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# Variable Geometry Acoustical Domes - Towards an architectural design method based on spatial sound behavior

David Serero

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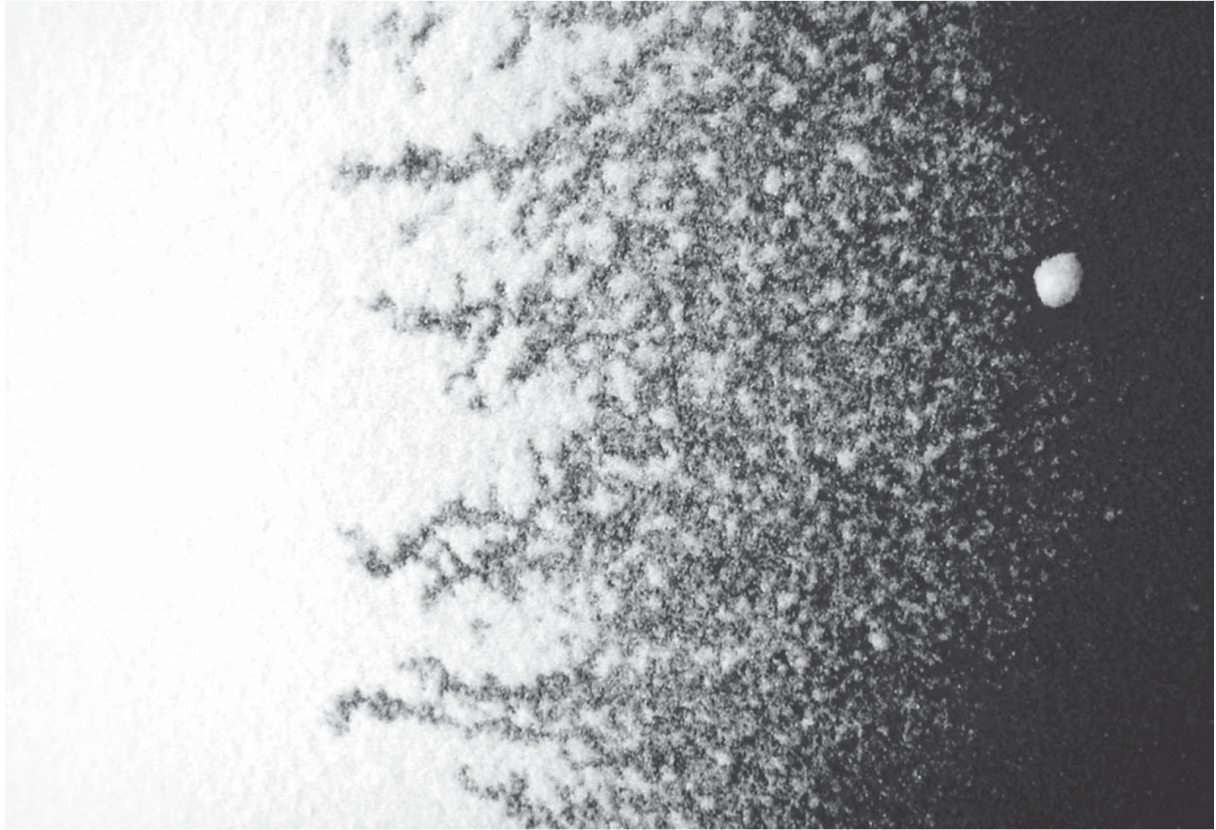
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thresholds 31

# EPHEMERA

*Established in 1992, Thresholds is the annual peer-reviewed journal produced by the MIT Department of Architecture. Each independently themed issue features content from leading scholars and practitioners in the fields of architecture, art, and culture. The Thresholds advisory board, composed of internationally recognized figures in various fields of art culture, drives the development of each issue through intellectual support and the pursuit of high-quality submissions from fine arts, design, graphics, media arts and sciences, film, photography, and more.*

Massachusetts Institute of Technology  
Department of Architecture, room 7-337  
77 Massachusetts Avenue  
Cambridge, MA 02139

