Construction Knowledge in Comparison: Architects, Mathematicians and Natural Philosophers Discuss the Damage to St. Peter's Dome in 1743

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When the structural damage to the dome of St. Peter's in Rome was perceived as critical in 1741, nothing less than a major symbol of the Catholic Church came to the focus of attention. Eventually a rather unspectacular, yet effective, solution to the damage was implemented between 1743 and 1747. The solution consisted in wrapping iron straps around the body of the dome. It was proposed by Giovanni Poleni (1683-1761), a mathematician from Padua University, and the work was carried out under the direction of the architect Luigi Vanvitelli (1700-73). Far more interesting was the preceding and at times even ferocious dispute (1742-43) involving architects, mathematicians and natural scientists about what had really caused the damage. Their arguments are documented in a long series of printed and manuscript experts' reports (Table1), which have been studied as part of the general history of St. Peter's cupola (cf. Di Stefano 1963 and 1980, Mainstone 1999). The reports by the mathematicians have been extensively analysed for their significant role in the development of modern construction science (cf. Benvenuto 1981, Heyman 1988, Guerra 1991, Di Pasquale 1994, Pescinellesi-Rapallini 1995, Di Pasquale 1996, Como 1997). Other studies have looked at the collaboration between the mathematician Poleni and the architect Vanvitelli (Brusatin 1971, Cavallari-Murat 1973). On the other hand, reports by building professionals (architects, master builders) and by philosophers have rarely been studied. Apart from this series of known expertises, we have five further, hitherto unpublished manuscript reports in the *Biblioteca Apostolica Vaticana* (Cicognara V 3849, Table1). Authors include an architect and several mathematicians. Another richly illustrated manuscript showing the damage to the cupola is found in the *Gabinetto Nazionale per la Grafica* in Rome.

This paper proposes yet another approach to the subject, and aims to read this material as a unique cross-section through competing "inventories" of construction knowledge. What methods, arguments and tools were used by the different professionals? Topics for reflection are, for example: to what extent had the experimental approach of mathematicians and natural philosophers in the tradition of Galileo Galilei (1564-1642), and their interest in everyday building techniques, led to an alternative building expertise? And to what degree were construction principles, handed down from mediaeval and Renaissance times, still a reference point in the eighteenth century? How helpful was general practical experience in dealing with a huge and unique cupola like that of St. Peter's? (Fig.1). And how did the different bodies of knowledge interact? For reasons of space, the present study does not cover all available expert reports on the cupola of St. Peter's and has to

remain indicative. The discussion of the entire source material would provide the subject for a longer essay.

Table 1. Expert reports concerning the damages of the dome of St. Peter's 1680-1767.
Listed are the written reports available today

	DATE	NAME, PLACE	APPOINTMENTS, FIELDS OF EXPERTISE	TITLE AND BIBLIOGRAPHICAL INFORMATION
1	**1680**	**Giuseppe Paglia**, Rome	architect	manuscript; AFSP (1° P., Arm. III, n. 3, fasc. 6).
2	**1694**	**Carlo Fontana**, Rome	architect of the Reverenda Fabbrica di San Pietro	printed: *Templum Vaticanum et ipsius orig : cum aedificiis maxime conspicuis antiquitus, & recens ibidem constitutis; … .* Rome: Francisi Buagni 1694.
3	**1695**	**Paolo Falconieri** , Florence	mathematician, architect	manuscript: *Discorso sopra la cupola di S. Pietro, fatto a requisizione dell'illustrissimo signor Paolo Falconieri in agosto 1695.* BNCR (Ms. 787).
4	**1742**	**Tommaso Leseur, Francesco Jacquier, Ruggiero Giuseppe Boscovich**, all Rome	mathematicians, Leseur and Jacquier at the Ordine dei Minimi, Boscovich as prof. at the Collegio Romano	printed: *Parere di tre mattematici sopra i danni, che si trovano nella cupola di S. Pietro ...,* Rome 1742.
5	**1743**	**Anonymous**, probably the gesuit **Favré**, Rome	philosopher	printed: *Sentimenti di un filosofo Sopra le Cause, e Rimedi de' danni della Cupola di San Pietro E sopra il Parere dato su tale Argomento da' tre Matematici al fine del 1742.* Rome 1743.
6	**1743**, 22 January	**Giovanni Gaetano Bottari**, Rome	librarian of the Vatican Library; curator of the Corsini Library, antiquarian	manuscript: *Parere d.o in voce nel congresso antecendente da Gio. Bottari,* BAV (Cicognara V 3849).
7	**1743**, 16 February	**Giovanni Amico**, Trapani	architect	manuscript: *Brieve Relazione Del autore del Modello,* BAV (Cicognara V 3849).
8	**1743**	**Lelio Cosatti**, Rome	architect	printed: *Riflessioni ... sopra il sistema dei tre rr.pp. mattematici e suo parere circa il patimento, e risarcimento della gran cupola di S. Pietro,* Rome: Bernabò & Lazzarini, 1743.
9	**1743**, 2 March and 24 April	**Gabriello Manfredi**, Bologna	mathematician, prof. at Bologna University	manuscript letters, BAV (Cicognara V 3849).
10	**1743** 21 March	**Giovanni Poleni**, Padua	mathematician, prof. at Padua University	manuscript: *Riflessioni sopra i danni e la ristaurazione della cupola del tempio di San Pietro in Roma.* BM (5519, cod. DCLVIII).
11	**1743**	**Anonymous**	mathematician	manuscript: *Sentimento di uno matematico scritto currenti calamo sopra il parere di tre matematici romani* BAV (Cicognara V 3849).

