Geometría del Sonido. Sala de Conciertos D.U.M.B.O. Brooklyn N.Y.C.

Mario Vergara
Universidad Mayor
mvergara@pratt.edu

Abstract

1. The Research Objective.

Friedrich Schelling's famous quote, "Architecture is Frozen Music" attempted to find a relationship between the solidity of architecture and the intangibility of music in his era. While the Baroque, and subsequent Rococo, styles in architecture contain a plasticity and flow of ornament that seems to validate the statement, it does not go beyond purely surface characteristics.

If we look at the purpose, goal and process of both music and architecture, finding clear relationships is difficult, though this does not deter architects from finding inspiration in music, and vice-versa.

1.1 Problem statements and Research Questions

As Brandon LaBelle describes in his work "Site of Sound"1, "sound exist as a phenomenal presence involved in and determining the shape of the world. It partially defines our perceptual, emotional, spiritual and psychological spaces; and contributes to our understanding of ourselves, our environment, and our relationship to each other".

Can sound be used in a generative way in order to produce an architectural piece of work? If that is possible architecture will not only provide new possibilities of looking at form, but linking form to a physical context. Can form follow sound?

One of the main aspects that will be considered is the relationship between exterior and interior of the building (city-exterior and auditorium-interior), through one of the most important programmatic parts, "the foyer". This space will be idealized as a filter or a threshold condition between two instances and will create an articulation in spatial, acoustical terms. Then we could think of an architectural design as a series of discreet structures that convey some sort of narrative whose plot basically involves transitions from one state of equilibrium to another, when describing this vision of a future of architecture it is possible to think of it as the materialization or architecturalization of the ephemeral and invisible forces around us, such as sound.

2. The Method.

2.1 Generative sound, concepts of interior and exterior.

The project is dealing with the issue of sound and space in two different aspects; interior and exterior conditions.

On the one hand, the interior conditions are constrained to produce the volume required for a specific type of music, as seen in *Figure 1*.

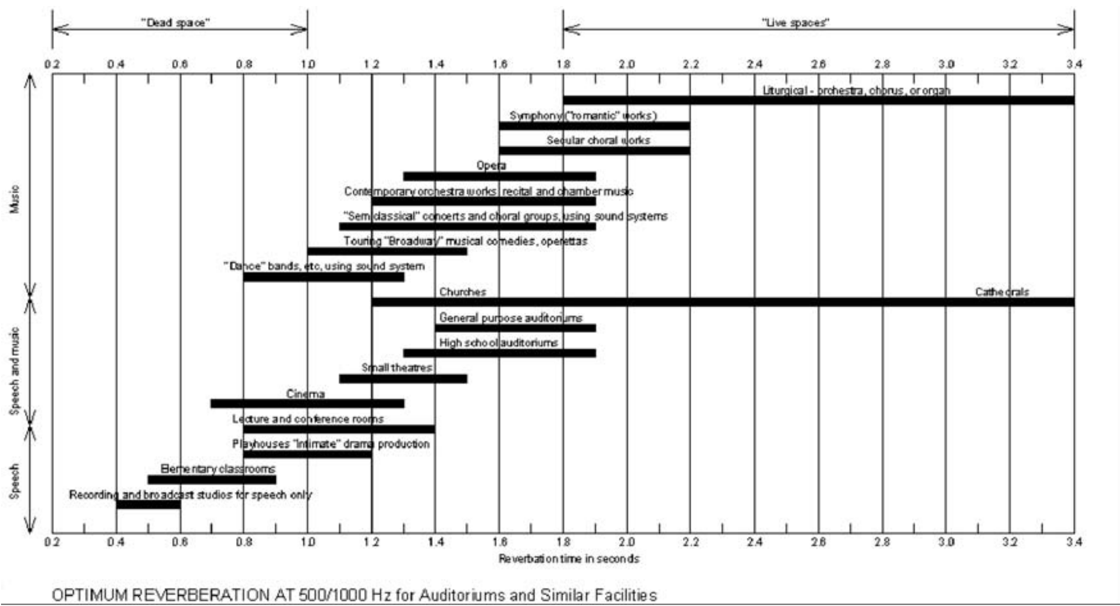


Figure 1: Optimum reverberation time, according to types of music, taken from "Acoustics in buildings / Bernard Grehant"

