DIGITAL HERITAGE (2025)
S. Campana, D. Ferdani, H. Graf, G. Guidi, Z. Hegarty, S. Pescarin, and F. Remondino (Editors)

Palazzo della Loggia According to Luigi Vanvitelli: a Digital Reconstruction

S. De Matteis 0009-0005-9994-0151

Università degli Studi di Roma La Sapienza, Italy

Abstract

This paper aims to describe the process of 3D Reconstruction of Luigi Vanvitelli's (Naples, 1700 – Caserta, 1773) second design for the Great Hall of the Palazzo della Loggia in Brescia, and the drawing analysis that it entailed.

In 1575, the 16th-century Loggia was consumed by a fire that devastated first floor interior and roof, but left the lower floor and the exterior largely unscathed. The roof was hastily repaired, the still-serviceable areas sectioned off, and the building languished in this precarious state for nearly two centuries. Eventually, local authorities commissioned its restoration (1764).

Due to the monument's significance, Vanvitelli needed to utilize the pre-existing structure, damaged though it may be. These constraints resulted in two designs, drafted between 1769 and 1771, which displayed the same radial distribution but differed in the shape of the plan (circular and octagonal, respectively). Construction of the 1771 design began after Vanvitelli's death, and only reached the entablature before halting indefinitely.

This paper aims to describe the challenges and questions posed by the process of 3D reconstruction of Luigi Vanvitelli's second design for the Great Hall (Salone) of the Palazzo della Loggia in Brescia, particularly with regards to the articulation of the vault. The reconstructions are based on two series of drawings in the hand of Vanvitelli and Piermarini, presently hosted at the Archivio di Stato di Brescia, occasionally interpolated with the information that can be gleaned from Baldassarre Zambone's engravings (1778).

Three potential geometric interpretations, which the present paper seeks to explore, were identified by analyzing the area of the vault, first through the lens of "necessary" (brought about by the transition from circle to octagon) versus unforced changes, and then in light of the discrepancies found both within and among the drawings.

CCS Concepts

● ***Applied Computing*** → Arts and Humanities; ● ***Human-centered Computing*** → Visualization

1 Introduction

In 1433, *podestà* Marco Foscari, who ruled over Brescia on behalf of the Republic of Venice, decreed the opening of a new square. This was possibly done in an attempt to appease the local populace's discontent over Venice's recent decision to restrict access to *Cittadella Nuova*. In 1434, the new *podestà* and the municipal Council decided to ornament the square with a Loggia, which was to double as the *podestà*'s audience. However, the structure was soon judged too small for its purpose, and subsequently torn down and laboriously rebuilt between 1492 and 1573. This new *Loggia* however proved woefully short-lived, and was consumed by a fire on the 18th of January, 1575. (On the formation, design and construction of the square and original *Loggia*, see [FGR95]). The fire spared the exterior and ground floor of the building; the upper floor, which originally was occupied by one rectangular hall, as shown in Gaspare Turbini's reconstruction [Tur78], plates II-IV, was hastily covered with a provisionary wooden roof and divided into two sectors: to the west were placed the municipal archives, leaving a square space for the Great Hall (*Salone*).

Only in 1764 did the City of Brescia decide to amend the situation, announcing a competition for the restoration of the *Salone*. Already at this stage, abbot Gaspare Turbini sent a report (not accompanied by drawings or models) in which he outlined two possible alternatives: in his opinion, the Hall was to be covered either with a flat ceiling or a vaulted octagon. In 1766, architect Giacomo Colossio won the commission with a simple flat ceiling design, in no small part because his was the lowest price estimate. That same year, Colossio's newly-made roof crumbled. In 1769, Turbini's two proposals were delivered in six drawings to the Public Deputies. In the meantime, Luigi Vanvitelli had been called to Milan to work on the renovation of the Royal Palace. The local authorities invited him to Brescia, that he may see the *Loggia* and chime in on Turbini's solutions. He visited the city together with his apprentice Giuseppe Piermarini, and had the opportunity to see the proposals, from the 1765 competition to Turbini's, for himself. Eventually, the Deputies invited him to devise an original design. He kept in touch with local abbot and architect Antonio Marchetti, who became his primary contact in Brescia. Later in 1769, Vanvitelli sent the Deputies five drawings (plan, section, carpentry half-plan and half-section, corner solution indicating structural

DOI: 10.2312/dh.20253042

reinforcement, and façade) accompanied by a detailed written description. These documents illustrated a circular design for the *Salone*, which, according to brief, was to host a courtroom ("*Nello spazio del Salone dovrebbonsi stabilire, secondo fu detto, li luoghi per i Sedili o sien Cattedre di quattro Tribunali della Giudicatura.*", Milan 15th of October 1769). This proposal encountered the favour of the Deputies.

Turbini, understandably, felt sidelined and cheated, and thought that Vanvitelli had copied his ideas, while maintaining that his own octagonal design was superior to Vanvitelli's circular one. The Deputies exhibited the two designs side by side, invited Turbini to illustrate why an octagonal solution would be preferable, and forwarded the drawings first to the Accademia Reale di Architettura di Parma, accompanied by a letter by Turbini (which, in the words of De Bernardi Ferrero, comes across as rather bitter and lifts several suggestions from Vanvitelli's own 1769 design and description) and then to the Accademia Clementina di Bologna, inviting them to weigh in on the matter, while not mentioning Vanvitelli by name. The Academies voiced concerns regarding the structural viability of both designs, and identified a number of naivetes in Turbini's (some of which do not appear in the engravings, which has led both Segnali and De Bernardi Ferrero to conclude that the one discussed so far is an earlier iteration) while acknowledging his commitment. Turbini addressed these criticisms, creating the published version of the design. The Deputies tasked him with the realization of a hybrid model, which was to merge Turbini's design and Vanvitelli's attic.

Vanvitelli, who had long since returned to Naples, had received no word of these developments, and in June 1771 he found himself contacted simultaneously by Turbini (on behalf of the City) and Marchetti, who attached some sketches of Turbini's latest design and informed him that his project had been doomed by his rival's attacks on the circular shape. In Vanvitelli's reply to Marchetti (which he later explicitly asked to keep private), the architect scathingly criticizes the first iteration of Turbini's design, and accused the second of plagiarism. In September that same year, Vanvitelli sent in six drawings (façade, plan, attic plan, section, detail of the arch, corner solution detail), accompanied by the description of a new octagonal design. The situation soured considerably after Marchetti published Vanvitelli's incendiary June letter, to which Turbini replied with his own open missive.

Luigi Vanvitelli died in 1773, before the *Eletti* could reach a decision. Later that year, his octagonal design was chosen over Turbini's. (For more information on the 1764-1773 events and the Turbini-Vanvitelli controversy, please see [Seg38], [Seg39], and [DeB80], which the author has presently summarized.)

Zamboni, who wrote only a short few years after the fact and published a series of engravings by Turbini himself, does not mention Turbini or the controversy at all, citing the expected costs of Vanvitelli's first design as the sole reason why there had to be a second. Vanvitelli does address financial concerns in the August 1771 letter: for instance, he explicitly mentions that the mouldings, which ideally ought to be made of stucco, can be simulated with paint, and hints towards the use of stucco being reduced to a minimum (accordingly, while the first design's section clearly showed the mouldings in the nested frames of the vault, the second's is almost completely smooth; in the model, this was visualized by colouring the middle frame a dark grey in an otherwise white rendition) "*Le Pitture devono contribuire a facilitare la spesa degli ornati di stucco, che far si dovrebbero nella Volta. Però in quello Progetto quelle Sirene, e Tritoni aggruppati, che formano piede alle Lunette dovrebbero essere di scoltura in stucco, con aggetto però assai moderato, e Umilmente li festoni, che discendono dalli occhi dell'Attico.*" Naples 27th of August 1771. In that same vein, further on he suggests that the Hall be roofed in lead, whereas in the first design he had enthusiastically championed copper, a significantly more expensive material.

