FLEXIBILITY AND COMFORT IN LIMITED DWELLING INTERIOR

UPDATED CONSIDERATIONS REGARDING TECHNICAL POSSIBILITIES, FUNCTIONALITY, TRENDS AND IMPACTS ON CONTEMPORARY LIVING SINCE THE PERIOD OF 1970s

IDENTIFICATION OF FUTURE DIRECTIONS

PhD Thesis

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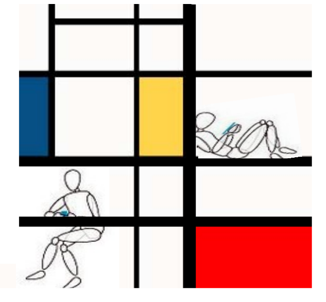


Charles Darwin has suggested that the problem of survival always depends upon the capability of an object to adopt in a changing environment. This theory holds for architecture. (Zuk and Clark 1970)

I am using this opportunity to express my gratitude at the first place to my advisor Prof. Francesco Scullica and all professors at the department (especially Prof. Gianni Ottolini and Prof. Luca P. Basso) who supported me throughout developing my PhD. I am thankful for their aspiring guidance, invaluably constructive criticism and friendly advice during the various research activities. I am sincerely grateful to them for sharing their truthful and illuminating views on a number of issues related to my work.

Additionally, I would like to express my warm thanks to my dear mother. I am forever indebted to her for understanding, endless patience and encouragement when it was most required.

Finally, I would like to express my special appreciation to Salar, who was cheering me up and stood by me through the good times and bad times.

The constant and growing need for functional and affordable dwellings in high-populated urban areas emphasises the importance of flexible dwelling interiors, which have definitely become a priority in the evaluation of housing. This kind of necessity has changed the traditional understanding of interior to a living organism which should “grow” according to our needs inside a given context.

Confronted to this “challenge” (or situation) of decreased affordability of commodious living spaces, flexibility is considered as the most appropriate tool for experimentation. Today’s architects and designers are rapidly developing a wide variety of concepts where fusion between architectural and interior elements is more evident than ever. Space optimization and compressed functionality of furniture have become one of the main sources of inspiration in order to achieve the maximum functional flexibility of spaces. Additionally, movable and sliding walls or hinged partitions, which support a fluid space that can be divided, separated, integrated or opened according to the needs and wishes of the occupants represent only a small part of all the applicable concepts.

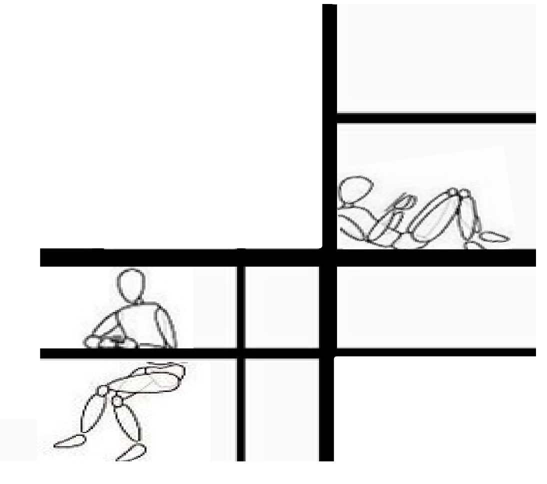
Consequently, we can notice that over the last few decades ergonomic regulations have changed, as well as the general perception of comfort. People have found themselves in a condition which requires “adaptation to less“. Not rarely, architects and designers make experiments on space through the constant reduction of standard scales and the exaggeration in minimalism or in multi-functionality, which raises the question of real usefulness and space durability for its inhabitants. Accordingly, some new trends of transition of living intimacy towards exterior spaces are appearing, which gradually brings into question the essential right to personal privacy for all individuals.

Starting from these facts and through a more detailed analysis of some past and present case studies, this research aims to analyse flexibility and comfort in limited dwelling interiors with special emphasis on the updated considerations about the technical possibilities, trends and impacts on contemporary living since the period of 1970s. These results can contribute to understanding the relevance of today’s occupants intimate comfort conditions in everyday living, as a direct response to the rapid development and popularity of flexible interior methods in the residential architecture of the last few decades. Furthermore, the aim of this research is to detect tendencies for the future developments of flexibility methods and comfort conditions in dwelling, which could be helpful to identify the appropriate target market for such type of living options in the future. Consequently, the research outcomes might be a base for further discussion on how these types of dwellings can be considered an appropriate “way of living in the future” also for more heterogenic audience.

CONCLUSION

Identification of future directions

APPROACH TO RESEARCH



0. Introduction

This Thesis reviews the progress and identifies (but also questions) the future developments of flexible dwelling interiors for a wide target. Due to the increasing housing density resulting from the growth in the urban population that we are witnessing nowadays, the above issue undoubtedly requires to be further investigated and criticized in order to figure out the most appropriate living conditions for people in the future.

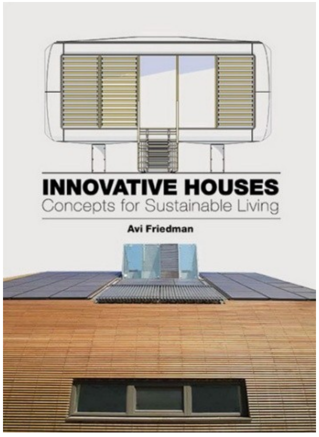
The Thesis consists of four main units: the first one is the *Introduction*, where general keywords are explained along with the historical background related to flexible living in general. The second unit is dedicated to the *Field of investigation*: this chapter provides a general classification and selection of related case studies. This general classification is categorized into three main typologies referring to the context of architecture and design. For example, the first typology includes examples of architectural and building techniques that allow layout changeability inside given spaces (e.g. *Schröder House* by Gerrit Rietveld, Utrecht, 1924; or *Flexibo* by Fællestegnestuen, Følfodvej, Amager, Copenhagen, 1976). The second typology applies to single space structures (or so called "capsules") arranged in a compact or optimized manner and able to be upgraded or combined with one or more structures together, in order to ensure that functional variability of interiors is achieved. This typology could be best defined as "plug-in/out" capsules (e.g. *Hexacube* by Georges Candilis and Anja Blomstedt, France, 1974). The third typology focuses on multi-purpose furniture solutions for multi-functional contexts (e.g. Joe Colombo, *Total Furniture Unit*, 1972).

Furthermore, the third unit of this Thesis is dedicated to the *Results analysis*, highlighting important considerations obtained from the related case studies analysed in the aforementioned unit. Here, the analysis is based on two main viewpoints: the technical and the social. In the Technical part, the investigation aims to review various flexible methods from the 1970s till today, as well as identify the current trends considering architecture and interior settings. In the Social part, most of the attention is placed on the analysis of human comfort conditions and living patterns influenced by flexible approaches.

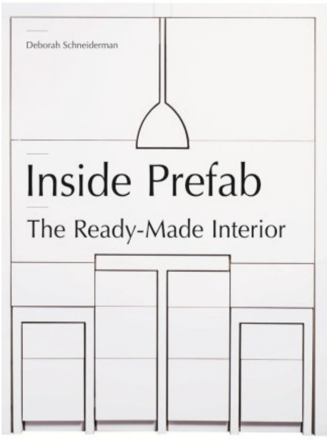
Finally, the fourth unit focuses on the conclusion and on the possible future developments, reflecting on what has been achieved and what trends for the next steps are currently being experimented.

This Thesis ends with *Proposal* for further upgrades of recently identified new models of flexible interior concepts. This observation could be considered as an important guidance as how to construct a prototype that is in balance with nowadays developments, living problems and human needs. Furthermore, this model can be later tested, and eventually implemented in residential buildings in dense urban environments in the close future.

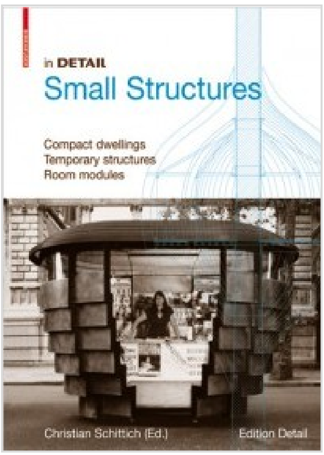
0.1. Main literature guidelines



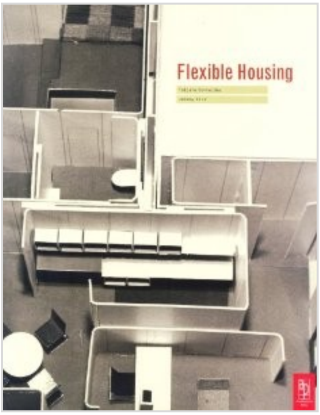
Book summary. Idea of housing is rapidly transforming under global changes of the twenty first century. These changes include appearance of "non-traditional" households (households made of singles, couples with no children, single parent families and a number of other diverse arrangements), increased costs of construction, problems regarding climate changes, and the depletion of natural resources. These conditions emphasized the need of re-focusing the criteria while designing residential environments. Accordingly, this book reviews these challenges and trends in residential housing that have arisen in response. The content is divided in four areas that are tightly focused on topics such as live/work; adaptable housing; prefabrication; water efficiency; green roofs; innovative landscaping. Each of these topics emphasizes methods and principles how professionals approach to the mentioned conditions. In sum, this book represents a collection of strategies that can be considered as a base for future housing developments.



