Edition Axel Menges GmbH
Esslinger Straße 24
D-70736 Stuttgart-Fellbach
tel. +49-711-5747 59
fax +49-711-5747 84

Marios C. Phocas

Technology-Driven Design Approaches to Utopia

With a foreword by Theoharis David, Pratt Institute, New York.

180 pp. with 153 illus., 230 x 170 mm, hard-cover, English
ISBN 978-3-86905-002-7
Euro 39.00, £ 29.90, US $ 42.90

Together with his colleagues and students at the University of Cyprus, Phocas challenges traditional definitions of utopia by presenting us with analytical research and clearly delineated visions of some architectural futures, which defy easy description.

Some may view the architecture-diploma projects in this book skeptically as fantastical or even as frightening visions of some technologically driven future, but they are anything but fantasy. They should be appreciated as a continuing creative search for the defining of what is the meaning in our 21st-century world of »utopia« and the role of architectural technology in expressing it. This search takes us beyond the traditional notions of utopia, which have historically been illustrated as overtly romantic, whimsical images along with a plethora of mechanistic formal architectural or architectonic proposals for utopian cities or communities. Some of these utopian visions, which were realized as isolated acts during the first half of the 20th century, in as socio-economically and culturally diverse places such as the United Kingdom, suburban North America or the Indian sub-continent proved to be, once inhabited, less than utopian.

In studying the student proposals, one could argue that these architectural visions are derived from an evolution of human technology and an understanding of growth and adaptability in nature. For instance, some of the projects propose new »building blocks« which can be likened to the ancient technology of making bricks and the quarrying and shaping of stone which led to the development of masonry construction and an entire new architecture. Other proposals can be likened to the self-generating growth and renewal process of plant life. Like in nature, we see in the students' work proposals for structural systems that grow vertically out of constructed or natural landscapes in a symbiotic relationship with the forces of gravity, wind and sun, while mining these primal forces to enable human habitation. Others appear as in natural growth, as expandable adaptable infrastructure systems intertwined with and serving existing conditions. And yet other proposals are developed as independent systems that are more autonomous in their form and function.

Marios C. Phocas is currently Associate Professor at the Department of Architecture of the University of Cyprus. From 2006 until 2013 he served as interim head of the Department of Architecture and was responsible among others for the development and implementation of the programs of undergraduate and graduate studies in architecture at the University of Cyprus. From 2011 until 2015 he served as member of the Advisory Committee of the European Network of Heads of Schools of Architecture. Since 2007 he serves as a national representative in the European Committee on Education and Training in the Field of Architecture.

Distributors

Brockhaus Commission
Kreidlerstraße 9
D-70806 Kornwestheim
Germany
tel. +49-7154-1327-33
fax +49-7154-1327-13
menges@brocom.de

Gazelle Book Services
White Cross Mills
Hightown
Lancaster LA1 4XS
United Kingdom
tel. +44-1524-68765
fax +44-1524-63232
sales@gazellebooks.co.uk

National Book Network
15200 NBN Way
Blue Ridge Summit, PA 17214
USA
tel. +1-800-4626420
fax +1-800-3384550
custserv@nbnbooks.com

Together with his colleagues and students at the University of Cyprus, Marios C. Phocas challenges traditional, outdated definitions of utopia by presenting us with analytical research and clearly delineated visions of some architectural futures, which defy easy description.

Some may view the architecture diploma projects presented here skeptically as fantastical or even as frightening visions of some technologically driven future, but they are anything but fantasy. The work should be appreciated as a continuing creative search for the defining of what is the meaning in our 21st-century world of »utopia« and the role of architectural technology in expressing it. This search takes us beyond the traditional notions of utopia, which have historically been illustrated as overtly romantic, whimsical images along with a plethora of mechanistic formal architectural or architectonic proposals for utopian cities or communities. Some of these utopian visions, which were realized as isolated acts during the first half of the 20th century, in as socio-economically and culturally diverse places such as the United Kingdom, suburban North America or the Indian sub-continent proved to be, once inhabited, less than utopian.

In studying the student proposals, one could argue that these architectural visions are derived from an evolution of human technology and an understanding of growth and adaptability in nature. For instance, some of the projects propose new »building blocks« which can be likened to the ancient technology of making bricks and the quarrying and shaping of stone which led to the development of masonry construction and an entire new architecture. Other proposals can be likened to the self-generating growth and renewal process of plant life. Like in nature, we see in the students' work proposals for structural systems that grow vertically out of constructed or natural landscapes in a symbiotic relationship with the forces of gravity, wind and sun, while mining these primal forces to enable human habitation. Others appear as in natural growth, as expandable adaptable infrastructure systems intertwined with and serving existing conditions. And yet other proposals are developed as independent systems that are more autonomous in their form and function.

These proposals are both visionary and program-rich. They contribute to the discourse of redefining what we imagine as utopia, whilst critically assessing the role of radical advances in technology in bringing them all into being. They aspire to achieve what is achieved by natural precedents: the useful preservation of the host environments, and the providing of sustenance and a home (estia) for all living beings in a humane, elegant way.

Theoharis David, Professor of Architecture, Pratt Institute, New York

039.00 Euro
029.90 £
042.90 US $
ISBN 978-3-86905-002-7
9 783869 050027 54290

Phocas **Technology-Driven Design Approaches to Utopia** Menges

Marios C. Phocas

Technology-Driven Design Approaches to Utopia

Dedicated to my father, Constantinos L. Phocas

Marios C. Phocas

Technology-Driven Design Approaches to Utopia

Edition Axel Menges

© 2017 Edition Axel Menges, Stuttgart / London
ISBN 978-3-86905-003-4

All rights reserved, especially those of translation
into other languages.

Printing and binding: Graspo CZ, a.s., Zlín, Czech Republic
Design: Marios C. Phocas,. George Paparoditis
Typesetting: [synthese] Björn Schötten

Marios C. Phocas is currently Associate Professor at the Department of Architecture of the University of Cyprus. From 2006 until 2013 he served as interim head of the Department of Architecture and was responsible among others for the development and implementation of the programs of undergraduate and graduate studies in architecture at the University of Cyprus. From 2011 until 2015 he served as member of the Advisory Committee of the European Network of Heads of Schools of Architecture. Since 2007 he serves as a national representative in the European Committee on Education and Training in the Field of Architecture.

Content

Foreword

Marios C. Phocas and his colleagues and students at the University of Cyprus challenge traditional, outdated definitions of utopia by presenting us with analytical research and clearly delineated visions of a number of architectural futures, which defy easy description.

The architecture diploma projects represented here, which some may view skeptically as fantastical or even as frightening visions of some technologically driven future, are in my opinion anything but fantasy. The work should be appreciated as a continuing creative search for the defining of the meaning, in our 21st-century world, of »utopia«, and the role of architectural technology in expressing it. This search takes us beyond the traditional notions of utopia, historically illustrated with overtly romantic, whimsical images and a plethora of mechanistic formal architectural or architectonic proposals for utopian cities or communities. Some of these utopian visions, realized as isolated acts during the first half of the 20th century, in places as socio-economically and culturally diverse as the United Kingdom, suburban North America and the Indian sub-continent proved to be, once inhabited, less than utopian.

Looking at the students' proposals, one could argue that these architectural visions are derived from an evolution of human technology and an understanding of growth and adaptability in nature. For instance, some of the projects propose new »building blocks«, which I liken to the ancient invention of the technology of making bricks and the quarrying and shaping of stone which led to the development of masonry construction and an entire new architecture. Other proposals can be likened to the self-generating growth and renewal process of plant life. In a parallel with nature, we see in the students' work proposals for structural systems that grow vertically out of constructed or natural landscapes in a symbiotic relationship with the forces of gravity, wind and sun, whilst mining these primal forces to enable human habitation. Others resemble natural growth, because they are expandable adaptable infrastructure systems intertwined with and serving existing conditions. Still other proposals are developed as independent systems that are more autonomous in their form and function.

These proposals are both visionary and program-rich. They contribute to the discourse of redefining what we imagine as utopia, whilst critically assessing the role of radical advances in technology in bringing them all into being. They aspire to achieve what is achieved by natural precedents: the useful preservation of the host environments, and the providing of sustenance and a home (estia) for all living beings in a humane, elegant way.

Theoharis David

Theoharis David received a Bachelor of Architecture degree from Pratt Institute and a Master of Architecture degree from Yale University, where he studied with Serge Chermayeff and Paul Rudolph. He has been in private practice since 1974 in New York and Cyprus. He is Professor of Architecture at Pratt Institute teaching graduate and undergraduate design and is a former Chair of Graduate Architecture and Faculty President of the School of Architecture. He has been named Pratt Institute's Distinguished Teacher for 2013–2014.

Introduction

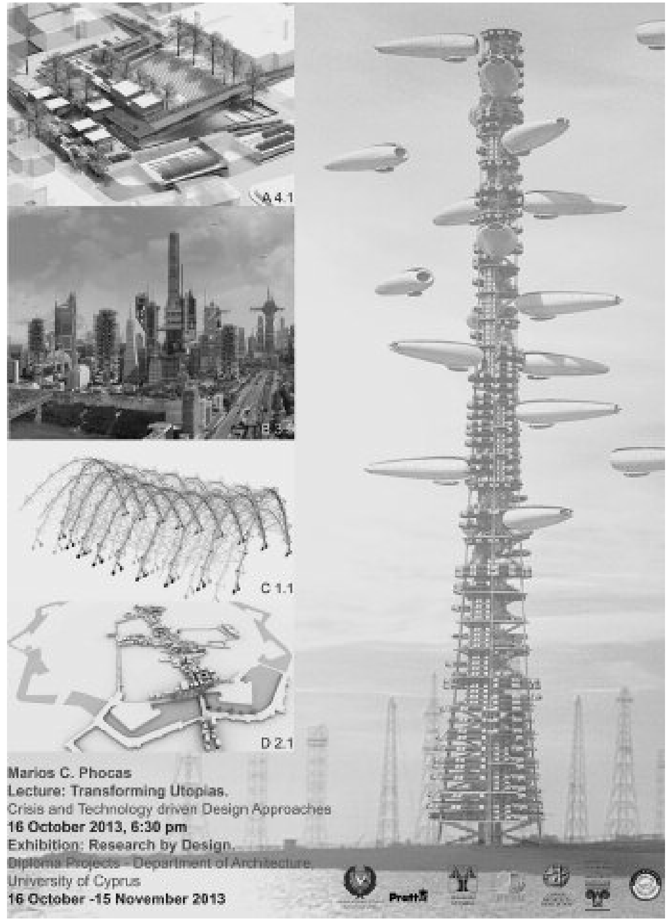


Fig. 1 The poster of the New York exhibition on transforming utopias and technology-driven design approaches

