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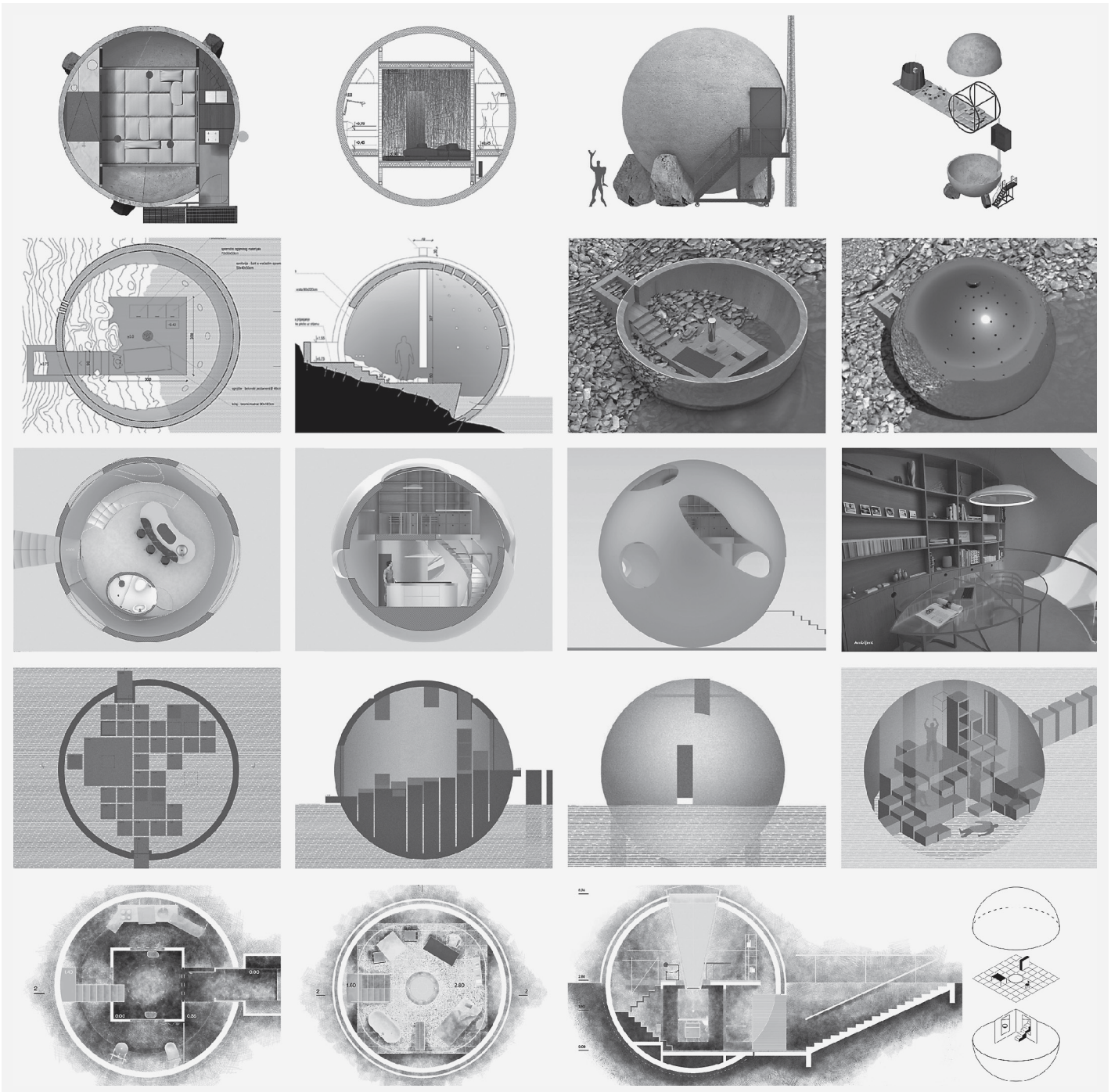

Fig. 1 Student projects on the theme of a sphere with set dimensions,
Interior Workshop, academic 2020/2021.
From top to bottom, the students Jelka Bogdanić, Filip Herljević,
Val Kalinić, Lovro Markus, Miljenko Lovre Trutina;
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From Bubble to Habitable Sphere
The Potential of Sphere in Individual Housing

BUBBLE HOUSE
HABITABLE SPHERE
INDIVIDUAL HOUSING
NEW DOMESTICITY

The objective of this research is to examine the potential of the sphere in the context of architecture for individual housing. The point of departure is the idea of the bubble and the identification of the connotations inherent to it since antiquity that have inspired architects to employ spheres that challenge settled architectural paradigms. The development and use of the sphere are presented through a selection of the most important examples – from the first known utopian vision designed by Antoine Laurent Thomas Vaudoyer in 1783 to the constructed and actually used facilities designed for individual dwellings in the 20th century. The interior design strategies that can address the challenges posed by curved envelope and optimize the use of space in spherical individual dwellings have been further explored in a practical assignment given to students enrolled in the Interior Workshop in the Graduate Programme of Architecture and Urban Planning at the Faculty of Architecture in Zagreb in the academic year 2020/2021. In addition to these architectural problems of formal nature, the intention of this design-driven experiment was to examine the affinity of the younger generation towards moving away from traditional models of layouts for individual housing, with the goal of possibly creating more humanized spaces that support the idea of a *new domesticity*: nomadic lifestyles, the integration of work into the domestic sphere, new family models (e.g., single-occupant) or the increasing need for privacy. In the architecture of individual housing, the sphere is in general an uncommon phenomenon. And yet there is a perceptible continuity of innovative architectural forays into the search for the most effective application of this elementary geometrical form.

Introduction

The sphere is applicable in design and in architecture, from the helmet that encases the head and the chair[1] that is a capsule partly surrounding a space for the body to the residential scale of a dwelling place (Fig. 2) and sphere on a town planning scale, of the kind conceived by Buckminster Fuller.[2] A building with spherical geometry is inherently evocative, provocative and appealing, particularly in comparison with orthogonal structures. It will also provide, depending on the properties of the membrane that defines it, a distinctive spatial experience. The sphere is autonomous, without any dialogue with the context. It can have at one and the same time the character of timelessness and overtones of futurism. The universality of the form has its own symbolic and metaphorical charge, potentially intelligible to heterogeneous classes of people. The very form, if it is integral, suggests the possibility of mobility, of hovering, rolling or floating. The full experience of the form will sometimes involve not only the sense of sight but other senses and feelings.

