A Contribution to the History of Architectural and Environmental Representation

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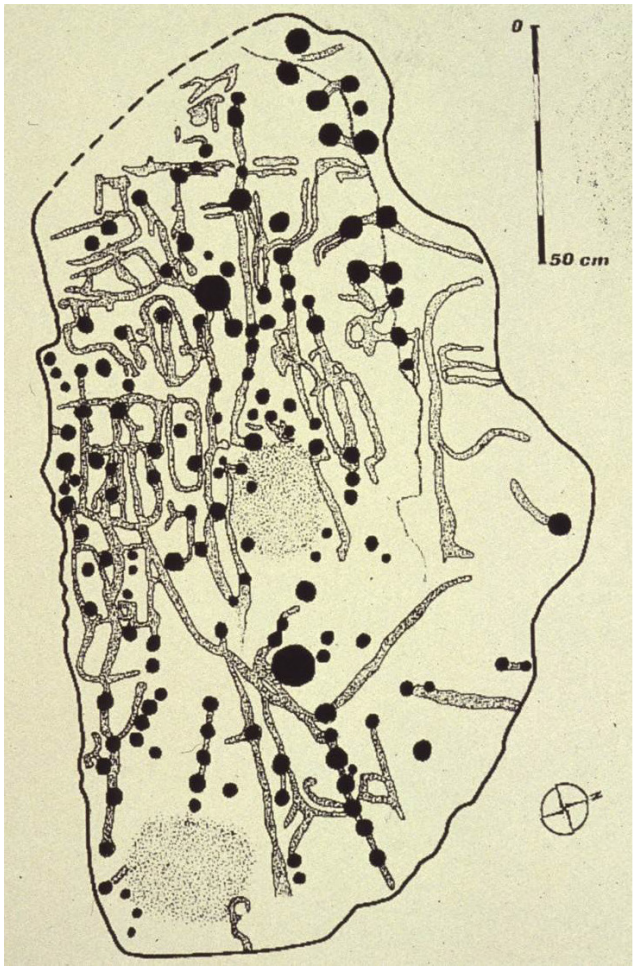
Introduction

It is necessary to reflect on the meaning of the term 'Architectural Representation' before tackling the themes related to its history over the centuries; this denomination was fully accepted into technical language only in relatively recent times, starting from the middle of the last century, while previously other terms were used, such as 'drawing', 'architectural drawing', 'technical drawing', 'descriptive geometry', 'applications of descriptive geometry', 'methods of representation'.
Some Italian dictionaries define the term 'representation' as the operation of representing, with figures, signs and sensible symbols, or with various, even non-material processes, objects or aspects of reality, facts and abstract values. Representing is the operation of graphically reproducing an object, also a geographical region, etc. by projections, according to appropriate criteria, onto a plane surface.
Representation can be applied differently in various fields, ranging from philosophy to law, to mathematics, as well as to the field of architecture and engineering.
Specifically approaching the field of architecture, we can say that the activity of representing is as ancient as the world [1], but over the centuries it has taken on different connotations and denominations, as I wrote back in 1997: "Historical analysis has investigated in depth the role

This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editor-in-chief's responsability.

Fig. 1. On the left, Map of Abel Jamud (Wadi Rum) graphic transcription, Neolithic period 3000-3500 B.C. (graphic elaboration by the author); on the right, Map of Abel Jamud (Wadi Rum), in a detail (photo by the author). Engravings locating roads and round notches showing villages can be noted.



played by the methods of representation and in particular by perspective; in this respect, it is sufficient to recall the fundamental contributions of Erwin Panosky and Decio Gioseffi. While there have been many studies dedicated to the problem of the history of perspective, few have been dedicated to the more general history of representation and only very few, finally, are the studies that deal with the relationship between design drawing and architecture in its historical development: yet in this relationship lies the key to understanding the progressive development of methods of representation and, more generally, of solid, sites and descriptive geometry. To convince oneself of this it is enough to think of two emblematic cases, situated exactly at the beginning and at the end of the period in which the transformation of current knowledge took place: Vitruvius and Frézier. In Vitruvius the method of representation is clearly consistent in all respects with the design process: *ichnography*, that is, our projection onto a plane, precedes all the other representations of architecture, because it simulates, chronologically, even with drawing, the first operation carried out at a construction site, that related to tracing the plan of a building on the ground. The term that Vitruvius proposes to us, in fact, stands for 'drawing the footprint'; only after this operation can you proceed to erect walls and columns, whose graphic correspondence can be found in the term *orthography*. Finally, once the construction is complete, we have the *sciography*, that is, the 'overall view,' which by some is considered an elevation, perhaps a '*promenade architecturale', ante litteram* resolved thanks to the graphic simulation that provides an overall vision. It is interesting to observe how for the great Roman theoretician there exists a precise link between the graphic operations performed at the drawing board and those at the construction site; this allows us to also understand how some graphic constructions, for example, the division of a circumference into a certain number *n* of equal parts can be carried out with exactly the same rules, whether on a sheet of drawing paper or at the construction site. In fact, we know that to divide a circumference into four parts without performing complex calculations, it is enough to draw two straight orthogonal lines passing through its center; repeating the operation, we obtain divisions into eight, sixteen or thirty-two parts: that is why Sangallo's domes have sixteen or thirty-two spirals, and that is also why a wind rose has eight or sixteen winds. The same graphic procedure performed at the drawing board can be repeated on site. In this way, therefore, the part of geometry that is dedicated to the representation of three-dimensional objects by means of two-dimensional graphic models is closely linked to the project" [Docci 1997, pp. XII, XIII].

