# Extended Perspective System

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**Abstract.** This paper presents a new system of graphical representation, which has been given a provisional name: Extended Perspective System - EPS. It results from a systemic approach to the issue of perspective, sustained by several years of academic research and pedagogical experience with architecture students. The EPS aims to be a global and unified perspective system, gathering the current autonomous perspective systems and turning them into particular states of a broader conceptual framework. Through the use of in-built specific operations, which become particularly effective in a computational environment, the EPS creates and contains an unlimited set of in-between new states, which can also be considered legitimate and particular perspective systems. Considerations of its potential role in architectural descriptive drawing are discussed.

**Keywords.** Linear perspective; curvilinear perspective; graphical representation; conceptual drawing; visual perception.

## Introduction

EPS analysis and evaluation are the main issues of an ongoing Ph.D. research, which early progresses have been already the subject of a poster presentation (Correia, 2005), available at the web (home.fa.utl.pt/~correia/curv_persp_caad.pdf). Since then, this system has been conceptually improved and is now ready to give rise to a computational implementation, as result of a team project in a collaborative academic context. Priority is being given to the field of architectural drawing, due to one of the major virtues of the EPS: an ability to improve the representation of space and objects within large fields-of-view.

Architectural descriptive representation, from conceptual drawings to final presentation depictions, is supported on geometric systems that mainly address, alternately, the visual appearance or the shape identity of objects, namely: perspective, axonometric and orthogonal views. These systems are the visible expression of the structuring role of geometry over representational drawing, and the success of an architect's drawing strongly depends on their adequate and complementary application.

In this paper, it will be considered the geometric structure that supports drawing when it aims to be a graphical simulation of the direct visual experience: the perspective. If we take "visual experience" in a broad sense: not only as the result of a momentary gazing but, furthermore, as the product of a dynamic visual perception and also as visually based cognition, the notion of perspective will have to be more inclusive, as well. It has to gather the dominant classical linear perspective with the alternative curvilinear perspective systems, each one with specific capabilities.

Learning and lecturing different perspective systems reveal the conceptual similarities and the noticeable relationships between their diverse graphical results. Consequently, a formulation of a single unified perspective system can be conjectured. Thus, a research work envisaging that goal and consisting on a systemic approach and review of the conceptual basis of perspective, gave rise to a new theoretical framework, by which all possible perspective representations of an object can potentially be generated.

In the following sections, referential ideas to the formulation of EPS and its geometric description will be addressed. At the end of the paper, some possible global and specific repercussions of the EPS in the domain of architectural drawing will be discussed.

## The Framing of the EPS

Firstly, it is important to define some terms and clarify correspondent concepts that are used in this text. *Linear perspective* refers to the linear component of pictorial perspective, not the straightness of projection rays: these will be always considered as straight lines, diverging from a central point (standpoint or viewer location - V). *Planar perspective* refers to the classical linear perspective, where a planar surface (picture plane) is used to support projection and drawing. *Cylindrical perspective* also refers to linear perspective but using a viewer centered cylindrical surface for projection surface, which is then unfolded to the picture plane. *Spherical perspective* also refers to the linear perspective but using a viewer centered spherical surface for projection surface, which is then transferred to the picture plane. Generally, in planar, cylindrical and spherical perspectives, a straight line in space is respectively represented by: a straight line, a sinusoidal line and a circumferential line. These three systems have counterparts in the domain of photographic imagery: the reliability of planar perspective is confirmed and reinforced by widespread common photography; the cylindrical perspective has its similar in panoramic photography; lastly, the spherical perspective has its similar in fish-eye lenses photography.

The production of representations for vision simulation purposes is mostly sustained on the structure of planar perspective, as an optical phenomenon in common photography and as an expertise in graphic and pictorial activities. Those representations acquired a significant role in our visual experience, as reliable supports for a mediated-vision that strongly complements the direct vision of objects. Therefore, planar perspective is consensually accepted to be the best underlying structure for images that intend to simulate and replace direct visual perception. However, its known limitations arise when wide fields-of-view are considered, allowing major distortion effects to take place, jeopardizing objects recognition.