A geometrically regular spherical or hemispherical body has over the course of history tended to symbolise completeness, perfection, the heavenly vault. True, symbolism in architecture does not stand still, developing in time in tune with changes in the cultural and social contexts. And yet a work of architecture can still retain the fundamental significance and relevance of its symbolism over the long term, if it stems from the most elementary sensations of perception.[3]

Based on this context, the research seeks to address the following questions: What architectural, structural, and socio-cultural factors make the sphere suitable for individual housing? How can design strategies respond to challenges associated with spherical geometry, such as space optimization and construction methods? And finally, can the sphere contribute to a redefinition of domesticity, creating symbolic spaces that reflect contemporary living patterns?

Constructing according to the bubble principle is building with air.[4] Air can be identified with flight in physical and figurative senses. According to Gaston Bachelard, the element of air contains the psychology of the imagination of movement (Bachelard, 2011: 7), i.e., serves as driver of the dynamic process of the imagination.

In a creative partnership with Shoji Sadao, Buckminster Fuller devised the utopian architectural vision of Cloud Nine[5], 1960, a levitating sphere 1.6 km in diameter meant for the accommodation of thousands of inhabitants forming the aerial city (Fig. 2). The idea draws on the hypothesis that the raising of the inside temperature by a single degree would enable the sphere to levitate like a balloon. In opposition to floating spheres was the dystopian vision of subterranean spheres beneath Manhattan thought up in 1969 by Oscar Newman and illustrated by Jean Laggarigue (Fig. 2). Underground spheres with a volume of about 5 cubic kilometres were conceived as huge nuclear attack shelters; the author's paradoxical idea was that they could be built with the aid of multiple nuclear detonations (Newman,

1 There are clear references to the bubble in the Ball Chair and the Bubble Chair designed by Eero Aarnio. The Bubble Chair has no legs, the sphere being fixed to the ceiling with a chain, and is made of translucent materials. Both models create the sense of a private and to an extent isolated space around the user and feature unique acoustics.

2 During the 1960s Buckminster Fuller and Thomas Howard presented the Manhattan Dome project, their visionary objective being the upgrading of living conditions in the urban space. The geodesic dome, diameter about 3 km, would protect a given urban area from extreme weather conditions. Inside the dome, climate would be controlled and energy use diminished. Although the Manhattan Dome was not constructed, it did embody Fuller's futurist approach to sustainability and is held to be one of the emblems of futuristic architecture.

3 *The most powerful symbols derive from the most elementary perceptual sensations because they refer to the basic human experiences on which all others depend.* (Arnheim, 1977: 73)

4 Pneumatic construction is supported by compressed air inside its inflatable structural elements.

1969: 186). The buildings and streets of the underground city were similar to the above-ground network, with additional levels of underground spaces. Air would be recycled via air filters that went up to the surface.

Research Methodology

The paper is devoted to a depiction of the potentials of spherical constructions meant for individual housing triggered by their inevitable symbolic properties and immanent a-contextuality.

The basis of the research is a comprehensive analysis of the specimens selected as points of reference in the architectural application of the idea of the bubble in the 20th century. The methodological approach included a combination of historical evidence within theoretical frameworks as well as experimental design-driven method. The evolution of the spherical individual house was studied by using primary and secondary sources for architectural scientific research complemented with the insight into cultural, social and technological context. In addition, the focus was on the specific and variable symbolic values of sphere. Insight into the topic was created by using archival material from archival collections and various published sources specified in the bibliography, through personal contacts with selected contemporary key architects and their personal documentation, as well as by conducting the experimental design assignment that students had completed during one semester. The design assignment had been done within the course Interior Workshop in the Graduate Programme of Architecture and Urban Planning at the Faculty of Architecture in Zagreb.

Homo Bulla Est

The origin of the metaphorical expression *homo bulla est*[6] is a Latin saying, about the brevity of life[7] as recorded by Roman writer and scientist Marcus Terentius Varro in his *Rerum rusticarum, libri tres* (Varro, [about 37 BCE] 1912: 7). During the 16th century the expression was popularised by Erasmus[8], in order to emphasise the preciousness of each moment of experience as against the futility of human existence. During the 16th and 17th centuries, the *homo bulla* concept is often shown in the allegorical painting known as Vanitas[9] in the motif of boy or putto blowing soap bubbles. The fact that at one moment the bubble will be splendid and perfect and vanish in the next is suggestively symbolic of transience. The depiction of soap bubbles continued to be used in the following centuries, but in time this symbolism linked with ideas about the futility and brevity of the human span was enriched with other interpretations involving connotations of either melancholy or else playfulness and well-being (Fig. 3). In Japanese painting the aesthetic beauty of the soap bubble was much appreciated as was the perfection of its spherical form (Mori, 1996: 172). Today the expression to be in a bubble of

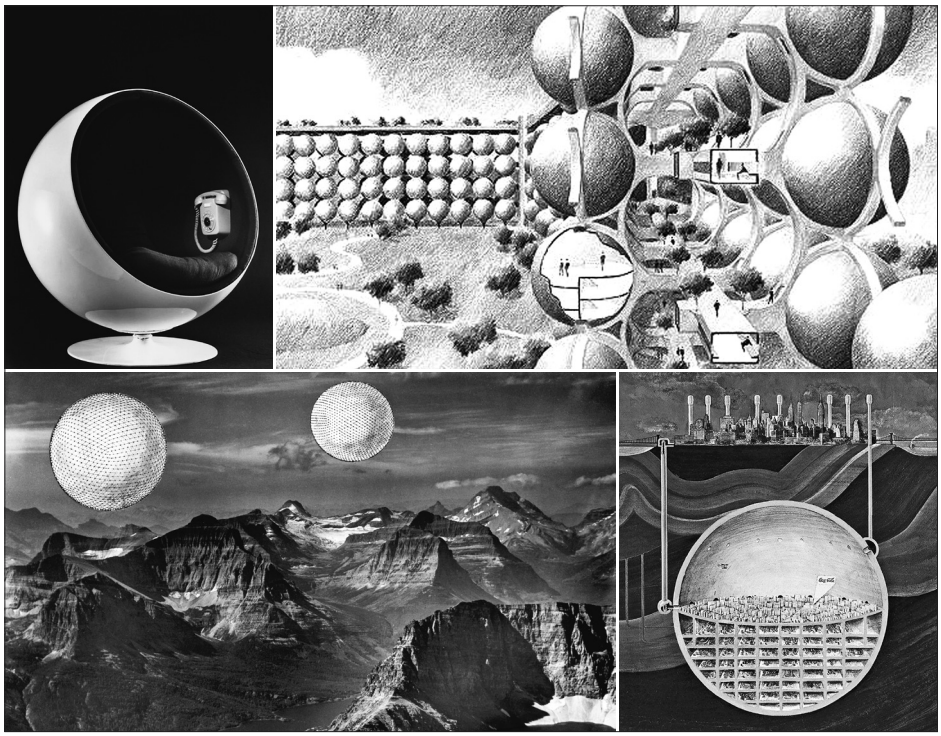

Fig. 2 Eero Aarnio: Ball Chair, 1963 (top left); Eduardo Longo: Study of a housing complex, 1970s (top right); Buckminster Fuller and Shoji Sadao: Cloud Nine, about 1960 (bottom left); Jean Laggarigue after a description by Oscar Newman: Underground City Beneath Manhattan, 1969 (bottom right)

