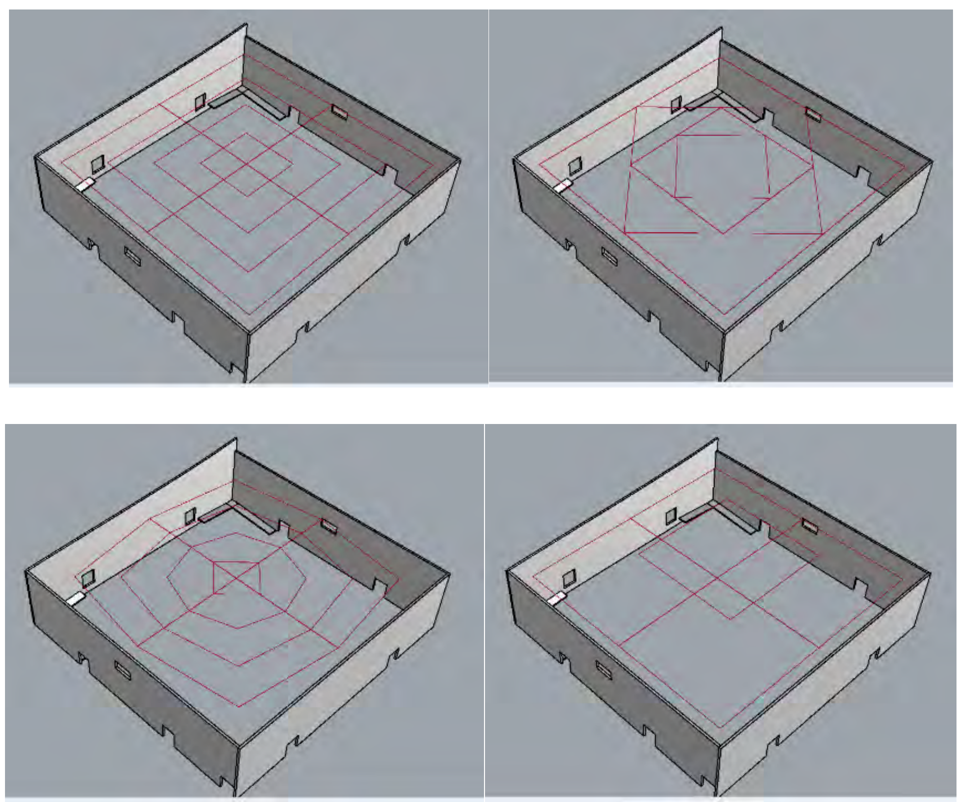

Figure 45. Illumination grid configurations, rectangle-rectangle, rectangle-rhombus, octagonal, and rectangle-movable (own images from Rhino).

Section 10. Outside Design

The skin of the building, or the third element, the disruptive one, is the main concern of this section. The design of this element follows these conditions: the skin needs to open in the west and south side -volcano and woods sight plus access-, close in the east -service area and other building adjoining- and leave free space in the north -service access and emergency exits-. The illumination grid and acoustic ceiling design gives an important parameter to consider, the height of the Blackbox, and the Revit model gives the U element heights and dimensions that the exterior structure, shell, or skin, need to respect. Is also important to highlight that this structure can invade some of the areas, such as the gallery, being not only on the outside but in the inside of the building, as part of the lobby-gallery environment. The same effect of complement is expected in the terrace, where the shell is shadow provider and frame of views.

Two different solutions for the skin were made, one using FF and the other FM, the first one using curves and organic shapes, and the second using orthogonal guidelines. In both, the same parameters or conditions are taken in count and the algorithm make the final form decision based on those inputs. For the first experiment the Kangaroo plugin was used. As seen in Figure 46, the FF process consisted in a grid base populated with points and curves drawn directly on the Rhino environment to be used as attractors of those points. The manipulation of the curves gave the process an artisan aspect, however, the algorithm worked as FF workflow, since the architect did not have the exact answer to how the geometry of the shell would behave. In Figure 47 the mesh re quad can be observed, being the first proposal for the skin. However, one of the main ideas for the outside structure was the well-defined legs or supports and the sharp geometries, that will also demonstrate that PD and Parametricism are not the same, respecting the orthogonality as part of the geometric world that CD has influence on.

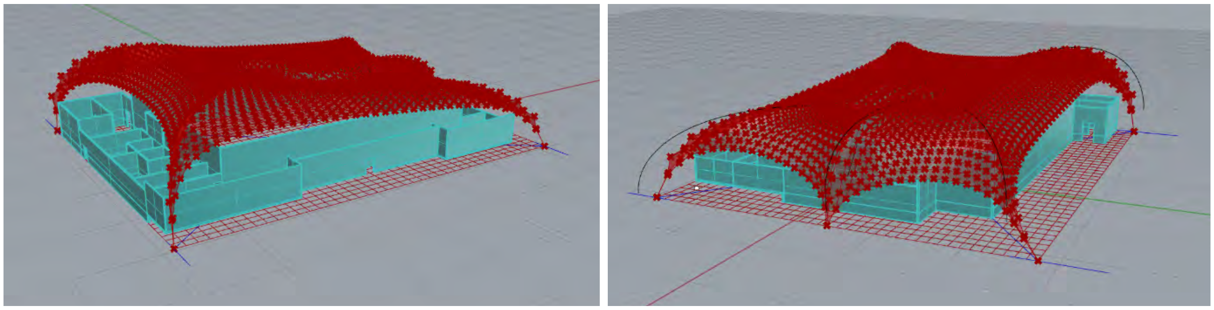

Figure 46. Southwest and northeast views of the mesh made with Kangaroo (own images from Rhino).

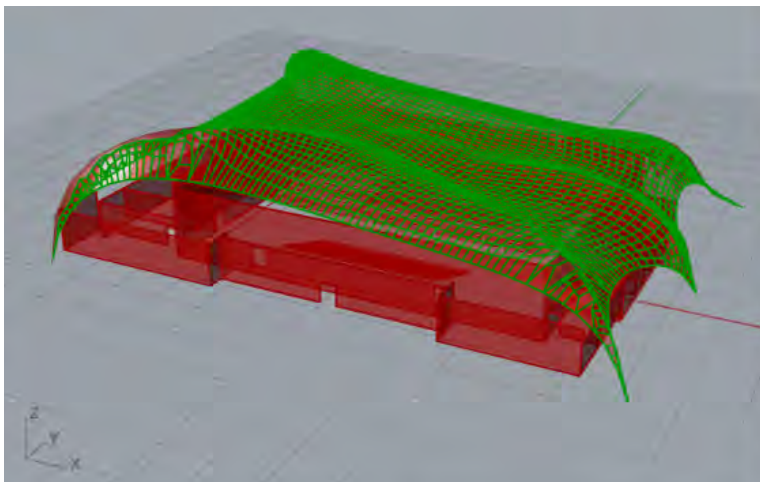

Figure 47. Re-quad mesh (own image from Rhino).

The second and final option was made using the Lunchbox plugin. This plugin works better with quadrangular surfaces, so that was the first condition of the shape, be based only in quadrangular surfaces. As seen in Figure 48, the structure was first traced in the GH environment using lines to get the wireframe base for the surfaces used in Lunchbox. The height of each point is totally controllable, like the base point ubication and central point height. However, is recommended that the height of the points that joint the supports with the others in the middle to stay equal for the eight, to avoid structural performance, as it was explored later in Karamba. Because the designer has more control in the points that create the surfaces, this is consider a FM process. Figure 49 shows the Lunchbox output after processing the surfaces, converting each one in a tridimensional pipe structure, where thickness can be controlled. In difference with the membrane presented in the first attempt, this skin is more likely a structural element with the capacity of carrying the height of the acoustic ceiling and illumination grid. The almost final geometry present in Figure 50 will be tested for structural capacity in the next Section. The shell should be disruptive, even aggressive, and orthogonality helps that image better than the organic one. In conclusion, the second try is closer to the original idea of Figure 30, and will be the structured tested and taken to the Revit environment for presentation.

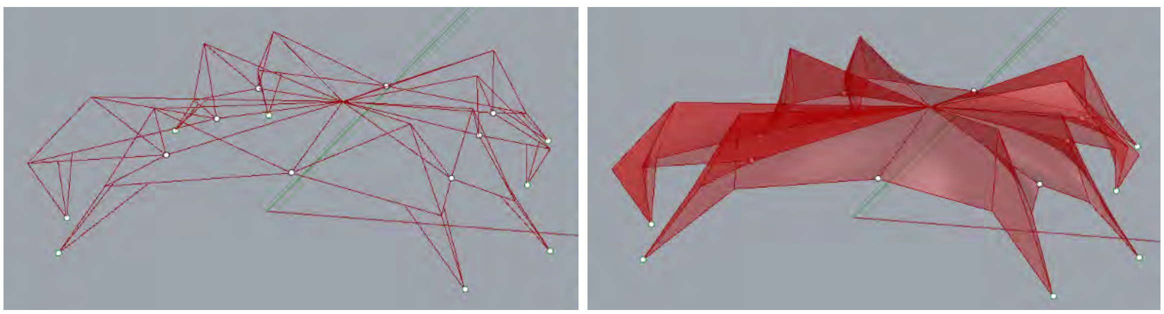

Figure 48. Wireframe and Surface making for the skin in a FM solution using Lunchbox (own images form Rhino).