	DATE	NAME, PLACE	APPOINTMENTS, FIELDS OF EXPERTISE	TITLE AND BIBLIOGRAPHICAL INFORMATION
12	1743	**P. Abate Raviglia, Domenico Sante Santini**, both Rome	Santini is *dilettante* in mathematics at the Maddalena	printed: *Risoluzione del Dubbio proposto dal Padre AbateRaviglia e parere intorno alli contraforti, ed altri danni della Cupola Vaticana del P. Domenico Sante Santini De Ministri degl'Infermi, Dilettante di Matematica alla Maddalena*, Rome: Rosati, 1743.
13	1743	**Anonymous**	--	printed: *Lettera del Signor N.N. al Signor N.N. sopra il parere del P. Domenico Sante Santini intorno i danni della cupola di S. Pietro.* Rome 1743.
14	1743	**Tommaso Leseur, Francesco Jacquier, Ruggiero Giuseppe Boscovich**, all Rome	mathematicians, Leseur and Jacquier at the Ordine dei Minimi, Boscovich as prof. at the Collegio Romano	printed: *Riflessioni de padri Tommaso Le Seur, Francesco Jacquier dell'Ordine de' Minimi, e Ruggiero Giuseppe Boscovich della Compagnia di Gesù, sopra alcune difficoltà spettanti i danni, e risarcimenti della Cupola di S. Pietro...*, Rome 1743.
15	1743	**Lelio Cosatti**, Rome	architect	printed: *Aggiunte ...* Rome: Bernabò & Lazzarini, 1743.
16	1743, 21 May	Capomastro Muratore (probably **Nicola Giobbe** or **Giuseppe Sardi**), Rome	master builder at the Reverenda Fabbrica di San Pietro	printed: *Breve discorso sopra la Cupola di San Pietro di N.N. capomastro Muratore*, later printed as: *Breve discorso in difesa della Cupola di S. Pietro di N.N., capomastro muratore, regolato circa i danni secondo la prima scrittura de' rr. pp. mattematici l'anno 1744.* Rome 1744.
17	1743, 10 June	**Giovanni Poleni**, Padua	mathematician, prof. at Padua University	manuscript: *Aggiunte alle riflessioni sopra i danni e sopra la ristaurazione del tempio di San Pietro in Roma.* BM (5520, cod. DCXLIX).
18	1743, 14 June	**Luigi Vanvitelli** et al., Rome	architect and mathematician, architect of the Reverenda Fabbrica di San Pietro	manuscript: *Osservazioni sui danni della cupola di S. Pietro*, 1743. GNS (F.C. 128989-128994, vol. 158 H 14); the manuscript was handed over to the pope on 14 June 1743.
19	1744	**Giovanni Rizzetti**, Castelfranco Veneto	natural philosopher, (amateur) architect	printed: *Elementi di architettura per erigerla in scienza, con un discorso sopra la cupola di S. Pietro in Roma.* Venice 1744.
20	1748	**Giovanni Poleni**, Padua	mathematician, prof. at Padua University	printed: *Memorie istoriche della gran cupola del Tempio Vaticano e de'danni di essa, e de'ristoramenti loro, divise in libri cinque.* Padua 1748.
21	1767	**Gaetano Chiaveri**, Rome, Dresden	architect of the King of Poland and Prince Elector of Saxony	printed: *Breve discorso di Gaetano Chiaveri circa i danni riconosciuti nella portentosa Cupola di San Pietro di Roma, e le sue principali cause, con la maniera durabile, e più sicura per la reparazione.* Pesaro 1767.

Figure 1. Dome of St. Peter's (foto H. Schlimme)

THREE MATHEMATICIANS 1742

The whole 1742-43 debate about the cupola of St. Peter's had its pivotal point in the report of three mathematicians: Tommaso Leseur (1703-70), Francesco Jacquier (1711-88) of the Ordine dei Minimi and Ruggiero Giuseppe Boscovich (1711-87) from the Collegio Romano. Pope Benedict XIV gave them the commission after a series of verbal reports and two on-site-visits with architects and building experts to the cupola in September and October 1742, in presence of the architects Ferdinando Fuga (1699-1782), Luigi Vanvitelli and Nicola Salvi (1697-1751). Benedict decided not to rely entirely on building experts, probably because he was well aware of the developments taking place in science. Benedict had studied canonical and civil law and, since 1725, cared for the "Istituto di Scienze". He continued the promotion of modern physics, chemistry and medicine after his election to the Holy See in 1740.

