1668Santissima Sindone
Turin, Italy

Guarino **G**uarini

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History/Context

The high renaissance was a time of great development in a wide variety of fields that included both sciences and arts. By the 17th century, the world was viewed through an entirely different lens of rationality than the old, spiritually biased lens of the Mid-Ages. That is not to say, however, that spirituality was not present in the renaissance, it was instead manifest through new forms of rational thought. Guarino Guarini, a true renaissance man educated in many fields, is a marquee example of one such thinker. Guarini expressed complex notions about the manifestation of god within the fields of science and art, and these notions all culminate in his masterpiece, the dome of Santissima Sindone in Turin, a construct not of stone but light. Through an examination of this building designed to house the holy shroud, a synthesis of Guarini's beliefs in the physicality of light, the universality of mathematics, and the rationality of projective geometry can be seen as his response to the problem of creating a house for god and the unification of renaissance ideals to form a new type of spirituality.

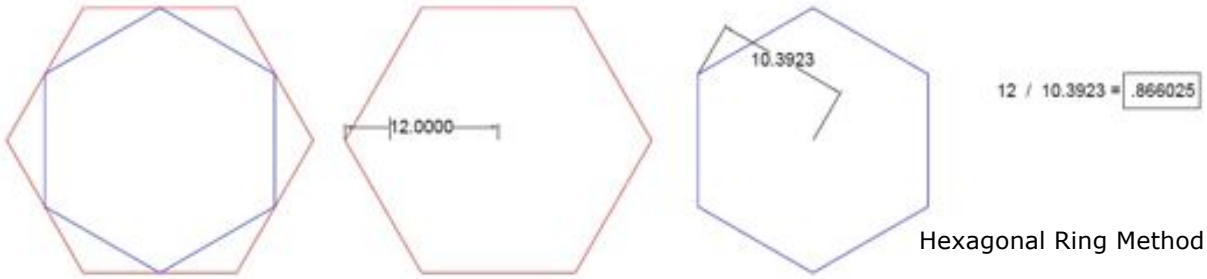
Santissima Sindone was a very important building at the time in which Guarini began his work on the chapel, justifying the intense attention with which Guarini employed the full expanse of his architectural skill coupled with spiritual fervor. House of Savoy monarchs ruled Turin for nine centuries, using their personal, religious artifact, the holy shroud said to have wrapped Christ's body after his crucifixion, to consolidate their power. The shroud was moved to Turin in the mid 17th century as the Savoy's capital shifted within Italy. A chapel, Santissima Sindone, was planned to house the relic, and it was to be attached to the already existing cathedral of Turin, elevated by one story so as to be on the level with the *piano nobile* of the Duke's residence.[1] Guarini, a mathematician and philosopher who expressed himself through geometry and, perhaps more important originally, light in his architecture, was hired to design the building in 1668.

Tectonics of the Dome

Because the chapel was an addition to the existing cathedral, Guarini's plan is best examined not through the floor plan, but rather through the principle piece of his composition, the dome. Upon a cursory glance from within the structure, some basic ideas about light that Guarini held can be gleaned with relatively little outside information. Guarini, in lieu of creating the typical, solid dome with an oculus, deconstructed the common, hemispherical shape of the dome with projections of light. He created a pattern of small, stone arch bridges that form a hexagon within a circle that contains within itself minor bridges between the sides of the hexagon. This pattern is repeated six times in ascension while steadily decreasing the lengths of the sides of the hexagon.[2] In this manner light is allowed to flood into the domed area, thus dematerializing the stonework and breaking up an otherwise heavy, solid dome into a translucent object seemingly made simply of light.

The exterior of this dome gives little hint of what lies within. Instead, it merely allows an understanding of the hexagonal super structure and suggests the influence of Chinese pagodas, which were to be circled in religious contemplation.[3] Interestingly enough, such a reference had been made before by the architects Aleotti and Magnani in the hexagonal structure of Santa Maria del Quartiere.[4] Perhaps Guarini was inspired by the pagoda and this earlier baroque building, but the simplicity of such a form on the exterior served only as a modest public front and as such it is likely that such projects only gave Guarini's design a basic beginning from which to progress.