Cylindrical and spherical systems generate curvilinear perspectives, where drew curved lines represent spatial straight lines. These alternative perspective systems are traditionally much less used and inherently produce less close-to-vision kinds of images. Nonetheless, these images have a noticeable character, since they incorporate, in a single graphical result, the simulation of the barely perceptible data collected by peripheral vision or, otherwise, synthesize graphically the perceptive result of a dynamic viewing (result of rotation of the eyes and/or the head), conveying a panoptical vision sense. Paradoxically, curvilinear perspectives do not seem to totally disallow objects recognition, as planar perspective circumstantially does.

Figure 1 presents some graphical results of using the three standard perspective systems, for a viewer located inside the depicted object. Images are equally framed for better assessment. Planar perspective keeps the straightness of object edges, though conveying a visual/haptic perception of the object. Cylindrical perspective is somehow a hybrid of the two other systems, showing vertical lines straight and horizontal lines curved. Spherical perspective introduces the global curvatures that seem visually less realistic. Despite visible differences and individual subjective evaluation, it can be stated that an effective visual communication is mainly provided by the three images.

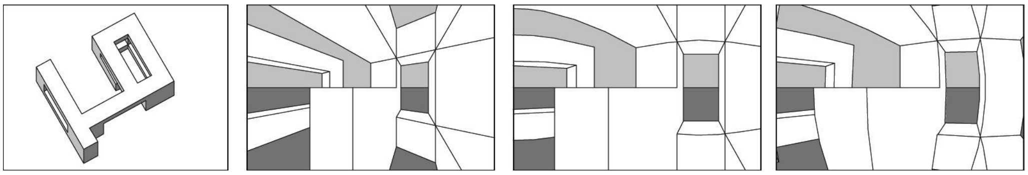

*Figure 1. Object; planar, cylindrical and spherical perspectives for a 120º field-of-view.*

Figure 2 shows the graphical results of stressing the three standard perspective systems to the limits, pursuing the largest field-of-view that each system can hold: planar perspective becomes an incongruent representation, filled with distortion effects; cylindrical perspective suggestively conveys a full panoramic view of the object surrounding the viewer: a sensorial experience achievable only through motion and time; spherical perspective also simulates a dynamic sight, result of a viewer gaze in motion, targeting up, down, left, right and front of the scene.

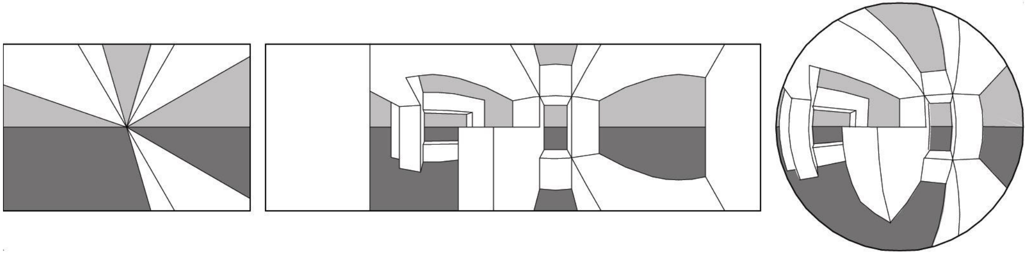

*Figure 2. Planar, cylindrical and spherical perspectives in full potential: 180, 360º, 180º field-of-view.*

A necessary statement is that the use of graphically curved lines turns out to be inevitable when the aim is to get wide field-of-view congruent representations of space. Although it is legitimate to inquire on the existence of a similar curvilinear phenomenon in direct visual perception, this matter is here overpassed, since it is outside the EPS ambitions. Focus is given to the fact that the use of curved lines effectively improves the visual communication of three-dimensional scenes, in terms of space and shape information conveyance. Therefore, beyond the specific virtues of each system, they can be seen as complementary methods of perspective.

