The Drawing of Measurable Space and of Calculable Space

Francesca Fatta

"Man is the measure of all things:
things which are, that they are, and
things which are not, that they are not"
Epigram attributed to Protagoras (490 BC-400 BC)

A science for measuring the earth

In the third century BC, it happened that Eratosthenes of Cyrene (a city located in today's Libya) wanted to measure the radius of the earth, and he tried to do so using the instruments that were available to him at the time. The experiment gave an incredible result, obtaining a measurement that differs only 5% from the value currently known.
The merit of Eratosthenes was to make a measurement with a good degree of accuracy using only one instrument: the gnomon, which is a stick planted vertically in perfectly flat, level ground [1].
This demonstration marked an important milestone in the field of mathematical science and of the measurement of the space within which we move. The measurement, both ancient and modern, of the earth, whether arable or constructible land, in a reference to farmers and masons [Serres 1994], is a mathematical geometric science. Geometry is a word derived from the Greek *γεωμετρία*, which is a fusion of the words *γή*, 'earth' and *μετρία*, 'measurement.' Stemming from its universal etymological meaning, 'measu-

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

https://doi.org/10.26375/disegno.7.2020.02

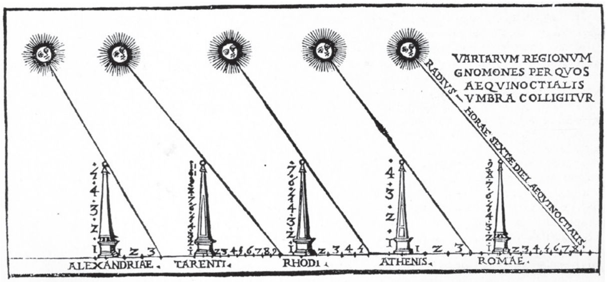
diségno ISSN 2533-2899

rement of the earth,' many other geometries and relative measures are differentiated: the simple figures of Pythagorean arithmetic, Plato's World of Ideas, Euclid's elements, Piero della Francesca's perspectives, Descartes' axes, the descriptive axonometries of the Industrial Revolution, the non-Euclidean reconstructions, Leibniz's *Analysis Situs*, the topology of Leonhard Euler, Georg Friedrich Bernhard Riemann and Henri Poincaré. Geometry is a *complex unicum* that deals with the science of measurement and adopts reasoning to prove all differences; it constitutes an objective investigation that observes reality with the detachment of universality.
But within this universality, the many geometries are nevertheless united by the Euclidean principles to which they all refer. In any case, the square and its diagonal, the triangle and its elements are present in every geometry, as if to testify the origin of everything, even if they refer to different systems of thought.

Measurement between space and time

Historians of scientific thought such as Alexandre Koyré and Michel Serres relate measurement to two important parameters: space and time. They propose a profound reading of the connection between infinity and eternity and of the inferences generated, especially between the sixteenth and eighteenth centuries, by the space-time relationship, which called into question all the elements of culture and common experience [Koyré 1988; Serres 1994].
The infinite, which eluded the Greeks, was dealt with by Titus Lucretius Caro, in *De rerum natura*, with the theory of space being 'infinite in all directions': "If the existing space were to be considered limited, assuming that a man runs forward towards its furthest boundaries, stops at its outermost limit and then hurls a flying javelin, do you think, once thrown with great force, the javelin will fly to a certain distance, or do you think that something will obstruct its trajectory to stop it? Either of the two suppositions cuts off your escape and forces you to admit that the universe stretches without end" [Lucretius, I, p. 420 foll.].
Nicolaus Copernicus, in 1543, published his treatise on the revolutionary theory of the earth revolving around the sun, questioning all the relationships between man-earth-space, and Giordano Bruno, in the wake of the new science, wrote fifty years later: "Henceforth I spread confident wings to space; I fear no barrier of crystal or of glass; I cleave the heavens and soar to the infinite" [Bruno 2002, vol. 2, p. 31].
René Descartes took up the same concept, differentiating the *Res extensa*, the physical world, and the *Res cogitans*, the human mind, two distinct realities from which the idea of measurable and immeasurable space springs: "The extended matter that composes the universe has no limits, because, wherever we would try to feign them, we still can imagine indefinitely extended spaces beyond, and because we do not merely imagine them, but we conceive them to be in fact such as we imagine them, in such a way that they contain an indefinitely extended body, for the idea of extension that we conceive in any space whatsoever is the true idea that we must have of body" [Cartesio 1644, parte II, par. 21, p. 52]. Cartesian thought generates the idea of an absolute space that Newton connects to an absolute time suitable to the spirit of modern man: "All things are placed in time as to the order of succession; and in space as to the order of situation" [Newton 1965, p. 104].
Space 'flows' like time, and time 'passes' like the water of a river or expands like music, made up of flows connected in such a way so as to compose the movement in which the oldest roots of the Italian word 'tempo' (time) are found: *τεμννω*, 'cut into parts,' and *τεὶννω*, 'extend continuously.' Immersed and carried along in a stream of harmonies generated by general and specific intuitions, man lives, thinks, invents, composes and remembers his own time and plunges into it, as if into a river. Michel Serres argues that time does not flow but 'percolates,' that is, like a liquid, it filters through a mass, more or less slowly depending on the density of the mass itself [Serres 1994]. The result is an idea of time that advances, stops, turns back, goes forward again, reconnects and intersects objects, spaces, thoughts and words.

