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The Conference Convenors received a total of 44 abstracts. Abstracts underwent a double-blind peer review by two members of the Conference Organising Committee. Authors of accepted abstracts (32) were invited to submit a full paper. All submitted full papers (18) were again double-blind peer reviewed by two reviewers. Papers were matched as closely as possible to referees in a related field and with similar interests to the authors. Sixteen full papers were accepted for presentation at the conference and a further 6 papers were invited to present based on submitted abstracts and work-in-progress. Revised papers underwent a final post-conference review before notification of acceptance for publication in these conference proceedings.

Please note that papers displayed as abstracts only in the proceedings are currently being developed for submission to a digital cultural heritage special edition of an academic journal.

HWANG, Cheng-Chun Patrick
School of Architecture
Chinese University of Hong Kong

Evaluating the rationality of Boullée through the chasm between conception and perception using digital modelling as a method of analysis: a case study on the Cenotaph of Turenne

Abstract

Between 1780 and 1797 French architect Etienne-Louis Boullée began projecting a vision of the architectural monuments during his twilight years through the use of ink-wash drawings on hot-pressed straw paper. The visionary projects embrace both formal simplicity and expressivity simultaneously. While simplicity of form was believed to be the key for ease of apprehending the work, expressivity was seen as necessary to convey the meaning of the form itself. This research presents a study of one particular project produced during this period: the Cenotaph of Turenne 1782, by reconstructing and analysing the unbuilt paper architecture through physical and digital modelling. It seeks to provide an alternative frame of reference to the discourse that evaluates the metaphoric or the iconographic aspects of Boullée's project. The goal of this study is to unfold the stereometric forms and examine the reciprocal relationship between the project's conceptual intention as conceived by Boullée with the effect of the spaces as perceived by the viewer. The paper proposes to investigate Boullée's Cenotaph through the chasm between the concept of the work and its representative images, the apparent and the literal solidity of structure, and the idealized form and the perceived form by the viewer. The research is organized in two parts. The first part aim to forensically deconstruct the guiding principles of Boullée's Cenotaph in order to reveal how the Cenotaph is conceived, while second part enable the reading of how the work is perceived. Although the project is well-publicized in books on Boullée through the five known orthographic drawings, very little has been written about it.

Keywords: Visionary architecture; computational modelling; conception and perception; architectural representation

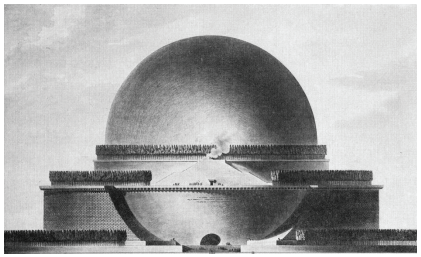

Figure 1. Cenotaph for Newton elevation, HA 57, No.7, ink wash on paper (1784) courtesy of Bibliothèque nationale de France.

Scholarship on Boullée

There are three significant research directions in the literature and scholarship on Boullée:

1) study characterises a strand of research by a group of specialists that focuses on translations and editions such as Helen Rosenau (Rosenau 1953);
2) the historically significant scholarships that attempt to reveal ideas behind his sombre imageries and 'shadow architecture' in Emil Kaufmann (Kaufmann 1939);
3) those that deal with his theoretical contributions reflected in *Architecture, Essai Sur L'Art* (1790) and relate them to a context, for example Antoine Picon has situated the work of Boullée within the sibling discipline of engineering (Picon 1992).

Writings by Boullée and subsequent scholars have addressed his ideas from the *metaphoric* point of view – by associating Boullée's use of stereometric forms as a way to represent the concept of regularity that is found in the laws of nature; and from the *iconographic* point of view – through projecting meaning associated with nature behind Boullée's painterly architectural images rather than substantiate its claim through evidence-based arguments (Rosenau 1953). These reflections are largely formulated upon an overarching argument that Boullée had dedicated a cenotaph specifically for Newton (Figure 1), thus there must be a rational design methodology connected with his works. While his admiration of Newton and reason might be true, it does not prevent us from forming a hypothesis questioning the rationality and perception of his work.

