

The Basilica of Saint Peter: Surveys as Models of Knowledge (XVII and XVIII Centuries)

Aldo De Sanctis, Antonio Lio, Nicola Totaro, Antonio A. Zappani

Abstract

St. Peter's Basilica has attracted painters and surveyors since the early stages of the construction site, but it was its completion and the start of the «sinisters and various voices» on the dome's solidity to promote unprecedented aptitude in surveys both to reveal the marvel of its forms and to verify the stability of its structures. Different surveys that take over a century to elaborate: from 1620, when Martino Ferrabosco published his renderings on the basilica, to 1743 when Giovanni Poleni and Luigi Vanvitelli did their surveys for their analysis on its static behaviour and for the restoration of the Vatican dome.

Keywords: Survey, Restitution images, Knowledge models.

Introduction

Among the surveys of Martino Ferrabosco on the Basilica of Saint Peter (1620) and those of Luigi Vanvitelli and Giovanni Poleni on the stability of the dome of the same basilica (1743), graphic renderings are created so as to transform the survey into the most versatile discipline available are drawn graphic returns such as to transform the survey in the most versatile discipline available for the analysis and knowledge of architecture. Clearly different surveys, which are used both to render the formal characteristics (functional etc.) of the entire building and to study of specific problems, such as the solidity of the resistant system formed by the tambour-dome-lantern. Surveys are, in any case, essential in order to know the different aspects of an architectural reality, to analyze its determinants (spatial and technical) and to intervene, having full awareness of its state.

Survey of the Basilica of St. Peter

As recalled, in 1620 Ferrabosco published his surveys [1] on the basilica of Saint Peter in the Vatican; it is an extraordinary work due to the size of the building and the figurative novelty reached (complexity of the drawings, selection of the graphic signs etc.).

The construction of the church has finished [2] and for the first time, a surveyor attempts to adapt tools, methods, scales and techniques of graphic mediation to know it in the variety of its forms and certify its quality.

Ferrabosco renders the Vatican basilica with drawings of sets and detail and, above all, with complex drawings –three plants and a section on 34 survey panels– used to render the articulation of the architectonically most important parts (the central part of the church and the dome). The drawings are so com-

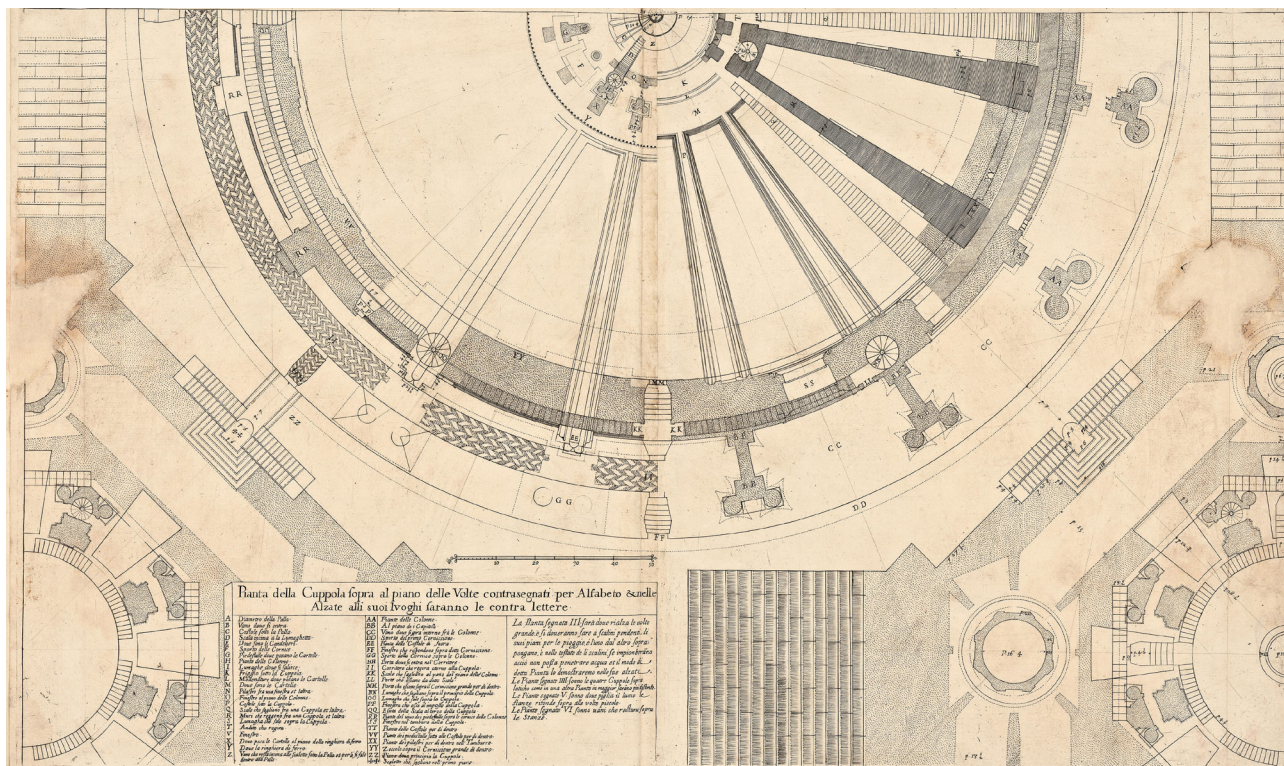
plex as to be a challenge for the “intelligent professor” [3] who will then have to read them.

