The Point of View of Measurement in Architectural Conception:

From the Question of Scale to Scale as Question

Philippe Boudon

Reflecting on the width of my bathroom I end up finding myself in a state of great perplexity as I try to know why (I'll be damned!) it had to have twice the wave length in the void of the radiation corresponding to the transition between the levels 2p10 and 5d5 of the krypton -86 atom; or, to put it more simply yet more grossly (a passage from the simple to the gross whose consequences should be measured), why did the bathroom's dimension have to be $(2/10)^7$ of the quarter of the earth's meridian.

For my bathroom measures 2 meters, and that is indeed what we are talking about to the extent that the meter is defined by the above mentioned elements.

It then made more sense for me to consider that the width of my bathroom corresponded to the bathtub's length, however paradoxical it might appear to measure the former by the latter whereas I had taken great care to choose the latter in terms of the former.

More satisfied to use my bathroom as an instrument of measurement relevant to the size of my bathroom, I then realized that things were not so simple. For the width of my bathroom was also equal to that of my kitchen, as imposed by the latter's proximity. Although this correspondence did not come about as a result of a necessary choice initially because my bathroom could just as well have found itself next to a stair. Moreover, the aforementioned width was also equal to the length of my daughter's bedroom wall, subject to substracting the width of a closet, itself corresponding to the possibility consistent with the installation of a bed. A bed, a closet, a bathtub: all are things which everyone can imagine more or less and there is no need for me to give the reader the dimensions of those objects.

From the outset, the preceding thoughts raised a number of problems

To begin with there is the question of the project. Although the user is going to choose his bathtub in terms of his bathroom, the architect is going to layout the bathroom in terms of the bathtub. The situation is then quite the opposite and, from an epistemological point of view, it cannot be taken for granted to think of architecture in this manner since it is basically contrary to the way in which we deal with it on a daily basis.[1]

Then comes the question of the relevance of the measurement: what interest is there in establishing a relation between the length of a quarter of the meridian and the length of kitchen? None whatsoever will be the reply, even though we remain objectively scientific, if one accepts that that there can be science only of the measurable. But regardless of the exactness of the length of my bathroom thus measured, we feel the inanity of the formula just the same. Let us note that the question raised is not the same as that shown by Bachelard on the excesses of precision.[2] It is of a different nature since it involves choosing the measurement that is of interest to us. A remark by an art historian mentioning the fact that the length of the city of Henrichemont is equal to the diagonal of the city of Richelieu will be of no interest, regardless of the mode of measurement and its degree of precision, unless we are given the relevance of the statement.[3]

Next we are faced with the question of the dimension. With the legitimate concern of tearing down my bathtub I worry more about the length of my bathroom than its height. The latter is of little interest to me (in my capacity as the user, although I recognize that the architect must have made some kind of decision in that respect). The width of the bathroom interests me little also since I cannot use it to place my bathtub, whereas the sink and other washroom accessories will have no difficulty finding their spot. The relevance that I have mentioned will apply to such and such physical support whose measurement I shall take into consideration. Thus, I shall call dimension that which I measure. When Le Corbusier attributes 7 meters to the diagonal of the maison des artisans over which he installs a mezzanine, the diagonal constitutes a dimension of this architectural object. The height of the Eiffeltower is certainly a priviledged dimension but its weight is not less important since the lightness of its structural idea is essential to the tower (its weight corresponds to that of of the prism of air of the same height and the same base). It is another way to take the measurement of the tower. Another scale.

Though I might give priority to my concern with the installation of my bathtub lengthwise, but the architect, in turn, must not have chosen the other dimensions of my bathroom unthinkingly. The length perhaps has something to do with technical problems of span and the height with a concern for optimization relative to the building. I can also imagine that in the architect's mind these constraints may be associated with different values and are part of an overall view of an entire set of constraints arising from the measurements he has taken to carry out his project. I imagine also that, consequently, he judges these measurements on given levels which are different from the one that holds my attention:the one concerning my bathtub. But who is to say that he was not merely satisfied with the "compatibility" between the length of my bathroom and the possibility of placing a bathtub there? Whereas his initial concern was for the length to fit in as a full division of the width of the building itself. Here, it seems to me, that basically he does not think out problems in the same space as I do. I am in a space of usage, of perception, he is in a space of conception.

The different measurements – including the length of my bathroom – are part of a set of other measurements which, once connected to each other, give form in the architect's eyes to a system. The relations between the measurements can be of different orders; these can be designated through graphs of varying complexity including the tree[4] or, at the other end – an extreme case –they can remain independent of each other.[5] And I am suddenly frightened at such complexity, to which is added the fact that the length of my bathroom is equivalent to the width of my kitchen. And yet in the long run a bathroom is a simple thing for which numerous models come to mind. We have before us, then, a doubly determined length. The latter is even overdetermined since my kitchen's width is itself equal to the width of the elevator shaft, the landing, and the stairway added together...

Relevance of measurement, dimension, levels, system, overdetermination, and model indicate some of the major interrogations on questions of measurement in architecture. The term scale is ever ready to refer to them through a system of polysemy that seems inherent to it and that is destined to express through words, as a shortcut, facts of measurement which are highly complex.[6] The first of these facts is that of the project

which must, as such, shift onto reality. It is an issue of scale. How is the project to be articulated through reality, through real space: the question of shifting.