Boullée's treatise: Architecture, Essai sur l'art

Despite the limited amount of his writing, Boullée's *Essai* is undoubtedly influential and is often cited alongside other referenced essays from Vitruvius and Alberti. One important contribution of the *Essai* is that it advocated his views on the *a priori* nature of thinking and picturesque representation over materialization. The stance of prioritising the pictorial image ahead of its technical concern marked a stark difference to the Vitruvian triad (Venustas, Utilitas and Firmitas). Boullée emphatically announced this position in the first paragraph of the *Essai*. 'What is architecture? Shall I join Vitruvius in defining it as the art of building? Vitruvius mistakes effect for the cause' (Boullée 1976, 83).

Nature as the source

Prior to the 18th century, architectural reference to nature is understood to be 'an amalgam in which *imitation* of nature, proportion, beauty and orders were all blended' (Madrazo 1995, 151). In lieu of such 'application', Boullée embraces nature as the source of architecture and order, which is to bring a direct connection between them without mimicking through forms of decoration. Boullée distinguishes himself from Piranesi's arbitrary and whimsical principles of design. He considers Piranesi's engravings to be the work of a dreamer composed of disconnected and scattered ideas with no particular order (Boullée 1976, 86).

Form of nature

When articulating how nature would govern architectural principles, Boullée describes the use of symmetry as a means of generating the image of order and rationality that conveys a sense of beauty and perfection. It allows the mind—which seeks understanding—to comprehend its form. The simple, symmetrical, perfect and regular form for Boullée is the best *iconographic representation* of this understanding. It is clear that Boullée acts upon the hypothesis that there is a rational correlation between simple geometry, nature and the human's perception (Figure 2). The autonomy of architecture through drawing helped to create a distance and independence from its projected building. In this instance, the conceptual project becomes the totality of the work itself.

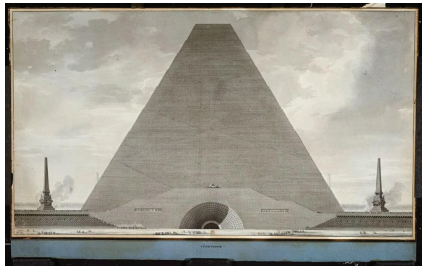

Figure 2. Cenotaph of Turenne elevation, HA 57, No.13, ink wash on paper (1782) courtesy of Bibliothèque nationale de France.

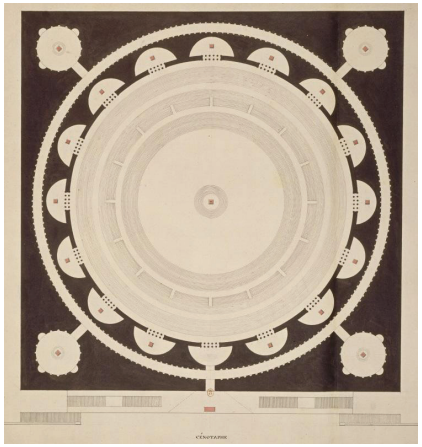

Figure 3. Cenotaph of Turenne Floor plan, HA 57, No.11, ink wash on paper (1782) courtesy of Bibliothèque nationale de France.

Assertion on Boullée's rationality

Boullée's work has been described by Pier Vittorio Aureli as having dealt with the technical requirements of the building as opposed to mere fantasy that embraces the monumental sublime. In *Architecture as a state of exception,* Aureli warns of misreading Boullée's drawings as simply visionary, and calls for a wider acceptance of the view that Boullée has in fact articulated the 'specific conditions' of each project through adopting 'technically inventive and individual approaches to functional, programmatic, and even contextual problems (which) demonstrate a concern for public welfare with its unprecedented provisions for egress in the event of a fire'(Aureli 2011, 142-143). But exactly how did Boullée accomplish that? In the case of the cenotaph, there is certainly no evidence to support such assertion, where the giant spherical space with a span of 160 meters covering some 80,000 square metres of area offers only one means of egress for the entire monument (Figure 3).

Similarly, in Rosenau's *Boullée's Treatise on Architecture*, she notes that 'It would be erroneous, to classify Boullée as a Romantic, since his individualism was based on a reasoned appreciation of function, and ruled by the recognition of the laws of nature' (Rosenau 1953, 12). Rosenau argued that the cypress tree in Boullée's elevation is a good example for his 'endeavor to include the effects and the products of nature in his composition' (Rosenau 1953, 19). Critique and assertion as such addresses the issue of 'nature' through oblique remark and selective examples. As my analysis reveals, the tendency to rely upon the drawings to confirm Boullée's intellectual assertions remains highly problematic.

