Visualizing Complexity in Extreme Architecture

ekstrem Çevre Koşulları
dijital Görselleştirme
Sunum
kompleksite,
mimarlık
extreme environments
digital visualization
representation
complexity
architecture

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Mimarlık, insan faaliyetleri için mekanların tasarımı ile ilgilenir ve sayısız çevre koşullarında sakinlerine konfor sağlar. Ekstrem çevre koşullarıyla karşı karşıya kalındığında, mimarlık duyarlı olmalı ve bu olumsuz şartları, insan koşulları için rahat bir alana dönüştürülmelidir. Yaşar Üniversitesi Mimarlık Bölümü'ndeki Ekstrem Mimarlık Şubesi, öğrencilerin ekstrem koşullar için yapılar tasarlamanın teknik gereksinimlerini karşılayan mimari projeler geliştirmeye davet edildiği kavramsal bir çatıdır. Bu tür ekstrem gerekliliklerin doğasına dair kanıtlarla karşı karşıya kalırken, öğrencilerden tüm tasarım öğelerinin kök saldığı ekstrem bir senaryo geliştirmeleri istenmektedir. Bu bağlamda, görsel bir anlatım, projelerin sentaksını kodlamak ve her bir projenin anlaşılabileceği mantığı açıklamak için kilit araçtır. Bununla birlikte, ekstrem mimarlık şubesi, ekstrem koşullara duyarlı ve dolayısıyla bilimsel bir yöntemle geliştirilmeye yakın bir projeyi sürdürmek için teknik argümanların kullanılmasını talep etmektedir. Öyleyse, görselleştirmeler, teknik bir sorunun birden fazla çözümüne yönelik bireysel yaklaşımları nasıl ifade edebilir? Projenin teknik taleplere verdiği yanıtı ifade ederken görselleştirmeler eşsizliğini nasıl korur? Her iki soruyu da cevaplamak için, ekstrem ortamların içsel karmaşıklığını benimsemek gerekmektedir. Görselleştirmelerin kullanımı, öğrencilerin beyan ettiği bu karmaşıklıklarla kendi bakış açılarını kullanarak başa çıkmalarına olanak tanır. Bu yazıda yazarlar, ekstrem mimarlık şubesinde geliştirilen iki projeyi eleştirel bir şekilde gözden geçirerek bu sorulara cevap vermeye çalışmaktadır.

Architecture deals with the design of spaces for human activities, providing comfort to its occupants, within a myriad of environmental conditions. When placed in extreme environments, architecture must be responsive and turn these adverse conditions into a comfort space for human occupation. The Extreme Architecture Unit at the Department of Architecture, in Yasar University, is a conceptual umbrella under which students are invited to develop architectural projects meeting the technical demands of designing buildings for extreme conditions. While confronted with the evidence of the nature of such extreme demands, students are requested to develop an extreme scenario, which is indeed the storyline wherein all design elements are rooted. In this sense, a visual narrative is the key instrument to code the projects' syntax and to explain the logic by which each particular project can be understood. However, the unit demands the use of rather technical arguments to sustain a project that is responsive to extreme conditions, thus close to being developed through a scientific method. But then, how can visualizations express individual approaches to the otherwise obvious solution to a technical problem? How can visualizations maintain uniqueness while expressing the project's response to the technical demands? To answer both questions, we must embrace the inherent complexity of extreme environments. The use of visualizations allows students to deal with such complexity from their own perspective, expressed in the language of those representations. In this essay, the authors attempt to provide answers to these questions by critically revising two projects developed in the unit.

A SOURCE OF DESIGN COMPLEXITY

Architecture deals with the design of spaces for human activities, within a myriad of environmental conditions. From a physical point of view, one outcome of architecture is a construction whose goal is to provide comfort to its occupants. The amount of work, or energy, involved in providing this comfort is closely related to how far are the comfort conditions from the environmental conditions, which are usually measured in terms of temperature, daylight, ventilation, acoustics, and so on. All these conditions display average values that define what we could call 'normal' environmental conditions, and to which architecture responds in a similar fashion, i.e. with technology and construction-related knowledge that entail the design of an average building or construction. Obviously, these normal conditions are highly dependent on specific locations; for example, in terms of temperature, what it could be considered cold for a place, may be considered warm in another. The obvious point here, in the definition of so-called normal architecture, is that the conditions designers provide to the occupants of these spaces, are setting up comfort levels within environmental conditions, to which humans - in one way or another- could adapt without threatening their very existence. However, how does architecture respond when the environmental conditions do pose a threat to life? To attempt a response, we must first address the concept of extreme environmental conditions, which is encapsulated in the idea that all environmental conditions are extreme as long as humans cannot live or even stay within them, without resorting to life-support equipment or outfits. This is the case of extreme cold environments, such the Artic, or extreme hot environments, like deserts. But also, conditions created by human-made disasters, such as nuclear radiation, droughts, or rising sea level. Consequently, architecture that must be responsive to these extreme conditions, must first equip itself with a set of technical knowledge - the goal of which is to support a design that can turn these adverse conditions into a comfort space for human conditions. Thus, how can this architecture that is responsive to extreme environmental conditions be defined?