Furthermore, underlining some essential similarities between these images, such as the convergence of parallel lines to vanishing points or the size-to-distance ratio of the represented entities, it will be sustained that those systems can be just single parts of a whole: as the description of EPS will show, the three systems are gathered into one and linked by an unlimited number of in-between single systems, all of them being a legitimate node of a comprehensive perspective system. The implementation of the EPS will significantly increase the number and variety of graphical replies to visual perception, someway fulfilling Flocon's (1968) principle and statement:

> 'The observer translates a three-dimensional happening, sensed by the retina and elaborated by the brain, into a flat structure, a picture, a scene... Neither the image on the retina nor the image in the brain has ever been seen. One must be content with what every kind of image maker achieves. Every image contains a part of reality: the reality of the representer and the reality that is represented. It is never complete.'

## The description of the EPS

The EPS formulation is developed upon the acknowledgment of Flocon's (1968) theorization on the choice of a sphere (surrounding viewer) as the ideal surface for projection and delineation, though recognizing the paradigmatic and pragmatic values of the picture plane as the place to lay the depictions. Consequently, part of his research is dedicated to the evaluation and definition of the best way to transfer the information projected on the sphere surface into a planar surface. The objective is to get the minimum change of visual dimensional values: distances, angles and areas of projected entities. He concludes that Azimuthal Equidistant Projection is the best choice. EPS concept shares this selection, for the same reasons, and also establishes the planar surface as the place for current depiction: this system is intentionally targeted to the production of planar graphic representations, to which a long life is still expected, in the physical form of a sheet of paper or a computer screen.

But EPS starts at the point where Flocon's (1968) theorization kept someway crystallized: the single, immutable use of a sphere that is centered on the viewer. The description of the curvilinear systems shows an effective separation between the projection surface and the plane where the resulting image will be presented. The projection surface is, therewith, a three-dimensional entity, located outside the picture plane. In the EPS, this feature becomes critical and is affirmed as a turn of paradigm, regarding classical perspective, where the picture plane has an ambiguous double-condition, by gathering a conceptual role as surface for projection and a practical role as physical support for drawing or painting. Instead, in the EPS concept, there is a clear distinction between Projection Surface (PS) and Representation Surface (RS).

The other paradigm rising from the EPS concept is the mutability of the PS: it can take diverse geometrical identities and, considering the real-time interactive change of a 3D entity allowed by computer systems, it can also gain a dynamic parametrical condition, where its different form states are reached by user-controlled topological transformations. Consequently, new parameters shall be added to the conventional perspective parameters: camera and target locations; zoom factor (as named in CAD).

Figure 3 describes the manipulation of a new parameter – Radius – applied to the conventional (viewer centered) spherical and cylindrical PS's. As Radius increases, the center C of the PS moves backwards along the visual axis and the PS itself turns progressively up-scaled, till it becomes a planar surface. In this limit state, PS and RS are coincident and the graphical result will be a planar perspective. Along the path between the first and final states of the PS, every step can be considered a single stationary perspective system, inscribing at the RS (plane) a single perspective result. The continuous mutations of PS states and perspective results denote the dynamic functioning of the EPS. In this way, spherical and planar perspectives become unified; the same way, cylindrical and planar perspectives become unified, as well.