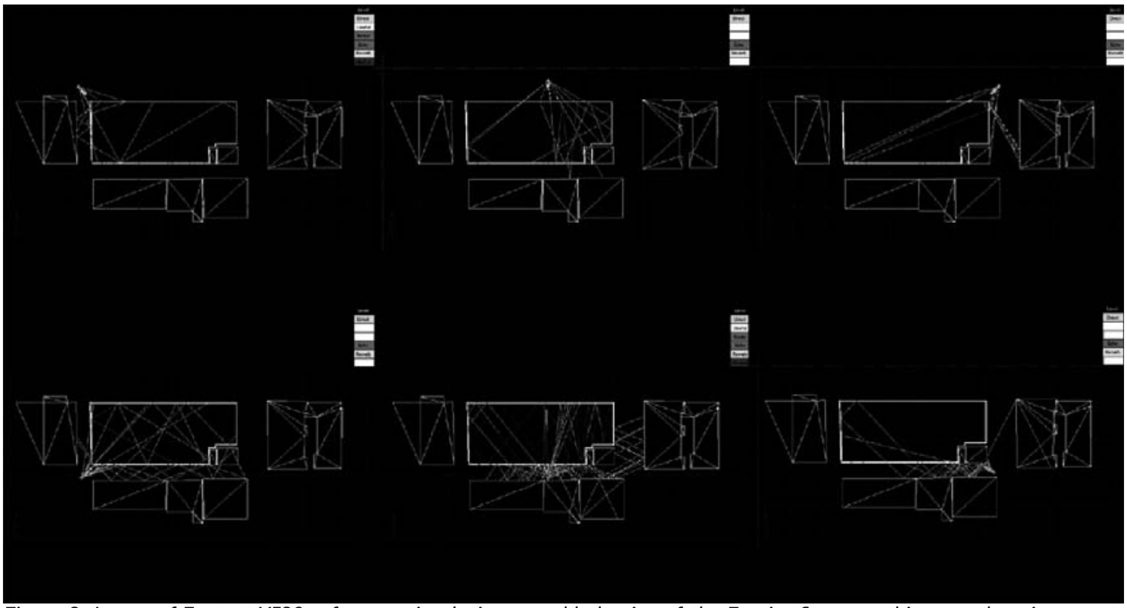


Figure 2: Image of Ecotect V520 software, simulating sound behavior of the Empire Stores and its sound environment.

This chart shows the relationship between volume, specific material (its coefficient of absorption) and time of reverberation. T = 0.05(V / a). Where T = reverberation time (seconds), V = room volume, cu ft), and a = total room absorption (sabins).

Different reverberation times are desired for different effects. A large reverberation time gives the sense of something very large and grand, thus cathedrals and many symphonic works desire something of a high reverberation time. (1.6 to 2.0 seconds, or even greater in cathedral settings).

It is important to consider that there are three basic uses of the reflectivity of sound in a room acoustics environment.
1- Reflection: the return of a sound wave from a surface.
2- Diffusion: Diffusion occurs when the wavelength is equal to the surface that reflects it. Diffusion is the scattering of a sound wave from a surface.
3- Diffraction: Diffraction is the bending of a sound around an object.

In addition to the acoustical constrains just mentioned, there are some other requirements with regards to visibility factors, these geometrical manipulations allow the designer to obtain optimum sight of the stage from any seating location.

On the other hand the exterior conditions required on site recordings, in order to obtain the data that would then be applied in a simulated computer environment. By the utilization of this technique the idea of sound generating architecture begins to take place. Sound Mapping is then a site specific music event.

As LAB[au] (laboratory for architecture and urbanism) notes in their text "The shape of sound", "Sonic space thus can be defined as the study of systemic relations between humans and acoustic environments formed through the conscious and subliminal perceptions of the listener. In this manner the analysis of sonic space is based on the cognitive and perceptual attributes such as: front, rear, contour, rhythm, silence, density, space and volume, which are derived of analytical concepts such as: note, sonic event, sonic object, sonic signals… In consequence the setting of sonic space is not only an organization of sound in time, but also the constitution of a matrix of acoustic, visual, behavioural patterns within their spatial expression".

2.2 The use of software.
In order to obtain that mentioned simulated computer environment, the Ecotect V520 software was used.

Basically after virtually modeling the Empire Stores building, sound sources were located in the same places were the sound was originally recorded, in this way it was possible to obtain a simulation of how the sound rays would behave with the existing structure, as seen on *Figure 2*.

After obtaining those results that information was merged together (*Figure 3, next page*) generating the main axis that would then become the initial state of the project.

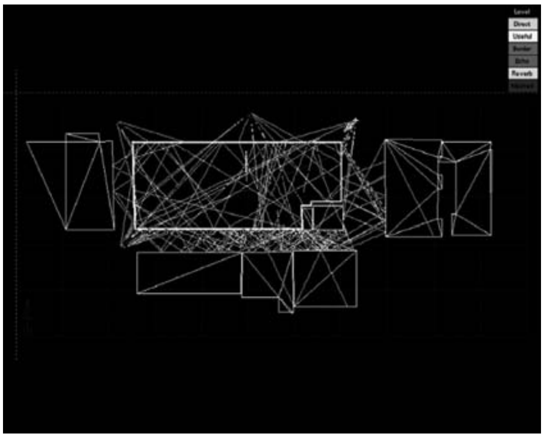


Figure 3: Merged data of Ecotect V520 software. The sounds in this enclosed space will produce multiple reflections that will blend together creating reverberation. This will be most noticeable if the sounds stop but the reflection continue.