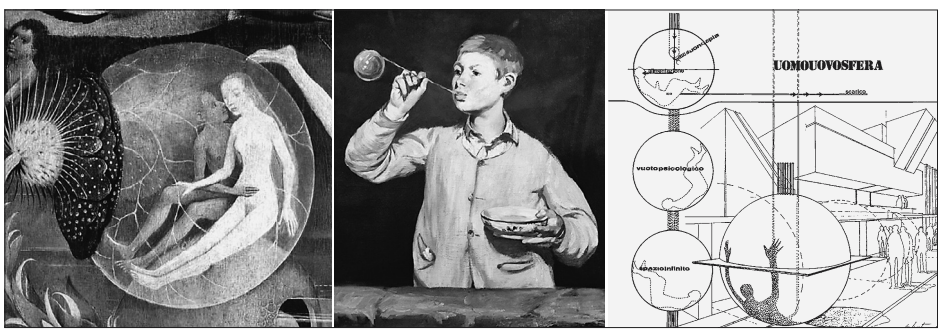

Fig. 3 Hieronymus Bosch: Third Day of the Creation of the World, triptych The Garden of Earthly Delights (*De tuin der lusten*), detail, 1490-1500 (left); Édouard Manet: *Les Bulles de savon*, 1867 (centre); Ugo La Pietra: *Uomouovosfera*, 1969 (right)

5 The actual name of Cloud Nine draws on the idiom *to be on cloud nine*, suggesting a condition of bliss. The aerial city offers to make the dream of flight, the overcoming of gravity, come true.

6 Lat. Man is a bubble.

7 *...quod, ut dictur, si est homo bulla, eo magis senex* (Lat. *...one says, if man is a bubble, he is all the more so in his old age*)

8 Erasmus quoted this Latin saying in his work *Adagiorum Collectanea*, published in 1500.

9 Vanitas (Lat. vanity) is a kind of genre painting with symbolic motifs that prompt thoughts about values and priorities and promote higher ideals referring to the transience of this earthly life.

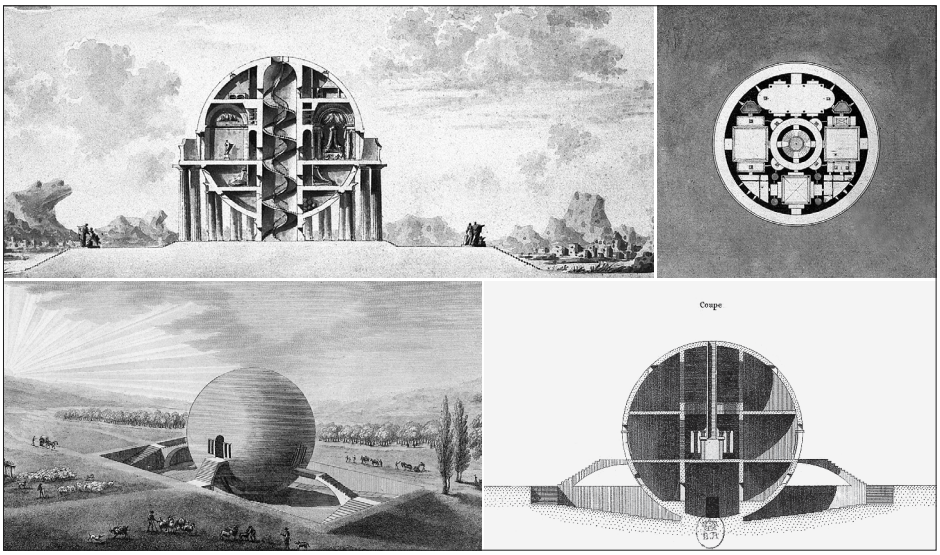

Fig. 4 Antoine Laurent Thomas Vaudoyer: Design for a house for a cosmopolite, 1783 (top left and right); Claude-Nicolas Ledoux: *Maison des gardes agricoles*, Maupertuis, 1804 (bottom left and right)

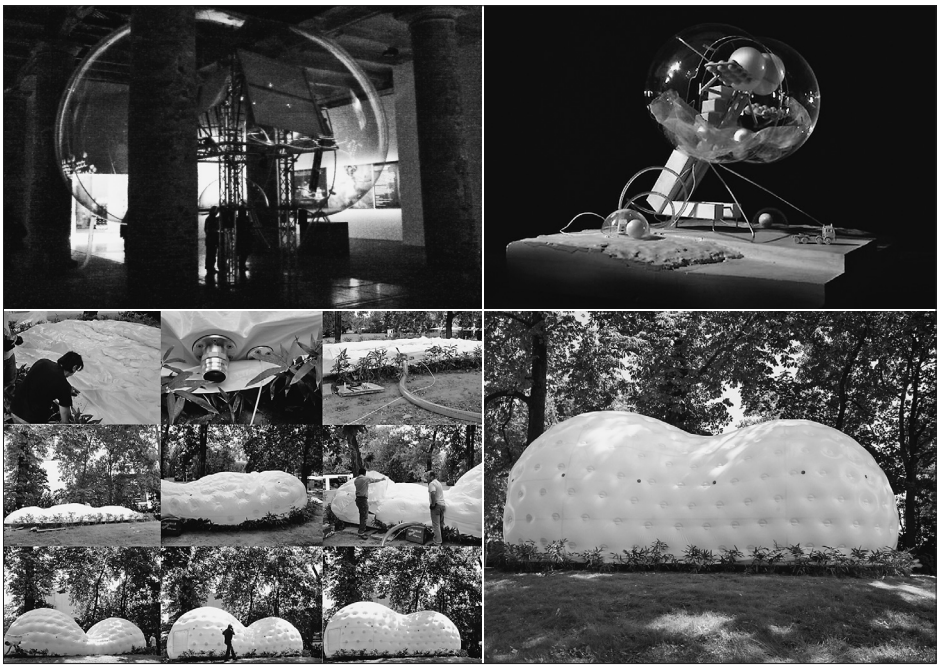

Fig. 5 Coop Himmelb(l)au: Astro Balloon [1969] Revisited – Feedback Space, 2008, Venice (top left); Coop Himmelb(l)au: The Cloud, 1968, model, photo: Markus Pillhofer (top right); Kengo Kuma and associates: Frankfurt Tea House, 2007, photos: Antje Quiram (bottom left and right)

one's own is often used to describe a particular state of awareness or immersion in one's own thoughts and a flight from reality.