The three mathematicians' specific goal was to provide a theoretical explanation for the dome's crack-and-damage pattern, and then to work out a solution (Fig.2). In their introduction, Leseur, Jacquier and Boscovich defended their position against anyone who would "prefer practical knowledge, or might even say that theory was harmful" (1742, p.4). They argued that someone with

4

a practical knowledge would not have had enough experience to deal with St.Peter's dome, which is not only enormous, but also unique, so there was no group of similar cupolas to refer to (1742, p.4). Mathematicians, who also knew the principles of mechanics, were therefore deemed essential. These remarks were probably addressed to the building experts among their readers. First of all, the mathematicians describe the cupola and its exact dimensions. They identify no less than thirty different types of cracks, indicating their orientation and width (Leseur-Jacquier-Boscovich 1742, pp.6-9). Then they quote every previous report on the cupola which describes the damage, expressing some doubts about their credibility. The mathematicians then suggest a pattern of movements within the cupola which would explain the whole crack system: the lantern presses on the cupola shell, which is cracked in vertical segments and therefore moves outwards, pushing on the drum. By doing so, the buttresses on the outside of the drum are sheared off. The three mathematicians at this point specifically quote Philippe de La Hire (1640-1718) (La Hire 1712, 1730) and his approach to the statics regarding the collapse of vaults and domes that follow specific patterns of movement.
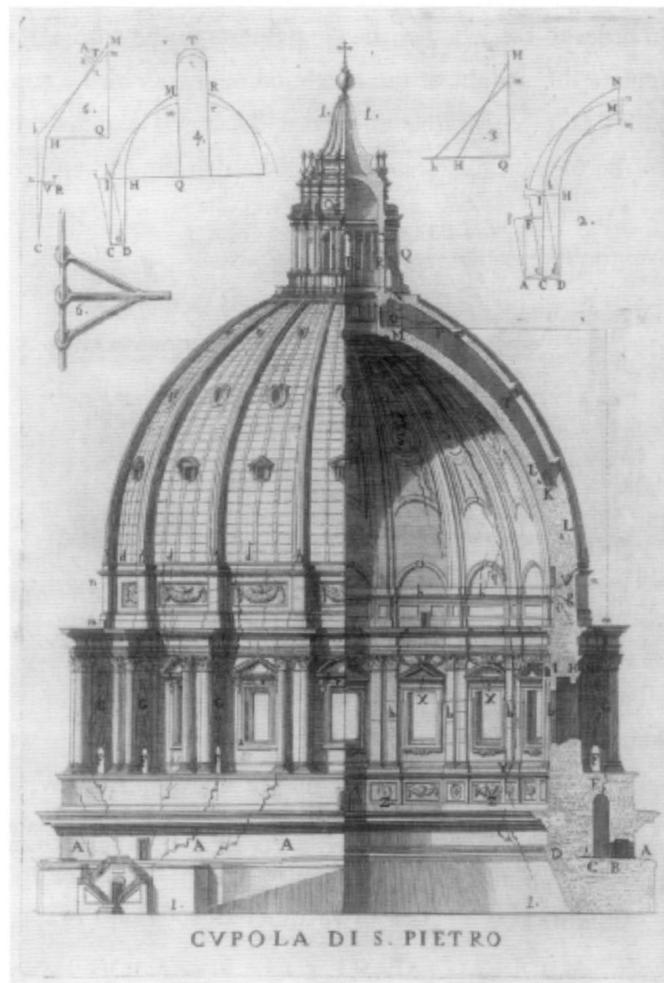

Figure 2. Leseur, Jacquier and Boscovich, damages of the dome of St. Peter's and pattern of movements (Leseur-Jacquier-Boscovich 1742)

La Hire analysed cupolas and vaults as if they were built without using mortar, composed of sliding elements (bricks). Leseur, Jacquier and Boscovich criticize this approach, stating that, imagined like this, a vault would produce much more thrust on the imposts than happens in reality. Actually, they said, the mortar was often so strong that the bricks are cracked instead (1742, p.23). However, the mathematicians recommended that the architects should proportionately rely as little as possible on the strength of the mortar the larger a building is. The resistance of a cupola is related to the surface of the cracks it develops, while the counterpart of the resistance, the weight of the cupola, is related to the volume of the cupola body (Leseur-Jacquier-Boscovich 1742, p.24). We may illustrate the explanation of the mathematicians with two different-sized cupolas. If these two cupolas have the same proportions, but one has a diameter twice as big as the other, the resistance of the larger dome would be four times greater than that of the smaller one, but it would weigh eight times more. It would therefore have a relatively lower resistance. The discourse of Leseur, Jacquier and Boscovich follows Galilei's rule (1638), exemplified with the bones of a giant that, in comparison to a normal-sized person, had to be more than proportionally increased in size. Though the importance of this discovery for buildings was soon recognized (cf. Di Pasquale 2005), it had not yet been commonly accepted (see below). In order to see whether the single parts of the whole dome are in equilibrium, the mathematicians calculate the weight of the single components of the cupola and the moments. The mathematicians call this moment the energy with which a determined force acts in the particular circumstances. To explain this concept, well-known in mid-eighteenth century, the three mathematicians use the example of the steelyard, with which it is possible, depending on the position of the counterweight, to balance different loads (Leseur-Jacquier-Boscovich 1742, p.26).