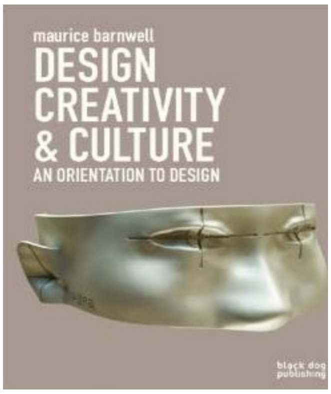
Book summary. Prefabrication is considered as adequate building method mainly due to sustainability and affordability benefits. In recent years it has expanded drastically, attracting both clients and professionals. Since this method is investigated till now mainly through architectural achievements, the author's intention was to focus more on approaches developed by interior designers. Therefore, trough reviewing wide historical background starting from first Asian paper screens to the packaged kitchens of the mid-twentieth century, this book illustrate history of prefabricated interior design solutions, followed by additional descriptions of related case studies. The topics range from interior walls, kitchens, bathrooms, furniture, and offices to complete prefabricated house interiors.



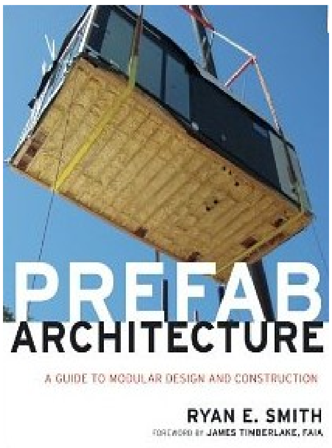
Book summary. The focus of this book is related to compact and small architectural solutions that are autonomous, but could be also expanded for many other purposes and additional functions as well. Accordingly, it collects examples of shelters, kiosks, snack bars, market stalls, bus stops, telephone booths, toilets, advertising columns, ticket booths, mobile tents or housing units, emergency shelters, or etc. As such, it provides a palette of examples how architectural structures because of their spatial limitations become more related to the strategies common in the field of product design.



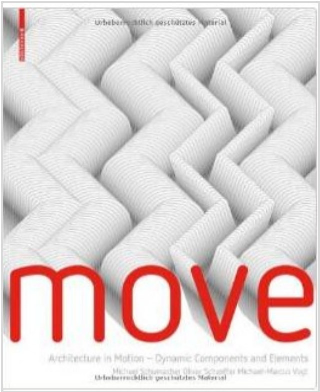
Book summary. The book *Flexible Housing* by Jeremy Till and Tatjana Schneider examines future development of housing throughout examination of 160 case studies worldwide that are based on concept of “flexibility”. All the case studies are reviewed in detail, with plans printed in scale, descriptions, illustrations and diagrams, that are providing complete inside view about each single project. The time period of selection of case studies is broad, starting from beginnings of 20^{th} century till recent times. At the end, summary of the book provides both social and economic benefits that can be achieved due to such flexible approach, as well as its technical possibilities. The book ends with an accessible guide to how flexible housing might be designed and constructed today to achieve adaptable and ultimately sustainable buildings.



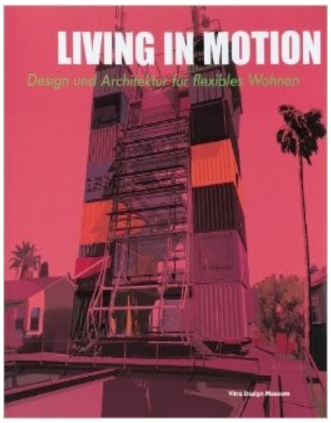
Book summary. This book is important for developing this Thesis as is offering a new and more innovative approach not only to dwelling culture, but also to assessing the cross-cultural, multidisciplinary nature of design. For developing the social perspective of this Thesis, this source is important since it observes but also criticizes the topics related to general design history; design progress; and influence which cultural differences, politic regimes, media, and above all information technologies make on creation of human environment.



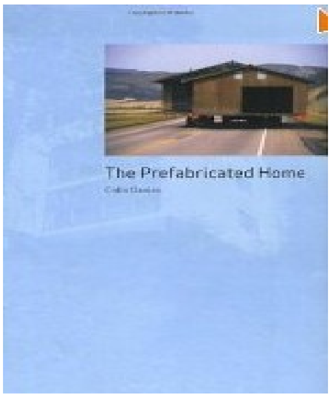
Book summary. This book represents a guide to prefabricated architecture, or more precisely, to off-site building structures. It contains benefits and challenges that professionals are facing in this field while using components, panels and modules as a core component of creation. Additionally, it demonstrates trough historical examples how prefabrication could be considered as a “smart choice”, how it is more efficient regarding delivery processes, and how it can be updated and transformed during its “life cycle”. The selection of topics include: 1) a focused history of prefabrication from the Industrial Revolution to current - more technologically advanced – times; 2) Analysis of fabrication method in terms of labor, costs and quality standards; 3) Analysis of prefabircation structures and interior building systems trough related case studies; 4) Comparison of benefits and weaknesses in terms of manufacturing proces, transportation and assembly process at construction site; 5) Presentation of recent projects of contemporary architects such as SHoP Architects, Office dA, Michelle Kaufmann, and many others.



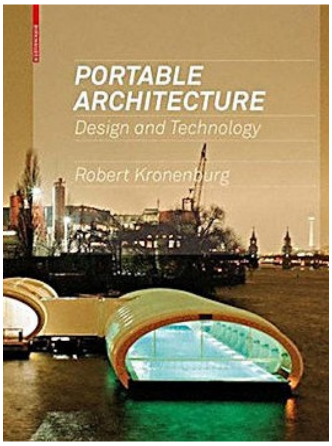
Book summary. This book is reviewing the issue of movement in architecture since this topic start to be more and more influential "tool" for further experimentation for architects, engineers and designers. The book topics are related to specific research questions that are examined –e.g. How can we control and reduce the energy requirement of buildings? How can we expand the range of possible uses? And how can we represent, accommodate, and control dynamic movements in buildings?



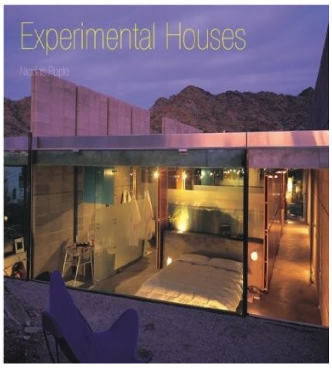
Book summary. This book is a sample of works collected by Vitra Design Museum around the idea of flexible living environment and its development trough history and different world cultures. Today way of living increased importance of mobile living and lifestyle solutions which offer not fixed, but flexible patterns of living environment. Here we can find great examples and see how people conscience changed during the history in direction ''less static'' understanding of house. Such changes affected also the approaches in the world of interiors, and we have great impact of famous examples and famous names which addressed this subject (F.L. Wright, M. van der Rohe, A. Castiglioni, J. Colombo, E. Grey, I. Noguchi, P. Starck, etc.). This preoccupation raises development of new concepts and we can witness lots of new approaches in multipurpose environments or multifunctional furniture which, at the end, can be used not only in domestic living spaces but also in means of transportations.



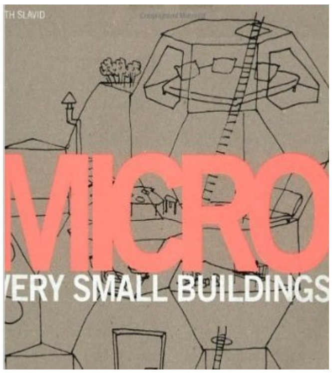
Book summary. *The Prefabricated Home* presents a vision of home trough the method of prefabrication, which is based on close relationship between residential architecture and buildings with more industrialized purposes. Therefore, the point of interest is strongly orientated towards methods and motives for implementing such approach in residential living, and additionally supported by numerous examples ranging from Dymaxion bathroom to IKEA's "Bo Klok" house.



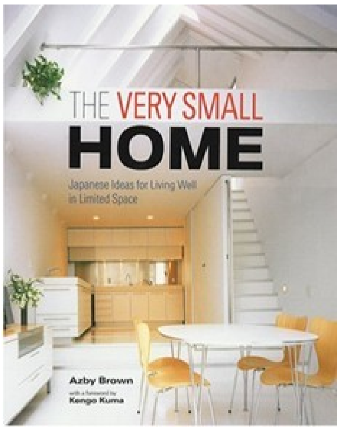
Book summary. First nomadic people had flexible lifestyle - they use to live in different locations, moving from one place to another. For them, mobility was the most efficient strategy in search of food and services that can accommodate their living needs. Accordingly, their dwellings were flexible – constructed in the way to be easily built and rebuilt as they were travelling to new locations in search for better living conditions. Therefore, this book discuss about these first nomadic tribes as a forerunners, but also evaluation of these types of approaches in present context and technology that was developed for this purpose. As such, it contains numerous examples worldwide and many areas of application. For example, Mark Fischer's stage construction for concert tours of U2 or Rolling Stones, flexible solution living proposed by Richard Horden (project name: *Micro Compact Home*), Container Home Kit from LOT/EK, mobile structures used in extreme climate conditions such as in Antarctic, or structures created to accommodate people after natural catastrophes, and many others.