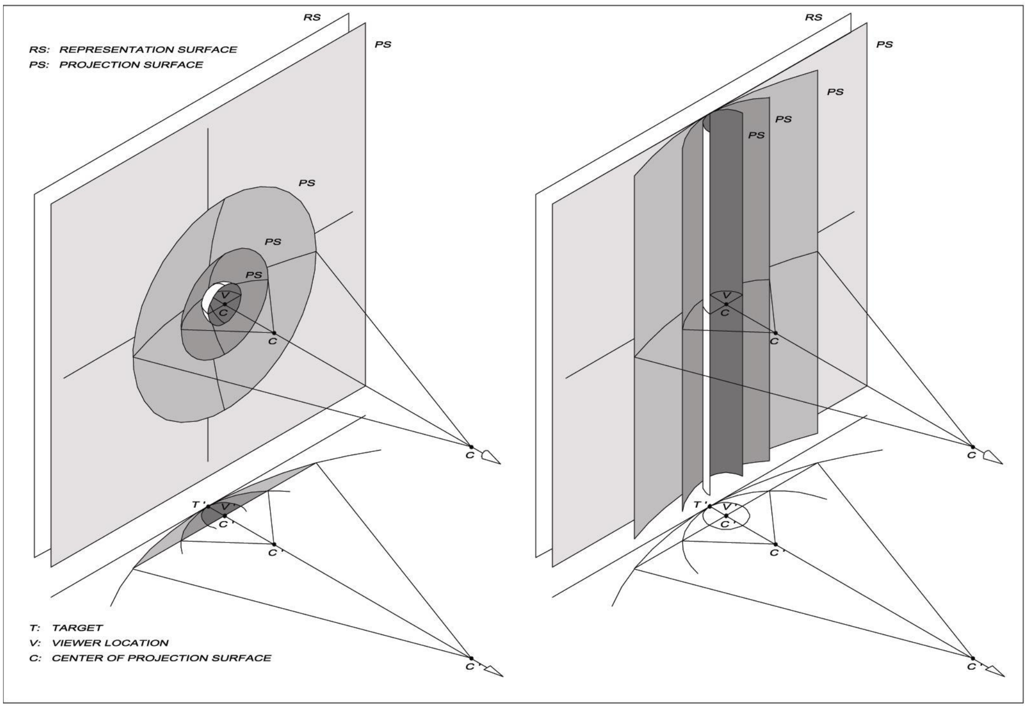

*Figure 3. Manipulation of the parameter Radius, in the EPS, applied to spherical and cylindrical PS's.*

Figure 4 presents a sequence of graphical results, achieved by changing the Radius of a spherical PS. The sequence can be eye-traveled in both directions. On the left appears a standard spherical perspective; on the right, a standard planar perspective; the two images on the middle are in-between perspective states, structurally new. The comparison of the images suggest the EPS capability to improve representation results, by blending and reducing, simultaneously, the typical distortion effects of both planar and curvilinear standard systems, whenever required.

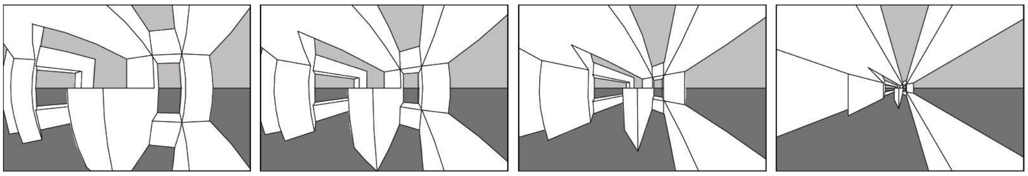

*Figure 4. Sequenced perspectives (174º field-of-view) changing PS from viewer centered sphere to plane*

To accomplish the aim of the EPS to constitute a global perspective system, the spherical and cylindrical perspectives have to be unified, also. This is conceptually achieved by the use of an ellipsoidal surface that can be, also by means of topological transformations, turned either into a spherical surface or a cylindrical surface, depending on the ratio between its axes. The new associated parameter shall be Eccentricity, which defines the specific form of the ellipsoidal surface and the curvature degree of the lines at the graphical perspective instance.

Figure 5 shows, on the left, the PS mutation from spherical state to cylindrical state, going through ellipsoidal in-between state(s), and also suggests, on the right, that each state of the PS can additionally be up-scaled by the manipulation of the parameter Radius. Thus, the planar state is always reachable from every PS state.