Without countermeasures the movements of the whole cupola would – as predicted by the calculations of Leseur, Jacquier and Boscovich – continue until a future collapse, which could however be prevented. The best solution would be, in their opinion, to put chains around the drum, while filling up the cracks in the building fabric would be of little use. Replacing the lead roof with a copper one would be enormously expensive and would do little to reduce the weight. This demonstrates that the mathematicians were concerned with financial aspects of the work as well. They were also more interested in aesthetics than one might expect mathematicians to be. For example, they rejected a proposal made by several architects (see below Giovanni Amico, Fig.3) to continue vertically the four pillars that carry the cupola, turning them into huge buttresses running up to the drum area. Their reason was not only because it would add more weight but also because it would ruin the cupola's aesthetics, in particular its grace (*vaghezza*). When the mathematicians actually proposed to extend the existing buttresses around the drum, surmounting them with pedestals, they only did so because this option was "allowed" in a drawing by Michelangelo, which the mathematicians cite explicitly (Fig.4) (Leseur-Jacquier-Boscovich 1742, p.31).

The mathematicians' report was sent on 12 January 1743 to several mathematicians in Padua (Di Stefano 1980, p.16), Bologna (cf. BAV, Cicognara V 3849, letter of Manfredi, 19 January 1743) and probably also to Naples (at least a report arrived from there, cf. Di Stefano 1980, pp.17-18).

The mathematicians reacted in very different ways. Leseur, Jacquier and Boscovich estimated that the base of the cupola had widened about two palms (*palmi romani,* about 440mm). Both Isaac Newton (1642-1727) and Philippe de La Hire described how iron can lengthen as a result of heat and fire, and classified the respective percentages. But neither heat nor fire could have lengthened the two iron straps that were built into the cupola shell from its very beginning, by as much as two *palmi.* Leseur, Jacquier and Boscovich therefore assumed that iron could also lengthen under a long-term tension load as well (1742, p.21) (the phenomenon known today as creep). Their assumption was promptly criticised in the "opinion of a mathematician" (BAV, Cicognara V 3849). The "mathematician" could actually have been any one of three persons: the mathematician and economist Bartolomeo Intieri (1676-1757), the physicist D. Giuseppe Orlandi or the astronomer Pietro di Martino, all from Naples University. Gabriello Manfredi (Bologna University) on the other hand, refused to comment on the conclusions of Leseur, Jacquier and Boscovich because he felt inadequately informed about the damage. Giovanni Poleni (Padua University) soon got deeply involved in the question and developed an alternative approach to the problem and its solution. This attitude may have been strategic in order to get the commission (and in fact this happened); however, Poleni is not the focus of attention in the present paper.
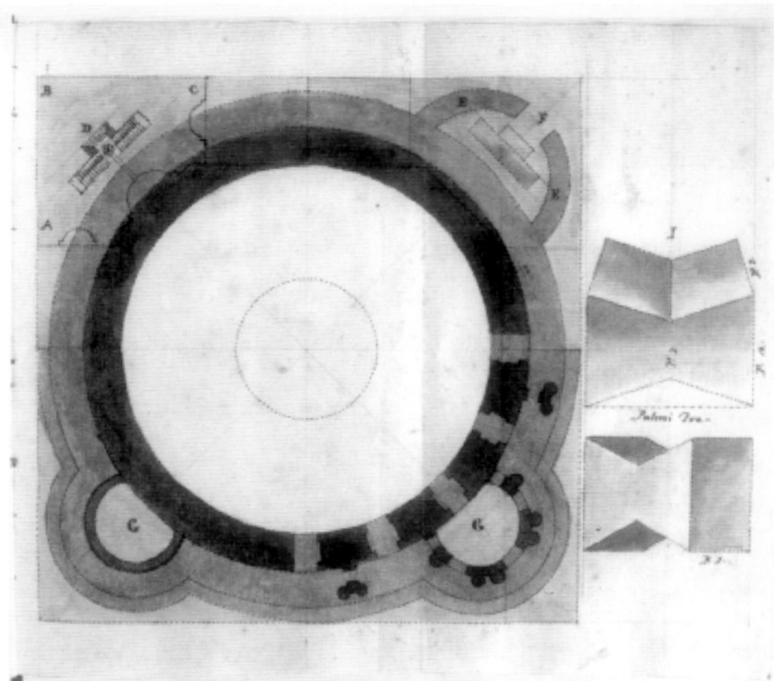

Figure 3. Giovanni Amico, dome of St. Peter's, buttresses to be erected at drum level and stones in form of a double dovetail for repairing purposes, BAV, Cicognara V 3849, unpublished, reproduced with kind permission

CRITIQUE FROM A "SCHOLASTICALLY TRAINED PERSON"

