BUILDING WITH SOUND: INTEGRATING THE SCIENCE OF ACOUSTICS WITH THE POETRY OF SPACE

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1.0 ABSTRACT

High performance architecture—architecture that not only serves its functional purpose, but also improves the human experience—requires that the acoustical environment be designed to the same exacting level as aesthetic and technical components of the building. Acoustics too easily succumb to value-engineering and are lost in the overall architectural design process, often to the detriment of the overall spatial experience.

By exploring the perception of sound within architecture, and by determining how sound can mold and shape the architectural environment, design goals and methods based upon acoustical science can be developed which will fully integrate acoustics into the overall architecture. Sound will become a fundamental aspect of architectural design.

Designing with sound can be accomplished using a palette of scientific parameters poetically applied during the creative process. Thus, the objective characteristics of acoustical design can be translated into the subjective experience of architectural space.

2.0 THESIS STATEMENT

Building with Sound: Translating the science of acoustics with the poetry of space

Thesis title

Statement

Sound influences the design of architectural space though the establishment of acoustical parameters that create desired acoustical characteristics that, when utilized within the artistic design process, result in the development of space built from sound.
Acoustical science and engineering, along with the poetics of space, will drive the research and application of this project. A distinct dichotomy exists between the logical, scientific application of sound and the theoretical implications of sound upon architectural space. Acoustics shares an intimate relationship with architecture; each space created within the architecture establishes a unique acoustical environment and character which can be described by quantifiable factors.

However, a poetic understanding of space, entering a realm of subjective perception and feeling, exists simultaneously. The intangible, qualitative facets of space that influence our self-awareness and interaction with architecture provide an alternate lens to analyze space. Despite the dichotomy between calculated and measured figures and poetic perceptions, ample opportunities exist to push the established boundaries of architecture and acoustics, and merge them into a cohesive whole—creating harmony between science and poetry.

Within the context of science and poetry, certain dominant themes arise that will be addressed during the research and application of the project. Firstly, an understanding of high performance architecture, meaning architecture that not only performs its programmatic and technical functional requirements, but also improves and enhances the human condition, is needed to determine how best to apply the poetry of space within the context of acoustical science. As an extension of acoustical science, the science behind perception will also demand intense study to assure that the developed spaces have the intended impact.

Designing space poetically requires an understanding of what conditions or characteristics control the subjective experience of space. The tools architects use to develop the atmosphere of space are critical in determining how acoustic principles can be most successfully translated into poetic space. Foremost, a synthesis of the research will lead to an understanding of how sound can become a fundamental component of the design process.

As architects have historically used logical, scientific understandings of light, shade, and shadow to poetically influence the creation of space, this research seeks to find parallel quantifiable acoustic values that will aid in the creation of poetically informed space.
3.2 Literature Review

The application of acoustics in an architectural design project normally falls low on the list of design priorities. At worst, acoustics become relevant only after acoustical problems ensue, and a post-construction band-aid must be applied. If acoustics became more than recommendations made by acousticians, if acoustics became an integral part of the architectural design process, would the principles of sound be applied in architecturally sensitive and supportive way? Merely applying acoustics to space fails to solve the problem of the acoustical spatial experience being separate from the rest of the physical, spatial experience. For the science of acoustics and the poetry of space to merge, and for sound to become fundamental to the design process, sound needs to be viewed as a tool in the creation of space.

The manifestation of sound as a building tool is simple in concept, but complex in its execution. The architect can take a literal, figurative, or integrated approach. Depending on which path the architect chooses to follow, the architectural outcome can represent varying levels of legibility. The clarity of the integration can be described using Robert Venturi's theoretical ideas established in his book *Learning from Las Vegas*. Venturi posits that buildings can fall into one of two categories: duck or decorated shed. A duck is a direct, literal symbol of the building's function, program, or identity; a decorated shed requires signage and applied ornament to reveal the building's function and identity.

Thus, in relation to building with sound, a duck characterizes a building that takes on the physical likeness of a musical instrument, takes on the forms of items associated with music, or makes other gestures which directly relate to music. A decorated shed, conversely, can be functionally related to music—such as a concert venue or opera house—but requires signage or ornamentation to clarify its identity because the building does not directly appear to be musical.

Looking at several examples provides clarity to the argument. The Piano House literally takes on the form of a piano and guitar, representing a duck. While painfully obvious, this example emphasizes the transparency of its design intentions. The architecture has been built with music by literally becoming a representation of a musical instrument. Without any signage or any applied ornamentation, this building loudly proclaims its function through its physical manifestation.

Decorated sheds require more analysis to understand because their forms do not necessarily reflect their functions. A traditional decorated shed, such as a retail store, does not readily reveal its design intention. The retail store's architecture generally takes the form of a generic box which requires the addition of a sign or other ornamentation to establish the necessary for the consumer to associate the building with a specific brand and function. The lack of transparency denies users the ability to read into the building.

Within the context building with sound, an additional category of building needs to be considered beyond duck and decorated shed. The decorated duck departs from the hard dichotomy established by Venturi and permits a blurring of the line separating each form. Following in Venturi's vocabulary, the decorated duck shares elements of each original building typology: the idea behind the form can be construed upon study, but to be clear to the average user, signage or ornamentation needs to be applied. Buildings like Frank Gehry's Walt Disney Concert Hall in Los Angeles fall into the decorated duck category. Gehry's design shares theoretical roots with the interpretation of architecture as frozen music, established by Johann Wolfgang Von Goethe. One means to achieve such a construct requires analyzing a piece of music, plotting points on a graph that represent the music, and connecting the points into a formal model that develops architectural space.

The Metaphone by Hérault Arnod Architectes represents a different take on the decorated duck. In this building, the architecture becomes a musical instrument, blurring the line between designing with sound in a literal way, and using sound as a design tool in an architecturally poetic way. Duck-like in its transformation into a musical instrument, the Metaphone is not a complete duck because its forms do not immediately recall those of musical instruments. Furthermore, the building requires signage to reveal its true nature: giving the Metaphone characteristics of the decorated shed. The decorated duck can be semi-transparent in its presentation of the design idea. Upon intense study, the underlying design motivations can be found, but signs and ornamentation are required for the common user to understand the depth of the design.
because superficially, the building can appear to be a simple decorated shed. An additional form of decorated duck should also be analyzed to understand its implications in the construction of buildings with sound. Rhythm as a design tool can begin to inform a building following in the duck category by directly relating to a musical precedent and demonstrating musical quality. However, it also follows in the form of a decorated shed because without signage or other ornamentation, the rhythm and the musical precedent that established it, can go unnoticed by the normal user. The use of rhythm in architecture rests upon a long tradition of architectural history. Classical ornamentation establishes repeated motifs which create a rhythm of light and shade, protrusion and reveal, solid and void. Modern examples again use the same elements but in different forms and with different results. Rhythm also serves as an additional example of architecture as frozen music. Thus rhythm’s significance as a tool to build with sound and to poetically design space cannot be neglected or understated.

A primary concern with this thesis project is the ability of the user to understand the architectural reasoning behind the final formal composition of the building. Part of the value of sound as a building tool comes from its ability to reinforce the importance of acoustics in the design of space. Therefore, to be successful, the architectural design needs to achieve a high level of scientific acoustical competency while still demonstrating a poetic awareness of space which can be understood by the user. If the project falls too heavily on the side of duck—where the building screams its identity as a musically inspired structure—it runs the risk seeming mediocre and representing a parody. If the project becomes too heavily theoretical, in the case of a decorated shed where signs or ornament must be applied for the building’s function to be evident, then the building could become too inaccessible to the average user and reduce its impact and teaching effectiveness. The integrated typology, the decorated duck, appears to be the most logical approach for demonstrating building with sound.

Having established a typology through which building with sound can be understood by users, the discussion now shifts to an analysis of the poetry of space, the design tools currently used by architects, the new tools that need to be developed, and finally the synthesis of these elements into a cohesive solution for integrating the science of acoustics with the poetry of space.
When talking about the poetics of space, and particularly the ability of space to improve the human condition, the atmosphere of the space cannot be over-emphasized. The same tenet holds true when considering the acoustical environment of a space; acoustics play a large role in the feeling and mood of the space. Peter Zumthor addresses the importance of atmosphere in the development of architectural space in his book *Atmosphere’s*. Zumthor believes that first impressions of a space are non-linear, a rapid process that represents a spontaneous reaction. Music brings about a similar process; the audience knows almost immediately if the piece is good or bad. Much of what establishes the gut-level reaction is the atmosphere of the space, or the mood of the music. Igor Stravinsky talked about musical grammar and its ability to help a composer reach an audience by building the appropriate atmosphere. Zumthor postulates that an architectural space can also have a grammar, or underlying structure that helps the architect develop a proper atmosphere.

