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# Utopian Kinetic Structures and Their Impact on the Contemporary Architecture

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**Abstract.** This paper delves into relationships between twentieth century utopian concepts of movable structures and the kinematic solutions implemented in contemporary architectural projects. The reason for conducting this study is to determine the impact of early architectural conceptions on today's solutions. This paper points out close links that stem from the imagination of artists and architects working in 1960s and 70s and the solutions implemented by contemporary architects of that era. The research method of this paper is based on comparative analyses of architectural forms with adopted kinematic solutions. It is based on archive drawings' studies and the examination of theoretical concepts. The research pertains to different forms of such mobility that evolved in 1960s and 70s. Many of them, usually based on the simple forms of movement were realized. The more complicated ones remained in the sphere of utopian visionary architecture. In this case, projects often exceed technical limitations and capabilities of design tools. Finally, after some decades, with the development of innovative architectural design tools and new building technologies many early visions materialized into architectural forms. In conclusion, this research indicates that modern kinematic design solutions are often based on conceptual designs formed from the beginning of the second half of the twentieth century.

## 1. Introduction

Despite the dominance of static notions of space in philosophical concepts of architecture, mobility has accompanied architecture from the beginning of its existence. The first buildings inhabited by humans very often moved, which resulted directly from a nomadic lifestyle. A representative example of such a shelter was the yurt, the tent of nomadic tribes that inhabited the Great Steppe of Mongolia. Along with the change of lifestyle into a semi-nomadic, which was related to plant cultivation and animal husbandry, the phenomenon of mobile structures gradually disappeared and our architecture become static. However, in the evolution of architectural thought throughout the centuries, numerous experiments were carried out that were focused on kinematic solutions. Since the first decades of the twentieth century more and more architectural concepts have evolved that involved different forms of movement. There were visible in the Light-Space Modulator developed in 1921-30 by Laszlo Moholy-Nagy and early changeable interiors designed by Gerit Rietveld. Kinematic visions once again became one of central themes explored in the 1960s and 70s both by artists and architects. Those were kinematic machines constructed by Jean Tinguely or environmental works presented by Hans Haacke and Salvatore Romano [1]. Those were also architectural fantasies proposed by Archigram group, utopian drawings of changing urban spaces created by Constant Nieuwenhuys and many other experiments questioning permanence and stability as dominant characteristics of architecture. Almost none of those concepts materialised as



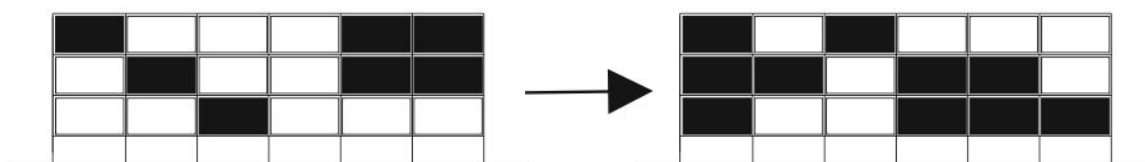
built objects. However, as research shows they could be considered as an important inspiration for today's architecture.

The method used to conduct this research involves the comparative analysis of representative examples of utopian architectural conceptions from the middle of the twentieth century and recently built structures. The study takes into account objects that involve movement – where movement is an important element affecting aesthetic, functional and spatial qualities of the constructed form. The study shows the impact of early utopian architectural conceptions on modern day architecture that involves movement.