Minimal Surfaces: A Combination of Mathematical Model and Architectural Concept

Bubbles and films of a soap and water solution are examples of the mathematical concept of minimal surface. Individual bubbles are always spherical. The surface tension of the film of soapy water and the pressure of air inside the form created arrive at an equilibrium thanks to the bubble taking on the form of sphere or the geometrical form that has the least possible surface area for the given volume. The first systematically to research into the geometry of the bubble and soap films was Joseph A.F. Plateau, who formulated the general rules governing the forms of possible surfaces. The basic principle of the geometry of soapy water films and bubbles runs: *A physical system will remain in a certain configuration only if it cannot readily change to a configuration with less energy* (Almgren and Taylor, 1976: 83).

Models of minimal surfaces or forms that minimise the surface area can be made by dipping a wire loop into a soap solution, the soap film forming a minimal surface restricted and defined by the framework chosen. Multiple experiments in this field were carried out by the architect Frei Otto, who brought in the concept of form-finding, referring to the use of physical models as means for discovering forms with the use of the smallest possible amount of materials and energy (Zexin and Mei, 2017: 1).

In 1961 Otto started off a sequence of experiments with bubbles according to the minimal area principle. A special machine was constructed for the purpose of systematically recording and measuring the geometry of the soap film model (Serebryakova, 2016). Thanks to these experiments he managed to develop innovative avant-garde forms and constructions, specialising in light tensile and membrane structures. Frei Otto is recognised as the originator of parametric design in architecture.

Spheres, Bubbles, Clouds, Capsules: From Utopian Visions to Temporary Architecture

The application of ideal elementary geometrical forms like the sphere is characteristic of French neo-classicism. The best-known names here are Étienne-Louis Boullée and Claude-Nicolas Ledoux and the sphere appears as part of the composition of structures of various purposes. According to current knowledge and excepting primitive and vernacular constructions or traditional shelters considered a type of dome (Steadman, 2006: 121), the first spherical house for residential purposes was designed by Antoine Laurent

10 Günther Zamp Kelp, one of the co-founders of Haus-Rucker-Co gave simplicity and effectiveness as the main reasons for the use of pneumatics (Mollard, 2020).

11 The installation Astro Balloon was reinterpreted as Feedback Space at the 2008 Venice Biennale and at the Beijing Biennial in 2022. The heartbeats of the visitor are measured and transformed, by way of feedback into visual phenomena.

Thomas Vaudoyer for the cosmopolite, for someone, that is, who regards the whole planet as their home. Hence, probably, the choice of the sphere (Fig. 4). This is a palace, and also a temple devoted to all kinds of human knowledge. Claude-Nicolas Ledoux designed the famed *Maison des gardes agricoles* for the estate of the Marquis de Montesquieu in the commune of Maupertuis in 1804 (Fig. 4). A perfect sphere was surrounded by growing areas and was used as a shed for farm workers, containing a kitchen and four dormitories for living in and various utility and auxiliary spaces.

From the mid-20th century experimentation with the form of the bubble gained in popularity as an innovative architectural alternative that called into question the entrenched idea of the traditional home. The house of the future referencing the soap bubble was thus founded on the concept of a flexible, unconventional and open plan, with the application of technology. This was architecture as cloud, seemingly *as light as air* (Wolf D. Prix, in: CoopHimmelb(l)au, [1968] 2009).

In his 1965 article "A home is not a house", Reyner Banham describes a contemporary house. As form of the residential space described, the artist François Dallegret proposed an inflatable transparent bubble. The ever-greater importance of complex mechanical equipment is to be seen in the dimensions and prices of devices needed for contemporary housing. Pipes, ducts, antennas, cables, heating elements, solar cells and suchlike are the main features in the design. Privacy in the traditional sense is downplayed, and the interior of the house is in visual terms part of the wider spatial environment. Banham sees the housing of the future as transportable and self-sustaining machine located anywhere in the natural environment. Architecture is fully independent of the context, reduced to the transparent membrane of the bubble, and ultimately to the consumable of mass culture (Banham, 1965: 77). Architecture is content, not envelope.

In the post-war decades, spherical architectural structures remained in most cases in the domain of utopian projects or architecture on paper: Living Capsule (Raimund Abraham, 1966), The Suitaloon (Micheal Webb, 1967), The Cloud (Coop Himmelb(l)au, 1968; Fig. 5), *Uomouovosfera* (Ugo La Pietra, 1968; Fig. 6), Villa Rosa (Coop Himmelb(l)au, 1968). According to Wolf D. Prix, *The Cloud is an organism for dwelling, mobile and spatially changeable. The building materials are air and dynamics* (Wolf D. Prix, in: Coop Himmelb(l)au, [1968] 2009).