However, construction ground to a halt after the ultimation of the order, four corner apses, and attic. Furthermore, all interior elements were left unfinished, at the stage of pure volume. The hall was roofed at a lower level, leaving the attic completely exposed (https://catalogo.cultura.gov.it/detail/PhotographicHeritage/0800391977). In 1914, the attic was torn down and the *Loggia* received a new overturned ship's hull roof (lead over a wooden structure) that spans both the *Salone* and the archives, in an effort to replicate the *Loggia's* original Renaissance appearance. In 1923, following repairs to the roof, the Hall was covered with a flat wooden ceiling, which resulted in the structure we can see today. (See **Figure 1**).

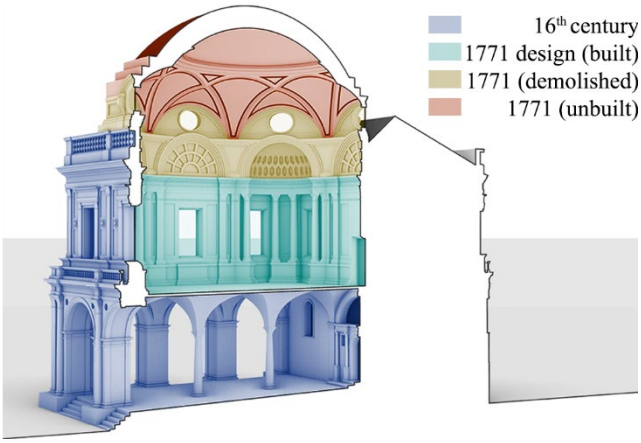

Figure 1*: Visualization of the fate of the different portions of Vanvitelli's design (Elaboration by the author).*

1.1 Objectives

This study was conducted in the context of an exploration launched in 2023 into some of Vanvitelli's unbuilt designs, which betray nods to the more daring of the Baroque masters, such as Francesco Borromini, Guarino Guarini, and Bernardo Antonio Vittone. This appears especially surprising for an architect whose style is generally characterized by a restrained, academic eclecticism, and routinely (by himself even) described as "serious" [Bon79]. The *Loggia* designs, crowned as they were by interlaced arches, seemingly harked back to Guarini's centralized spaces (San Lorenzo and the Sindone chapel in Turin come to mind, see [Car70]; [Dar22]) and perhaps, given their visual-structural coherence, even Vittone's early works (such as Vallinotto, see [Wit58], p. 284; [Can05]) Vanvitelli, of course, employs interlaced arches in the vestibule sequence (called *cannocchiale*, "spyglass") on the ground floor of the Royal Palace of Caserta. However, here this solution takes center stage, which was deemed notable.

Originally, the 3D reconstruction was aimed at visualizing the spatial impact of these arches and of the overall design, in order to verify their level of indebtment towards these seemingly idiosyncratic sources. As the making of the model progressed, however, it became clear that the first hypothesis presented some incongruities (see [Dem18], p. 104). Therefore, the focus shifted

towards utilizing the model as a means to test out different hypotheses regarding the configuration of the vault, which in turn became a means to investigate the origin of the incongruities themselves. The aim of this paper is to present an array of possibilities with regards to the unrealized portion of the *Salone* (see **Figure 1**) and utilize the reconstruction process to shed light on the drawings themselves, the way they diverge from one another, and their intended purpose.

2 Literature Review

Research into the 18th-century restoration process of the Loggia could be said to have begun already in 1778, when Baldassarre Zamboni published his *Memorie intorno alle pubbliche fabbriche piu insigni della città di Brescia* [Zam78]. His book is to this day cited as a credible historiographical source and contains direct transcripts from official documents. Supporting documentation includes a series of engravings by Gaspare Turbini, which depict the original configuration of the *Loggia,* Vanvitelli's second and definitive project, and even Turbini's two proposals. The engravings recite "*Ab. Gasparo Turbini Archit. delin."* ("Drafted by abbot Gaspare Turbini, architect") on the bottom left corner, and "*Pietro Beceni Sculp. Brixia*" on the bottom right. On Beceni (1755-1829), local engraver of moderate success, see [Lon94].

Research into Luigi Vanvitelli's designs specifically, however, had to wait until the late 1930s, when Pietro Segnali published the epistolary exchange between Vanvitelli himself, abbot Antonio Marchetti, and Turbini, in an effort to assign responsibility for the controversy (with Marchetti emerging as the principal instigator) and determine the viability of the two architects' reciprocal accusations of plagiarism [Seg38]. He then summarized and contextualized the material, interpolating it with Turbini's 1778 *Giunta alle memorie intorno alle pubbliche Fabbriche più insigni della città di Brescia* [Seg39], whilst adding scans of the section of Turbini's octagonal design (from Zamboni) and of the sections of both of Vanvitelli's designs (from the originals). More recently, Daria De Bernardi Ferrero revisited the design sequence and published nearly all of the Vanvitelli originals (plan, section, carpentry plan, corner detail, façade of the first design; plan, section, façade, corner solution of the second, plus a carpentry section of the second design she attributes to Giuseppe Piermarini), adding a thorough historical architectural analysis and cross-referencing Segnali and Zamboni's accounts with fresh archival material, [DeB80]. Eventually, the Archivio Storico del Comune di Brescia (hosting a large portion of the visual material surrounding the restoration of the Loggia), was transferred from the Biblioteca Queriniana to the Archivio di Stato di Brescia. On this occasion, Giuseppe Merlo systematically reviewed the composition of the albums and drew attention to Marchetti's own version of the Loggia, publishing the drawings he had drafted before he threw his weight behind Vanvitelli [Mer97].

There seems to be some degree of disagreement between the three around the identity of the draftsman behind the Vanvitelli drawings (between Vanvitelli, Piermarini, and Marchetti). Merlo, who carries the most thorough physical examination of the material, maintains that albums ASCB 1238 A and B (containing the Vanvitelli drawings of the second and first design, respectively) are in Vanvitelli's own hand. Marchetti copied this series (albums D, numbered II; and C, numbered I, respectively) and integrated it with three more drawings, including a detail of the vault structure. De Bernardi Ferrero attributes the drawings of the first design, along with the carpentry section of the second, to Piermarini's hand. The version of the first design section she publishes lacks a small tear that was already visible in Segnali. Combined, these factors seem to indicate that the drawings she saw and published were albums C and A, and that she identified the author of the copies and integrations as Piermarini rather than Marchetti. As for Segnali, while he certainly published the sections from the Vanvitelli albums (A and B) he still attributed them to Piermarini's hand. Marchetti's personal designs, and his elaborations on Vanvitelli's, are in albums E and F (III-IV) [Mer97].

3 Methodology

Literature tends to sort 3D models into two categories, according to their provenance: Emanuel Demetrescu [Dem18] writes of Reality-based Modeling versus Source-based Modeling, whereas Münster et al. [MAB*24a] of Raw Models vs Informative Models. While there are areas where the categories do not wholly overlap, broadly speaking these concepts define models obtained directly (from, say, laser-scanning) and models obtained deductively though a reverse-engineering process.

The model described in the present study falls squarely into the latter category (Source-based / Informative), since it derives all information from drawings. Since the aim was to analyze geometrical coherence within and between drawings, a continuous method employing NURBS was deemed preferable to a discrete one employing mesh. This was achieved through a blend of direct (Rhinoceros) and parametric (Grasshopper-in-Rhino) surface-based modeling (categories adopted from [MAB*24a]). Since the goal was the study of the spatial qualities of the designs and the geometric characteristics of the vault, the level of detail has been kept at the general volume of the architectural elements. For this reason, and because of the risk of affording reconstructions an undue level of perceived "certainty" [MAB*24b], photorealistic texturing was not applied.