Introduction

Restructures and technology-driven design approaches to utopia

From 16th October to 15th November 2013, fifty diploma design projects completed between 2009 and 2013 at the Department of Architecture of the University of Cyprus were exhibited at the Cyprus House in New York. The architectural exhibition entitled »Research by Design. Diploma Projects – Department of Architecture, University of Cyprus« was co-organized by the Pratt Institute and coordinated by the author. While the exhibited work spanned different research scales of design processes, it aimed to demonstrate that »research by design diploma thesis«, as practiced at the Department of Architecture of the University of Cyprus, creates an experimental paradigm, positioning architecture at the forefront of redefining design research as action, following a methodology that often bridges epistemological boundaries and combines scientific rigor with innovation and creativity. In the opening lecture of the exhibition, »Transforming Utopias: Crisis and Technology-Driven Design Approaches«, reference was made by the author to design projects at the interface of vision and reality that set out to produce architectural innovation through contemporary technological means, in response to the needs of individuals, the society and the environment (fig. 1). In line with this, the designs presented in this book are enhanced through utilization of technological advances, with open-loop interdisciplinary research-based processes on the one hand and integration and transfer of technology on the other. This background shapes, in its turn, one's own initial structures for the formulation of architectural proposals for transformable prototype units for the next century featuring flexibility, customization, optimization and responsiveness to external conditions and the changing needs of the users and their times.

In all cases, performance-based processes of development in architecture are critically investigated in terms of their anthropocentric implications and efficiency and the sustainability of our

Fig. 2 R129 Project, Sobek 2012

Fig. 3 Dome over Midtown Mandhattan, Buckminster Fuller, 1960

Fig. 4 Empire State Building Zeppelin Docking Station, 1931

built environment. Underlying this is the belief that architecture, although not exclusively grounded on a scientific approach, is directly related to aspects of material, form and function and the efficiency of our built environment, and, »applied« in its nature as it is, often depends for its realization on technology transfer. Frequently, it may even act as the generator for new technological developments (figs 2–4). At the same time, architecture often offers new directions for staging life on a global and local scale, for forming cultures. It may also stimulate experiences, based on the activation of the human senses in the perception of the physical and natural environment.

In terms of »utopia«, the first question that arises is that of the relationship of architectural vision to reality that the word conveys. Whilst utopias are fundamentally not concerned about the planning of the next hundred or thousand years, and instead design a »future orientation« as a design attitude per se, the scientific, technological, intellectual or social details of future environments are expected to be elaborately worked out and founded on well-defined contemporary or predictable principles [1]. In the genre of utopia, one needs to evoke realism, so that we, in the present, can relate to the future, and, furthermore, can believe in transforming visions into reality. Otherwise, utopia becomes fantasy. Technology as perceived and applied today across various disciplines acts horizontally as an integral component throughout the design development, grounding the final design proposals that come from the imagination in the reality of the achievable.

Any investigation of the contemporary overarching crisis is pursued from the standpoint that man does not, in the end, master nature in the 19th Century sense, but instead collaborates with nature, with his very existence depending on an intricate balance of forces within which he is an active agent. One of the most significant crisis situations we are presently faced with is directly related to the eco-system – which, since the industrial revolution, includes man's machines, products and incalculable capacity to alter natural balances. Some of the mandatory requirements for the merely adequate maintenance of the eco-system are already clear. We need to recycle our minerals and metals; increasingly, we need to employ the energies of solar, wind, water and nuclear power, to draw upon microbiology and related fields of bioengineering, to reorganize our

Fig. 5 Killesberg Tower, Stuttgart, Schlaich, Bergermann & Partner, 2001

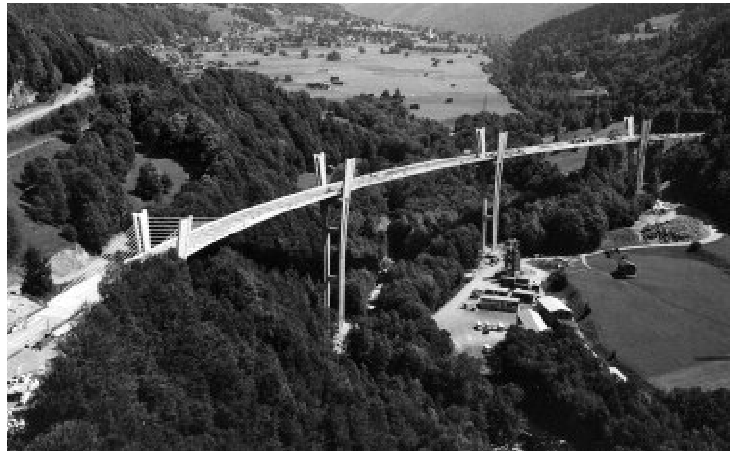


Fig. 6 Sunniberg Bridge, Christian Menn, 1998

industrial activities in new forms symbiotic with each other; to reformulate architecture to become more efficient. At architectural level, sustainability is directly influenced by the materials used, the methods of construction, erection, energy efficiency and the life cycle of the buildings. Most importantly, sustainability derives from the syntax of design that, in some cases only, enables flexibility, customization, optimization and responsiveness to external conditions and the changing needs of the users and their times (figs 5, 6). Directly related to this syntax of design is a temporal architecture whose development reflects, to the best of its ability, responsive, varied design and operational procedures.

Technology-driven design implies that different types of knowledge need to be an inherent part of the process, including individuals' existing technical and architecture frameworks, rational (interdisciplinary, research-based, theoretical and scientific) knowledge and design-driven ways of thinking (new knowledge inquiry and acquisition at each intermediate design stage), plus knowledge production. In this context, the designer's individual knowledge (their existing framework) may not only be the basis for creative action, but also the basis for understanding and interpretation.
From a technical perspective, Buckminster Fuller, above all others, is seen as representing the extreme embodiment of a scientifically oriented environmental specialist: the architect as inventor and design engineer. He worked intensively for over fifty years on self-supporting modular constructions and geodesic domes, based on principles of prefabrication and standardization and the subsequent industrial production and erection process [2]. The same is true of Konrad Wachsmann [3].

In describing the search for lighter and more efficient structures and technologies, Buckminster Fuller formed the term ephemerization. In this respect, Frei Otto concentrated his research activities among others on the fundamentals through observation, analysis and experimentation, he examined foam bubbles that always form an optimized surface, the smallest possible one, which not only saves material but also, because of its form has the highest possible stability [4] (fig. 7).

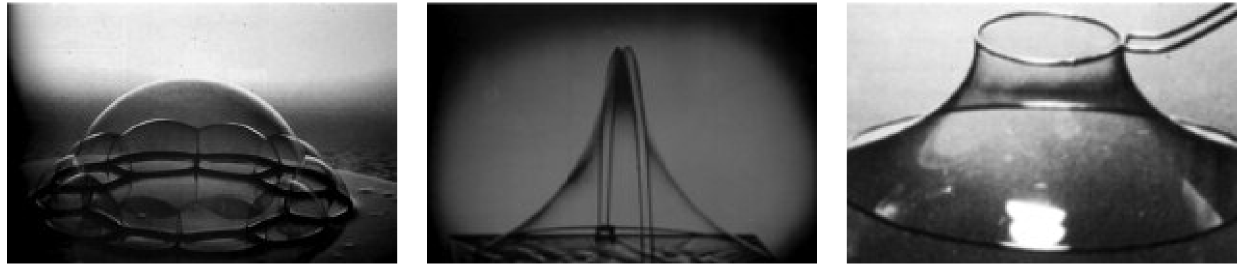


Fig. 7 Spans and lightweight structures experiments by Frei Otto

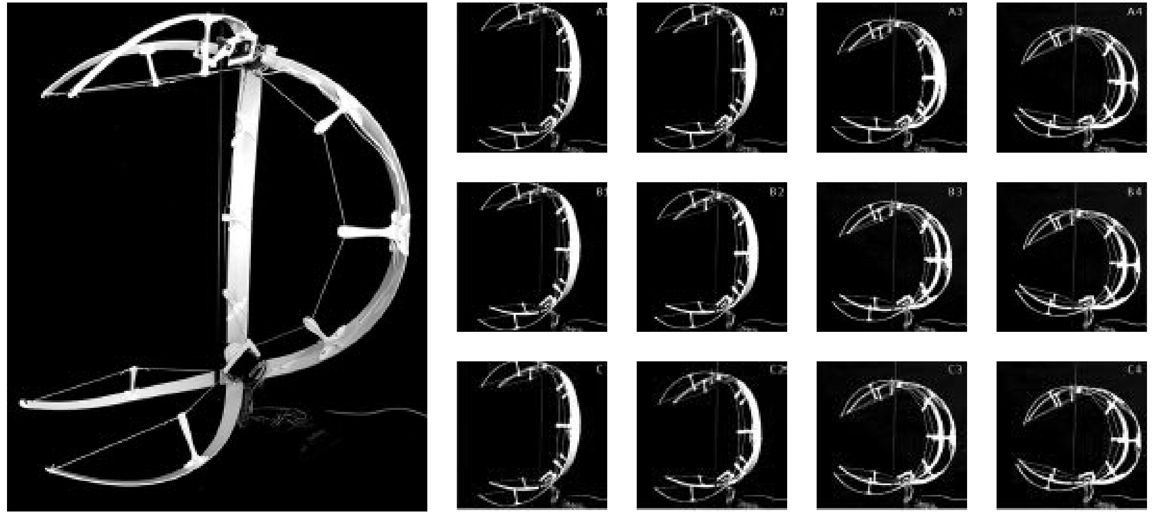


Fig. 8 Adaptable hybrid structure [Design: George Tryfonos]

Contemporary research and design approaches featuring material-efficient structures (self-weight minimization and adequate stiffness) concentrate on bio-inspired adaptable systems derived from nature, based on elastic kinematics as found in complex plant movements. Bending-active elastic members, for instance, enable the structures to move and change their shapes thanks to natural adaptation processes [5]. Their application was originally demonstrated using a prototype pavilion construction of birch plywood slats at the University of Stuttgart in 2010 and the kinetic shading elements development for the Biomimetic media façade of the Thematic Pavilion at Expo 2012 in Yeosu, South Korea. Further development of such adaptive structures to create hybrid systems has been proposed, with the primary bending-active members stabilized and kinematically controlled by a secondary system of struts and continuous cables of variable length [6] (fig. 8).