In the printed publication, there is a little of all the known methods of representation, but it is in the orthogonal projections and especially in the use of plants and “multiple” sections –obtained by combining different levels on a single projection plane– that Ferrabosco seems to find the most convincing way to establish the characteristics of his work and restore the architectural complexity of the “great, and portentous Machine” [Curcio 2003, p. 20]. Plants and multiple sections that become real analytical tools, rich in detail and that, in spite of any figurative complication, are perhaps the most convincing result of his activity as a surveyor.

The “*Pianta della Cuppola sopra al piano delle Volte contrasegnati per Alfabeto &nelle Alzate alli suoi Ivoghi saranno le contra lettere*”

contra lettere” [Ferrabosco 1620] describes, for example, the half plan of the dome system, from the octagon on which the tambour is placed to the golden ball which surmounts the lantern, of which the diameter is given (fig. 1). In evidence, six of the sixteen ribs are shown, presented two by two so as to define, sector by sector, the role (the shape, the step etc.) of each component: two ribs are seen from the outside, two from the inside and two in the intermediate space between the calottes that form the dome. The first two start from the cornice of the attic, above the twin columns outside the tambour; and arrive at the “iron fence” of the lantern. The final parts of this sector on one side present the wall section of the tambour (with the annular herringbone floored corridor which runs inside the base of the tambour; the ramp which leads to the floor

Fig. 1. Martino Ferrabosco, *Pianta della Cuppola sopra al piano delle Volte contrasegnati per Alfabeto &nelle Alzate alli suoi Ivoghi saranno le contra lettere*, 1620.



of the columns and the spiral staircase which crosses the tambour); on the other side the plan of the lantern (with the spiral staircase which crosses it and the stairs on the extrados of the small dome). With the same herringbone flooring, it is possible to see the passage which –leads to the annular corridor in the basement from the external stairs– on the octagon base.

The ribs, seen from the inside, show the drawings and the thickness of the decorative part above the dome. The terminal parts of this sector, one side, show the section of the tambour (at a different part from the previous one) with the twinned columns cut at the upper scape (the projection of the capitelli is seen) and on the other side the shelves of the lantern (which are not drawn).

The ribs between the two calottes, characterised by a strong dotting, present the way in which the same ribs taper and the twinned columns sectioned at the column base (the projection of the base of the columns is seen): the section plan passes from the start of the lantern, does not consider the presence of the external calotte and shows the ribs in orthogonal projection at the height of the annular corridor (dotted) between the two calottes. The final parts of this sector present, on one side, the section of the tambour and, on the opposite side, the corridor and the spiral staircase which climbs above the lantern. Two ramps of steps which climb the extrados of the calotte within the dome can be seen. The tambour results as being sectioned three times, but the masonry seen in the different sectors is not continuous: it presents two different parts of the tambour, one towards the inside and one towards the outside. The drawing, despite using several viewpoints and the multiplicity of information deriving from it, is clear and without graphical interference. It presents a description which serves not only to reproduce a state which is, however, difficult to represent, but to analyze it showing the resisting sections and all the paths –horizontal and vertical– necessary to pass from one level to another and arrive at the summit. In addition to the full masonry and the voids of windows and doors, we find all the elements of passage that lead from the basic octagon to the fastigium ball: the passage that runs around the tambour and that between the two calottes of the dome; all the ramps with steps and the paths that lead inside the dome; the spiral staircases of the tambour and of the lantern and the steps on the extrados of the inner calotte and the small dome.

In the drawing –perhaps so as not to compromise the readability of the whole– there are not too many mea-

surements; however, the reference to the graphic scale in Roman palms and a rich legend, with letters in the graphic field for identification of the individual parts, appears. The rendering scale is approximately 1:100.

The 3D model we developed, derived from the plans, confirms the descriptive richness and the metric accuracy of the work of 1620. Furthermore, it also confirms how Ferrabosco uses the survey both to evaluate the organization of an architectural reality and to analyze its components [4] (fig. 2).