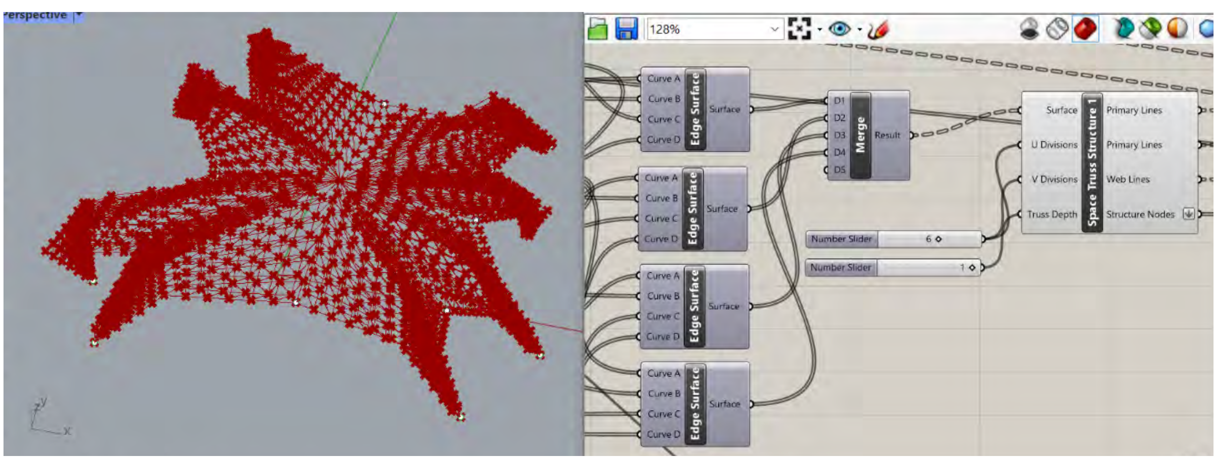

Figure 49. Geometry output and Lunchbox definition (own image from Rhino and GH).

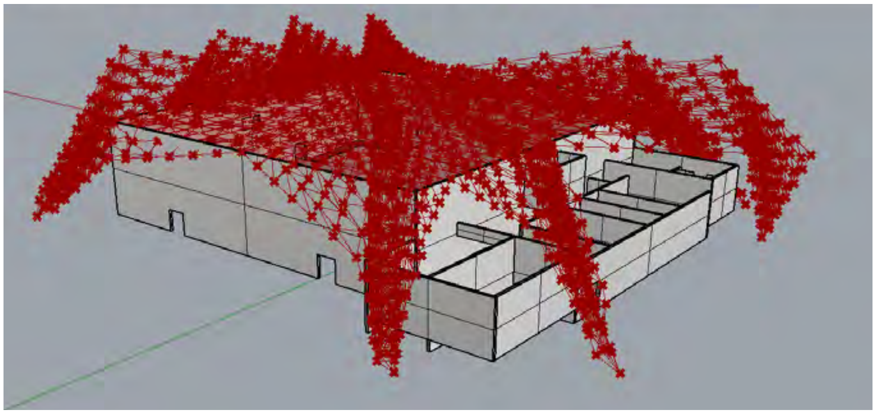

Figure 50. Image example of the skin embracing the structure (own image from Rhino).

Section 11. Analysis And Optimization

The analysis through technology helps to test important factors about the project and to improve if necessary. As mentioned in the first chapter, the computer allows to process great amounts of data in a short period of time, making easier for the design process to take into consideration more dimensions. The only limitation will be time -referring to optimizations that could take days to be finished in an optimum- and the computer itself -the technical characteristics-. This Section will expose the analysis of the fluxes, acoustics and structural behavior of the skin, and the optimization of the acoustics, and will leave open paths for further investigation, analysis, and optimization for the project.

The BBT, as a performance space, have the necessity of attend spectators, artist, and staff in different moments and rooms that met all in the stage. In a changing scenario, these fluxes need to be allowed no matter the configuration. The Blackbox was thought to have two main entrances for spectators and four for artist and staff, without including the control rooms. However, the dynamics of the artists going in and out the stage will not be analyzed in this project and will be left to further work. The fluxes analysis will be focused on the spectators at an emergency, where everyone needs to leave the building. According to the Mexican laws, in case of an earthquake, the most likely disaster event to happen in Puebla, the evacuation time for every building should be less than 3 minutes. This evaluation was made using the plugin Mouse, using the arena configuration as base. The plugin works in a two-dimension plane where a grid determines the walls -non full cells- and walking space -full cells-. The starting points are the spectators, points projected in the plane, and the destination points are the emergency exist. Three of them were proposed thinking in the possibility of leaving at least one free in every configuration. Figure 51 shows the Mouse solution and in Figure 52 the evaluation of the length of the curves is shown, taking the average speed of a human of 0.83 meters per second, to determine if the room will be completed evacuated in 180 seconds. Also, is possible to analyze the critique points of possible congestion while leaving, as observed in Figure 53. This kind of information is useful to prevent any risky situation, and, for example, the spectators can be better acknowledged about the exit on the left, to avoid those congestion points in the right corridor.

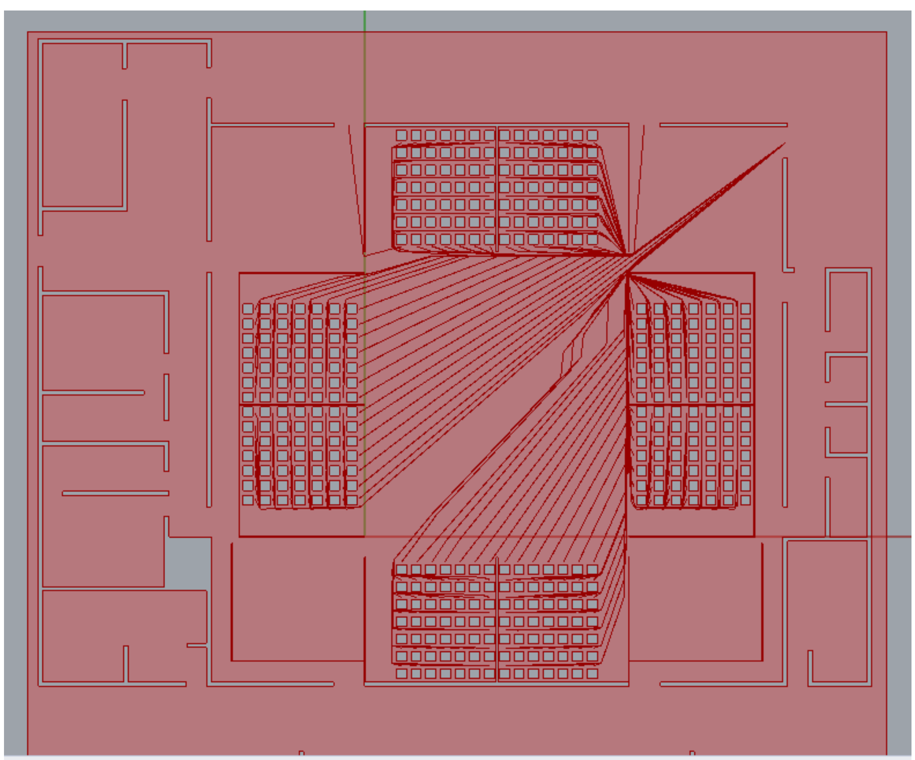

Figure 51. Mouse solution to evacuate the arena configuration (own image from Rhino).

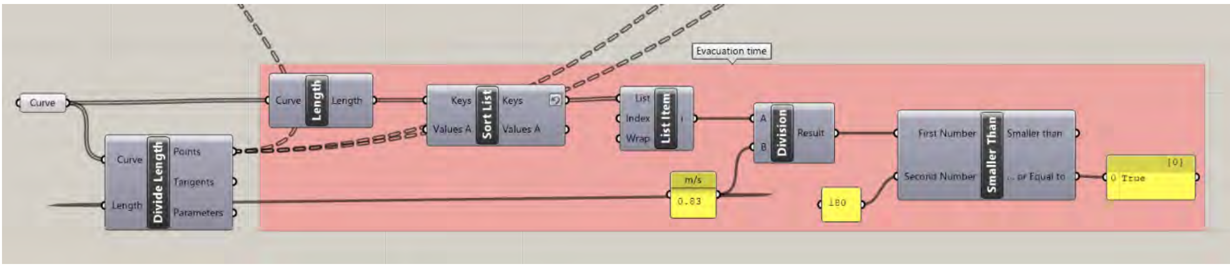

Figure 52. Time needed for evacuation (own image from GH).

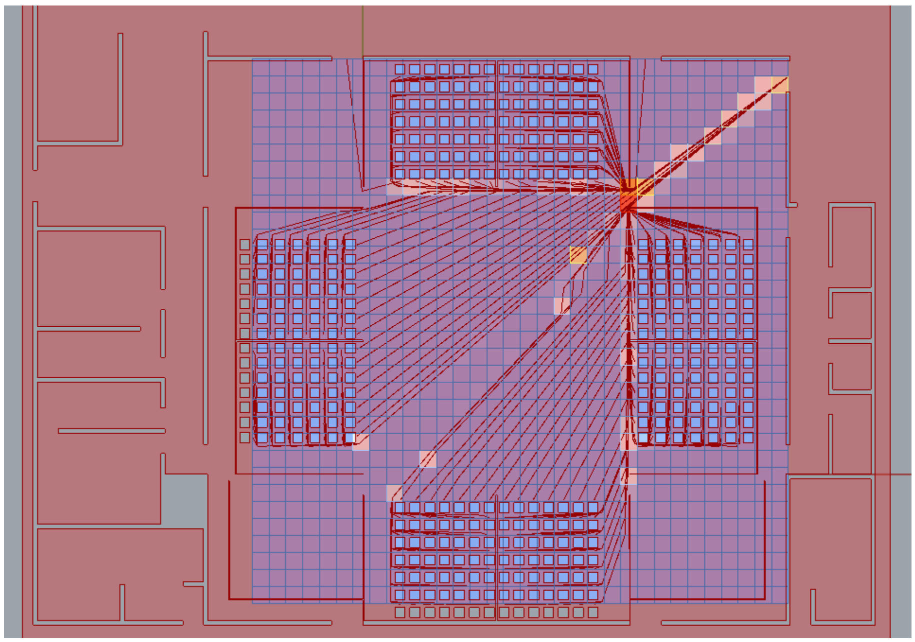

Figure 53. Congestion points (own image from Rhino).