Fig. 1. Cesariano, Measurement of the meridian solar radius on the day of the equinoxes as a function of latitude, 1521.



Man lives his own time, which in turn, while 'percolating,' deforms space and shapes it according to the geometry regulating it. Perhaps this is precisely why there are many geometries, to identify time spheres or flows that flow differently.
To measure the earth through geometry means, according to Serres, writing "a universal language that neither engraves nor traces any mark on any medium since no figure shown on it could correspond to the one it in truth measures and proves. In order for no point or stylus, as sharp as you'd like, to be able to cut or incise into it, in order for no engraving or wrinkle to be preserved in it, a more than adamantine hardness, infinite, and a more than aquatic, aerial or ethereal softness, infinite as well, are required for this earth whose material or special consistency causes the infinite of a maximal resistance and the infinite of a minimum of light breath to become equal in it" [Serres 1994, pp. 10, 11]. Thus measuring means accessing a land that is not the domain of geography, but a 'non-place' that includes all the knowledge of the universe, from astronomy to biology, art, music, architecture.
Geometry measures both physical and mental places; Albert Einstein clarifies that, if it were to investigate only physical spaces, it would cease to be an axiomatic-deductive science to become part of the natural sciences; this frees measurement from the behavior of physical bodies and to assume conventional values deduced from the type of geometry adopted. In this regard, the conventional value of geometry is proposed by Henry Poincaré, who supports the theory that there are no geometries 'truer' than others, but only geometries 'more functional' or suitable to the measurement that needs to be produced. Just as Newtonian space represented a convention that was well suited to the scientific discoveries of that particular moment in history, the geometry of the Greeks based on proportions was equally suitable for defining the dimensions of the classical world.

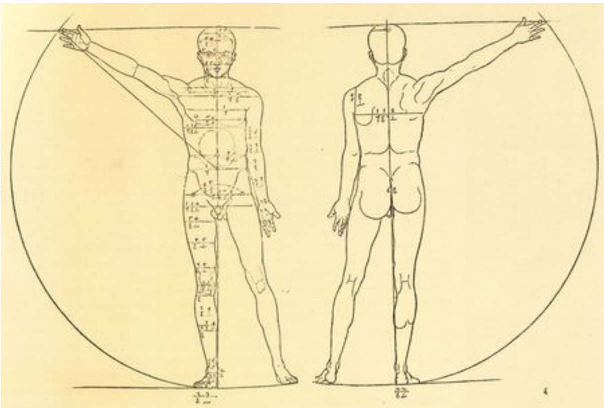
The dimensions of geometry

All geometries have a common basis, a three-dimensional continuum identical for each one; they constitute an indispensable science for relating the mind with space; but we must go back to the Pythagoreans to find the first school of thought in which the study of the world was expressed in terms of number and measure. Mathema-

Fig. 2. Daniele Barbaro, Cover of I Dieci libri dell'architettura by M. Vitruvio, 1556.

tical science for the Pythagoreans was applied mainly to numbers and to the geometric constructions that could be deduced from them: the mind produces numbers applicable to the formal qualities of the real world so that a certain geometric figure, however it is present in nature, will always have the same characteristics for the intellect and the same geometric-mathematical laws will always be applicable to it. The Pythagorean spirit considers number not a symbol, but a 'thing,' and 'things,' according to this school of thought, take on the appearance of geometric quantities: the sequence of numbers is a line, the product of two numbers is a plane, and of three numbers, a volume, since it is conceived as a combination of points. "The unit is conceived as a point having position and extension: a number both even and odd. Even numbers are, in fact, made up of units that are represented in equal quantities on one side and the other of another unit or point. The juxtaposed units form fields (*χώρα*) that represent numbers, and the properties of these numbers are in turn determined by the figures they give rise to. These figures can be of one, two or three dimensions and thus we have (linear) numbers in general, 'plane' numbers and 'solid numbers.' Euclid did not ignore this tradition and defined the plane number as the product of two numbers and the solid number as the product of three numbers. Plane numbers, then, according to the different properties of the figures that arise from the arrangement of their units are further