In articulating the distinction between Reality-based and Source-based modeling, Demetrescu [Dem18] observes that the former, whose accuracy is quantifiable, results in a linear process with a closed output. The latter, however, lends itself to an iterative process, in which encountering incongruities leads the researcher to re-examining the data, potentially *ad infinitum*. This is exactly what happened in this project (see 4.2), and it highlights the value of 3D reconstruction as a scientific tool for history of architecture: the process and effort of rebuilding the object at hand, visualizing it in space, forces the researcher to engage with the source material in a "physical" way and interrogate it under this reverse-engineering lens, which may in some cases lead to an extensive reevaluation of the sources.

What makes this iterative process possible (ultimately, the absence of a physical object for researchers to check their hypotheses against) also makes it impossible for 3D reconstructions to escape a degree of uncertainty. This is especially true of this study, which is based on a limited and, as we will see in 4.2, in some regards contradictory set of drawings. Over the years, several systems have been devised to quantify and/or visualize uncertainty (For a comprehensive overview, see [Caz23], ch. 2). Of these, false-color visualization methods in which the degree of uncertainty was assessed on the basis of source reliability appeared the most suitable to this model's characteristics. More to the point, the scale developed by Fabrizio Apollonio, Federico Fallavolita and Riccardo Foschi in [AFF21] was specifically tailored to unbuilt architecture. This scale ranges from level 1

("Reliable assumption derived from reality-based data (i.e. the full real object or parts of it, well preserved archaeological founds, direct surveys, laser scans") to 7 ("Conjecture based on personal knowledge due to missing or unreferenced sources").

Based on this scale, the level assigned to the present reconstruction up to the internal entablature would be 2 (the reconstruction is based on clear and accurate direct sources – 2, although it can be verified against the existing object – 1); the area of the attic would also belong to level 2 (clear and accurate direct sources – Vanvitelli's original drawings and the photographs of the unfinished surfaces from before 1914). As for the vault, the options described in **Figure 11** and **Figure 12** would belong to level 3 (primary sources are available but inconsistent, resulting in conjecture aided by stylistic references by the same author), and the one in **Figure 9** to level 4 (drawing by a different author).

These types of sources occupy the higher-reliability end of the spectrum, not only in [AAF21] but in all the uncertainty assessment systems reviewed in [Car23]. It follows that, barring significant mistakes on the researcher's part, the vaulting possibilities explored in this study ought to be fairly low on the uncertainty spectrum in absolute terms, and thus have a good chance of accurately representing the vault Vanvitelli had in mind.

3.1 Background

This study derives its theoretical framework for the geometric construction of vaults from [Cur69], [DM93], integrated with the more recent analyses by Roberta Spallone on geometric composition in Guarini's treatise [Spa19] and survey of Piedmontese banded vaults [LSVN20]. In 2010, the University of Florence carried out an extensive survey-based work of systematization and cataloguing of the range of geometric solutions found in Renaissance umbrella vaults. These studies, in particular [LS10], [DAm10], have been employed as a point of reference in the elaboration of the present model. Previously, they had found application in the field of Baroque historiography in the analysis of Bernini's Sant'Andrea al Quirinale [Tab16].

The bounds of the range of vaulting solutions likely to be used by Vanvitelli specifically were drawn from the comprehensive survey of the Royal Palace of Caserta carried out in 2005 by the Soprintendenza per i Beni Architettonici e per il Paesaggio, per il Patrimonio Storico-Artistico e Etnoantropologico per le Province di Caserta e Benevento, jointly with Sapienza Department RADAAR (Rilievo, Analisi, Disegno dell'Ambiente e dell'Architettura). In the Palace, the architect showcases his knowledge and ingenuity on the subject, particularly when employing *incannucciata* (see 4.1) technology. In particular, commentaries by [BG05] and [Col05]; as well as standardized survey drawings [Cun05] were useful for examining the *Loggia*.

3.2 Process

Since the purpose of the reconstruction process was interrogating the geometric and spatial qualities of Vanivitelli's designs for the *Salone*, the modeling process began from the inner surface of the Hall and then expanded outwards, eventually encompassing the 16th-century structures. These, although extant, were also reconstructed by combining the Vanvitelli drawings with photographic evidence.

First, the 1238/A version of the plan and section of Vanvitelli's second design (**Figure 6**, **Figure 7**) were transferred into Rhinoceros and brought to scale with the aid of the measurements provided by the architect himself. In his letter to Marchetti, 25th of June, 1771, (in [Seg38]), it is clearly stated that the *Salone* measures 53:9 *braccia bresciane* ("Brescia arms", one of which = ~ 67cm, to be divided into 12 ounces). The drawings were then analyzed from a geometrical standpoint, according to an order of precedence that went Vanvitelli-Marchetti-Turbini, and the information thus obtained was interpolated with the letters and archival sources.

Figure 2: *Semantic articulation of the model. Elaboration by the author*

The hierarchical segmentation of the model (**Figure 2**) was organized according to the symmetries and repetitions that could be located in the drawings. The vault is regulated by 8 axes of symmetry, 4 of which also apply to the first floor interior (imperfectly, because of the presence of two doors). Of these, one transfers to the biaxial symmetry of the first floor exterior, and then to the axial symmetry of the lower floor exterior. Individual elements (columns, pilasters, arches, pillars, entablature profiles, windows) followed a similar partition and were gradually assembled according to the patterns of repetition and symmetry of the units they belonged to. It must be noted that, in order to preserve the unity of the elements, the syntactic units of the model (the lower and upper interior levels of the Hall) follow a rotational symmetry, instead of the reflective one that regulates the drawings (therefore, they interlock instead of mirroring one another). Similarly, since the 16th-century exterior is characterized by overlapping syntactic units, the sematic articulation of the model does not strictly follow that of the building as to avoid repetition.

The parametrization of certain elements of the model was crucial, since it allowed the researcher to immediately verify the changes arising from an alteration in the parameters. This was true of the entablatures, which were made dependent on an algorithm that associated a single profile curve to all its iterations, so that changes to the profile would automatically be transmitted to the entablatures. This extremely simple algorithm was employed in every instance where a profile and a rail could be identified (even

balustrades, in which the individual element was obtained through revolution and then placed in an array). Parametric modeling was also utilized for the nested frames of the vault, which had the unforeseen effect of allowing the researcher to better discern the shrinkage of the foot of the *pieducci* in each option. Yet another application can be found in the lunettes in **Figure 5**; **Figure 9**; **Figure 12**, generated by nets of arcs stretching between the border curves (locate X points along the length of the curves, trace arc that stretches between each pair of points with the intended tangent or radius resting along the horizontal or vertical plane).