Essentially, we can say that for many centuries, until the end of the seventeenth century, to represent an object, a drawing was made reproducing, on a two-dimensional plane, the features of the object itself, without any strict correlation between its form and its representation. With the developments of mathematics and geometry, starting from eighteenth century, Projective Geometry [Amodeo 1939] was codified, whose principles are based on two fundamental operations: projection (construction of a projective ray passing through the center of projection and through a point of the object to be represented) and the section (intersection of the projective ray with the plane on which the representation is formed).

Going back to the aforementioned preface we can say that: "Taking a forward leap of twenty centuries, we reach Freziér who, as we know, represents the last author of treatises before the industrial revolution, mistakenly known among experts on geometry as the author of a stereometric treatise, while he should be known for an extensive work of

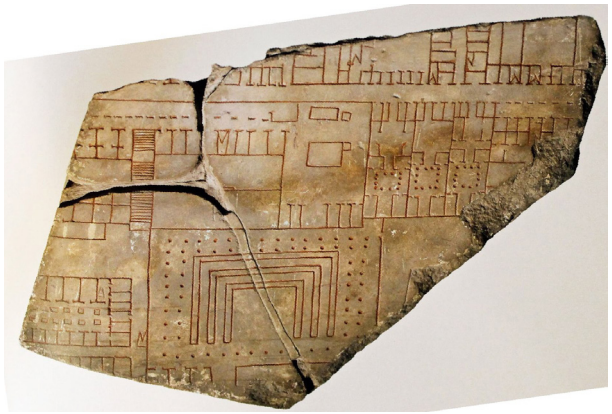
Fig. 2. Map of Nippur, engraving on clay tablet, 1500 B.C. On the right, the floor plan of the Royal Palace with indications of doorways can be noted: <https://pierrickauger.wordpress.com/2014/03/19/la-plus-ancienne-carte-du-monde/> (accessed 2018, June 10).

Fig. 3. Turin, Egyptian Museum. The so-called 'goldmine papyrus' with a map of Wadi Hammamat. Cyperus papyrus. New Kingdom, 20th Dynasty, reign of Ramses IV (1156-1150 B.C.). The representation of mining tunnels can be noted: <https://it.wikipedia.org/wiki/Papiro_delle_miniere_d%27oro#/media/File:TurinPapyrus1.jpg> (accessed 2018, June 10).

geometry, drawing and civil architecture, in which all the observations advanced up to now are admirably developed. He begins with a passionate defense of the theory, essentially, of geometric studies, as a prerequisite of architecture and ends with an exhibition of the five orders, well known to historians, in which he assigns to Vitruvian rationality the genuine origin of what in Architecture is authentic beauty" [Docci 1997, p. XIII].
Starting from these principles it has been possible to rigorously realize the representation of an object in space, by its projection onto a representation plane (picture plane) from a center of projection at a finite distance from the plane itself (central projection), or from an infinite distance from it (parallel projection). Thus, between the object and its representation, under specific condition is established, for which, given the representation, one can trace back to the object that determined it and vice versa. All this makes the representation scientifically objective and allows its use in physically constructing the object through a univocal process, on which all projects are based.

Starting from the principles of projection and section, various methods were developed which allow rigorous and objective operations of representation, designated by the term 'methods of representation', which are characterized in relation to the different type of center of projection (optical center) and its position with respect to the projection plane (picture plane) on which the projection is formed. Over the centuries the Method of perspective (or central) projection, the Method of double orthogonal projection (or Monge's Method), the Method of axonometric projection and the Method of topographic projection have been codified; each of them is distinguished by a different representation result. In particular, the methods that use a center of projection at a finite distance (proper center) construct a representation very similar to human vision (perspective) and therefore are used for realistic representations. The methods that use a center at infinity (improper center) realize, instead, more abstract representations (orthogonal projections, axonometric projections) but that have the great advantage of an immediate measurability, since the lines and points are not altered in the drawing; this type of representation is mainly used in the technical field and in design.