Fig. 3. Albrecht Dürer, Figure in metric scale, 1528.



defined as triangular numbers, square numbers, gnomon numbers, oblong numbers; solid numbers were considered tetrahedral, cubic (hexahedral) numbers etc." [Bairati 1952, p. 29]. A vision of the number is thus deduced analogous to a figurative construction consisting of or designed from geometric units that express the representation of mathematical facts. Form (*εἶδος*) and number (*λόγος*) mark a conjunction between concrete and abstract, measure and reason. A theory that does not intend to measure nor calculate, but to 'harmonize,' in simple ratios, the relationships between the parts.
Cesare Bairati observed that when the tension of the relations generated by the magnitudes is understood by the observer, then the sense of human rationality is satisfied. But the aesthetic emotion goes far beyond, it invests the spirit, and yet none of the many factors that intervene in the poetic synthesis lends itself to the reading of the artifact as much as the numerical entity. In the Egyptian pyramids, the unity of the architecture is expressed by the simplicity of the form, that seems to exalt the concept of absolute unity in the vertex. The major Roman architectural works put the accent on the volumetry of the organism that shapes harmonized, unitary spaces; while Gothic cathedrals find their unity in the overall structure and in the detail of the construction according to vertical directions and geometries, Renaissance geometry finds its unity in the central plans of its buildings, surmounted by domed vaults, the maximum expression of the spatial unity of the composition.
The concept of compositional unity in the Baroque period is to be referred to the symmetrical scheme of the plans and façades; the absolute obedience to symmetry gives rise to, despite the spatial jaggedness given by the redundant decoration, an impression of unity expressed (and emphasized) with vigor.

Space and symmetry, time and *eurythmia*

Symmetry, from the Greek *συμμετρία*, composed of *σύν*, with, and *μέτρον*, measure, represented for the Greeks all that is commensurate, proportional. The notion of symmetry as a harmonic proportional system became canon, a unit of measurement that goes beyond number itself. Of symmetry, one of the best definitions of the original term is that of Hero of Alexandria (Ist century BC), who considered symmetrical quantities those measurable with a

common measure, and asymmetrical quantities those that do not have a common measure. Vitruvius, in Latinizing it, makes the concept broader, though less precise, referring it to the "harmonic relationship of the individual members of a building" and "proportional correspondence, calculated in modules, of the individual parts with respect to the overall figure of the work" [Vitruvius, Book I, Chap. 2].
Symmetry contains within itself two categories, one logical and the other aesthetic, and all the works by authors of treatises can be read from two different angles. These texts always deal with these two moments, theoretical and operative, and the treatise, with all its rules, becomes a code of interpretation and measure, even aesthetic, and Leon Battista Alberti, Filarete, Sebastiano Serlio and Andrea Palladio, on the Vitruvian model, clarify (or simplify) the complexity of reality. Thus, at the end of the sixteenth century, Mons. Daniel Barbaro interpreted Vitruvius: "Order is thus comparison of inequalities which commences in a previously taken quantity (notion of module) that serves as a regulator for all the parts and refers to those and to the whole, making an agreement of measure called symmetry" [Barbaro 1567, p. 28]. These considerations contain notions of quantity that determine the aesthetic criteria referred to architecture, the mother of all arts.
A few centuries later, Le Corbusier wrote, "In order to construct well and to distribute your efforts to advantage, in order to obtain solidity and utility in the work, units of measure are the first condition of all. The builder takes as his measure what is easiest and most constant; the tool that he is least likely to lose: his pace, his foot, his elbow, his finger. In order to construct well and distribute his efforts to advantage, to obtain solidity and utility in the work, he has taken measurements, he has adopted a unit of measurement, he has regulated his work, he has brought in order. […] He has imposed order by means of measurement. […] By imposing the order of his foot or his arm, he has created a unit which regulates the whole work; and this work is on his own scale, to his own proportion, comfortable for him to his measure" [Le Corbusier 1973, pp. 53, 54].
The sense of proportion, the study of ratios and proportions, the concatenation of proportions in symmetries and *eurythmia* are based on the mathematical order of the parts in analogy with musical harmony. The belief that architecture is a science and that each part of a building must be integrated into a single system of geometrical-mathematical relations can be seen as the fundamental axiom of architects of the classical age. This system was born from the proportions of the human body, the highest and most complete expression of 'divine will.' Within themselves, architectural proportions must comprise and express the cosmic order. This order is revealed by Pythagoras and Plato and taken up in a cosmic key by Renaissance theories.
On the other hand, the harmony of the infinitely great is already reflected in the infinitely small in God's command to Moses when he ordered him to build a tabernacle on the model of the universe; later, Solomon transferred those qualities to the Temple of Jerusalem, in the architectural proportions.