The idea of an acoustic identity of a city then emerges, were sound is used as a three dimensional tool to create an architectural proposal.

The design process:

The design process began with a series of diagrams, renders and study models that intended different approaches with regards with the architectural problem.

At an initial state Euclid's Sectio Canonis, or the division of the musical scale was used trying to find a relationship between numeric proportions and possible composition for the project. This initial idea intended to organize the material organization of the project in an "in crescendo" condition between solid and void, exterior and interior, having a threshold condition, a filter, the foyer.

As a next step the intention was to test the site maximum capacity with regards to programmatic requirements, considering the acoustic and visual constrains described in the beginning of this chapter. It was necessary to know how many concert halls would be possible to fit in the site considering the idea of having Concert Halls that would be used for specific types of music. Then the idea of how architecture could be understood as an instrument emerged, could it be possible to create an architectural proposal that could tell the visitor how the city the building it is placed in sounds? How could the material organization of the site be constrained by the sound environment?

As a following stage this idea was formalized as a system of tubes that intended to capture the sonic condition of the site, working also as circulations for the overall project. These systems of tubes would bring the exterior sound to the inside of the project, the foyer and the Concert Halls, creating a sonic merging condition of the city's environment.

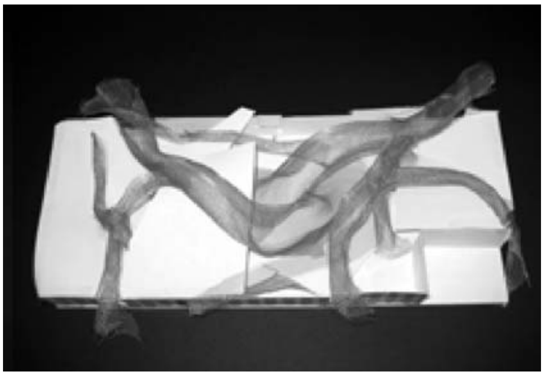
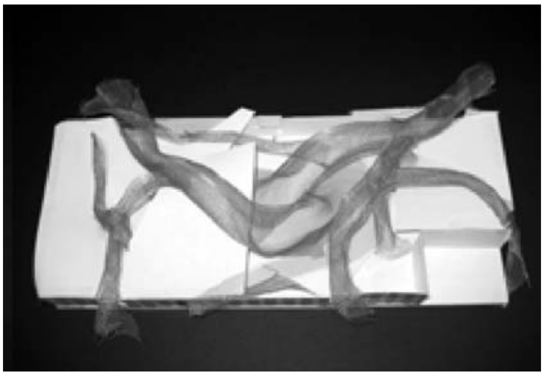


Figure 4: Following stage study models.



The addition of so many supplementary systems began to make the architectural proposal less robust, because the sense of exterior and interior was unclear.

It was finally decided that the only material organization necessary to develop a design and architectural process was the Empire Store itself. By going back to the Ecotect V520 diagram (*Figure 3*), it was possible to differentiate areas of sonic shadow and sonic flow. In this way programmatic and circulation areas could be defined.

By reusing the structure of the Empire Stores, especially the building's porosity conformed by its windows openings. The idea of capturing and manipulating the site's environmental acoustic condition re-emerges.

The extrusion and the circulatory condition of those opening start to behave as tubes that will carry the site's sound. Performing as sonic agents that sculpt the material organization of the building, in this way a series of sonic events will travel through these circulations merging as different acoustic events.

As a final step for this idea, the facades inside the mentioned sonic shadow areas were extruded, giving space to the programmatic requirements (Concert Halls, Cafeteria, Administration and Music Store). Taking the geometry obtained in Figure 3, those areas also went through a process of sloping, in order to follow up with the concept of the Berlin Philharmonic "Music as the focal point", where there is not a mathematical centre, but a condition that surrounds the visitor inside this acoustic landscape.

Extruded facades and tubes went finally through a process of subtraction, creating a series of perforations and porosities that allowed the visitor to penetrate the solid mass of the Empire Stores, creating a circulatory system for the project that communicated the exterior courtyard to the interior of a series of hollow spaces that contained the required program described in the next chapter.

By these series of operations, it is intended to also follow the concept used by Rem Koolhass in Casa Da Musica, where there is a negotiation between exterior and interior conditions, by the penetration of the city to the building and vice versa.