From an architectural perspective, modernists incorporated the reality of an industrialized society into their designs fifty years ago; some of them even believed that architecture is technology, and is all about technically advanced solutions for both old and new problems and tasks. The believers went further: they envisioned and pictured what might be feasible in a near or distant future (fig. 9). In developing their designs, others embraced the most advanced technology at hand: that of the space industry. In doing so, they discovered that they could do far more than represent power technologically in an aesthetic form; they could shape society. For the most part, the utopias designed in the 1960s were urban utopias, comprising ideal visions of both a technological and social nature [7]. Along with advances in technology and engineering, the emerging utopias were viable and actually feasible, either immediately or in the near future. Most importantly, the utopias of the 1960s are understood as part of the process of »society reforming itself«, which accelerated the accumulation of surplus value and increasingly made aspects like flexibility, adaptability, transportability and mobility reflective of modern society, while challenging the conventional view of architecture. Archigram's work was perhaps the most widely publicized, primarily because the group's intention was to communicate ideas. Plug-In City, a concept by Peter Cook published in 1964, was one of several projects that dealt with the idea of prefabricated homes assembled into dense fluctuating urban patterns. The Stadt Ragnitz project by Günther Domenig and Eilfried

Fig. 9 High-rise building at railway station Friedrichstraße, Mies van der Rohe, 1922

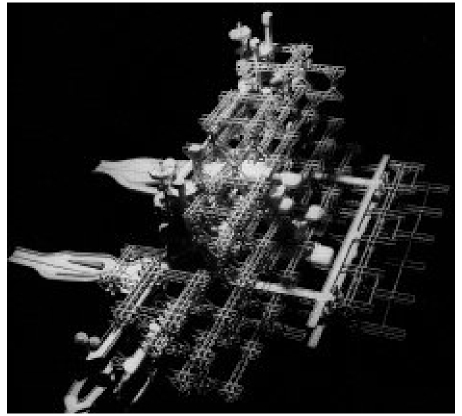


Fig. 10 Stadt Ragnitz project, Gunter Domenig and Eilfred Huth, 1963

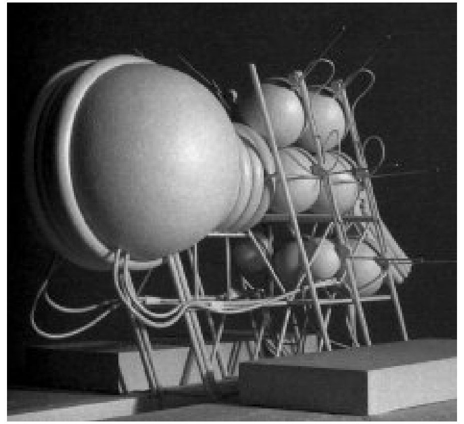


Fig. 11 Villa Rosa, Coop Himmelblau, 1968

Huth, from 1963, was based on a similar syntax of design. It consisted of a megastructure plus flexible capsule-like living units that could be plugged into the system at many potential points (fig.10). Pneumatic structures used to create inflatable living spaces, were particularly popular as they also incorporated powerful associated imagery. Instant flexible organic architecture was proposed by Himmelb(l)au in the late 1960s (fig. 11). Himmelb(l)au created Cloud I and II. Cloud I was designed as part of the »Future Forms of Living« program conducted by the city of Vienna in 1968. Cloud II was designed as a »mobile playground for four to six families«. It had spaces for being alone with someone or for group activities. In parallel, the idea of the extreme situation of emergency evacuation forcing technology back into its original function as an artificial »organ« appeared in Himmelb(l)au's transformable 1968 Villa Rosa project; a pneumatic living environment that could be carried in a suitcase. Transformable units marked the transition from the utopias of the 1960s towards their concrete manifestation in the 1970s. The generation mechanism behind the development of such visions is clearly reflected in a statement from Haus-Rucker in 1977, connected with an exhibition at the Centre Pompidou [7]:

»All those who are familiar with the phenomenon of the new technologies for environmental control, already know that buildings will no longer be built the way they were built hitherto. This is the end of a tradition. The power of technology is inevitable: Supersonic speed, the computer, the moon landing and the increasingly widespread consumption of drugs are all giving rise to an evolution in human nature. Technology is here. We must accept it and simultaneously develop a new way of thinking, feeling, being and loving.« The installation Oasis No 7, an inflatable construction with psychedelic performative dimensions designed for Documenta 5, projects out from the Fridericianum museum in Kassel, into the city space.

The Olympic Stadium in Munich, completed in 1972, represents the culmination of utopia, whilst fusing elements of the situational design of the 1960s with aspects of an »urban landscape« development (fig.12). The project simultaneously promotes close cooperation of architecture with the engineering disciplines required by the inherent interactive form-finding process of light-

Fig. 12 Olympic Stadium, Munich, Behnisch & Partner, Leonhardt, Andrae & Partner, Frei Otto, 1972

Fig. 13 Megastructure - Expo Shanghai 2010, Knippers Helbig Advanced Engineering

weight tensile structures [8]. In particular, this design saw the finite-element method that revolutionized all engineering sciences expanded and applied for the first time internationally, with development and analysis of this specific long-span structure making the realization of the original utopia feasible.

The historical importance of the Olympic Stadium in Munich is universally recognized today. Almost 40 years later, the megastructure of the Expo 2010 in Shanghai demonstrates that the methodology of design and analysis of such structures follows similar modes of interdisciplinarity, albeit in significantly smaller and iterative discrete development steps in that case [9] (fig. 13). Enabled through advances in digital technology, construction design is now directed by structural constraints of geometrically refined overall design forms and automated fabrication processes.

Such »preconceived ideas«, our existing frameworks, constitute the most important backbones of technology-driven design. At the same time, contemporary design approaches, enhanced to a great extent by digital technology platforms, are gradually acknowledging the fact that architecture encompasses a number of disciplines, bringing together a number of distinct modes of research and types of knowledge. Design provides possibilities for interdisciplinary research through an integrative approach to education and practice, while also crossing traditional research areas. The rationale for this change is based on widely recognized transitions from the linear, hierarchical thinking of industrial societies to the emerging post-industrial era of deeply interrelated types of knowledge and complex system thinking. Whereas the 1980s are characterized by the systematic methodologies of »engineering design« and the emergence of cognition in design, the more recent advances in disciplines, specialization, materials, system science and digital data-driven computation have brought a radical change in the contextual frameworks in which architectural design and production are normally placed. Such advances have paved the way to achieving »integrated inter-, multi- or even transdisciplinary design« – in all cases, a type of praxis that embraces a mindset of collaboration and cross-disciplinary communication and experimentation, visualization and research at different stages of the design process. Such integrated ac-

Fig. 14 AA Membrane Canopy, M. Hensel, M. Weinstock, A. Menges, 2007

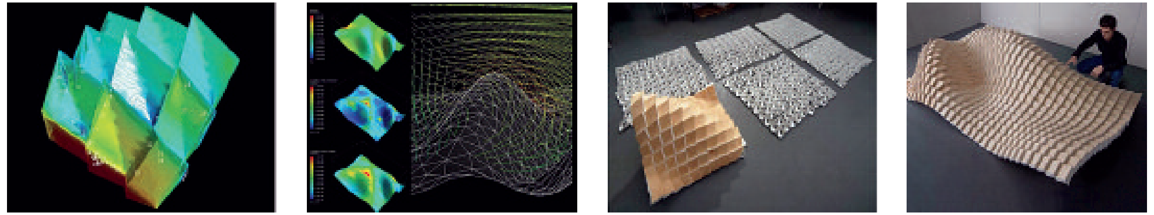


Fig. 15 Responsive Surface Structure, S. Reichert, A. Menges, 2007

Fig. 16 GFRP Membrane Pavilion, ITKE, 2004

tivities promise to generate substantially new, innovative and transformative solutions for buildings and their designs, as well as for the associations, the industry and methods employed to realize them [10] (figs 14–16). As the complexity and sophistication of buildings grow, technology should increasingly commit to realizing an integration of design considerations throughout the development process.

The diploma theses in the final fifth year of architectural studies at the Department of Architecture of the University of Cyprus supervised by the author, presented in this publication, experiment with the implications of this position and adopt an explorative and integrative approach to research and the design process in interdisciplinary environments.

From the initial conceptual phase, design proposals for structure prototypes have been realized in an integrated interdisciplinary context, relying on experimentation, physical modeling, digital simulations and analysis in an interactive architectural-engineering context (fig.17). In real terms, the setting of the boundary conditions, whether geometrical, functional, or environment-specific, comprises the basis for subsequent interactive development of the system's behavior. The results of such design-driven investigations could be used to develop a rationale for an open-loop design of multi-variable prototype systems, with the emphasis on the physical properties of the materials and the systems applied (fig.18). The following case studies are exemplars of how utopian transformation could enable achievement of optimized design solutions in terms of specific architectural aims.

A1. The prototype development and simulation of a kinetic spatial tensegrity structure aiming for minimal self-weight, optimal load transfer and structural transformability. The structure consists of continuous hinge-connected compression members, strengthened by an internal system of struts and continuous cable diagonals with closed loop and variable length. The static and kinematic operability of the system arises primarily from its integrative composition – specifically, from the dual capabilities of the secondary strengthening system.