The organization of the book moves the reader through distinct elements, or grammatical guidelines, that help the architect form architectural space with the appropriate mood. Zumthor’s understanding of atmosphere deals with space making on a poetic plane. Space is not merely a physical construct, the atmosphere of the space must be artfully considered in order that a deeper, poetic meaning becomes apparent. One section specifically deals with sound’s implications in the development of atmosphere. However, the importance of the acoustical environment of architecture persists throughout all of the sections.

Rhythm begins to play a role in terms of how people move through the building. Architecture is a static art whereas music is inseparably related to motion and time. Thus, when considering the movement through space, a musical, rhythmic element must be addressed. Movement through space can be forced, suggested, rushed, inhibited, restrictive, or freeing, to name a few. Each type of movement creates a different atmosphere, and a certain rhythm is established through the movement. The architecture influences rhythm and rhythm can influence architecture.

Thresholds and transitions also have a great impact on the atmosphere evoked through space. Not only do thresholds address the connection between exterior and interior, they also address scenarios like tall and short, big and small, warm and cold, alive and dead, among others. Within those conditions, public versus private space can be differentiated. As the architect plays with the transitions between different spaces, he can affect the movement through the architecture, and thus create rhythm.

Another element at the architect’s disposal is light. Zumthor challenges the architect to consider how light falls within the space, the shadows it creates, what it highlights, and what moods it reinforces. The architect’s ability to manipulate light relates to his ability to manipulate space, and, more broadly, the acoustical environment. A strategy suggested by Zumthor to design with light is to start with a dark mass and add light strategically throughout the mass. Zumthor’s method simplifies the design process, giving the architect a blank slate to begin creating space with light as the particular focus and without other distractions.

A similar approach can be taken when considering sound within the design process. Beginning with a blank slate in the acoustical environment allows the architect to focus on creating the acoustic he wants. Using massing, material selection, and detailing, the architect can design a specific acoustic that supports the underlying design concept and uses sound as a design tool. Within all of these conditions, the transitions and thresholds between the different acoustic areas must be artfully considered so that movement is facilitated throughout the design.
Zumthor closes his book by reminding the architect that the goal is to achieve beautiful forms, and to do so in an active, vibrant life within them. Music offers a vehicle to find and achieve the desired forms. By using music as an inspiration for architecture, music and architecture become linked and influence each other in intricate and delicate ways.

A key question left unanswered by Zumthor is the difference between music and sound. In the study of acoustics, sound is the broader category explaining sound waves, reflections, and absorption, amongst other scientific characteristics and quantifications. Music is a more refined, nuanced sub-category reflecting a very controlled form of sound. Music is an organized and planned kind of rhythm which is easily witnessed, versus how they are the same can change how each idea is applied to the creation of architectural space.

The question of semantics raised between music and sound seems to relate to a similar architectural quandary which seeks to understand the difference between physical space and poetic space. Physical space develops through the construction of building materials into various forms and results in a visible, quantifiable item. Poetic space develops through the subtle manipulation the characteristics Zumthor elaborates upon; poetic space takes physical space and elevates it to a higher level of artistic reasoning and meaning. The relationship between sound and music can be differentiated similarly. Sound is simply pressure waves that move through air, affect our ear drums, and allow us to hear. It is a quantifiable metric that does not necessarily come with deeper meaning or association. Music, however, results from the reasoned, artistic manipulation of sound.

Music has poetic characteristics that correspond intimately with architectural space development. Architecture can be formed to fit a specific piece of music, or a piece of music can be written for a specific work of architecture. As such, many of Zumthor’s atmosphere’s relate well to the composition of music. Discovering the relationship between space, poetic space, sound, and music, the architect finds himself with a means and a set of tools to begin designing poetic architectural space influenced by music or, more broadly, sound. Through the harmonic unity of architecture and music, a coherent architectural entity can form.

Further exploring the union between architecture and music, an exploration of rhythm is important. Rhythm is a fundamental component of music that separating the two is nearly impossible. Rhythm is part of the grammar of music; it helps to hold the music together by imposing an order on the nature of sound. Similarly, architecture seeks to impose an order upon the nature of space. Steen Rasmussen contemplates the impacts of rhythm and music on architecture in his book, Experiencing Architecture.

The architect adds regularity and precision as he develops systems of solid/void/solid/void, or arrangements of fenestration, and other architectural details. As the architect establishes order, music, similarly developed a rhythm. This rhythm is easy as it can be observed as in the town homes in London which comprise of three bays (one entry bay, and two window bays). The rhythm created on these facades feels like a waltz with its signature 3 beat cadence. A benefit of visible rhythms is the transparency of the idea and its evident manifestation, which makes the musicality of the design readily apparent and understandable to the user.

Rhythm in a building goes far beyond adding a regular beat, or simply adding an element of motion. As Rasmussen points out, appropriate rhythm can create fluid, natural energy that seems to be destined rather than forced. Jacob Voorhuis describes the poetic nature created through architecture and music in this way: “Architecture is an experience in which the body moves and is therefore moved. Music the bodily emotion that moves the body.” Furthermore, as the body is directed by rhythm, the mind is freed to explore higher level artistic and creative thought. Eric Mendelsohn listened to Bach as he designed his projects because he claimed it freed his mind to create extraordinary projects.

Complicating the matter though, is the fact that architecture does not have a true element of time or motion. Thus, what is perceived as rhythm in architecture is actually a creation of the mind. While walking past a colonnade, the regular cadence that moves the user through the space is not created by physical movement, but rather through a creation of the mind. Rhythm in life may help with the perception of the motion and element of time within architecture. As every culture and era has had its own pace of life, architecture has come to reflect that pace, and we can learn how to understand larger ideas of rhythm in architecture through that lens.
For instance, the Spanish Steps in Rome were built with the rhythm of a Polonaise—a Polish dance in 3/4 time with a ceremonial, march-like feel—in mind. Therefore, the architecture was reflecting the culture of that time, which helps users to comprehend the intended architectural rhythm by providing a frame of reference.

The example of the Spanish Steps demonstrates how architecture provides a framework for people’s lives. Just as rhythm establishes the framework for music to flourish, architecture provides the underlying structure necessary for life. With such a critical role, great responsibility falls upon the architect because what he creates determines how we will live in and move through the built environment. Through the framework established by the architect, the rhythms of life can be easily transferred from person to person, almost in a contagious fashion. The propensity of cultural norms to spread can perhaps be explained by the influence architecture has upon the functioning of society within the built world.

An additional component that should be considered is the power of the collective ensemble of architecture. A single bay of a cathedral or a single arch in a facade, has very little power; it has no motion and no meaning. But when multiple bays combine into the dominant axis of a nave or the regular motion of an arcade, rhythm is established. Along with the rhythm comes motion, procession, time, and meaning. To describe this scenario in musical terms, consider a pipe organ. An individual tone can drone on endlessly, with no shape, no articulation, nor any meaning. However, when that tone is combined with others, structured by rhythm, harnessed by attack and release, and restrained by dynamics, beautiful and meaningful harmonies flourish.

Rasmussen continues his analysis as he looks more closely at the idea of hearing architecture. When walking into a space, great insight can be gained simply by listening to the sound of the space. The size, shape, materiality, and character of space are all evident through the sound of the space. Spatial experience is not limited to visual perception; all of the senses engage while determining the characteristics of architectural space. Consider how in a musical recording, the characteristics of the space in which the recording was made drastically molds and transforms the nature and color of the piece of music. Despite the physical space’s absence to a future listener, he can still understand and perceive the qualities of the original space. This point reinforces the paradoxical notion that architectural space is a catalyst for music, but also like a black void which is present and not present simultaneously.

The acoustic characteristics of a space are intricately linked to the architectural design of the space. For instance, chanting developed in the Christian church as a way to present clear and understandable scripture and sermons to the people in the large cathedrals common in the middle ages. In this way, architecture was used as an instrument. The Christian experience in a cathedral was a full sensory experience; the visual, soaring height lifted the soul, the hard stone provided a solid foundation on which to build faith, the incense cleansed and purified the body, the sacraments awakened the body through nourishment and spirit, and the sounds of the choir enlightened the mind and stirred the soul.

In other musical terms, the music of Bach would likely not have developed as it did had the architectural conditions of his church, St. Thomas Church in Leipzig, resulted in different reverberation times. Bach’s distinct, contrapuntal compositions were only possible with the audible clarity afforded through smaller reverberation times, yet the full development of sound possible in a resonant space.