Question of project: scale as shifting

So we are then concerned with the question of measurement.[7] But, right from the start, we run into an important epistemological problem. The term measurement must be understood in a different manner whenever it comes down to thinking it out in the field of architecture. Taking the measurements of a building does not differ in any way from everyday measurements as we know them (why not in our bathroom before buying the bathtub), but the measurement in which the architect becomes involved in of necessity[8] for his work has the particular characteristic that the object measured is not given at all a priori. Instead, he must give measurements to an object that as yet has none. What is at stake here epistemologically? It is necessary to think out this measurement outside the context of problems it gives rise to elsewhere, as in physics or geography; and irrespective of the real complications involved, though perhaps of a different nature, in thinking it out in the above-mentioned fields.[9]

We shall not deny here that – over and beyond the problem of the tub, which though it represents a special situation it is as real a situation as those encountered by the architect – the geographer or the physicist themselves will not run into difficulties (some of which are even found in architecture) in thinking out measurements. The first will select theoretically relevant dimensions for the territory he intends to explore. The second will take measurements with infinite care while at the same time being unable to reach the infinite; for dipping the thermometer into the liquid will automatically change – however minimally – the temperature.[10]

As in the case of the tub, all of these questions can confront the architect himself. With respect to a natural or urban site they can involve, for example, the problem of selecting the relevant dimensions on the one hand, and problems concerning the instruments for measuring used, on the other. But however important these parameters might seem to be – such as the graphic scale chosen by the architect for his drawing or the pernicious effects of the so-called "crane-route" architecture – and whatever need both geographer and physicist might have to set up theoretical models without which they would be unable to take measurements and with which they can confront reality in order to test the model's validity, they are all dealing with a given, whose measurements they will then proceed to take. The architect however, is going to have to give measurements to the building. Nothing will affect this process even if the surveyor, the aesthete, the art historian and the critic proceed to take measurements with respective aesthetic or metric gauges.[11]

There are cases, however, when an architect may be called upon to inscribe his design into an architectural given: The Gare d'Orsay is one such case whereby the architect had to change the given station into a museum (the question concerning the thermometer would indeed be raised here: To what extent did the measurements of the 20th century architect distort those of the 19th century architect?). But this situation, however frequent, is also very special; and, in any case, the architect is going to have to, in the given context and no matter what, give measurements to her project. This is why it becomes imperative to distinguish between two classes of measurements: those which are given, such as the site, the materials, the programme (usages, costs, etc.) and many others which range from construction site tools to graphic instruments. And then there are those which emanate from the designer's intentions and work, regardless of how successful the result is.

From the epistemological point of view it is the second group that seems to raise a major problem. We know that the physicist is

> motivated by the deep conviction that nature, in spite of its apparent complexity, obeys principal laws that are simple and general and which our mind is capable of discovering and analysing.[12]

However, this confrontation with reality could not serve, in[13] principle, as driving force for investigation by an architecturology or, in more general terms, by a science working on the the artificial. In the event that a science has to deal with the artificial it is difficult to envision

the «reality» to which it can refer for confirmation (or invalidation) of its models. By definition nothing can be taken for granted. The very idea of a science of the artificial would tend to weaken and be replaced by creativity, and the designer's imagination and free-will, should the artificial fail to implant itself in a given reality. In the face of unlimited possibilities for creativity a place for a science of the artificial can take form.

In architecture, givens do exist: the geographic site, natural or urban; the technical and financial considerations; the history of architecture itself with its assemblage of edifices and models; All the environments in which the artifact which the architectural object will find itself, whether those environments are taken into consideration or not during conception. By this fact alone, the class of givens moves over to that of intentions because the taking into account of the givens passes through the design of a project. Whereas the physicist's model is 'confronted' with a reality (in conventional situations), the architect's (or, usually that of the designer of an artifact) would be described as "shifted" onto the real. And it is precisely this shifting that converts the issue of "the scale" into a problem for the architect and into a series of questions for architecturology. Let us assume that the shifting represents only a problem for the cartographer involving, for example, the graphic inscription linking the map to the territory, that is, to its own referent. But the shifting cannot be treated in the same terms in matters concerning the architect since the latter is by definition, deprived of a referent. The architect finds himself in a project mode, in which he has to deal with the problem, or rather, the problems of scale through which he must carry the project so that it is gripped onto the real. We encounter here one of the meanings of the term scale: the scale of the map is tantamount to shifting the latter onto the territory.[13] But supposing that for the cartographer the shifting involves a problem of conventions (I am simplifying here and I apologize for it), for the architect the problem presents itself in terms of conception.

Obviously similar givens exist potentially in infinite numbers. The most common one is perhaps the parcel on which the architect is going to build. Its influence can be decisive to a lesser or to a greater degree. Thus, we have the Flat Iron in Manhattan that is informed by its parcel, and Palladio's Villa Rotonda in Vicenza which, at that level, is in total contrast irrespectively of the non-historicism of such a proposition whose theoretical value, as I see it, is not diminished in any way. Even if we exclude the genius of Palladio or the fascination of Manhattan there still remains the possibility of establishing a major theoretical distinction between two architectural objects and their design on the basis of a parcel that does or does not inform the measurements of the object. The same holds partly true for the difference between Le Corbusier's plan Voisin for Paris and the parcellar distribution in the Halles which he wants to replace.