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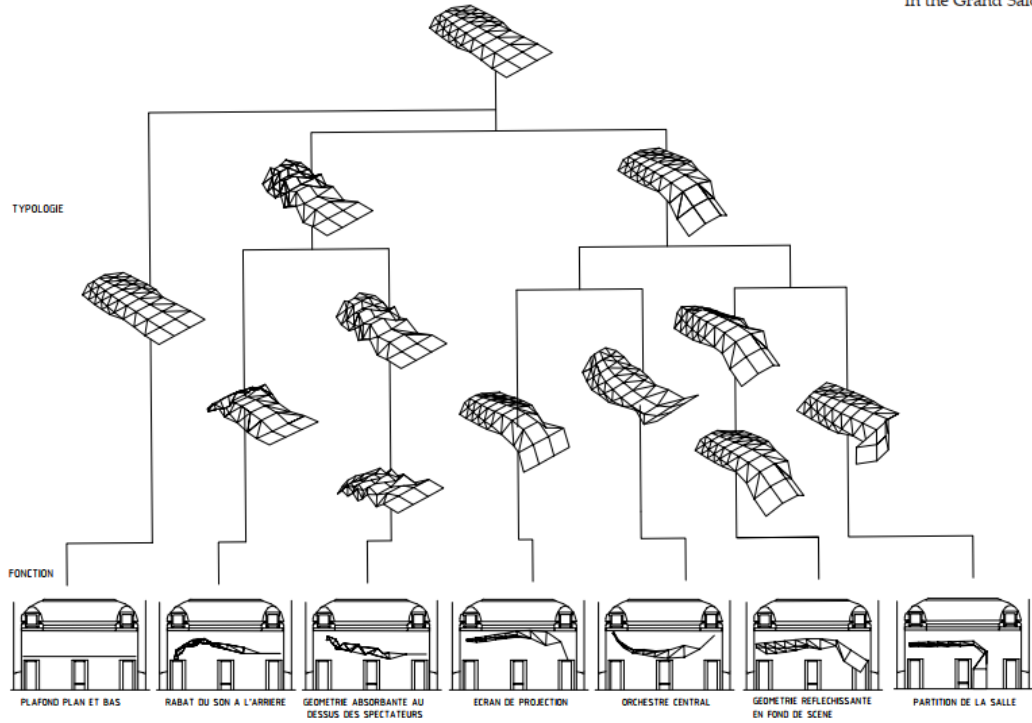
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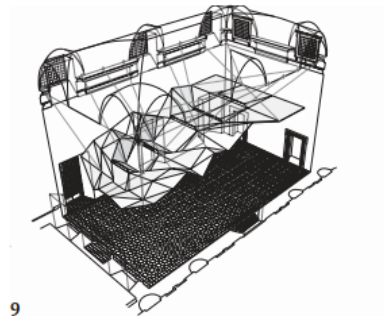
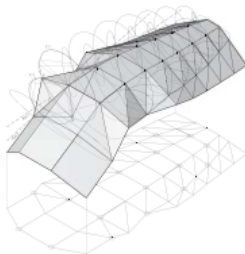
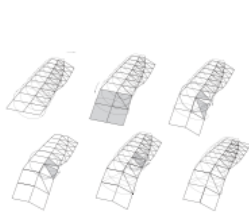
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Figure 7, 8  
Process for geometric calculation  
of dome shapes, based on  
acoustical simulations

Figure 9  
Axonometric view of the  
*Acoustical Dome* device  
in the Grand Salon



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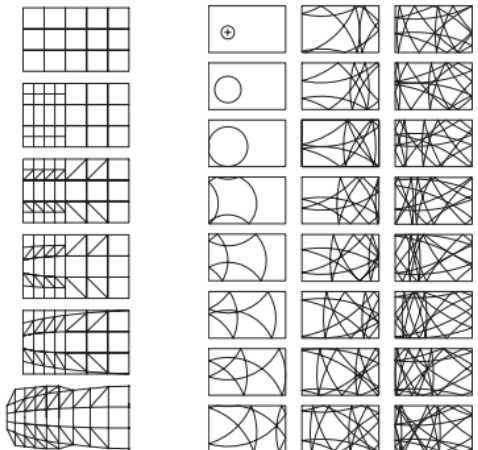


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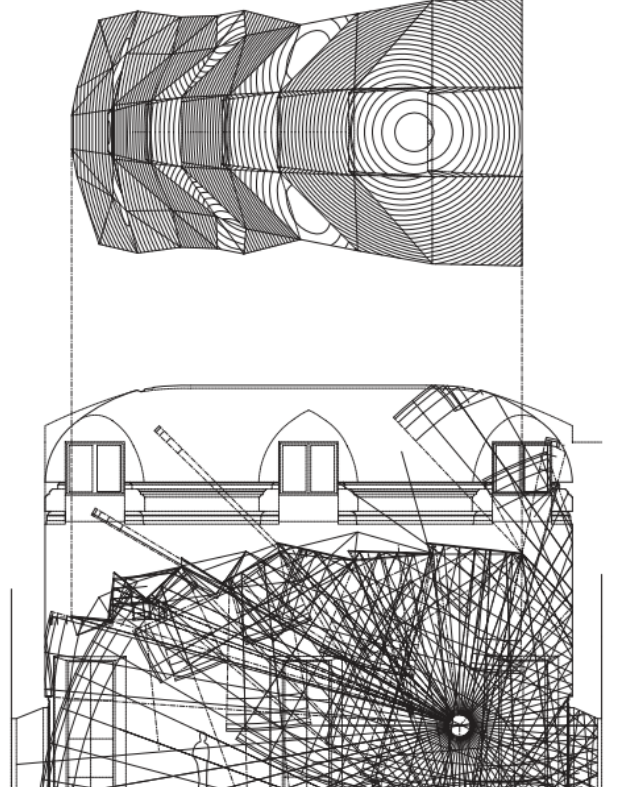
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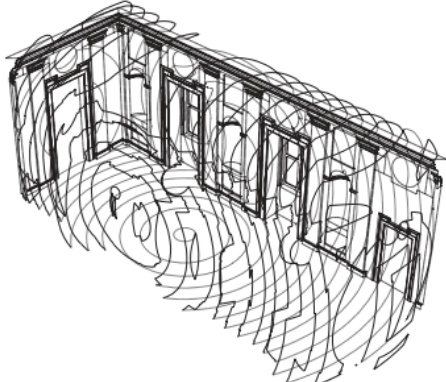