Tracing the conception of the idealized form

The setting-out of the geometry in 2D section can be read as a composed geometric relationship between the triangle and the circle for extrapolating and synthesising the overall stereometric massing. The diameter (Ø) of the dome is half of the circumference (Cir.) that defines the outer extent of the triangle

(Figure 4). Three-dimensionally it is the interplay of composition between four primitives: pyramid, cone, spheres and cylinders, resulting in forms of subliminal spaces.

Stereometric translation

The first nuanced finding is an apparent 'oversight' between Boullée's theoretical text and its mirroring image. When describing the design for the Cenotaph, Boullée writes, 'I have given the Pyramid the proportion of an equilateral triangle because it is perfect regularity that gives a form its beauty' (Boullée 1976, 106). However, when examined closely, only half of the statement is true. Due to his training as a painter, Boullée was perhaps more interested in the iconographic image rather than the exactitude of geometry. The pictorial representation of the idealized pyramidal body is neither *literal* nor *perceptual*, literal in the sense that the appearance of the 'equilateral triangle' pyramid is in fact an isosceles triangle. The perfect equilateral occurs only in projection (Figure 5). Perceptually, the magnitude and scale of the project prevents a total and inclusive reading of the form when viewing normally.

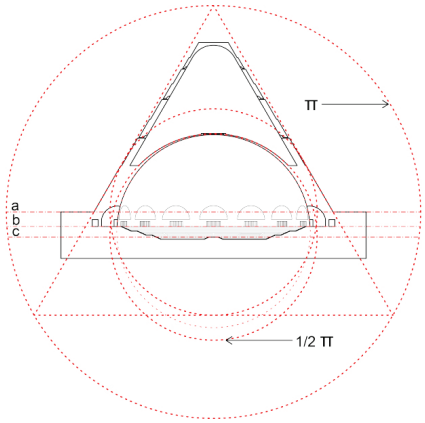

Figure 4. Geometric principles of the Cenotaph of Turenne (drawn by the author).

$$tan\,60° = \frac{h}{a}$$

$$a = \frac{h}{\text{Tan } 60°}$$

$$\frac{\sqrt{(\frac{h}{\text{Tan } 60°})^2 + h^2}}{(\frac{h}{\text{Tan } 60°})^2} = \tan \alpha$$

$$tan\,\alpha = \frac{\sqrt{(\frac{h}{\text{Tan } 60°})^2 + h^2}}{\frac{h}{\text{Tan } 60°}}$$

$$tan\,\alpha = \frac{\sqrt{\frac{h^2}{\text{Tan } 60°} + h^2}}{\frac{h}{\text{Tan } 60°}}$$

$$tan^2\alpha = \frac{\frac{h^2}{\text{Tan } 60°} + h^2}{\frac{h^2}{\text{Tan } 60°}}$$

$$tan^2\alpha = 1 + tan^2\,\text{Tan } 60°$$

$$\boldsymbol{\alpha = 63.435°}$$

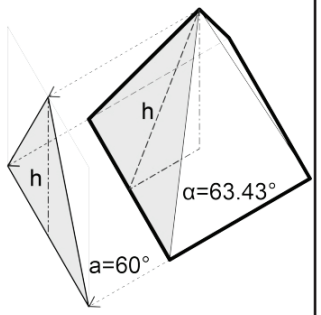

Figure 5. Equilateral pyramidal geometry as established through graphic and mathematical method (drawn by the author).

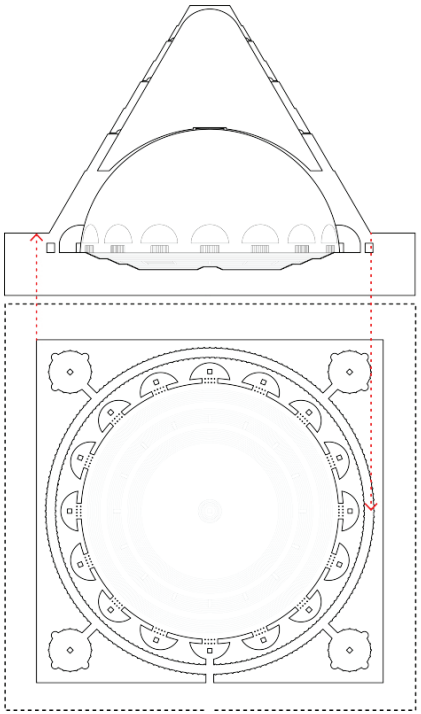

Figure 6. Drawing incongruence between plan and section (drawn by the author).