The printed report written by an anonymous author reveals yet another enlightening viewpoint on the cupola problem. The author describes himself as a *Filosofo,* stating that he is a "scholastically

trained person". His knowledge proves to be wide-ranging, with the quality of a handbook, and he uses it fully to broach the issue. He entirely rebutts the conclusions of the mathematicians and is convinced that the damage to St.Peter's cupola has been caused just by intense extremes of heat and cold, humidity and dryness. In the course of a century and a half, these elements would inevitably have a much stronger effect on a huge, tall building like St.Peter's than on smaller ones (Filosofo 1743, p.61). The anonymous author then proceeds to give many examples of how shrinking and expanding affects materials. He quotes a wide range of authors, including also Newton and Pieter (Petrus) van Musschenbroek (1692-1761). His conclusion is that no-one could doubt that the cupola of St. Peter's expands with humidity too. He sees the cupola as part of a more general world view, rather than as construction in its own right. Significantly, the *Filosofo* does neither conduct nor even propose a survey of the cracks in hot, dry summertime and then compare the results with a crack survey conducted in cold, damp wintertime.
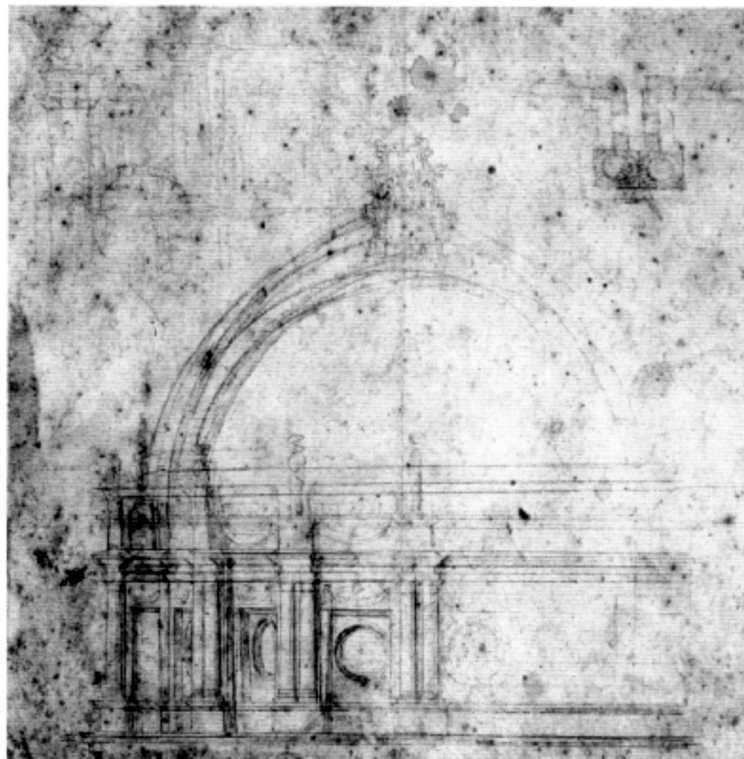

Figure 4. Michelangelo, project for the dome of St. Peter's, Lille, Musée de l'Art
et d'Histoire, inv. 93-94, chalk 259-257 mm, reproduced with kind permission

Analogies play an important role in the thinking of our *Filosofo*. Since mortar hardens due to the presence of water, humidity should also be good for aged mortar. And since the vault above the apse in S. Ignazio has a crack that is one *oncia* (1.4 cm) wide, the St. Peter's cupola could tolerate cracks of 24 *oncie* without risking collapse, because it is 24 times larger. The *Filosofo* believes that the same relation in terms of proportion between crack width and vault span should also be true in terms of relative dimensions (i.e. size is unimportant). The cupola's dimensions do not, in his eyes,

make it a "special case". As to the iron chains, the *Filosofo* quotes the "Sperimenti Fiorentini", a series of experiments conducted by the Florentine Accademia del Cimento, and published in 1666 by Lorenzo Magalotti (1637-1712), as well as Musschenbroek's experiments. He then states that, due to iron's great cohesiveness, it would stand up better to expansion than cement or mortar would (Filosofo 1743, p.75). This is a clear example of how the *Filosofo* thinks in terms of animated objects, where the principal characteristic of a material is valid for all other types of properties as well. The *Filosofo* in continuation switches between what he calls *filosofia antica* and *filosofia moderna* (the latter intended as philosophy following Galilei). Trying to learn from both, he however rather tends to apply the former. He clearly favours the experience of architects and professionals involved in the construction of buildings over the theory-based position of the mathematicians. Behind the anonymous *Filosofo* probably hides the Jesuit Favré. In the copy of the *Filosofo's* expertise from the Vatican Library, the name "Favré" is given in a manuscript comment. The author's identity also becomes clear in a letter from Domenico Sante Santini, dated 10 April 1743 (BAV, Cicognara V 3849). Maybe Favré preferred to remain anonymous out of respect for Ruggiero Giuseppe Boscovich who was Jesuit too. However, these questions and especially the second part of the *Filosofo's* text, where he comments directly on the report of the three mathematicians, must remain as the subject for a further essay.