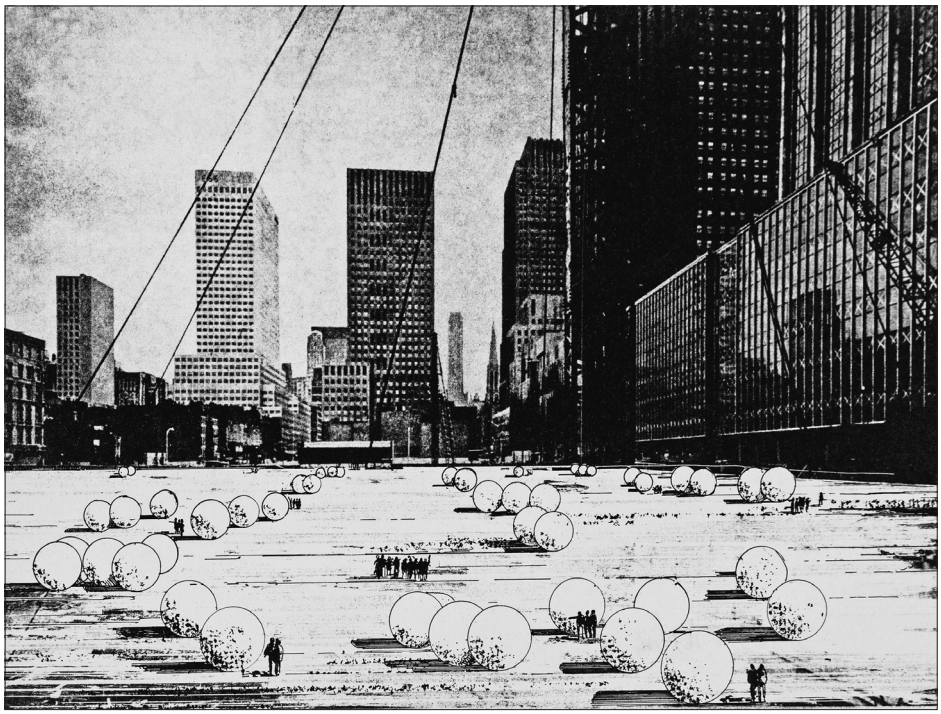

Fig. 6 Ugo La Pietra:
Immersioni – Uomouovosfera, 1969-1970
The immersions are an invitation to quit reality and discover a refuge in a kind of privacy that is both a separation and a way for exploring the possibilities for intervention through elements that shift and break with the traditional codified terms. (Ugo La Pietra, 1967/1969)

Some experiments, however, have been given concrete form.[10] The availability of cheap polyvinyl has enabled young authors to translate the concept into reality, not as models, but on a 1 to 1 scale. Research is being conducted into the experience of almost dematerialised form along with the intensification of sensory experiences or the potentials of the human senses: Astro Balloon[11] (Coop Himmelb(l)au, 1969; Fig. 5), The Restless Sphere (Coop Himmelb(l)au, 1971), Balloon for Two (Haus-Rucker-Co, 1967), La Ballule[12] (Gilles Ebersolt, 1977)...

Pneumatic construction entails a membrane stabilised by compressed air.[13] In the following decades the bubble appeared but seldom in architecture, only in some extreme situations such as for example the construction of Rem Koolhaas and Cecil Balmond in the form of a ball filled with helium above their design for the Serpentine Gallery in London in 2006, or various spatial interventions of artists and architects reminiscent of the experiments of the 1960s.

Constructions made of single layer membranes have typically been characterised as

12 *La Ballule* is primarily meant for rolling. This is a zorb ball that was first registered technically and commercially by architect Gilles Ebersolt in 1981.

13 In 1917, Frederick W. Lanchester was the first to patent an air-supported structure; in 1920 he registered a patent for an air-supported exhibition hall with a dome diameter of 329 m. Although these structures were not built, both designs were published in key architectural publications and can be considered prede-

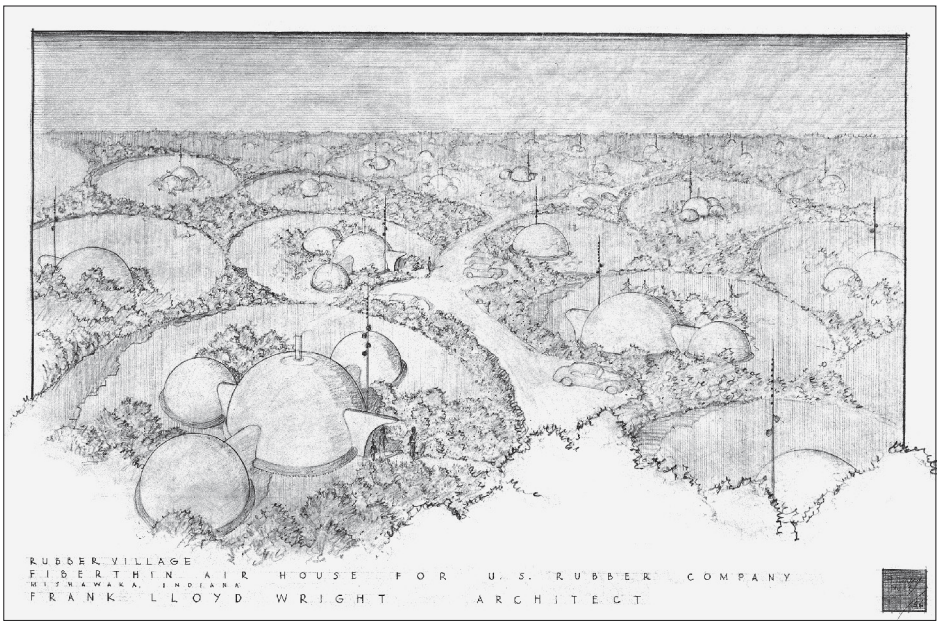

Fig. 7 Frank Lloyd Wright: Rubber Village – Fiberthin Air Houses, 1950s

transient and temporary. However, membranes with double walls have been used as durable building systems for composite pneumatic constructions. When ethylene tetrafluoroethylene (ETFE), a sturdy, recyclable, transparent and very light material, was introduced, architects began to use pneumatic technology in their structures. Particularly notable examples include: the Allianz Arena in Munich (Herzog & de Meuron, 2005), the Media TIC Building in Barcelona (Enric Ruiz-Geli, 2009), and the Water Cube in Beijing (PTW Architects, 2008). In his Frankfurt Tea House (Fig. 5), Kengo Kuma wished to achieve a breathing architecture, meaning the incorporation of the dynamics of breathing as metaphor for interactivity with the environment. A double-skinned membrane filled with air is made of a soft, light and translucent material called Tenara. The two membranes are fastened together with polyester tape. Breathing architecture is an attempt to get as close as possible to the original character of the ephemeral space for the tea ceremony, in contrast to *the nonbreathing concrete architecture of the 20th century* (Kuma: 2007).

Materialisation of the Bubble in Durable Sphere for Housing

The first constructed spherical building is reckoned to be the *Kugelhaus*[14] built in 1928 to a design by Peter Birkenholz, while the first housing structures inspired by the soap bubble and built with the pneumatic technique were put up in Falls Church to a design of Wallace Neff during World War II (Head, 2011: 34). Neff called this technology *airform*. After a circular concrete slab was poured for the foundation, a balloon was sprayed with a kind of concrete known as gunite. After the concrete was cured and set, the balloon was deflated. Such a manner of construction enabled homes to be built in 48 hours. The architect was convinced that the speed, simplicity and economy of this kind of construction would provide an answer to the housing crisis of the middle of the 20th century (Head, 2011: 13, 15). Bubble Houses in Hobe Sound, completed in 1954 and designed by Eliot Noyes, used Neff's airform system.