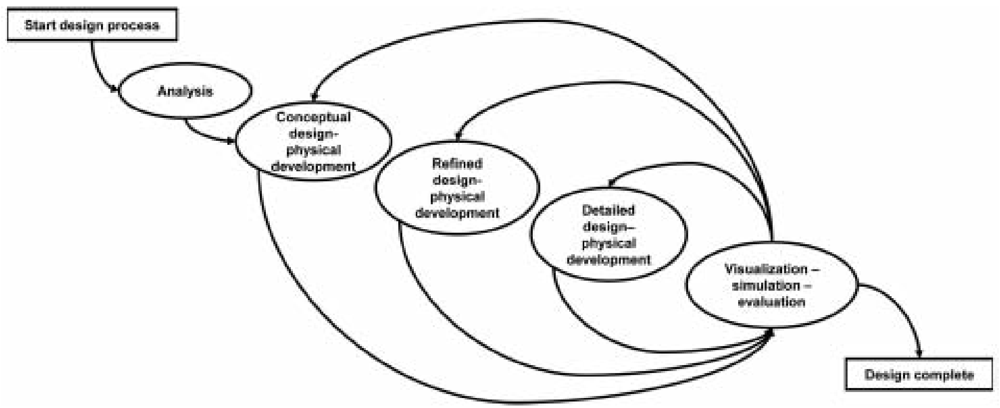


Fig. 17 Open Loop Deisgn Process with Conceptual, Refined and Detailed Design Phase

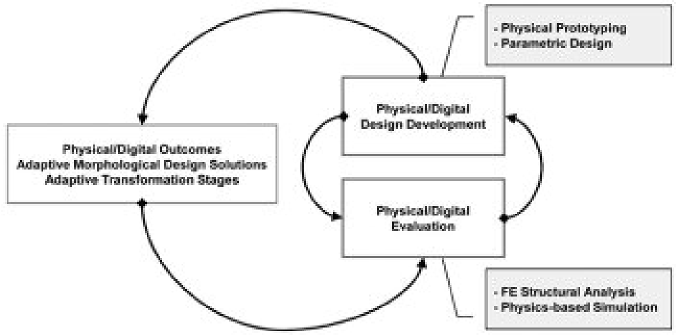


Fig. 18 Feedback Loop Performance based Design Process

A2. The prototype development of a kinetic form-active membrane system coupled by struts with an underlying continuous cable-net with closed loop. The potentialities of the system's morphology states in terms of load transfer, stability and kinematics are primarily investigated through variability of the membrane unit supports and tracing of sequential free-form variations. Thus, the design of the hybrid system follows a material-form generating process.

A3. The prototype development of a kinetic form-active building envelope driven by integral characteristics of natural systems and kinematic mechanisms in biology. The primary structure is composed of scissor and bending-active members interconnected in series and stabilized through continuous cables with closed loop, also responsible for the kinematics of the system according to possible different operational configuration states of the building envelope. The membrane envelope is conceived to act as an architectural technological filter and can adapt its shape according to the functional needs of the building.

A4. The prototype development of a cable bending-active structure consisting of two parallel series of bending-active members with initial inverted curvatures to form continuous elastic curvilinear elements, which are horizontally interconnected through pre-tensioned cables. The structure's adaptive behavior is examined in a footbridge architectural application, with the imposed external moving loads of pedestrians. The specific prototype development provides an alternative and sustainable way to generate morphological and structural design solutions that effectively adapt to human-related conditions in an interactive and experiential way, whilst allowing for a new »soft« architecture to emerge.

A5. The prototype development of a transformable hybrid structure composed of primary bending-active members stabilized through struts and continuous cables with modifiable length. The primary arches are connected horizontally by rhomboid bending-active members twisted towards the strong axis at mid-span to obtain adequate stiffness against vertical loading. The lightweight structure is capable of different configurations based on the nonlinear elastic behavior of the local and global system.

A6. The prototype development of a transformable elliptical scissor structure to accommodate different user needs. The structure consists of primary scissor elements combined with special hinge-connected members and stabilized with upper and lower continuous cables. The transformability and stability of the structure is provided by linear scissor-elements and cables of modifiable length.

A7. The prototype development of an adaptable envelope structure composed of bending-active members and a secondary system of struts and cables that are responsible for the kinematics of the system. Linear compression by the actuators is transformed into bending deformation of the elements and responsive modification of the membrane surface of the building envelope units for the control of air ventilation and physical lighting in the interior spaces.

The design projects featuring transformable functional units are derived from a comprehensive exploration of structural typologies in different contextual frameworks, subsequent to iterative design process-related research incorporating analysis, evaluation, application and intermediate developments. These examples combine technology-driven design with the necessity of creating habitable living and working spaces, resulting in an architectural language and overall form enriched by advanced building technology. In the following case studies, technology serves as a design tool enabling innovation in the structure, construction, and architecture of utopia.

B1. A proposal for floating structural units with integrated photovoltaic membranes for solar energy collection, above the city core of Nicosia, aiming to supply the full electrical energy requirement for the city center. The units may land within the city, their transformable structure generating capsule towers serving various public and private functions.

B2. A proposal for marine renewable energy production units for cities with a strong dependence on electricity. The units incorporate two turbines below sea level and a special membrane pillow filled with air. The building units above sea level host different public spaces used for research and exhibitions of energy production and marine life.

B3. A design proposal for a three-story glass pavilion with the primary structure, envelope and movable panels constructed entirely from glass. The different themes for the building's different levels, supported by varying degrees of transparency and user activities, are intended to enhance the layers of technology, thus providing visual and physical experiences for users.

B4. A proposal for a traffic flow redistributor structure for city centers with high-intensity problems with private and public internal traffic flow circulations. The structure would be placed on the city's main arterial roads. It incorporates pedestrian bridges and units serving public civic functions. The proposal and functions for the structure are adjusted to the prevailing morphology and usage of each site.

B5. A proposal for a transformable pier structure composed of bending-active elements in different typologies, capable of interacting with the pedestrians' moving loads, functions and activities in connection with the prevailing environmental conditions at the site and on the water.

B6. An urban regeneration proposal involving energy collection and supply for the development of interacting urban functions within the existing city layer. The elements proposed consist of floating bending-active units responsible for energy collection above the city layer. They can individually land within the existing urban fabric to form functional tower structures in a related technological context.

B7. The development of a kinetic prototype unit for extreme environments. The unit adjusts to the external environmental conditions and internal usages through its morphological transforma-

Fig. 19 High-Rise Traffic-Port systems prototype [Design: Marios C. Phocas, Niki S. Nikolaou and George Tryfonos]

bility. It is composed of a prefabricated lightweight core element that hosts all secondary functions, six curved bending-active elements that can rotate along the circumference of the unit and a horizontal tensairity hybrid pneumatic system to provide stability to the main structure. The surface of the unit is composed of double membranes.

The following case studies address related issues of technology-driven design in transformable tall structures.

C1. A proposal for an energy-autonomous tower structure that supports autonomous functional units for researchers working and living in remote areas. The kinematics of the structure enables the accumulation of kinetic energy and its transformation into electrical energy for the purposes of the building operation.

C2. A proposal for a high-rise building prototype aiming to customize form and functions from a performative perspective. The design is primarily characterized by aspects of lightweight and efficiency of the structure, modularity and prefabrication of the construction elements.

C3. A proposal for vertical layers of urban functional units in different spatial conditions, aiming to reorganize existing individual »dysfunctional« urban environments. The developed structures, characterized by lightweight, prefabrication, expandability, transformability and re-use, have been determined by varying shape and scale in a multi-criteria, performance-based architectural context.

C4. A design proposal for a tall lightweight structure to act as an urban element with different functions. The structure consists mainly of an outrigger system, with the core element stabilized by vertical cables placed on the circumference. The functional units are prefabricated and consist of transformable components to accommodate different user needs at different levels and on different scales.

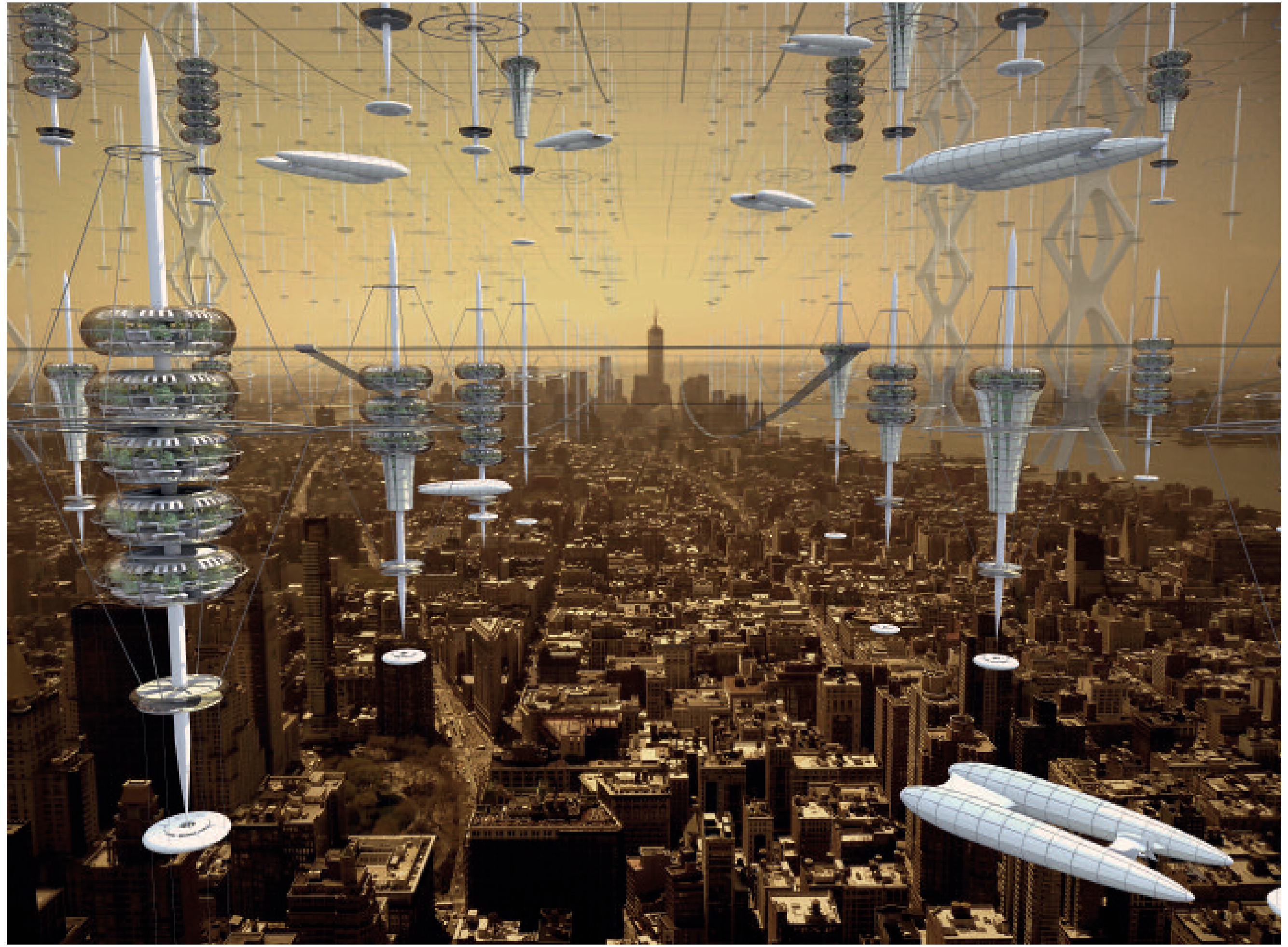


Fig. 20 Floating high-rise urban layer [Design: Marios C. Phocas, Niki S. Nikolaou and George Tryfonos]

C5. A proposal for an offshore high-rise building promising improved working and living conditions for oil rig environments. The floating building accommodates private and semi-private spaces in the suspended clip-on units, depending on operation intensity and functional requirements. The intermediate spaces provide a bridge for the flows of permanent and temporary users at the site.