The parting wisdom with which Rasmussen leaves his reader is the warning that the acoustical environment should not be an afterthought. Each space should be unique both architecturally and acoustically. The sound of a space should not be artificially determined. Achieving the proper character should be done through the marriage of form, materials, and acoustics. The idea of music influencing the creation of space in a meaningful and direct way is explored in great detail within Elizabeth Martin’s book, *Architecture as a Translation of Music*. She begins by saying:

Architecture represents the art of design in space; music, the art of design in time. Nature continually manifests motion in space or motion and space bound together as one; it is LIFE (emphasis in original text). The properties of space and time are inseparable. Without time and space, matter is inconceivable. Spaces give form and proportion; time supplies it with life and measure.
In summary, she concludes that architecture and music are so intricately linked that one cannot exist without the other. Good design must recognize the fact that acoustics cannot be an afterthought; rather, acoustics must be an integral component of the design process. We must hear space, as Rob Metkemeijer declares in his essay on *The Acoustic Space*. Kloos further elaborates on this point as he discusses the notion that our world view—the way in which space is manifested in our minds—is influenced by how we listen and what we hear. B. La Belle perhaps the explains hearing space the most clearly as he says,

Sound and space are inextricably connected, interlocked in a dynamic through which each performs the other, bringing aurality into spatiality and space into aural definition. This plays out in an acoustical occurrence whereby sound sets into relief the properties of a given space, its materiality and characteristics, through reverberation and reflection, and, in turn, these characteristics affect the given sound and how it is heard.

To successfully create an architecture that emphasizes and magnifies the expressive depth of music and adequately represents the hearing of space, Martin argues that sound should become a building material used in the creation of space. Acoustical space coordinates and mixes with architectural space. As light, shade, and shadow provide tools for the architect to sculpt space with an intangible building element, sound can also become a tool for the architect as he molds acoustical and physical space.

Traversing the realm between physical space and acoustical space requires subtle distinctions between the physical and emotional feelings of space and the emotional feelings evoked through music. If music is considered an expression of an idea or feeling, considering the role of architecture in aiding in that expression leads to outcomes of highly emotive space. Whereas if music is considered more of an exploration into temporal and aural realms, then space becomes a much more technical and rational tool.

A striking thought derived from Martin's analysis lies within the grounds of the poetics of architecture and music. If music is a higher form of sound—a more organized, controlled, and harmonious version of sound—is architecture a higher form of building—a more structured, reasoned, and cohesive form of space? The poetry of music and architecture offer ample opportunity to explore the distinctions and similarities within these ideas.

Moving forward, using the insight gained through the review of an extensive variety of literary resources, a system intended to help architects design using sound will be expounded upon in greater detail. The science of acoustics can very much influence the poetic creation of architectural space, and thus permit the architect to build with sound, perhaps physically and certainly metaphorically.

The reflections, analyses, and conclusions arrived at and expanded upon in this literature review are by no means and complete a review of all works referenced in the bibliography. Many texts were used to gain background information or to support the findings of the main texts referenced.
3.3 Theoretical Issues Raised

The topics of acoustics and architecture offer a plethora of theoretical issues and questions. Providing direction for the research by narrowing the scope and breadth of the topics is paramount. Of particular interest is the relationship between space, sound, and the experience of architecture. Understanding what tools are currently used by designers in the execution of poetic spatial design can help lead to an understanding of how sound can be poetically applied in architecture. These questions represent the driving forces for the research inquiry, and reveal the narrowed scope of interest within the broader categories of architecture and acoustics.

Does every space have its own particular sound? How does that acoustic environment affect our perception of the overall space?

How is the atmosphere of a space affected by sound?

How does the architectural design of a space influence the acoustical environment within it?

What effect does the sound of a space have on the occupant/user? Does it reinforce the architectural design and effect the programmed use of a space?

How can sound become a fundamental component of the architectural design process?

Can sound be used as an intangible building material: a way to sculpt and form architectural space despite its lack of physical manifestation?

How can acoustical thresholds be used in the development of sound spaces?

Can sound be designed similarly to how space can be designed?

If architecture is an experience of the body in physical space, what kind of experience is music?

How can the elements of time, motion, and mood be harnessed through sound and architecture? How can they influence the sculpting of architectural space?

3.4 Architectural Issues

The application of the thesis in a real architectural project will subject the ideas to the realities of building design, systems, and construction. Although challenging, the project will offer ample opportunity to test the proposed solutions. During the course of the design phase of the project, many architectural issues will arise which will require particular attention and concern.

Architectural Acoustics will be paramount to the success of the project. Application of materials both in quantity, quality, and location will critically affect the acoustics of the spaces. The aesthetic effects of acoustical treatments must be artfully considered. Integrating the acoustical treatments into the design, rather than being secondary thoughts, is essential. Appropriate acoustical environments must be provided for the function of the spaces to be successful.

Spatial development, particularly considering how architectural spaces are formed, molded, and treated, will play a large role in the overall design. The perception of those spaces, in terms of acoustics and overall mood, will influence the manner in which the spaces are created. In a similar thread, the atmosphere of the architecture, and the characteristics which affect it, will be considered in a holistic sense.

Transparency in the architectural design, particularly with the relationship between public and private space, will play a large role in the formal development of the design. Finding means to unify programmatic elements and spaces through visual connections will help to emphasize acoustical thresholds and create the interconnectivity missing in current music schools.

Throughout the design process, this project will challenge the design process to integrate sound into formal and spatial considerations. Architecturally, the emphasis on acoustics will raise questions about material selection, initiate a reconsideration of spatial construction and the experiencing of architecture, and the effects of transparency on sound within space and within the broader social function of making the new system of architectural apparent to the community outside of the specific building or space.
3.5 Architectural Precedent

Lincoln Center - NY, NY
Various architects

The plaza sits at the intersection of Broadway, Columbus Ave, and W 65th Street. Transparency is a very important factor; the interior program is evident from the exterior. People are drawn into the site by the programming and because the architecture welcomes them into the complex.

Kimmel Center - Philadelphia, PA
Rafael Viñoly Architects

The Kimmel Center is unique in the way that it creates public space between the programmatic masses encased under the large barrel vault. The shape of the main concert hall was influenced by the acoustical properties of a violin. The impact of acoustical principles upon architectural design is highly evident throughout the building.

SOURCES: fineartamerica.com, nymag.com, nycgo.com
SOURCES: rvapc.com, phillychitchat.com
Toronto Opera House - CA
Diamond+Schmitt Architects

Transparency is one of the defining characteristics of this hall, even within the interior, glass elements help to achieve a clear appearance. Although the opera house is hidden within the building mass, the lobby spaces still help to show life and activity which helps to draw the audience into the building. The auditorium follows the traditional massing and volumes used by successful halls throughout modern history. Materials used differ by the type of space in which they are placed, determined in part by acoustic needs.

Canada's National Ballet School - Toronto Canada
KPMB Architects

To help revitalize the urban fabric of the city, the National Ballet School uses transparency to help display the art happening within the building, and attempting to pull the rest of the city into the building. The image below demonstrates how the dancers can be seen by passerby’s. The massing and materiality of the school reinforce the architectural idea. As a school deeply invested in music, the formation of spaces—in scale, material, and shape—was influenced by architectural acoustic concerns.
3.6 Analysis of Architectural Precedent

The architectural examples presented in Section 3.5 Architectural Precedent were selected for specific qualities and characteristics that inform or reinforce ideas derived through the literature review and design explorations relevant to the specific project in which the thesis premise will be tested. From the precedents, several dominant themes arise which demand further explanation and elaboration.

Common among all the precedents is their programmatic function as homes to the performing arts. As large civic projects, they offer the scale and complexity to explore a variety of spaces in which the premise of building with sound can be explored. Performing arts centers also seem to be an appropriate, if not poetic, building typology to test the premise. Because of the strict and intensive acoustic demands within the program areas, the application of acoustical science will be paramount. Looking at these precedents provides ideas for how to organize the program elements, what materials are appropriate, and what acoustical constraints must be met.

Transparency is an important component of all four precedent buildings. While not directly related to the broader desire to influence the design of buildings through sound, the notion of transparency is critical to the general public's ability to understand and relate to architecture, and thus interact with it on a deeper and more informed level. Building with sound has limited effectiveness if the users of the building never realize the influence sound had on the design of the architecture. Having the building and its users perform, and opening the building up to the public, invites the community into the buildings and opens the possibility for a discourse about the architecture. All of the precedent buildings open up a public face and offer exemplars for how to promote performance and how to draw in the public.