Guarini developed a brilliant structure from this starting point that made possible his construct of light within the dome. He began his work from the height of the first order of the existing cathedral up. He could not alter the circular plan, lateral staircases, or windows that already existed.[5] There were many questions of structural integrity even before Guarini began his work; therefore, he first strengthened the core foundation. From there he executed his structure in such a way that what is structurally necessary is difficult to separate from what is aimed at achieving compositional goals. The visible and common pendentives just below the drum of the dome serve little structural role, but instead, masonry arches are hidden within the walls.[6] Guarini was obviously attempting to provide visible forms of his own design without having to worry about their structural feasibility. This was largely necessary due the precision in visible form which Guarini's design demanded



Hexagonal Ring Method

as will be later seen.

Higher in elevation within the dome, the boundary between structural and compositional becomes increasingly blurred. The arches in the basket of the dome are made of two parts. Masonry forms on the outside follow those on the inside, but they do not emphasize the windows which are so important for introducing light.[7] Thus, seen from the exterior, the marble interior arches with ribbing that follows the inset windows are not revealed. Instead, sets of ribs running down the dome are emphasized on the exterior as main structural elements. These ribs support the majority of the mass, while the interior arches are for the most part ornament.[8] This, however, is somewhat misleading as Guarini's original designs did not include the rib system, leading to the conclusion that the arches were originally assumed to be structural.[9] The inclusion of such ribs as stiffeners can only be explained again through Guarini's desire for having an exacting interior composition without the

bother of implicit structural integrity. A base with an even number of load points, in this case the six of the hexagonal form, is essentially weak at those points.[10] The ribs stiffen the arches between those points so that the entire structure does not fold in on itself, and Guarini was not therefore forced to provide a base with an alternate number of sides. The inclusion of ribs to facilitate the hexagon provides basic evidence of the exacting way in which Guarini was envisioning the interior of his dome.

Dome Exterior

Guarini and Light

Guarini's structural genius and the complex forms he produced allowed him to work with light in a way that aligned to both his own ideas, and the ideals of the time period. Guarini and other philosophers and scientists at the time were interested very specifically in the materiality of light. They understood light as being made up of tiny particles that were constantly colliding and transforming, allowing matter and light to exchange properties.[11] Having the belief that light could take on the physical properties of matter; the dazzling light spectacle that Guarini's dome creates within can be viewed in an entirely different manner. The light emanating from between the stone arches can be seen through Guarini's eyes as a physical construct itself, both supporting the masonry shell between the arches and creating a new structure of light within the dome at the same time.

Such beliefs can be seen further expressed artistically within baroque paintings of the period in which Guarini was working. The painter Caravaggio, and others like him, from the late 16th century used high contrast, deep darks and brilliant highlights in their paintings to form the matter of their subjects. Light was itself constructing the emphasis of their works along with the contrasting, sharp transitions to darkness. Ideas such as these began to influence baroque architecture shortly before Guarini's time.[12] Borromini, a leading Baroque architect of the time who was certainly known to Guarini, employed similar ideas in many of his buildings. Ultimately, Guarini was surely inspired by the light in Borromini's architecture, but the symbolism within Caravaggio's paintings was perhaps even more important to Guarini.

Caravaggio, upon turning to religious subjects at the age of 26, used light and shadow to convey religious feelings within his works. Often, large areas of darkness dominated his paintings that could symbolize God's authoritative presence.[13] Light, however, had an equally important role as a contrast in Carvaggio's compositions. Caravaggio's light has the power to reveal and to conceal, creating patterns within the painting. Such patterns, by superimposing a stylized play of light and shade over the natural forms, can introduce a concept outside the frame of reference of the work entirely.[14] Guarini is seemingly doing the same thing with light within his dome, introducing the concept of a permeating, godly presence that exists completely outside the heavy stonework of the chapel below the dome.