Fig. 4. Forma Urbis Romae (Severan Marble Plan), Severan period, fragments 11e, f, g, h [Docci, Maestri 1993, fig. 30, p. 25]. On the right there are three domus and an odeon, with indications of seats in the center and of the colonnade supporting the roof.



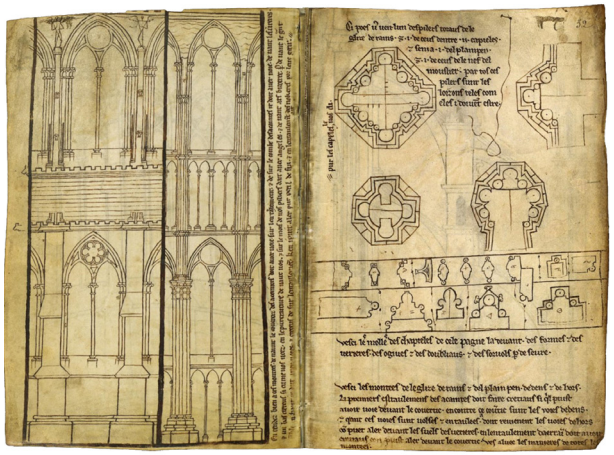
Finally, it should be remembered that the advent of computer science determined the birth of virtual representation, which is not a physical representation, but which could be, since it exists in the computer's memory and can be displayed on the screen; and therefore it can be used as the project of a work to be realized [2].

The Roman School and the first steps towards the creation of a new discipline: Architectural Representation

In the early 1960s, the Faculty of Architecture in Rome, like other Italian faculties, was besieged by a multitude of young students who wanted to become architects: enrolments had for a few years largely exceeded the number of three hundred and many courses were in crisis because they were too crowded. Due to these demands, the Faculty began to 'split' some courses and in the spring of 1962 it was decided that this procedure should also be applied to *Applications of Descriptive Geometry*; the new course was entrusted to a young professor, Gaspare De Fiore, who already taught *Drawing from Life*, in the hope that he would undertake a profound renewal of teaching; the other course of *Applications of Descriptive Geometry*, entrusted to professor Ing. Maria Luisa Ganassini, instead developed, more traditionally, the methods of Descriptive Geometry applied to the problems of architecture.

Fig. 5. Map of Jerusalem, floor mosaic in the Church of Saint George at Madaba, second half of the 6th century A.D.: <https://en.wikipedia.org/wiki/Madaba_Map#/media/File:Madaba_map.jpg> (accessed 2018, June 10).

Gaspare De Fiore brought together some of his collaborators from the *Drawing* course and other young architects, such as myself, stating that he would accept the course if we committed ourselves to taking charge of it, under his coordination. So it was during the summer of 1962 when we organized many meetings with Gaspare De Fiore and other colleagues, such as Igino Pineschi, Achille Pascucci and Camillo Ianniccari –I believe that sometimes Franco Donato also took part– in it order to develop the program of a course that was not to be the duplicate of the one already initiated and that, above all, addressed with greater incisiveness the representation of architecture and, in particular, the realization of projects and the analysis of urban or territorial context; I would like to mention here that a project begins with the first concept sketches, followed by the definition of the project itself, up to its communication, and continuing towards the executive project.
It was from these debates that a distinction was made between the terms 'applications of Descriptive Geometry', which only refers to Monge's Method, or double orthogonal projection, and the term 'representation'; it was clear to us that in order to represent the project, an architect also needs other methods of representation, such as perspective, axonometry and topographic projection, bearing in mind that the modern world also proposes other techniques such as photography and scale models (models or maquettes). These were the main reasons for finding a new name for a course that intended to explore all aspects of Representation.
It should be remembered that an architect or a civil engineer should use Representation not only during the design and definition of a project but also in the phase of gathering information about the places in which the new work is planned to be builtand, similarly, for interventions on historical architecture and on cities; in fact, by using architectural surveying he needs, after having measured the characterizing points of a work, to represent the single building or the urban sector; he therefore needs to employ all the methods and tools of representation in a broader way than what the *Applications of Descriptive Geometry* could offer us at the time.
On that occasion we fully understood how architects had by then come to use systems of representation that in those years were already more complex than the classical ones which, although constituting the scientific foun-