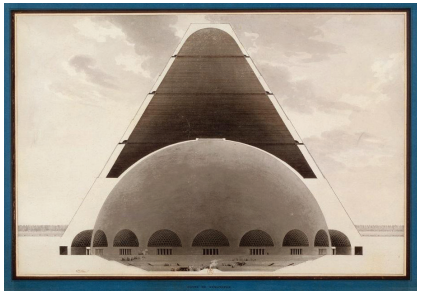

Figure 7. Cenotaph of Turenne section, HA 57, No.14, ink wash on paper (1782), courtesy of Bibliothèque nationale de France.

The figurative poche

It is impossible to match the plan with the section as the perfect alignment between the square boundary of the pyramid and the circular ambulatory does not actually exist. Therefore, the placement of poche is used when different geometries come together (Figure 6). The figurative poche serves as surplus strategy deployed by Boullée as a necessary mediator between the boolean interior form and the primitive exterior shape. Through the manipulation of the poche and augmentation of the massing, the scale of the Cenotaph is further exaggerated.

This manipulation and augmentation is also used to differentiate the construction principles between the inside and outside (Figure 7).

The ambulatories at the base of the pyramid as shown in the section drawing indicate an impossibly thin wall, where the poche's thinning is taken to the maximum extremity. The fact that it appears to support the coffered dome above is defying any structural and material logic—a condition contravening basic gravitational laws of nature (Figure 8). In this instance, the *literal* solidity of structure is disregarded. Incoherence is also evident in the ways the dome is represented. One could read this articulation of the dome as either a section or an oblique elevation, but not simultaneously.

The shadow spaces

A digital model containing geometric traits of the Cenotaph was created in Rhinoceros 3d and rendered in 3ds Max to offer an index for determining the theoretical lighting conditions within the Cenotaph (Figure 9). The simulated model of the Cenotaph was positioned at the latitude and longitude coordinates of Paris (48.864716, 2.349014). It was set up as if the Cenotaph were constructed in half section, therefore allowing natural light to penetrate into the interior space. Given the hermetic composition of the forms, the purpose of the oculus remained unclear. It is more likely that the oculus holds an iconographic reference to nature, e.g. in connection to the environment

and atmosphere, as opposed to serving any literal function.

(re)Forming of an idea

Images in the following section are produced through the *method* of digital modelling to offer a *means* to perceive and to compare the five drawings presented to us by Boullée. In addition to offering alternative point of views of the Cenotaph, the images of digital modelling also differentiate themselves from Boullée's hand drawings by minimizing the sublime dramatization, to offer a neutral depiction of the spaces (Figures 10-13).

What the images reveal refutes the notion of regularity and beauty, since it is perceptually impossible to consume the totality of the space at once. The idea of order resulting from the composition of volumes – which forms a part of Boullée's argumentation – could not be contained within the human perception like the 'picture frame' of a drawing. Therefore, the statement 'The arrangement should be such that we can absorb at a glance the multiplicity of the separate elements that constitute the whole', as stated by Boullée can only be understood *notionally* rather than as something that could be experientially perceived (Boullée 1976, 89).

Perceiving the space

Each image frame is rendered in two focal-length settings: 10mm and 24mm positioned at the eye-level. The first set offers a more inclusive view, the near panoramic vision. However, it presents the target (Cenotaph) in a way that is impossible to perceive due to its expansiveness, similar to those orthographic sections and elevations drawn by Boullée. Instead, it is the second set of renditions, which are the equivalent to the perception of human eye that needs elaboration. In the realm of visual perception, we may consider two contributions affecting one's perception: *objective* and *experiential*. Experiential contribution is understood as relating the perceiver's own-self through *memory*, *experience* and *expectation to* the