Fig. 4. Matila Ghyka, Les nombres et les forms, Planche V, in: Philosophie et mystique du nombre, 1952.

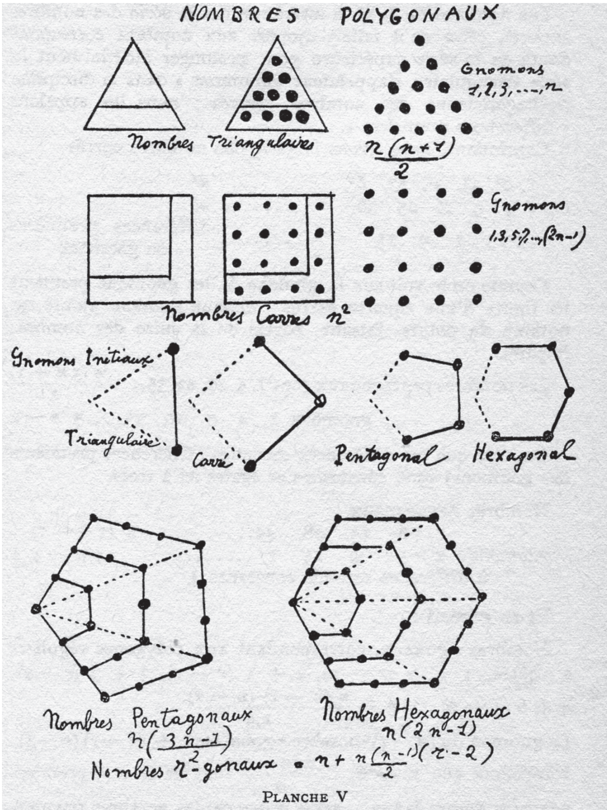
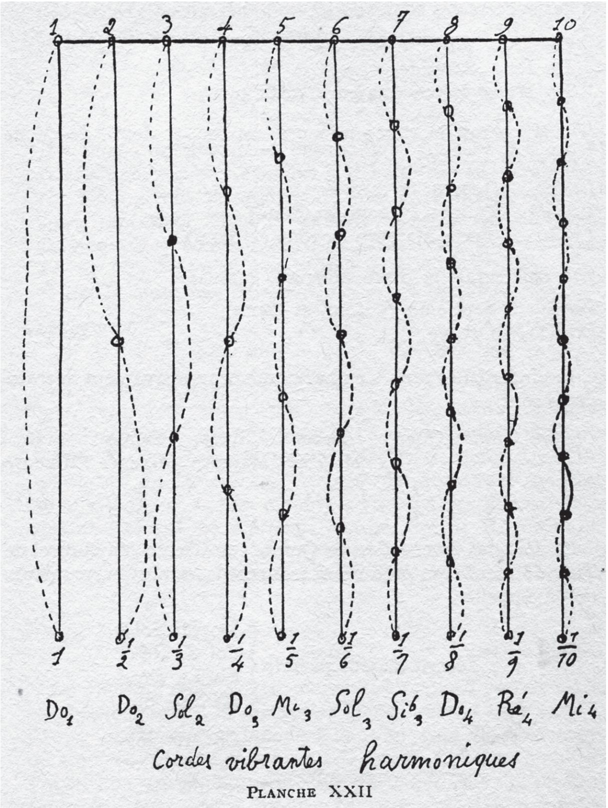


Fig. 5. *Matila Ghyka, Le nombre et la musique Planche XXII, in: Philosophie et mystique du nombre, 1952.*