dations of Descriptive Geometry, needed to be expanded with other methodologies in order to meet all the needs of contemporary architects. Thus, the name of the course, while maintaining the official title of *Applications of Descriptive Geometry*, was completed with the subtitle: *Theory and Techniques of Representation*. It was conducted by our group, under the supervision of Gaspare de Fiore and, in particular, we, Pascucci and I, were very involved; unfortunately for our experimentation, starting from 1968 the course was passed on to another teaching professor because Gaspare De Fiore had in the meantime won the chair of *Architectural Composition* in Palermo.
Our experience thus ended, but the commitment of Gaspare De Fiore students did not cease; we devoted ourselves to further explore the themes of Representation, so much so that in 1965, I, on my part, published a monograph entitled *Theory of Representation*: nothing particularly significant, but we had now reached the full awareness that Representation was our disciplinary sector. Following Gaspare De Fiore advice, in 1966 I decided to participate in the competition for professorship and, again on his suggestion, I decided not to participate in the that for *Drawing* or *Applications of Descriptive Geometry*, but in that for a new discipline we were experimenting in Rome. In May 1967, I

Fig. 6. Villard de Honnecourt, Sketchbook, folios 62 and 63, mid-13th century: <http://classes.bnf.fr/villard/feuillet/index.htm> (accessed 2018, June 10).

Fig. 7. Cristoforo Buondelmonti, Map of Constantinople, 1422, Liber insularum Archipelagi, 1824; Paris, Bibliothèque nationale de France: <http://gallica.bnf.fr/ark:/12148/btv1b55010482q/f79.item> (accessed 2018, June 10).

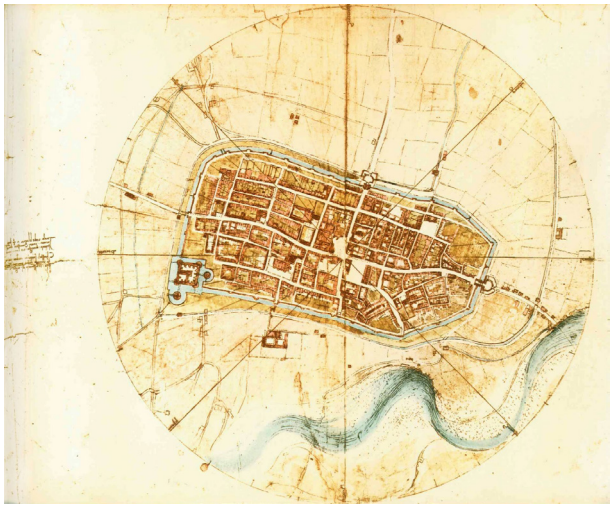


Fig. 8. Leonardo da Vinci, a plan of Imola, c. 1502, Windsor Castle, Royal Library, no. 12284. The representation of blocks and public buildings with their plans can be noted [Docci 1987, fig. 2, p. 182].

Fig. 9. Map of Baghdad, 1533. The plan of the city shows the buildings tilted away from the Tigris River; the walls are represented turned back at a 90-degree angle in order to show their elevations: <MuslimHeritage.com> (accessed 2018, June 10).

obtained, by unanimous decision of the examination board, the qualification as professor of *Theory of Architectural Representation*, a discipline that for the first time entered the Italian university world.
As known, in 1969 the new regulations of the Faculties of Architecture were published which profoundly reformed the previous one and heavily affected our disciplines, reducing them from six to two, namely, *Applications of Descriptive Geometry* and *Drawing and Survey*, completely eliminating the two courses of *Drawing from Life* and the two courses of *Survey of Monuments*. The teaching of *Applications of Descriptive Geometry*, having to deal with the scientific foundations and techniques of representation, took very different forms depending on the teacher's either limiting himself to providing the teaching of methods of representation or, otherwise, trying to make the course of *Science and Technique of Representation* come back to life. That's what happened for the course of *Applications* that was entrusted to me starting from the academic year 1970-1971 and that I kept up to the year 1974-1975, in which I again took up what I had already experimented with Gaspare De Fiore from 1962 to 1968.
In the 1970s, therefore, the experiment began again and continued for many years thanks to the contribution of