Large public gathering spaces also reveal themselves as a common element amongst the precedent buildings. Related to transparency, these spaces permit the audiences, general users, and performers to interact with each other. By promoting visibility and incidental interactions, the program of the buildings becomes an engaging component of the overall design. Atria and other similar gathering spaces create a difficult acoustical environment. To assure that such spaces are comfortable and useful, and not detrimental to the functioning of adjacent program areas, their designs must face intense scrutiny to assure that they function properly acoustically. Because the varied and complex demands of these spaces, they seem to be an apt location to test the thesis premise.

As the proposed tools to design and build with sound comes to fruition, these buildings will serve to benchmark the progress and success of the tools' application. The success of these buildings in terms of acoustics, transparency, public access, and programmatic efficiency makes them ideal reference points. The complex nature of performing arts centers becomes more manageable through the study and consideration of existing, successful buildings, and that is an additional function of the precedent study.
4.1 Design Tools

Describing the architect's various and complex concerns while designing poetic space, Peter Zumthor, in his book *Atmosphere's*, provides a set of categories in which broader design goals can be classified. Zumthor establishes nine over-arching categories which together represent the requirements for the artful and poetic design of space.

**THE BODY OF ARCHITECTURE**

Architecture, and the art of space making, must view its forms as an anatomical body. The various elements that create space must work in harmony as a cohesive whole so that the space will work. The architecture is a living thing, which responds to the environment and which takes on a poetic, living sense.

**MATERIAL COMPATIBILITY**

Materials offer an endless set of variations and possibilities for establishing mood and character. They interact with together: sometimes clashing, blending, enhancing, and detracting. Materials have a certain radiance and life which helps them bring about an atmosphere unique to each individual space.

**THE SOUND OF A SPACE**

Zumthor comments that interior space is like a large instrument, capable of collecting, amplifying, and transmitting sound. The shape of the room and the materials that articulate it define the acoustic of the room. The sound of space helps us to understand the space and influences our perceptions of the architecture.

**THE TEMPERATURE OF A SPACE**

A space can feel warm, cold, welcoming, or disconcerting. The temperature of a space can be both physical and metaphysical. Materials are an important factor in determining how a space feels. Zumthor notes that in an open air wood pavilion he designed, the pavilion is warm when the outside air is cold, and cold when the outside air is warm.

4.0 THESIS PROPOSITION

The placement of objects in space is essential to the architect's role. How he places objects—whether densely packed, sparsely spaced, random, or ordered—plays an integral role in the atmosphere of a space. Zumthor reminds the architect that his building has a future without him; he must imagine the future of the space as it will actually be used.

**SEXTRA COMPOSURE AND SEDUCTION**

Movement through architecture awakens the spaces. How the architect moves people drastically influences the atmosphere. He can allow total user discretion, create strict and rigid circulation, or take a middle ground where discretion is provided, but the architect seduces the user to follow an intended path.

**TELEION BETWEEN INTERIOR AND EXTERIOR**

The architect creates a very tiny box of enclosed space by taking away a part of the free expanse of the globe. Thus, he is creating tension between his built environment and the natural, open environment. He must carefully articulate the divide between interior and exterior, and respond to the transitions of public versus private. The facade either hides the interior, or provides a glimpse inside.

**LEVELS OF INTIMACY**

Human sensation and perception of space is intricately linked to the massing and scale of the building in relation to the scale man himself. Proximity and distance affect our perception of scale. The architect must carefully design so that he creates space which is appropriately scaled for the human experience.

**THE LIGHT OF THINGS**

Zumthor speaks of light in a reverential, spiritual way. As the sun rises each morning, it casts its rays across the earth, lighting objects and giving them definition and highlighting their character. As the architect creates space, he must give great care to how light interacts with his space.
Having analyzed a series of components which together aid in the holistic creation of poetic space, the next logical step is to study the standard tools that architects use in the design process in order to create poetic space. The following twelve architectonic elements were selected to demonstrate the varied assortment of tools typically used by architects.

The twelve tools represent common means through which architects take concrete and pragmatic elements and attempt to build poetic space. Zumthor’s atmospheres become the framework for the narrative; the design tools become the syntax that makes telling the story possible. Together, ideas and tools for assembly, the grammar for poetic design is realized. If either element were missing, the story would falter and fail.

As architects use their tools, they begin to methodically assemble the story. The narrative provides the foundation; it establishes the mood, and informs which tools will ultimately be used during the design process. Based upon the desired atmosphere of the space, the architect makes judgments upon the importance of different characteristics and arrives at parameters which provide limits, or guidelines, for the application of the architectonic elements.

For instance, he may conclude that visual weight of the building mass needs to be minimized, and so, he restricts the height of the building to a certain limit. In doing so, he may also be engaging with the urban fabric, which can inform other elements of the design. Perhaps the building requires additional program area, beyond what the visual massing limits; here is an opportunity to engage with transparency and lighten the building without shrinking it. The architect can determine that the top 25% of the building should be glazed to create the desired effect. In this process, the architect is using the tools at his disposal, within established limits, to fulfill his ultimate of creating poetic space.

Standard architectural design follows this grammar. However, the standard process generally designs with a visual poetic, and forgets the audible poetic. The sound of a space, as Zumthor claims, must become more integrated into the design process so that sound becomes an element of the building process. In this way, sound can affect both visual and audible design.

The architect can have a similar grammar for the design of poetic space based upon the fundamentals of acoustical science. Acoustical parameters can be established which inform a set of design tools that can be used by the architect in the creation of space, thus allowing the architect to essentially build with sound.
4.2 Acoustic Parameters

To begin designing with sound, a fundamental understanding of several important acoustical parameters should be achieved. A list of ten terms has been assembled to provide a sampling of essential characteristics. All of the terms relate to the development of sound in space. Some are more objective and can be succinctly measured and analyzed—such as reverberation time, intimacy, and loudness— while others are more subjective and describe subtle perceptions— such as envelopment, texture, and warmth.

Using these acoustical parameters, the architect can design an acoustical environment which suits the designated program, responds to site constraints, or creates an ideal atmosphere or mood. As Peter Zumthor comments, architects need to design for the sound of a space. These parameters provide the tools for an architect to begin understanding the science behind sound and then how to design with sound to create a specific sound for a specific space.

For instance, reverberation time is one of the most noticeable characteristics of a space. Enter a darkened room, speak a few words or sing a few notes, wait for the response, and upon some analysis, a decently accurate perception of the volume and surface treatments of the room can be inferred. If the space is highly reverberant, the user can infer that he has walked into a large room perhaps with hard and reflective surface materials. If the space is minimally reverberant, the user can infer that he has walked a smaller room perhaps with soft and absorptive materials.

The architect can use the knowledge of which acoustical parameters create the environment he is seeking to create, and then conclude which informs which materials, volume, scale, and construction will result in that acoustic characteristic. As the architect combines and mixes the different parameters at different values and intensities, he can establish different acoustical characteristics for various kinds of space. In essence, he is creating acoustical typologies, from which he can reference while designing space.

**REVERBERATION TIME**

The time it takes for sound pressure level to decrease by 60 dB after the sound source has been terminated

**BINAURAL INDEX QUALITY**

The effectiveness of a space in providing equal sound quality to both sides of the listener

**LOUDNESS**

An auditory sensation dependent on the sound pressure level and the frequency of the sound

**WARMTH**

A factor of reverberation time for low frequency sounds; more base reverb increases the warmth, but too much can muddy the sound

**ENVIRONMENT**

The time between the arrival of the direct sound and the first reflection determines the perceived proximity to performers

**CLARITY**

A measure of intensity of the direct sound and the reverberant sound; the greater the intensity of reflected sound, the more full the room sounds

**TEXTURE**

A description of the smoothness of sound in a room; dependent on the time between successive reflections of a sound reaching a listener

**SPEECH INTELLIGIBILITY**

The degree to which speech is comprehensible and can be understood; effected by reverberation time, loudness, clarity, et cetera
4.3 Acoustic Typologies

Creating acoustical typologies is the next essential step in the process of developing a system with which to build with sound. By creating these typologies, acoustical parameters and characteristics can be matched with poetic descriptions of space. In doing so the architect builds upon the foundations of acoustical science and begins to apply poetic space making to them. This is the essence of hearing space, or the sound of a space.

For instance, one typology could be Intimate spaces. Relevant acoustical parameters could include speech intelligibility, reverberation time, loudness, and isolation. Within an Intimate space, high speech intelligibility is important, as is a low reverberation time, a quiet environment is logical, and strong acoustical isolation from outside noise is also critical. These define the parameters through which the architect can then research applicable massing, materials, etc. to realize the desired acoustical environment.

From the defined acoustical parameters, the architect can determine several characteristics about the space will be useful in its inception: sound diffusing materials, small room volume and scale, minimal background noise, and absorptive materials. These characteristics inform material selection, construction, among other design considerations. Soft materials which absorb sound, perhaps like carpet, acoustical ceiling tile, drapery, or absorption panels, should be used. A good construction type should be used; partition walls should extend to structure to increase the sound isolation, and batten insulation specifically designed for sound isolation should be used between studs.