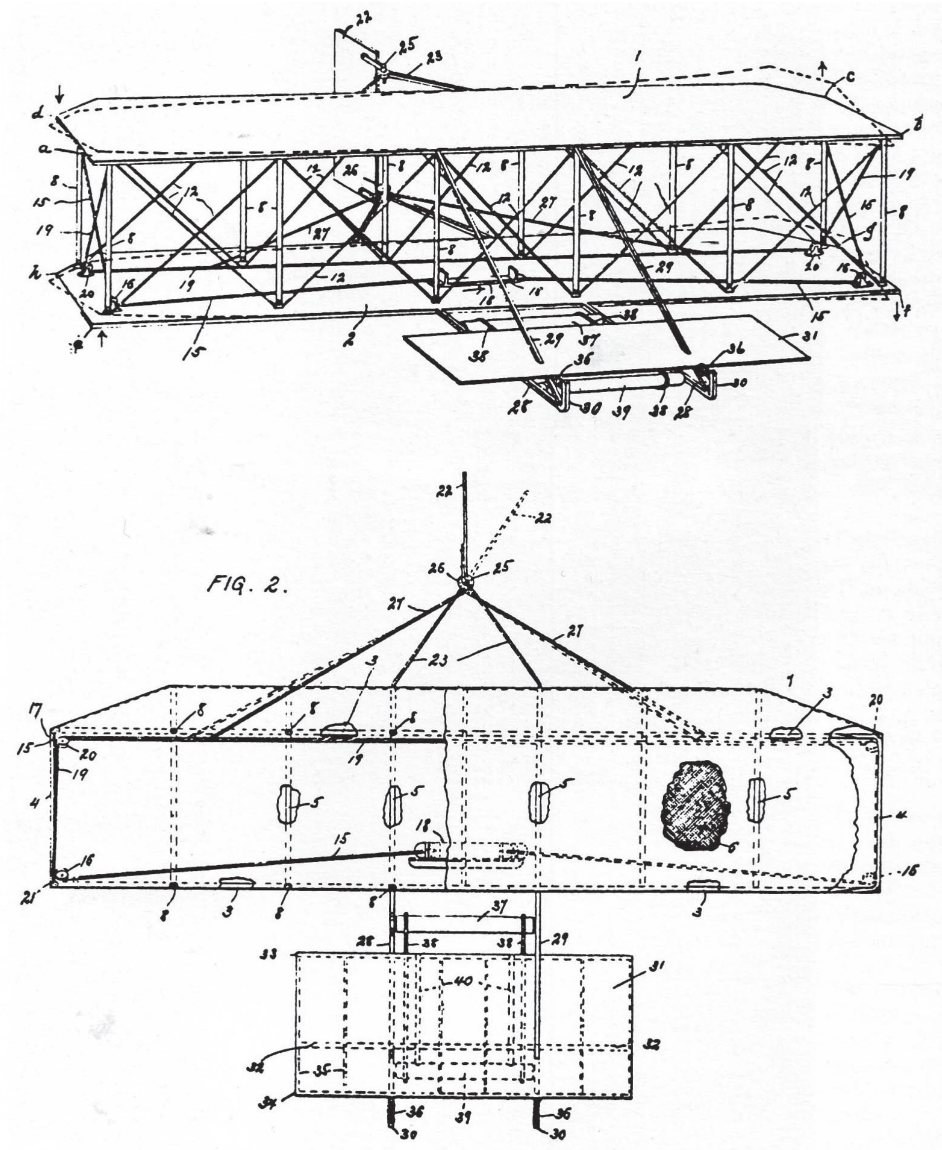


Order, clarity, simplicity are the prevailing requirements in the beauty of classical compositions where number and measure are revealed in the highest aesthetic expression. These are commonly summarized in the concept of 'serenity' (what aesthetics at the beginning of the twentieth century called *Einfühlung*), as architectural forms are 'ordered' according to a perceptive understanding of the dimensions. The 'symphonic' concept of architectural composition, and of artistic work in general, derives from the classical idea of a measured and harmonious universe, musically ordered according to a comparison made by the Neo-Pythagoreans between the geometric theory of proportions and that of the intervals of the musical scale.