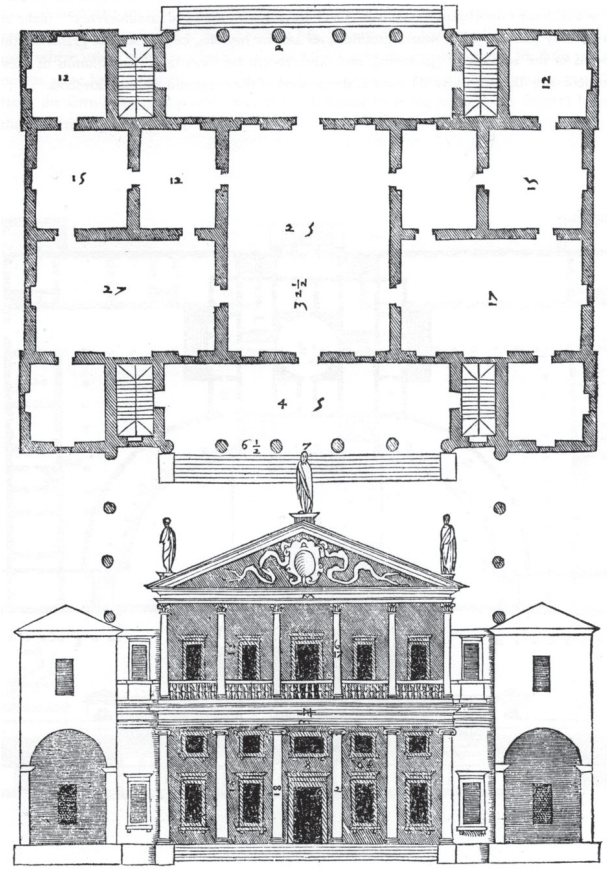


Fig. 10. Andrea Palladio, Villa Valmarana in Lisiera, Bolzano Vicentino, Vicenza. Engraving [Palladio 1570, libro I, p. 59].

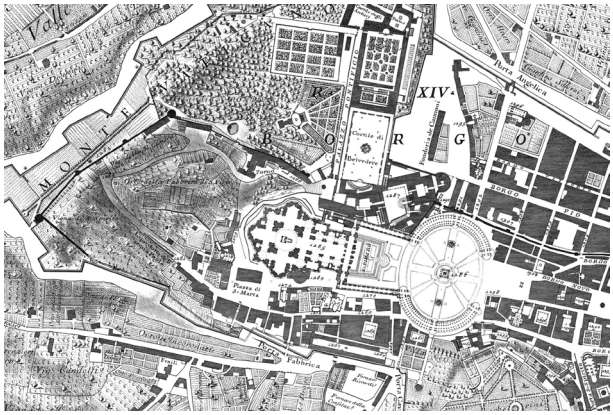


Fig. 11. Giovanni Battista Nolli, Nuova Pianta di Roma, 1748. Detail of the area around Saint Peter's Basilica. The representation of the city is realized using a rigorous orthogonal projection; in addition, the public buildings are also represented with their interior spaces.

Achille Pascucci who took over my course, continuing to teach *Theory of Representation*. Maintaining this course not only meant facilitating the diffusion of knowledge in the field of representation, but also the development of research and scientific contributions unfolded over time, as I will explain below.

The birth in 1983 of departments at the Sapienza University and the creation of a department called 'Representation and Survey' –which included all the teachers of Drawing, about thirty, scattered throughout the Faculties of Architecture, Engineering and even in those of Mathematical, Physical and Natural Sciences– determined a considerable step forward for the activity of scientific research and also a greater diversification of scientific skills.

A great confrontation of ideas took place in those years concerning the issues related to representation in its various aspects. In 1986 a particular initiative was taken to organize an International Congress entitled "*I Fondamenti Scientifici della Rappresentazione*" (that is, *The Sicentific Fundamentals of Representation*), whose scientific directors were Roberto De Rubertis and myself. In order to address our topics from an interdisciplinary point of view, in addition to all Italian teachers of Drawing, the following teaching professors were invited: Decio Gioseffi, professor of History of Art at the University of Trieste; Richard Gregory, professor of Neuropsychology at the University of Bristol; Giuliano Maggiora, professor of Architectural Composition at the University of Florence; Corrado Maltese, professor of Art History at the Sapienza University

of Rome; Mario Rasetti, professor of Theoretical Physics at the Politecnico di Torino; Alessandro Polistena, professor of Computer Graphics at the Politecnico di Milano and René Taton, director of the *École des hautes études en sciences sociales* (School for Advanced Studies in the Social Sciences) in Paris. The proceedings of this congress constitute a definitive report on the state of the art of Representation and also of its history; at same time, I would refer to the lectures by Decio Gioseffi and René Taton, but I think that the interventions during the round tables should also be carefully analyzed by those who want to deal with the theme of the History of Representation [AA.VV. 1989]. The congress took place in the Palazzo della Cancelleria, a prestigious venue, as I said in the opening of the works: "As you may have intuited, the choice of this hall, wonderfully frescoed by Giorgio Vasari, where our Congress is being held, was not accidental; who better than the great Florentine draftsman could have said: 'drawing is not other than the visible expression and declaration of our inner conception and of that which others have imagined and given form to in their idea'?" [3].
Bearing in mind the results of this important Congress, the Department of Representation and Survey organized a new on April 1993, also closely linked to the topic of Representation, entitled *Il Disegno di Progetto. Dalle origini al XVIII secolo* (that is, *Drawing for Project. From Origins to VXIII century*) which traced the features of the History of Representation of architectural projects; the proceedings of the congress –particularly interesting, also taking into account submissions from various European schools– can be found in the book containing the most significant papers [Docci 1997].
After many years of discussion in 1993 the Faculty of Architecture decided to deal with the problem of revising its regulations, believing that they, dating back to 1969, were no longer able to satisfactorily address the education and training of young architects, also taking into account the European Community Directive relating to the profession. After a series of confrontations between the different faculties and the various disciplinary sectors, the new Table XXX was approved which called for considerable changes in the education and training of architects [4]. The new organization envisaged a three-cycle structure (2 years + 2 years + 1 year); in addition, for the first time, eleven disciplinary areas were introduced and the '*Area XI*' was called '*Area della Rappresentazione dell'Architettura*' e dello Spazio. This system, which remained in existence for about