Caravaggio Painting

Guarini's Mathematical Religion

Mathematical theory and precision were the agents that Guarini employed within his interior forms that allowed him to create a grand presence within the chapel. The simple applications of math in Guarini's work can be seen through the mathematical developments that were occurring in Guarini's time. Integral calculus was being developed by Newton and Leibniz at nearly same time in which Guarini was working.[15] This becomes important because one way in which the surface of a sphere, or hemisphere in the case of the dome, can be measured is by breaking it down into triangles of infinitesimal size. Integral calculus can calculate the surface area of these triangles in order to approach the surface area of the sphere. Guarini, being a mathematician himself, must have been aware of such developments when he chose to make his bridge structures in the form of triangles, allowing the light between the arches to represent the surface area of each triangle, thus transforming the light, which was viewed as a physical substance, into the surface of the hemisphere itself.

In fact, Guarini was a very accomplished mathematician with extensive knowledge in the theoretical side of the subject. Among his many writings on the subject was the Euclides Adauctus et Methodicus Mathematique Universalis which he wrote in 1671; this writing in particular expresses his ideas about universal mathematics that was connected to god as well as the importance of architecture for expressing mathematical theories in physical form.

> "...but above all it is architecture that shines thanks to the distinguished and truly regal Thaumaturgy of the miracles of mathematics. ... Hereby receive, your Royal Highness, with benign visage and serene clemency, that which several times with the breadth of its ingeniousness in conceiving the most sublime ideas has fostered mathematics and all of the efforts of my work in adorning it."[16]

This passage from his writing clearly gives mathematics an important role for understanding god and advocates architecture as a great tool for understanding math. From this it can be inferred that architecture was an exercise in understanding god for Guarini, and therefore Santissima Sindone and all of Guarini's mathematical efforts therein was a clear attempt at bringing the presence of god into the chapel.

Understanding the math behind the dome of Santissima Sindone is therefore important to understanding the influence behind the entire design as a vessel for god. Guarini saw the practicality of math in architecture as a tool from god. Within every writing of Guarini's, he includes examples of the practical uses of his theoretical mathematics which may be seen as an attempt by Guarini to connect math to his understanding of the world as a whole.[17] Speaking of his work, Guarini once wrote, "The value and usefulness that this kind of work can have to irradiate with mathematical light and make evident all things with a single luminous source."[18] The particular wording in this quote clearly connects Guarini's mathematical philosophy with his reverence for light as a product of god. Once again, two ideas expressed within Santissima Sindone are tied to god as could only be appropriate for the chapel to house the holy shroud.

The practicality of math as a product of god continues to be a main argument by Guarini for its careful employment by man. He refutes the idea of the infinite as an existing condition, instead stating that it could only be conceived of in the mind and realized by god.[19] Since Guarini attempted to create in his architecture a sublime emotion through the appearance of infinity in a structure of light, it can be inferred that this was yet another attempt to tie his work to god.

Guarini's written work continued to tie into his architectural practice. One book in particular exemplifies this with reference to Santissima Sindone. Guarini made special note to mention in one of his mathematical works that Euclid ignored the construction of a hexagon inscribed within a circle that circumscribed another hexagon.[20] Santissima Sindone's cupola was constructed precisely in this way. Perhaps the choice of the hexagon by Guarini can be seen as an expression the mathematical importance of the hexagon that previous thinkers largely ignored Guarini believed. In this way, Santissima Sindone can be viewed as a sort of critique on ancient mathematical thought.

In an appendix to Euclid's own work, Guarini provides further improvements upon classic math that make appearances within SS. Sindone. He focuses chapter three of part two in his appendix upon the measurement of vaults based on squares and other figures.[21] The structurally unimportant yet mathematically impressive pendentive vaults in his cupola embody his own, personally derived mathematical principles and possibly explain further his inclusion of such forms without structural need. He also mentions in his work that there is a particular set of relationships between the vertices of four, six, and twenty-four sided polygons.[22] His cupola is constructed with a hexagon upon four pendentives, expressing physically his interest in just such mathematical properties that could be tied to god.