The Extreme Architecture Unit is part of the Graduation studio at the Department of Architecture, Yasar University, in Izmir, Turkey. The main goal of the unit is a conceptual umbrella under which students are invited to develop architectural projects meeting the technical demands of designing buildings for extreme conditions. The unit encourages design explorations within a wide spectrum of extreme environmental conditions, including deserts, space exploration, post-disasters, social inequalities, and so on. While confronted with the evidence of the nature of such extreme demands, students are requested to develop an extreme scenario that justifies what seems a contradiction in itself: why anyone would live under these conditions? And the answer is meant to support, primarily, the arguments needed to define the users-function relationship (e.g. researchers- facilities for exploration, or astronauts-habitat) and the particular technical demands over the design (e.g. the role of the building envelope or structural challenges). Nevertheless, when we considered the different projects developed in the unit during the last semesters, we realized that the extreme scenario is indeed the storyline wherein all design elements are rooted.

VISUALIZING COMPLEXITY

The realm of these explorations is the digital environment, thus the visualizations represents an immaterial world, where rather than bounded by physical laws, the visualized objects acquire value as cognitive tools because of their semantic value. Referring to digital models in cultural heritage (Pietroni and Ferdani, 2021), explain that the 'content' of such digital models is not just a mere reproduction of a physical entity, but 'a communicative and cognitive unity, endowed with form and meaning.' Such an approach is valid beyond the limits of cultural heritage and applicable to any digital model used in a design process, because it is in this dynamic process where the designer experiences and simulates possible scenarios, which ultimately leads to meaning and understanding, and thus to acquiring knowledge. Hence the importance of experimenting with the virtual model. Visualization tools are not only useful to enhance students' understanding of somewhat complex theoretical subjects but also promote self-learning by experience and interaction. For example, they "include dynamic demonstration of theoretical engineering models allowing students to manipulate, experiment, and translate theories into real-world applications." (Haque, 2003). Visualizations can be used to cover the entire design process, from the initial design concepts to the final stages of fabrication and building construction. Moreover, 3D models can be used by design teams for coordination and also to convey design ideas to clients and stakeholders (Bouchlaghem et al., 2005). Although a 3D design process enhances data integration, visualization, and interaction, the use of 3D models in the context of coordination and discussion of the work associated to build what the model represents, remains a challenge for design teams because these digital models are difficult to print (Tory and Staub-French, 2008). The main disadvantages of 3D models are the often-large file size, their inherent complexity that makes them unsuitable for a larger non-specialized audience, and that the potential of using structured information is lost due to the use of non-architectural applications to produce the design outcomes (Boeykens, Santana Quintero and Neuckermans, 2008)

The main role of digital visualization in Architecture is representing relationships beyond the geometrical and establishing "relationships between analysis and visualization to the structure of abstraction" (Koutamanis, 2000). In their study, Cao, Kahlon and Fujii (2021), remind us of the key role of design interpretations during the design process, bridging the gap between reality and designers' imagination. Design interpretations are inherently ambiguous and hence, their value as both tools and framework of design explorations. In this sense, a visual narrative is the key instrument to code the projects' syntax and to explain the logic by which each particular project can be understood. And herein lies one first apparent contradiction. The unit demands the use of rather technical arguments to sustain a project responsive to extreme conditions, thus close to being developed through a scientific method. Then, how can visualizations express individual approaches to the otherwise obvious solution to a technical problem? Whereas it is possible that visualizations allow the uniqueness to appear in the design, as they bring in aesthetical or artistic perspectives, in this case the technical dimension of the projects are also to be expressed. Thus, how can visualizations maintain uniqueness while expressing the project's response to the technical demands?

To answer both questions, we must embrace the inherent complexity of extreme environments. In all scenarios, narratives, and visualizations, there is one common aspect: complexity. The use of visualizations allows students to deal with such complexity from their own perspective, expressed by the language of those representations. In the following sections, two projects developed in the unit will answer these questions.

DESIGNING FOR MARS

Why going to Mars? Planet Mars represents the hope for a better future for humanity and an opportunity to avoid repeating the mistakes made on Earth, polluted and in countdown to extinction. For this reason, a pioneering research centre is proposed for colonization and habitation on Mars. The Lava tubes located southwest of Mount Olympus, were selected as location. Lava tubes are important because they protect from radiation and sandstorms, and because they provide access to underground dry ice. This extreme scenario is completed with the use of a superconducting substance, able to produce magnetism when the air temperature is -120 Celsius degrees. In architectural terms, the complexity is addressed by revolving around three aspects: material of the project, the 3D printing-based structures, and the verticality which converts mechanical to static energy. The project comprises three types of spaces: flying and fixed research units, and research centre. Flying research units have the ability to 'fly' thanks to the superconductor properties and provide quick and easy access to conduct research at any point on Mars. The main crew accommodation units are located close to the Martian surface, and include all living areas; they are located inside the lava tubes to be protected from external factors. The construction of the first structure will be built using 3D printer technology before the astronauts reach Mars. Aluminium and dry ice will be used as main building materials. The 3D printed structure will be vertical to avoid dealing with the complex forms of the Martian landscape. Vehicles with wheels will not work here, so the design is not based on the use of the land, but on the floating elements and the advantages of the Martian atmosphere.