Fig. 12. François Demesmay, Concorso Clementino, 1758, second class: 'Ridurre la Basilica di S. Paolo sulla via Ostiense a forma moderna'. Plan of the proposal for trasformation. Rome, Accademia di San Luca (Dis. Arch. 0564), [Docci 1997, fig. 4 p. 324].

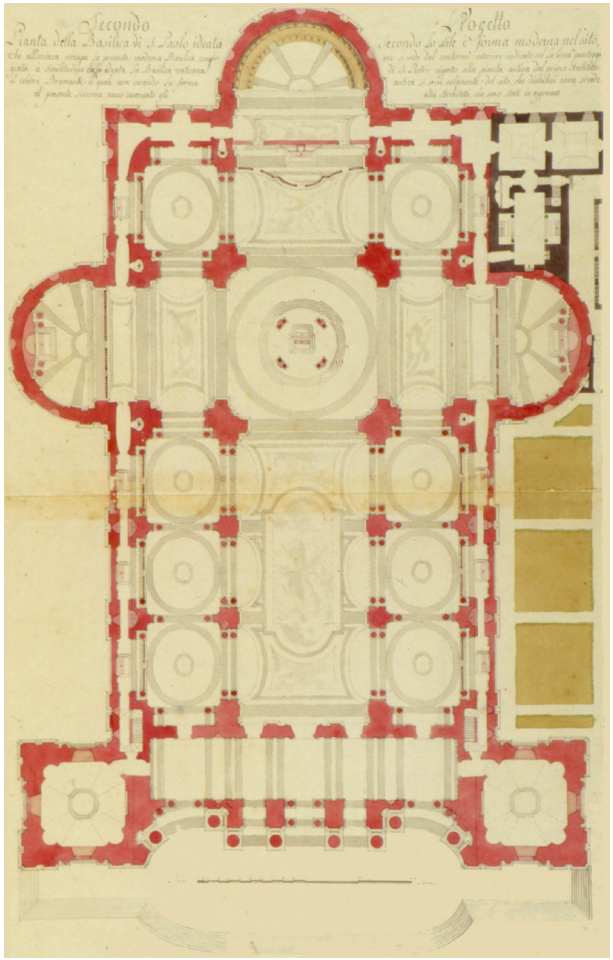
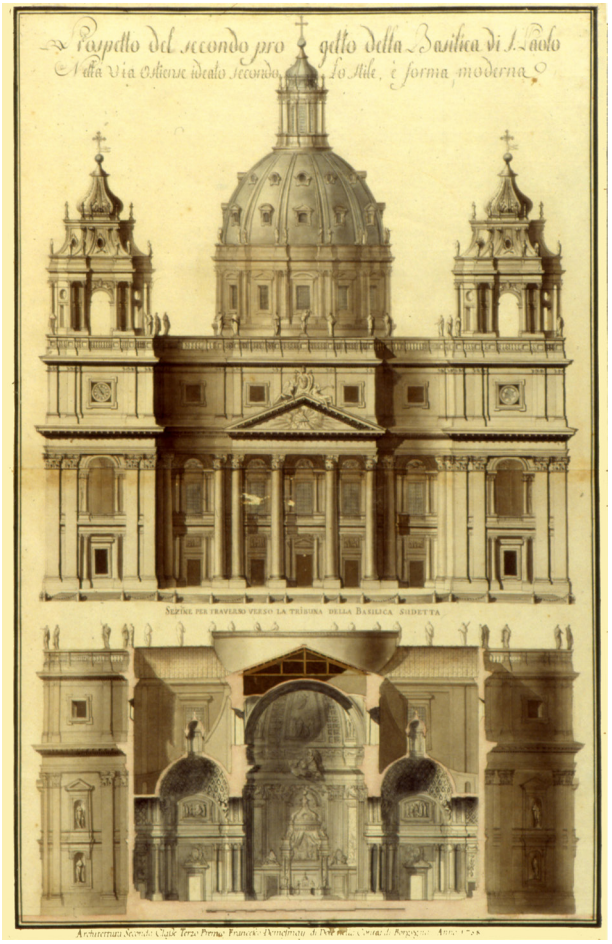