4 Results

4.1 A note on the expected construction technology

From the very start, Vanvitelli intended for the Hall to be covered with a double wooden vault banded with iron, which only simulated a masonry vault. This is true of both the first design "*[…] "Dalli Pieducci delle otto Lunette si dovrà cominciare il primo sedimento curvo dell' armatura di legname, che deve reggere le Volte; una che farà mostra nella Sala, sulla quale resterà distesa la tonaca per dipingere, l'altra distaccata dalla inferiore per difesa delle Pitture, formata tutta come la prima di stagionato legname bene contesto, colligato insieme con delli cerchioni di ferro intorno, che perfettamente le racchiudono, qual fossero un sol pezzo di eguale resistenza*", and the second "*Otto pieducci, come il primo Disegno sosterranno le otto lunette, che restano condotte alla figura perfetta circolare della Volta, la quale intendo, che abbia ad essere con 1' armeggio di legname, e quindi Gesso o Calcina affissa con le canne secondo si costuma nel Paese. La Coperta sopra quella Volta, sarà di figura ottagona, con l'armeggio di legno, che parimenti deve sostenere la copertura di piombo, conforme ho veduto praticare in Venezia. Converrà però fare di quelli due coperti insieme un ben regolato modello prima di accingerli all' opera. Converrà apporre una chiave, che circondi in ottagono tutta l'opera, la quale per altro con l'Attico soprapoggia sulle muraglie, e resta luminosa per ogni parte. Le Pitture devono contribuire a facilitare la spesa degli ornati di stucco, che far si dovrebbero nella Volta.*" (letter attached to the first design, Milan 15th of October 1769; letter attached to the second design, Naples 27th of August 1771. Both found in [Zam78], Appendix). Vanvitelli was no stranger to these "fake vaults", as he himself calls them, having made ample use of them in Caserta. For example, the upper vault of the Great Staircase (*Scalone*) is likewise made of canes woven together, affixed to a complex wooden skeleton suspended from the rafters, and covered in plaster, a technique called *incannucciata,* see [Col05]. The *Scalone* is merely the most illustrious example though: the *incannucciata* was widely used in Caserta, see [Tal05]. The main difference between the technique envisioned for the Loggia and that employed in the Reggia lies in the function of structural collaboration between upper and lower vault (heavily emphasized in Brescia, nonexistent in Caserta where the lower vaults appear to be purely ornamental).

Vanvitelli devoted a great deal of thought and research to the state of the structure, and what needed to be added or repaired in order to ensure the columns he meant to add to the *Salone* would be properly supported (see his inquiry after the state of the corbels in [Seg38], and his plans to insert new ones in the detail of the first design (ASCB, 1238 B) and in that of the second (ASCB, 1238 A, fF)). This suggests that his insistence on a wooden vault may be related to concerns regarding the soundness of this heavily damaged structure. In upper vault of the Grand Staircase of Caserta, this lighter construction method had allowed the architect to solve the question of the angle through a composition of intersecting barrel vaults [Col05]. Therefore, the pliability of the intended technology, along with the architect's willingness to take full advantage of it, constitute factors that must be taken into account when formulating and evaluating solutions.

4.2 Square into Circle into Octagon

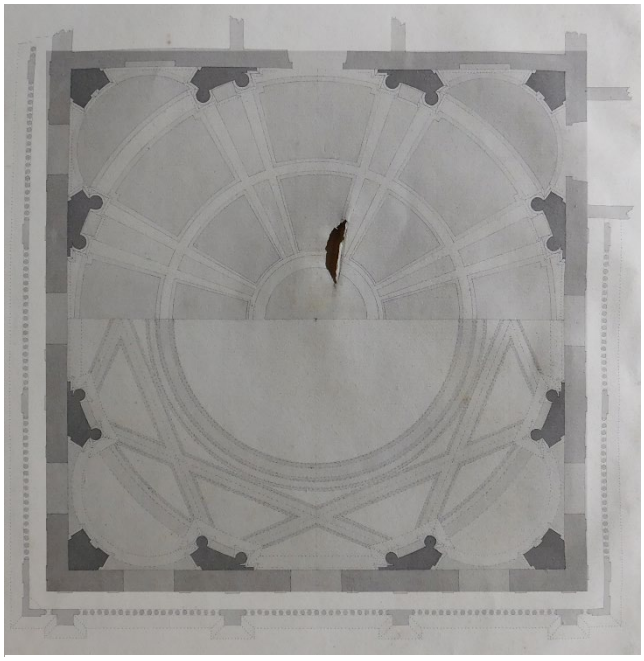

Figure 3*: ASCB, 1238 B. [Luigi Vanvitelli] 1769, first design for the Salone, plan.*

In the letter accompanying his first design (Milan 15th of October 1769), Vanvitelli explains that, since the height of the arches appeared insufficient to the proportion of the hall, he had had to raise the vault above them "*Sul cornicione dell'ordine principale, che in varie guise senza intermittenza di tempo tutto lo corona, sorgono le regolate aperture delli otto archi; e siccome 1'altezza di questi non sarebbe sufficiente alla proporzione del Salone; perciò vi ho replicato sulli medesimi un altro cornicione di proporzione leggera, che viene sostenuto con ragionevole bizzarria da otto gruppi di Sirene e Tritoni, apposti in vece di mensole, che servono a determinare l'imposta dei pieducci delle otto Lunette corrispondenti sopra gli Archi […]".*

In this first design (**Figure 3**; **Figure 4**), the arches on the lower level are three-dimensional, being generated by the intersection of cylindrical surfaces (as evidenced by their appearance in section), and the surfaces stretching between them are leftover portions of the original cylinder (in plate XIII, Turbini envisions a similar relation between planar arch and wall). The structure germinates into niches along the diagonals, to fill up the corners of the square. The vault, shifted slightly inwards (likely in order to accommodate the transition from masonry to wooden structure) so that the *pieducci* end up resting on siren-shaped corbels, is a dome-like structure, oval in section, whose lower regions are criss-crossed by a system of interlaced arches. This system also defines the lunettes, which are best approximated as a net of arcs resting on horizontal planes, stretched between the border curves. The arcs all sweep the same angle, and consequently their radiuses decrease as they

approach the top (method 2b outlined in [LS10], p.108; see **Figure 5**). The resulting sails are then cut by the cylindrical wall (Vanvitelli cuts the sails in a similar manner in the lower vault of the Grand Staircase of Caserta, see [Col05]).

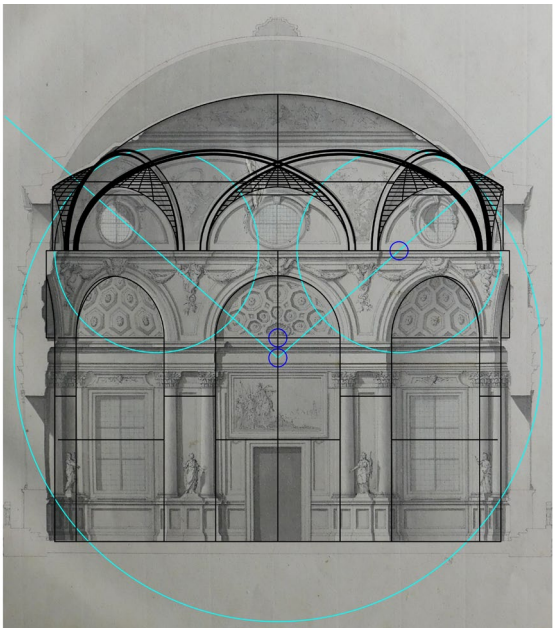

Figure 4: *Correspondence between the author's reconstruction and Vanvitelli's first design section (ASCB, 1238B). Blue circles represent compass picks in the original.*

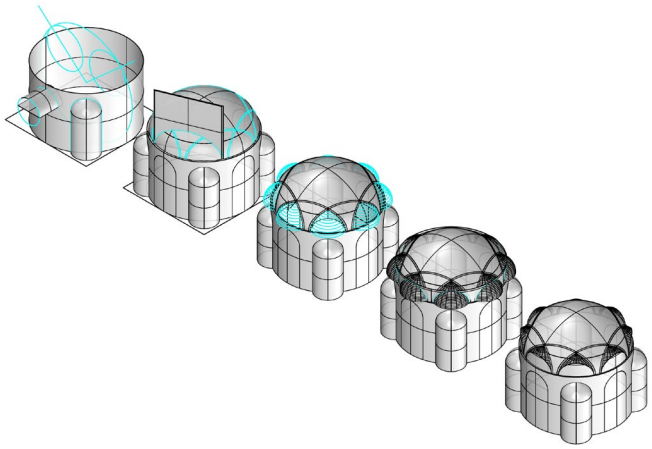

Figure 5: *Volumetric reconstruction of Vanvitelli's first design. Elaboration by the author.*