## 2. Comparison of kinematic utopian architectural forms from the second half of the twentieth century and contemporary architecture

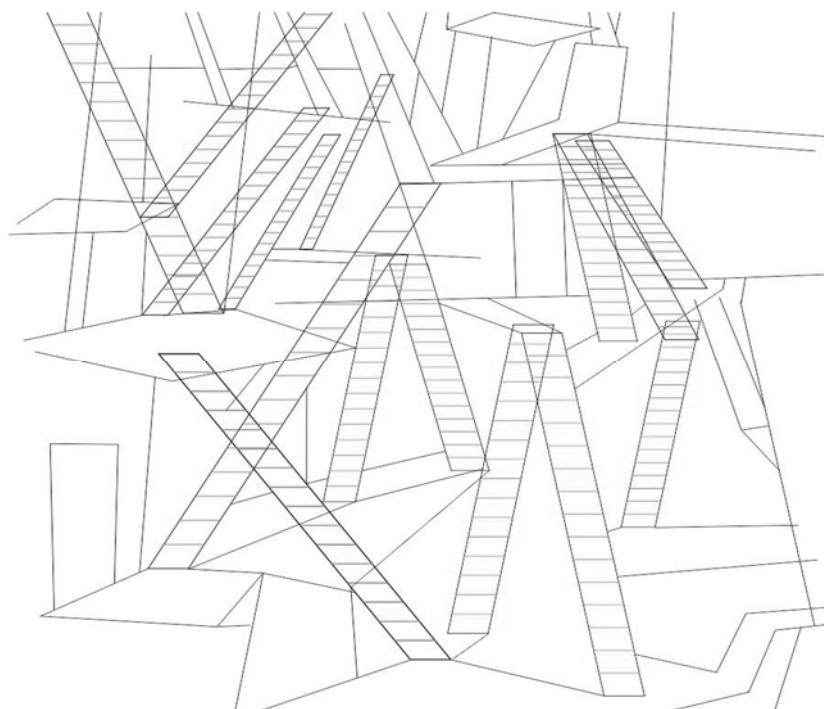
### 2.1. Utopian architectural visions from the twentieth century

Concepts taking into account the movement started to grow rapidly in Europe in the middle of the twentieth century. During the X International Congress of Architecture in Dubrovnik in 1956, Yona Friedman presented *Manifeste de l'architecture mobile*. Friedman introduced to architecture the phenomena associated with the search for mobile spatial solutions, aimed at adapting multi-family buildings to the ever-changing needs of their residents. Friedman's actions were not limited only to architectural scale; also, his urban concepts were strongly inspired by movableness. The concept of mobile architecture assumes the ease of such movement and the ability to optimize the maximum functional system by adapting to the requirements of its user. Applications of movement fascinated Friedman from the very beginning of his creative work. In his early works such as "Panel Chains" and "Movable Boxes," the architect sees the potential that is brought by kinematics and its implementation in architectural practice. Both projects are an attempt to propose reconfigurable space that could be created and controlled by the user. [2]



**Figure 1.** Movable boxes

In the Netherlands, various architects have also created a utopian idea of mobile architecture. Already in the 50s Constant Nieuwenhuys had created bold architectural visions. Nieuwenhuys worked on his project of a nomadic city called the New Babylon. The utopian concept assumed creation of a multi-level city with an irregular grid which allowed for flexible relationships between objects, which could undergo many different daily changes. These changes would not be controlled in any specific way. In the world created by the architect, the most important objectives would be associated with social aspects such as self-satisfaction and self-fulfilment. Therefore, any collective action in a natural way would be eliminated. The structure would develop in an unpredictable way, unrestricted, without beginning or end or even without a plan. Often Nieuwenhuys's idea is described as a grim counterpart of the subsequently-formed Plug-in City.



**Figure 2.** New Babylon

One of the most dynamic centres of avant-garde architecture of the twentieth century was the United Kingdom, where Cedric Price and other architects gathered in a group called Archigram to create their unique works. Price, who began his career working for Richard Buckminster Fuller, had gained international recognition thanks to the innovative project called Fun Palace in 1961. The project, carried out together with the theatre director Joan Littlewood, was an attempt to develop an experimental entertainment space. By using various types of interactive technology and lifts inside the structure, this space was adapted to the needs of its users. The project encompassed a variety of solutions used in theatres like descending ladders, rotating floors and water sprinklers. Mechanical control systems were supported by sensors and actuators. Price's work served as a crucial inspiration for the project by Renzo Piano and Richard Rogers which was realized much later in the Paris Centre Pompidou, [3].