The integral calculus that can be seen in the basic structure of the dome, as well as the focus on a light construct also appears within Guarini's written works. Guarini discusses the determination of curved figures with those of straight edges, mentioning the classic problem of squaring the circle, in treatise thirty of his work.[23] This displays the relevance of the ancient problem of a circular light form projected through square framework, and Guarini's own attempt to reconcile such a phenomenon through math. He turns to integral calculus methods involving the inscribing and circumscribing of rectangles until the difference approaches zero in a similar technique to the method of finding the surface area of a sphere that was discussed earlier. He also makes takes special consideration to reiterate the process for obtaining area of the first rotation of the Archimedean spiral.[24] Such a spiral form can be seen in the new columns he designed for Santissima Sindone, proving mathematics to be a unifying factor yet again in his architecture, even in structures that occur outside the confines of the dome.

Squaring the Circle (Michele Sbacchi, "Projective Architecture," Nexus Network Journal 11 (2009): (442.)

Practicality was not the only way in which Guarini saw math as a connection to both light and god as pure theoretical math played a large role in his understanding of the world. Mathematics was seen as a transcendental, universal art to Guarini that was linked inexorably to light.[25] Guarini attempted, like many other baroque mathematicians, to connect theology with mathematics, seeing the presence of mathematical laws as a signifier of god. Since Guarini was so intent on connecting math with theology, it becomes highly logical that he would create his greatest work of math and geometry to house one of the holiest relics in existence. To Guarini it would seem that a high degree of mathematical precision and law would be the only acceptable method for protecting and presenting such a holy artifact. This mathematical precision as a route to god would ultimately become the principle design factor for Guarini's dome.

Projection and Guarini's Architecture

In the 17th century, Descartes and Galileo were beginning to recognize math as a basis for causality, but Guarini did not accept these new views yet, seeing math as a pathway for recognition.[26] He used proportional projection of forms as a design tool in an attempt to achieve cosmic mimesis. This was important because at the time, the cosmos was seen as the greatest force in the world of art.[27] Once again, the philosophy of the time reinforces the idea that Guarini was actually trying to construct space through the projection of light, thus tying the space to god and the heavens rather than simply creating a perspectival illusion of impressive, complex mathematics in order to dazzle visitors.

This method of proportional projection as mimesis would proves to be important as the final key to understanding the inspiration behind the geometries of the dome of Santissima Sindone. Guarini was not so much interested in rationalizing orders or inventing a basic system of building through math, but instead he attempted to apply his understanding of universal mathematics to create harmony within his works.[28] Proportional projection can therefore be seen within his dome as an attempt to not merely invent a new projective system or new orders for decorative purposes, but instead as a tool for applying his mathematical philosophies in such a way as to tie the spatiality of his building with the emotions of the visitor and the religious purpose of the entire structure. And once again, this idea can be related back to an idea about light.

Ultimately, the role of perspective and projective geometry in Guarini's work is that of a tool for unifying ideas of god, math, and light into a method for creating a piece of architecture. Projections of objects by light in the 17th century were seen as a miracle due to the transformation that is observed in such projections.[29] Most notably, as has been mentioned before, this occurs when sunlight passes through a square body yet is projected as a circle on the ground. Perspective illusions such as these were seen as divine projections and hailed as miracles.[30] It is completely logical, therefore, that the use of such a miracle would be important to Guarini when designing a holy space.

Beyond the miracle, projective geometry and light as a source of creativity can be traced back just as far. According to Pliny, at the root of art lies projection. He described the first art as the tracing of a shadow, or the demarcation of light and dark.[31] Light and projected shadow is then later used to establish the laws of perspective and astronomy during the renaissance, which were both being explored in the 16th and 17th centuries.[32] Serving as a tool for expression, projective geometry could certainly have an equally strong role in architecture as it had in art.