All this complexity is expressed through the use of simple visualizations. Because the Martian elements are unknown and their behaviour is therefore unknown to humans, their use in the design needs to be easily understood. Consequently, the building shapes are simple and organized around three types: the flying elements based on the superconductivity on Mars, which allows them to float in the Martian atmosphere. The shape of these elements is shown with simple geometries; the ones with the spheres represent one-person capsules for searching & exploring the unknown Martian landscape. The shape of the research centre appears complex in opposition to the overall simplified forms. The reason is that this complex shape can create new structures and new stations, so its complex shape represents the complexity of organisms. The capsules' forms are spheres and circles, which can be created by the 3D printers. These simple geometries are supported by vertical structures, which are very tall. The vertical shapes give the feeling of 'height' compared to the small shapes, defining the border of the building areas. Because the main idea is showing the visuals with the simplest geometries, the research center and the building design uses only tubes, because a hierarchy is implied in the organization based on simplicity. This is for avoiding a crowded and huge building, so only one of the buildings uses this complex shape.

DEALING WITH UNCERTAINTY IN REPRESENTATION

The Martian landscape is an uncharted territory. The absence of real photos of the area where the project was located, made it difficult for realistic visuals and required the use of abstraction. This proposal deals with the complexity of the Martian context by increasing the intelligibility of the axonometric image (Fig. 1), drawing it as simple as possible. Since the form of the project responds to the 3D vertical printing logic of the structure, the best technique to show the resulting architecture is the axonometric drawing technique. The building type and mass are thus defined by and through the axonometric, which is the output of the modeling software. The uncertainties of the Martian environment, on the contrary, are just hand drawings, added later through the use of shadows, textures and selected colours. The choice was thus drawing the axonometric in a cartoon style, blending the fictional aspects of what is imagined to be or happen, with the abstractions used to represent both the conceptual ideas and the location of the project. These abstractions are represented primarily by non-scaled drawings. However, cartoons are usually images depicting bright colours, which would contradict the overall simplification of the building drawing, where the cartoon technique covers up the need for detailing and joints. For this reason, pastel tones are used to visualize the complexity of the project. Colour choices define materiality. Blue represents the building envelope made of dry ice and yellow represents the 3D printed structure. The yellow-white texture indicates the surface and atmosphere of Mars. The clouds and surface layers look like a rusty paper texture, matching the land surfaces. And this kind of form expresses the yet unknown Martian underground. Grey indicates the crest of a crater and its darkness. Since the project was located inside a crater, part of the surface is cut off in the drawings, so that the interior can be shown. Finally, the astronaut is placed as the key element of the visual narrative: who will use this building? The astronaut is the reason for the structure to be designed that way. The human figure entails life, and thus it is the first element of the project that attracts attention, while simultaneously staying in both surface and underground layers, breaking the dimensions of the drawing.