Vanvitelli's Milan 15th of October 1769 letter contains passages that become especially poignant when analyzing the transition from the first design to the second, because it is possible to already glimpse in them ideas that will morph later. The stepped exterior envisioned for this first dome is a deliberate reference to the Roman Pantheon: *"Per condurre una conveniente unione dalla ultima superiore cornice esteriore dell' Attico, con la porzione curva del Coperto, che oltrepassa, vi ho introdotta la figura di tre alti gradini in giro, a similitudine di quelli, che intorno alla consimile porzione di Cupola dell'antico Panteon di Roma si vedono."* Vanvitelli does not overhaul the project from the first design to the second; in fact, the two sections appear strikingly similar. Therefore, when analyzing the second design it is important to keep how the elements that make up the first came to be, and try to determine how those same elements morphed to adapt to a polygonal plan. For example, once Vanvitelli shifted to the octagonal plan, the Pantheon reference in the attic area was certain to be lost, but the stepped exterior was kept at the base of what now was a cloister vault. Analizing the new section, however, it appears that the reference was transferred to the interior: the vault morphed from a polycentric surface of revolution to the portion of a sphere whose diameter was equal to the total height of the space.

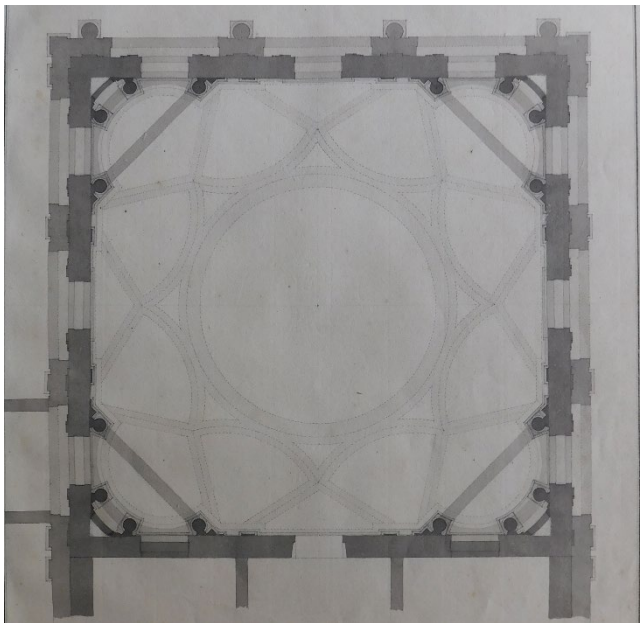

Figure 6: *ASCB, 1238 A, fB. [Luigi Vanvitelli], 1771, second design for the Salone, plan.*

The most obvious change from the first of Vanvitelli's designs to the second is the shift from circular to octagonal plan. However, this comes with a series of other more subtle shifts: for starters, the perfect symmetry of the circular plan is sacrificed in the octagon, since the diagonal and orthogonal sides belong to octagons of different sizes. This is both stated in Vanvitelli's letter "*Tutto il piantato resta ottagono; ma quattro lati cantonali hanno la faccia una picciola differenza più stretta delli altri quattro.*" (27th of August 1771, in [Zam78], Appendix), and immediately observable in the drawing: the elements of the vault maintain perfect radial symmetry, but their projections in plan intercept the walls at different points, making them appear to tilt slightly. This artifice is masked by the transition to the columnar system in the diagonal sides (ASCB, 1238A, fB, **Figure 6**), and hidden in the thickness of the arches in the transition to the pendentives. The need to transition from a polygonal plan to a circular vault determines the insertion of a level of pendentives, instead of letting the perimetral walls continue to frame the arches.

Moreover, in the first design the "*pieducci*", which is to say the second tier of pseudo-pendentives, were defined by interlaced arches that followed the Guarinian model: they were the result of the intersection between a vertical plane and a surface of revolution. Each *pieduccio* was in turn delimited by the intersection of three consecutive arches. In the second project, that is no longer the case: the *pieducci* in projection are delimited by three distinct segments, the central one being an arc, as already

observed in the southern vestibule in the Caserta *cannocchiale* [Cun05], plate LV. This seems to indicate that the *pieducci,* which in the first design were merely the result of the subdivision of the vault, attained a greater degree of conceptual autonomy in the second. A similar understanding of the *pieducci* as their own visual unit underscores the central and northern vestibules of the *cannocchiale* (plates LIII and LIV).

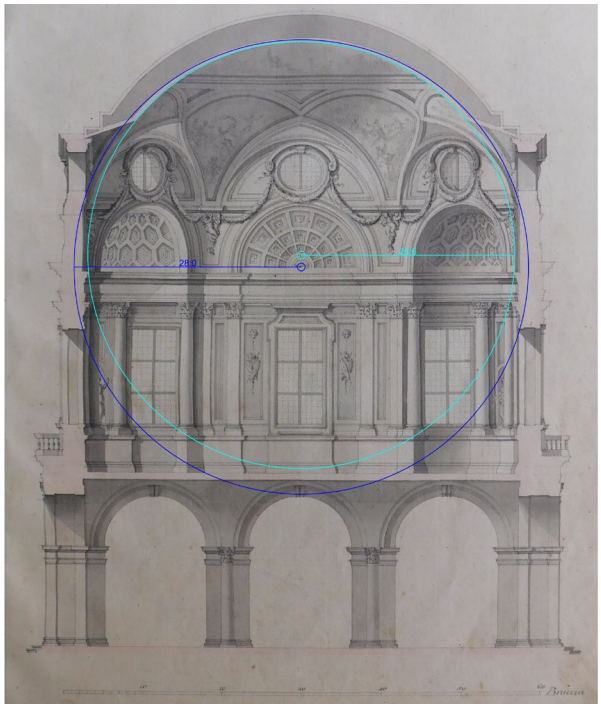

Figure 7*: ASCB, 1238 A, fD. [Luigi Vanvitelli], 1771, second design for the Salone, cross-section. In cyan, the profile and center (identified via compass pick) of the vault as it appears in the present section. In blue, the profile and center of the vault according to Marchetti's carpentry (ASCB, 1238A, fG).*

The second design section (1238 A, fD; **Figure 7**) clearly displays a number of incongruities, which can give rise to differing interpretations. Vanvitelli himself seems to have been at least somewhat aware of the obscure elements of his creation, since he remarked that it would be best to make a model of the vault first. "*Converrà però fare di quelli due coperti insieme un ben regolato modello prima di accingerli all' opera."* Zamboni, while thanking Marchetti for giving him leave to publish the letter, remarks that it would have nonetheless been helpful to also publish the documents and drawings detailing the corner and vaulting solutions "*Sarebbe stato bene, che, dalle molte Lettere del Vanvitelli scritte allo stesso si fossero scielti e stampati i ricordi relativi all' esecuzione del Disegno, in proposito delle imposte delle Basi e dei Volti degli archi acuti, che debbono andar nascosti nel pieno della fabbrica, dell'artificio e ligamento della volta tra di se e colle pareti già esistenti ec.*" [Zam78], p. 162 note 1.