Fig. 13. François Demesmay, Concorso Clementino, 1758, second class: 'Ridurre la Basilica di S. Paolo sulla via Ostiense a forma moderna'. Elevation and section, third prize. Rome, Accademia di San Luca (Dis. Arch. 0565), [Docci 1997, fig. 5, p. 324]. The perfection of the representation, which follows the canons of the orthogonal double projection method, is evident.



ten years, has been taken as a model by many European schools and, in my opinion, should be analyzed with great care since it is still today a model of modern training and more effective than the system currently used [5].
These innovations did not go unnoticed by publishers at the national level; in 1995, in fact, the '*Nuova Italia Scientifica*' (NIS) publishing house asked me to compile a monograph on Representation including the knowledge of Descriptive Geometry as well as other methods of representation. I asked my colleague Riccardo Migliari to collaborate and together we addressed this topic. In the presentation of the book we had the opportunity to write: "It is known that the term 'descriptive geometry' (*géométrie descriptive*) was coined by Gaspard Monge to baptize the new science of which he declared himself the creator. It is written in the sources of this history that after the 'invention' of descriptive geometry it would be possible to solve, thanks to the latter, every problem first faced with the means of perspective, gnomonic perspective, stereometry and all the other sciences applied to representation of architecture and engineering, topography and geodesy, etc. It is also known that many 'ways of representing,' which at the time had not yet achieved the dignity of being called 'methods of representation,' found it in a more recent history, so much so that today the so-called Monge's Method has been joined by others, at least three, all with equal dignity as mathematical tools. It therefore seems absurd to continue to include under the aforementioned denomination such ancient, noble and complete sciences as double orthogonal projection (in the form of the architectural drawing illustrated in this book), perspective (or central projection, if you prefer), axonometry (completely ignored by Monge), or topographic projection, and studies that make better use of these other methods, rather than Monge's Method, such as the study of surfaces, that of vaults and the theory of shadows and chiaroscuro. Instead, it seems dutiful, in order to understand the teaching of history, to understand all these disciplines, together and alongside the geometry of Monge, under the new title that could be that of 'Science of Representation', a title that is proposed for this book" [Docci, Migliari 1996].
In those years, therefore, the need to historicize the Science of Representation was alive in all of us, as can be seen in the publication mentioned here, where each method of representation is preceded by a brief historical introduction which highlights its development and its codification.

The birth of the courses in Science of Representation

The new regulations of 1993, already mentioned earlier, started from the following academic year; in many faculties, within the Area of Representation, the subject was still taught for some years in courses that maintained the traditional names they had in the pre-existing disciplinary Area ICAR17 (ICAR was the acronym indicating Civil Engineering and Architecture), in many cases passing from two to three courses made mandatory by the new system. In the Faculty of Architecture at the Sapienza University of Rome, it became immediately clear that it was necessary to make an effort to try to overcome the old disciplines by finding broader terms to designate the different aspects of Representation, and Techniques of Representation, as well as Survey with all its methodologies, including scanner surveying, without neglecting Life Drawing, with its various techniques, such as watercolor. Regarding the name of the course, beginning with the academic year 2001-2002 it was decided to designate it with the name of *Science of Representation I*, *II*, *III*, although perhaps we could have more coherently called it *Science and Techniques of Representation*; simplicity, however, always pays. The problem of the contents of the three courses was solved through the commitment and coordination of the three professors, with diversified skills, of Architectural Drawing, Methods of Representation and Survey. In three years, however, knowledge is not acquired in a linear manner: for example, the first year is mainly devoted to free-hand and architectural drawing techniques, but the graphic analysis of architecture is dealt with as well; in the last year, in addition to the main Survey methodologies, the virtual modeling of architecture with the use of computers for constructing virtual 3D models is taught.

Topicality and complexity in the elaboration of the History of Architectural Representation

From what has been outlined above there emerges the current complexity of the forms that Representation assumed in the first twenty years of the 21st century, since not only the advent of computer science determined the birth

Fig. 14. Paul Letarouilly, Plan général del la place et des édifices du Capitole, 1860. It can be noted that the representation is not always objective but tends to interpret the forms [Letarouilly 1860, fig. 15]: <https://www.fulltable.com/vts/aoi/l/letr/15.jpg> (accessed 2018, June 10).