ARCHITECTS

It might seem obvious that architects and building experts would want to counterattack the mathematicians in order to defend their own reputations and expertise. But in fact, they took very different attitudes towards the mathematicians' expertise. The fact that people at the time spoke of a "quarrel between mathematicians and architects" is mostly due to some comments made by Lelio Cosatti (1677-1748 ante), who heavily attacked the mathematicians. Noting that they did not take into account some conspicuous cracks in the arches below the drum, he casts serious doubts on their approach to the whole pattern of movements within the cupola. His criticism about the mathematicians' claim that the weight of the lantern causes a horizontal thrust (thereby contributing to the cupola's static problems) is particularly insightful. Cosatti is actually convinced that the opposite is true, stating that the lantern is a necessary element, which strengthens and consolidates a cupola and that many professors of mathematics would agree with him (1743, p.8). Significantly, Cosatti cites no names to support this. Instead he cites what Giorgio Vasari (1511-74) says about Filippo Brunelleschi (1377-1446), who attributed to the lantern exactly this reinforcing role for the cupola. In his will he imperatively declared that the lantern of the cupola of Santa Maria del Fiore in Florence should be erected soon according to his plan. Brunelleschi is referred to as a sort of "institution" with irrefutable authority. Cosatti moreover declares that the general experience of master builders would prescribe loading pointed arches with weight to strengthen them (1743, p.9). It would be instructive to follow this analysis through, from the mathematicians' answer to Cosatti in their *Riflessioni* (1743) and Cosatti's reply in his *Aggiunta* (1743). All these questions, however, cannot be dealt with on this occasion.

In another manuscript, dated 16 February 1743, the Sicilian architect Giovanni Amico (1684-1754) proposed a classical solution, which would however be highly invasive from an aesthetic point of view: four buttresses in a half-*tholoi* shape were to be erected at drum-level (Fig.3). Amico, who focuses very much on his own experience, refers to the cupola of San Lorenzo in Trapani that he had built in 1734-36 (Fig.5). The larger cracks in the cupola shell would then be bridged with stones, creating a double dovetail effect. Amico had already used this technique (as he declares explicitly) to repair buildings after the Palermo earthquake in 1726. He simply made the double dovetail stones considerably larger, so they would have measured 3 by 2 by 1 *palmo* (ca. 67 x 44 x 22 cm) so that, presumably, they would be in proportion to the size of the cupola of St. Peter's. He seems to be unaware that much smaller marble stones in a double dovetail shape had already been placed across the cracks of the cupola, with the opposite purpose in mind. They were actually used as indicators, because if they cracked it was a sign of movement within the cupola. For his report, however, Amico did not have all the available information about the damage to the cupola of St. Peter's at hand. His starting point was a letter from a Roman colleague which contained some general information about the damage extracted from the mathematicians' report. Amico cites this letter as introduction to his own text.

Figure 5. Giovanni Amico, dome of San Lorenzo in Trapani (Sicily),
1734-36, (from Mazzamuto 2003, p.94)

Gaetano Chiaveri (1689-1770), like Amico, was also willing to make a remote diagnosis. Chiaveri, who was architect to the King of Poland and the Prince Elector of Saxony, insists on the principle of *forze contrapposte*, by which he means a construction where the parts balance each other. His example of this is the Pantheon. The cupolas of Santa Maria del Fiore in Florence and St. Peter's in Rome, on the other hand, do not have a *forza esteriore contrapposta* to oppose the *spingimento interiore*. Chiaveri praises the mathematicians' report, explicitly preferring it to that of the *Filosofo*. He follows the mathematicians' analysis of the cupola damage, adding that Poleni did well to put chains into the cupola. However, in his opinion, chains were not safe in the long-term since, he asserts, their life span was relatively short. He also quotes what the mathematicians wrote about the fact that chains were not very reliable, since both the material and the section might not be homogeneous (Chiaveri 1767, p.9). However, Chiaveri's praise of the mathematicians was also a piece of strategy, since his final goal was nothing less than to tear down the existing cupola and then be hired to build a new one (Fig.6). Chiaveri proposes a design with an undulated drum. This was not primarily intended as an aesthetic update on the cupola. Rather, its purpose was to strengthen the ribs of cupola and drum mainly for statical reasons. Ultimately, Chiaveri proposes to substitute active security measures like chains (cf. today's sprinklers as active fire prevention) with passive security: a building constructed in such a way that it keeps its own balance (cf. fire-proof building materials as passive fire prevention).
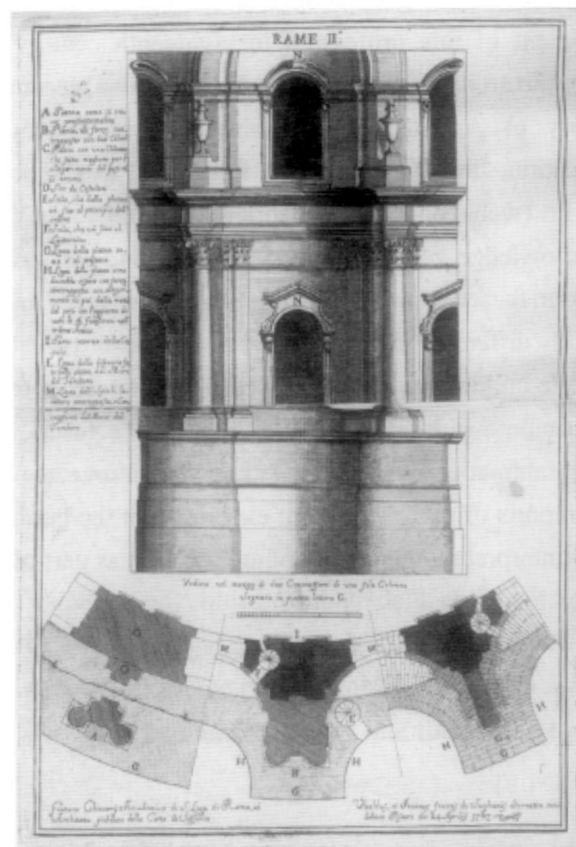