In his carpentry section, Marchetti depicts the profile of the vault as a continuous semicircle sharing the spring line of the arches (ASCB, 1238 A, fG. **Figure 8**). More specifically, the vault is depicted as a hemisphere circumscribed to the arches: a continuous surface encompassing the first level of pendentives, the pseudo-pendentives, and the central span. Turbini, however, in his diagonal section of this project [Tur78] plate VI, also published by Zamboni, places the vault impost at the *lunette* level, as it was in the first

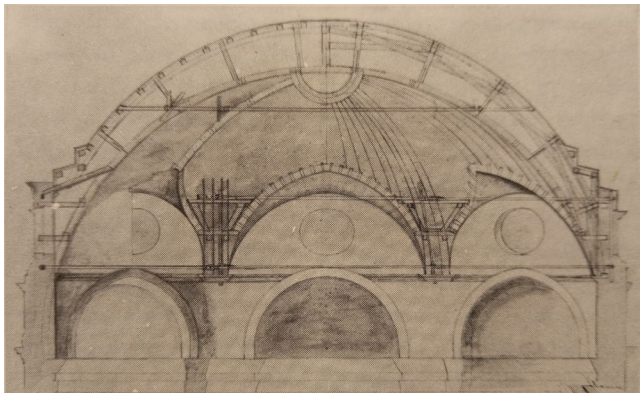

Figure 9*: ASCB, 1238A, fG. [Antonio Marchetti], second Vanvitelli design for the Salone, carpentry section. In [DeB80].*

design. Furthermore, this diagonal section (which, ideally, would cut through both the first and second level of "pendentives") displays a semielliptical profile, which suggests that Turbini interpreted Vanvitelli's dome as a cloister vault (see [DM93] ch. 7) This is perhaps less surprising if we keep in mind that Turbini's own proposal contemplated a cloister vault (plate XIII), and that his engravings of the original Loggia depict a trought vault (plates III-IV). Between 1774 and 1776, Piermarini was contacted by the City of Brescia to elucidate certain aspects of the design and supervise the creation of the model that was to guide construction up to the entablature. Of the vault, he wrote that they would worry about it when the time came (*"[…] il detto Capo Maestro non avrà più bisogno di alcuna sorta di direzione per la costruzione dell'intiera Sala fino sotto il volto, per il quale poi si pensera a suo tempo*"), and asked to be contacted again when they got to that part as to prevent execution errors "*Per quanto però nel rimanente io mi persuado che il lavoro possa seguirsi a dovere, tuttavia reputerei nel caso di esser presente allorché si dovrà alzare il volto, affinché non succeda sbaglio o inconveniente alcuno*" (Letters addressed from Giuseppe Piermarini to the Deputies, Milan 5th of July 1775, 27th of September 1775, in [Fil12]). All this points to

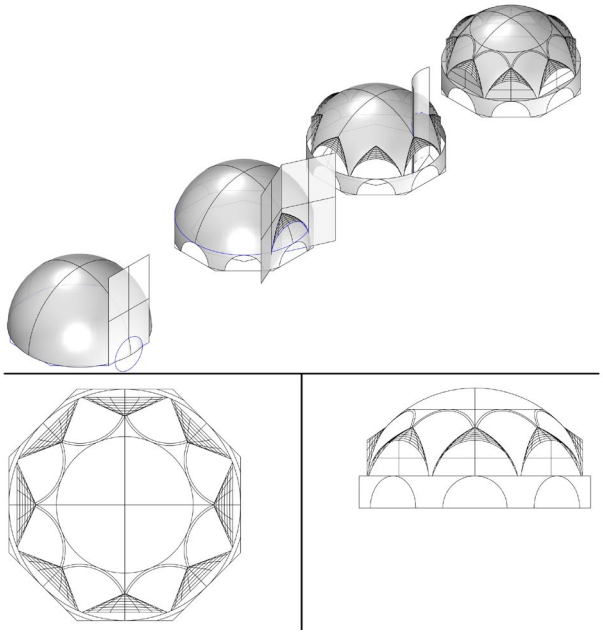

Figure 8*: Second design vault according to Marchetti's fG (hemisphere). Elaboration by the author.*

the existence of not-readily explainable anomalies in the vault that Vanvitelli designed, that made interpretation difficult already a scant few years after the architect's death.

There are aspects of Marchetti's carpentry section (**Figure 8**) that are difficult to explain internally, while others are difficult to reconcile with Vanvitelli's section (**Figure 7**). As for internal inconsistencies, if the vault is a single hemisphere springing from the impost of the arches, it cannot possibly be intercepted by a sequence of arch and lunette resting along the same vertical plane, since the dome would be curving away (**Figure 9**). In other words, the attic would need to fall to the inside of the room, which is clearly not the case in either section, nor in the Vanvitelli attic plan (ASCB, 1238 A, fC). And, as for external inconsistencies, in Vanvitelli's section the sphere that the top portion of the vault belongs to is simply too small to encompass the pendentives too, falling well inside the perimeter of the arches (whereas, in order to belong to the pendentives, it ought to circumscribe the arches). This, as well as the fact that all other relevant representations (attic plan, plan, section) in 1238A show the *pieducci* and lunette springing directly from the perimetral wall, points towards the pendentives in the Vanvitelli section being "empty". In other words, they are not actually carrying the second level, much less are they one with it. Their function would be, as for the arches in the first design, merely to lift the impost of the vault, and the final visual effect would closely resemble that of an open double vault. A lower masonry vault opening into an upper *incannucciata* one would also perfectly replicate the sequence found in the Grand Staircase of Caserta [Col05], a structure that the next interpretation proposed (**Figure *11***) takes several cues from.

Figure 10*: Close-up of ASCB, 1238A, fD (**Fig. 7**). See the discontinuity between the central portion of the vault and the lunette.*

A closer look at the vault in the Vanvitelli section (**Figure 10**) reveals yet more peculiarities, specifically regarding the curves that constitute the borders between the lunettes and the *pieducci.* Looking at the lunettes placed at a 45° angle to the section plane, we can see an inflection point on the border curve. This detail was retained in both Marchetti's and Turbini's copies, and remains extremely difficult to explain or reproduce, especially since it does not appear in any other border curve – not even in the outer border of the same lunette. Even more surprising is the fact that the border curves of the lunettes perpendicular to the section plane would spring *outwards* to intercept a wall that is quite distant from the surface of the main sphere, when ordinarily they would share the sphere's tangent at the intersection and then curve inwards as they cut away a portion of the sphere (**Figure 10**; compare to **Figure 9**). As a result, the *pieducci,* especially the two near the section plane, appear to billow away from the central ideal surface.

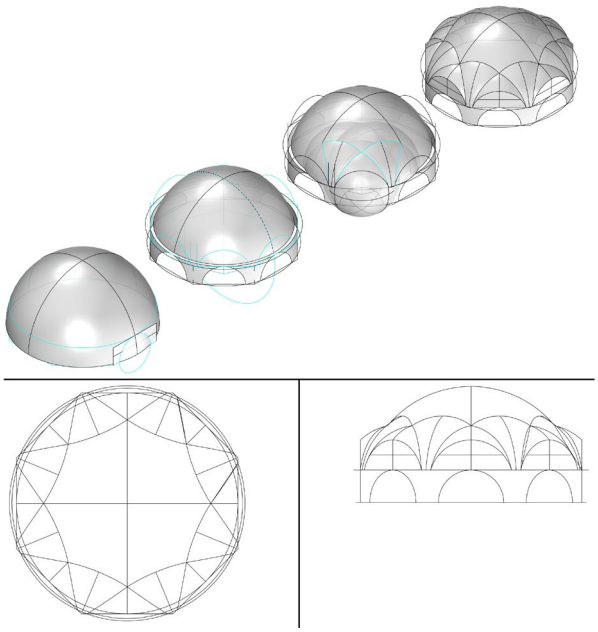

Figure 12*: fD vault as portions of spheres. Elaboration by the author.*

These considerations are compatible with the hypothesis that, in the passage from the first design to the second, the *pieducci* acquired not only a significant degree of visual autonomy from the central portion of the vault, but *spatial* autonomy as well. In this light, the simplest solution from a geometric standpoint is to assume that the *pieducci* are portions of smaller spheres, that redirect the larger one towards a wider perimeter and verticalize the tangent in the process (**Figure 11**). This solution fits best with the idea of the *pieducci*'s new-found spatial autonomy, and with the sense of outbound expansion conveyed in the section as well. Colonnese's work on the vault of the Grand Staircase of Caserta shows both that Vanvitelli freely employed complex and at times