Having selected acoustical parameters, and established different materials and means to successfully create that environment, poetic ideals for space creation can now be used. Using the established tools of architectural design discussed in section 4.1, the architect can now sculpt and form poetic space within the ideals of Zumthor’s atmospheres.
4.4 Design Matrix

As an aid to visually see the relevant acoustical parameters and their magnitudes of influence per typology, a design matrix graphic has been developed to organize the information. Various parameters can fill the arms of the radial diagram; depending on the magnitude of its importance, a point can be placed along an axis arm. The graphic provides, at a quick glance, the relevant parameters and their magnitudes.

When characterizing spaces throughout a building, this matrix helps to clarify the design intent and serves as a label which can then be referenced throughout the design process. Imagine the matrix as a sort of room tag, a labeling device typically used on construction documents, which can accompany drawing sets and serve as a reminder of the acoustical and poetic goals for any given space.

In the application of the thesis premise in the design solution, this matrix will be used to help guide the creation of the necessary spaces in a poetic way.

---

**RECTORAL HALL: Musical Performance**
- **capacity**: 150 persons
- **uses**: musical performance
- **area**: 10,000 sf
- **volume**: 200,000 cf
- **materials**: wood, plaster, glass, upholstery, carpet
- **additional**: corner of hall is glazed + looks into Hort Woods; designed for small ensembles + recitals
- **poetics**: comfortable, secluded, warm, dynamic, evocative, personal, engaging

**THEATRE LOBBY: Public Typology**
- **capacity**: 400 persons
- **uses**: gathering
- **area**: 10,000 sf
- **volume**: 180,000 cf
- **materials**: wood, gypsum, glass, metal, carpet, ACT tile
- **additional**: corner of hall is glazed + looks into Hort Woods; designed for small ensembles + recitals
- **poetics**: welcoming, warm, open, transparent, active, moving, soaring, broad
5.0 SITE AND CONTEXT ANALYSIS

5.1 Site Introduction

In order to test and apply the thesis premise, a real site and design problem is proposed to facilitate the necessary exploration. Located on the The Pennsylvania State University's University Park Campus, the selected site resides within the Arts District in the north section of campus. Falling at the intersection of important pedestrian circulation paths and serving as an anchor for the performing arts on campus, this site holds a prominent presence on campus.

However, the current arrangement of buildings—Music Buildings I and II, Theatre Building, and Forum Building—and their programmatic elements do not function efficiently or pragmatically for the students and faculty who use them. Many opportunities to engage students outside of the College of Arts and Architecture, the home to the academic areas which use this space, are neglected or left unrealized. The current buildings are closed off to the surrounding campus and lack a welcoming public face. The courtyard formed by the buildings is isolated and rarely engages students.

Surrounding the site are additional important buildings in the life of the campus. The Pasquerilla Spiritual Center, Palmer Museum of Art, Stuckeman Family Building (which houses the School of Architecture and Landscape Architecture), the Child Care Center, Chambers Buildings (which houses the College of Education), and the Moore and Cedar Buildings (which house the Psychology and Educational Psychology Departments) are all located within close proximity to the site. Respecting the urban fabric of the campus while creating the new buildings will be paramount to the success of the project in the context of the greater campus.

Additionally, the performance spaces lack proper acoustics and thus negatively impact many of the events hosted by the Schools of Music and Theatre. Both schools also require significant programmatic additions to meet the needs of their current and future students. Specifically, the School of Music needs additional rehearsal space, practice rooms, instructional facilities, and a full scale concert hall to support full orchestra and symphony. The School of Theatre requires a black box theatre, sound stages, scene construction space, and additional support spaces.

The site’s proximity to Hort Woods, located just to the north, also influences the design. The University intensely protects trees, especially historic trees, groves, and other green spaces. Hort Woods is one of these protected areas on the University Park campus. Efforts must be made during the design phase to respect and preserve this historic grove of trees. Because of this design consideration, the building footprints attempt to remain a respectful distance from Hort Woods. Design opportunities develop as well from this constraint; when possible, the design tries to highlight the woods and provide strategic views towards them.

A large water tower, critical to the University's water supply and fire protection systems, is also located close to the site to the east. With plans to expand the tower vertically and in diameter in the near future, efforts must be made to accommodate and mitigate the effects of the tower. The current Master Plan, as designed by Westlake Reed Leskosky, will no longer be viable once the expanded tower is realized. Thus a total reworking of the site and all of its buildings is the most logical option, and will result in the most cohesive and comprehensive design solution.

Being located on the University Park campus brings additional regulations and requirements to the project. The design will be subject to the regulations defined in the International Building Code 2012. Additionally, the site falls under the jurisdiction of the State College Borough Zoning Code. University Park is uniquely categorized as a University Planned District, and is further divided into zones depending on adjacent properties. The zoning code restricts building height, Floor Area Ratio (FAR), and primary and secondary uses, among other characteristics.
5.2 Annotated Aerial Photos and Maps

LOCATION INFORMATION:
- United States of America
- Pennsylvania
- Centre County
- Penn State University
- University Park Campus
- Arts Campus

SOURCES: colleges.usnews.rankingsandreviews.com; maps.google.com; psu.edu

SOURCES: www.ncdc.noaa.gov; weatherspark.com; maps.google.com; psu.edu

Annotated Aerial Photos and Maps

5.2  Annotated Aerial Photos and Maps

Regional map

Location map

Undergrad Students: 40,085
College of Arts and Architecture
School of Music Enrollment: ~350 students
School of Theatre Enrollment: ~100 students
Music Degrees: 4
Theatre Degrees: 3
Forum Building Seating: 1,000

GENERAL INFORMATION:

SITE STATISTICS:
- Site Area: 200,900 ft²
- Current Bldg. Area: 84,650 ft²
- Elevation Min: 1,219 ft
- Elevation Max: 1,227 ft
- Heating Degree Days: 6,345
- Avg. Min. Temperature: 20°F
- Avg. Max Temperature: 81°F
- Average Temperature: 48.5°F
- Orientation: North-West

ADJACENCIES:
- Hort Woods
- Child Care Center
- Stuckeman Family Building
- Pasquerilla Spiritual Center
- Cedar Building
- Palmer Museum of Art
- Water Tower

SITE STATISTICS:
- Site Area: 200,900 ft²
- Current Bldg. Area: 84,650 ft²
- Elevation Min: 1,219 ft
- Elevation Max: 1,227 ft
- Heating Degree Days: 6,345
- Avg. Min. Temperature: 20°F
- Avg. Max Temperature: 81°F
- Average Temperature: 48.5°F
- Orientation: North-West

ANOTATED AERIAL PHOTOS AND MAPS

ANNOTATED AERIAL PHOTOS AND MAPS
5.3 Site Documentation

SITE DESCRIPTIONS:
- Quiet and calm near courtyard
- Loud and busy near Forum
- Ample green space
- Private architecture
- Minimal glazing and connections between architecture and the surrounding environment
- Isolated and secluded
- Lack of exterior seating
- Lack of way-finding devices
- Inaccessible entries
- Inability to experience internal functions of the buildings

EXISTING BUILDING AREAS:
- Theatre 28,600 gsf
- Music II 12,700 gsf
- Music I 19,850 gsf
- Forum 23,500 gsf
TOTAL = 84,650 gsf

The courtyard:
This part of the site offers outdoor seating and open green space for students and faculty. It links the various buildings on the site. The public faces of the buildings face this space, instead of the more public street fronts. The courtyard is largely underutilized and does not integrate with other green spaces on campus. The fountain has limited functionality due to weather.

The buildings:
- Forum Building is located along Curtin Road and intersects with major pedestrian paths. Its lecture halls attract large numbers of students. Site topography makes accessibility a challenge. The building has a weak public presence.
- Theatre Building's facade has minimal window openings and does not respond to Hort Woods or the Stuckeman Family Building.

The buildings:
- Music Building II has a bland facade that features applied musical ornamentation in the form of a frieze of staff lines. The building does not respond to its prominent proximity to Allen Street.
- Music Building I suffers from a lack of transparency, with little fenestration and small public entries. Again, this building has little street presence and ignores its proximity to Allen Street.
5.4 Site Studies

A thesis founded upon the integration of architecture and music calls for a site that offers ample opportunities for the mixing of the two disciplines. As such, a music school appears as a logical and artistic opportunity to test the thesis premise. Penn State’s Schools of Music and Theatre are ideally situated because of their proximity to one another and to North Allen Street and Curtin Road—crucial circulation paths on campus. The Forum Building draws university students from many disciplines onto the site.