Many theoretical projects were developed in the UK by the members of the Archigram group. Most of the works produced by Warren Chalk, Peter Cook, Dennis Crompton, David Greenego, Ron Herron and Mike Weeb, challenged the principles of traditional architecture and were aimed at finding new answers to the challenges of architectural design. Members of Archigram exerted a huge influence on the younger generation of architects, as they were teaching in the best architecture schools in Great Britain and the United States: Architectural Association, Bartlett at University College London, Westminster, Columbia University, Cooper Union and Princeton. At these universities research teams focused around members of Archigram became centres of development of innovative architectural solutions, many of which were characterized by implementation of kinematic elements in architecture [4].

The most influential and widely commented upon work of the group was the concept of Plug-in City developed in 1964 by Peter Cook. The intention of the author was to create modules with certain necessary functions, which could be arranged and re-arranged in response to emerging needs. The modules could be connected to base points to then supply the main structure with anything that was needed at a particular time. The architect described his idea as follows: "Plug-in City is set up by

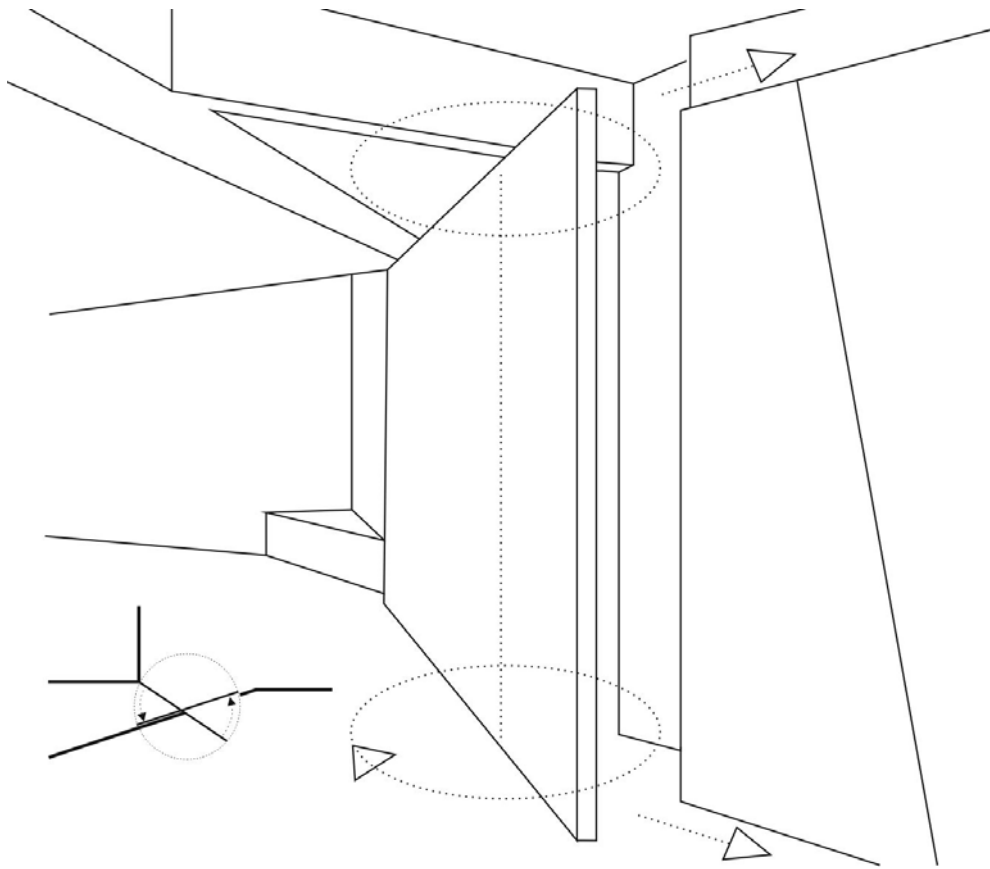
applying a large scale network-structure, containing access ways and essential services, to any terrain. Into this network are placed units which cater for all needs. These units are served and manoeuvred by means of cranes operating on a railway at the apex of the structure. The interior contains several electronic and machine installations intended to replace present-day work operations.” [5]