One of the most important aspects in a performing space is the acoustics, as mentioned before, is one of the desirable characteristics in architecture for the performative arts. Even if Sabine's formula is applied or not, the behavior of the sound can be predicted in many ways, for experience or by imitation, for example, even more in small spaces. However, the box shape is one of the most complicated to predict because the size of the box and the number of bodies inside it determine the real behavior. Most technicians think that acoustics in a performance space, not focused primarily on music, have nothing to do with the room itself because the sound systems make the work. But the reality is that every space, for music or not, needs of good acoustics and can be analyzed to improve the quality of it, so the sound systems could work better, and human voices could be heard better, without microphones. This is more important in the BBT for a university community, were one of the programs is music, that is proposed to be an experimental space for performative arts, including music. So, no taking in count acoustics would be a mistake for not understanding the nature of the BBT.

The acoustic analysis was made with Snail, a ray trace -Figure 7- plugin that helps to predict the way the sound will travel inside a room and how good it will be the reception of it in each seat. The plugin works with a closed brep were the rays, having a source, get up to four bounces in the space, trying to reach the surfaces that are equivalent of the seats. It was necessary to take from Revit all the geometries, walls, and ramps, that represent the physical objects were the rays could bounce on. The acoustic ceiling, previously mentioned in Section 9, also was set up for the simulation. The Figure 54 shows the behavior of the parameters on the ceiling, that was divided in 16 independent groups capable of determine hanging height and rotation angle in one axis -Y-. The size of the panel was a variable for all, the size of all could change but would change equally. The first acoustic simulation was run in the base conditions of hanging height zero and rotation zero, just to demonstrate that the basic shape of a box is not acoustically beneficial for the sound. Figure 55 shows the base position vs the variable positions used in the optimization process. The Snail simulation ran with 2,500 rays, being 1,373 the ones that impacted in the surfaces of seats, but these impacts were not uniform in all surfaces, as can be seen in the predomination of color blue in the seats of Figure 56. Not even the 10% of seats had a direct ray impact. Then the optimization with Galapagos took place -Figure 57-. Using the panel size, the hanging height, and rotation as parameters, the optimization ran for more than 24 hours, getting less than a 10% optimization, increasing the impacts of rays from 400 to 410 only.

This slow optimization showed that the parameters needed to be different, and further explorations areas could be the rotation in the X axis as well and wall diffusers as the Room 3 case. The maximum of the optimization could not be possible because a crashing error -Figure 58-, being the computer a direct limitation for the CD process.

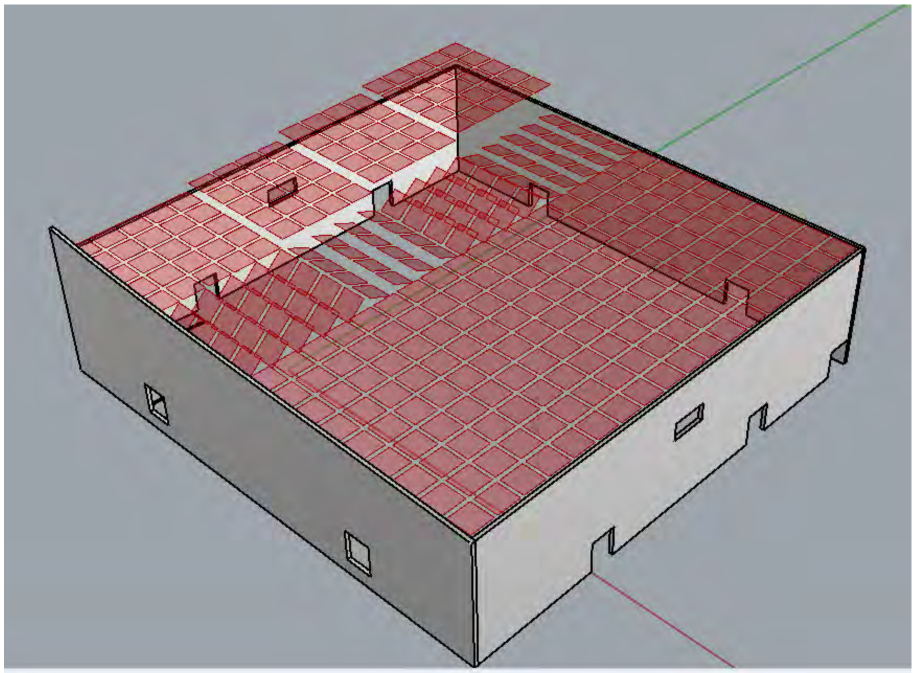

Figure 54. Acoustic ceiling parameters demonstration (own image from Rhino).

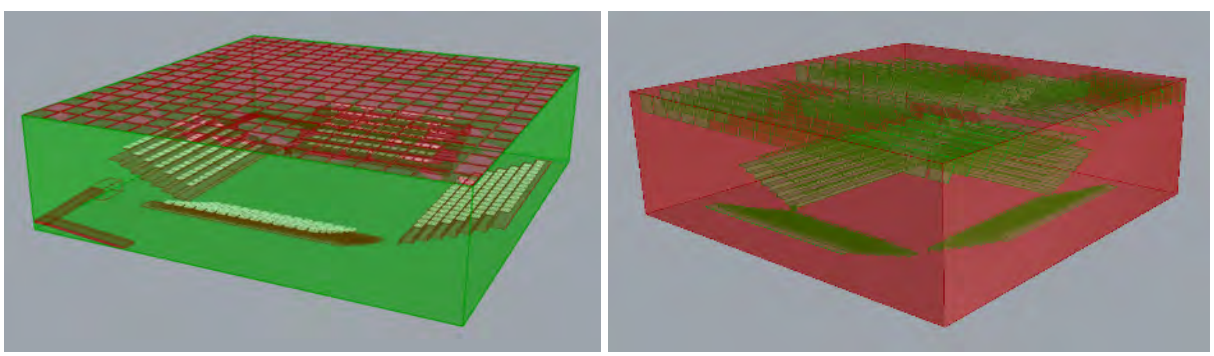

Figure 55. Base position for Snail simulation vs capacity of movement of the ceiling for Galapagos optimization (own images from Rhino).

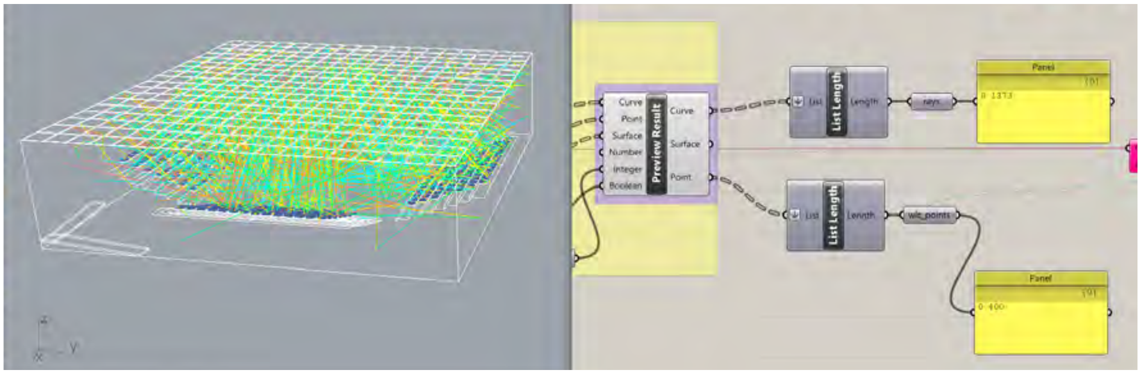

Figure 56. Snail solution of analysis (own image from Rhino and GH).