Measured rhythm

Auguste Choisy wrote that *eurythmia* seems to imply a rhythmic composition [Choisy 1873], and, in fact, the etymology of the word derives from the Greek *αριϑμός* and *ρυϑμός* (from *ῥέω*, flow), which both mean number; the first refers to the isolated number and gave rise to the arithmetic meaning, the second is used to indicate the number as an element of a succession governed by a law and gave rise to the word 'rhythm' with which the concept of periodicity, of measure is expressed.
Architecture, "composition, structure, the way in which the various parts of an organism or work are designed and distributed," [2] participates from an aesthetic point of view in the 'arts of duration.' One can also speak of rhythm for architecture, in analogy with music, substituting 'space' for 'tempo.'
Matila Ghyka studied the analogy between architectural and musical *eurythmia* at great length. He drew on Pythagorean and Platonic aesthetic studies that, for the arts of space proposed the human body as a model of ideal *eurythmia* [Ghyka 1938]. For architects, the temple was the 'proportional medium' in the mystic universe-human proportion; but just as the human body had provided architects with models of eurythmic lines and proportional scales from large to small, for the "arts of duration," man returns as a model for the rhythms that vibrate in him, which are the expression of his soul, his vitality [Ghyka 1938]. The two vital psychophysiological cadences: heartbeat and breathing, give us a sense of the search for the fundamental rhythm, for an order that flows within us. These natural rhythms each involve a tension, a deceleration and a pause. Similarly,

Fig. 6. O. e W. Wrigth, Technical table illustrating the flying machine, U.S. Patent Office, May 22, 1906 (patent and design) [Rassegna n. 46 1991, p. 43].



human physiology also searches for rhythm in visual perception. The measure of architecture is structured rhythm; the aesthetic function takes on the role of making this scansion evident to the eye by defining rhythms and measures that in turn are formalized into 'styles.'
It has already been said that aesthetics had a strictly mathematical starting point with the theory of proportions and symmetry; it has also been mentioned that initially the meanings of 'rhythm' and 'number' were equivalent; and it has been observed that the ratios or periodic series that identify proportions or rhythms are perfectly expressed in numbers, both integer (discontinuous proportions) and irrational (continuous proportions). These numbers and their geometric figurations, for the "arts of space," were examined in detail in the works dedicated to the study of Greek canons with renewed enthusiasm at the beginning of the twentieth century.
Proportions, canons, the golden ratio, anthropomorphism, symmetries and regulating lines were restored to the tradition of design, they became tools that facilitate the creation of spatial arrangements, essential for the structuring of a renewed geometric language of architecture.
Jay Hambidge published *Dynamic Symmetry* in 1919, Paul Valéry published *Eupalinos ou l'Architectur*e in 1921, Miloutine Borissavlievtic published *Théories de l'Architecture* in 1926 and Matila C. Ghyka, *Le nombre d'or* and *Estetique et proportiones dans la nature et dans les arts* in 1926; the rereadings of texts such as August Thiersch's 1888 volume also promoted this interest.
Le Corbusier, taking up the theories on the module, devised the Modulor: a range of double measures derived from the subdivision, according to the golden ratio, of the average height of a man (red series), and the height of a man with his arm raised (blue series). He thus realized a modern synthesis between man and space for the design of houses and the modern city. Just as Le Corbusier attempted a synthesis between classical language and modern architecture, the Bauhaus school also interpreted the efforts to re-establish contact between the structure of the object and its aesthetic value through the search for a renewed link between nature and geometry, structure and form.

Measure and/is module

The module is a measure, according to the meaning of the Latin word '*modulus*', that is, element, model, quality to be compared to a whole [3]. The module, in architecture and classical art, is the unit of measurement that lies at the basis of any proportional calculation between the individual parts of the work and the whole, and vice versa. Established on the basis of technical-constructive, aesthetic, mathematical criteria, the module was the compositional rule linked, in particular, to the syntax of orders. In Greek architecture it was identified with the base of the column shaft (*imoscapo*), or with the distribution of triglyphs. This criterion was taken up by Vitruvius (Ist century BC) and later, from the Renaissance on, it was investigated for several centuries by architectural treatises. In the language of modern architecture, a module is a normalized unit of measurement, intended to facilitate the design and assembly of building elements.
A measurement is a numerical value attributed to a magnitude, expressed as the ratio between this and another quantity of the same kind, conventionally chosen as a unit of measurement.
This concept of measure, intimately linked to that of dimension and magnitude, is referred to any type of organism: it must verify certain formal properties and is the subject of study of the theory of measurement, in which the procedures for measuring lengths, areas, volumes, etc. are studied. Measurement is knowledge, it enters into the nature of things. At the end of the fifteenth century, thanks to the rediscovery of Vitruvius's treatise and its diffusion, the knowledge of ancient thought was discussed and deepened. The "modern" spirit of knowledge and the desire to study the architecture of the classical age led many scholars and architects, not only Italian ones, to concentrate on Roman ruins. The need to see those testimonies first-hand was described by Vasari: "measuring the cornices and taking the ground-plans of those buildings. There was no place that they left unvisited, and nothing of the good that they did not measure" [Vasari 1962, p. 251]. Alberti wrote of his activity as a geometer-architect: "No building of the ancients that had attracted praise, wherever it might be, but I immediately examined carefully, to see what I could learn from it. Therefore I never stopped exploring, considering, and measuring everything, and comparing the information through line drawings" [Alberti 1966, vol. II, lib. VI, cap. 1, *Gli ornamenti*, p. 440]. On the other hand, the eagerness to know, measure, represent and document is fully understood in the design research of Renaissance architecture. Measurement is a conquest of the modern world, an expression of a quality inherent in classical *mimesis*. Alberti, speaking of the power of drawing, defines it as ideal form par excellence,