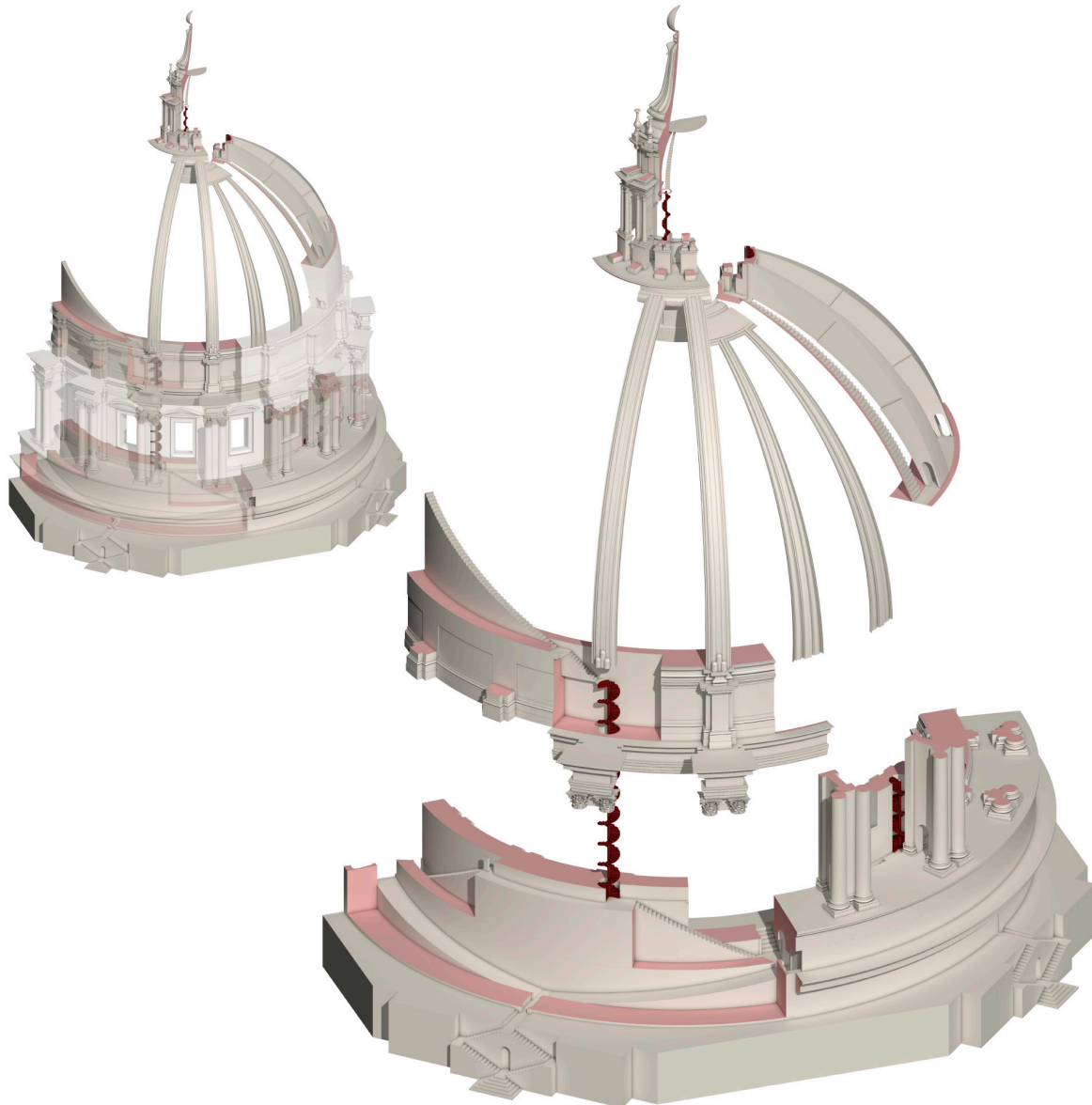
In other words, it confirms that Ferrabosco knows the concept of graphic scale and the selective value that representation can play in architecture well. The figurative specifications that articulate the plan are in fact real opportunities to study the Vatican 'machine' and to disassemble it graphically, in order to understand the functioning of each part and the relationships that each part has with the whole. Each element is represented with the same logical and figurative clarity with which, in modern times, the formally completed architectural components or even the mechanical parts are represented. Yet there is more, the complex drawing we in discussion seems to have been created to restore the same architectural complexity of the work, through the very special inventory of all its elements and spaces; an inventory able to renew the wonder that the work raises in reality for the "vertigo of the list" [5] produced by the enumeration of all its constituents (distributive, constructive etc.).

At the end of the century, to dispel rumors of a possible collapse of the dome, Pope Innocent XI commissioned a new survey to Carlo Fontana. A work that therefore arises with the aim of clarifying the "sinister and various voices" that circulate in the city and above all verify the stability of the dome, but which ends with the architectural exaltation of the building and with broad and generic reassurances on the 'steadiness' [Fontana 1694, p. 20] of the same dome. The work of Fontana is therefore transformed into a new documentation on the Vatican buildings to make their singular peculiarities known to all [6].