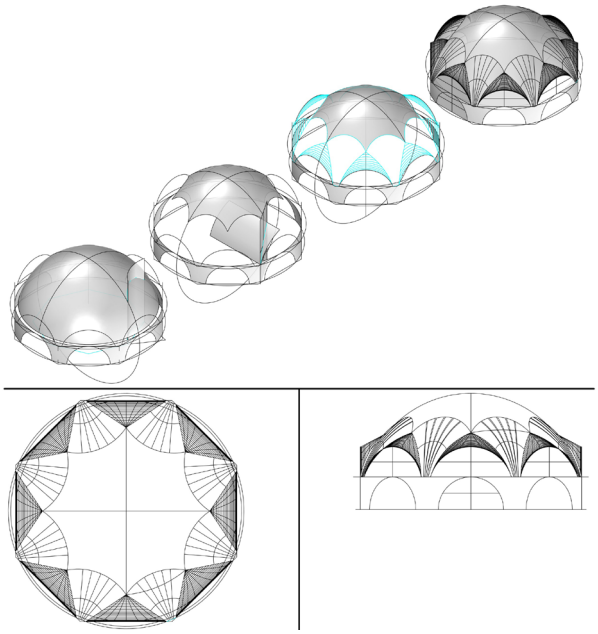

Figure 11*: fD vault from border curves. Elaboration by the author.*

arduous compositions of simple vaulting solutions (as does Barnobi and Giuffrida's work on the Theatre), and that this level of complexity was well within the technological bounds of the *incannucciata*. As a result, the lunettes become best approximated as spherical as well, which admittedly clashes with the linear planar projection they display in the drawn plan (compare (**Figure 11** planar projection with **Figure 6**).

Another possibility is to derive these problematic border curves from their depictions in plan and section (**Figure 12**). First, we vertically extrude from the plan the arches that delimit the central portion of the vault (still assumed as a sphere); then we do the same with the linear projections of the lunette border curves, while perpendicularly extruding their frontal found in section (**Figure 10**). The next passage is stretching a surface between these curves to obtain the *pieducci* and lunettes. The lunettes in this case are generated by a net of arcs resting on vertical planes, all sharing the same radius. This method however turns the *pieducci* into complex surfaces, and does not allow for any degree of graphic simplification on Vanvitelli's part.

Of these two options, however, the former (**Figure 9**) appears more likely, if only due to its greater simplicity, and the architect's penchant for achieving complex compositions of elements that are on their own extremely simple.

5 Conclusions

Both explanations derived from fD (**Figure *4***) result in a geometrically complex composite vault liable to generate confusion without the architect present to provide a ready explanation, not to mention the difficulties in execution that would inevitably arise. One must therefore wonder whether the Marchetti section (**Figure *5***) constitutes a conscious attempt to simplify the vault structure and geometry. After all, its main idiosyncrasy can be remedied relatively easily, by extending the lunettes until they reach the wall, even though lesser discrepancies (such as the shrinkage of the base of the *pieducci* until they become nearly triangular) persist.

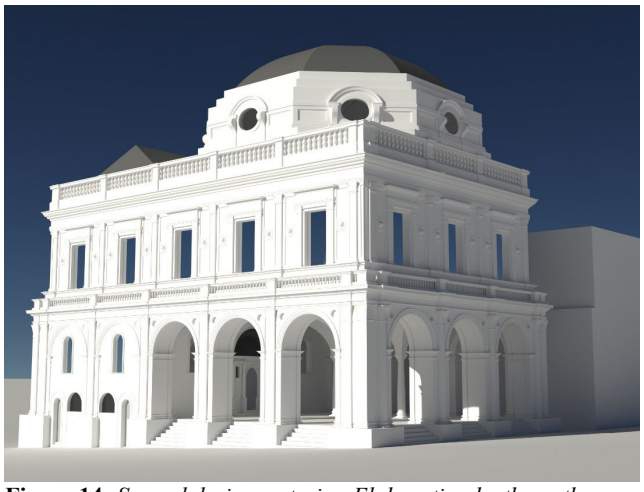

Figure 14*: Second design, exterior. Elaboration by the author.*

The interpretation reached at the end of the reconstruction process, then, is that the vault envisioned by Vanvitelli for the Great Hall of Palazzo della Loggia is best approximated as a composition of spherical portions (**Figure *11***). This solution was

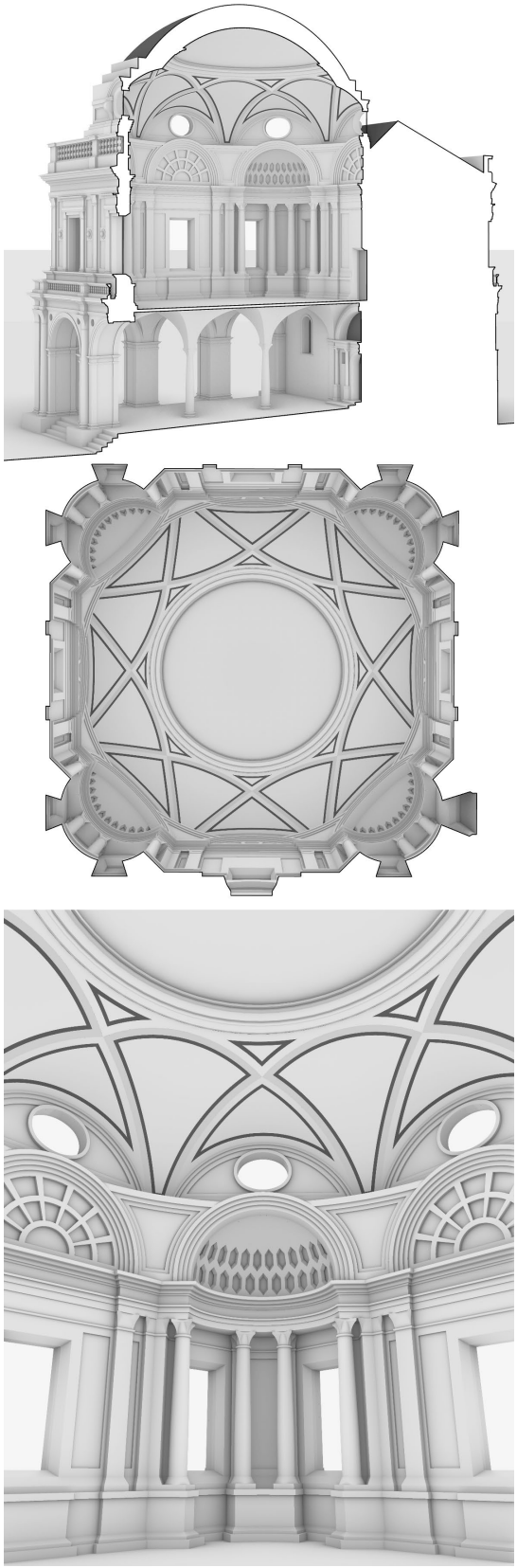

Figure 13*: Pespective section, view from below, interior of Vanvitelli's second design, vault according to* **Figure 11.** *Elaborations by the author.*

eventually reworked into a single hemisphere (**Figure *9***) after the architect's passing, before being abandoned altogether.