C6. A high-rise building prototype proposal for a transformable inner core that enhances the vertical air-flow, with a coupled outer member structure of rotating diagonal members and vertical cables forming a hybrid tensegrity-outrigger system. The airflow building prototype filters the moving air masses in dense urban environments and provides vertical levels of green areas.

In reformulating utopia towards transformable high-rise prototype units, two designs created for the International eVolo-Skyscraper competitions of 2013 and 2014 are referenced. The aspects of globalization, sustainability, technological material and system advances and modes of interdisciplinarity have been driving forces for the development of the designs.

The proposed high-rise traffic-port systems prototype requires reduced footprint in dense urban environments, adapts efficiently to differing urban sites and programmatic requirements and uses fewer resources (fig. 19) and transformable structures, the »port-elements«, are positioned as fine arteries within major European cities creating a network of physical and cultural inter-transfer and intercommunication. The journey of the pneumatic airships above the urban grounds ends with a vertical journey. Landing at the port-element induces vertical bridging to the reality of the contemporary city, through private, public and green open spaces. Equally, an experiential journey develops from the ground to the respective intermediate departure floor above. Furthermore, the port-elements offer an infrastructure of applied digital activities, thus becoming significant nodes of transnational urban reference.

In another proposal, inhabited floating urban layers act as regeneration mechanisms with minimal physical intervention within the existing contemporary city, which is characterized by scarcity of natural resources and infrastructure, exponential increases of inhabitants, pollution and lack of usage diversity and expandability (fig. 20). An applied example: the island of Manhattan, New York, the area between the Empire State building and the Lower Manhattan District (i.e. 34–14th Street). The high-rise structures with building units and functional capsules are fixed to cable nets above the existing urban structure. The high-rise cores are enveloped by rotating photovoltaic membranes for energy supply. The air-transfer elements comprise vertical airship elevators and hybrid airships. The vertical airship elevators travel along vertical cable rails to connect to the ground. The hybrid airships interconnect the high-rise structures. They can dock to boarding and recharging station units.

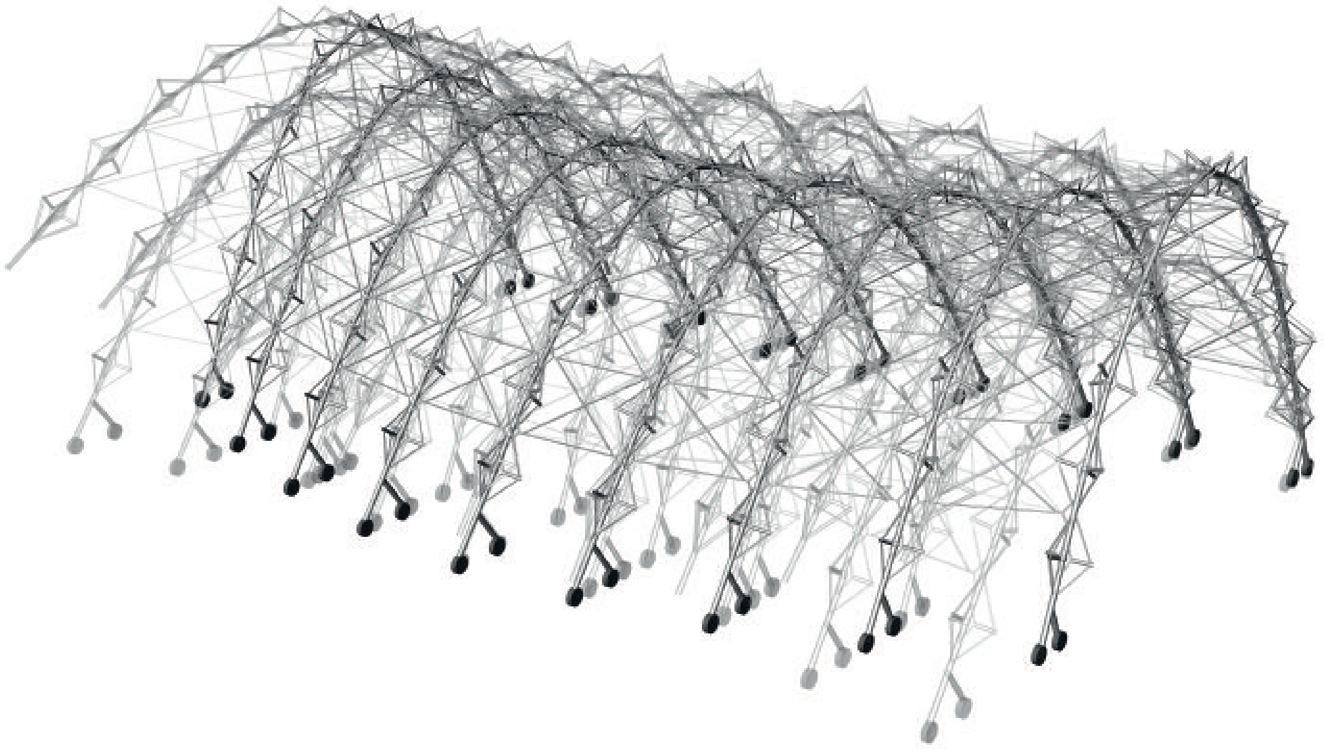
In designing the future, we certainly do appreciate our existing frameworks. We deal with fundamental questions throughout the architectural design scales, and try to identify the forces to drive innovation and compelling solutions. These investigations become invaluable within the technology-driven design of utopia, and lead to more inclusive concepts of a sustainable future, as influenced, for example, by the human subject, the environment, the technology and the structural and material organization complex.

Marios C. Phocas

References

1. K. May, *SCI-FI*, Clog, New York, 2013.
2. J. Krausse and C. Lichtenstein, *Your Private Sky. R. Buckminster Fuller Design als Kunst einer Wissenschaft*, Lars Mueller, Zurich, 2000.
3. K. Wachsmann, *Wendepunkt im Bauen*, DVA, Stuttgart, 1989.
4. R. Finsterwalder, *Form Follows Nature*, Springer, Vienna, 2011.
5. J. Knippers and T. Speck, »Design and Construction Principles in Nature and Architecture«, *Bioinspiration & Biomimetics*, 7, 2012, accessed: 22 June 2014: http://iopscience.iop.org/1748-3190/7/1/015002.
6. O. Kontovourkis, M.C. Phocas and G. Tryfonos, »Prototyping of an Adaptive Structure based on Physical Conditions«, *Architectural Computing*, 11/2, 2013, pp. 205–226.
7. D. Steiner, *The Austrian Phenomenon. Architecture Avantgarde 1956–1973*, vol. 1, 2, Birkhaeuser, Zurich, 2004.
8. A. Boegle., P. C. Schmal and I. Flagge, *Light Structures. Joerg Schlaich, Rudolf Bergermann*, Prestel, Munich, 2003.
9. J. Knippers, J. Cremers, M. Gabler and J. Lienhard, *Construction Manual for Polymers + Membranes*, Institut für Internationale Architektur-Dokumentation, Munich, 2011.
10. M. Hensel, A. Menges and M. Weinstock, *Emergent Technologies and Design: Towards a Biological Paradigm for Architecture*, Roudledge, Oxford, 2010.

A. Prototype Structure Design



Hybrid Structure Reconfigurations

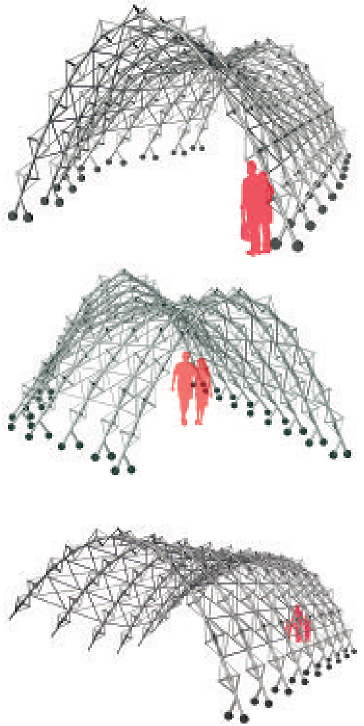
Kinetic and Interactive Architecture

Matheou Maria
Phocas Marios C., Charalambous Nadia, Kontovourkis Odysseas (Diploma Committee)
09.2009–05.2010