Let us call parcellar scale that which, characterized by the parcel, will inform the building. The variety of modalities for such information will be maximal. Nevertheless the parcellar scale will not be reduced in any way as a fact which acts as a constituent element of conception. Piazza Navonnna inherits its morphology from the Roman circus. The Flat Iron draws its form (and name) from the pointed parcel on which it is constructed at the corner of Broadway and 5th Avenue (Fig. 14 of my preceding article). We also have before us a radical difference between the traditional city and the Great Ensemble. The first corresponds to a parcellar scale and the second to a geometric scale. Let us take care not to consider these spaces of reference as "constraints". With a few exceptions it is up to the designer and his intentions to put them into play in an active manner in the realm of conception. They are all modes of shifting.

With respect to the above kinds of constituent measurements, it would seem that we find ourselves at a rather considerable distance form the geographer or the physicist. The architect, indeed, has to deal with a reality, which he appropriates (as does the client) and which is dependent on his representations of the same reality. And it is onto this – represented – reality that he is going to "shift" the design, whether he is dealing with a visible, social, economic, or geographical reality. One aspect of the full tenor of the term "scale" is that of designating the variety of the references that will enter into play in conception. Compare, for example,

the variety of references of a social order accounted for by Jean-Pierr Martinon in the article that follows.

But what can justify reducing such a variety to the single term scale ?

Question of measurement: scale as relevance

The reason I have attributed a central role to scale in the aims of architecturology is in connection with a heuristic hypothesis relative to the scale. It is here that resides the difference in the manner of thinking space for geometry and the other manner – to be studied by architecturology – for architecture. For the architect's cube is not the same as the geometrician's: it has a measurement. The cube's dimension is of no interest to the geometrician whereas for an architect a 3 meter as opposed to a 30 meter cube are not the same thing. As Valéry puts it in his Eupalinos: »Everything changes with size».

The formula disputes the validity of the invariance of scale of scaling figures propounded by the mathematician Mandelbrot. Those figures are not rejected per se, that is, as mathematical figures (In my view fractal objects provide a better example)[14] which continue to contribute to the construction of a geometric space without scale, the same one invented by Thales. Michel Serres has described well the beginning of Thales' invention, but when he states that Thales invented the scale, the scale invented is very special since it establishes the similarity of similar triangles and denies their difference, a difference which in the architect's eyes corresponds precisely to the difference of scale. For architecture, triangles are not similar, could not assume the same meaning, or have the same relevance.

The geometrician's scale – which is also the cartographer's – implies a proportion which, inversely, requires the scale. The architect and, in his own manner, the cartographer use scale also for the purposes of representation; however, at the level of conception the geometrician's and the cartographer's scale has value only as a false representation of the work of conception. It is Viollet-le-Duc, as the first to make a distinction between scale and proportion,[15] who writes that «in architecture, one cannot say that 2 is to 4 as 200 is to 400».

Nevertheless it is necessary for the above difference to be made clear for the scale, which was barely perceived by Vitruvius, denied by Leonard de Vinci,[16] understood by Galileo, undetected by Quatremère,[17] was not that clear even for Viollet-le-Duc (and extended so far as the aporia of Le Corbusier's Modulor).[18] The conceptual distinction is so difficult to accept and the paradigm of proportions is so imbedded in our minds, that the scale ends up designating the relation of similarity that is responsible for the elimination of all distinction ... of scale. Even Poincaré will fall victim to this effect by imagining a universe with doubled dimensions while failing to consider the repercussions due to the differentiated growth of diverse parameters.

Viollet-le-Duc explains well a major difference between Greek and Roman architecture: he tells us that the first does not have a scale since the temple will proportionately reduce or increase its parts according to its small or large size, whereas the Roman temple whether small or large will not change certainparts, such as the steps or doors, which are determined by human measurements and vary in size no matter what the dimension of the temple may be. But that does not imply that the Greek temple can expand indefinitely without encountering difficulties since, as Galileo showed for the skeleton, it has constraints imposed by the scale.[19] Neither can the temple be without a scale; contrary to what Viollet-le-Duc maintains, it cannot be just pure geometry.

But the question is not even limited to the considerations on the scale as formulated by Galileo: supposing (as Poincaré might have done)that it would be technically possible to carry out a purely geometric enlargement of architectural space into a limited architectural space, the fact that this space could be drawn on paper and freed from technical constraints, as Boullée lets us imagine, it would not mean that the resulting effects created (optical, symbolic, etc.) would be the same. This obvious fact merits a reminder if only because it indicates that the questions of scale in architecture cannot be limited to the kinds of problems raised by Galileo (in architecture it involves a specific case of a technical nature which I refer specifically by the term technical scale) and that Valéry's «all changes with size» encom-

passes mutiple difficulties whose technical aspects represent but one part. Whatever the proportions a temple might have, a size is conferred to it: how? For example, in the case of the Parthenon, if Doxiadis is correct, it is a view angle which determines its size. In architecturological terms this means an optical scale,[20] or else this means a certain relevance within a potential multiplicity of cases. We can therefore speak of diverse scales since the possible relevances are multiple.

But here our problems are not over for Valéry's proposition, however superb, is false.[21] To begin with, within certain limits, within certain the temple can be more or less large andnot everything changes with magnitude (otherwise all models would be excluded). But what is even more serious about the Valerian proposition is that it might be interpreted as if the change were a function of the magnitude. This magnitude (size, dimension, whatever) is supposedly a parameter[22] as if the scale existed in and of itself, as if it were a graduated ruler, in short, as if the scale existed in the singular, measuring «the» magnitude. But the size here cannot exist as such, independent of the multiplicity of heterogeneous scales through which the architect articulates his work.