A major green axis extends from southern campus, through the Forum Building and continues to Hort Woods. Unfortunately, rather than serving as an entry or gateway, the Forum Building blocks the axis. An additional axis from the Nittany Parking Deck to the site entry is respected by the existing architecture, but is underutilized. The lack of a public face or entry in the current buildings along this axis shows the failing of the current architecture to fit within the urban context of the campus. The courtyard and sidewalks around the area also direct students near and through the music and theatre buildings.

As a major intersection on campus, this site offers an opportunity to reveal the architectural discoveries made through the thesis research to the broader university community, in addition to taking advantage the concentrated performing arts area. The complex building fabric around the site, driven by the variety of building types, programmatic uses, green spaces, and other university conditions, will require the architectural solution to not only follow the thesis premise, but also respect the broader surroundings. By demonstrating the flexibility and viability of the idea in a complicated scenario, the idea will be validated.

Forward-thinking and architecturally interesting performing arts centers have a tendency to support inter-disciplinary interaction and look beyond the usual archetype in order to create more functionally effective and aesthetically pleasing spaces. Referencing the precedents seen in Section 3.5, examples of these claims can be seen. Using this site to test this thesis project will follow in the architectural trend and allow this work to continue building upon the prior work as the project drives forward and strives to discover new ground. Key considerations related to site and concept are shown on the next page.

### Key Considerations

#### URBAN FABRIC

The urban fabric of the surrounding area plays a role in how the architecture will interact with its surroundings.

#### INTERSECTION

The intersection of critical circulation paths helps bring an audience to the site.

#### PROXIMITY

The proximity of the different buildings and the program housed within them allows them to interact and share resources.

#### TRANSPARENCY

The visibility of the interior program functions helps draw people into the buildings and allows the building users to engage with their surroundings.

#### SIGHT LINES

The continuation of sight lines and major axes throughout campus and the architecture effects the urban condition.
5.5 Site Parameters

International Building Code - 2012

Table 503: Allowable building area and heights

<table>
<thead>
<tr>
<th>Assembly</th>
<th>SCB §1202</th>
<th>SCB §1203</th>
<th>SCB §1206</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IBC §504.2</td>
<td>IBC §504.2</td>
<td>IBC §504.2</td>
</tr>
<tr>
<td>3</td>
<td>IBC §506.3</td>
<td>IBC §506.3</td>
<td>IBC §506.3</td>
</tr>
</tbody>
</table>

A sprinklered building's maximum building height is increased by 20 feet and given an additional one story.

A sprinklered building's maximum building area is increased by 200% for buildings with more than one story and 300% for single story buildings.

Automatically Sprinkler System Increase

University Planned District - State College Borough Zoning

Accessory Use: Buildings less than 20,000 ft² may have up to 2,000 ft²; buildings exceeding 20,000 ft² may have up to 10% total building area.

General uses are restricted to university related functions.

Open space in the UPD must be at least 45% of the total area.

Maximum impervious surface coverage is 55% of the total area.

Maximum building height is 45 feet.

FAR (Floor Area Ratio) maximum is 1.0.

*Site is in Subdistrict 5, which is comprised of 456 acres; all percentages and areas are based upon the total for the subdistrict.
6.0 PROGRAM

6.1 Program Type, Description, Assessment

In 2011, Penn State and the College of Arts and Architecture hired the firm Westlake Reed Leskosky of Cleveland, Ohio to complete a Master Plan to provide input on the current status of the College’s facilities, suggest improvements and renovations, and suggest new building projects. At the conclusion of the study, a comprehensive guideline was produced with recommendations and early massing studies. The programmatic conclusions within this document have become the basis for this thesis project’s program. The Master Planning document is on record with Penn State’s Office of Physical Plant and available online and by request.

Unlike the proposal of the Master Plan, this thesis project assumes that the current buildings on the site will be razed, allowing for a complete, fresh architectural intervention on the site. This concept means that Music Buildings I and II, Theatre Building, and Forum Building will be removed. The surrounding campus buildings will be preserved, however.

The use of the site will remain consistent with its current programming; it will be used as educational, research, and performance space for the School of Music and the School of Theatre. Both Schools will continue to have their primary instructional and performance spaces within the site. General classroom space, particularly large lecture halls that the Forum Building currently provides, will be included within this project. Taking into consideration the evolving nature of performance art education, the need for improved performance spaces, and the lack of support space, additional programmatic elements will be included within this project.

Outlined on the following page are the proposed program elements. These elements are essential to performing arts education and performance spaces, and offer an incredible opportunity to explore the influence of sound upon the architectural space in which the program takes place. The critical junction on which this site sits in the university context allows for the architectural ideas to be experienced by students from across the spectrum of the university.

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6.2 Programmatic Elements and Interrelationships

<table>
<thead>
<tr>
<th>Total Programmed Area</th>
<th>Music School</th>
</tr>
</thead>
<tbody>
<tr>
<td>100,500 SF</td>
<td>Recital hall 10,000 SF</td>
</tr>
<tr>
<td></td>
<td>Concert hall 15,000 SF</td>
</tr>
<tr>
<td></td>
<td>Ensemble rehearsal rooms 7,000 SF</td>
</tr>
<tr>
<td></td>
<td>Practice rooms 1,500 SF</td>
</tr>
<tr>
<td></td>
<td>Theatre School</td>
</tr>
<tr>
<td></td>
<td>Large theatre 15,000 SF</td>
</tr>
<tr>
<td></td>
<td>Black box theatre 6,000 SF</td>
</tr>
<tr>
<td></td>
<td>Dance studio 5,000 SF</td>
</tr>
<tr>
<td></td>
<td>Sound stages 5,000 SF</td>
</tr>
<tr>
<td></td>
<td>University Functions</td>
</tr>
<tr>
<td></td>
<td>Large lecture halls 8,000 SF</td>
</tr>
<tr>
<td></td>
<td>Small classrooms 4,000 SF</td>
</tr>
<tr>
<td></td>
<td>Support Functions</td>
</tr>
<tr>
<td></td>
<td>Mechanical 5,000 SF</td>
</tr>
<tr>
<td></td>
<td>Storage 2,000 SF</td>
</tr>
</tbody>
</table>

Total Estimated Gross Area 167,500 SF
6.3 Graphic Representation of Program

- Music (43%)
  - Theatre School (35%)
  - Music School (13%)
- Theatre (42%)
  - Lecture Halls (61%)
  - Practice (3%)
- Support (9%)
  - Sound Stage (14%)
  - Ensemble (16%)
- Administration (2%)
  - Recital Hall (27%)
  - Concert Hall (34%)
- IT Services (3%)
  - Cafe (4%)
  - Classrooms (31%)
- Instruction (13%)
  - Storage (22%)
- University Functions (13%)
  - Theatre (25%)
  - Support Functions (9%)
  - Lecture Halls (41%)
- SOURCES: thenounproject.com

GRAPHIC REPRESENTATION OF PROGRAM

TOTAL

University Functions
42,500 SF
Theatre School
36,000 SF
Support Functions
13,000 SF
University Functions
9,000 SF
7.1 Design Solution

The existing site plan presents the current arrangement of Music Buildings I and II, Theatre Building, and Forum Building in the North Campus Arts District. The application of the thesis solution will take place on this site. The site analysis presented in Section 4 reveals problems with the current site that the architectural solution will attempt to solve.

In this proposed site plan, the new combined Music Building, Theatre Building, Lecture Hall, and Cafe are shown. The Lecture Hall is below grade under the new courtyard, which continues a major greenway moving from South to North Campus. The arrangement of the new buildings seeks to continue the circulation paths from West Campus to East Campus, while also providing a new public face to the School of Music and School of Theatre.
A schematic level design of the ground plane was undertaken to determine general programmatic arrangements and adjacencies, with respect to larger campus master planning goals. Because of the performing arts focus of the buildings, acoustical considerations played a large role in the formation of the spaces. The main event spaces hold a prominent presence in the design of the building. Additional support spaces surround them and reside on upper and lower levels.

The schematic elevation reveals the massing of the building. Immediately evident are the large volumes articulated in metal panel which house the Black Box Theatre and Main Theatre.

The schematic section shows how the Lecture Hall rests below grade to create a pedestrian plaza above. The Main Theatre features a fly house and full orchestra pit for performances.
An additional architectural concern explored through the execution of the design solution was the engagement of the ground plane. Using a map similar to the one developed by Nolli for his map of Rome, private space is hatched with solid poche, while public space is left white. Through this map, the closed, secluded nature of the existing building on the site becomes apparent. An analysis of gross area, net area, and public space is shown on the next page.