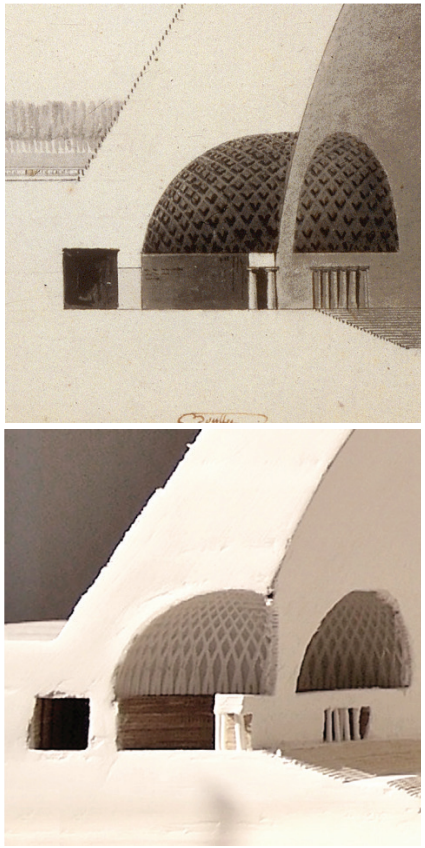

Figure 8. Discrepancy between the partial section of cenotaph ambulatory as drawn by Boullée (left) and the reconstruction of the physical model (right).

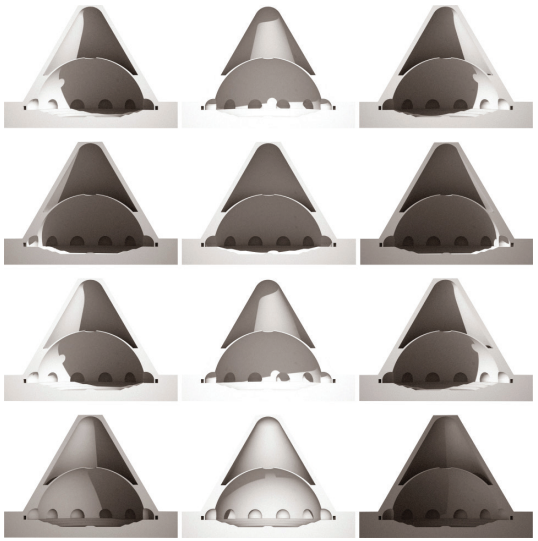

Figure 9. Daylighting study of the reconstructed cenotaph model, images were created in four seasons from top to bottom: vernal equinox, summer solstice, autumn equinox and winter solstice. Three time frames were rendered for each season, from left to right: 9am, noon, 3pm. (images by the author).

Figure 10. View toward the triumphal arch entry shown in the perceptually natural focal –length of 24mm (above) compared with the expansive and inclusive view of 10mm (right).

target being viewed; whereas objective contribution is the literal observation of the thing one perceives. It means perceiving all that is presented before the awareness, it is a matter of seeing things as they are, rather than through tangential experience.

Most people oscillate between these two contributions and are never quite fixate in one mode. I would argue that these contributions may be used to interpret Boullée's work and it is his desire to draw attention from the beholders to perceive the drawings through an *objective* lens: objective in the sense that the presence of the geometric body, whether spheric, pyramidal or conic to fit within the picture as a projected image, was a matter of greater concern than the literal purity of the geometry or the perception of it or within it. He expects the viewers to take the *literal* readings across his drawings by consuming the emotional expression and *apparent* clarity of form and structure it emanates. In fact, the literal reading of the drawing is affirmed by Boullée in the *Essai,* suggesting

his reader consult his plans in place of all possible explanations, for he is persuaded that what should be required of an *artist* above all is not that he explain well, but he execute well (Boullée 1976, 90).

Materializing the space

In addition to the images generated digitally, a physical model was constructed through *sectioning* by layering multiple laser-cut sheets of cards, a process best reflective of the construction logic of the Cenotaph (Figures 14-16). The differentiation between inside and outside is further exacerbated through the use of colour that magnifies the reading of the poche. While the staggered exterior implies a system of unitary construction, the austere, unembellished interior suggests a smooth plaster finish, enhancing the scaleless reading of the surface, and to receive a play of light.

Conclusion

This research project began with the premise to search for an alternative frame of reference for reading and evaluating Boullée's project by investigating the split between the intellectual motivations for how the work is conceived versus how the work is perceived via the idealized form represented through the drawings. The evidence produced and articulated in the analysis—including the challenge of spanning significant distances by the dome, or painting the interior spherical wall with daylighting as if it is a canvas, or the lack of passage for air within the funerary, or an imprecise reference to the use of perfect geometry for the pyramid, or the many inconsistencies and phenomenological impossibilities that lies within the Cenotaph – all points to the fact that Boullée was more invested in the notion of *objective perception* of form in drawing rather than its *experiential perception* in space. In Boullée's attempt to establish a structured-relationship between the concept of his idealised project with an *objective perception* by the viewer, he has largely overlooked the influence of the *experiential perception* (Figure 17) as I have argued for

Figure 11. Rendition within the cenotaph ambulatory with coffer-ceiling, represented by focal –length of 24mm (above) and the expansive and inclusive view of 10mm (right).