So we need to examine this graduated ruler since that is the common name covered by the term scale, a term initially defined in the following manner by a famous encyclopedia – since it was the first – and to whose author the present one renders a tribute:

> In geography and in architecture, a scale is a line divided into equal parts and placed at the bottom of a map, a drawing, or a plan to serve as a common measurement for all the parts of a building or for all the distances or places in a map.

The psychologist's and the economist's scales are also graduated rules. As can also be the musician's.

Even though we find ourselves far from the semantic implications that the architect attributes to the term scale scale when he uses it and which originates in the multiplicity of factors that he is managing, it is worthwhile to ask ourselves what is at stake in this "simple" graduated ruler.

As the cartographer, the architect is going to draw at a given scale. But individually, each will choose such and such a scale deemed to be most "relevant". Nevertheless, the referent of the representation is not going to change because it is supposed to remain identical in all cases. Yet out of the possible infinite scales of representation a choice will enter into play in relation to the estimate made on a relevance of measurement.

In spite of the identical referant the choice of scale corresponds to a point of view that changes the nature of the scale. The angler with line and hook, the customs official and the navy officer will not deal with the coast of Brittany on the same scale and their different points of view would produce maps at different scales since the relevance of one's ideal measurement does not necessarily correspond to the other's. Whenever a point of view participates in the constitution of a known object the resulting object will not be the same. But the perfect correspondence of the measurement found cannot be taken as a mere accompaniment of the measurement or as a simple improvement. Such correspondence in the measurement is precisely what constitutes it. B. Mandelbrot has shown that the coast of Brittany is of infinite length if you begin to reduce the unit of measurement. This is why not only does it make sense to choose a "good" unit of measurement but also it is impossible to have a measurement without that choice. Without it the coast of Brittany is not measurable. Since this choice does not belong to the realm of mathematics[23] we are obliged to put forth the the relevance of measurement as a key concept for the study of the measurement in architecture.

We then have the crucial notion of overdetermination (architecturological)[24] since the multiplicity of possible relevances can affect the one and same measured object: minimally, the length of a lintel comes at the same time[25] from a measurement complexity of a technical nature (spanning/bearing) and a functional nature (passageway). It follows also from the above that the limit of an attributed measurement can depend on a given relevance or on another: the skyscraper can find a limit in height that may be induced not by the technical capability of realising such a structure as we might expect, but rather as a result of the number of

required elevators to service it and whose area of occupancy must not exceed... that of a floor.[26]

Question of system: scale as hierarchy

Thus, as to the essence-oriented question raised above, "does the scale exist?", we have to answer no. As the relevance of the measurement it holds an infinite variety of possibilities. By its very nature it is multiplicity and therefore irreductible as such to a single principle, unless the latter is arbitrarily imposed. An example would be the graduated ruler without any precaution taken with respect to the gradation.

Moreover the above variety is limited not only to the multiplicity of possible relevances but it extends also to the multiplicity of shifts. Let us ask once again how the architect's cube is measured. Let us admit that the cubic form originates in the artist's private sense of aesthetics over which we have no rights. The fact remains that the cube can be shifted onto in at least three different manners, depending on which of the three – length, depth, or height – provide the support for the shifting.Here, we also have to deal with the concept of dimension in addition to the concepts of relevance and shifting which I mentioned above.[27] From architecturology's perspective, understanding the concept of dimension requires that it not be confused with dimension understood commonly as volume, or with dimension in its mathematical meaning.[28] A cube whose measurement would be determined because of its depth is a single dimension architectural object. But it can have three dimensions should three measurement choices have been carried out independently of each other and if they converge on an equal level with respect to the three measurements involved (for example, an aesthetic point of view concerning the width, for a front view, a technical point of view concerning the depth, in cross section, and a functional point of view concerning the depth, in plan).

Thus, the architectural cube can evolve from a rather high number of different architecturological theoretical cases, even when we limit all of the possible dimensions to the sides of the cube and eliminate other and yet possible types of dimensions such as diagonals or sets of sides. The latter case is quite plausible sinced Le Corbusier's "maison des artisans" provides us with an example (the constituent dimension of that building is a horizontal diagonal).[29] It is furthermore possible to find architectural objects with four dimensions, such as a pool whose width, length, and depth on the shallow and deep ends are decided on separately.

All these examples chosen on purpose, illustrate the complexity of the facts of measurement once one adds (in a plausible manner all types of connections governing the dependency between dimensions and the values attributed to them by the designer (or the client, or the social or regulatory context) and which constitute the architectural object finally designed as a system (here the term designates merely a set of elements linked to each other). The well-known relation "of the whole to the parts and of the parts to the whole and of the parts among themselves" mentioned in all architectural treatises from Vitruvius to Venturi ("the heavy obligation of the whole") enters into play here.

But in spite of its internal complexity the idea of system leads us back to the question of unity. Very often a principal dimension will determine the place of the others."With the height given, the width flows from it" (Le Corbusier).[30] In that case, the architect speaks of scale, in the singular.[31]

I have drawn attention to the probable complexity of the system linking measurements among themselves and to the multiplicity of scales. However, the use of the term scale in the singular remains to be interpreted, an interpretation which can be done in different ways.

I shall single out three of them. One way is for a general rule to impose its structure to the whole from a given point of view. Thus Durand supposedly would have wanted to see built a round Pantheon since, as he put it, it would have cost less to the Nation. Such a conception falls under an economic scale. Architecturology will describe that situation by saying that the global scale is constituted by a particular scale – economic in this case –, or by a special relevance.