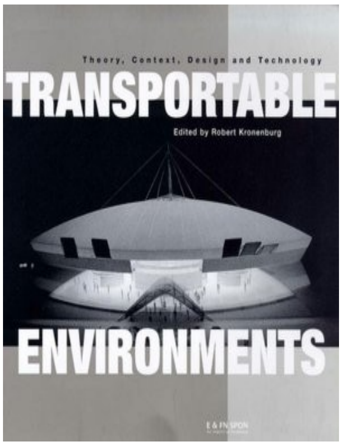
Book summary. This book examines methods that radically transform the traditional architectural approaches to houses. It examines the ways how professionals try to implement new solutions in order to find adequate answers to the problems of form, function, capabilities of materials, and limitations of space. Accordingly, the book investigates examples of work related to famous architects such as Adolf Loos, Mies van der Rohe, Le Corbusier, Pierre Chareau, Frank Lloyd Wright and others. In addition, it reviews in parallel which are the key social, political and economical driving forces behind that prompted new approaches in residential architecture.



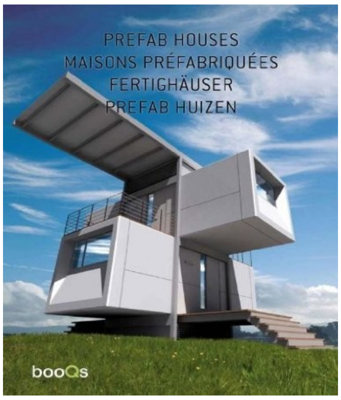
Book summary. This book examines very small spaces that have in most of the cases limited possibilities regarding implementing an “ideal living scenario”. Therefore, it explores intelligent spatial methods in the compact spaces that can provide as much as possible comfortable living environment. Accordingly, the thematic chapters are divided to the topics such as Public Realm, Community Spaces, On the Move, Compact Living and Extra Space. Presented case studies in each of these fields include various living solutions for homeless people, portable houses for victims of hurricanes, transportable houses or even churches (e.g. a case study from Finland), plug-in/out capsules for many functional purposes, and many more.



Book summary. The book “*The Very Small Home*” examines small houses in Japan. It contains a collection of inspiring interior and design methods as how to make the home feel more spacious than it actually is. Some of the examined methods include: how to implement more natural light; how to make compact but functional kitchen; how to organize the storage space; how to make layout organization by creating unobtrusive partitions and unobstructed circulation paths; etc.

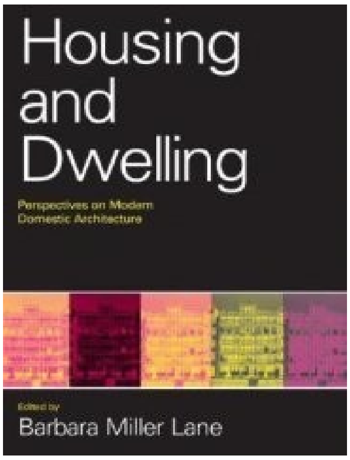


Book summary. Transportable Environments contains essays related to the development of temporary and transportable buildings and places, explores aspects of the historical and theoretical basis for portable architecture and provides an insight into the wide range of functions that it is used for today, the varied forms that it takes and the concerns and ideas for its future development. Meaningfulness in portability, connection between man and environment, relationship with personal/private space and public environment, are some of the subject in the field which are explored from psychological point of view. It is also pointed out the importance of Richard Buckminster and his Dymaxion Deployment Unit, as an archetype in transportable living. This was one of the first example where house was designed to be delivered in two cylindrical packages. With its variability, structural adaptation, suitable weight issues, fire and bullet resistance, easy ventilated and heated characteristic, economic acceptability, this innovation make a widespread and important use in the military purposes.

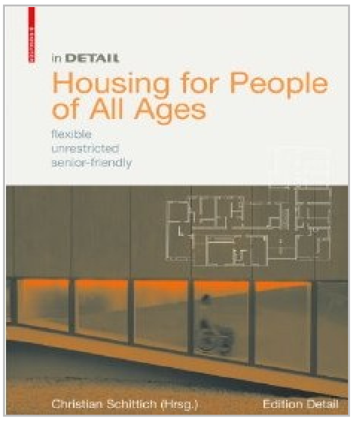


Book summary. This book contains huge selection of experimental houses made by implementing prefabricated techniques. As noted, many of them show the great potential in terms of functional rearrangements of layout during the passage of time. The fabrication method allows easily relocation of house unit, and extending/reducing floor area based on the new emerged functional needs of the household. Additionally, the passage of time it is also noted that aesthetic approach in prefabrication drastically improved by more careful use of various building materials, and by giving more attention to the details in construction. Finally, the main key point that is getting obvious trough the collection of all this case studies in the book is that such approach is more practical, affordable and more respectful of the environment than any other architectural technique known before.

Book Summary. Trough deep analysis of the housing projects during 1920's till today it is noted that approach to residential interior architecture is drastically changing. This change reveals significant new elements that are result of integration between furniture and architecture. Accordingly, as it is examined in the book, such situation stimulate development of new approaches in interior architecture that overcome traditional approach to building design and to design of everyday objects. Instead, functional units with determined, static and fixed purposes become variable, movable, extendable entities which can free spaces from fixed and limited functions through their flexibility. Such attitude improves significant efficiency regarding to the space and various functional possibilities.

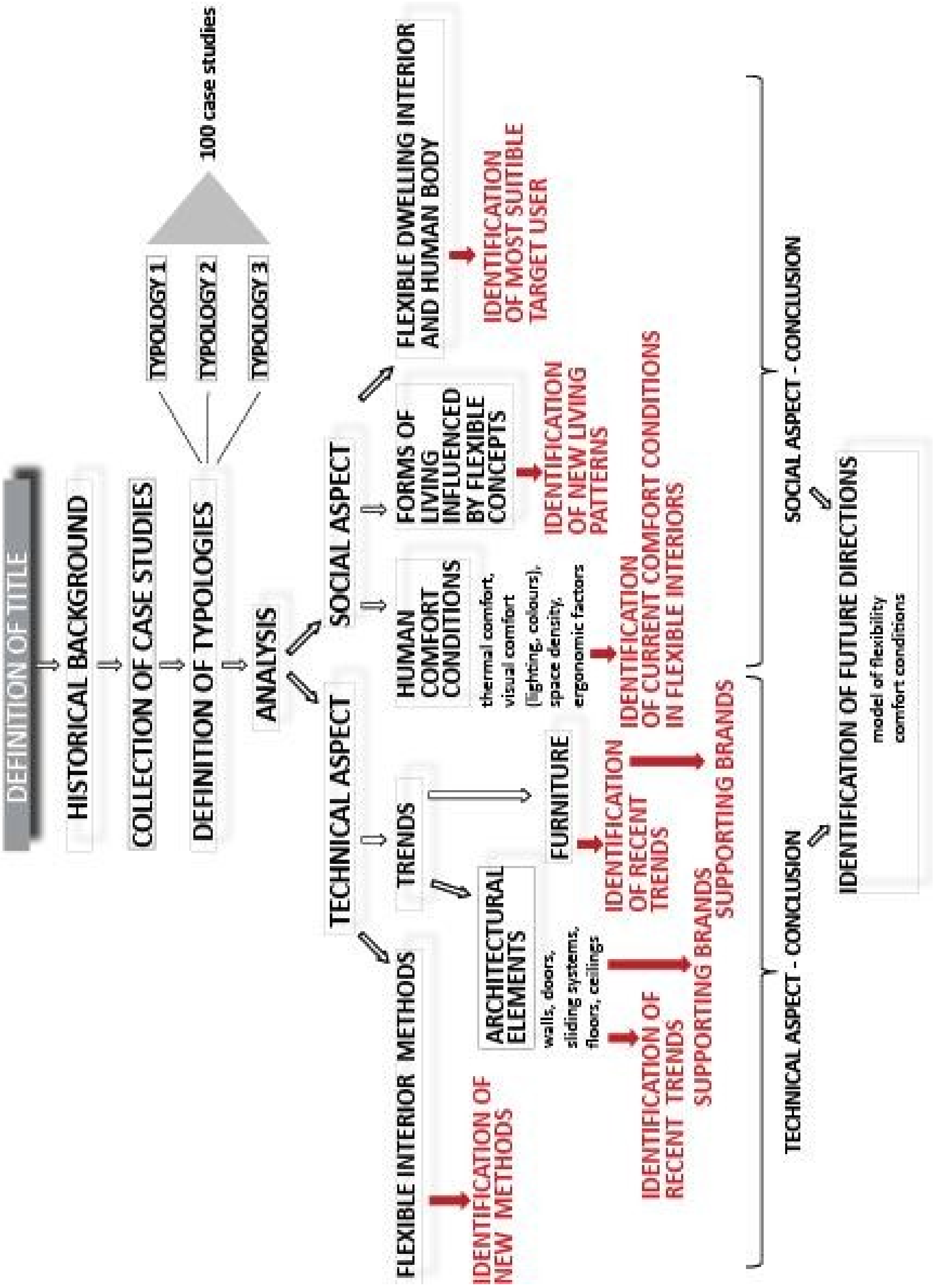


Book summary. This book collects discussions about history of domestic architecture in the nineteenth and twentieth century. The main focus is based on innovations as well as underlining the importance of user's needs, and changing living habits that make influence on the evolution of perspective in domestic architecture. "This book is a valuable asset for students, scholars, and designers alike, exploring the extraordinary variety of methods, interpretations and source materials now available in this important field. For students, it opens windows on the many aspects of domestic architecture. For scholars, it introduces new, interdisciplinary points of view and suggests directions for further research. It acquaints practising architects in the field of housing design with history and methods and offers directions for future design possibilities."