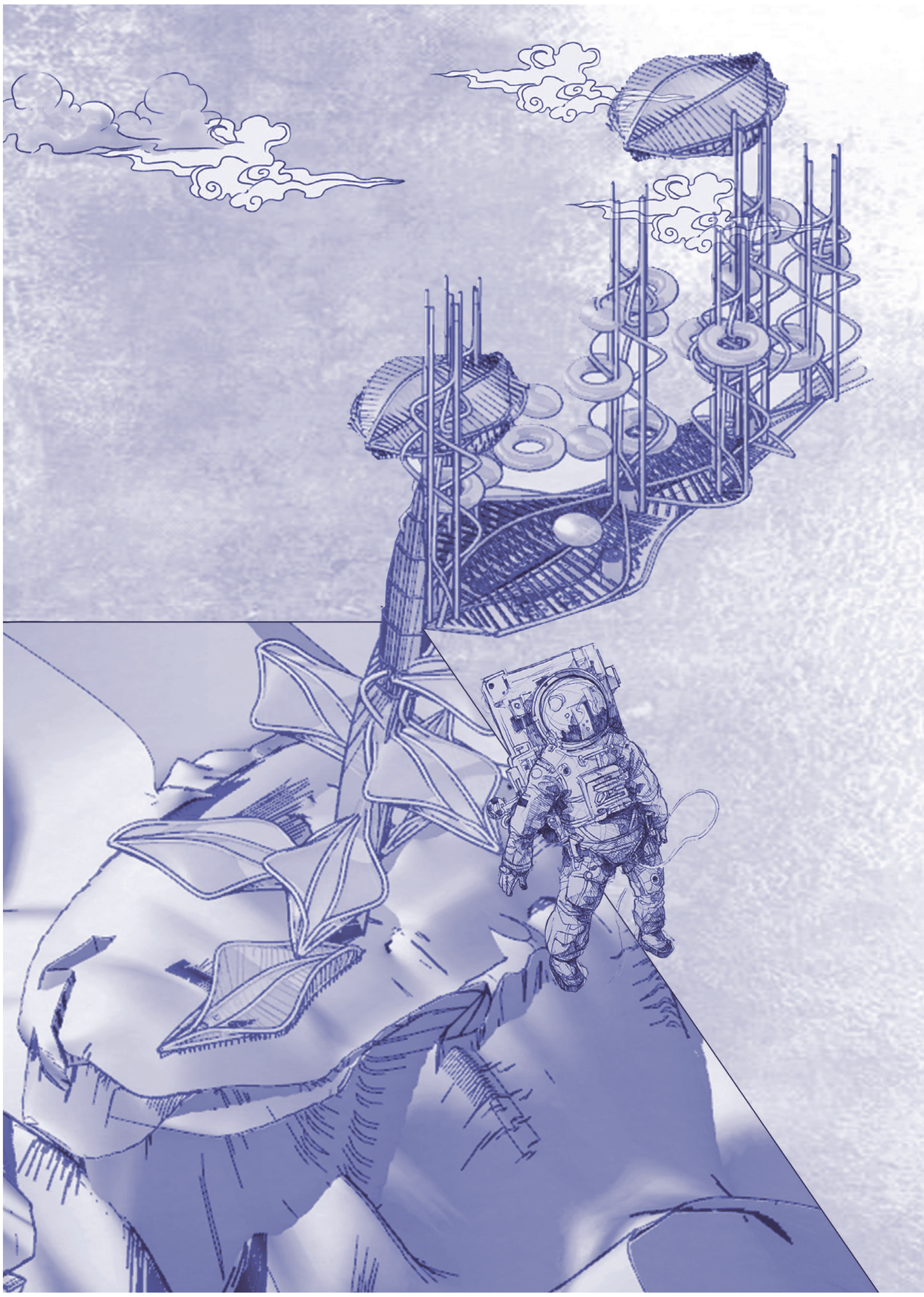

Fig. 1 - Superconductivity on Mars. Axonometric (Berca Kavani).

The section drawing technique is chosen to express the dynamic of the structure and the life inside the project. The section drawing (Fig. 2) answers the question of how life on Mars would be? However, unlike the axonometric drawing, the section follows the conventional rules of technical drawing, yet is based on using two specific tools: a range of pastel tones and lines of different geometries. The colour scheme defines the use of each material.

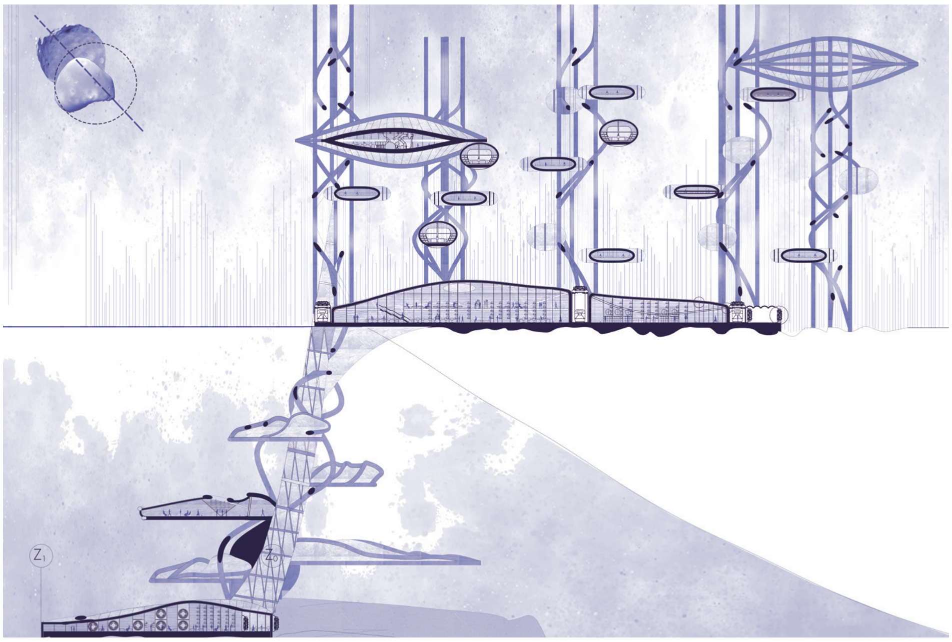

Fig. 2 - Superconductivity on Mars. Section (Berca Kavani).

Fig. 3 - Superconductivity on Mars. Render Visualization (Berca Kavani).

Brown colours indicate the crater where the project is located. Thick and sharp brushed style is used to represent abstract and functional visualizations. In this case it is used to express the irregularity of the crater's form. In the section, the structure is indicated in grey for a better fit with the idea of being a technical drawing. Attached to this structure, blue is chosen to represent the materials used to build the flying units' structures. Gray is for the structure and the super conductivity elements. The gray lines in the background represent the superconductivity between the linear structures, emphasizing their heights. Thin straight lines were used in the background to emphasize the heights and verticality of the slender superconducting structures. Since the goal of the section is to show human life on Mars, the circulation, the elevator and the underground areas are highlighted in here. The circulation in the section helps to explain the connection between the research units and the research centres in particular. At the same time, the circulation logic in the project was explained by showing the elevator between the research centre and the flying research units. Due to the complexity of the project, two further drawing decisions are set up to emphasize the key aspects: a strong horizontal line connecting the two visuals (above and under) — thus connecting the external life with the inner living space —, and using pop-up circles to provide further information of the designed areas. These close-up images give insights into the way people will live in the Martian environment.

The accommodation units located inside the crater symbolize the hope for all humanity (Fig. 3). The uniqueness of the designers' approach is expressed by depicting the cave as dark and somewhat scary; conveying feelings of insecurity in the background. However, the structure and all design that is made by humans come from the light, which represents hope, a new life and a new beginning. The scary cave emphasizes the contrast between the bright layers and the background, representing what is still undiscovered and untouched.

From the surface the light comes in, thus the structure is very bright; hope is depicted by showing the survival units in white. Visually then, the accommodation units are highlighted and the emphasis is put on the feeling of hope. Life on Mars is indicated by placing the astronaut figure in the centre of the image.

The astronaut represents humankind. No longer on Earth but somewhere else on Mars. This visual technique is not a cartoon but a sort of rendering, which we can call an abstract render. Some bright brush touches show the contrast between the dark background and the brightness, revealing the feeling of hope and a new beginning.