Another way is for the organization of the measurements among themselves to produce a resulting scale through the comprehensiveness of the approach to a

perception interpreted in a gestalt manner. As examples of a scale produced by such structuring we have the scale of a Savoyard village, a Moroccan douar, a pueblo village, or the scale of Manhattan or that of Leningrad. The scale in these examples has nothing to do with the economic scale of the Pantheon or with the parcelar scale of the Flat Iron building.

These two first cases are in fact opposed depending on whether the whole determines the structure of the parts or whether it is structured by them. The first case is initiated by the whole "W" the second by the parts "p".

We shall now see that the third possibility starts neither from the whole nor from the parts but rather from their reciprocal interactions It is only under such a situation that we shall speak of system in the strong sense of the term.

The model/scale system

Although above all interested in drawing the reader's mind away from the preponderance of geometry,[32] I have nevertheless spoken about the cube and shown that the architecturological cube was not the geometric cube. And I have done so in order to clarify architectural conception through that model. In fact it is highly unlikely for an architect to have to manipulate cubes or triangles (even if such is the case at times). That is why I spoke of an architecturological cube – not an architectural one –, that is, a theoretical model intended for a better understanding of the particular reality that architecturology is seeking to comprehend: architectural design. As in any theoretical model it too abstracts reality[33] but it is important to know how far the degree of such abstraction is suitable. For the interest of a model lies in its capacity to provoke a critical examination of itself.

Rather than cubes or other triangles or pyramids, the architect does manipulate models corresponding to models bestowed on him historically. Pei's pyramid, situated as it is in the Louvre, is not of geometric but of historical origin. Alain says, probably too didactically, that "every boat is copied from another boat". Regardless of what type of scale he operates through the architect is going to shift his model onto reality using one or a set of scales. But the model in question already has a scale as a result of its historical existence (I include here both great History – the Pyramids – and the lesser history – the neighbour's house). In other words the architect is going to shift a scale (or, rather, a set of scales S2) onto a model M1 itself initially endowed with a scale S1 (or, rather, a set of scales) and he is going to produce a new model M2. The preceding may be formulated: M1(S1) – ->S2 – ->M2(S2).

The range of possibilities available for the play of conception between S1 and S2 is considerably broad. The variety is high enough to allow a number of remarkable examples to stand out. Should S1 be equivalent to S2 then we are in the order of the copy. Every boat is not necessarily copied from another, but it can happen:doesn't San Gallo build approximately the same portal as Brunelleschi ninety years after him on the plaza Santa-Maria Annunzziatta in Florence. But more fascinating still is the case where S2 is opposed to S1. This is illustrated by Pei's pyramid which from the point of view of the technical scale replaces groundedness with lightness and, with respect to the constructive principle, weight with structure. As for the effects of "greatness" which seem to fascinate so much the authors of Treatises on Architecture they presuppose an application of S2 with respect to S1: Loo's column for the Chicago Tribune competition with the height of a skyscraper.

Epistemological questions: scale as question

"It is then necessary to take up the question again and treat it thoroughly because it merits such consideration", thus wrote Viollet-le-Duc at the end of the preamble to the article Echelle in his Dictionnaire. He had been disheartened by the fact that his previous remarks – as was the case with those of his fellow scholar Lassus – had not been "heard". To treat questions or to ask questions involves two different things. In one case we find ourselves in an architectural discourse, in the other we move over to an architecturological one.[34] One will have noticed that in this article I have not «treated» the question of scale. We have not looked for any type of «essence» of scale in accordance with Popper's principle of anti-essentialism which is

> never to give in to the temptation of taking seriously problems concerning words and their meaning. What must be taken seriously are those questions which concern facts and the affirmations on those facts; that is, the theories and the hypotheses; the problems they solve and the problems they raise.

What we are attempting to do here is to ask the principal question for architecturology: "how does the architect give measurements to space?"

It is the scale of course that gives rise to this question since it enables me at first to point to the impossibility of reducing architectural space to a geometric space, however readily available the latter may be to account for the former.[35] So it is through the heuristic advancement of architecturology that scale emerges as an object of study and that is what is of interest. A second area of interest, also of a heuristic nature, resides in the diversity of facts of measurement characteristic of architectural work which it forces us to identify. This approach is necessary due to the variety of modalities covered by its polysemy[36] and due to the complexity too briefly described here with the help of a few notions such as shifting, dimension, overdetermination, and which we find among many others too numerous to include in this article.[37]

The above notions generate true questions that may be asked of architectural design: How does the project accomplish the shifting? What are its (architecturological) dimensions? Where do we find the overdeterminations? Here, we are not treating the question of scale in architecture nor are we studying what certain authors view as a "formal invariant" in architecture or even as a "conceptual invariant". Neither is it a matter of proposing a representative model of architecture, although the epistemological difficulty involved here, is, as real: thus, Philippe Deshayes writes:

> In the field of architecture we encounter the same problem as that raised by G. Canguilhem in biology, namely, that it is more difficult in that science as opposed to physics to resist the temptation of attributing to a model a value of representation.

In line with the above considerations by Philippe Deshayes and G. Canguilhem we can identify a posteriori models which belong to the order of a representational epistemology – a conception of knowledge as image and worldview,[38] and a priori models which belong to a constructivist epistemology.[39]The

> concept of scale, central for architecturology... results from a theoretical effect involving a priori constructions ... whereas from another point of view it is an actual problem for the architect and, consequently, is subject to the problem of the representation of his work.[40]

Though the architectural scale is a question that that the architect asks himself,[41] the architecturological, or,rather, the whole of architecturological scales are in turn questions asked of architecture, questions that will likely add a degree of differenciation to the fundamental question: »how does the architect give measurements to space?» The fact that scale may have for architecturological work a function close to that played by G. Holton's «themata» which, according to him, support scientific work, must not overshadow the rupture that transforms the scale in architecturology into a set of questions to be raised, with it no longer being a question to be treated [42]. At this level we leave architecture in order to enter into architecturology. We abandon architectural space and turn our eyes toward architecturological space. The difficulty resides, however,in the fact that the first is not representative of the second.