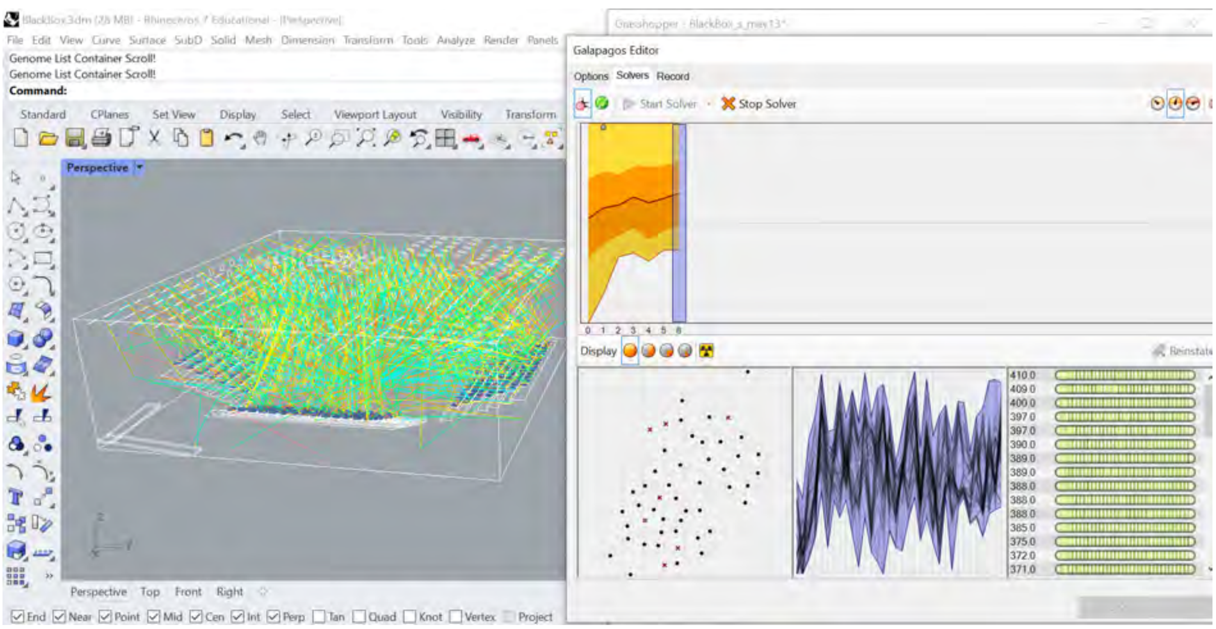

Figure 57. Galapagos optimization process (own image from Rhino and GH).

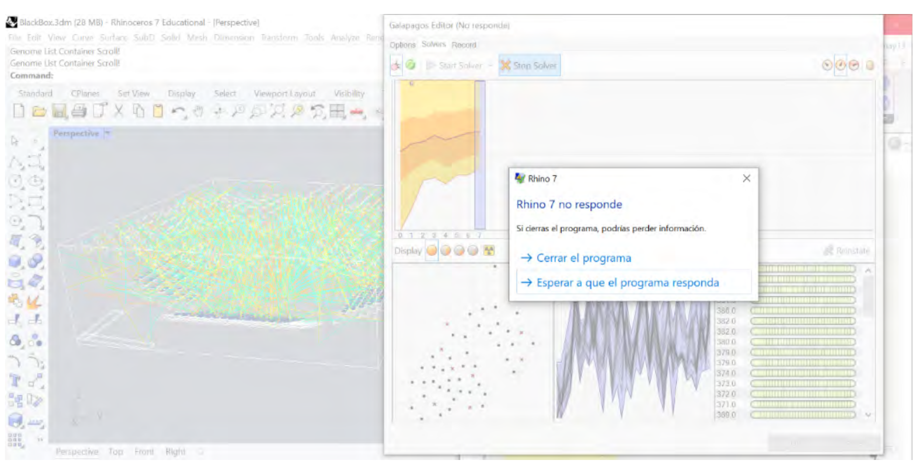

Figure 58. Galapagos and Rhino error message (own image from Rhino and GH).

Finally, one of the main aspects of the skin is that is a structural element. Because its complexity, the CD process allows to analyze the structural behavior of it without loads of calculations made by hand. The Lunchbox mesh result was taken to Karamba, a plugin used to calculate structural elements, running the definition with no other load than the own weight of the proposed structure. Some of the relevant data got as output is the deformation, that got to be 8.52 cm -Figure 59- that is not much for a structure over 40 x 40 m area; the utilization of the structure is minimum, as the purple color revels in Figure 60, and the occupation is only in its center, represented by the red lines of Figure 61. The structure itself can stand up and is not being used in is potential capacity. Therefore, is viable to assume that the shell can carry the height of the acoustic ceiling and illumination grid. Further design work will need to be done for the analysis and optimization of the structure including the alive loads of these two other elements.

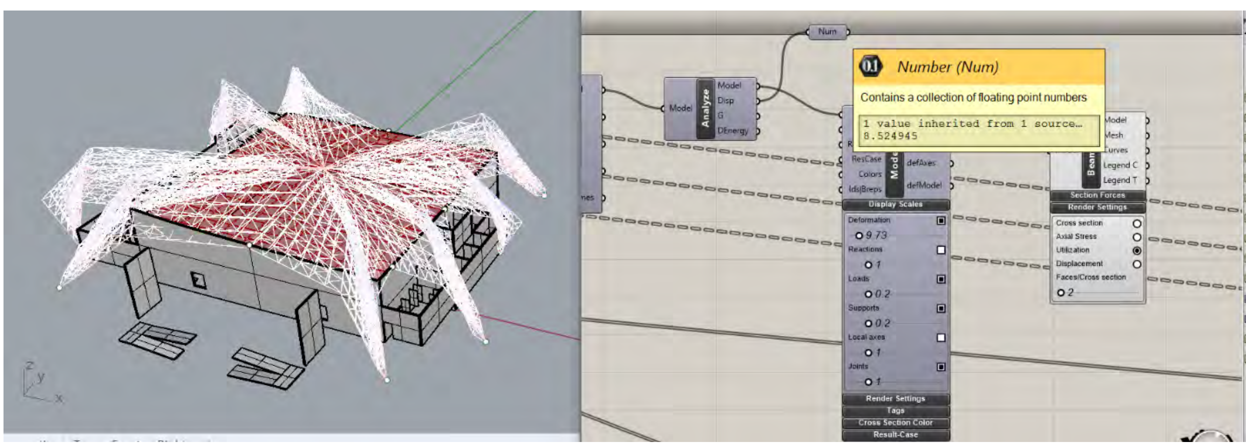

Figure 59. Karamba analysis results (own image from Rhino and GH).

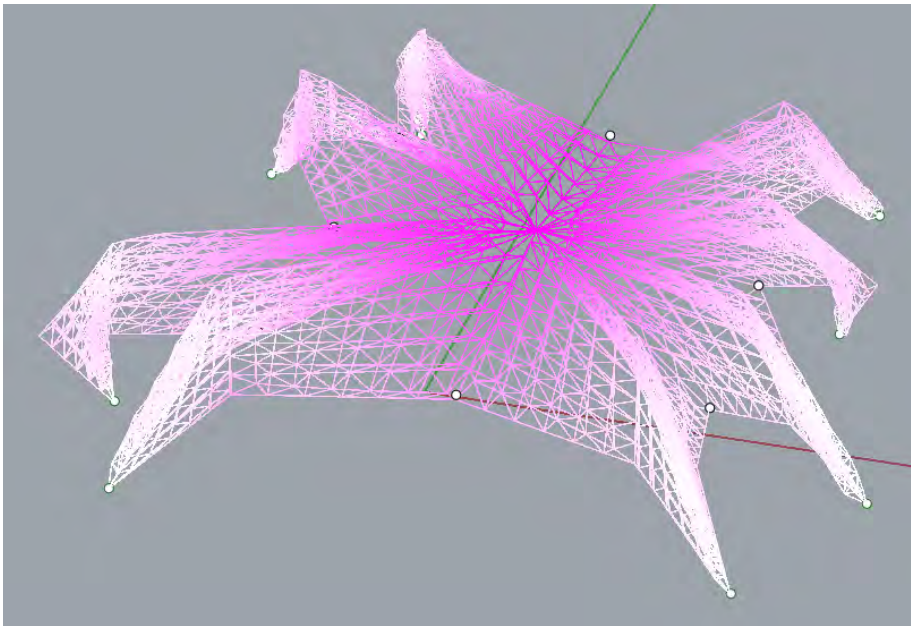

Figure 60. Karamba utilization model (own image from Rhino).

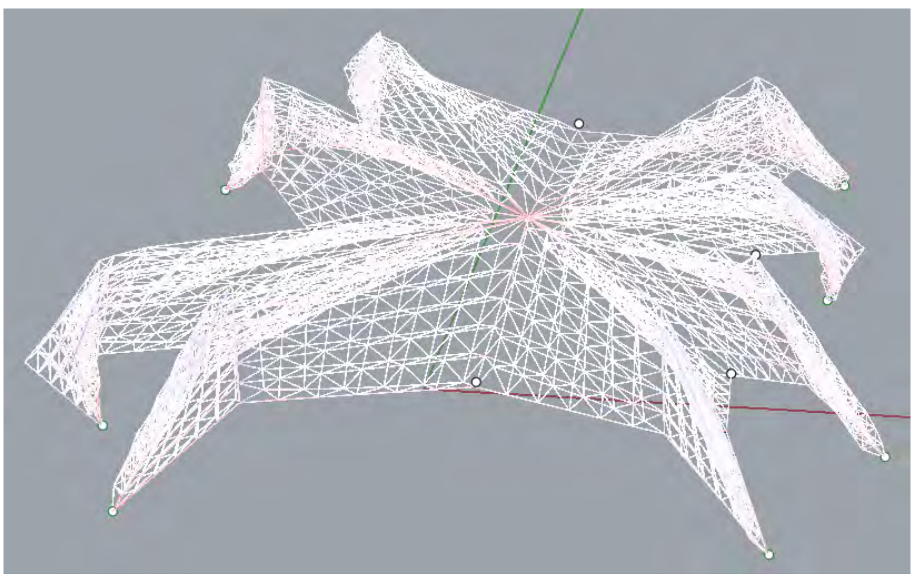

Figure 61. Karamba occupation model (own image from Rhino).