EXTREME TRANSPARENCY IN THE NORTH SEA

A white background provides an adequate framework to highlight the scale of the oil refinery complex and the complexity of its structural design (Fig. 4). While the original contextual chaos is depicted in simple black and white, the colour will be used in further stages of the project to express a new complexity of both interior and exterior design. The use of drawings meant to devise a way to explore how intricate and compact the features of the existing structures were. The intricacy of the structural components was one of the key references in forming the idea of uniqueness in the design. In the early phases of the design process, sketches are used to identify those key design aspects that lay the foundation of what will be developed as an architectural project. Such key aspects are often complex compositions that, through the design process, fostered an architecture in harmony with this complexity. However, since the distinctive lines were clashing with the black lines of the background, a further simplification of the design was required. Gradually, the lines' thickness and colour contrast with the external elements and, thus combined, highlighted specific features against the deconstructed blank design canvas.

Transparency and depth slowly began to play a role in the developing of the project and the expression of its technical features (Fig. 5). To achieve a full sense of integrity, the complexity of the parametric design is integrated using transparency in a way that the even the supporting elements are interlaced with the aesthetic features of the proposal. The drawing, thus, turns itself into an illusion, a jumble: it provides a distinct perception by generating the sense of depth in this project, while simultaneously, grabbing attention by displaying a graphic language, which is close to a hand drawing. The simplified features intend to encourage the observers to figure out by themselves

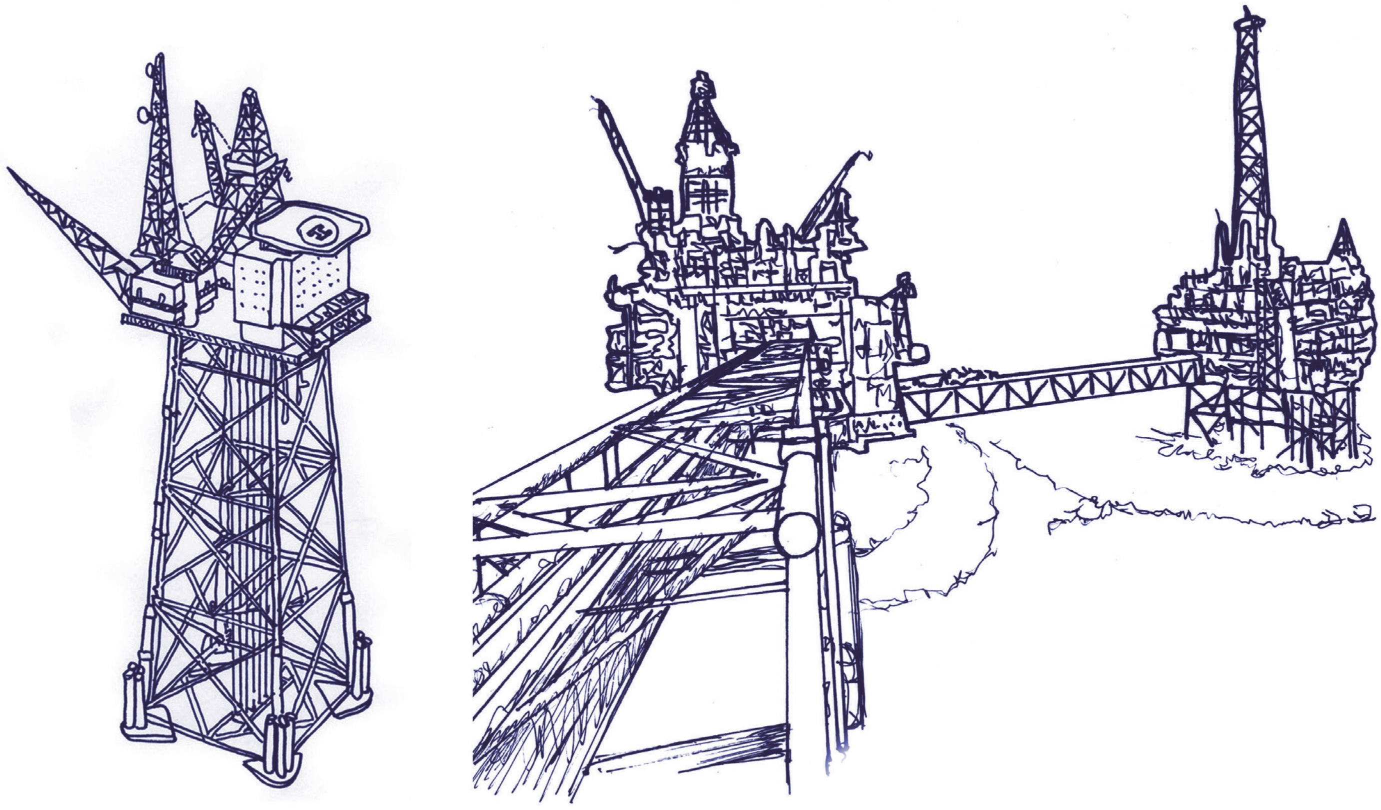

Fig. 4 - Oil Rigs Representations (Kaan Çetin).