Figure 12. View of the cenotaph ambulatory looking toward the rhythmic and alcove-formed circular corridor as represented by focal –length of 24mm view (above) and the 10mm view (right).

Figure 13. Rendition within the cenotaph of the sunken funerary hall as represented by focal –length of 24mm (above) and the expansive and inclusive view of 10mm (right).

in this paper. An analysis made possible through the use of digital modelling tools.

Since the use of computing software became an integral part in the research of architectural heritage beginning in the late 20th century, there are two ways in which the tools have played a role: First, those whom use the software to study and survey architectural heritage sites. Using the collected data file as a way to archive the relics of the city. On another stream, there are those in the likes of Kent Larson, who calls attention to the use of computer-graphic images through the unbuilt work of Louis Kahn with the aim to 'create new imagery that communicates Kahn's unbuilt space as it might have been experienced' (Larson, 2000). What this investigation revealed is, within the two spectra, there lies a third approach where one sees the realization of the rendered images and the models not as an end to itself, but rather, as an alternative perspective to transgress the unchallenged assertion. By all means, Boullée's architectural drawings and treatise should never be studied independently; they support and complement each other and the reader would fail to grasp the intended meaning without oscillating back and forth in these two modes of signification and it would be erroneous to draw a definitive conclusion discrediting the rational basis of Boullée. Asserting the disclaimer is not to render this part of the research trivial or peripheral. Rather, it highlights the importance of defining the lens for evaluating his work. Finally, the long-term research motivation is to build up a catalogue of analysis on Boullée's unbuilt architecture to advance the knowledge of this brilliant 18th century master.

Figure 14. A reconstructed section model exposes the atmospheric effect and daylighting qualities of the cenotaph (Image by the author).

Figure 15. View of the physical model from the sunken funerary ground towards the ambulatories on the left. The enormity of the unornamented surface contrasts distinctively with the textured surfaces of the inner conic geometry on the right (images by the author).

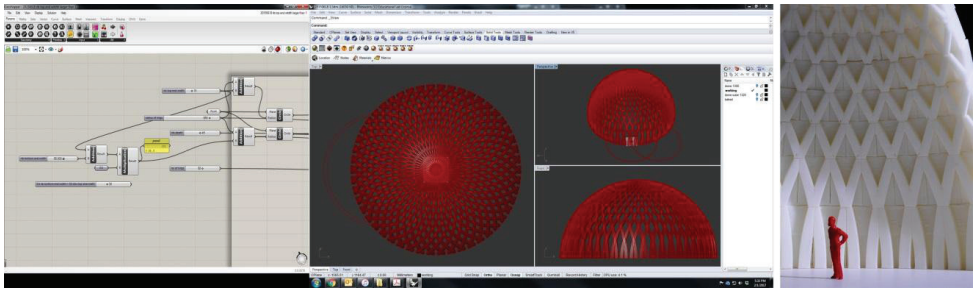

Figure 16. Tracing the geometric origins of the coffer ceiling pattern through parameters established and assisted by Grasshopper (images by the author).

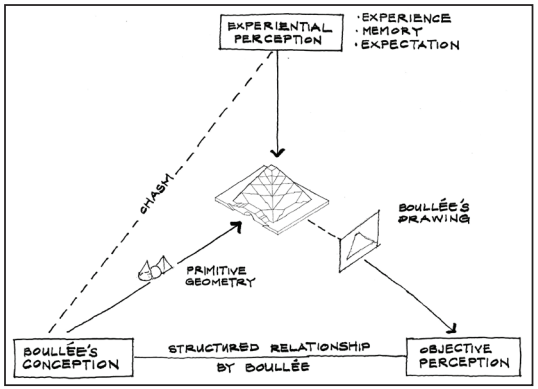

Figure 17. The multiple trails to understanding the conception and perception of the idealised project by Boullée (drawn by the author).

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