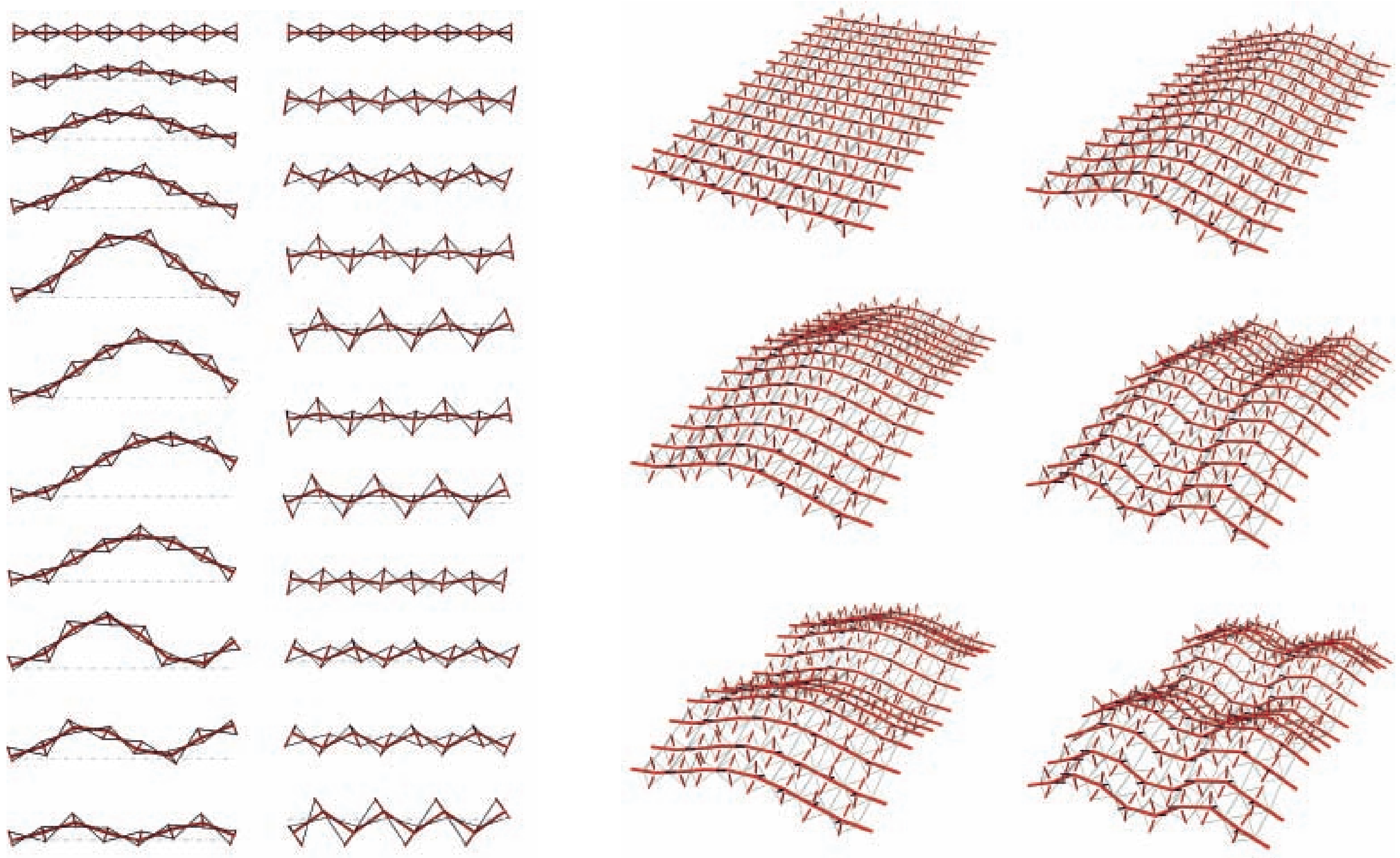
The investigation focuses on the analysis of kinetic and interactive architecture. It explores the concept of transformation as a structural, interactive design and the design process. The main motivation for the development of the specific research-driven design was the dynamic, changing and interactive capacity of human existence and the natural environment. Architectural projects that are examples of kinetic and interactive architecture have been analyzed to achieve a classification of kinetic concepts. The main development was driven by the syntax of parametric design. The architectural proposal is not perceived in finalized form, but as a rational linkage of adjustable member units. If one parameter is modified, then the entire system is modified. The result is based on a variety of morphological reconfigurations.

The design development originated from the construction design of the structural prototype, based on human body and tensegrity structures. A fundamental founding principle of the structural prototype, and, at a later stage, the interactive system, was the synergy of the skeleton and muscular system of the human body. This is applied in the form of tensegrity structures that work on the same logic as the human body, i.e. a balance between tension (pre-stressed cables/muscles) and compression (struts/bones).

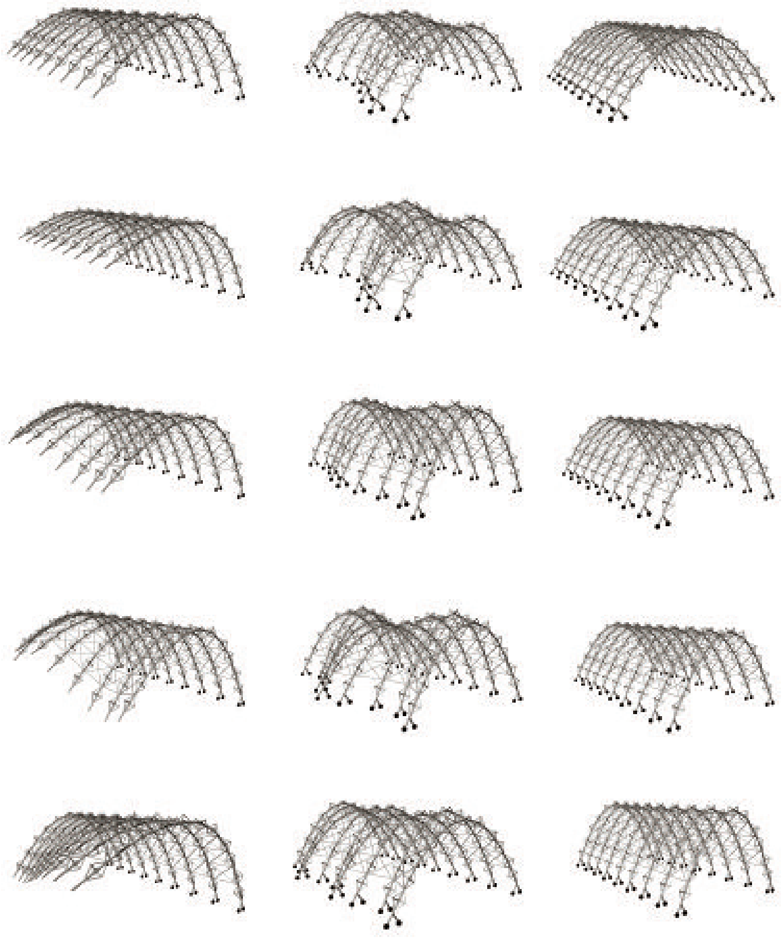
The hybrid system developed consists of continuous hinge-connected compression members, strengthened by an internal system of struts and continuous cable diagonals with closed loop. The kinetic mechanism is achieved through alteration of the cable lengths and the responsive relative inclination of any adjacent compression members. Thus, the transformability of the system arises primarily from the inherent integrative composition and dual capabilities of its members. Following the construction design of the prototype structure, the interactive development, with regard to geometric properties and structural configurations, has been analytically investigated based on a parametric-associative design approach. Along these lines, the specific syntax of structural development and simulation through parametric design is suggested as a way of supporting, in real terms, the control design of the structure in an integrated interactive context.



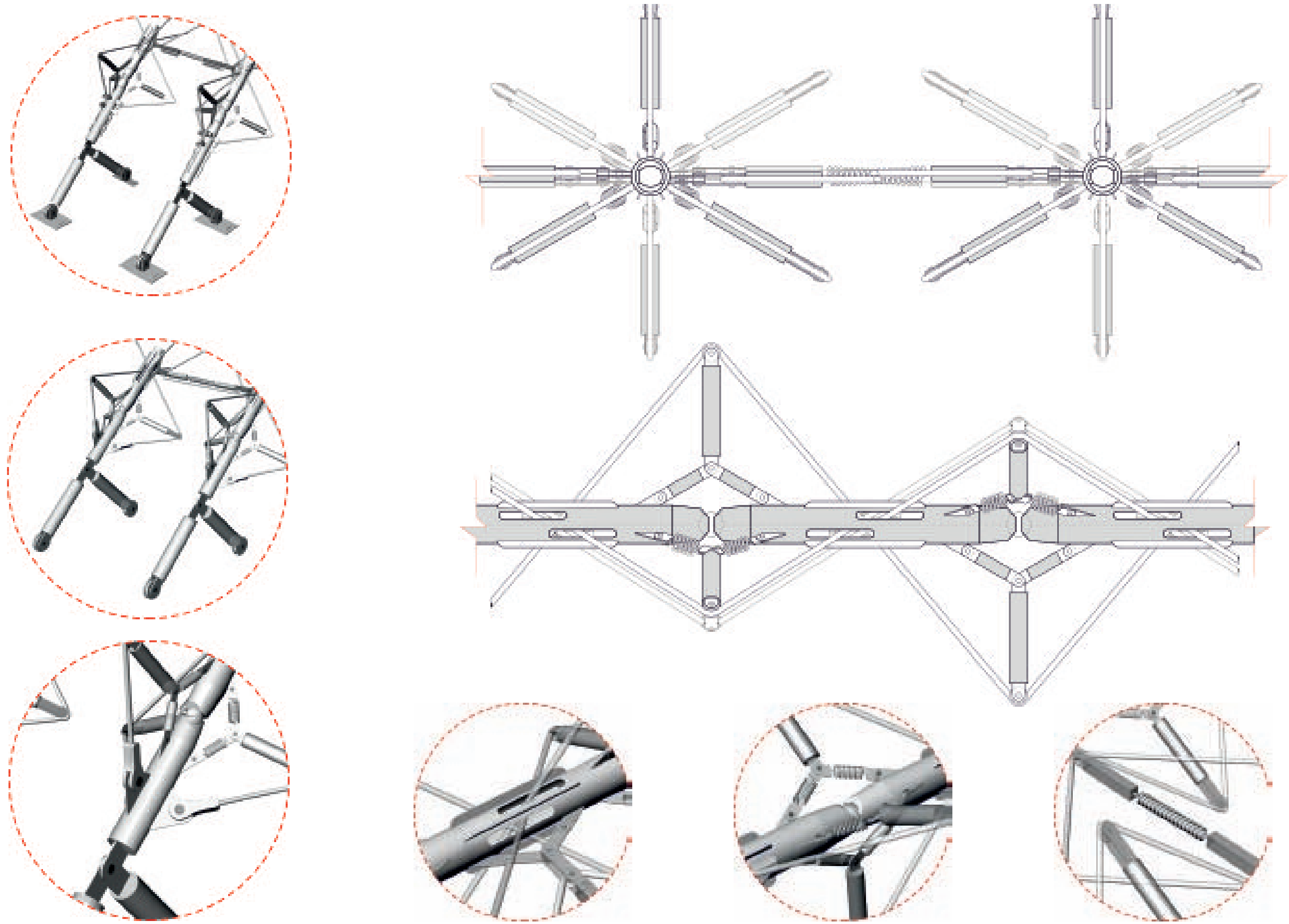
Case Study Perspectives



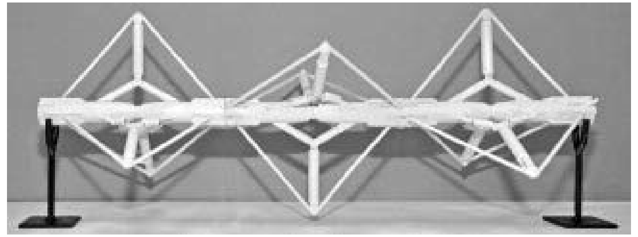
Associative Parametric Analysis of Primary Structure