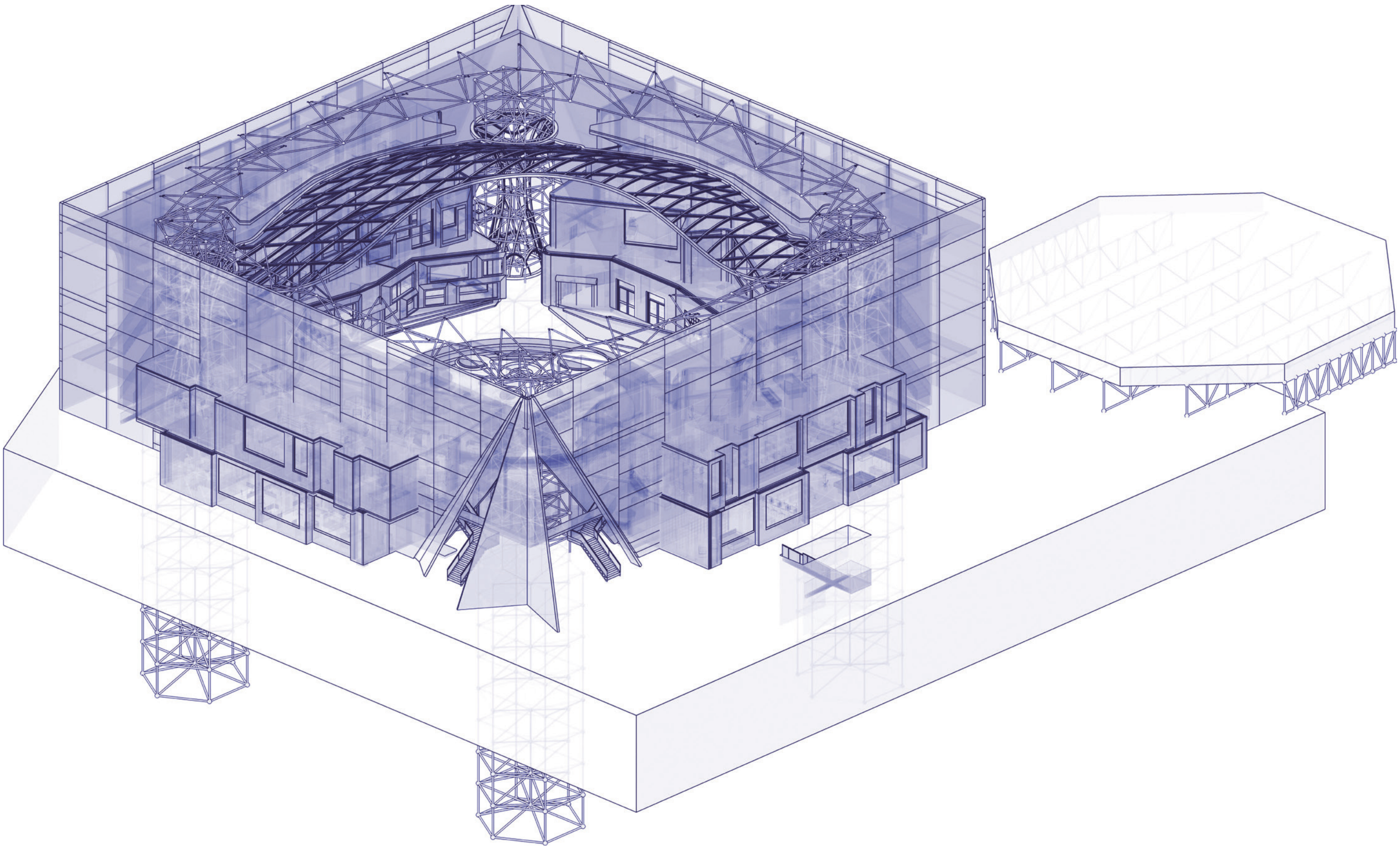

Fig. 5 - Proposal axonometric (Kaan Çetin).

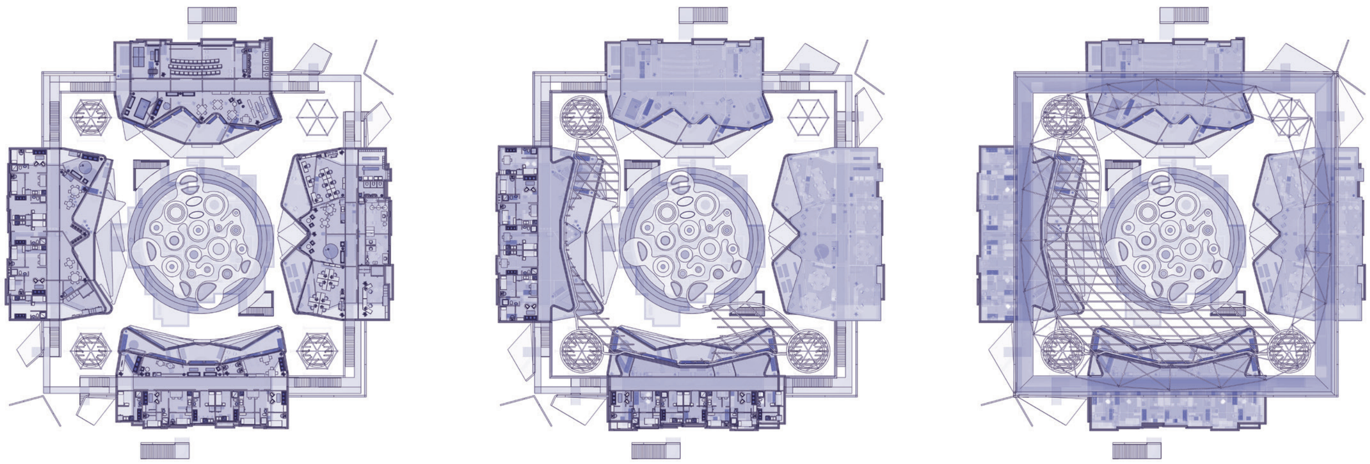

Fig. 6 - Plans (Kaan Çetin).

the mystery of the inside box, which was lacking details and transparency. During the design process, the density and intricacy of the project's features, have resulted in unusual intersections. Simultaneously, along with the simplified diagram descriptions, the focus shifted to specific design concerns, which required to solve the overall confusion. The design components were put in focus by the use of sketches and colours, yet the resulting jumble began to decay along with the many foci.