Figure 6. Gaetano Chiaveri, St. Peter's, project for a new dome (Chiaveri 1767)

FINAL REMARKS AND PERSPECTIVE

Comparing the various reports on the damage to St. Peter's cupola, a series of different attitudes emerge. Gaetano Chiaveri's report seems strategically aimed at obtaining the commission to rebuild the cupola. Leseur, Jacquier and Boscovich, on the other hand, aimed at a scientific publication in the modern (Baconian) sense: they clearly described their whole line of thought and openly declared the limits of their expertise. By doing so, the mathematicians deliberately exposed themselves to criticism. Giovanni Gaetano Bottari described their attitude as naive (BAV, Cicognara V 3849, cf. Table1). Leseur, Jacquier and Boscovich collected all the information about the cupola of St. Peter's and its specific damage in order to propose and then prove a hypothesis. The scholastically-trained *Filosofo* preferred to build a more general picture, collecting information on topics such as the expansion of materials due to humidity, which he then fits to the specific case of St. Peter's cupola. The building experts follow different approaches. The architect Lelio Cosatti rebutted the mathematicians' report, using his own visual perception of the cupola. Cosatti contradicts a number of their arguments, defending his own knowledge of construction issues and referring to irrefutable authorities of cupola construction like Brunelleschi. The architect Giovanni Amico relies on his own very specific experience in the field, transposing it to the context of St. Peter's.

Giovanna Curcio (2001) has provided a general overview of the profession and self-definition of the architect, on the development of this profession in eighteenth century Italy and on the tools, approaches and knowledge the architects had at their disposal. The present author is member of the project "Epistemic History of Architecture", a joint research endeavour of the Bibliotheca Hertziana, Max Planck Institute for Art History in Rome and the Max Planck Institute for the History of Science in Berlin (website in the references). The subject of this project is the design, technical and logistical knowledge of construction experts, and its structure, development and transmission. Dwelling on these approaches the present paper has compared "knowledge inventories" of people with different professional backgrounds involved in construction issues, while looking just at a single building exemplar. It would be interesting to broaden the perspective on these issues and to provide a more general overview on the forms, practices, dynamics and general results of the direct interaction of competing "knowledge inventories". To do so it would be necessary to compare the reports of more groups of experts from the building industry. This would contribute to a new way of interpreting the history of architecture as part of a history of knowledge.

REFERENCES

Archivio della Reverenda Fabbrica di San Pietro, Rome (AFSP)
1° P., Arm. III, n. 3, fasc. 6

Biblioteca Apostolica Vaticana, Rome (BAV)
Cicognara V 3849

Biblioteca Marciana, Venice (BM)
5519, cod. DCLVIII
5520, cod. DCXLIX

Biblioteca Nazionale Centrale di Roma (BNCR)
Ms. 787

Gabinetto Nazionale delle Stampe, Rome (GNS)
F.C. 128989-128994, vol. 158 H 14

Anonymous, 1743. *Lettera del Signor N.N. al Signor N.N. sopra il parere del P. Domenico Sante Santini intorno i danni della cupola di S. Pietro.* Rome.

Anonymous, 1744: *Breve discorso in difesa della Cupola di S. Pietro di N.N., capomastro muratore, regolato circa i danni secondo la prima scrittura de' rr. pp. mattematici l'anno 1744.* Rome.

Becchi, A and Foce, F, 2002. *Degli archi e delle volte. Arte del costruire tra meccanica e stereotomia.* Venezia: Marsilio.

Benvenuto, E, 1981. *La scienza delle costruzioni e il suo sviluppo storico.* Firenze: Sansoni.

Brusatin, M, 1971. "La cupola di S. Pietro che crolla per un'indagine-intervento al XVIII secolo: Giovanni Poleni e Luigi Vanvitelli", *Controspazio*, 3, pp.20-32.

Cavallari-Murat, A, 1973. "Collaborazione Poleni-Vanvitelli per la cupola vaticana (1743-1748)" in *Luigi Vanvitelli e il settecento europeo.* Naples.

Chiaveri, G, 1767. *Breve discorso di Gaetano Chiaveri circa i danni riconosciuti nella portentosa Cupola di San Pietro di Roma, e le sue principali cause, con la maniera durabile, e più sicura per la reparazione*, Pesaro.

Chierici, G, 1937. "Luigi Vanvitelli e il consolidamento della cupola di San Pietro", *Pan*, 3.

Como, M, 1997. "Un antico restauro statico della cupola di San Pietro a Roma" in Conforti, C (ed.), *Lo specchio del cielo. Forme, significati, tecniche e funzioni della cupola dal Pantheon al Novecento.* Milan: Electa, pp. 244-59.

Cosatti, L, 1743. *Riflessioni ... sopra il sistema dei tre rr.pp. mattematici e suo parere circa il patimento, e risarcimento della gran cupola di S. Pietro.* Rome: Bernabò & Lazzarini.