In the late fifties, Frank Lloyd Wright and the United States Rubber Company joined forces on an experimental project and prototype of an inflatable dome known as the Fiberthin Air House (Fig. 7). The approachable and practical shelter 6 m in diameter was conceived as a temporary dwelling space or as a vacation home. The use of robust nylon covered with vinyl and known as fiberthin was envisaged (Frank Lloyd Wright Foundation, 2019). Although the project was never fully articulated and the prototypes were not used successfully in practice, the Fiberthin Air House shows the continuity of the application of the bubble concept in architectural terms and in the context of residential applications.

During the 1950s Johann Wilhelm Ludowici constructed spherical house prototypes[15] 4.5 m in diameter. A dwelling for two people consisted of kitchen, bathroom and a combined living and bedroom. It was imagined as being constructed in lightweight reinforced concrete, in metal or in plastic. The transportable construction was primarily meant for use in crisis or emergency situations (Science and Mechanics, 1961: 57-58).

The first practical example of a geodesic dome[16] used for individual housing was

cessors of the new technology (McLean, 2018: 921). Air-formed structures or designs for enclosed spaces entirely supported by air pressure differentials were developed by Walter Bird and Dante Bini.

14 The building was put up in Dresden in 1928 but was demolished in 1938. Constructed for the annual exhibition Technical City it functioned as an exhibition space with a panoramic restaurant on the top floor. The 24 m diameter sphere of steel frame construction was placed on an 11.5 m diameter cylinder. The final façade layer was made of sheet aluminium.

15 The only example was restored in 2002 and can be visited in the *Ziegeleimuseum* in Jockgrim.

16 The geodesic dome was invented by German engineer Walther Bauersfeld, who was also the inventor of the modern projection planetarium. The dome was put up to house a planetarium on the roof of the Carl Zeiss factory in Jena, opened in 1926. Fuller popularised the construction in the late 1940s. Jeffrey Lindsay, a student of Fuller, produced the dome known as Weatherbreak in 1950. Additional help came from sculptor Kenneth Snelson, who made spatial constructions, researching

called Weatherbreak and put up as a self-supporting geodesic dome founded on the shape of a triangle. It was constructed in 1950 by Jeffrey Lindsay in accord with the ideas of Buckminster Fuller[17] (Moonan, 2023). The Weatherbreak dome embodied a new system of construction, impervious to gusts of wind and blizzards. It could be put up in two days with light and accessible materials, simple tools and with only a small on-site crew. It was put up in a suburb of Montreal, but Lindsay ceded it to Bernard Judge for him to use for the construction of his own Dome House. With his project for a site in the Hollywood Hills, Judge wanted to examine the economics and applicability of the geodesic dome for residential purposes. In 1962 a structure known as the Triponent House[18] was completed with state-of-the-art technology; it was also the first constructed work of architect Judge. The dome[19] had a diameter of 15 m, while the core housed all the elements related to utility systems. The main characteristic of the interior space was its complete openness to the panoramic views, its open plan floor area that permitted the flexible formation of functional units (Fig. 8). Judge used the building for a short time and then disassembled it, relocating it once more, this time in the Smithsonian National Museum of American History (Moonan, 2023).

The works of Buckminster Fuller are particularly inspirational, revealing the ongoing endeavours to find an optimal, autonomous and sustainable *machine for living in*, dominated by the application of the sphere. The Dome Home or Bucky Dome (Fig. 8), the home of Buckminster Fuller himself, was located in Carbondale. It was used by the Fullers as their residence between 1960 and 1971. From 1938, Fuller made use of the term *ephemeralization*, meaning the ability of technological advances to do more and more with less and less until eventually you can do everything with nothing (Fuller, [1938]1973: 252-259). He highlighted the rapid increase in efficiency as the ineluctable direction of development and a means through which to achieve an ever-greater standard of living for a constantly growing population. From this point of view, the choice of spherical geometry and the construction of the geodesic dome was consistent with the fact that the sphere encloses the greatest volume for the given ground plan. Fuller's tensegrity structure uses the least possible amount of material to enclose the sphere (Fuller, [1938]1973: 252-259). The Fly's Eye Dome[20] was the last prototype he designed, in 1965, intended as a solution for an economical and portable residential space with the emphasis being