In reality, Fontana does not fail to point out the damage he finds. Furthermore, in his book of surveys he also writes of a lesion along a rib of the dome, but which is due to minor causes (settling, collection of materials etc.); a lesion that does not appear in the drawings because all the parts of the building are without any doubt solid [7].

In the archive documents there is no trace of the report that Fontana prepared for the Pope, but in his book and in a letter from 1695, he writes of the iron chains existing in the

Fig. 2. Dome 3D model according to Martino Ferrabosco's plan; all the elements of the ingenious Vatican "machine" can be seen (graphic elaboration by Antonio A. Zappani).



construction and of the proposal for three new chains (fig. 3) to improve the resistance of the tambour and the dome [8]. In general, Fontana's renderings are rich in information and each drawing presents attention to architectural forms and a good number of measurements: there is also reference to the graphic scale in Roman palms.

Differing from the previous plan, Fontana does not launch challenges to "the intelligent professor", but seeks with different drawings to describe even the parts which are formally difficult to represent. The theme of the dome, for example, as well as with plants, sections, elevations and details [9] is rendered with five partial plans (1/4 dome), sectioned at different parts (fig. 4); plants which contain the same information and the same elements present in Ferrabosco's drawing, but separated into more drawings and therefore easier to examine.

In the surveys, each component is delineated with clarity and highlighted with shadows or shadow effects. The parts sectioned are dotted both in plan and in section although often to balance the graphic tone of the drawings, the sections are left blank.

Beyond the banal professional rivalries, it is possibly worthy of highlighting the different nature of the surveying operations conducted by the two authors. Ferrabosco does not appear to worry to much about the difficult drafting of his graphics, nor does he worry about the judgement of who will consult them. His aim is to find a way to render—even with the invention of new figurative tools—both the articulation of forms and spaces as well as the catalogue of elements which make the ingenious Vatican machine work. Instead, Fontana's intention seems to be that of presenting everyone with all the beauty of the buildings now complete; the new basilica of Saint Peter appears to him as a perfect example of project method and of architectural knowledge and it is above all this type of information that the author appears to want to remember and share.

Survey of the constructive system of the dome

In the surveys seen so far, no alarming instabilities were reported and nor were any urgent restoration interventions indicated. However, the concern continues so much that, some decades after Fontana's publication, Pope Benedict XIV will assign other Commissions [10] to verify the integrity of the dome, such as the commission for-

med by mathematicians Tommaso Le Seur, Francesco Jacquier and Ruggiero G. Boscovich [11]. The explicit task of the three mathematicians is that of removing any doubt on damage present, studying the causes and proposing necessary remedies [12].

The work of this Commission is notable and includes both the detailed survey of the cracking pattern as well

Fig. 3. Carlo Fontana, *Settione della cuppola vaticana con tamburo piloni e lanterna*, 1694; hypothesis of the positioning of the iron chains.

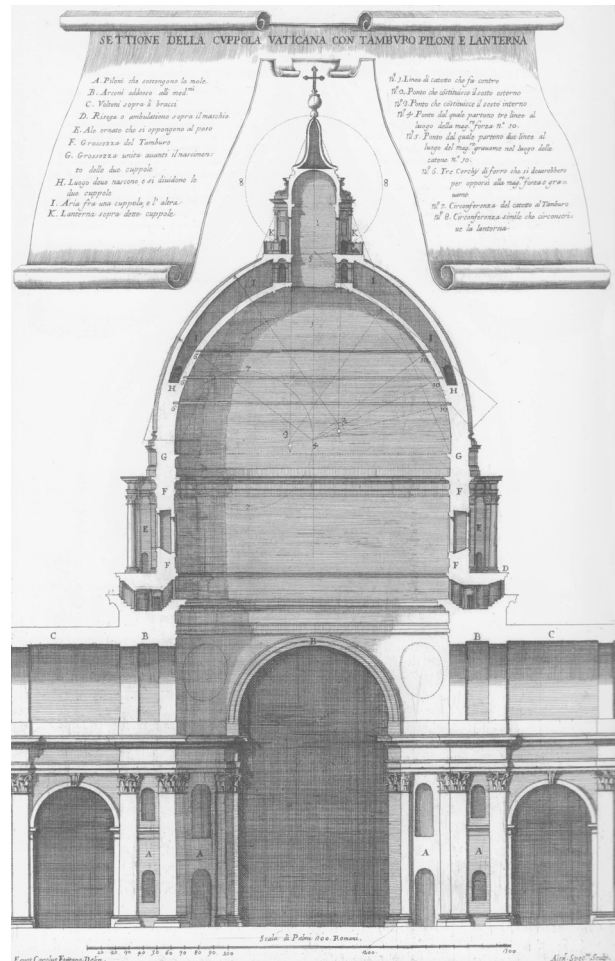
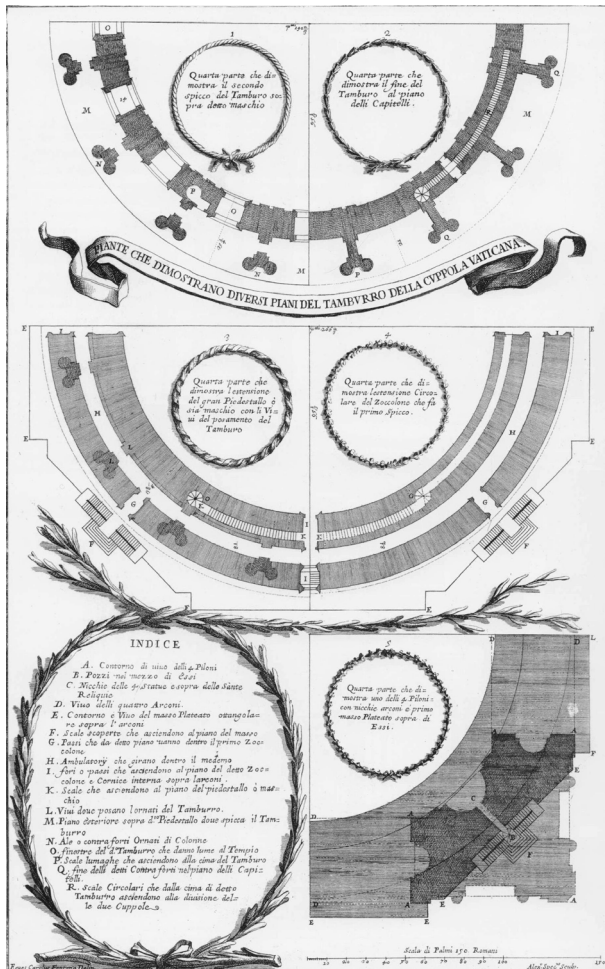