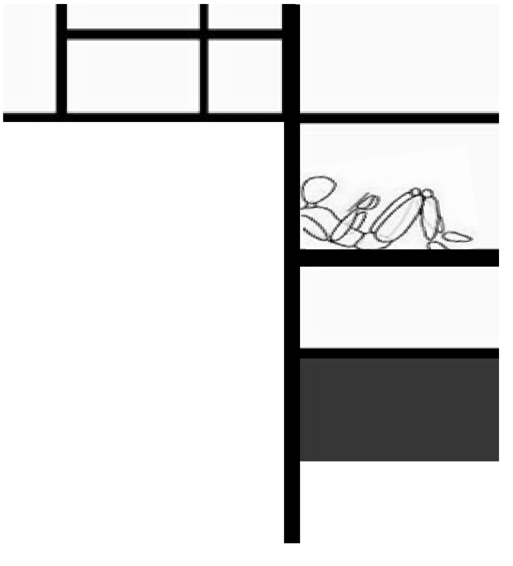


Book summary. This book highlights the potential of flexible dwelling spaces due to their ability to support variety of life-cycle needs of the occupants. Therefore it focus on examples of projects where is handicap-accessibility and flexibility of use main motivation factor of creation.

0.2. Organization of research topics



INTRODUCTION



1. Definition of macro-areas

In order to approach to the subject, it is important to first define the three main keywords which will be investigated throughout the whole Thesis. The first keyword refers to the explanation of the term "dwelling" according to the different viewpoints of various scholars. The second one refers to the explanation of the term "flexibility" - the basic definition; the variety of meanings according to various disciplines; and the specific meaning in the context of architecture, interior design and furniture design. Finally, the third keyword refers to the explanation of the term "comfort" – the basic definition; its classification; and its meaning in the context of architecture, interior design and furniture design.

1.1. Dwelling

Before starting to explore the history and future development of this specific topic of the Thesis, it is necessary to explain the definition of dwelling (or home). There are several definitions which differ according to the various approaches that could be considered from the historical, philosophical, architectural or social point of view. For example, the most basic explanation provided by the Oxford dictionary is that *dwelling* is "the place where a person lives". Furthermore, according to the German philosopher Martin Heidegger (September 26th, 1889 – May 26th, 1976) whose groundbreaking thoughts influenced many fields among which architecture, art and design, "*building* and *dwelling* are a single phenomenon, the creation by the individual consciousness out of its rootedness in culture, time and place"[1]. The architectural critic Reyner Banham (2nd March 1922 – 19th March 1988) "was closely affiliated with the visionary British Archigram group in the 1960s, and then took on the role of gadfly to modern architectural historians. Banham argues that the modern home is a set of modern appliances and services, not bound to any location and therefore essentially rootless" [2.] The sociologist and anthropologist Mary Douglas (25th March 1921 – 16th May 2007) known for her writings on human culture and symbolism, suggests that "home is a place where households organize themselves over time by practicing the planning of resources and by developing household rituals; for Douglas, home is thus an early form of social organization" [3]. The English professor and social activist Gloria Jean Watkins (born September 25th, 1952), better known by her pen name bell hooks, reminds us that for African-Americans, home is a place of resistance to the norms of a hostile society"[4].

Understanding the concept of dwelling also depends on the period concerned, especially if we take into account the time before and after the 1960s. Looking back to the Victorian perception of *ideal* home (or dwelling) we can notice that great emphasis was put on the strict distinction between the "front" and "back", or the "public" and "private" spheres of the home, as well as on the proliferation

[1] Lane, Barbara Miller. *Housing and dwelling perspectives on modern domestic architecture*. London: Routledge, 2007, pp. 50-72.
[2] (Lane Miller, 2007)
[3] (Lane Miller, 2007)
[4] (Lane Miller, 2007)

of rooms with special purposes[5]. Therefore, "houses in their internal arrangement tend to have separate rooms for distinct purposes as the city came to have precise locations for various functions"[6]. Further on, as Mike Hepworth explains in "*Privacy, security and respectability: The ideal Victorian home",* "two important features of the ideal home as a retreat were particularly significant. The first one was the constructed façade – the physical structure of stone, bricks and mortar which helped to conceal residents from public view – and the second [...] was the social organization of private life inside the private spaces such as bedrooms, studies and the various forms of special social interaction that were possible in these rooms"[7].
Moreover, as Martin Heidegger highlights in his 1954 "*Building, dwelling, thinking"*: "We attain to dwelling, so it seems, only by means of building. [...] Still, not every building is a dwelling. Bridges and hangers, stadiums and power stations are buildings but not dwellings; railway stations and highways, dams and market halls are built, but they are not dwelling places. Even so, these buildings are in the domain of our dwelling. That domain extends over these buildings and yet is not limited to the dwelling place. The truck driver is at home on the highway, but he does not have his shelter there; the working woman is at home in the spinning mill, but does not have her dwelling place there; the chief engineer is at home in the power station, but he does not dwell there. These buildings house man. He inhabits them and yet does not dwell in them, when to dwell means merely that we take shelter in them"[8].
On the other hand, Mary Douglas in her 1993 article "*The idea of home: A kind of space*" explains her own interpretation. She suggests that "Home is located in space, but it is not necessarily a fixed place. It does not need bricks and mortar, it can be a wagon, a caravan, a boat, or a tent. It need not be a large space, but space there must be, for home starts by bringing some space under control. Having shelter is not having a home, nor is having a house, nor is home the same as household"[9].
In the Twentieth century we inherited and further developed such concept of home. This reform may be the result of a change in the living behaviours towards a stricter definition of the physical environment. According to Elizabeth Blackmar (*Social meanings of housing: 1800-1840*, 1989) "whatever the depth of psychological needs individuals brought to the construction of home life [...] they organized their housing to serve a wide range of social activities that differed from those of earlier generations and varied according to material means. In order to consider how particular cultural values and expectations shaped housing as a new social institution, we must move beyond its characterization as a "private sphere" and explore the publicity of new housing practices"[10].

[5] Lane, Barbara Miller. *Housing and dwelling perspectives on modern domestic architecture*. London: Routledge, 2007, p. 149.
[6] (Lane Miller,2007. p130)
[7] Hepworth, Mike. "Privacy, security and respectability", in Lane, Barbara Miller. *Housing and dwelling perspectives on modern domestic architecture*. London: Routledge, 2007, p. 150.
[8] Heidegger, Martin. "Building, dwelling, thinking", in Lane, Barbara Miller, *Housing and dwelling perspectives on modern domestic architecture*. London: Routledge, 2007, p. 50-54.
[9] Douglas, Mary. "The Idea of a Home: A Kind of Space", in Lane, Barbara Miller, *Housing and dwelling perspectives on modern domestic architecture*. London: Routledge, 2007, p. 61-67.
[10] (Lane Miller, 2007. p108-109)

1.2. Flexibility

"The quality of being adaptable or variable"[11]; "the range of motion in a joint or group of joints, or, the ability to move joints effectively"[12]; "quality of bending easily without breaking; ability to be easily modified; willingness to change or compromise"[13]; "susceptible of modification or adaptation"[14]: all these are general definitions of flexibility according to various dictionary sources.

In psychology, the term known as "psychological flexibility" means "*contacting the present moment fully as a conscious human being, and based on what the situation affords, changing or persisting in behaviour in the service of chosen values".* In everyday language, this means holding our own thoughts and emotions a bit more lightly and acting according to longer term values rather than to short term impulses, thoughts and feelings. This is because thoughts and emotions tend to be unreliable indicators of long-term values. We have little control over them and they tend to ebb and flow – sometimes dramatically. If we trust our thoughts and emotions and act on the basis of them, we can often overlook the more important, sustained patterns of action which bring true meaning, vitality and richness to our lives. It is for this reason that Kashdan and Rotterburg (2010)[15] define psychological flexibility as *the measure of how a person: (1) adapts to fluctuating situational demands, (2) reconfigures mental resources, (3) shifts perspective, and (4)* balances competing desires, needs, and life domains. *Thus, rather than focusing on a specific content (within a person) the* definitions of psychological flexibility have to incorporate repeated transactions between people and their environmental contexts"[16].