The architecturological space

Constituting architecture as an object of knowledge means building an object[43] different from architecture and to which we shall give the name of architecturological space. In other words it is the space of conception seen as different from the architectural space (space of perception and usage) and approached from the point of view of measurement.

Since it is different from geometric and architectural space, what can we say at this stage concerning architecturological space since its existence, in principle, has been demonstrated here through the type of architecturological cube described herein?

There was one question among all those referred to throughout the texte and mentioned with respect to the tub which has remained unasked: the question of

levels.

"At the level of", "on a scale of" are expressions which are often interchangeable. They are governed by a paradigm of representation in which the plan has an important function as regards both the cartographer and the architect; the plan is intrinsically linked in its representative power to a scale. Brunelleschi's architectural space and the perspective which he invented are bound to each other and the scale determines the dimensions of the perspective. With respect to Ambrosi Lorenzetti's Annunciation to which Panofsky attributes a "considerable importance" that "resides in the rigour with which for the first time an artist forces the visible perpendiculars of he plan to converge on a unique and same point", the author further writes that "the checkerboard pavement thereafter flows under the figures, thereby providing a scale for all spatial values, that apply both to the bodies themselves and to the intervals".[44] Though historians are often tempted to retrace the birth of architecture back to this Brunelleschian and Albertean period, this form of the architectural space was preceded by others and represents a historical moment only. But the idea of scale as level is closely related to the cartographic representation, or perspective, that accompanies it. In such a case the levels become subject to the cartographic paradigm without there being any need for that space whatsoever. The segmentation of the architecturological space into levels does not proceed from from either cartographic levels or scale.

A plan, such as Alvar Aalto's for the Turun Sanomat newspaper building is for me a model of another type of model, a model without module. It is characterized by a multiplicity of scales. The multiplicity does not correspond to a unique event in his architecture. When asked "What is the module for this office?" – Aalto writes that he said "I did not reply because I didn't know". If we consider the brick facade of his house in Muuratsalo, it also escapes moduled network. Extended more generally to his architecture, we see that it consists of a space whose multiplicity of view points goes counter to the single point of view of the perspective. I have shown elsewhere how his vases are an illustration of such multiplicity.[45]

Alvar Aalto forces us to give relative value to the idea of a natural (so to speak) architectural space reduced to the essential and defined by its general isometry; one that Mies van der Rohe pushed to the limits. But such a space needs to be considered from within a perspective that is historical. So its value is not natural. To think through this "built" space, built by the architect that Brunelleschi was, means calling into question the presumption of singularity of scale.[46]

The rupture between architecture and architecturology at the point of scale proceeds basically from a classical distinction between object and object of knowledge. It is eloquently expressed by Descartes:

> Although every architect knows that he knows the art of building, such a consideration is not indispensable for him to be actually an architect.

It doesn't matter that here escartes was thinking less in terms of architecture than its use as a metaphor for a more general knowledge. Yet, instead of using the reciprocal effects of external sciences[47] as a means to gain better knowledge of architecture – even though the examples chosen were based on an architectural metaphor – the question for architecturology would be to produce a basis of knowledge to enrich the general epistemological landscape other than in a metaphorical manner. I maintain the hope that while I have limited myself to an examination of the architectural field from an architecturological vantage I will have raised questions concerning scale in the minds of those representing other disciplines. For, it seems to me, scale, however often it is used, is seldom questioned.[48]

Notes

1. Cf. P. Boudon, Sur l'espace architectural, 1971, Paris, Dunod, which proposes a transfer for the object of knowledge of architecture, taking it from buildings toward the work of conception (and not towards the method as had been advanced by C. Alexander and others). Several articles in the present work emphasize the importance of this point of view.
2. Cf. G. Bachelard, Essai sur la connaissance approchée, Paris, 1973.
3. In a review of my work Richelieu, ville nouvelle, the aut-

hor criticized me for not having thought about associating these two measurements, but without a justification as to why such an association is necessary. Yet the work did refer to the importance of the relevance of the measurement. Unfortunately, the history of art sometimes makes use of the analogy as a too hastily used tool.