Fig. 4. The theme of the cupola is also rendered with five partial plans, extended to 1/4 of the dome, sectioned in different parts [Carlo Fontana 1694].



as the characteristics of resistance and the mechanism of the breaking of the used construction materials.

The method which the mathematicians say they will use includes direct observations and an updated theory on the mechanics of structures capable of recognising the causes producing instability of the work from the effects [13]. In their study, they list thirty-two critical points and warn, moreover, that the base of the tambour is damaged, the walls of the buttresses are all damaged, there are vertical lesions between the ribs and the calottes, horizontal detachments between the bricks, broken architraves of the windows, unstable spiral staircases to enter the tambour etc. In their report to the Pope, they also provide a possible dating of the main damage, which they clearly consider to be caused by structural defects and not from the settlement of materials.

The report is detailed and the indications for restoration foresee remedies in all the critical situations; remedies which, in line with the knowledge of the period, consist of the placement of six new iron chains, in the enlarging or the remaking of the ribs, in the creation of a 'buttress' and of a statue for each of the existing sixteen buttresses [14].

All the planned interventions –the mathematicians write– have an irrelevant weight, which is worth 1/60 of the existing one. What the mathematicians do not write of are the operational difficulties and the cost of the proposed remedies. Moreover, the mathematicians minimize the effects of such an intervention, which radically transforms the work of Michelangelo and Giacomo Della Porta.

The observations made and surveys conducted in this phase obviously regard only the part involved and are dedicated to defining the cracking pattern and the erroneous leaning of the tambour-dome-lantern system: they describe the form of the elements, the organization of the masses involved and the state of the lesions.

From the surveys, mathematicians also deduce a schematic model (consisting of four graphic drawings) on the static behaviour of the work. A model which is inserted in the survey drawing (fig. 5) of 1742 attached to the report and which allow the same mathematicians to analyze the stress patterns under its own weight, to predict the collapse mechanisms of the resisting elements and to define the works for restoration of the work. According to these graphic schemes, the separation of the tambour and the dome into sectors –produced by vertical lesions– provokes a rotation towards the outside of parts of the tambour with consequent lowering of the portions above the dome and

the lantern towards the inside. With “such kinematics – writes Mario Como– the scholars also carry out an evaluation of the thrust of the dome segment” [15].

On the basis of their schemes, the mathematicians hypothesise the ‘imminent’ collapse of the entire resisting system, but as recalled also propose restoral solutions shown in the report and summarised with the detail of an iron chain inserted in the schemes.

The conclusions cause strong disagreement and discussions so that the same mathematicians, in 1743 published a second report [Le Seur, Jacquier, Boscovich 1743] in order to better explain the content of the first both in terms of the language used to analyze the damage and in terms of the solutions proposed.

The reactions provoked by the relation of the mathematicians convince Pope Benedict XIV to further deepen the problem inviting new experts, including Giovanni Poleni [16] who from the beginning has the merit and authority to attenuate any controversy, to use the experience of Luigi Vanvitelli and to promote a favourable study climate in order to know about the actual situation of danger.