In sport, the term could be closely related to "flexibility training" or may be more familiarly known as "stretching", which is used in a variety of forms among coaches, athletes and physiotherapists on a regular basis. In this context, "flexibility has been defined as the range of motion about a joint and its surrounding muscles during a passive movement. Passive in this context simply means no active muscle involvement is required to hold the stretch. Instead gravity or a partner provides the force for the stretch." The main benefit is that "a more flexible athlete is a more mobile athlete. It allows enhanced movement around the court or field with greater ease and dexterity. Some other benefits may include an increase in body awareness and a promotion of relaxation in the muscle groups stretched - both of which may have positive implications for skill acquisition and performance"[17].

In economy, flexibility can refer to a number of different areas. In business, its most common usage "is in the workplace where it refers to such things as flexi-time, variable hours and extended periods

[11] Free dictionary. [http://www.thefreedictionary.com/flexibility (accessed 10th October 2013)]
[12] [http://weightloss.about.com/od/glossary/g/flexibility.htm (accessed 10th October 2013)]
[13] Oxford dictionary
[14] [http://dictionary.reference.com/browse/flexibility (accessed 10th October 2013)]
[15] Kashdan, T., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health Clinical Psychology Review, 30 (7), 865-878. DOI: 10.1016/j.cpr.2010.03.001
[16] "What is psychological flexibility?" [http://workingwithact.com/what-is-act/what-is-psychological-flexibility/ (accessed 10th October 2013)]
[17] "The benefits of flexible training" [http://www.sport-fitness-advisor.com/flexibilitytraining.html(accessed 10th October 2013)]

of leave. But the word has a longer pedigree in the area of strategy, where it generally refers to a firm's ability to respond to changes in its environment both rapidly and at low cost"[18].

In engineering, "flexibility is used as an attribute of various types of systems. In the field of engineering systems design, it refers to designs that can adapt when external changes occur. Flexibility has been defined differently in many fields of engineering, architecture, biology, economics, etc. In the context of engineering design one can define flexibility as the ability of a system to respond to potential internal or external changes affecting its value delivery, in a timely and cost-effective manner. Thus, flexibility for an engineering system is the ease with which the system can respond to uncertainty in a manner to sustain or increase its value delivery. Uncertainty is a key element in the definition of flexibility. Uncertainty can create both risks and opportunities in a system, and it is with the existence of uncertainty that flexibility becomes valuable"[19]. Some engineering design solutions are the *Mobile Pedestrian Bridge* by Zoran Novacki (DeFlexible systems, 2013); the *WhoWhatWhenAIR* actuated tower by Philippe Block, Alex Kilian, Peter Schmidtt, John Snavely (2006), etc.

Flexibility as an architectural approach has its own definitions. The most known term used in this context refers to "flexible architecture" which could be generally connected with the extension of spatial functionality, the opportunity to modify the layout according to different patterns of use. Additionally, it could be also connected with the techniques of prefabrication and mobility in the form of house-vehicles.
For example in the residential context, according to *Flexible Housing* by Tatiana Schneider and Jeremy Till, the related term "flexible housing" refers to "a housing that can adjust to changing needs and patterns, both social and technological. These changing needs may be personal (say an expanding family), practical (e.g. the onset of old age) or technological (e.g. the updating of old services). The changing patterns might be demographic (e.g. the rise of the rental market) or environmental (e.g. the need to update housing to respond to climate change). This definition is deliberately broad. It includes the potential to make changes prior to occupation as well as the ability to adjust one's housing over time after occupation. Flexible housing thus works across the life of a housing development. Prior to occupation, a flexible approach will allow future users a degree of

Fig.1.2.1. Linear Deflexible Modul, by Deflexible Systems, 2013. Source [http://www.deflexible.de/ (accessed 12th October 2013)]

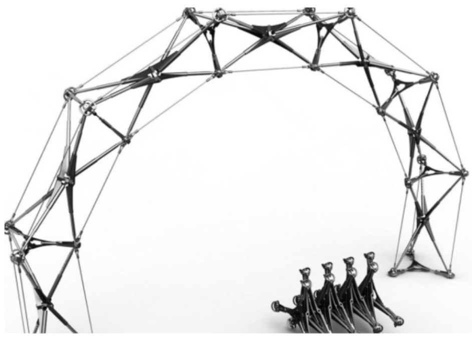


Fig.1.2.2. Arc Deflexible Modul, by Deflexible Systems, 2013. Source [http://www.deflexible.de/ (accessed 12th October 2013)]

[18] "Flexibility" [http://www.economist.com/node/14298966 (accessed 10th October 2013)]
[19] Flexibility (engineering) [http://en.wikipedia.org/wiki/Flexibility_(engineering) (accessed 10th October 2013)]

choice as to their layouts. Post occupation it enables people to occupy their homes in a variety of ways, not tied to the specifics of room designations, and allows them to make adaptations to their home. In the longer term, flexible housing enables to adapt on mix of units, to change the layouts, and also to upgrade their properties in an economic manner"[20].

If we exclude strictly residential contexts, "Flexible architecture" can also refer to temporary private or public structures for different types of temporary usage. This could include the shelters for people in extraordinary circumstances like natural disasters and war conditions (e.g. *Future Shack* emergency house by Sean Godsell, 1985-2001); commercial units, like temporary showrooms in the town centres or during exhibition fairs, which need to be easily transported, assembled, and need to be light in weight, efficient in use and able to be re-assembled and removed fast and easily (e.g. *IBM Pavilion* by Renzo Piano Building Workshop, 1982-84; *Japan Pavilion* by Shigeru Ban Architects and Otto Frei, 2000; *Spirit of Dubai* by Tectoniks Ltd, 2007); shops (*Puma retail unit* by LOT-EK, 2010); summer restaurants, bars (e.g. *Pavilions pour la rade*, Bakker & Blanc Architects, 2004-2008); entertainment structures like stages or tents for big events (e.g. *Valhalla* by Rudi Enos, 2000; *U2 Vertigo Tour Stage Set* , 2005-2006 and *The Rolling Stones Bigger Bang Tour Stage Set*, 2005-2007 by Mark Fisher) or even hotels.



Fig.1.2.3. Bathing Ship by AMP arquitectos / Wilk-Salinas, Berlin, 2004; **Fig.1.2.4.** IBM Pavilion by Renzo Piano, 1982-84; **Fig.1.2.5.** Uniqlo pop-ups by LOT-EK, 2006.

[20] Schneider, Tatjana, and Jeremy Till.*Flexible housing*. Oxford, UK: Architectural Press, 2007.

1.3. Comfort

Comfort could be defined in the most simple manner as a state which expresses satisfaction with the surrounding environment. A lack of satisfaction is connected with discomfort.

In sum, the level of comfort can be a synonymous of “quality of living”. With this in mind, scientifically speaking, two main definitions can be adopted. The first one refers to “the sense of well-being of the individual; satisfaction or dissatisfaction of the individual from his or her life” [21]. Therefore, the quality of living in this context is emphasized as being related to individual perceptions and senses. The second definition defines quality of living “as an interaction of social, health, economic and environmental conditions that have an impact on the development of the individual and the society”[22].

The first definition is common in psychology under the term “mental comfort” and refers to a degree of convenience that can be achieved “by recreating experiences that are associated with pleasant memories, such as engaging in familiar activities, maintaining the presence of familiar objects, and consumption of comfort foods. Comfort is a particular concern in health care, as providing comfort to the sick and injured is one goal of healthcare, and can facilitate recovery. Persons who are surrounded with things that provide psychological comfort may be described as being within their comfort zone.”[23] Factors that determine mental comfort also can include temperature of the surrounding environment, humidity of the air, air motion, etc.[24] Because of its personal nature, psychological comfort is highly subjective.[25]

However, as previously mentioned, the level of comfort can depend on social, health, economic and environmental conditions as well. For the scope of this thesis, the concept of comfort will be considered one of the main focuses as it touches and is closely dependent on measurable parameters like physical environment and human body. More specifically, the main area of interest that can be extracted from this domain is related to ergonomics, whose main task is to examine human body and its behaviour in order to provide relevant data on how to build human-friendly (or comfortable) environments. Therefore, ergonomics encompass anatomical and physiological parameters and also use findings of other disciplines like medicine, psychology, mathematics, optics, acoustics, etc.[26] due to their contribute to human satisfaction with environment.

[21] Kasapoglu, Esin. “Quality of Life Criteria of House Design for Sustainability” in Frattari, Antonio. *XXXII IAHS world housing congress: Trento, Italy, September 21-25, 2004 : sustainability of the housing projects : proceedings*. Trento] : [Trento: University of Trento(IS), Università di Trento, 2004.
[22] (Kasapoglu, 2004)
[23] Comfort [http://en.wikipedia.org/wiki/Comfort (accessed 13th October 2013)]
[24] Human comfort [http://www.ask.com/question/what-is-human-comfort (accessed 13th October 2013)]
[25] Comfort [http://en.wikipedia.org/wiki/Comfort (accessed 13th October 2013)]
[26] Ergonomija [http://hr.wikipedia.org/wiki/Ergonomija (accessed 13th October 2013)]

2. Definition of field of interest

This chapter will illustrate the main contexts useful for defining the Thesis' focus, so as to make clear which initial factors will be taken into account as relevant criteria for further analysis on the matter. More specifically, the target households related to the subject of the thesis will be identified and the concept behind the expression "limited dwelling interior" will be deeply investigated. Furthermore, this chapter will provide a review of well-known problems occurred in history related to the scope of the Thesis, as well as introducing the main motivations and research questions which will be examined throughout the whole research. Thereby, any other factors not mentioned in the Thesis are considered as not crucial for obtaining the responses to the research questions that will be investigated.