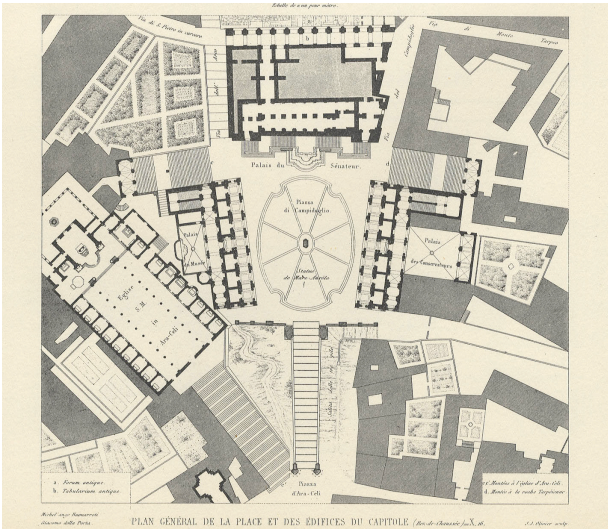


Fig. 15. Paul Letarouilly, Vue général del la place et des édifices du Capitole, 1860. It can be noted that the perspective representation is performed with great accuracy [Letarouilly 1860, fig. 16]: <https://www.fulltable.com/vts/aoi/l/letr/16.jpg> (accessed 2018, June 10).

of Virtual Representation [Docci 2007] but also because other representational methods such as three-dimensional models (scale models or maquettes) and Reverse Modeling, photography and film shooting became more and more relavant in our research field. Other aspects have to be considered, such as those of the three-dimensional representation of an object or an artifact, that is, the models generated by 3D printers managed by software and derived from three-dimensional scans with laser scanners and other methods such as photomodeling.
In addition, there are specific and autonomous sectors in the world of Architecture and Engineering, such as that of the representation of the territory, or cartography, which, while resting its scientific foundations on the method of topographic projection, in present a series of particular aspects regarding the symbology, the graphic signs and the thematisms, so much so that it can be defined territorial representation, and which in some cases becomes a real discipline: think, for example, of thematic Cartography.
Exactly defining which fields Architectural Representation embraces today is therefore a very complex task, also due to the continuous contributions of computer science and of the new technologies.
It is, therefore, perhaps the moment to propose a new definition, broader than the term 'representation', which I believe should take into account that Representation is the result of a process that has as its purpose the representation of a real or virtual object, on a representation plane or in 3 dimensions (physical model) following specific laws of correlation between the points of the real or virtual object, and the corresponding points represented, on a plane or belonging to a three-dimensional model.
The History of Representation, like other histories such as that of Architectural Survey, is none other than one of the many chapters of the History of Science [6], and therefore will have to follow the previously proven rules, developing along paths that cross all the periodizations that have been defined, from the origins to the present day.
In my opinion, there are three paths along which the History of Representation develops.
A first path is that of the scientific foundations of the subject, a history already largely written by mathematicians and philosophers who dealt first with Descriptive Geometry and later, with the Methods of Representation; I would mention, in this regard, Gino Loria [Loria 1919; 1924; 1931] and Luigi Vagnetti [Vagnetti 1965; 1978].
A second path is that of the methodologies of representation, including all aspects related to graphic conventions, from the symbologies to the nature of the graphic supports.
The third path is that concerning the instrumentations – from the simplest to the most complex– in the contemporary world, used in the process of representation, an aspect on which there is much work to be done.
In conclusion, it is hoped that young people will dedicate themselves to historical research in the field of Representation since, although some studies have been undertaken in the sectors of Survey and Freehand Drawing, the History of Representation is still largely to be written.

Notes

[1] The text is accompanied by a series of images, not directly mentioned in the paper, which illustrate the transformations of the methodologies of representation used during the course of centuries.

[2] On virtual representation see: Docci 2007.

[3] Mario Docci, Opening address. In AA.VV. 1989, p.11.

[4] The Italian Ministerial Decree relating to Table XXX for the Faculties of Architecture was published in the Italian Official Gazette No. 153 of 2 July 1993.

[5] For example, for the Area of Representation it is stated that the disciplines of the area are aimed at achieving the following objectives: to form the theoretical and practical knowledge necessary for the representation of architectural space, also through the analysis of their historical development; to practice all the graphic techniques, in order to achieve full control of the tools of representation, applying them to the analysis of architectural values, as well as to survey and to project design; to practice methods of direct and instrumental surveying as well as the consequent techniques of metric, morphological and thematic restitution; to form the ability to control the mental model of space, which is the premise of every design activity (see page 28 of the Italian Official Gazette No. 153).

[6] For more information on this type of path, see, for example, Docci, Maestri 1993.

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