The next step for this project would be to share the model to an open access repository, in order to try to circumvent the access and obsolescence problems implicit in 3D reconstructions. Another avenue to pursue may be to contact the Brescian authorities and integrate these visualizations (images and videos) into visit to the Loggia, or even devising games to help the public understand the history of the palace.

6 References

[AFF21] Apollonio, F. I., Fallavollita, F., & Foschi, R.: The Critical Digital Model for the Study of Unbuilt Architecture. In F. Niebling, S. Münster, & H. Messemer (Eds.), *Research and Education in Urban History in the Age of Digital Libraries* (2021), CCIS vol. 1501, (Proc. UHDL 2019), 3–24 doi:10.1007/978-3-030-93186-5_1

[BG05] Barnobi, L., & Giuffrida, A.: Il Teatro. In C. Cundari (Ed.), *Il Palazzo Reale di Caserta.* Vol. 1, 187–192. Edizioni Kappa, 2005.

[Bon79] Bonelli, R.: Vanvitelli e la cultura europea: Proposta per una lettura europeista della Reggia di Caserta. In *Luigi Vanvitelli e il '700 europeo* (1979), vol. I, (Proc. Celebrazioni vanvitelliane MCMLXXIII 1973), 135–147.

[Can05] Canavesio, W. (Ed.): *Il voluttuoso genio dell'occhio. Nuovi studi su Bernardo Antonio Vittone*. Società piemontese di archeologia e belle arti, 2005.

[Car70] Carboneri, N.: Guarini ed il Piemonte. In *Guarino Guarini e l'internazionalità del barocco* (1970), vol. 2, (Proc. Accademia delle Scienze di Torino 1968), 347–383

[Caz23] Cazzaro, I.: *Digital 3D reconstruction as a research environment in art and architecture history: Uncertainty classification and visualisation* Doctoral Thesis, Alma Mater Studiorum - Università di Bologna, 2023. doi:10.48676/unibo/amsdottorato/10817

[Col05] Colonnese, F. Lo Scalone d'Onore. In C. Cundari (Ed.), *Il Palazzo Reale di Caserta.* Vol. 1, 157–164. Edizioni Kappa, 2005.

[Cun05] Cundari, C. (Ed.): *Il Palazzo Reale di Caserta. Immagini e Rilievi: Vol. 2.2*. Edizioni Kappa, 2005.

[Cur69] Curioni, G.: *Geometria pratica applicata all'arte del costruttore*. Augusto Federico Negro Editore, 1869.

[DAm10] D'Amico, S.: Il rilievo come strumento per la ricerca di geometrie. La volta a ombrello della Sacrestia vecchia di San Lorenzo a Firenze. *Materia e Geometria*, *18* (2010)., 116–118.

[Dar22] Dardanello, G.: Costruire l'esperienza di una visione di infinito: Le ragioni della luce per una dimostrazione in opera del pensiero di Guarini. In M. Feroggio (Ed.), *La cappella della Sindone tra storia e restauro* (2022) (Proc. Musei Reali 2022), 56–77.

[DeB80] De Bernardi Ferrero, D.: Il Vanvitelli a Brescia: Vicissitudini di una mancata ricostruzione. *Palladio*, *29* (1980), 89–108.

[Dem18] Demetrescu, E.: Virtual Reconstruction as a Scientific Tool. In S. Münster, K. Friedrichs, F. Niebling, & A. Seidel-Grzesińska (Eds.), *Digital Research and Education in Architectural Heritage* (2018), CCIS vol. 817, (Proc. DECH 2017, UHDL 2017), 102–116. doi:10.1007/978-3-319-76992-9_7

[DM93] Docci, M., & Migliari, R.: *Scienza della rappresentazione: Fondamenti e applicazioni della geometria descrittiva*. La Nuova Italia Scientifica, 1993.

[Fil12] Filippini, E.: Giuseppe Piermarini a Brescia. *Archivio Storico Lombardo : Giornale Della Societa Storica Lombarda*, *17(33)* (1912), 114–122.

[FGR95] Frati, V., Gianfranceschi, I., & Robecchi, F. (Eds.): *La Loggia di Brescia e la sua piazza*, Grafo, Vols. 1–2, 1995.

[LS10] Lavoratti, G., & Salemi, P.: La volta a ombrello della cappella Pazzi a Firenze. *Materia e Geometria*, *18* (2010), 107–112.

[Lon94] Lonati, R.: *Dizionario degli incisori bresciani*. Novalito 1994.

[LSVN20] López González, M. C., Spallone, R., Vitali, M., & Natta, F.: Baroque Banded Vaults: Surveying and Modeling. The case study of a Noble Palace in Turin. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLIII-B2-2020* (2020), 871–878. doi:10.5194/isprs-archives-XLIII-B2-2020-871-2020

[Mer97] Merlo, G.: Il palazzo della Loggia di Brescia nei disegni di Luigi Vanvitelli e di Antonio Marchetti. *Arte Lombarda*, *121* (1997), 91–101.

[MAB*24a] Münster, S., Apollonio, F. I., Bluemel, I., Fallavollita, F., Foschi, R., Grellert, M., Ioannides, M., Jahn, P. H., Kurdiovsky, R., Kuroczyński, P., Lutteroth, J.-E., Messemer, H., & Schelbert, G.: 3D Modeling. In *Handbook of Digital 3D Reconstruction of Historical Architecture* (2024), SLETS vol. 28, 107–128. doi:10.1007/978-3-031-43363-4_6

[MAB*24b] Münster, et al.: Visualization. In *Handbook of Digital 3D Reconstruction of Historical Architecture* (2024), SLETS vol 28, 129–163. doi:10.1007/978-3-031-43363-4_7

[Seg38] Segnali, P.: L' opera del Vanvitelli a Brescia. Carteggio inedito tra gli architetti Luigi Vanvitelli e Abate Antonio Marchetti. *Quaderni della Sezione Bresciana della R. Deputazione di Storia Patria per la Lombardia* (1938), 1–47.

[Seg39] Segnali, P.: L' Abate Gaspare Antonio Turbini, architetto bresciano, e la sua polemica col Vanvitelli. *Commentari dell'Ateneo di Brescia*, *per il 1938 vol. A* (1939), 60–93.

[Spa19] Spallone, R.: Geometry of vaulted systems in the treatises by Guarino Guarini. *EGE-Expresión Gráfica En La Edificación*, *11* (2019), 79–93. doi:10.4995/ege.2019.12872

[Tab16] Tabarrini, M.: Bernini illusionista e la cupola di Sant'Andrea al Quirinale. In M. Bevilacqua & A. Capriotti (Eds.), *Sant'Andrea al Quirinale: Il restauro della decorazione della cupola e nuovi studi berniniani*, 59–75. De Luca Editori d'Arte, 2016.

[Tal05] Talamo de Vargas Macciuccia, F.: Le volte ad incannucciata. In C. Cundari (Ed.), *Il Palazzo Reale di Caserta.* Vol. 1, 31–33. Edizioni Kappa, 2005.

[Tur78] Turbini, G. A.: *Il Palazzo Pubblico Alle Ragioni della Città di Brescia Antico, e Moderno, Misurato, Disegnato, e Descritto In XVI Tavole Dall'Ab. Gasparo Turbini, Architetto Bresciano*. (1778); Bibliotheca Hertziana. https://hdl.handle.net/21.11153/1ebb-c7ae-dad3

[Wit58] Wittkower, R.: *Art And Architecture In Italy 1600-1750*. Penguin Books, 1958. http://archive.org/details/in.ernet.dli.2015.462112

[Zam78] Zamboni, B.: *Memorie intorno alle pubbliche fabbriche piu insigni della città di Brescia*. In Brescia : Per Pietro Vescovi (1778); Getty Research Institute.http://archive.org/details/memorieintornoal00zamb