2.1. Definition of target households

Small household

A small household is understood as a basic residential model which consists of one or maximum two persons living in one dwelling. This model actually represents the contemporary household of many developed countries and highly populated urban areas around the world and do not correspond to the nuclear household of our past which many building codes tend to favour. [27] For example, in New York "only 18 percent of the city's housing is occupied by the so-called nuclear family; that is, two parents and children under the age of 25. In fact, the majority of households are increasingly made of singles, couples with no children, single parent families and a number of other diverse arrangements"[28]. Therefore, case studies which can accommodate such household patterns will be the focus of this Thesis' investigation.

Middle class household

In America, "middle class is broadly defined as households earning two-thirds to twice the median income, or about $35,000 to $100,000 a year. The beginning of the 21st century was a "lost decade" for the middle class, Harvard economist Lawrence Katz said, but the decline has been under way for decades. In the early 1970s, middle-class households earned 62 percent of the national income; today, they bring in just 45 percent. These households are more vulnerable, economists say, than at any time since World War II".[29] According to the same source, the situation had worsened with the Great Recession when sixty percent of job losses affected middle income positions. During the recovery period, the middle class was in such a situation that, instead of having the possibility to renew their previous positions, they were lucky if they managed to find any job positions, even

[27] "Making room" [http://www.domusweb.it/en/architecture/2013/03/05/making-room.html (accessed 18th February 2014)]
[28] ["Making room"]
[29] Sullivan, Amy. "The American Dream, Downsized." Www.nationaljournal.com. April 25, 2013. Accessed November 7,2014. http://www.nationaljournal.com/next-economy/solutions-bank/the-american-dream-downsized-20130425.

lower-wage ones. Today, the middle class makes up barely half of the population (unlike in 1971, when it constituted 61 percent) and the percentage of low income households is increasing[30].

A similar situation can be found also in Europe, especially in important urban metropolis. Because of the squeeze between earnings and life expenses, many people are concerned about their economic security. Also, another factor which contributes to this instability is that people cannot count on steady or rising income nor on lifelong working positions. “Part-time” or “limited contract” positions are the most widespread options in all range of professions, which also goes along with decreased employment security, limited working benefits and sometimes with a cut in pay[31]. The fear of debts and of taking risks marks today’s middle class society and it is reflected in all points of decision making in life. Thereby, this situation also influences the choice of appropriate housing options.

2.2. Definition of “limited dwelling interior“

Since people has become a little more cautious about economical uncertainty on the long term, as well as weighing risks more carefully in their lives, the increased demand for “studio apartments” represents one of the best solutions for people who choose to become homeowners and at the same time want to live in urban areas, where the living costs are higher. If we consider the matter from the perspective of traditional interior arrangement, such living option can hardly support all our necessary requirements in a long-term living context. A studio apartment, also known under the term “bachelor style apartment”, usually consists of one big room which accommodates living, dining and bedroom altogether. Sometimes a kitchen could also be a part of it, or it can be located in a small isolated niche or a small separate room. The bathroom is small and always in a separate unit. The floor area of such apartments generally ranges up to 45 m2 and varies from state to state. For example, in America the average size is 25-45 m2, but in Japan, South Korea and some European capitals it could be much smaller[32].

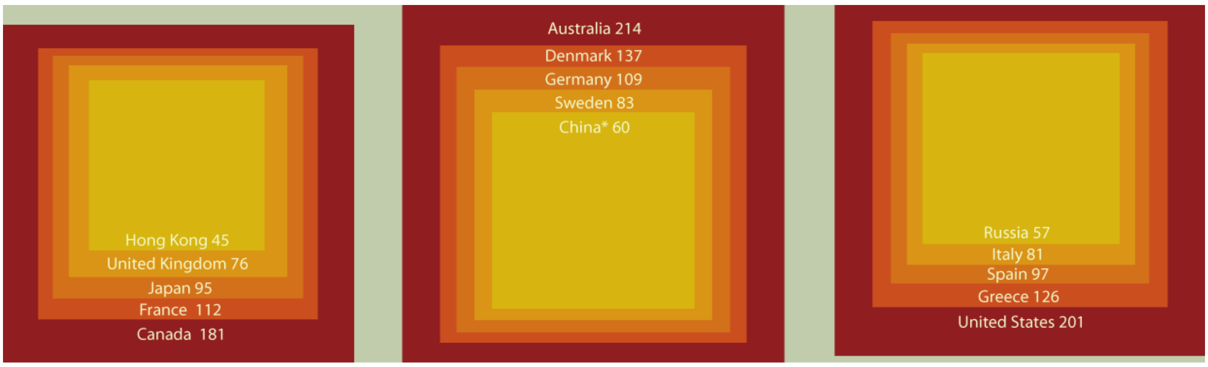


Fig.2.2.1. Average home size around the globe in m^2 acording to researches of CommSec, RBA, UN and US Census from 2009. Source: "How big is a house? Average house size by country." shrinkthatfootprintcom RSS. http://shrinkthatfootprint.com/how-big-is-a-house (accessed March 21, 2014).

[30]Sullivan, Amy. "The American Dream, Downsized." Www.nationaljournal.com. April 25, 2013. Accessed November 7,2014. http://www.nationaljournal.com/next-economy/solutions-bank/the-american-dream-downsized-20130425.
[31] (Sullivan, 2013)
[32] Studio apartment [http://en.wikipedia.org/wiki/Studio_apartment (accessed 15th October 2013)]

Another alternative is represented by the small-sized and "ready-to-use" prefabricated dwellings which also respond to the needs of nowadays' middle class society, because of lower building costs compared to those of the traditional building techniques. At the same time, the advantage of this technique is that various combinations of prefabricated modules can increase layout flexibility, which in turn can help expand the necessary floor area. In this context the use of shipping containers as a core component for building a structure is the most common scenario (e.g. *The Quick House* by Adam Kalkin, 2009; etc). Although this approach is typical of suburban contexts, there is an increasing number of examples where these types of dwellings are incorporated also in the urban environment as "parasite" structures (e.g. *Drop House* concept[33] by Antoine Cordier, Olivier Charles and Armel Neouze, Paris, 2005).

Considering all this, we can conclude that such living options frequently suffer from a "lack of something" in the long-term; it could be either one extra room or merely a bigger storage, etc. Therefore, such type of spatial limitations is the starting point for developing various flexible interior solutions and the focus of the following chapters of this Thesis.

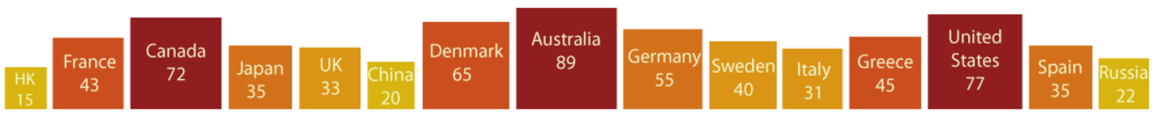


Fig.2.2.2. How much space is considered as enough? – average residential floor space per capita in m^2 according to researches of CommSec, RBA, UN and US Census from 2009. Source: "How big is a house? Average house size by country." shrinkthatfootprintcom RSS. http://shrinkthatfootprint.com/how-big-is-a-house (accessed March 21, 2014).

Fig.2.2.3. *Drop House* by Antoine Cordier, Olivier Charles and Armel Neouze, Paris, 2005. Source: [http://inhabitat.com/drop-house/ 5th Aug 2014)]; **Fig.2.2.4.** *Loft cube* by Studio Aisslinger, Germany. Source: [http://www.loftcube.net (accessed 12th May 2014)]

[33] "Residential Shipping Container Primer (RSCP™)." Drop House. Modular Prefab Recycled Shipping Container Home. Residential Shipping Container Architecture. Accessed October 15, 2013. http://www.residentialshippingcontainerprimer.com/Drop House.

2.3. Concerned problems

As mentioned in the previous subchapters, the emergence of compact and flexible concepts is a response to various social and demographic conditions occurring in today’s society. Furthermore, the consequences of such living go hand in hand with various behavioural changes and restrictions which were not so common in human nature before. Finally, from a technical point of view, it was shown also that some approaches based on flexibility were not appropriate for long-term living contexts.

a. Demographic and social problems

In a highly populated city, rents are extraordinarily high. For example in Hong Kong, according to the article “Shocking Aerial Views Of Hong Kong's Tiny 'Cage' Apartments”[34], 80$ per square foot per month is the common price, so “people are forced to live in tiny caged homes or wood-partitioned cubicles”[35]. According to SoCO (Society for Community Organization)[36] at least 100,000 people live in sub-divided apartment units no larger than 40 square feet (ca 3,7 m2) and worryingly this number is increasing. Therefore, people deal with affordability problems and, in most cases, the size of the space they rent or buy cannot support their real needs.