Considering the presence of movement in architecture, the most surprising concept was the idea of Walking City, where Herron proposed a form of a living robot-city. The project assumed that the facility would be equipped with artificial intelligence responsible for its control. The object itself would be able to move freely on the ground, and could even walk to any larger metropolis. Similar to the concept of Cook was the idea of Gasket Homes drawn by Ron Herron and Warren Chalk in 1965. The proposed system was based on the arrangement of attached capsules, representing individually designed apartments. According to intentions of the authors Gasket Homes would have been suitable for mass production. A similar experiment on the urban scale, but going one step further, was presented by Dutch architect Merete Mattern who created Flying Town – a city that was floating above the ground and had the possibility of changing its location.

Similar concepts were formed almost simultaneously in Japan, mainly within the avant-garde movement of the Metabolists. These architects were experimenting on mega-structure projects in which change and motion were fundamental characteristics of the whole concept. In 1960, Kiyonori Kikutake presented his concept of Marine City, a city floating on the surface of the bay of Tokyo. Objects were designed on a core, which could adapt new modules with different functions. The whole complex could be adapted to the needs of residents. [5] Also essential for the development of the idea of movement in architecture were concepts of Kisho Kurokawa. Particularly innovative was the organic structure of Helix City from 1961. The city was developed in forms resembling the structure of DNA and could grow and shrink according to the natural processes of change. [6]

## *2.2. Materialization of utopian architectural visions from the twentieth century*

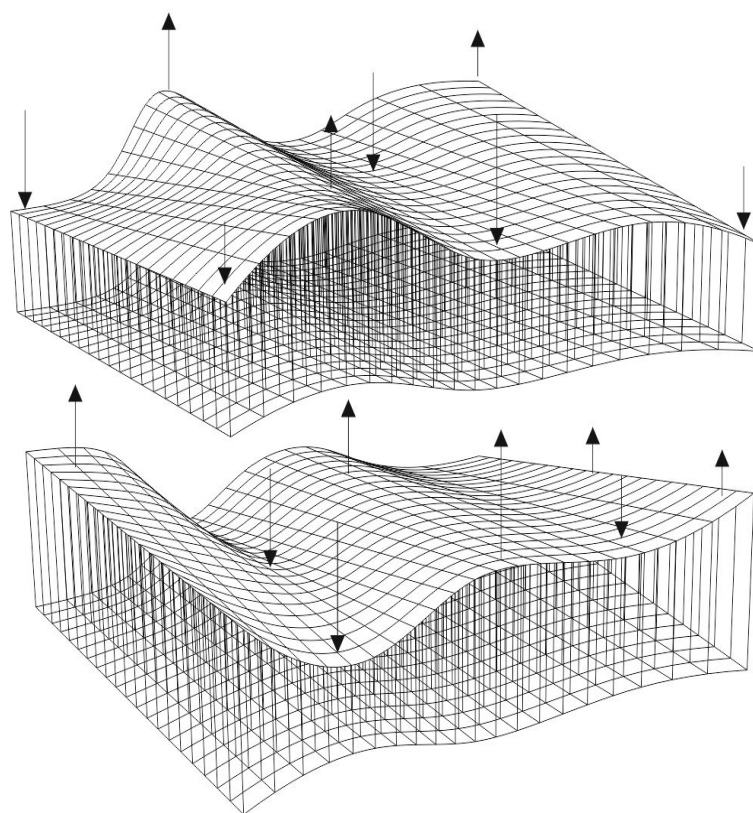
In the vast majority of cases, the concepts proposed by the authors in the twentieth century were impossible to implement. The main factor that prevented this was the lack of appropriate tools for the precise design of such advanced systems as well as the lack of technical ability to carry them out, [7]. However, there were some exceptions. One of the representative examples of implied kinematics in a built structure was a project created by Price himself. The architect realized some of the established theoretical assumptions from Fun Palace in a temporary facility created in 1972 called InterAction Centre. InterAction Centre had been built in Kentish Town in 1971. As the architect suggested the construction could serve as an innovative office space, warehouse and manufacturing centre. This project was an attempt to create a framework that will allow for placing different activities in ready-made containers, which could host offices and other supporting facilities. InterAction Centre functioned until 2003 as a place for integration and support for the local community and a creative space in the city. The idea of mobility had been fully realized in this concept. The architect assumed that the InterAction Centre should run for twenty years. Ultimately it served the community for more than three decades, when Price contributed to its demolition, fighting with activists who called for its preservation.