3. Site Documentation / Analysis and Program Development

3.1 Site Identification and Area Infrastructure.

After analyzing the Metropolitan area, and studying the number of "Music Buildings". It was unexpected to notice that there are no concert halls in the Brooklyn borough besides the Brooklyn Academy of Music.

The site to be analyzed is located in the D.U.M.B.O (Down under Manhattan Bridge Overpass) neighborhood, specifically in the Empire Stores building.

This abandon building, located between Water and Main Street, faces the Brooklyn Park and the Manhattan skyline. Also, the presence of both the Brooklyn Bridge and the Manhattan Bridge creates a special acoustic experience, considering that through the Manhattan Bridge the B, D, N and Q subway lines pass every five minutes in rush hour, and the hundreds of cars that go across the two boroughs. The D.U.M.B.O. neighborhood has a cultural identity, enhanced by the location of various art galleries, St. Anne's Warehouse Cinema, parks and restaurants. These characteristics conforms an area of family and tourist destination.

3.2 Development of Program.

One of the ideas for the Brooklyn Park Concert Halls project was to have two different kinds of concert halls, designed for two different types of music, giving the visitor different possibilities of musical experiences. In addition to those spaces, the project required support facilities as Administration, Cafeteria, Music stores and Retail. The programmatic requirement for that kind of project is described as it follows:

Brooklyn Bridge Park Concert Halls:

1- Site:		8.284 m2
Main Concert Hall:		713 m2
2.1- Stage:		254 m2
2.2- Foyer:		266 m2
2.3-	Tickets:	18 m2
2.4-	Storage:	65 m2
2.5-	Green Room:	117 m2
2.6-	Rehearsal Room:	203 m2
2.7-	Store:	68 m2
	Subtotal:	**1.704 m2**
	Secondary Concert Hall:	**465 m2**
3.1-	Stage:	139 m2
3.2-	Foyer:	164 m2
3.3-	Storage:	80 m2
3.4-	Rehearsal Room:	52 m2
	Subtotal:	**1.021 m2**
	Administration:	**344 m2**
	Cafeteria	344 m2
	Music Store:	159 m2
	Retail:	283 m2
	TOTAL (constructed):	**2.828 m2**
9-	**Circulation / Main Courtyard:**	**5.456 m2**

3.3- Reverberation Time Calculations:
Reverberation Chart. 2

T=0.05X V/A					
T=REVERBERATION TIME					
V=VOLUME					
A=TOTAL ABSORTION (MEASSURED IN SABINS)					
A FOR WALLS =0.6	SHREDDED WOOD FIBERBOARD 2 IN.THICK ON CONCRETE				
A FOR CEILING=0.5	SHREDDED WOOD FIBERBOARD 2 IN.THICK ON LAY IN GRID				
A FOR FLOOR=0.1	CARPET, HEAVY, ON CONCRETE				
OPERA HOUSE					
/ SECONDAY HALL					
VOLUME FT3	445,602				
WALLS LENGTH	318				
LENGTH X HIGHT	21,942				
AREA X 0.6	13,165				
CEILING AREA	6,458				
AREA X 0.5	3229				
FLOOR AREA	6,458				
AREA X 0.1	645.8				
SABINS TOTAL (A)	17,040				
VOLUME / SABINS	26.15				
T=0.05X(V/A)					
T=	1.6				
SYMPHONY HALL					
VOLUME FT3	664,943				
/ MAIN HALL					
WALLS LENGTH	364				
LENGTH X HIGHT	28,756				
AREA X 0.6	17,254				
CEILING AREA	8,417				
AREA X 0.5	4208.5				
FLOOR AREA	8,417				
AREA X 0.1	841.7				
SABINS TOTAL (A)	22,304				
VOLUME / SABINS	29.81				
T=0.05X(V/A)					
T=	1.8				

5. Thesis Proposal.

5.1 Final Renders and Architectural Drawings

Figure 5: Brooklyn Bridge View, Project Proposal, Final Renderings

Figure 6: Manhattan Bridge View, Project Proposal, Final Renderings.

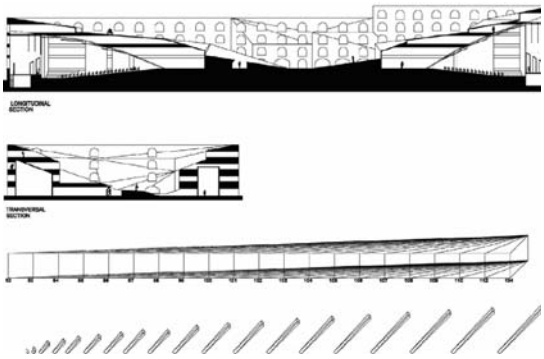


Figure 7: Section View, Project Proposal.

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