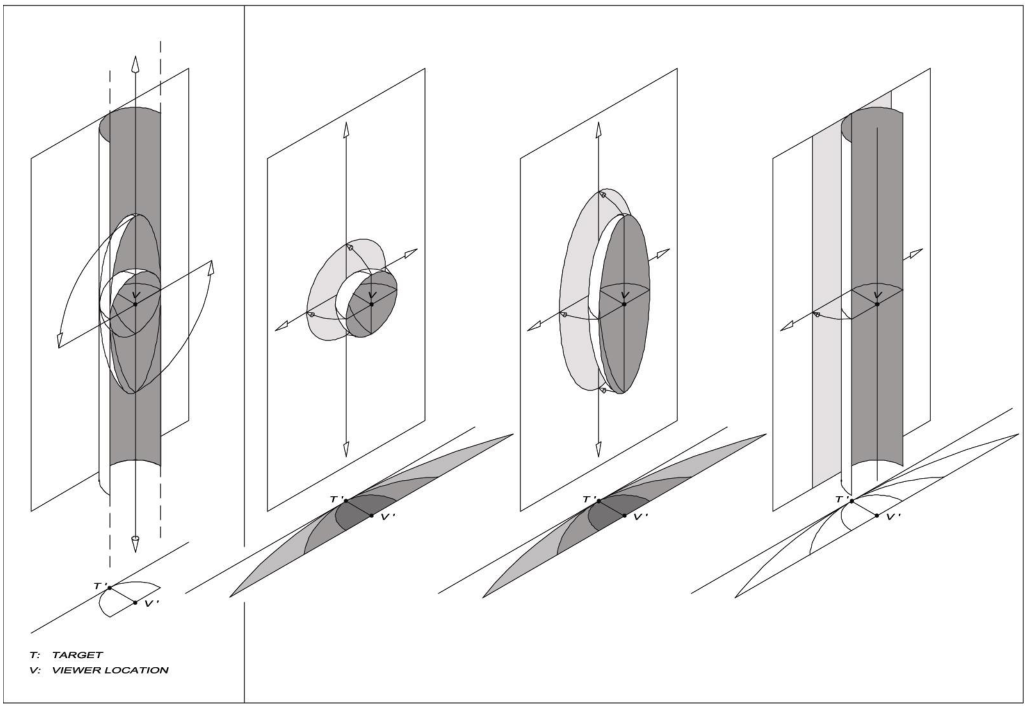

*Figure 5. The unification of spherical and cylindrical perspectives through EPS concept.*

Therefore, the EPS core concepts are: (1) the dissociation of the Projection Surface and the Representation Surface; and (2) the mutability of the Projection Surface, by means of topological transformations. Consequently, the Projection Surface becomes a parametrical entity and its diverse mutations are to be experienced and controlled by Radius and Eccentricity changeable values. The different configurations of the Projection Surface will inscribe the new perspective delineations into the Representation Surface. A continuous change on the Projection Surface will produce a continuous change on the perspective results at the Representation Surface (displayed at the computer screen), allowing the search and choice of the best graphical result, in each representational case and purpose.

## Preliminary discussion

The first outcome of the EPS to be emphasized is the systemic assemblage that it brings to the field of perspective representations. Through this broad system, perspective, as a knowledge that supports and structures the graphical representation when it aims to simulate visual perception, becomes expanded and upgraded.

The diagram in the figure 6 is an attempt to outline the EPS achievement. On the left, the three standard systems are shown separated, just as they are currently defined and used. The vertical lines represent variations of the conventional perspective parameters, so each individual point on each line represents a single perspective projection. On the right, the three lines are arranged in order to become the edges of a prism. The prism faces represent the unification of the three isolated perspective systems, by variations of the parameters Radius and Eccentricity – R and E. Consequently, every point on each face represents a new single perspective projection. In addition, since every ellipsoidal state of the PS can evolve to the planar state, by the up-scaling effect of Radius increase, then all internal points of the prism also represent a new perspective projection, which shall be turned into a planar drawing by the transfer-to-RS procedure. Therefore, the entire prism symbolizes the global and systemic nature of the EPS, and the whole set of its constituting points expresses the significant increase of perspective projections and graphic results that the EPS implementation will generate.