### BUILDING LIST

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Gross A. (SF)</th>
<th>Net Area (SF)</th>
<th>Public Area (SF)</th>
</tr>
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<tbody>
<tr>
<td>01 Nittany Parking Deck</td>
<td>76,200</td>
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<tr>
<td>02 Ford Building</td>
<td>07,000</td>
<td>05,140</td>
<td>73%</td>
</tr>
<tr>
<td>03 Moore Building</td>
<td>26,600</td>
<td>18,670</td>
<td>70%</td>
</tr>
<tr>
<td>04 Cedar Building</td>
<td>12,340</td>
<td>09,550</td>
<td>77%</td>
</tr>
<tr>
<td>05 Rackley Building</td>
<td>08,680</td>
<td>06,450</td>
<td>74%</td>
</tr>
<tr>
<td>06 Chambers Building</td>
<td>40,430</td>
<td>31,235</td>
<td>77%</td>
</tr>
<tr>
<td>07 Child Care Center</td>
<td>16,600</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>08 Theatre Building</td>
<td>26,010</td>
<td>20,400</td>
<td>78%</td>
</tr>
<tr>
<td>09 Music Building 2</td>
<td>11,915</td>
<td>09,395</td>
<td>79%</td>
</tr>
<tr>
<td>10 Music Building 1</td>
<td>19,185</td>
<td>14,295</td>
<td>75%</td>
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<tr>
<td>11 Pasquerilla Spiritual Center</td>
<td>31,320</td>
<td>13,615</td>
<td>44%</td>
</tr>
<tr>
<td>12 Forum Building</td>
<td>22,620</td>
<td>19,035</td>
<td>84%</td>
</tr>
<tr>
<td>13 Beam Hall</td>
<td>15,700</td>
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<tr>
<td>14 Stuckeman Family Building</td>
<td>27,790</td>
<td>17,340</td>
<td>62%</td>
</tr>
<tr>
<td>15 Palmer Museum of Art</td>
<td>18,000</td>
<td>10,000</td>
<td>56%</td>
</tr>
<tr>
<td>16 Patterson Building</td>
<td>08,080</td>
<td>07,295</td>
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</tr>
<tr>
<td>17 Armby Building</td>
<td>11,375</td>
<td>09,935</td>
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<td>18 Weaver Building</td>
<td>08,250</td>
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<tr>
<td>19 Visual Arts Building</td>
<td>24,660</td>
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<tr>
<td>20 Arts Cottage</td>
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<tr>
<td>21 Runkle Hall</td>
<td>15,300</td>
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<td>NA</td>
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<tr>
<td>22 Agricultural Eng. Building</td>
<td>36,700</td>
<td>35,460</td>
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<tr>
<td>23 Borland Building</td>
<td>24,600</td>
<td>19,140</td>
<td>78%</td>
</tr>
<tr>
<td>24 Pavilion Theatre</td>
<td>06,970</td>
<td>06,070</td>
<td>87%</td>
</tr>
<tr>
<td>25 Ferguson Lab Building</td>
<td>07,850</td>
<td>06,460</td>
<td>82%</td>
</tr>
</tbody>
</table>

Avg. 77% Avg. 23%
Satisfying Penn State's strict guidelines for net versus gross building area while still creating more public space was a significant challenge in the architectural solution. By rearranging program into a more logical order, public spaces were created along the heavily traveled Allen Street. By facilitating movement through the site along sections of the building with increased transparency and a more public nature, the buildings become more engaging at the ground plane for the pedestrian. The chart on the next page shows an analysis of the new design.

<table>
<thead>
<tr>
<th>BUILDING LIST</th>
<th>GROSS A. (SF)</th>
<th>NET AREA (SF)</th>
<th>PUBLIC AREA (SF)</th>
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<td>76,200</td>
<td>0</td>
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<tr>
<td>02 Ford Building</td>
<td>07,000</td>
<td>05,140</td>
<td>73% 01,860 27%</td>
</tr>
<tr>
<td>03 Moore Building</td>
<td>26,600</td>
<td>18,670</td>
<td>70% 07,930 30%</td>
</tr>
<tr>
<td>04 Cedar Building</td>
<td>12,340</td>
<td>09,550</td>
<td>77% 02,790 23%</td>
</tr>
<tr>
<td>05 Rackley Building</td>
<td>08,680</td>
<td>06,450</td>
<td>74% 02,230 26%</td>
</tr>
<tr>
<td>06 Chambers Building</td>
<td>40,430</td>
<td>31,235</td>
<td>77% 09,195 23%</td>
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<tr>
<td>07 Child Care Center</td>
<td>16,600</td>
<td>0</td>
<td>NA 00,905 05%</td>
</tr>
<tr>
<td>08 Music Building</td>
<td>47,855</td>
<td>35,295</td>
<td>74% 12,560 26%</td>
</tr>
<tr>
<td>09 Lecture Hall Entries</td>
<td>02,200</td>
<td>01,095</td>
<td>50% 01,105 50%</td>
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<tr>
<td>10 Theatre Building</td>
<td>45,260</td>
<td>34,215</td>
<td>76% 11,045 24%</td>
</tr>
<tr>
<td>11 Pasquerilla Spiritual Center</td>
<td>31,320</td>
<td>12,615</td>
<td>44% 17,625 66%</td>
</tr>
<tr>
<td>12 Cafe</td>
<td>03,000</td>
<td>00,905</td>
<td>30% 02,095 70%</td>
</tr>
<tr>
<td>13 Beam Hall</td>
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<td>0</td>
<td>NA 00,900 05%</td>
</tr>
<tr>
<td>14 Stuckeman Family Building</td>
<td>27,790</td>
<td>17,340</td>
<td>62% 10,450 38%</td>
</tr>
<tr>
<td>15 Palmer Museum of Art</td>
<td>18,000</td>
<td>10,00</td>
<td>56% 08,000 64%</td>
</tr>
<tr>
<td>16 Patterson Building</td>
<td>08,080</td>
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<td>90% 00,785 10%</td>
</tr>
<tr>
<td>17 Armsby Building</td>
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<td>09,935</td>
<td>87% 01,440 13%</td>
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<td>18 Weaver Building</td>
<td>08,250</td>
<td>07,265</td>
<td>88% 09,95 12%</td>
</tr>
<tr>
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<td>21,485</td>
<td>87% 03,175 13%</td>
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<tr>
<td>20 Arts Cottage</td>
<td>04,275</td>
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<td>NA 00,900 05%</td>
</tr>
<tr>
<td>21 Runkle Hall</td>
<td>15,300</td>
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<td>NA 00,900 05%</td>
</tr>
<tr>
<td>22 Agricultural Eng. Building</td>
<td>36,700</td>
<td>35,460</td>
<td>97% 01,240 03%</td>
</tr>
<tr>
<td>23 Borland Building</td>
<td>24,600</td>
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<td>85% 00,900 13%</td>
</tr>
<tr>
<td>25 Ferguson Lab Building</td>
<td>07,850</td>
<td>06,460</td>
<td>82% 01,390 18%</td>
</tr>
</tbody>
</table>

Avg. 73%  Avg. 27%
7.3 Thesis Application

Using a site plan of the proposed design, the design matrix has been overlayed to highlight the specific programmatic elements of the design which are being considered for this example. The recital hall in the Music Building, and the lobby of the Theatre Building are two prime locations within the design to apply the thesis premise. They offer unique acoustical demands and have separate poetic interests.

Basic characteristics of each space are identified within the matrix: the occupancy capacity, programmatic use, floor area, total volume, materials, and any additional relevant information. The other part of the diagram shows the relevant acoustical parameters and their magnitudes of importance. Using the pragmatic information derived from the desired acoustical environment, the poetic environment can be created using the architectonic tools traditionally used by architects.

For instance, when designing the recital hall, knowing that there will be a large volume of space that requires hard, reflective surfaces to create the proper acoustic, the architect can look at ways to integrate materials that make the scale of the space feel more intimate and appropriate for the user, while also creating a warm, comfortable environment in which to enjoy shows. If there is daylighting, a play of light could also be used to effect the mood of the space. However, using glazing in the hall would require intense acoustical analysis to assure appropriate performance.

In this way, the design of the space can be fundamentally based upon the sound of the space, and allows acoustical principles to influence a poetic creation of space.