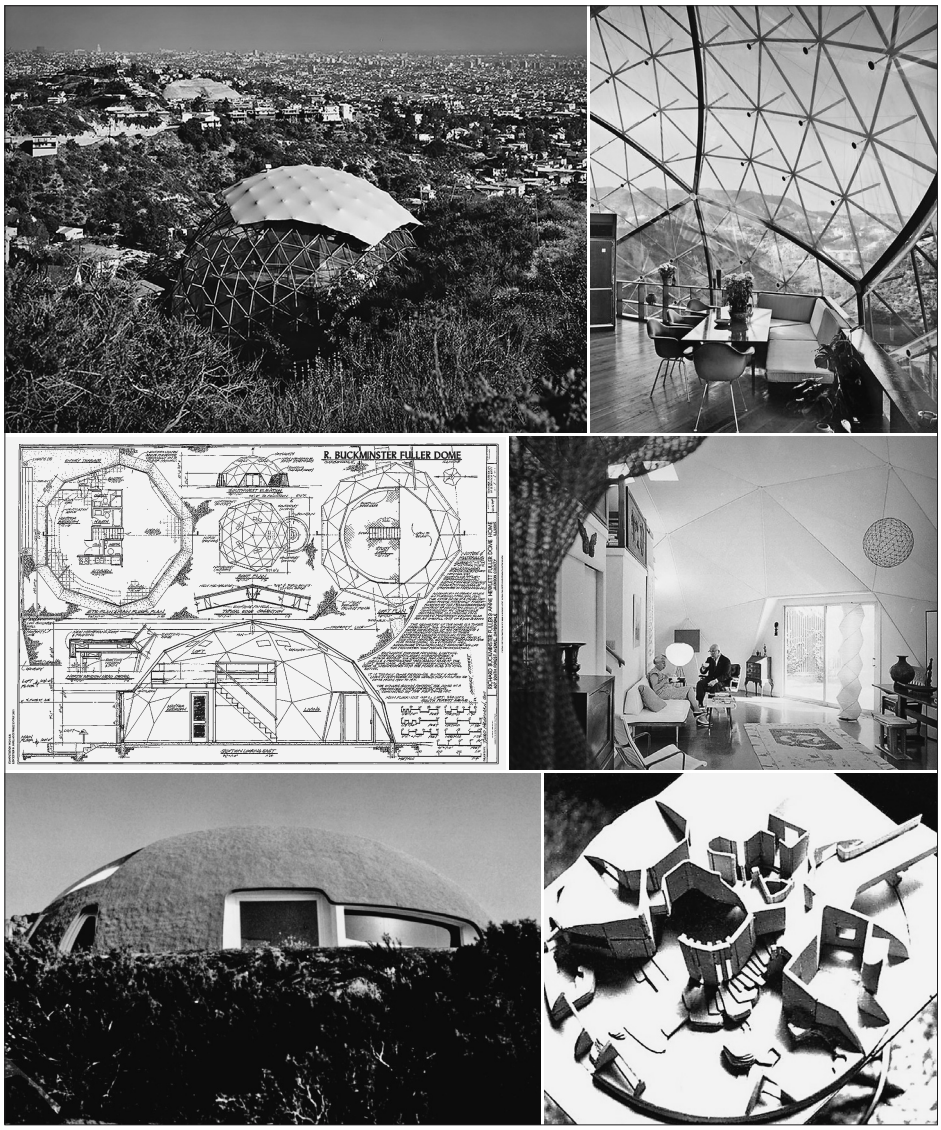

Fig. 8 Bernard Judge: Triponent House, Hollywood Hills, 1959-1962, photos: Julius Shulman (top); Richard Buckminster Fuller, Bucky Dome, Carbondale, Illinois, 1960 (middle); Dante Bini: La Cupola, Costa Paradiso, 1970 (bottom left); Dante Bini: La Cupola, model (bottom right)

the relation between tensile and compressive forces, known as tensegrity (Moonan, 2023).

17 Over the course of time Fuller and Lindsay stopped working together, because of a dispute over intellectual property rights to the dome, Fuller being granted the first patent in 1951, but using the drawings by Lindsay for Weatherbreak.

18 Triponent House was chosen as the name to reflect the three basic elements: envelope, core and characteristic interior spaces.

19 The dome was covered by Mylar – polyester film of remarkable mechanical and chemical properties. It is partially shaded. It was dismantled at the end of the 70s and moved to the Smithsonian National Museum of American History.

20 Fuller built three Fly's Eye Dome prototypes of different diameters. The current owners of these specimens are Norman Foster (ø 12-foot), Craig Robins (ø 24-foot), and Crystal Bridges Museum of American Art, Bentonville (ø 50-foot). (Moonan, 2023)

Fig. 9 Eduardo Longo: Casa Bola, São Paulo, exterior view, photo: Chico Prestes Maia (top left); view of the seating area on the top mezzanine, photo: Chico Prestes Maia (top right); Eduardo Longo: Casa Bola, plans, 1974 (bottom)

placed on the reduction of the constructive weight of the building. The design was inspired by the structure of the eye of a fly.

For his lightweight circular-ground-plan domed constructions, Dante Bini developed and applied the Binishell[21] technique – a system of pneumatic formwork and inflated membranes used in the pouring of the reinforced concrete shell. As in the airform technique of Wallace Neff, the formwork was deflated after the hardening of the concrete. The most important advantages of the *pneumoform*[22] procedure were the simplicity of construction, the economisation of on-site labour and the radical reduction of the amount of material required. The binishell was developed with the objective of producing affordable, safe and interesting structures of various dimensions and for different purposes that would have a minimal impact on the environment.

La Cupola on the Sardinian coast is the best-known house of Dante Bini.[23] It was put up with the binishell technique in 1970 for director Michelangelo Antonioni and Monica Vitti (Fig. 8). The dome is 20 m in diameter, and the shell is 12 cm thick at the base tapering to 6 cm at the top (Bonomo, 2023: 189). The interior space is defined not only by the segments of the sphere but by asymmetrically deployed apertures, a rather unconstrained ground plan geometry achieved with vertical partitions between the spaces and the main double-height living area with large windows and a sea view. The access to the front door is by pedestrian bridge. The functional elements of the interior are made to comply with the uncommon geometry of the space. The oculus over the small interior garden is the central circular aperture that enables the enjoyment of rain and the sound of the sea. The simple exterior is the result of the agreement between client and architect to let the form merge into the landscape (Bonomo, 2023: 189).

The Brazilian architect Eduardo Longo selected the form of the sphere as ideal for individual houses, conceived as systems of prefabricated modular spheres with a total ground plan of 100 m2 (Fig. 2). His Casa Bola[24], 8 m in diameter with an area of 135 m², was built on top of his own family villa in S□o Paulo as spatial model suitable for a future lifestyle. He developed the idea from 1972; from the 1980s, the sphere was a part of his residence. The structure is made of steel pipes. The outer walls consisted of three layers: an outer layer of reinforced mortar, an extruded polystyrene layer of 2 cm and an inner layer of plastering. A few years later, an extra layer of polystyrene was added and on top of that a shell of aluminium (Fracalossi, 2014). All the angles of the building are rounded. The perimeter surfaces and fixed furniture are white, appearing to be monolithically constructed. The design, furniture and fittings evoke the interiors of naval architecture. The sphere has six half-floors with centrally located communications, ceiling height varying from 1.8 m to 4 m in the upper half of the sphere. The unified space at the top is articulated with variations in the height of the floor and a gallery motif. The main space features panoramic views and an oculus at the highest point (Fig. 9).

The Bolwoningen estate built in 1984 consists of 50 self-supporting fibreglass spheres, 5.5 m in diameter, each placed on a 3 m di-

21 In addition to Binishell, the Binistar, Binishelter, Binix, and Minishell systems were also patented. Domes of various dimensions have been built for diverse purposes and in various locations. The construction technique was patented in 1964, and the first concrete shell was erected in 1965. Nicolò Bini, Dante Bini's son, is the architect of the villa of Robert Downey Jr in Malibu, a more recent example of the Binishell system's application from 2022.

22 The coinage pneumoform was used by Dante Bini for this pneumatic formwork.

23 *Rem Koolhaas, while the curator of the Venice Biennale of Architecture of 2014, officially declared the home of Antonioni and Vitti to be one of the most significant expressions of residential architecture in the last 100 years* (The Plan, 2022).

24 Spherical House

25 The mandatory course Interior Workshop is worth 3 ECTS credits.

ameter cylindrical base (Fig. 10). Each sphere consists of two joined hemispheres. The architect of this new morphological approach to housing on an area of 55 m² is Dries Kreijkamp. He was convinced of the large-scale applicability of these spheres weighing a mere 1250 kg – which could float or hover or be interconnected (de Graaf, 2024: 30, 31). But the attempt at the creation of a new housing typology remained at the level of isolated experiment in Den Bosch. The space meets the housing requirements of one or two persons. A spiral staircase links all the levels. The most attractive and the biggest is the living room, which occupies most of the upper half of the sphere affording panoramic views through the sequence of circular windows. The top includes an oculus motif and the space has special acoustic properties. These houses are ecologically acceptable, energy efficient and cost-effective.