4. Cf. Christopher Alexander, "La ville n'est pas un arbre", Architecture Mouvement Continuité (today AMC), 1967, No 1: In this very important article for the theoretical reflection in architecture, the author opposes the arborescent schemata of "tree-like thought" of the architect to the "semi-latticed" outline that is more representative of the traditional city.
5. An excellent example of autonomy of measurements is provided in Saint-Pierre en Voluwe (Belgium) by the medical student's building of the University of Louvain-la-Neuve by the architect Lucien Kroll. There, the dimension of the windows are freed from subordination to the repetitiveness of the main structures which characterize modern architecture and extend to buildings from the most squalid low-rental housing developments to the superb Mies van der Rohe buildings.
6. Reducing theoretical work in architecture to this particular aspect of measurement emanates from an unusual epistemological position in this field. In architecture, "theory" generally focuses on the Whole of Architecture.
7. Quatremère de Quincy had understood the general nature of measurement in architecture but he reduced it to Proportion alone.
8. In spite of its specific nature the measurement constitutes a necessary and permanent fact of architecture through its historical and cultural transformations an as such, a theoretical object of general value. But that has nothing to do with the Shakespearean title of a recent publication: "Measures for measures" ("MeasureMENTS for MeasureMENTS" would have been a better title!) following the symposium «L'Architecture en question», where I gave a presentation entitled «Measurements of the measure». The Shakespearean title of the book missed the question! Translator's note: Philippe Boudon wonders whether the English «measurement» does not convey better than the French «prise de mesure» the fundamental idea that the measurements are determined, and not taken, by the architect.
9. For a cross-disciplinary approach cf. Les difficultés de la quantification de la mesure, published under the direction of J. Parrain-Vial, 1981, Paris.
10. We recognize, even at a macroscopic level of classical physics, that any act of measurement applied to a system upsets it up to a certain point." (A.M. Munn, Freewill and Determinism, London, 1960).
11. To make myself clear, I start here with the conventional representation we may have of these fields. The same perhaps does not apply exactly to present-day physics which I do not take into consideration One might imagine, however, that through the "New Alliance" (Prigogine and Stengers) we might come accross epistemological questions criss-crossing between physics and the sciences of conception or architecturology.
12. Cf. J. Bok, "Un modèle d'auto-organisation", in Colloque de Cerisy, L'auto-organisation. De la Physique au Politique, Paris, 1983, p. 72, and D'une science à l'autre, under the direction of I. Stengers, Paris, 1987.
13. cf. P. Boudon, Une architecture mesurée, Critique, p. 476–77, janvier–février 1987.
14. In an article in Débat ("Les fractales, les monstres et la beauté" mars, 1983) the mathematician B. Mandelbrot examines the architecture of the Opera and holds it to be a fractal object. Unfortunately, as I have shown (cf. op. cit., footnote 13, above) the former does not offer at all the characteristics defining the latter according to the author himself. This assimilation between figures (without scale) and real objects (endowed with scale) indicate the limits on applying mathematical models to architectural objects. Cf. the drawing at the end of this article.
15. Consult the two individual articles, "Proportion" and "Echelle", in his Dictionnaire de l'architecture française du XIe au XIVe siècle (1854), which remains as a major work on theory in architecture.
16. Vitruvius states that reduced models cannot find confirmation for any given operation in the functionning of normal scale models.I intend to show in what follows that this conclusion is false." Cf. Carlo Pedretti's introduction to the collective work Léonard de Vinci, ingénieur et architecte, Musée des Beaux-Arts de Montréal, 1987.
17. "Proportions are nothing but calculations of measurements."
18. Galileo was the first to point out that things changed from one scale to another even though the models could appear similar:"Note how from these demonstrations it becomes clear that it is impossible either for the art, or for nature itself to increase their constructions to enormous dimensions; thus it would be impossible to build vessels, palaces or temples huge in size and whose oars, yards, beams, keys, and, in short, all other parts would still hold together.» See the concluding drawing in the foreword (Discours concernant deux sciences nouvelles, Paris, 1970, p. 170). The technical questions of scale of this nature are of major importance of course in architecture, but are not the only ones.Even today still, the idea of an invariance of scale remains so strong that the physicist is obliged to rectify it:»As the physicist G.Weisbuch stated in a debate at the Colloque sur l'auto-organisation

in Cerisy-la-Salle (cf. op. cit. footnote 12 above):»Contrary to what could be expected the invariance of the scale is not the rule.» Curiously the author adds something rather telling for me:»It would be interesting however to study systems with an invariable scale», and he refers then to B. Mandebrot's fractal objects. Would the reason for this lie in our inability to study the variations of scale? It is true that the question of the mutual independence of forms and dimensions of geometric figures creates difficulties in physics As a result of this «fact» which according to A. Koyre «forms the foundation of Euclid's postulatum», La Place «finds an analogous example in the Newtonian world» (Koyré)»Should the dimensions of all bodies in the universe, their mutual distances and speeds come to increase or decrease proportionately, they would trace entirely similar curves to the ones they now form; the universe thus reduced to the smallest imaginable space would still offer the same appearances to the observer. Consequently, these appearances are independent of the dimensions of the universe.» (Laplace, Système du monde, V, 6) As reported by Koyré again, P.-M.Schuhl shows how Poincaré allowed himself to be misled by such a thinking experience (cf. P.-M Schuhl, «Le thème de Gulliver et le postulat de Laplace», in Journal de Psychologie, 1947, N°2) should we extend the mutual implication of form and scale to the occurrence of the couple organizing-organized to which J.-L Le Moigne attributes enormous importance with respect to conception?