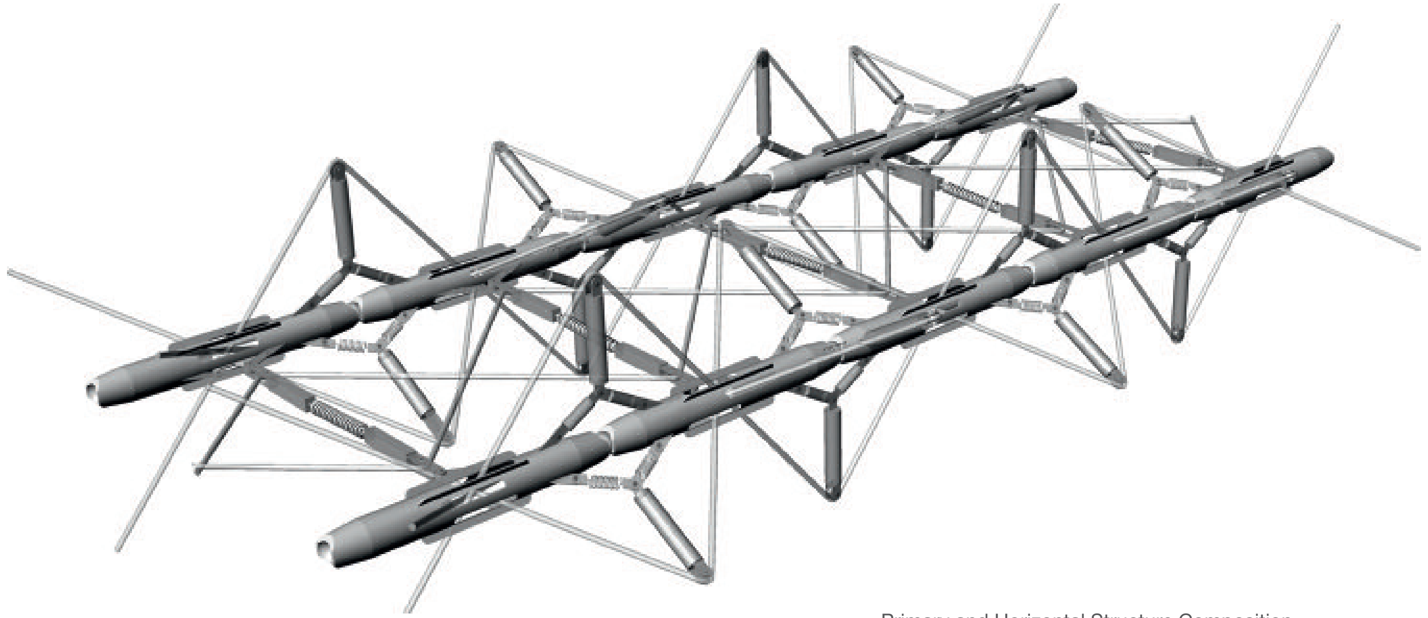


Interactive Structural Reconfigurations

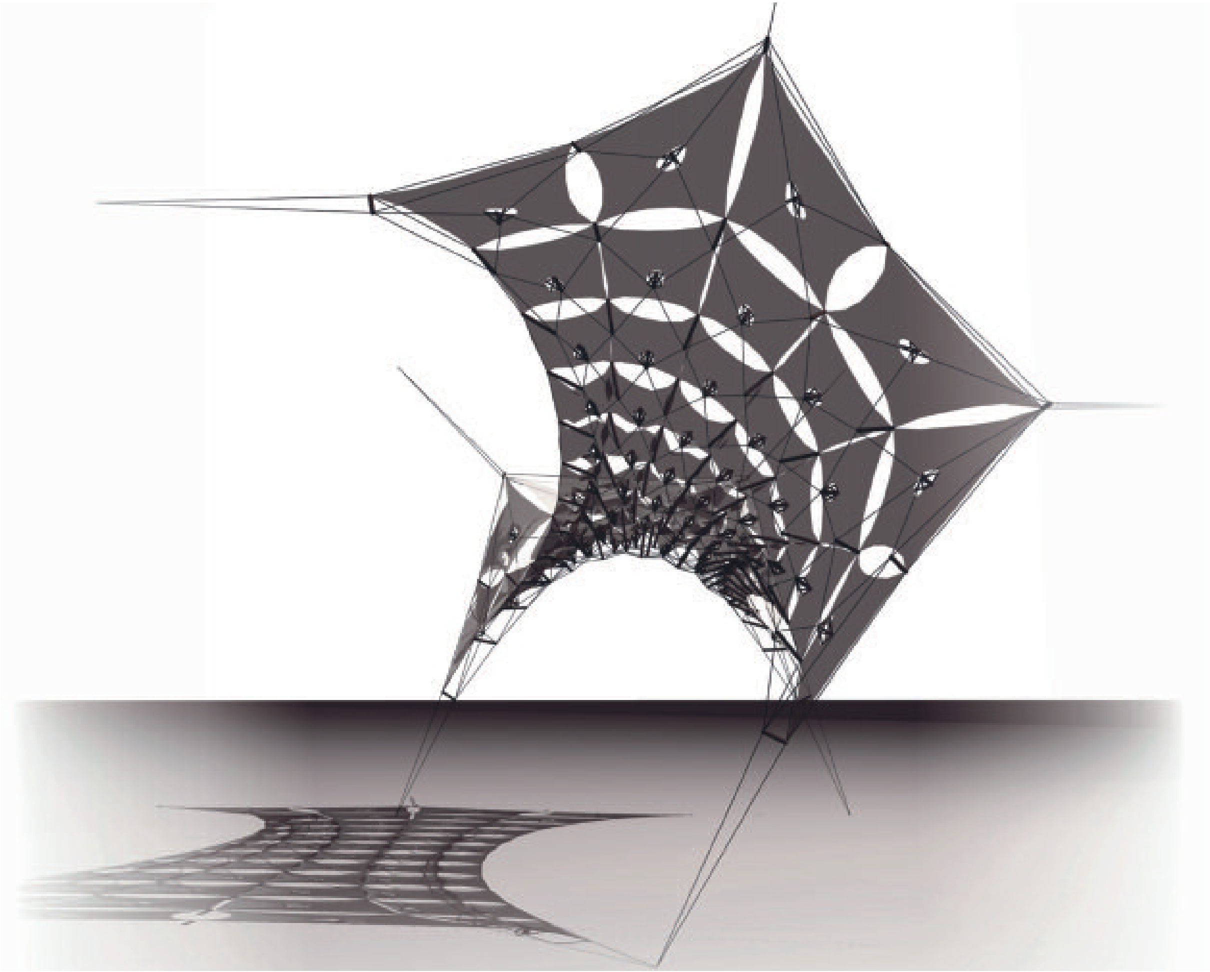


Construction Design of Structural Members and Connections





Primary and Horizontal Structure Composition



Kinetic Tensile Structure

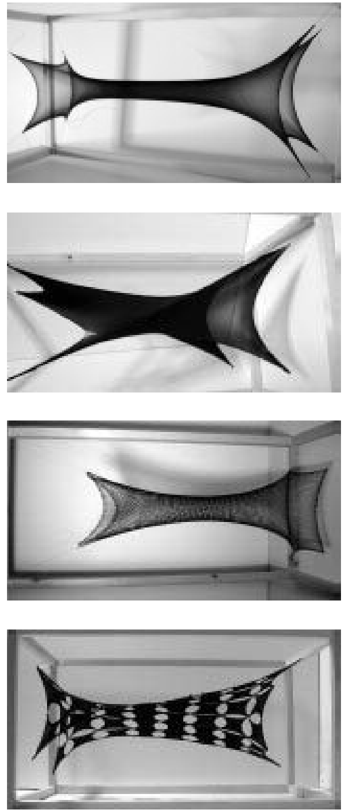
Inter-Responsive Architectural Adaptive System

Ioannou Anastasios G.
Phocas Marios C., Kontovourkis Odysseas, Vrontissi Maria (Diploma Committee)
09.2010–05.2011