Projections for architecture rely on the projected plane serving as the surface of the paper on which drawings are made. Guarini believed that creating such projections was the main activity of the architect in the design process.[33] Santissima Sindone may therefore be seen literally as a translation of this belief of Guarini's in physical form, as the dome projects itself away from the eye further than it is in reality in the same manner that perspectival projections on paper seem to diminish into the projected plane itself. The light entering the structure would then seemingly serve as a projective force, casting the form of the structure upwards onto different surfaces.

Such a projection could indeed have been made without the use of perspective; however, Guarini saw perspective as a key element to projective geometry as a distortive force, again like in the case of squaring the circle. Up until the Renaissance, the use of perspective was meant to replicate human sight. Eventually, objects represented in perspective were seen as altered or changed from their original format so that they might better represent the real object. This was often to the point that the perspective lines did not represent the actual shape

at all, but distortions of that shape.[34] This shift can be seen in Guarini's work as well. By understanding that he might use altered shapes and forms to better represent an enormous space than pure shapes, he applies projective geometry to the design of his building to alter those forms instead of using the standard geometrical circles and triangles.

Guarini's Methods United for God

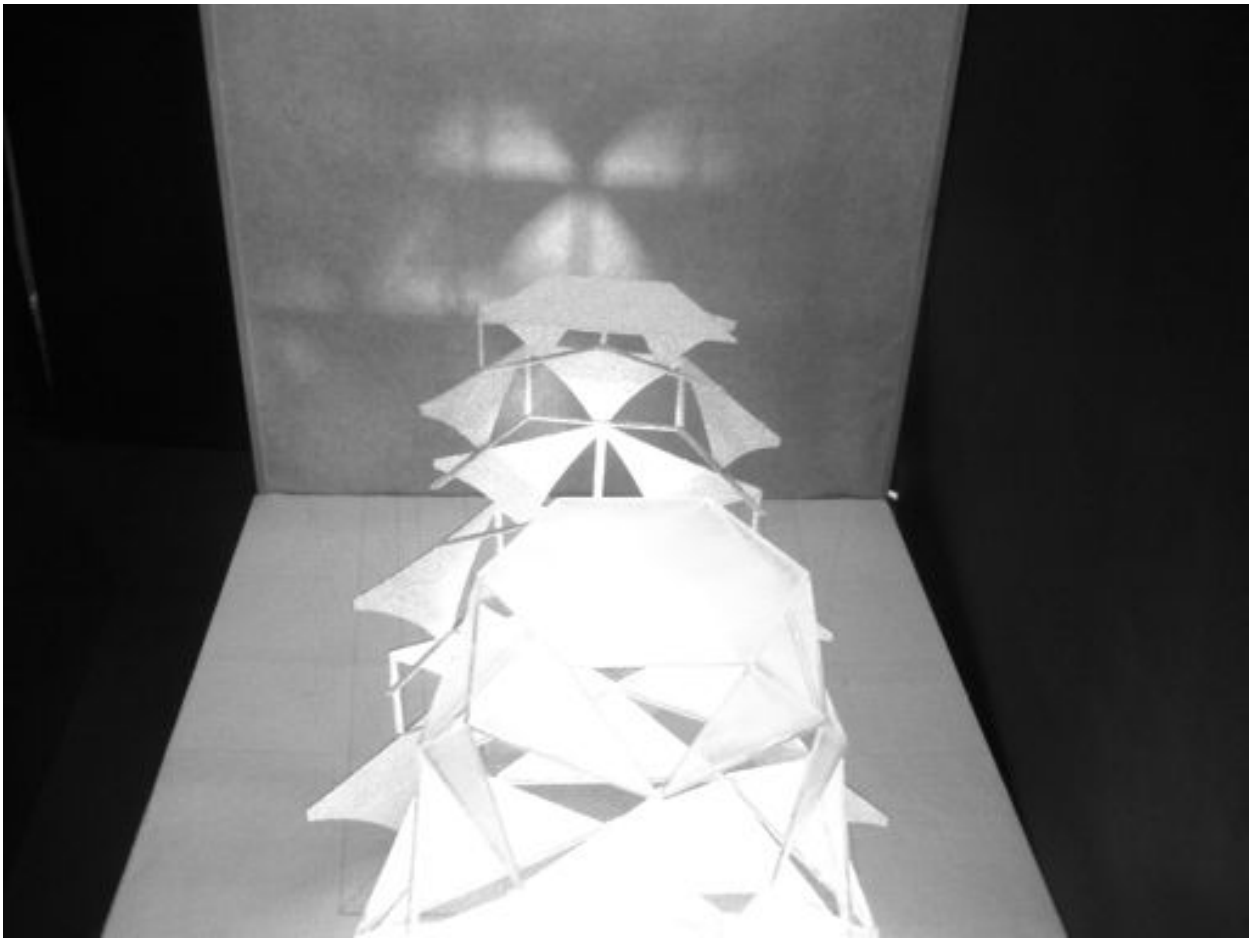
Light and shadow relate directly to perspective ideas within the realm of projective geometry, especially in relation to the practice of architecture. Vitruvius included sundials in his books on architecture, thus linking from the start architecture with projected shadows. Through this idea, projections serve as yet another link between architecture and other disciplines such as math and astronomy, both of which interested Guarini.[35] Guarini was very much intent on projecting his elevations and sections into plan, opposite to the common practice at the time, such that they corresponded to one another in the same way that light corresponds with shadow projections.[36] From this it can be assumed he applied the same practice to Santissima Sindone, foreseeing the section of his dome within the existing plan, viewed as a projection, with which he had to work. The dome therefore becomes the object projecting the circular structure below. It also follows that Guarini attempted to elicit the same feeling of projection that he strove for in his drawings within the physical dome itself, tying the three dimensional to the two dimensional through the idea of projection.