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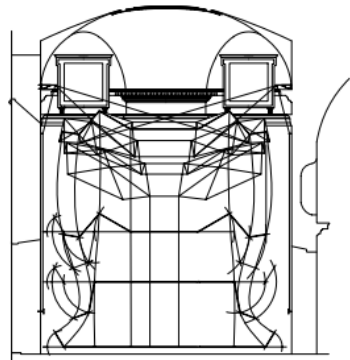
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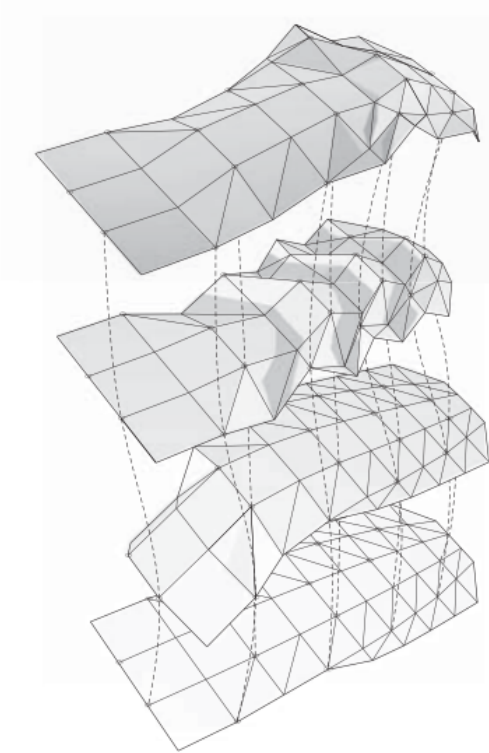
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Figure 4  
Reverberation  
simulation of  
Grand Salon with  
the Acoustical Dome

Figure 5  
Transversal section  
showing the process  
of transitioning the  
Acoustical Dome  
between states

**Figure 10**  
The form of the *Acoustical Dome* is controlled in real time by 12 points precisely linked to a network of cables and CNC winches

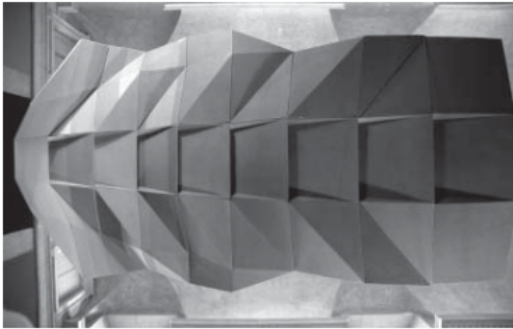
**Figure 11, 12, 13**  
The *Acoustical Dome* in situ in the Grand Salon at Villa Medici, Rome



10



11



12



13

## Variable Geometry Acoustical Domes

Towards an architectural design method based on spatial sound behavior

in EPHEMERA – Thresholds 31, Annual peer-reviewed journal produced by the MIT Department of Architecture, editor Talia Dorsey, Massachusetts Institute of Technology, Spring 2006, P52-57, ISBN-10 : 1334243190

*Established in 1992, Thresholds is the annual peer-reviewed journal produced by the MIT Department of Architecture. Each independently themed issue features content from leading scholars and practitioners in the fields of architecture, art, and culture. The Thresholds advisory board, composed of internationally recognized figures in various fields of art culture, drives the development of each issue through intellectual support and the pursuit of high-quality submissions from fine arts, design, graphics, media arts and sciences, film, photography, and more.*

Traditionally, domes are seen as architectural elements, which allow for the covering of large spaces by the structural assembly of discrete components. I recently developed a new kind of dome, which does not relate to structure but instead to acoustics. In collaboration with an acoustician and a programmer, I have been developing techniques to simulate soundfields of a given space and construct domes based on these fields. Suspended from the ceiling of an existing space, the Acoustical Dome is an experimental device, whose geometry allows for the variation of position in space and an adjustment of form to modify the acoustical behavior of the hall.