Curcio, G, 2001. "La professione dell'architetto: disegni, cantieri, manuali", in Curcio, C and Kieven, E (eds.), *Storia dell'architettura italiana. Il Settecento*. Milan: Electa, pp.50-69.

Di Pasquale, S, 1994. "Giovanni Poleni tra dubbi e certezze nell'analisi della cupola vaticana", *Palladio*, 14, pp.273-8.

Di Pasquale, S, 1995. "On the Art of Building before Galilei" in Radelet-de Grave, P and Benvenuto, E (eds.), *Entre Mécanique et Architecture*. Basel: Birkhäuser, pp.102-21.

Di Pasquale, S, 1996. *L'arte del costruire. Tra conoscenza e scienza.* Venice: Marsilio.

Di Stefano, R, 1963. *La cupola di S. Pietro. Storia della costruzione e dei restauri.* Naples: Edizioni Scientifiche Italiane.

Di Stefano, R, 1980. *La cupola di S. Pietro. Storia della costruzione e dei restauri.* 2nd edition. Naples: Edizioni Scientifiche Italiane.

Filosofo 1743. *Sentimenti di un filosofo Sopra le Cause, e Rimedi de' danni della Cupola di San Pietro E sopra il Parere dato su tale Argomento da' tre Matematici al fine del 1742.* Rome.

Fontana, C, 1694. *Templum Vaticanum et ipsius orig : cum aedificiis maxime conspicuis antiquitus, & recens ibidem constitutis;…* Rome: Francisi Buagni.

Fontana, C, 2003. *Il tempio vaticano 1694. Carlo Fontana.* Curcio, C. (ed.). Milan: Electa.

Galilei, G, 1638. *Discorsi e dimostrazioni matematiche intorno a due nuove scienze attenenti alla mecanica et i movimenti locali,* Leiden: Elsevirij.

Guerra, G, 1991. "Riesame degli studi del Poleni per il restauro della Cupola di S. Pietro", in *Atti della Accademia Pontaniana*, 40, pp.43-53.

Heyman, J, 1988. "Poleni's Problem", *Proceedings of the Institution of Civil Engineers.* 84, 1988, pp.737-59.

La Hire, P. de, 1712, "Sur la construction des voûtes dans les edifices", *Mémoires de l'Académie Royale des Sciences*, 1712 (Paris 1731), pp.69-77.

La Hire, P.de, 1730. "Traité de mécanique, où l'on explique tout ce qui est nécessaire dans la pratique des Arts", *Mémoires de l'Académie Royale des Sciences*, 9, 1730, pp.1-331.

Leseur, T, Jacquier, F and Boscovich, G R, 1742. *Parere di tre mattematici sopra i danni, che si trovano nella cupola di S. Pietro...*, Rome.

Leseur, T, Jacquier, F and Boscovich, G R, 1743. *Riflessioni de padri Tommaso Le Seur, Francesco Jacquier dell'Ordine de' Minimi, e Ruggiero Giuseppe Boscovich della Compagnia di Gesù, sopra alcune difficoltà spettanti i danni, e risarcimenti della Cupola di S. Pietro...*, Rome.

Magalotti, L, editor, 1666. *Saggi di naturali esperienze fatte nell'Accademia del Cimento sotto la protezione del serenissimo principe Leopoldo di Toscana e descritte dal segretario di essa Accademia.* Florence: Giuseppe Cocchini all'Insegna della Stella.

Mainstone, R J, 1999. "The dome of St. Peter's: structural aspects of its design and construction, and inquiries into its stability", *AA Files*, autumn, pp.21-39.

Mannucci, A, 1987. "Il papa che non voleve essere ricordato per il crollo della cupola di S. Pietro", *Castelli Romani*, 32, pp.41-8.

Mazzamuto, A, 2003. *Giovanni Biagio Amico. Architetto e trattatista del Settecento*, Palermo: Flaccovio.

Pescinellesi, C and Rapallini, M, 1995. "The Analogy between Equilibrium of Threads and Thin Masonry Structures" in Radelet-de Grave, P and Benvenuto, E (eds.), *Entre Mécanique et Architecture*. Basel: Birkhäuser, pp.122-39.

Poleni, G, 1748. *Memorie istoriche della gran cupola del Tempio Vaticano e de'danni di essa, e de'ristoramenti loro, divise in libri cinque.* Padua, Stamperia del Seminario.

Pucci, E, 1924. "Le condizioni statiche della cupola di S. Pietro, nella storia", *Roma*, 2, pp.399-409.

Raviglia, P and Sante Santini, D, 1743. *Risoluzione del Dubbio proposto dal Padre AbateRaviglia e parere intorno alli contraforti, ed altri danni della Cupola Vaticana del P. Domenico Sante Santini De Ministri degl'Infermi, Dilettante di Matematica alla Maddalena.* Rome.

Rizzetti, G, 1744. *Elementi di architettura per erigerla in scienza, con un discorso sopra la cupola di S. Pietro in Roma.* Venice.

www.biblhertz.it/deutsch/forschung/wissensgeschichte.htm