The integration of sections and plans, which diverge with colours and the use of supporting detail drawings, had to be defined without scaling them or even adhering to any exact technical features of the oil refinery complex. Yet the intensity of the technical language of these drawings should not be underestimated. Along with the technical representations in the plan drawings (Figure 6), the colours and line choices, integrated in this context, play a significant role to convey the designer's intentions. The combination of a colourless, abstract, and translucent background generated by the facade and shell structure, in contrast with the aesthetic concerns and optimized structural system details, allows the designer to gradually forge a unique impression of the design solution, in a technical sense.

DISSECTING COMPLEXITY

The specifics of the intricate structural system, the extreme environmental conditions in which the project is located, and the current design of the oil refinery become the design substrate to which the architect is confronted. To display the resulting complexity, therefore, the design is deconstructed and thus, the parts that are intended to draw attention, exposed (Fig. 7). The deck, floors, structure, envelopes, and building systems structural systems have all been separated in an exploded diagram. The division helps to differentiate between the specifics of the intricate combination and the design's features. The inherent chaos inside the black box is separated into layers, using colour codes to highlight the contrast between the selected elements and the blank background. The intended visualization, somehow combines the visions, providing not only the exploded diagram, but also those from the plan layouts and systems sections. This singular image is, thus, based on minimal features to emphasize a design narrative where the

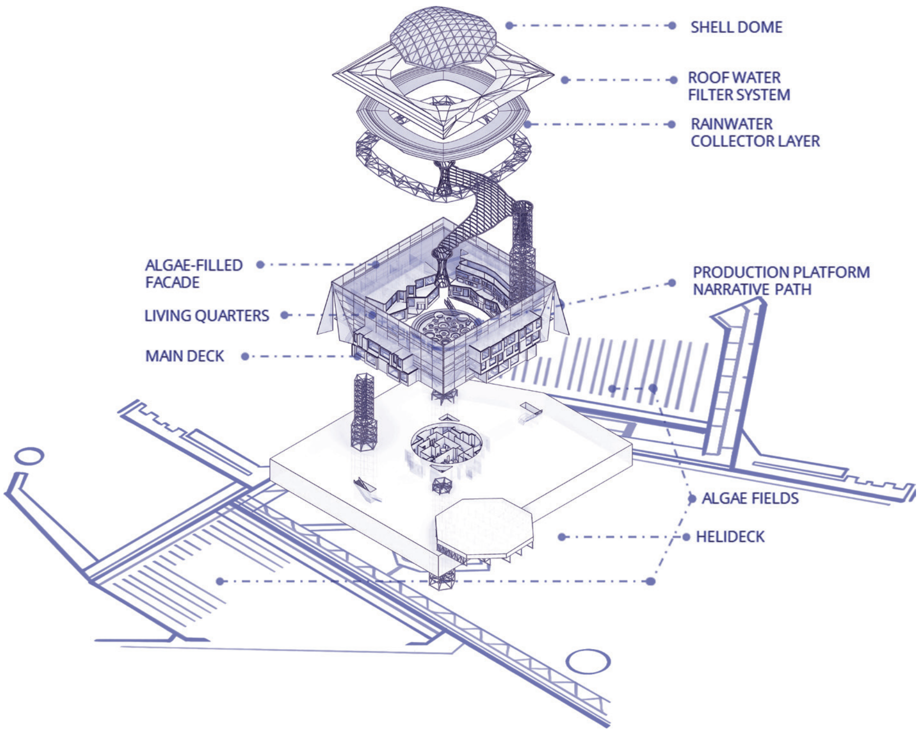

Fig. 7 - Exploded Axonometric (Kaan Çetin).