The historical and contemporary examples of spherical housing discussed above illustrate both the formal possibilities and the practical challenges inherent in this architectural form. They reveal how spheres can offer unique spatial experiences, structural efficiency, and symbolic resonance, yet require careful consideration in design and construction.

Case Study: The Design Brief for the Interior Workshop Course

Building on these insights, the following case study with students of the Interior Workshop course explores how the sphere can be interpreted, inhabited, and adapted in contemporary individual housing, bridging theoretical precedent with practical experimentation.

In the academic year 2020/2021 100 students enrolled in the Interior Workshop course[25] in the Graduate Programme of Architecture and Urban Planning at the Faculty of Architecture in Zagreb. The design brief defined spatial units of fundamental forms – cube, cylinder and sphere. The forms had the same volumes and a reinforced concrete envelope 25 cm thick. The interior dimensions of the cube came to 5.4 × 5.4 m, the cylinder was 6 m in diameter and 5.4 m high, while the internal diameter of the sphere amounted to 6.6 m. The students were free to choose any one of the set reinforced concrete modules according to their own liking and were allowed to perforate them according to the design adopted, but the elementary forms had to be structurally well considered and recognisable in their geometrical purity. The solution had to include only the space within the given membrane, within which the students had to accommodate and define by their interior design all the spaces required for one, two or more people to live in, for known or unknown occupants. Only 7% chose the sphere, 76% the cube and 17% the cylinder. In view of the relatively large numbers enrolled, the preferences of these future architects can be considered representative and show that only a few were ready to experiment with the form of the sphere – even in a situation in which only their own choice was concerned, without any influence of all the other factors that attend architectural design in everyday practice.

Fig. 10 Dries Kreijkamp: Bolwoningen, drawings, Den Bosch, 1984; photo, 2017

The results of this experiment can be interpreted through observations of two main topics. One is focused on the formal aspect; the other relates to the development of *new domesticity*.

Apparently attracted by the uniqueness of a striking and timeless appearance of the sphere, the students placed it in different ways: completely above ground, laid on the ground, partially underground, partially un-

derwater. With their design they tried to emphasize the continuous, flowing space that emanates a sense of wholeness and connection with nature.

The designs produced (Fig. 1) confirm that the spatial organisation of the interior is characterised by openness and a liberal formation of the ground plan, which is dominated by one large space in order to facilitate a more direct experience of the sphere in the interior of the structure. This central or main space would not infrequently feature split level flooring and/or the gallery motif, additionally pointing up the geometry of the circumferential surface. Secondary and utility rooms are reduced to the minimum.

While the spatial envelope of spherical structures rise at varying angles and heights, the placement and design of furniture elements required careful consideration. During the design process unusual and variable vertical dimensions are experienced as both an advantage and a problem. The furniture design in some projects followed a softer, organic form with segments of the interior equipment designed as a visually integral part of the spherical membrane. Meanwhile, in other projects a counterpoint is visible between the curved membrane and freely placed, but rather conventional, furniture elements.

It seems that the oculus motif or some other types of skylights that allow even light distribution have been accepted as a formal advantage that should be incorporated into the solution.

Applied architectural motives clearly overlap with those of the solutions of the authors who devoted themselves to the design of spherical forms.

To a certain extent, the topic of *new domesticity* coincided with realised examples created in the second half of the 20th century. However, partly it went beyond implemented solutions which already existed. The students' concepts noticeably suggested a more radical move away from traditional domestic models towards a fluid one that reflect present-day, diverse ways of living much less defined by traditional functional zones. Symbolic quality of sphere that includes its use as a metaphor for individuality was supposed to instigate these ideas of adaptable contemporary spaces with evocative values. According to one's own choice, all projects were intended for a single occupant and offered spaces of a contemplative character that gave the impression of a protected, introverted and safe places to live in.

Discussion and Conclusion

As is well known, the sphere is an exception in architecture. It is not probable this will change soon what is clearly confirmed by students' choices. Future architects are predominantly inclined towards orthogonal shapes, and only a small percentage are willing to experiment with the shape of a sphere. However, there exists a continued and persistent affinity for designing individual housing spaces outside of the orthogonal pattern throughout the history of architecture up to the present time.

As a result of this research, the following key factors for choosing a sphere for individual housing were identified: rapidity of construction, the possibility of pre-fabrication, strength and durability, superior energy efficiency, efficient material use, natural air and light circulation, symbolism, attractive user's experience. Furthermore, the results of student design assignment confirmed that the sphere could support a *new domesticity* concept by creating symbolic spaces and re-inventing contemporary living environment. Although there are challenges when designing the interiors of such spaces, unique spatial experience can be a sufficient argument for such a formal choice.

It follows, then, that as sophisticated materials and methods of construction develop, further applications of sphere in the domain of housing can be expected. A movement away from the dominance of orthogonal geometry in the direction of the regular sphere can be triggered in several ways. But the common feature of spherical works of architecture is the ineluctable effect of the exceptional and the unexpected. As powerful symbolic devices spheres evoke ideas from timeless to futuristic, while associated with elemental, abstract and with historical examples.

Regarding the spatial design and functional potential, the research can be further directed towards more elaborate and innovative interior design strategies that adapt to the challenges posed by curved envelope. As well as functional aspects, it is important to examine how does living in a spherical space influence the psychological well-being, sense of comfort, and daily life experience of inhabitants compared to traditional orthogonal living environments.

In terms of formal composition the research can be enlarged to cover housing architecture that is defined by smaller or larger modifications of a geometrically regular sphere (e.g., Matti Suuronen: Futuro House, 1968) and/or to structures for individual housing with more complex formal characteristics founded upon spherical and circular geometry (e.g., Antti Lovag: Maison Bernard – *Le Palais Bulles*, Théoule-sur-Mer, 1989).

As for structural feasibility, the research can be aimed at innovative structural systems and building materials that are most effective in constructing durable, cost-efficient, and easily replicable spheres for individual housing. Similarly, it would be worth precisely investigating to what extent does the sphere offer superior structural integrity, resilience against natural forces and material efficiency compared to conventional housing forms.

Considering sustainability and environmental efficiency, some future research may provide answers to what extent does the optimal surface-to-volume ratio of a sphere contribute to superior energy efficiency compared to a rectangular building of similar volume, considering factors like natural convection and ventilation.

Furthermore, from the point of view of urban regulations, the regulatory and building code challenges are involved in constructing spherical homes, so future research could determine which design approaches can facilitate easier permitting and acceptance.

This study demonstrates that spheres, despite their uncommon status in individual housing, offer unique architectural, structural, and experiential potentials that merit further exploration.

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