as *imago ab omni materia separata* [a separation of image from all matter]; capable of subtracting from architecture the inertia of matter, the quantity that disposed it, sublimating itself in the quality of form.
Modularity requires precision, and precision, as Alexandre Koyré explains, is the modern conquest that has revolutionized the space in which we live [Koyré 1967] The discovery of precision leads us to verify quantitatively (with the theory of measurement) the quality of architecture [Docci, Maestri 1984, cap. III, *Teoria della misura*]. The approach to measurement in architecture is the practice of surveying which, in addition to being irreplaceable for the understanding of the architectural object under investigation, constitutes a very important training ground because, with direct observation, one becomes accustomed to spatial synthesis, to the geometric-structural understanding of the composition and to the graphic representation of the measurements reported in scale.
The accuracy of the measurements reported allows us to reproduce the shape of the object surveyed, to reread the dimensional and spatial relationships between the parts, and between the parts and the whole, coming to express, thanks to a deeper knowledge, a judgment of value De Simone 1990]. "Today's thought, architectural culture and historical-critical culture almost unanimously recognize a strong educational content to survey operations. Those who approach this type of experience, in fact, have the opportunity to confront the operational reality, measuring, operating rationally, getting used to the practice of perceptual control of the physical dimensions of an architectural work, not to mention that the graphic analysis, conducted directly, is a great and irreplaceable means of knowledge." [Docci, Maestri 1984, p. 15].

Fig. 6. Le Corbusier, Le Modulor, 1950.

"What cannot be measured does not exist"

Starting from these reflections, we can consider the operations of survey, the analyses, the phases of knowledge of a work of architecture, as the premises that make clear the reasons of a certain form that has found substance. The classical world already specified how the *dispositio* alludes to a hierarchical system of competence. The codes of classical order, for example, refer to hierarchical statutes through which history and theory become science, skill, competence.
"What cannot be measured does not exist," states Carl Werner Heisenberg in his famous *Uncertainty Principle* [4]. In refuting the classical principle of randomness, he argued that only what is measurable can be produced experimentally; that is, what can be measured is also possible, while what can be calculated is merely potential [5].
To take measurements, to interpret the measurements taken, to know, to reveal, are operations falling within the sphere of the possible that in essence allow passing from the description to the understanding of the phenomena of architecture.

The role of drawing becomes the passage from description, to interpretation, modification: from knowledge (survey), to possession (interpretation), to use (project). Here, therefore, the sequence 'knowledge-possession-use' completes the cycle of intervention on the existing.
But representing means entering into the merits of the possible and the calculable; it is possible to measure what already exists, that has a form (survey) while everything for which a modification, a prediction (project) is necessary, is calculable.
This duality defines the field of validity of our work: on the one hand, the sphere of the built, of the existing, on the other hand, towards the sphere of the modification.
This duality also marks the fields of training and research: if teaching work is mainly a work that conveys previously consolidated knowledge, research work is a work that ventures into the elaboration of knowledge and experimentation.
In our field, for example, this means overcoming the descriptive habit of cataloguing ('quantitative' recording of data) to aim towards the interpretative context of classification ('qualitative' aggregation of data). In fact, classifying means recognizing areas of relevance and analogy: to include and exclude from classes and families according to an evolutionary order of language. To classify is also to exercise a judgment on the rule and its variation. The notion of order guides this practice since, in the absence of rules (rule = order = hierarchy = recognizability) it is not even possible to transgress the rule itself. Even in architecture, the notion of transgression, of exception, exists if the concept of order is clear. How would it possible to understand the giant order of Michelangelo, or the neoclassical language, or the references of the postmodernists, or the liquid architectures of the digital, without knowing the notion of classical order?
Order, hierarchy, harmony, *eurythmia* and symmetry are tools that make known things decipherable. From this certainty, from this confrontation with nature, all the evolution of architecture becomes a question of challenge between rule and exception, between order and disorder, between nature and artifice.
But evolution itself is a continuous transformation of rules into exceptions and exceptions into rules. Inhabited places are the sum of the successive stratifications of different types of settlement amplified by the space-time dimension. Contemporaneity is also the segment of an evolutionary process that comes from afar, since awareness of the present stems from the knowledge of history. That is to say, the center of the issues related to the studies of representation of architecture is always a matter to be connected with a context of very integrated relationships in which to find the less apparent and deeper sense of meanings.
Drawing, in essence, not only describes architecture, but explains it and often constructs it; just think of the relationships between representation and non-Euclidean geometries or even the four-dimensional or hyperdimensional implications of the current processes of digital and virtual representation.
Drawing, in relation to measurement, implies a continuous experimentation that leads to a wealth of interactions, a constant challenge between sign and number, between observation and transformation, between theoretical component and instrumental component. Measurement and drawing are, in any case, instruments in precarious equilibrium: drawing is an instrument, since it is an extension of the hand and of the mind, while measurement is an instrument of reason for investigating the properties and the quality of things.