Fig.2.3.1. Shocking Aerial Views Of Hong Kong's Tiny 'Cage' Apartments by Adam Tylor in businessinsider.com. Source [http://www.businessinsider.com/hong-kongs-caged-apartments-are-tiny-2013-2?op=1 (accessed 18th July 2013)]

[34] Taylor, Adam. “Shocking Aerial Views Of Hong Kong's Tiny 'Cage' Apartments“ in Business Insider [http://www.businessinsider.com/hong-kongs-caged-apartments-are-tiny-2013-2?op=1 (accessed 17th July2013)]

[35] (Taylor, 2013)

[36] SoCO (Society for Community Organization) was founded in 1972 and is a registered non-profit and non-governmental human rights organization for the underprivileged. SoCO is active in lobbying for an improvement in the lives of the 1.3 million Hong Kong people who live below the poverty line - predominantly comprising the cage and cubicle dwellers, the single elderly, new immigrant women, children living in poverty, street-sleepers, people with mental illnesses, low-paid workers, refugees and ethnic minorities. SoCO also undertakes original social policy research, lobbies Hong Kong decision-making bodies and organizes direct action events. Source [http://www.soco.org.hk/artwalk2009/index.htm#about (accessed 17th July 2013)]

In Europe, according to the results of the European Union's Statistic on Housing Conditions, "over the past decade, worsening affordability, homelessness, social and housing polarisation and new forms of housing deprivation has been an increasing concern for public policy"..."One major element of the quality of housing conditions is the availability of sufficient space in the dwelling. The indicator that has been invented to describe space problems is the overcrowding rate, which assesses the proportion of people living in an overcrowded dwelling, as defined by the number of rooms available to the household, the household's size, as well as its members' ages and family situation. In 2011, the highest rates of overcrowding were observed in Romania (54.2 %), Bulgaria (47.4 %), Poland (47.2 %) and Hungary (47.1 %), while the lowest were seen in the Netherlands (1.7 %) and Belgium (2.2 %). The EU-27 average rate of overcrowding was 16.9 %."[37]

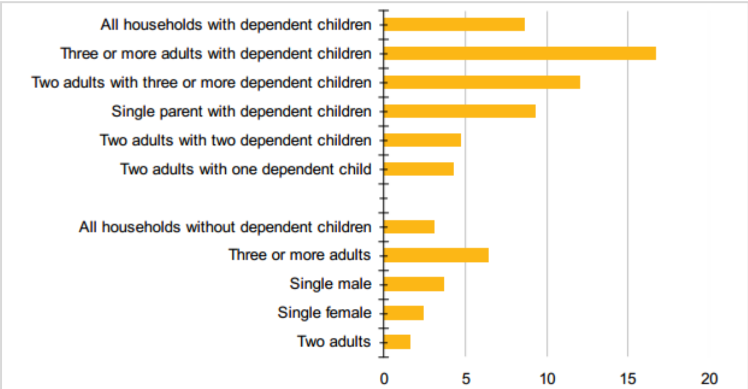


Fig.2.3.2. According to Eurostat, 30 million people in the EU suffered both lack of space and poor housing conditions in 2009. This table shows severe housing deprivation rate by household type (% of population). Source:[http://epp.eurostat.ec.europa.eu (accessed 20th July 2013)]

b. Life-style changes

In America, the growth rate for one and two-person households greatly exceeds that of households with three or more people. Therefore, the trend of building small apartments is constantly growing. According to the New York Observer, the rising population in New York motivated Department of Housing Preservation and Development to put more requests for proposals of micro-apartment sites in the city.[38] For example, at the beginning of 2013, Monadnock Development, Actors Fund Housing Development Corporation and nARCHITECTS won the city's "adAPT NYC" contest and were selected to build micro-apartments in a city-owned site in Kips Bay. The 10-story complex, located at 335 East 27th Street, will feature 55 apartments ranging in size from 250 to 370 square feet (ca 23 to 34 m2)[39]. Besides this project, for the year 2013 at least two or three more sites will be considered for building such micro-unit apartments[40]. The drawback of this development is that it supports one and two-person households, what results in crowded living conditions in already overcrowded urban areas.

[37] Source [http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Housing_conditions (accessed 19th July 2013)]
[38] Samtani, Hiten. "New York City Wants To Build Even More *Micro Apartments*".
Source:[http://www.businessinsider.com/new-york-city-wants-to-build-even-more-micro-apartments-2013-4 (accessed 17th July 2013)]
[39] (Samtani, 2013)
[40] (Samtani, 2013)

c. Living behaviour in small dwellings

Privacy is a highly desired quality, especially in crowded living conditions. Various studies highlight that crowded residential conditions can negatively affect psychological health.[41] Crowded physical environments have been shown to disrupt complex task performance,[42] negatively affect frustration tolerance and creativity[43] and interfere with verbal problem solving.[44] Generally, crowding disrupts the normally supportive relationships that exist within groups of cohabitating people, and results in various forms of social withdrawal[45].
Crowded living conditions can alter family activities as well as perceptions of family members toward each other. The problem is not the contact itself, but rather an unwanted contact that may be perceived as intrusive. Specifically, perceptions of crowding may result when “primary” environments (such as bedrooms) are mixed with “secondary” environments (such as living rooms).”[46]

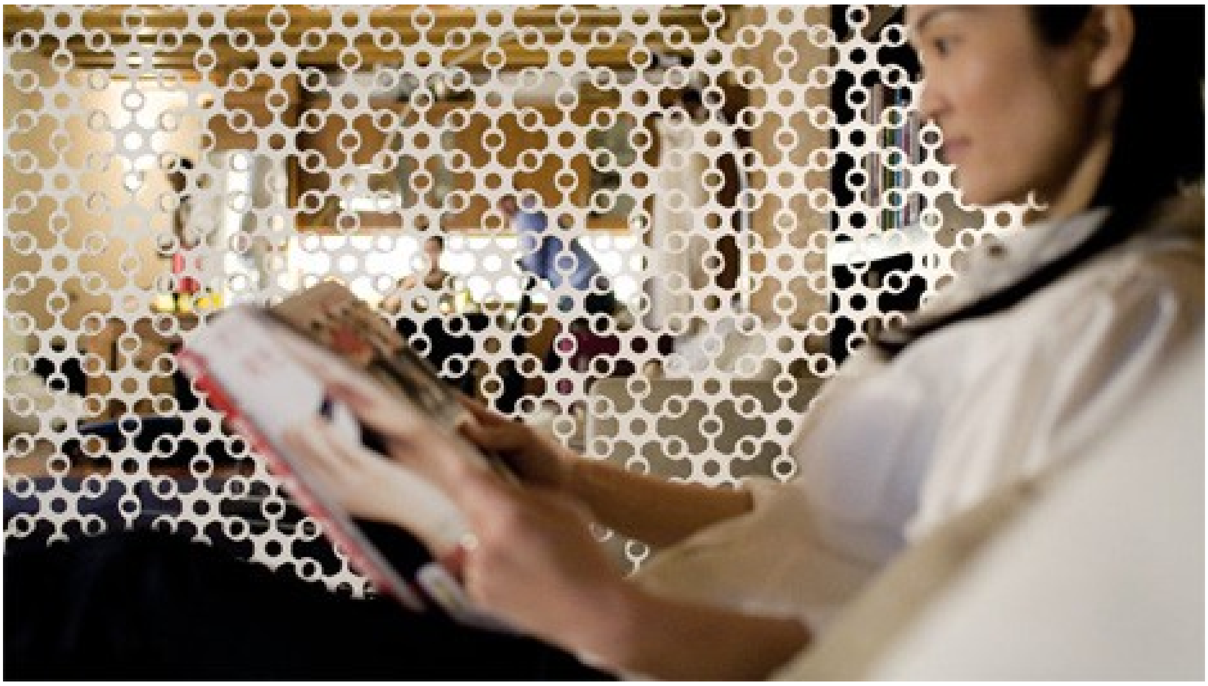


Fig.2.3.3. Space divider by designer Hiroshi Tsunoda. Source [http://www.apartmenttherapy.com/how-to-make-rooms-in-your-stud-60352#gallery/4004/0 (accessed 17th July 2013)]

[41] Evans, G., Palsane, M., Lepore, S., & Martin, J. (1989). Residential density and psychological health: The mediating effects of social support. *Journal of Personality and Social Psychology*, 57, p. 994–999.
[42] Paulus, P., Annis, A., Seta, J., Schkade, J., & Matthews, R. (1976). Density does affect task performance. *Journal of Personality and Social Psychology*, 34, pp. 248–253.
[43] Dooley, B. (1978). Effects of social density on men with “close” or “far” personal space. *Journal of Population*, **1**, p. 251–265.
Sherrod, D., & Cohen, S. (1979). Density, personal control, and design. In J. Aiello & A. Baum (eds.), *Residential crowding and design*(pp. 217–227). New York: Plenum Press.
[44] Aiello, J., DeRisi, D., Epstein, Y., & Karlin, R. (1977). Crowding and the role of interpersonal distance preference. *Sociometry*, 40, p. 271–282.
[45] Lepore, S., Merritt, K., Kawasaki, N., & Mancuso, R. (May, 1990). *Social withdrawal in crowded residences*. Western Psychological Association. Los Angeles, CA.
[46]Pable, Jill. “The Homeless Shelter Family Experience: Examining the Influence of Physical Living Conditions on Perceptions of Internal Control, Crowding, Privacy, and Related Issues” in *Journal of Interior Design* , Vol. 37 Issue 4, Dec. 2012, p. 9-37.