Poleni criticises the conclusions of the preceding Commission for the absence of “circular fractures along the intrados of the internal calotte” [Como 2015, p. 400] and, making the vertical lesions of the dome derive from subsidence localized in the tambour, does not hold the collapse of the work to be imminent.

In his 1748 *Memorie istoriche* [17], Poleni gives a detailed report both of the opinions of scholars who had intervened on the problem and of the results of his analysis “which had developed applying Robert Hooke’s 1675 theory of the stability of arches” [Como 2015, p. 402].

His inspections, substantially, confirm the cracking pattern detected previously, but exclude subsidence in the pylons [18].

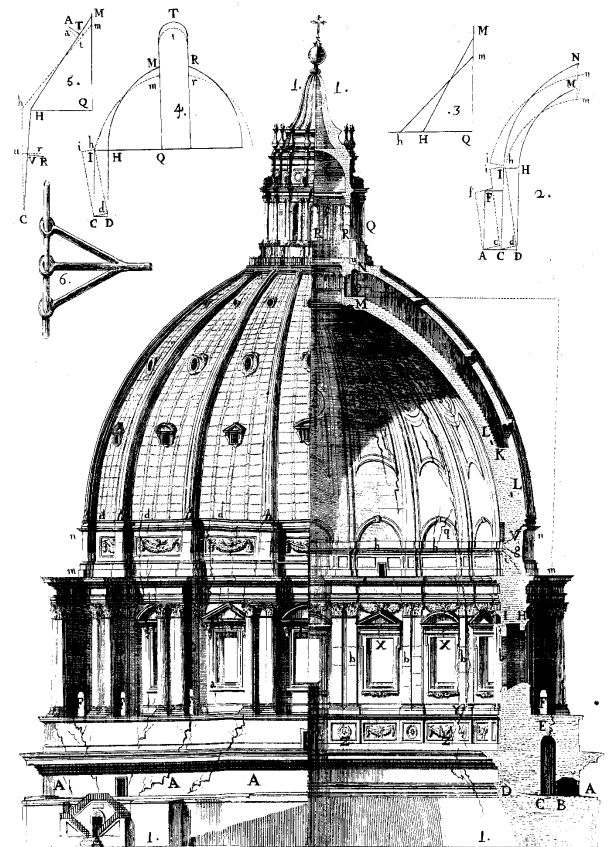
For the intervention to secure the dome, Poleni proposes the insertion of five new iron chains which will be implemented between August 1743 and September 1744. During the works, Vanvitelli reports that one of the old chains is broken and assumes that the second one is too. Poleni suggests repairing the broken one and adding a new rim “in compensation” [Poleni 1748, p. 438] of the one presumed to be broken.

For the different inspections [19], Luigi Vanvitelli slowly predisposed the drawings relative to the part to be examined on which all the lesions and necessary conditions are annotated. They are drawings which are “delineated

with perfect correspondence to the works” [Poleni 1748, p. 136] and which make it possible to have an exhaustive framework on each individual part and on the whole.

Vanvitelli works on the problem of the dome since the first Commission with the task of verifying and he has the occasion to execute a series of broad surveys, particularly calibrated on the theme and on the constructive problems of the work. They are surveys in which the decorative part is simplified, and the lesions are delineated in red

Fig. 5. Lesions on the dome and graphic schemes on its static behaviour [Le Seur, Jacquier, Boscovich 1742].