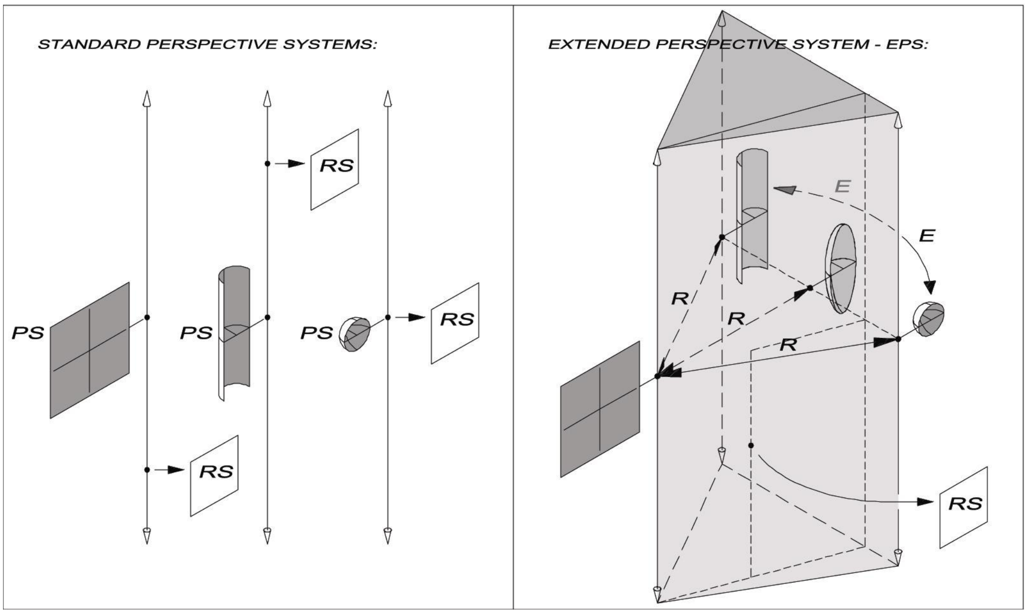

*Figure 6. An EPS schematic outline.*

Regarding a primary concern on the role of the EPS in the field or architectural drawing, the authors will hence shortly address the respective three domains where perspective graphical rules are influential and/or explicitly visible.

### *Conceptual freehand drawing*

This is, consensually, the most dialectic and creatively effective domain of architectural drawing, since it is sustained by the minimum interface between the architect and the graphical results. Drawing, herewith, is a direct consequence of the mental-bodily activity of the architect, upon a sheet of paper. Therefore, it constitutes an important physical and visible counterpoint to the executor's reasoning over space and shape issues. Architect's freehand drawing is a learned and trained activity, definitely influenced by the knowledge of the geometric systems of representation. These systems bring on freehand drawings an increased capability to communicate recognizable space and shape definitions, in a more or less explicit manner. Although, despite being necessarily referenced on the geometric systems, freehand drawings often escape from their theoretical corset: sometimes hybridizing those systems, other times spontaneously disrespecting their graphical rules. Particularly, on this matter, the graphical curving of lines in many architect's perspective drawings seems to suggest the dominance of a flexible and dynamical visual thinking over the strict geometric rules of the prevalent classical planar perspective, that would imperatively keep lines in obligatory straightness (figure 7). Therefore, the EPS concept provides to the geometry of perspective a further complicity with the freehand drawing qualities. The domain where this might be important and useful is the didactics of drawing in undergraduate academic levels, since the EPS concept shall induce in the learner's mind a wider and more flexible notion of the perspective and its capabilities.