Building with sound becomes a more manageable task with the aid of design tools. The matrix presented above is a graphic representation of the various acoustical parameters, and the magnitude of their importance, that affect the specified acoustic typology. As the architect designs a space, he can reference the acoustic parameters to determine materials, massing, scale, etcetera that will help create the intended acoustical environment.
7.4 Summation of Design Application

Through synthesizing the premise posited in the thesis with a real design problem, great insight into the process of building with sound was realized. Understanding the tools architects use in the typical course of creating a design solution provides the foundation of the system. If the creation of poetic space is possible using these tools, logic suggests continuing using them. Determining acoustical parameters that define an acoustical environment permits the development of acoustical typologies. From those typologies, poetic interpretations of space can be formulated. Using standard architectonic tools, poetic space can be created with the foundation of acoustical science and desired acoustical environments.

The proposed site on the Pennsylvania State University's University Park campus offers ideal conditions to test the thesis premise. The need for new and improved performing arts facilities with a variety of program areas allows for a broad and diverse exploration and application of the premise. A schematic level design solution provides the necessary framework for which the basic thesis idea can be applied, and leaves the potential for continued exploration. The design solution addresses not only the thesis idea, it also addresses various architectural and master planning concerns. Assuring that the project responds fully to pragmatic concerns, holistic design goals, and poetic, acoustical design was paramount during the design process.

On the following page a listing of quotes by architects and researchers demonstrates the mentality adopted during the design process. In attempting to create a holistic design that was at once pragmatic and simultaneously poetic, the design process required a unique frame of mind; a mindset that considered practical architectural concerns as well as music's influence upon architectural design. The quotes attempt to elaborate on that frame of mind to provide greater clarity to the notion of designing with sound.

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Frank Lloyd Wright —

Juhani Pallasmaa —

B. La Belle —

Sjoerd Soeters —

Machiel Spaan —

Elizabeth Martin —

Elizabeth Martin —

Johann Wolfgang von Goethe —

"When I see architecture that moves me, I hear music in my inner ear."

"Anyone who has become entranced by the sound of dripping water in the darkness of a ruin can attest to the extraordinary capacity of the ear to carve out a volume into the void of darkness. The space traced by the ear in the darkness becomes a cavity sculpted directly in the interior of the mind."

"Sound and space are inextricably connected, interlocked in a dynamic through which each performs the other, bringing aurality into spatiality and space into aural definition. This plays out in an acoustical occurrence whereby sound sets into relief the properties of a given space, its materiality and characteristics, through reverberation and reflection, and, in turn, these characteristics affect the given sound and how it is heard."

"Architecture is an experience in which the body moves and is therefore moved. Music is the bodily emotion that moves the body."

"If sound and architecture have more to offer one another than strictly acoustics, then it is perhaps in the area of adding ambiguity to the strictly functional and spatial programs of architecture."

"Architecture represents the art of design in space; music, the art of design in time. The properties of space and time are inseparable. Without time and space, matter is inconceivable. Space gives form and proportion; time supplies it with life and measure."

"The design of buildings, which must be stationary, should be based on the movement that will flow through them."

"Music is liquid architecture; architecture is frozen music."
Building with Sound: Integrating the science of acoustics with the poetry of space

Sound influences the design of architectural space though the establishment of acoustical parameters that create desired acoustical characteristics that, when utilized within the artistic design process, result in the development of space built from sound.

The desire to find architectural inspiration from music is long established and is a topic explored by many architects and theoreticians. The two disciplines share many common themes: the mixing of objective science and poetic art, a shared vocabulary such as rhythm and mood, and the ability to intimately respond to and inform the human experience. Even from a pragmatic standpoint, the acoustics of architectural space are critically important to the proper function of those rooms.

Considering the importance of acoustics, and the long standing desire to incorporate music in architecture, there is a glaring lack of insight into how to integrate the science of acoustics with the poetry of space making. This thesis posits a solution by proposing a method with which architects can poetically create space that is informed by acoustical concerns, thus providing architects a means in which they can build with sound.

The research for the thesis embodies a variety of topics from a broad range of authors. The first area explored was the idea of the atmosphere of a space, which is critical to its overall success. Many factors contribute to the environment created and what those spaces feel like. Considering movement throughout the building leads to the idea of rhythm in architecture. Thresholds are also an important component of establishing the mood of the space; juxtapositions, proximities, and contrast all effect the overall mood and are dependent upon the transitions. The process of playing with light, shade, shadow offers a method to use sound as a design tool. The atmosphere of a project establishes its poetic sensibility. It is through the creation of mood and character that architects begin to develop the poetic reality of a space.

Further analysis of rhythm offers additional insights into sound as a building tool. The rhythm of life, established through the way in which life is lived and the architecture guiding life processes, trains the mind to discover and recognize rhythms in broader life, and in the architecture surrounding life. Considering the idea of hearing space merges the ideas of rhythm and architecture. Combined, the two ideas allow space to act as an instrument and to accurately and precisely influence the mood or atmosphere of the space. Understanding how space sounds can lead to a better and more enjoyable architectural experience.

Elizabeth Martin emphasizes the idea that sound should be used as a building material. She also suggests the notion of using the example of light, shade, and shadow as a means to use sound as a building material. The poetics of space and music influence the overall effectiveness of the architecture and offers a deeper, more meaningful way to approach the design of space.

From the research, a system to apply the notion of building with sound was developed. Starting with an understanding of acoustical parameters, which provides the foundation for accurately creating a desired acoustical environment, the architect can develop acoustical typologies that correspond to the desired environment. From this point, the architect discovers the materials and means that can create the acoustic consistent with each typology. Using the standard architectonic space-making tools, the architect can then poetically create space which informed by the acoustical parameters and means to achieve that environment.

This thesis concludes with the determination that sound can truly inform the creation of poetic space. The theoretical and poetic goals of influencing the design of space through music becomes a reality by developing a concrete method by which architects can apply their skills in a knowledgeable and accessible means. By integrating the science of acoustics with the poetry of space, architects can build with sound.
9.0 BIBLIOGRAPHY

Music, Architecture, and Space

Music: Education and Social Interaction

Architectural Theory

Acoustical Design

Architectural Precedent

Architectural Master Plan
Building with Sound: Translating the science of acoustics with the poetry of space

Cory Clippinger     Academic Year 2014-2015     The Pennsylvania State University     Department of Architecture
ACADEMIC VITA
CORY CLIPPINGER
(724) 433-0359 // coryclip@gmail.com // coryclippinger.com

EDUCATION
The Pennsylvania State University
Schreyer Honors College
Bachelor of Architecture (Expected 2015)
Architectural History Minor

WORK EXPERIENCE
Desmone Architects
Summer 2014
Architecture Intern
Conducted code and zoning research in conjunction with creating pre-design and schematic models and drawings;
Produced extensive construction documentation for various project sizes and scopes;
Helped with construction administration and site visits.

Design Collective, Inc.
Summer 2013
Architecture Intern
Worked as a team member designing mixed use, residential/retail projects;
Produced and attended presentations for client and community meetings;
Participated in construction site visits and punch listing.

Trinity United Church of Christ
2011 - 2013
Organist
Skilled organist playing for church services during the summer season and for other special services throughout the year

ELECTIVE COURSES
Collaborative BIM Studio \ Teams of engineers, architects, and landscape architects design a comprehensive building, utilizing Revit to document the design
Architectural Acoustics \ Acoustical concepts including sound isolation and transmission, reverberation time, human perception of sound, and human health
Science of Music \ Learned about the scientific principles behind musical instruments and general acoustical science
Energy and the Environment \ A course analyzing energy resources, consumption, and conservation, and environmental impacts
Rammed Earth \ Independent study examining design and construction of rammed earth structures
Diversity Awareness \ A study of discrimination and civil rights in terms of sexual orientation and gender identity; outreach to peers

AWARDS
AIA Pennsylvania Student Award \ Selected by the Penn State faculty for academic and professional excellence
Premio Piranesi Prize Winner \ International architecture competition in Tivoli, Italy, 2013
Foreman Award for Architectural Design \ 2013 design studio, Spring Semester
Design Excellence Award \ Penn State Department of Architecture, 2011
Dean’s List \ Fall 2010 - Fall 2014
Student Marshall \ highest academic performance within the B.Arch class of 2015 at Penn State

SERVICE AND ACTIVITIES
Penn State Beehive \ Director; organize and run student workshops, tutoring, and technology resources
Penn State AIAS \ Member and mentor; active participant in events; help first year students
Penn State Building Committee \ Student member; advisory group selecting the new North Halls dorm architect
Water Tower Charette \ Student member; teams of professionals proposing solutions for a design problem
Kit-of-Parts Housing Research \ Research team member; participant in design charettes, creating graphics
Pride of the Lions \ Band member; play at athletic games
Boy Scouts of America \ Eagle Scout, 3 Palms; Junior Assistant Scout Master, Senior Patrol Leader, Quartermaster
Organ Scholar of the First Presbyterian Church \ Private pipe organ lessons with a professor of music

SKILLS
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<th>Advanced</th>
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