Section 12. Final Proposal

For the final model all the objects made, analyzed, or optimized in the GH environment were taken into the Revit one, for the plans -Figure 62 and Figure 63-, sections -Figure 64 and Figure 65-, elevations -Figure 66, Figure 67, Figure 68, and Figure 69-, and isometrics -Figure

70, Figure 71, Figure 72, and Figure 73- generation. Rhino inside Revit was the tool that allowed during all the workflow to move geometries to one software to another. The process to take GH elements into Revit allows different levels of detail. For the BBT purposes, the skin, ceiling, and grid were taken only with basic materials like generic model elements. From the Revit environment was possible to take the model to Enscape, a real time rendering software that allowed the generation of model renders -Figure 74, Figure 75, and Figure 76-. All the images presented in this section are for the presentation and explanation of the final proposal of the conceptual project of a BBT for the UDLAP community and have not executive plan quality. The images highlight the configuration of the space -Figure 62-, the way the skin embraces the whole building -sections and elevations-, the fact that the supports are able to penetrate the gallery area -Figure 66 and Figure 76-, or the fact that those supports also open in the west side -Figure 68, Figure 71, and Figure 76-. The proposal is a BBT that shows from the outside the CD capacity, from the skin structure to the box, flexible in its emptiness and capacity of being analyzed and optimized, no matter the configuration the artists desire.

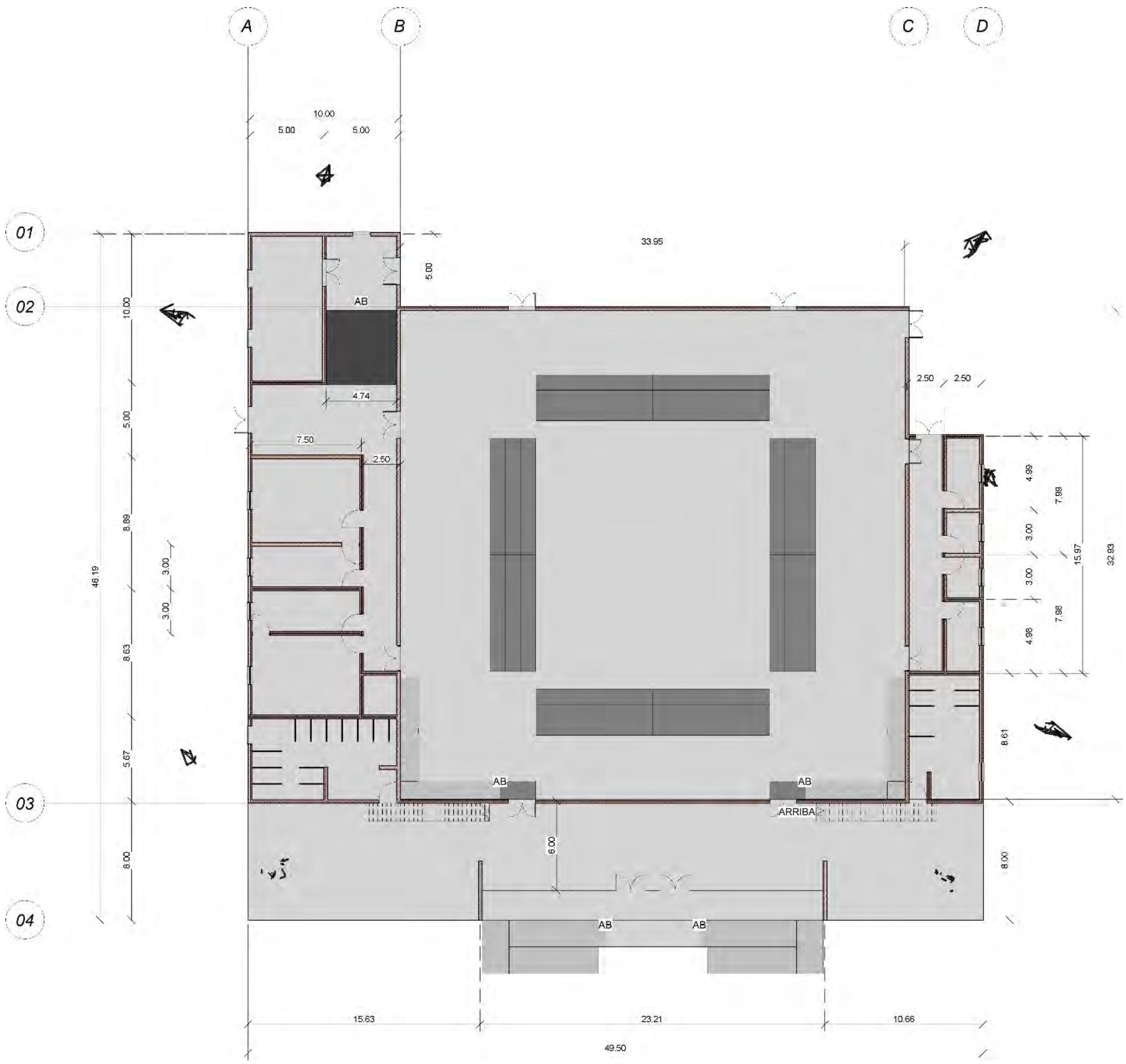

Figure 62. Levels 1-2 plan, shaded view, north oriented top (own image from Revit).

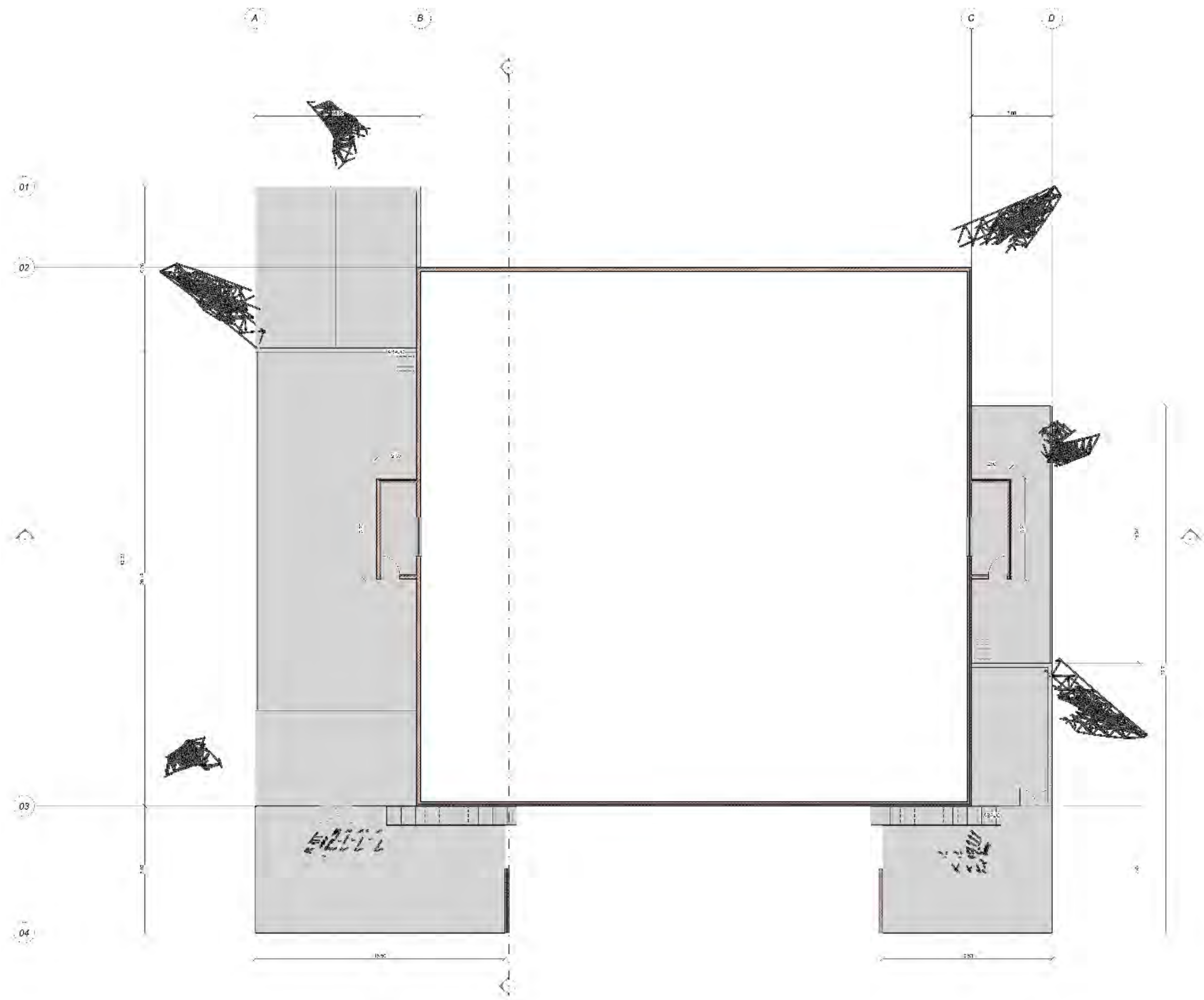

Figure 63. Levels 3-4 plan shaded view, north oriented top (own image from Revit).