Here, space is not passive to music; it proceeds in an interactive mode by which a musical composition is imprinted in a form, and the room's geometry can be modified for each performance—or each public—in real time. It is the type of event—a music concert, a lecture, a song—that inflects the computation, that folds and unfolds the Acoustical Dome under the vault of this space. The surface's tessellation and its increasing subdivision affect the number of folds and trigger a reconfiguration of the fields of reverberation and reflection. The form of the Acoustical Dome is generated from both a digital simulation of acoustic patterns and an analog model of foldable composite panels.

This project defines architectural form not in a final state, but rather as an ephemeral and variable condition, where the possibility of its transformation is inscribed inside of its geometry. Integrating ornamental patterns with acoustical form, the Acoustical Dome allows for an interaction between the volume of a room and the propagation of sound in space. The Acoustical Dome therefore maintains an open and flexible relationship between music, the spectator and its surrounding environment.

I was in the dark, a deep black night, both enveloping and disturbing, that I had never known before. The night was slowly ending but the depth of this abstract darkness did not run out of steam. I had nothing to light my way. There was not a light bulb on the horizon, not a candle, not a lighted window. I was leaving my studio, at Villa Medici, the French Academy in Rome, after a night of work. I went step by step and let my eyes get used to the darkness to try to overcome it. Gradually, I realized that I could hear my own footsteps echoing in a courtyard.

I tried to discern each of its sounds, where they came from, their distance, their reverberation time. I mentally reconstructed the thickness of a hedge, the proximity of a wall, then a courtyard, then the incessant murmur of a water fountain, then several water fountains aligned in an extended space, a virtual axis, which immediately made me think of the great transverse axis of the Villa Medici, then a deaf space, of infinite depth, and I suddenly discovered the Rome's skyline with a multitude of domes as far as the eye could see.

It was then, night after night, leaving my studio at the western end of the garden of the Villa Medici, in a dark and deep night. I began to build a mental acoustical map of a space that, for the first time, I discovered and rediscovered in the black not by its visual structure, but by its sound.

I discovered the sonority of gigantic walls, the echo of a travertine facade, the echo of a brick loggia, the absorbing thickness of these umbrella pine trees, and a cartography that night after night became evident. I liked to decode it, to discover this place, to get lost and then inevitably find my way.

This is how my fascination with sound began, a way of understanding architecture in its capacity for acoustic resonance rather than in its mere visual form. I was then working on acoustic devices, that could modify and redesign the acoustic space of gigantic reception hall in this Renaissance villa. Rather than exploring new architectural forms, I focused on the study of sound, its movement and its spacialization.

By using acoustic calculation software, the speed of sound propagation was studied and analyzed in its deployment. This research is not a simple acoustic simulation, but rather a way of understanding the deep logic of wave and frequency computation in order to program the organization of new materials, new structural principles, or more intelligent organizational patterns that will be able to meet acoustic requirements.

Traditionally, domes are architectural forms that allow the coverage of large spaces by accumulation of discrete entities according to forms regulated by the resistance of the materials. My stay in Rome gave me full freedom to design and develop the prototype of a new type of dome, which goes beyond traditional structural forms to acoustic functions.

In collaboration with an Italian mathematician, an acoustician and a programmer, we developed a new way of visualizing the acoustic behaviors of a space and of constructing acoustic fields, which served as a projective basis for the elaboration of its surfaces. Music, both a physical and an intangible phenomenon, is here the context of an intervention in the space of the large reception hall of the Villa Medici. Installed in the majestic 14 m high room, the Variable Configuration Acoustic Dome installation, which duplicates the vault of the existing room, is an experimental device whose geometry allows a variation in shape to adjust and transform the sound environment of this space, as well as its acoustic response.

The position of the "dome" in the volume of the space as well as its level of folding, modify the field of propagation and diffusion of sound in this space. Here the space is not passive to the music, it proceeds, in an interactive mode, where the musical work is inscribed in a form and where the geometry of the room can be modified, at each performance, at each audience, in real time.

This is the type of event, whether it is a chamber music concert, a conference, a song that influences the calculation of space that bends and deploys the ceiling suspended Acoustic Cupola in the large hall. The tessellation of the surface, and the iterative increase of the number of folds creates the possibility of a match between music and architecture. The shape of the dome is thought out as a convergence between a digital model of acoustic calculation and an analogous model of form deployment.

The project defines a form not in its finality, but rather in its variability and integrates within its geometry the principles of its formal modification. Crossing ornamental form and acoustic form. Acoustic Cupolas allow an interaction between the existing volume of the room and the way in which sound or music propagates in the space. This dome maintains a flexible and free relationship with the work, the viewer and its immediate environment.

***David Serero***