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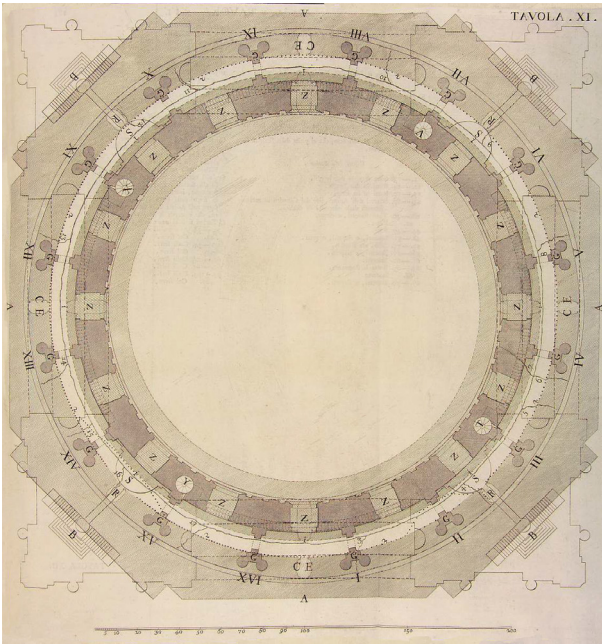
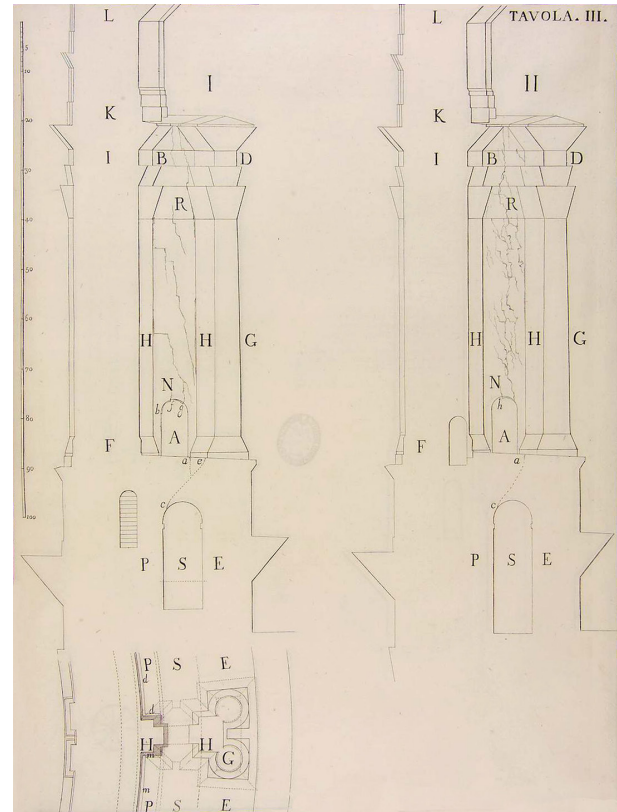


Fig. 6. Luigi Vanvitelli, *Pianta della cupola*, 1743-1748; the graphic complexity is necessary to show the relation between all the elements.

Fig. 7. Luigi Vanvitelli, lesions of the dome buttresses with the simplified decorative party, 1743-1748.

[20] (highlighting their position and progress in each part and in each single rib). The surveys also indicate erroneous leaning, etc. Poleni, in his book, praises the clarity of the drawings as they give simplicity to the elements, when “the appearance of the ornaments” is not needed [Poleni 1748, p. 140]. The “annotations placed in comparison with the drawings” [Poleni 1748, p. 140], necessary to evaluate the effective seriousness of the cracking pattern (with measurements of the lesions), in the reduced scale of the drawings, of approximately 1:200, complete the work.

Among the surveys, that of the *Plan of the dome* (drawing XI), sectioned at the start of the internal calotte, appears interesting. In this, it is possible to see: part of the calotte, the sixteen ribs (four with the spiral staircase), the twinned columns of the tambour; the windows that give light to the church, the annular corridor at the base of the tambour; the connecting octagon between the church and the tambour with the entrance steps and the contours of the four pylons that support the entire system. Furthermore, the main lesions (17 lesions) delineated with different graphic symbols, can be seen. In this type of rendering, the author



does not usually insert measurements (they appear in the annotations), but only the reference of the graphic scale in Roman palms (figs. 6a, 6b).

The plant is graphically accurate and as in the previous one by Ferrabosco, albeit with different figurative modalities, also in this one does the idea of a complex representation return, which is necessary to evaluate all the elements together; to show their dimensions and mutual relations; relationships that emerge for direct comparison between the parties (they reveal their 'complicit' role) and promote attention consistent with the architectural situation in question. The figurative complexity, as an analytical and operative requirement combined, is useful to adapt to the articulation of the work and –in the example of these notes– to give certainty on the static behavior and the safety of the constructive system considered.

Conclusions

The surveys seen so far present a discreet repertoire of graphic models and of figurative modalities that progressively adapt to reality in order to examine it and to get to know it in depth. Graphic models that at the same time make clear how the descriptive versatility of the renderings is the answer to different solicitations of study and how

the production of images for the knowledge of architecture develops for the simultaneous action of doing and all those factors of executive stimulus that derive from the means chosen to operate (scales, representation techniques etc.). In this sense, not only the probable renderings, but all the drawings –whether they are sets, wholes or schemes– become necessary in order to trigger a research process and to build conditions of coherence and analytical effectiveness.

The figurative complexity referred to above, therefore, is not a rule to represent, but as a necessary product (in a phase of study) to have drawings pertinent to the architectural problem to be investigated. Furthermore, even today, despite the evolution of tools and methods, this seems to be the prevalent attitude of surveys: not so much a way to replicate the appearance of an architecture in the laboratory, but an opportunity to analyze it through a succession of figurative reformulations. Capable of intentionally synthesizing the forms and spaces of architecture, making its decisive features emerge; or, on the contrary, figurative reformulations able to aggregate all the elements that contribute to define the articulation of the same theme of study. That is to say, an occasion to experiment on shapes and spaces and to realize the presuppositions, impossible otherwise, to see and fully understand the architecture or the parts that we intend to consider.