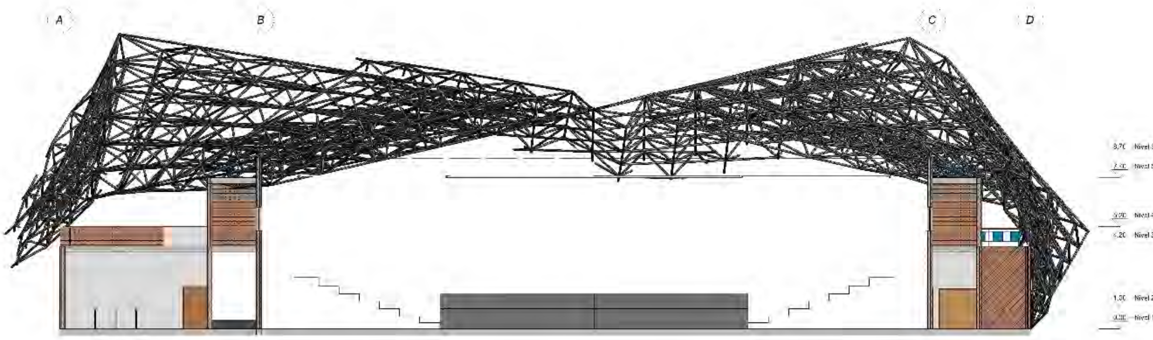

Figure 64. Section 01, west-east direction, shaded view (own image from Revit).

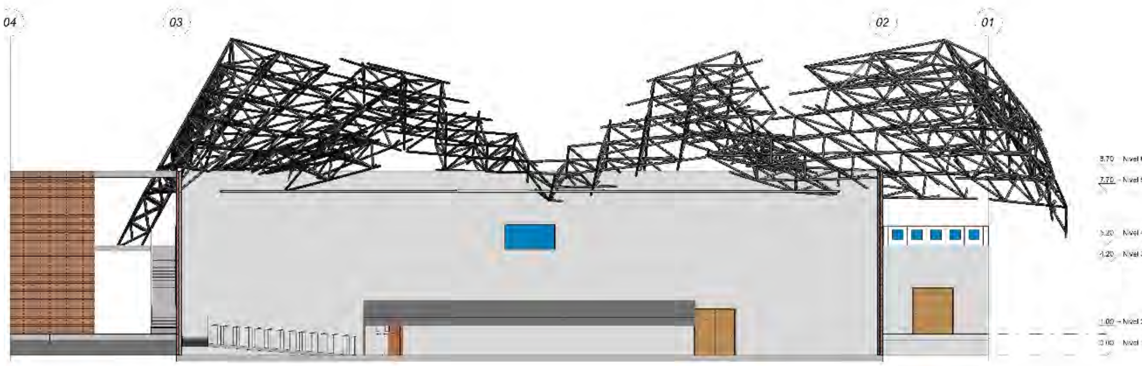

Figure 65. Section 02, south-north direction, shaded view (own image from Revit).

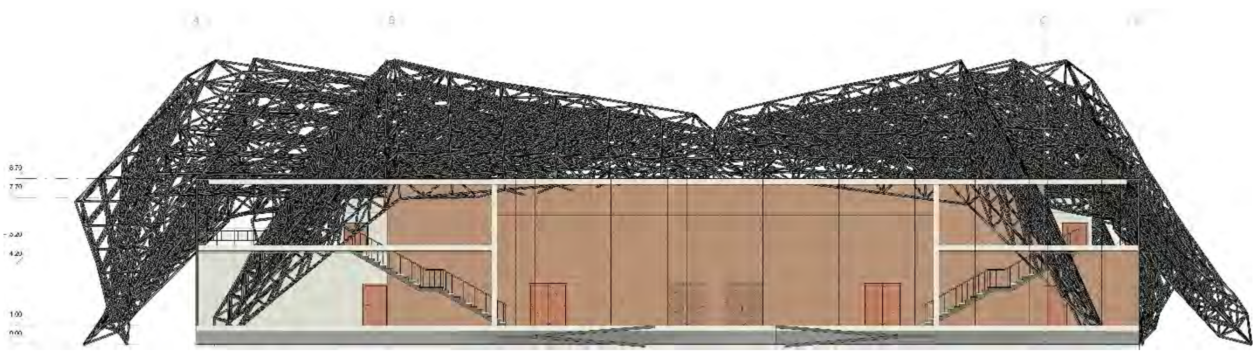

Figure 66. South elevation -principal-, realistic view (own image from Revit).

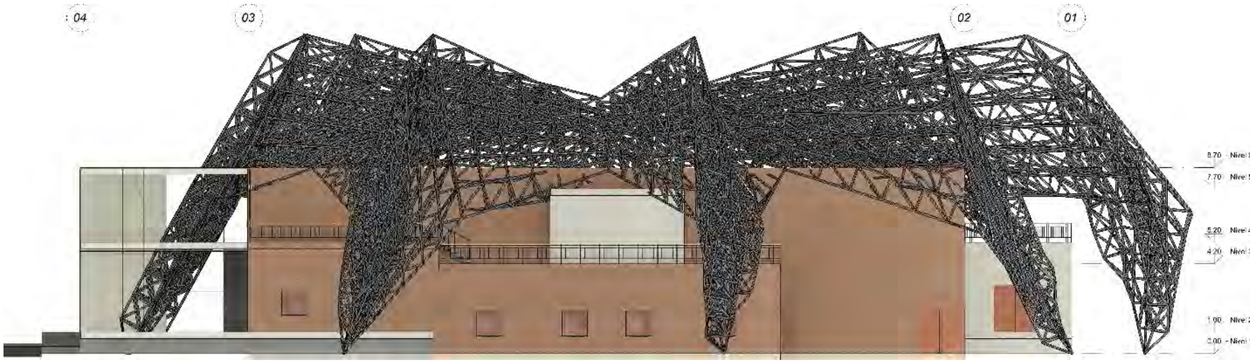

Figure 67. East elevation, realistic view (own image from Revit).

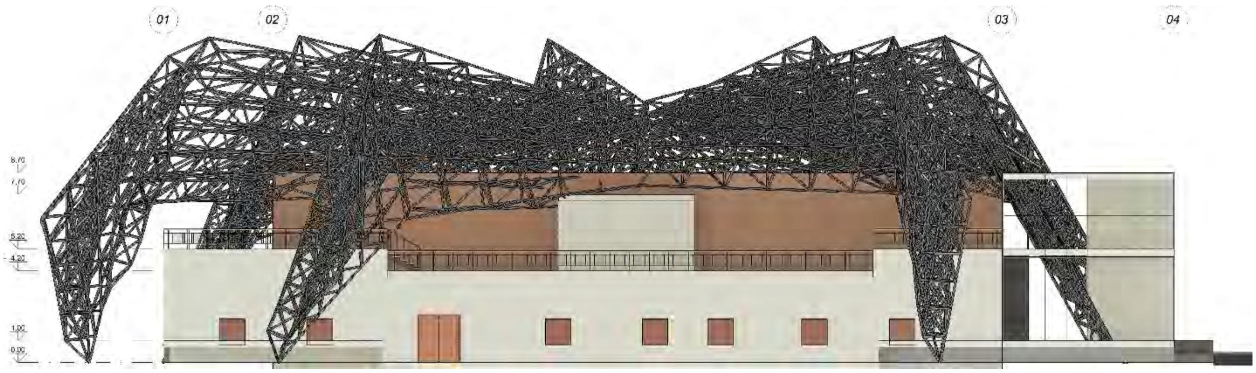

Figure 68. West elevation -open to the volcano-, realistic view (own image from Revit).

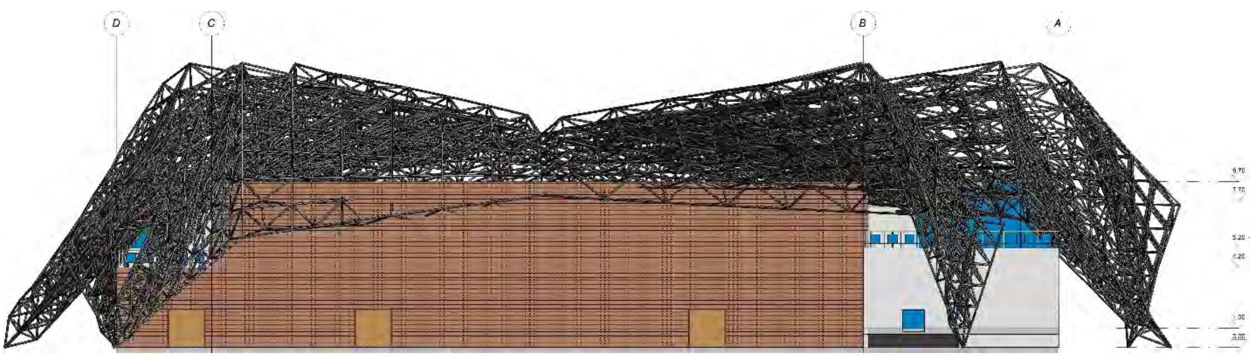

Figure 69. North elevation -back-, shaded view (own image from Revit).

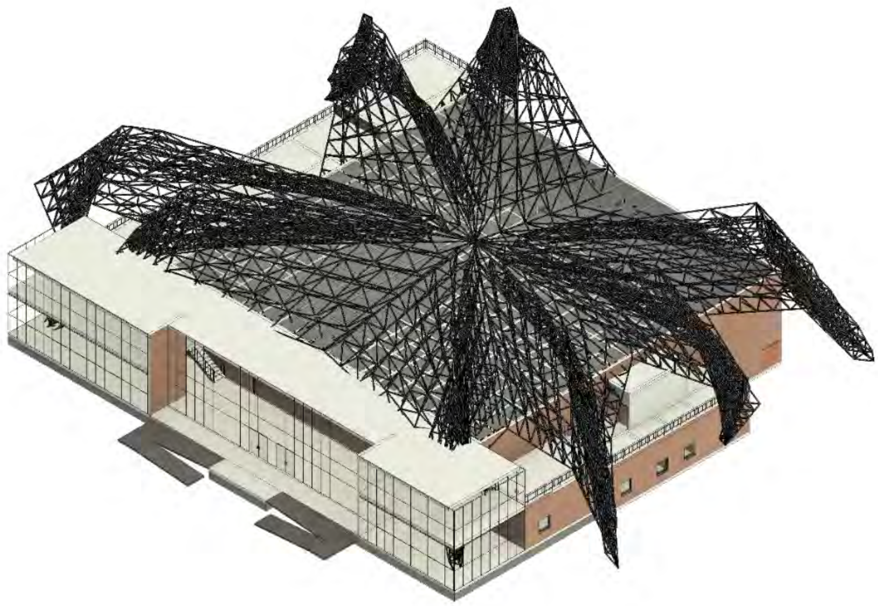

Figure 70. Southeast isometric, realistic view (own image from Revit).