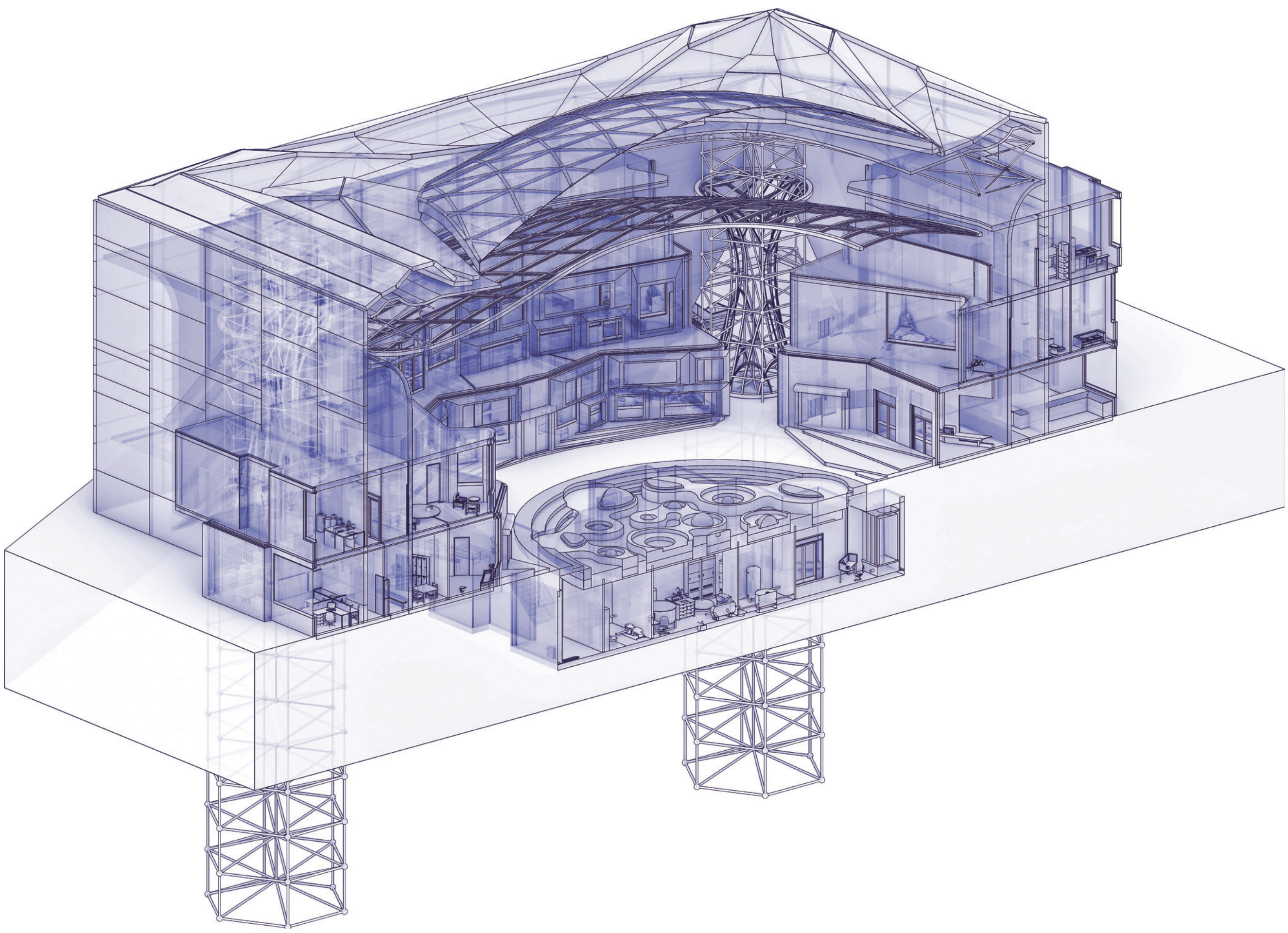

Fig. 8 - Axonometric section (Kaan Çetin).

complex aspects of the structure have disappeared.

Drawing techniques, such as system sections, based on accepted technical format provide integrity to the design; sketching over the drawings provide a better fit with the design intentions. A balance in the use of these drawing tools promotes design integrity and depicts a sense of harmony in the composition (Fig. 8). The basic scale-free sketch drawings reinforce the narrative of complexity in the design, without overcrowding the image with definitions but with design possibilities. This is achieved by drawing attention to the sense of void placed in the middle of the depicted section. While the position of the sketch drawings in the section have been carefully selected, the major setback is the possibility that the aimed visual complexity made the model complicated to read. The overlaying details might become progressively hazy, resulting in a confusing image. To circumvent this, without compromising design complexity, transparency and shading methods are employed to alter the composition. The result is a section full of design possibilities. Framed, coloured, transparent features, as well as contour lines, maintain the project's integrity when viewed from a distance; and carefully placed sketch drawings that explain the design's intention, help to focus on the details. This visual duality allows bringing together two distinct options at the same time, in clear reference to the sense of complexity.

REPRESENTATION AS THE PROJECT ITSELF

Following the design decisions derived from the initial analysis, case studies of structural forms that will ensure structural integrity, plan boundaries, and circulation within them, are bounded by the process of integrating visual design decisions into each other. These studies are not developed in a sequential order, but rather as a coordinated task. Their goal is to make the architect's and designer's perceptions aware of the extreme conditions in their projects, by experiencing the design values at every stage of the architectural project, from technical decisions in visualization design aesthetics to the mixture of representation techniques. In this regard, the section provided insights into the complex nature of the projects, unveiling new possibilities and horizons for explorations. As Lewis, Tsutumaki, and Lewis (2016, p.6) explained:

"... architectural section is key to architectural innovation. Given the environmental and material challenges that frame architectural practice in the twenty-first century, the section provides a rich and underexplored opportunity for inventively reimagining the intersection of structural, thermal, and functional forces. Moreover, the section is the site where space, form, and material intersect with human experience, establishing most clearly the relationship of the body to the building as well as the interplay between architecture and its context"

The final project as visually exposed, is a design product resulting from the use of visual coding and visualization tools, that are embodied within the architectural principles and realities. The design's abstractions and interpretation were combined with architectural drawings and structural technical solutions to create a form resembling technical drawings. In retrospect, one questions, as a reflection, if the representation of the project could not go beyond the mere description of what it attempts to show, and rather to extend the nature and logic of the representation to the point of becoming the project itself. From this perspective, building in a place of such a different reality, for example, might question the intrinsic nature of that difference, e.g. the lack of gravity, and thus moving away from describing reality to designing one where spaces are indeed very different from ours on Earth. This is the moment when representation takes commands of the project and thus reaffirming that indeed "architectural drawings are easily able to transcend any reference to reality" (Cook, 2014).

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