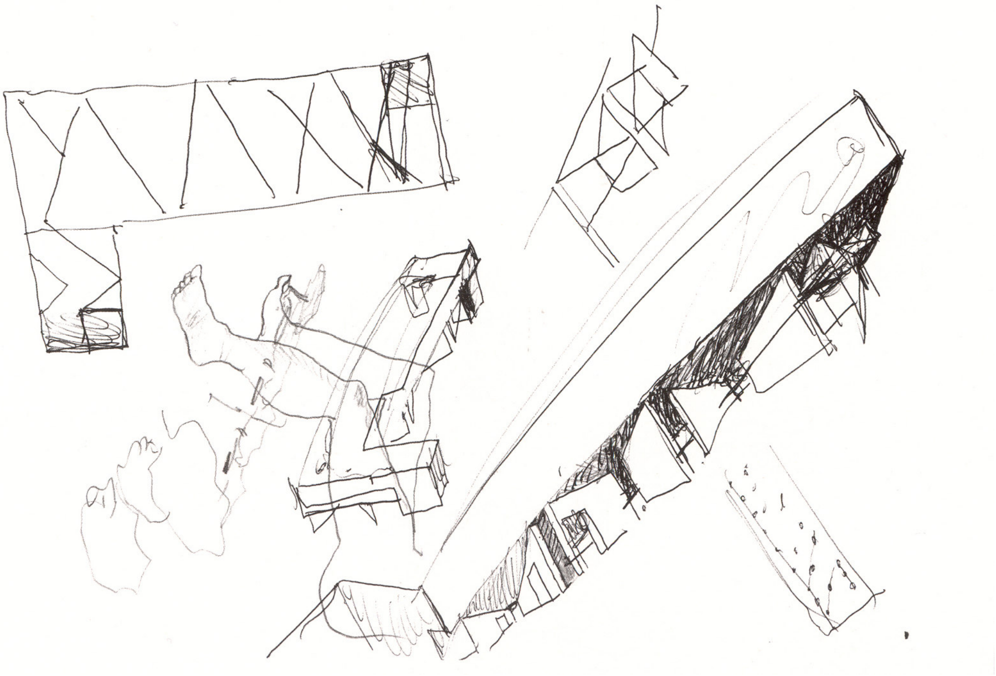

*Figure 7. A design sketch, by Álvaro Siza (from "On Display", exhibition catalogue, 2005 Serralves).*

### *Conceptual computational drawing*

Orthogonal and axonometric views communicate object's dimensional and volumetric identity: the most stable, objective and sharable one. On the other hand, perspective representation addresses the visual appearance of the object: an identity which is diverse and mutable. A perspective is by definition a parametrical result, since it depends, primarily, on the spatial relationship between the object and the viewer. This means that each perspective graphical result is eminently circumstantial: once selected viewer and object locations, visual axis and zoom factor, it will be a fixed depiction. What computational systems brought into this condition is visual dynamics: whether perspective visualization is made upon a preliminary virtual 3D model or a more detailed one, it has been turned into an experimental and real-time interactive experience, where dynamic graphical results also counterpoint and feedback the reasoning. The heuristic process is hereby introduced into computational perspective drawing. In a certain sense, this drawing is non-pictorial, since its viewer, who is firstly the architect himself, is not a mere spectator but likewise a virtual/imagined actor of the scene. EPS computational implementation shall provide kinds of perspective representations that are more synthetic, in terms of visually gathering more information regarding the object which is being created, thus expectedly helping on the conceptual cycles of analysis, evaluation and decision.

### *Final presentation drawing*

This is essentially an instrumental drawing field, dependent on the tools at the disposal of the architect. The aim of presentation drawings is to achieve an unambiguous communication of an architectural object that is defined, *i.e.,* has an objective identity, autonomous from its conceptive process and author. Perspective, in this context, has an essentially demonstrative and persuasive function. The EPS repercussion will be, naturally, the enlargement of possibilities to fulfill this role.

### *Final statements*

Beyond the expected repercussions described above, the EPS clearly has a potential applicability in other fields where effective visual descriptions of space are requested. Also, the EPS conceptual framework is not a closed one, as it constitutes an "open-source" concept, able to receive other and diverse kinds of Projection Surface and kinds of methods to transfer the projected information into the Representation Surface. Further studies will be made upon these matters.

## Acknowledgements

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## References

Barre, A. and Flocon, A.: 1968, La Perspective Curviligne – de l'espace visuel à l'image construite, Flammarion, Paris.

Correia, J. V.: 2005, Curvilinear perspective in CAAD, eCAADe 23 Conference Proceedings, Digital Design: The Quest for New Paradigms, September 21-24, IST, Lisbon