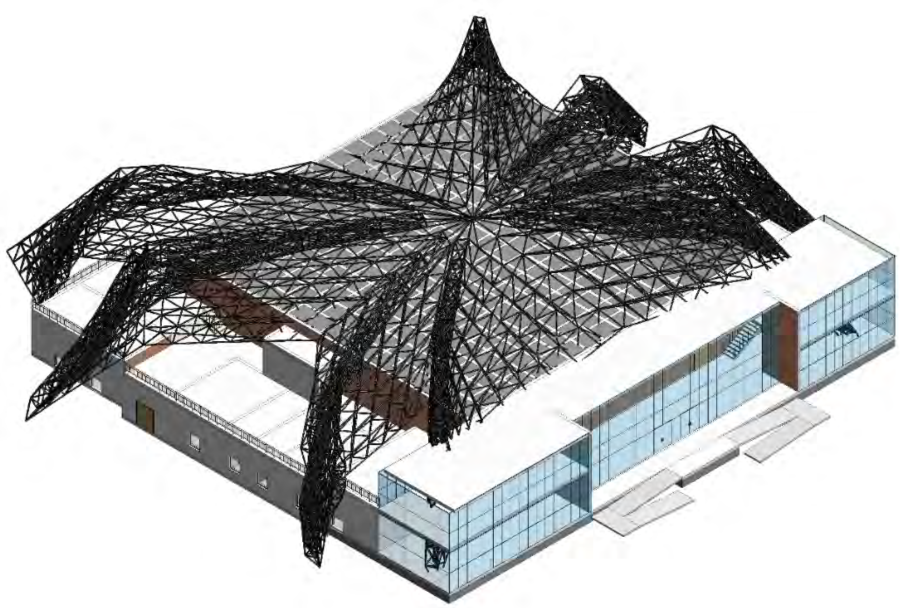

Figure 71. Southwest isometric, shaded view (own image from Revit).

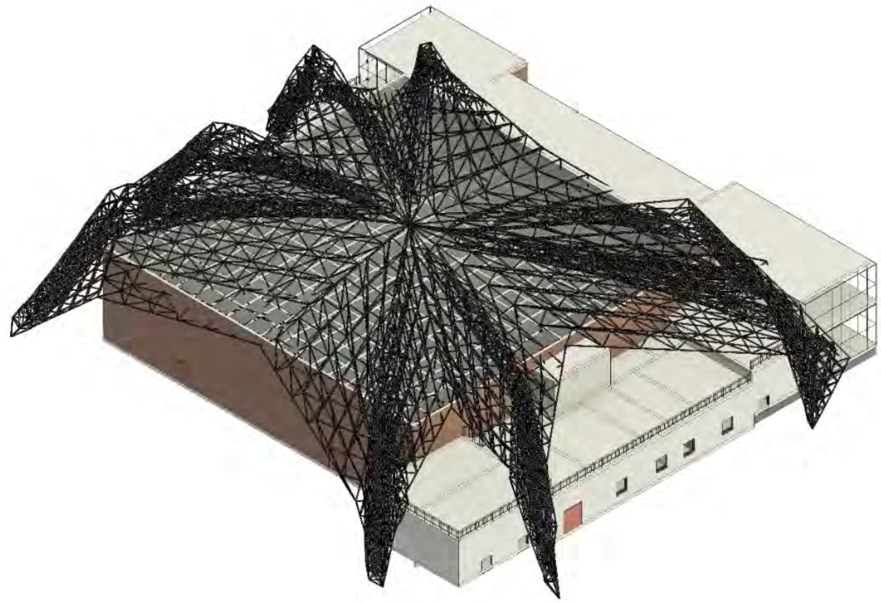

Figure 72. Northwest isometric, realistic view (own image from Revit).

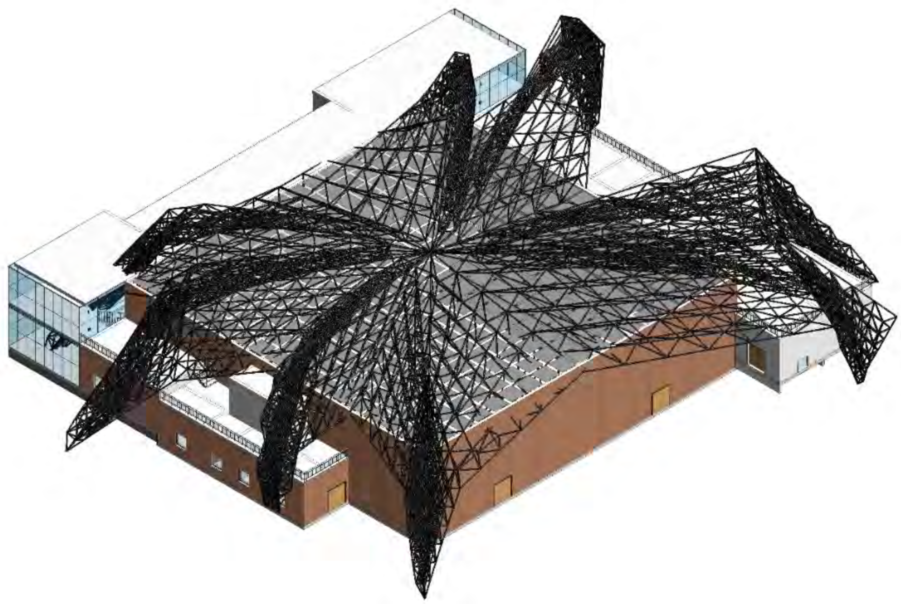

Figure 73. Northeast isometric, shaded view (own image from Revit).

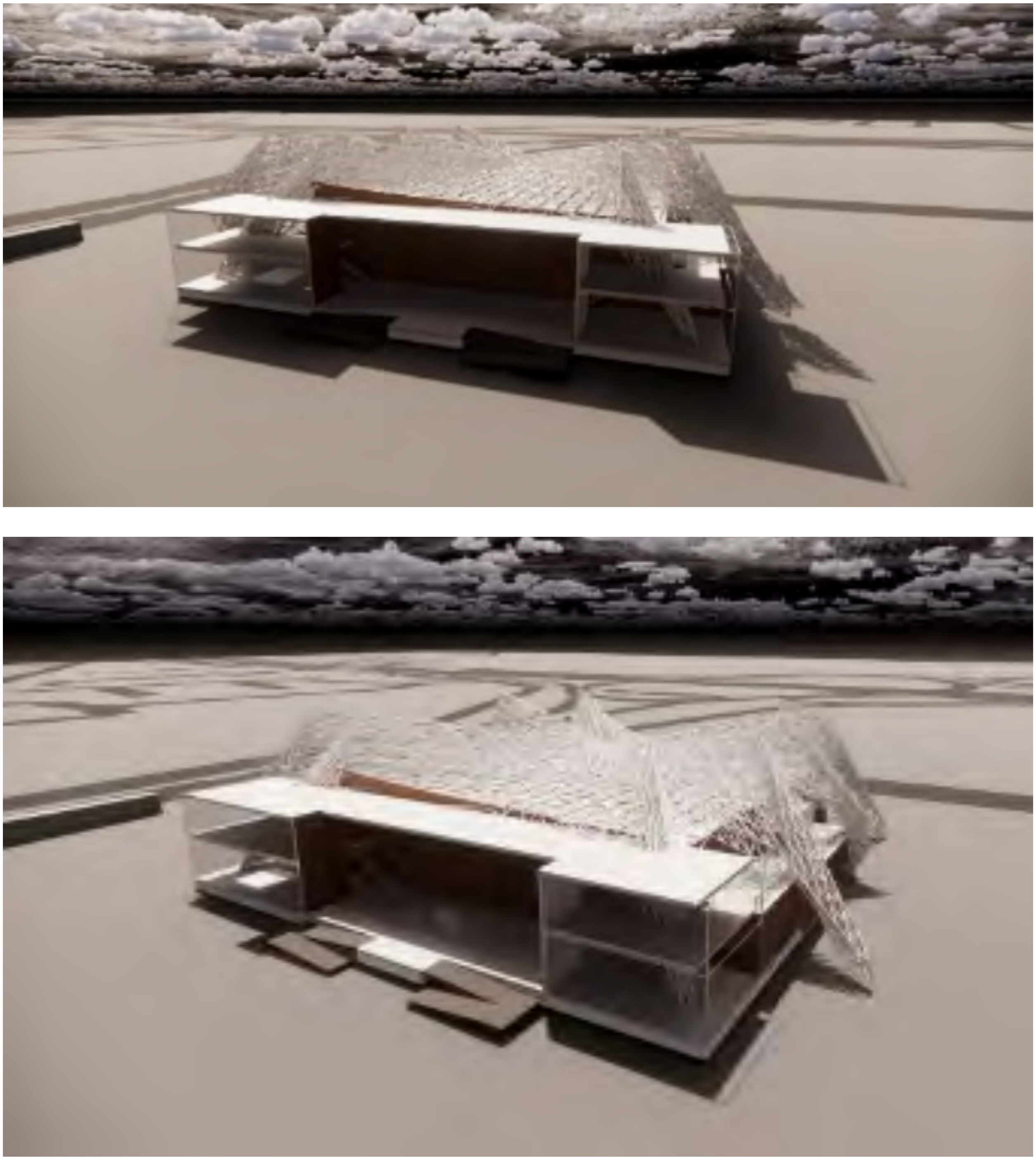

Figure 74. Renderer front views of the principal access (own images from Enscape).