**Figure 3.** Rotatable wall in FNS Apartment

While most of the projects on kinematic structures from the 1960s and 70s could have been perceived as utopian visions, referring to those projects Zuk and Clark wrote [8]: “What is presented is not an architecture of fantasy, but a prediction for the future based upon a natural evolution, a reasoned and reasonable extension of accelerating trends, and a need to satisfy a dynamically changing society.” Indeed, in contemporary architecture there are numerous experiments that could be considered as a continuation of twentieth century investigations of Rietveld, Friedman or Nieuwenhuis. One of them is a FNS Apartment project designed in 2011 by German architects from the Reinhardtjung office. The interior space could be altered almost entirely due to rotating and sliding action of different walls. The rotation is controlled by the inhabitants and allows the creation of different interior spaces by revealing and concealing chosen interior areas. To create a particular space, the selected items are rotated and moved. In contemporary architecture kinematic experiments go even further and bravely enter the sphere of a former utopia. It became possible due to the rapid development of technology, introduction of robotics, advanced interactive systems and new design techniques such as parametric design. All these allowed for building objects with integrated kinematic solutions that became very sophisticated, complex and even organic. Many of the new design tools came from outside of the discipline of architecture. Great examples of such were created by Kas Oosterhuis [9] or analysed by Lucy Bullivant [10]. A topotransegrity structure was created in 2006 as an experimental object designed by the 5Subzero office. Kinematic responses applied in the design were executed by actuators, which were arranged in several layers. They are mutually interconnected in this way that one affects the other. Consequently, the change of one level causes succession of movement at the lower and higher levels. This creates a non-linear developing surface of the floor and ceiling on a given floor. By staying in such space, the user could experience a non-linear multidimensional and interactive environment.