Notes

[1] With the measurement of the shadow, the movements of the sun can be followed both during the day and throughout the year.

[2] <https://www.treccani.it/vocabolario/architettura/> (accessed 2020, December 5).

[3] *Dizionario enciclopedico di architettura*. (1969). Item *Modulo*. Roma: Istituto Editoriale Romano.

[4] Carl Werner Heisenberg (awarded the Nobel Prize for Physics in 1932) was referred to for his theories on quantum physics in the opening address of the Conference *Il disegno di architettura come misura della qualità* organized by Rosalia La Franca, held in Palermo in May 1991, and in the context of the round table *La qualità tra misurabile e calcolabile*, in AA.VV. 1993.

[5] Enunciated in 1927 by W. Karl Heisenberg and confirmed by innumerable experiments, this is a fundamental concept of quantum mechanics that sanctioned a radical break with the laws of classical mechanics.

Author

Francesca Fatta, Department of Architecture ant Territory, Mediterranea University of Reggio Calabria, ffatta@unirc.it

Reference List

AA.VV. (1993). *Il disegno di architettura come misura della qualità*. Atti del Quinto Seminario di Primavera. Palermo: Flaccovio editore.

Alberti, L.B. (1966). *De re aedificatoria*. Trad. di G. Orlandi con note di P. Portoghesi. Milano: Edizioni il Polifilo.

Bairati, C. (1952). *La simmetria dinamica*. Milano: Tamburini.

Barbaro, D. (1567). *Vitruvius: I dieci libri dell'architettura di M. Vitruvio*. Venezia: Appresso Francesco de' Franceschi, Senese. <https://www.bibliothek-oechslin.org/library/online/vitruviana/barbaro-1567-1> (accessed 2020, December 5).

Bruno, G. (2002). De l'infinito, universo e mondi. In G. Bruno. *Opere italiane*. Torino: UTET.

Cartesio, R. (1644). *Principia Philosophiae. Amstelodami: Apud Ludovicum Elzevirium*: <https://books.google.it/s?id=lHpbAAAAQAAJ&printsec=frontcover&hl=it#v=onepage&q&f=false> (accessed 2020, December 5).

Choisy, A. (1873). *L'Art de bâtir chez les Romains par Auguste Choisy, ancien élève de l'Ecole polytechnique, ingénieur des Ponts et Chaussées*. Paris: Ducher.

Docci, M., Maestri, D. (1984). *Il rilevamento architettonico. Storia, metodi e disegno*. Bari: Laterza.

Ghyka, M. (1938). *Essai sur le rythme*. Paris: Gallimard.

Koyré, A. (1988). *Dal mondo chiuso all'universo infinito*. Milano: Feltrinelli [1ª ed. Baltimora, 1957].

Le Corbusier. (1973). *Verso un'architettura*. Milano: Longanesi.

Newton, I. (1965). *Principi matematici della filosofia naturale*. Torino: UTET [ed. orig. Philosophiae naturalis principia mathematica].

Serres, M. (1994). *Le origini della geometria*. Milano: Feltrinelli 1994 [1ª ed. Parigi, 1993].

Lucrezio Caro, T. *De rerum natura*. <http://www.audacter.it/Giussani.2.pdf> (accessed 2020, December 2020).

Vasari, G. (1962). *Le vite de' più eccellenti pittori scultori e architettori*. Nuova edizione critica. Vita di Filippo Brunelleschi, vol. II. Milano: edizioni per il Club del libro.

Vitruvio Pollione, M. *De Architectura*.