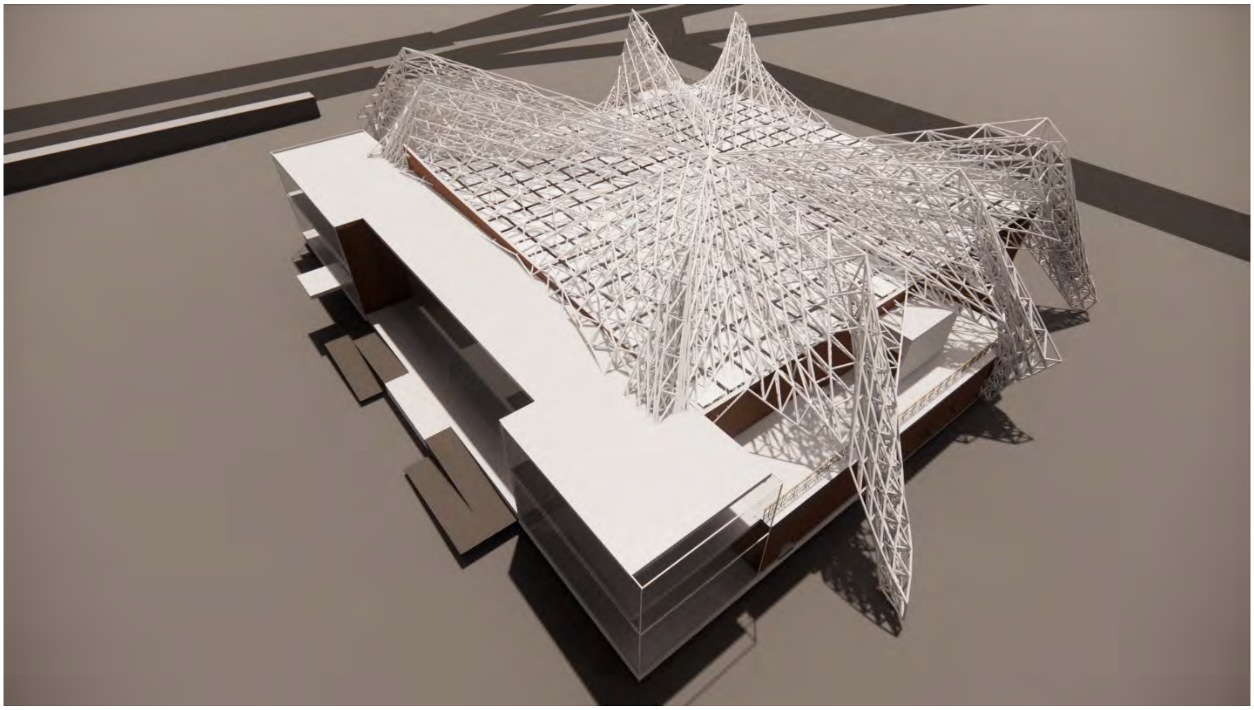

Figure 75. Rendered top skin view (own images from Enscape).

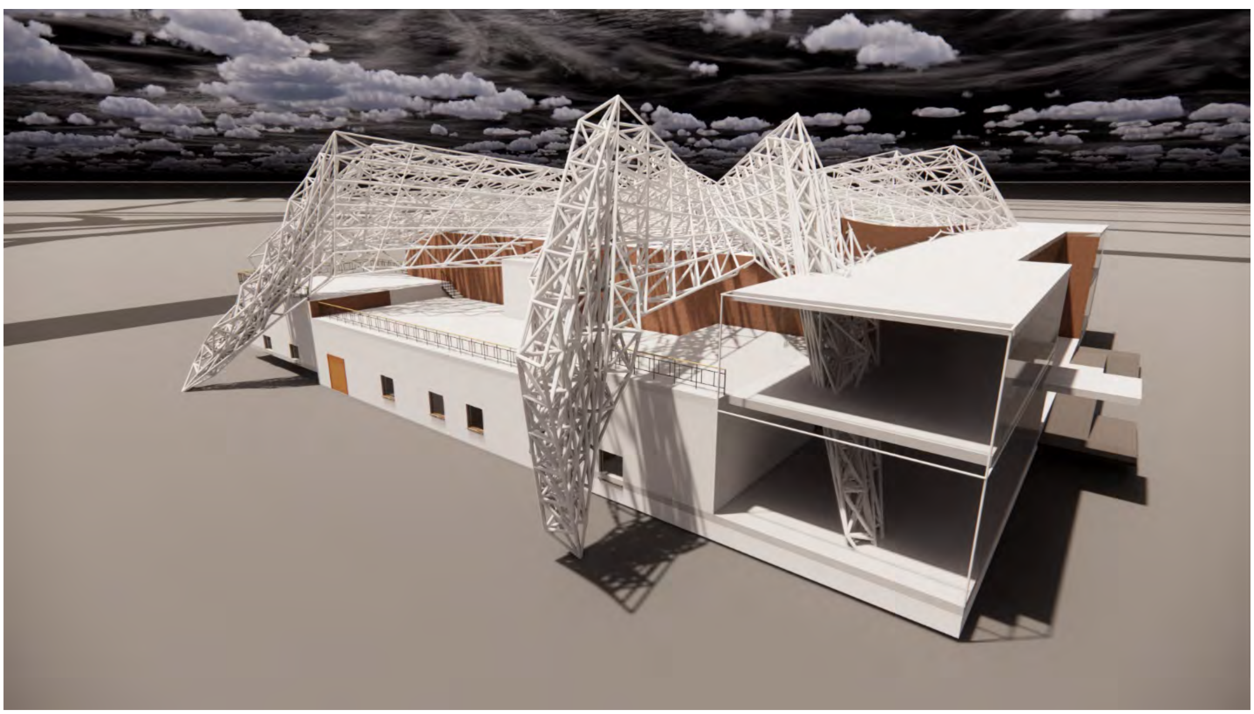

Figure 76. Render side view, terrace, and gallery (own images from Enscape).

Conclusions

The BBT is a modern concept, however, the necessity of transformable space is a matter that today goes beyond the performing space to go inside houses, offices, public space, and any sphere where spatial needs are required. This, in addition to the fact that art is the reflection of the era its living, leaves out of question if the flexible spaces for art are needed or not: they are. The BBT is only one reflection of the contemporary tendency of quick changes and this void, that could be seen as a simple space, can contain great amounts of complexity. This complexity and flexibility are reflected in the dimensions that the space can include, such as music, dance, theater, sound, movement, lighting, arts, contemplation, recreation, everything inside and outside the void of a box. Multidisciplinary is other word that can be included in adaptability or flexibility, and today we need architectural solutions that not only response to spatial problems, but to complex, multidimensional, problems.

Complexity is also something that technology is giving us the possibility to experiment with. Is true that technology changes the way architecture is constructed and conceived, and the demonstration is the fact that a small simple space, like an empty box, can be transformed in a complex void container that can be design, tested and optimized through a workflow that involves more than one technological tool. The reality of architecture nowadays is the capacity of giving these complex solutions to the simple, to give flexibility to the rigid, everything before the first rock is even put on site, only with a computer. The size of the project no longer matter, because the dimensions that are possible to imply are infinite, the only requirement is enough data to feed our algorithms with, and then one project can be tested over and over again, with greater detail level each time.

The BBT designed in this thesis is a small demonstration of the capacity of the computational design. The lack of information of the site and masterplan provoke that the project would never fit perfectly with a real project. However, the methodology applied, and the logic followed to give solution, test, and get better, allows the BBT to reinvent itself to match a new situation. When the parameters given are the correct ones, the same workflow have the possibility to adapt itself, to grow, and deliver the output we need. The capacity of adaption and the flexibility of the space are the most valuable conditions of the complexity of the project, because that complexity is the reflection of the alliance technology human that architects should be doing, not only big architectural offices, but in everyday projects, to give better solutions to the spaces we design.

As conclusion, the BBT design of this project covered a significant specter of dimensions applied to one space, always centered in adaptability and flexibility through technological design, testing and optimization. Even if this thesis only took the conceptual scope, the advantage of the usage of a BIM technology allows to get faster to the executive scope. Also, it would be interesting to test the space knowing more site factors and having a masterplan to evaluate the flexibility capacity of the volume. This small-scale computational design workflow is a demonstration of the relevance of these technologies being learned and applied in universities, so the next graduated generation have the capacity to give more complex solutions in less time than using traditional digital tools. I believe that computational design is a new language for architecture and is matter of time for us to start speaking it fluently. Architecture is a discipline that it has never been static through time, and the way we think and design is influenced by our time, that gets every day more complex in its interdisciplinary tendency of making alliances, to adapt the changes that are about to come, and to use technology in our favor.

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