19. Cf. preceding note.
20. Cf. C. Doxiadis, Raumordnung im griechischen Stadtebau, Berlin, 1937, Londres, Cambridge (Mass.), MIT, 1972.
21. False, not because of Valéry's supposed ignorance but because he is pushing as far as possible to get the idea of the question of scale accross (see footnote 23, which points to the difficulty involved). It is indeed a "capital correction", according to the expression used by Jean-Louis Le Moigne for the title of his article.
22. If you believe that science is possible only for the sake of the measurable it is always tempting to remain confused and hold the scales to be "parameters", an attitude that deprives you from understanding the work of conceptpion. Cf. also D'une science à l'autre, op. cit., p. 102.
23. Op. cit., footnote 13.
24. Obviously, I use the term neither with a Freudian nor a Marxist connotation.
25. As regards the use of the term "at the same time" I refer the reader to the importance attributed to it by Jean-Louis Le Moigne through his emphasis on the role of the conjuction in the designer's thinking, as distinguished from the analyst's who tends to focus, if we may say so, on disjunction.
26. Even if the problem could be solved by a simple regrouping of lifts allocated to given floors, that does not affect in any way the "eidetic" value of this example.
27. With Peano and Cantor we have an example of how the concept of dimension created major problems in mathematics and led to fractal dimensions, so that it is no longer possible in mathematics to maintain that the mathematical dimension is "natural".
28. It is meaningful to note that Moore and Allen begin their work Dimensions (French translation "L'Architecture sensible, 1981, Dunod, Paris) with some considerations on the mathematical notion of dimension. The architect always has recourse to the mathematical paradigm in an effort to think architectural space, in spite of the inadequacy of the model in question.
29. If we enumerate the possible cases for the sides, facades and facade diagonals, or cube diagonals, we come up with at least thirty-three.
30. Cf. Le Corbusier, Précisions sur un état présent de l'urbanisme et de l'architecture, Paris, 1960.
31. My purpose here is not for the scale to be taken as a unique notion with respect to perception. My comment addresses the problems of conception which relegate the scale to a necessary plural notion, as I have attempted to demonstrate. When considered instead as an aesthetic notion, the scale must be understood in my view as a kind of isotopy with the change of scale corresponding to a change of isotopy. But since I do not wish to treat here this type of question of different order (aesthetic) may I refer you to my paper in the symposium Esthétique et sémiotique de l'espace, Urbino, 1987.
32. Cf. footnote 35 above, as well as many statements made by architects (such as Boffil) explaining that architecture is geometry. H. Focillon has understood the problem well, cf. op. cit., note 1. See Philippe Deshayes on the relation between geometry and architecture.
33. Cf. P. Boudon, "Conception et conception architecturale: architecturologie et science de l'artificiel", in Sciences de l'intelligence, sciences de l'artificiel, Lyon, 1986. For Jean-Louis Le Moigne (on the topic of scientific pratice) "the very concept of modelling is still a new idea". He stipulates that "modelling postulates a priori not only the plurality of conceivable models for the same phenomenon, but above all the plurality of methods of modelling» (J-L Le Moigne, La théorie du système général, 2e ed. 1984, Paris, 1977, p. 14). This question can become quite complicated if extended to the field of architecture. On the one hand, we may consider the architect to be a «model maker» on the other, isn't he a model maker unbeknownst to him? All depends on the concept of a model that we have in mind. In his article here, Jean Louis Le Moigne establishes through the concordance with the real a link between the notion of scale and model. El-

sewhere he writes that «the debate on the "QUALITY" of a model can probably be developed beginning with the notion of "SCALE"» whose nature is fundamental in architecturology and therefore would be in modelling in general.»

34. Cf. P. Boudon, Discours relatifs à l'architecture, Paris, 1987.
35. It is necessary to make a distinction between geometric space as a tool of the architect and geometric space as a model for comprehension in architecturology, a function whose inadequacy is being questioned here.
36. Cf. op. cit. footnote 42.
37. Cf. Ibid.
38. G, Canguilhem, Etude d'histoire et de philosophie des sciences, Paris, 1975, p. 312.
39. Cf. P. Watzlawick et al., L'invention de la réalité, Paris, 1984.
40. P. Deshayes, "Modèles A PRIORI et modèles A POSTERIORI du travail de l'architecte", in La Recherche en architecture, bilan international, Paris, 1984.
41. For example, the chapter "Echelle (scale)" by Charles Moore and Gerald Allen, "L'Architecture sensible, espace, échelle et forme, 1981, Dunod, Paris, in whose preface D. Duke and Philippe Deshayes write : "G. Allen's and C. Moore's 'dimensions' act as a pragmatic echo to the theoretical interrogations of P. Boudon.»
42. G. Holton, L'imagination scientifique, Paris, 1981.
43. Cf. P. Boudon, "L'architecture comme objet de connaissance", in Esprit, "Réveil de l'architecture?", décembre 1985.
44. E. Panofsky, La perspective comme forme symbolique. Paris, 1975.
45. P. Boudon, "Paysage de l'architecture, architecture du paysage", Les annales de la Recherche urbaine, No 18–19, Paris,1983.
46. On the difficult question of the perspective, cf. Hubert Damisch, L'origine de la perspective, Paris, 1987.
47. Cf. P. Boudon, Introduction á L'Architecturologie, Paris, Dunod 1992.
48. It is possible to compare how little attention is paid to the term scale in the index of numerous works with the frequent use of the term in the texts themselves. Insofar as I know only Paul Valéry and Maurice Merleau-Ponty (see my Foreword) seem to have considered this question. Others (Gilles-Gaston Granger, Jean Ullmo, Edgar Morin) at times refer to its importance without dealing with it as an object of study.

Phillipe Boudon (born 1941) is professor at the School of Architecture in Paris-la-Villette, but is also affiliated to the School of Architecture in Nancy and the University of Nanterre. He graduated 1968 as an architect (DPLG, licensed as a practicing architect) from Ecole des Beaux-Arts, Paris, and was awarded his Doctor's degree at the University 5 in Paris 1986. He has been awarded several prestigeus prizes, amonst others the Grand Prix de la critique architecturale (in 1986, from the Ministry of housing) and the Prix de l'analyse architecturale (1984, from the Académie d'Architecture). He has been a guest professor at Harvard (1976/77) and at the School of Architecture in Geneva.