Without the proper use of perspective and projective geometry as unifying processes, Guarini's work would have failed in eliciting the kind of emotional response that he was aiming for in Santissima Sindone. Piero, a prominent 15th century painter, wrote extensively about the importance of understanding perspective. To him, someone who did not follow the rules of perspective would create a piece of work that was fundamentally flawed.[37] This was a consistent idea throughout the 15th and 16th centuries, lasting until Guarini's time, and most likely played a role in Guarini's understanding of perspective as an important part of both the drawing and construction of buildings outside of its religious implications.

Within this framework, however, ideas about god can still be seen. Desargues argued a form of perspective geometry that views the cylinder and the cone in the same way.[38] In his view, a cone is just a cylinder with a point that is located an infinite distance from a circular base.[39] Such theories form the foundation of Guarini's attempts at representing the infinite by creating a hyperbolic dome that terminates at a point. Pascal would later follow up such thinking with his well-known theorem of a hexagon inscribed in a conic.[40] Once again, another source of inspiration for the hexagon appears, as Guarini would have been well aware of Pascal's work. This last connection to mathematical theory completes the association of every aspect of Guarini's dome for Santissima Sindone to religion, light, or mathematics. Such a harmonious synthesis of ideas may truly be seen as a structure representative of the renaissance spirit.

Conclusion

In conclusion, Santissima Sindone reflects the ideals of an entire society as well as the individual notions about light, god, and math of its architect, Guarino Guarini. Light serves as a constructive element within the dome as well as a symbolic manifestation of god. Mathematics can be seen throughout the carefully controlled and designed structure from the basic hexagon to the complicated distortions of form created by perspective and projective geometry. It also serves as a symbolic yet practical connection between architecture, light and god. The House of Savoy could not have received a more powerful space to help them consolidate their power in Turin. Such a harmony of ideologies in the dome of Santissima Sindone is a fitting tribute to god from a true renaissance man, Guarino Guarini.



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