Notes

[1] M. Ferrabosco, *Libro De L'architettura Di San Pietro nel Vaticano*. Roma 1620, published again in 1684. The book presents 11 single and 23 double drawings. In the views of the volume we also find parts which have not yet been built such as the façade and the colonade etc.

[2] The ball which will go above the lantern is already under construction in 1592; the lead cover of the dome was finished in 1594; Carlo Maderno in 1608 transforms the Greek cross plan into Latin and in 1622 the façade will be finished; in 1614 the vault of the central nave was completed and in 1626 Urban VIII will consecrate the new basilica.

[3] The phrase is in a legend plant, "*La descrizione della Pianta non si nota per essersi fatta distinta dalla passata, e qualche differenza [...] l'intelligente professore la troverà facilmente*" [Ferrabosco 1620].

[4] In a 2010 study, in order to explain the complexity of the drawings, further explanations are offered, such as the articulation of the building, the theme of the fragment etc. see: Martínez Mindeguía 2010, pp. 46-57.

[5] The literature and the art are rich in similar lists "laid out for the same taste of the enumeration, for the cantability of the list" [Eco 2009, second cover].

[6] Fontana writes of publishing the surveys "*accìche più al vero, e con proprii termini siano le loro singolari qualità mandate alla luce, e possono essere manifeste non solo a' Popoli [...], ma anche a' Posterì*" Fontana 1694, p. 21.

[7] Fontana writes that the parts are solid "*da non potersi mai dubitare della loro permanenza e stabilità*": Fontana 1694, p. 185. The volume, published in Italian and Latin, becomes a sort of official certification of the architectural and construction quality of the new basilica of Saint Peter. It consists of seven books and 79 engravings.

[8] For the content of the 1695 letter see: H. Hager, *Del Tolo, o Cupola doppia che cuopre il Tempio Vaticano* in Fontana 1694, p. CLX. Furthermore, in his book, the author writes of "*Tre cerchij di ferro che si dovrebbero per opporsi alla maggiore forza e gravame*" [Fontana 1694, p. 226.]

[9] On the theme of the dome, we find: five sections of sets and two of detail; four plans of sets and six details; four elevation sets.

[10] In 1742 that guided by Abbot Saverio Brunetti in which also Luigi Vanvitelli participated.

[11] Le Seur and Jacquier to the Order of Minims of Saint Francis of Paola, Boscovich is of the Order of the Jesuits; all three are followers of the new scientific knowledge promoted by Isaac Newton.

[12] The task is that of studying "danni presenti che si osservano nella cupola [...], e molto più per la sua restaurazione" [Le Seur et al. 1742, p. III].

[13] The three mathematicians write to avail themselves of both "proprie oculari osservazioni, e sperienze, che di una buona teoria fondata sulla Meccanica per conoscere dagli effetti la causa del male" [Le Seur et al. 1742, p. III].

[14] For the mathematicians, the ribs threaten "imminente rovina. Vanno essi perciò rifatti". And against the danger that the stress breaks the attic floor; they write that they want to "alzare sopra il cornicione de' contraforti in m uno sperone ben centinato, che andasse a ripigliare la Cupola più alto in n. Potrebbe il medesimo cominciarci con un zoccolo, che sostenesse una Statua, e servisse insieme di peso, ed ornamento" [Le Seur et al. 1742, p. XXXIV].

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[15] For a discussion on the structure of the Vatican dome see the excellent essay: Como 2015, pp. 311-438. On the same topic see: Bussi, Carusi 2009.

[16] Giovanni Poleni (1683-1761) at the age of twenty-six he is professor at the University of Padova and member of the Royal Society of Londra. In 1743 he enters the debate on the dome provoked by the mathematicians writing *Riflessioni di Giovanni Poleni, sopra i Danni...* and on March 30th of the same year receives an invitation from the Pope to verify the state of the work.

[17] Poleni 1748. The volume consists of five books; the images are those of Luigi Vanvitelli, redrawn for the occasion. Before this publication, Giovanni Poleni writes *Riflessioni di Giovanni Poleni, sopra i Danni... (1743), Lo stato de' difetti da considerarsi... (1743) and an Aggiunta alle Riflessioni... (1743)*.

[18] In his book, we can read that: "ombra non vi era di patimento ne' Fondamenti, o di danno ne' Piloni" [Poleni 1748, p. 136].

[19] Poleni and Vanvitelli conduct 17 highly accurate inspections and create "appoggi [...] ponti e simili apparecchi" [Poleni 1748, p. 135].

[20] In his *Memorie storiche*, Poleni signals that the drawings in the publication are copied from those presented to the Pope, but "ne' nostri si sono tralasciati gli ombramenti, acciocchè in campi più chiari meglio potessero comparir li segni delle Fessure [underlined in red in the originals]" [Poleni 1748, p. 139].

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