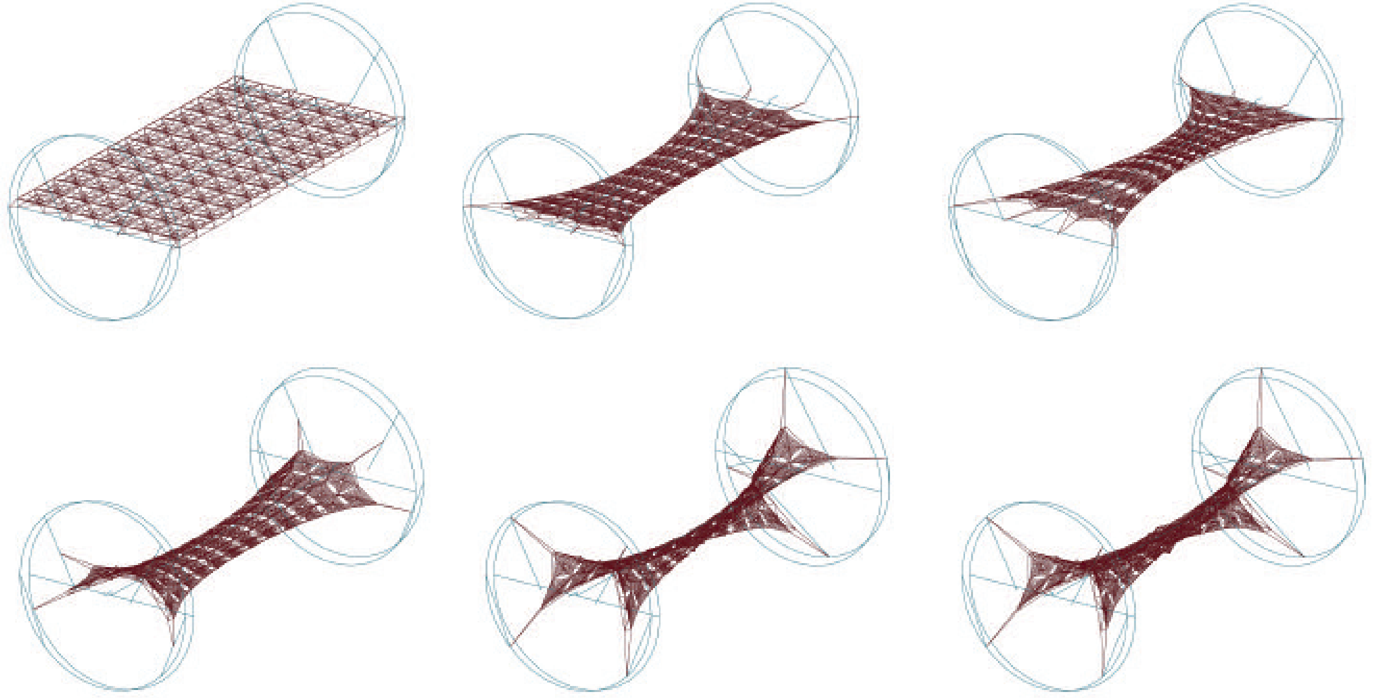
If architecture can be regarded as providing objects represented in space, then architects are largely concerned with geometry and a field of mathematics. Throughout history, there have been different architectural styles that seemed to represent (the logic of) each period in an attempt to resolve an issue. Our era can be characterized as the information age, and this may also be considered as a tool for an architect. The buildings that act as the fundamental basis for the information can be described as »smart buildings« or »kinetic architecture«, and are commonly referred to as interactive and responsive environments.

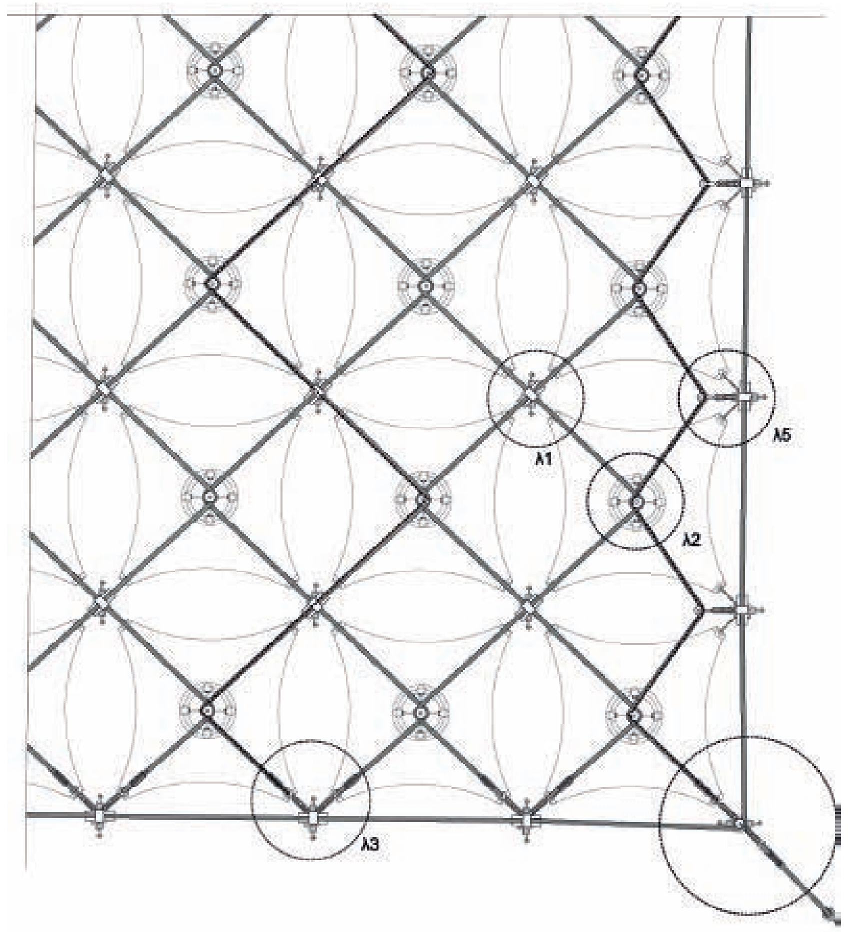
This thesis deals with making the concepts of »interactive« and »responsive« environments comply with a system that is able to adapt and respond to various changes and needs for space through the processes of »morphogenesis«. In this process, the role of the material is vital. Recent research activities based on existing theories and experiments have shown that membranes can easily adapt to various changes, which can also be used to transfer information whilst provoking interaction between the supports of the system.

The membrane, with its properties as a main carrier of tensile loads, can expand the potential form of the element by changing the mounting point of formation and rotation. The structural element is then divided into small units, creating a dual system of membranes and a cable net connected to it. Activation of the boundary and supporting conditions results in an increase or decrease of intensity of each unit during the transformation. In the initial stages, the possible forms that this tensile structure can achieve are physically and digitally investigated. With the aid of »productive algorithms«, various transformations of the overall system can be controlled by varying the tension of the cables respectively (locally). Further optimization of the kinetic system refers to the achievement of most uniform distribution of tension to all elements.

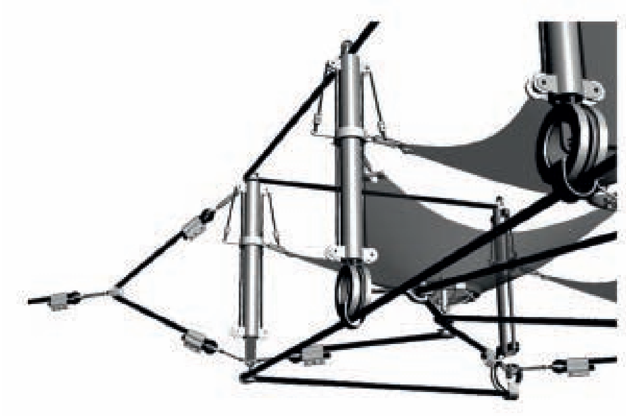


Expermental Investigations on
Tensile Membrane Structure

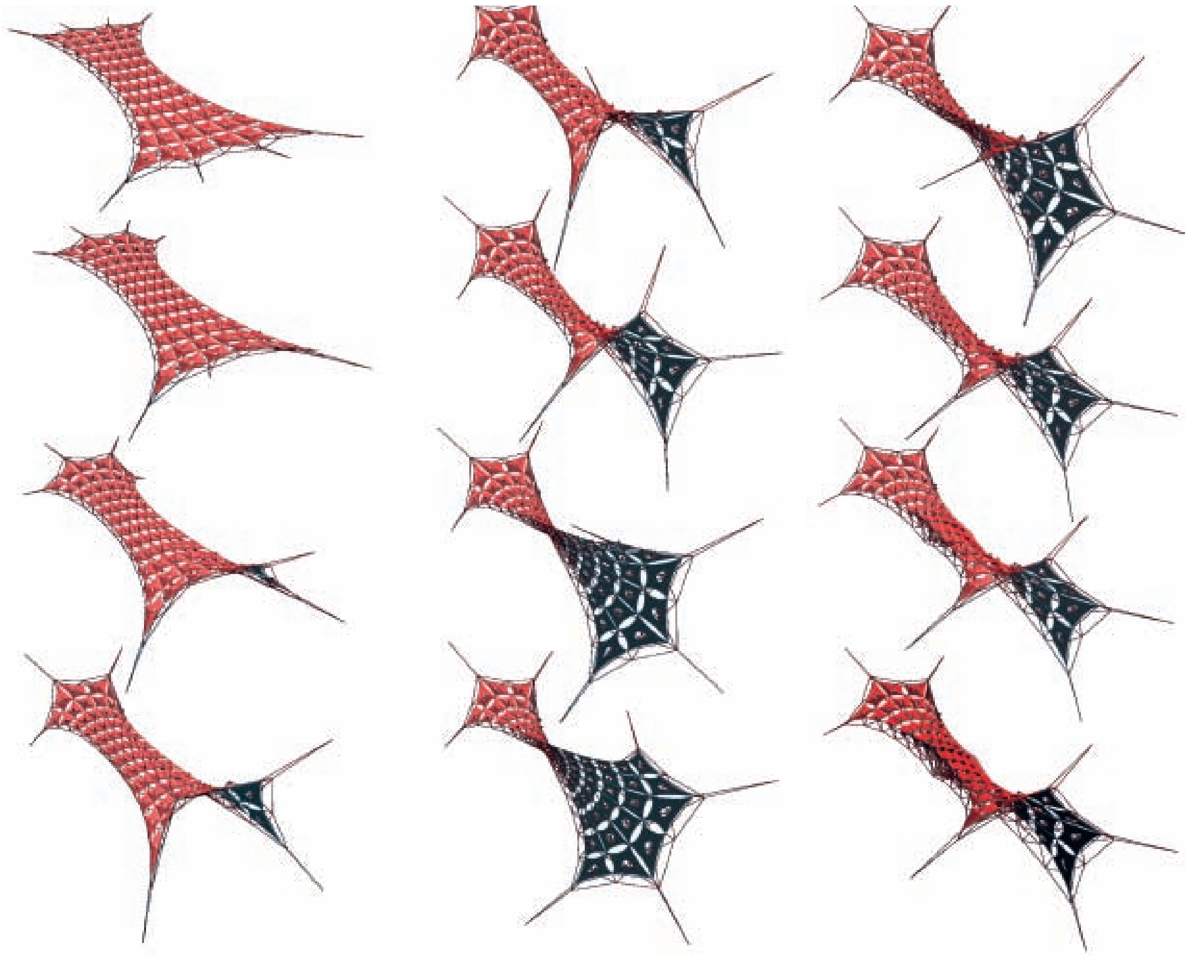

Elements Fragmentation and Transformation Path



Tensile Structure Top-View



Prototype System Units Composition



Possible Systems Transformation States