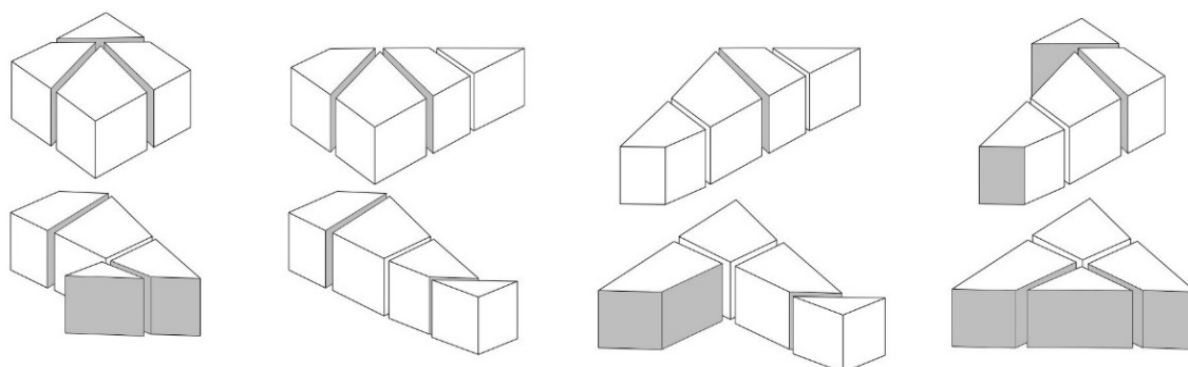


**Figure 4.** Topotransegrity movement structure

Kinematic architecture is not only experimenting on movable parts of the buildings but also on the movement of whole objects. Halley VI is an innovative building designed in 2012 by Hugh Broughton Architects as a result of such explorations. Halley VI is currently the most advanced research station located on the Arctic Circle. It consists of eight modules, which are equipped with a hydraulic foot, which have fixed runners. With this innovative hydraulic shock-absorber the structure can move and change location without interfering with the work inside, [11]. The blue modules are housing laboratories, offices, generators, observation platforms and dormitories for researchers. The red module is much larger, and is equipped with a dining room and recreation area. The object was built in response to the need of maintaining a good quality self-sufficient working space in different locations [12]. The project from its principals concerning the use of movement and operating rules is similar to the vision proposed by the Archigram group in the conceptual project of Walking City from 1964.

Similarly, several references to the twentieth century utopian visions, particularly to Yon Friedman's project of Movable Boxes, are detectable in the concept of a residential building in Lapland named D\* House. Initially, the project was created as a master's thesis by one of the authors, David Ben Grünberg. The goal was to create a house in Lapland on the Arctic Circle. Lapland is characterized by a relatively warm summer and unusually severe winter. This makes it difficult to create a static building that will function equally well in a variety of atmospheric conditions. While the primary form of protection against cold is increasing the layer of insulation and reducing windows, this would be unfavourable over the summer. To respond to this challenge, the structure opens out during the summer exposing the glazing and letting in the light, while during the winter it can be closed and limited to an energy-saving compact form. The opening and closing pattern of the form is based on a mathematical principle

developed in 1908 by Ernst Dudeney, which allows one to change a square into an equilateral triangle by dividing its form into four different parts. The process of complete change comes in eight steps.



**Figure 3.** D\*House

### 3. Results and discussions

Most of the kinematic architectural concepts proposed from the 1950s to the 70s were impossible to implement. The main factor that prevented this was the scarcity of appropriate tools for the precise design of such advanced systems, as well as the lack of technical ability to carry them out. Nevertheless, these projects contributed to opening a discussion about the possibility of introducing mobility to architecture. Today, many existing buildings draw upon the inspiration from avant-garde theoretical ideas taken from the second half of the twentieth century.

Theoretical concepts from the middle of the twentieth century, contrary to existing architectural structures, were very often based on spatial assumptions founded on complex and ambitious kinematic solutions. Mobility was intended to be multi-dimensional, and often almost environmentally organic in its effects. However, it should be emphasized that they were an excellent starting point for subsequent projects created after 1990. In spite of an almost utopian appearance, many of them became quite nearly direct prototypes for projects that are realized nowadays. Some early theoretical concepts such as Flying Town still remain in the sphere of utopia. Many other paths still need further exploration, such as those leading from the early experiments of Gordon Pask to different kinds of environmental ambient intelligence of the future. All these pursuits discuss the traditional understanding of architecture and are aimed at broadening the scope of the discipline.

### 4. Conclusions

It has been noted that such movement being understood as a component of form became an interesting field for architectural investigations and experiments already by the third decade of the twentieth century. This pivotal period brought a true explosion of conceptual research on kinematic solutions, carried out by such architects as Kishō Kurokawa or Cedric Price, or groups such as Archigram, the Situationists and Metabolists. It has been shown that these searches have continued throughout the decades, both in constructed objects and in theoretical concepts. In contemporary architecture we can find many examples with reference to conceptual explorations from the last century. This dependency is strongly visible in the case of kinematic architecture.

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