d. Project conception - technical and economic disadvantages in history

In *"Prefab architecture"* by Ryan E. Smith[47], the author points out precise conceptual problems which were occurring in history in the dwellings based on "capsule" structures and prefabrication techniques. A significant amount of solutions remained only in the form of concept proposals which were never realized because of either complicated or costly construction methods (e.g. Gropius and Wachsmann's "*Prepacked House*", 1942). On the other hand, many of the realized solutions were abandoned after a short period of usage and have never been replaced by any alternative purposes. The problem is that those concepts did not support well the possible changes in interior conception nor the new technology to come. Because of that, such structures soon became outdated and needed replacing. For example, solutions like the Fuller's Dymaxion house "were technically advanced but would have required a continual stock of supply in order to mantain the building systems during their lifecycle. Especially in the case of service pods, systems are updated frequently enough that the near entirety of the home is outdated after its first decade or two of life"[48]. Proposals "including Safdie and the Metabolist projects […] are rarely, if ever, a change because of the sheer cost of disassembling a module in order to update the technology or replace the model altogether"[49]. These modules usually "rely on a heavy infrastructure which cannot be manipulated without deep, invasive and expensive intervention, what is difficult to justify in the lifecycle costs of the building"[50]. Along with these technical problems, some of the solutions became outdated also due to a change in aesthetic preferences. Moreover, some solutions represented ideas, styles, and constructions that were difficult to change and adapt to individual living patterns or to the incoming styles and technology[51].

Fig.3.4.4. Sanzhi Pod Village, Hung Kuo Group, Taiwan, 1978.

Fig.3.4.5. Futuro, by Matti Suuronen, Finland, 1968/1978.

[47] Smith, Ryan E.. *Prefab architecture: a guide to modular design and construction*. Hoboken, N.J.: John Wiley & Sons, 2010.
[48] (Smith, 2010. p40)
[49] (Smith, 2010. p40)
[50] (Smith, 2010.p40)
[51] (Smith, 2010)

2.4. Motivation – Flexibility and comfort in limited dwelling interior

Walls, ceilings, floors, doors, windows, columns, furniture – if mutually combined, these elements form one functional unit which will be later defined as sleeping room, kitchen, bathroom, living room, etc. By putting more of these units together we will have the sum of separate units, each of whom will have its own separate purpose. This is what we call home. For example, if we want to commission a home project to an architect, we will most probably highlight our functional preferences and provide the number of units we want – if we are reading enthusiasts, we will require that our home include, among other necessary units, a separate room dedicated to reading, with shelves where all the books will be exposed and easily reachable. If we have children of greater age difference, we will probably require having separate rooms for each of them in order to facilitate their individual daily routine, and so on. If every action can have a dedicated and private space without any unwanted interferences from other actions and other private spaces, a satisfactory level of living comfort is then achieved. From a psychological perspective, this is important because it encourages people to have a positive mental approach. From an architectural perspective, this could be considered as a sort of "ideal" reality where everything is determined, secure and established. In general terms, along with all the technological developments achieved by the humankind in various fields, especially over the last few decades, this is the minimum level of comfort which every individual should enjoy.

However, we all know that, for a great majority of people, reality is everything but this. Change and uncertainty in living is a feature of human life now more than ever and this affects human nature by strongly orienting the way we live our lives. Mainly due to the population growth, there are many aspects of life in which people must adapt themselves and become flexible to the continuing changes and demands of the surrounding world. Our basic living needs are frequently not in line with our most intimate environment – our home. Homes are getting smaller and living comfort has become the first criterion to be eliminated.

In order to achieve the maximum spatial efficiency, particularly from the mid-1960s to the present time, professionals have been developing a wide variety of possible solutions to prevent further degradation of living conditions. Through functional flexibility of interiors, they have been trying to respond to the volatility of modern lifestyle as well as to create a sort of "life-time interior", where any possible changes could be predicted in advance.

The early experiments applying such approach date back to the mid-1960s, when new architectural responses were given as a reaction against the obsolescence of style which had marked the post WWII period - homes in the form of living capsules, expandable buildings which were incorporated into macro structures which represented a view of total urbanism. Some of these interpretations were presented in projects like "Capsule Home" by Warren Chalk (1964), "Living Pod" by David Green (1965) or group projects like the "Plug-in City" (1964) where the whole structure had the size of a city and contained "plugged-in" units for a wide variety of uses. Their work found like-minded followers in Italy with the groups "Archizoom" and "Superstudio" as well as in the "metabolist" architecture in Japan.

Influenced by the same dynamic principles, 1972 represents another important watershed for interior and furniture design. One ambitious exhibition took place in MoMa, New York, which also indicated a change in the lifestyle and a shift to more flexible and mobile trends. Under the name "Italy: New domestic landscape", Italian designers illustrated some of the living concerns of industrialized societies by using a new approach: they believed that an object could no longer be designed as a single isolated entity and they conceived their design as environment-oriented, aiming at flexible purposes and allowing multiple modes of use and arrangement[52]. Among them were the "Ettore Sottsass' micro-environments in plastic, each of whom was built on casters so that occupants could easily re-arrange them to fit their needs; Joe Colombo's fixed plastic units for bath, kitchen, sleeping, and storage that could be put into any existing space; Gae Aulenti's molded plastic elements which could be combined to create architectural multipurpose environments; Rosselli's aluminum mobile house which expanded from 7 x 14 feet (ca 213 x 426 cm) to 20 x 29 feet (ca 610 x 880 cm) ; Zanuso-Sapper's house, an aluminum container made of two molded plastic shells housing bedroom and bathroom/kitchen units; Mario Bellini's glass-walled *exploration* car which could also expand when stationary" [53], etc.

Consequently, it is sure that from those times to the present a wide variety of new concepts have been developed where fusion between architectural and interior elements is notable more than ever. Functional units with determined, static and fixed purposes become variable, movable, extendable entities which can free spaces from fixed and limited functions through their flexibility. Techniques like space optimization and compressed functionality of furniture have also become one of the main sources of inspiration in order to achieve maximum flexibility (e.g. *Oma's Rache* by Melanie Olle and Ilja Oelschlägel, 2006; *Parsons Kitchen* by Allan Wexler Studio, 1994; etc). Movable and sliding walls, or hinged partitions, which support a fluid space that can be divided, separated, integrated or opened according to the needs and wishes of the occupants represent only a small part of all the applicable concepts (e.g. *CityHome* by Kent Larson and MIT School of Architecture and Planning, 2012; *LifeEdited* Apartment by Modern Office Systems llc, 2012; etc).

In terms of innovation, today these kinds of approaches are becoming "eye-catching" and interesting to the very wide audience because of their innovative, unpredictable and dynamic nature. They are usually labelled as objects of "compact functionality": broadly speaking, anything that is made in a flexible manner is considered as the most suitable symbol for "today's way of living". Accordingly, flexible solutions have become attractive and a dominant subject of the majority of topics in websites, specialized magazines, architectural or design competitions and are widely adopted by furniture brands like Ikea and many others. They have become a sort of fashion trend, which even makes these concepts go beyond their initial purpose to become desirable objects of "entertainment" or "fun" that everybody should possess. That is why many architects and designers are even more motivated to make experiments with space or furniture elements through a constant reduction of standard scales and an exaggeration in minimalism or in multi-functionality. Due to that, the matter of real usefulness is sometimes brought into question, as well as those of comfort and space durability for occupants.

In response to this overwhelming variety of impulses, nobody is questioning the issue about ordinary people who suppose to live along with these solutions, or whose life quality depends on it. Accordingly, we have to ask ourselves: What form of lifestyle are these solutions imposing to people?

[52] Ambasz, Emilio. "Italy: New Domestic Landscape." Moma.org. May 1, 1972. Accessed November 7, 2014. http://www.moma.org/search?query=Italy: New domestic landscape exhibition.
[53] (Ambasz, 1972)

How does their daily routine look like? Which concepts would actually deserve attention according to the initial need? For what type of households are these solutions most useful? Can further development of such structures be considered as an appropriate prototype of home for a wider audience in the future?

2.5. Goals and research questions

Goal 1:

UPDATED CONSIDERATIONS REGARDING TECHNICAL POSSIBILITIES, FUNCTIONALITY, TRENDS AND IMPACTS ON CONTEMPORARY LIVING SINCE THE PERIOD OF 1970s

⇩

Research question 1: “**How has flexibility been implemented in limited spaces from 1970s to the present?** “ (technical aspect)

Research question 2: “**How flexible methods influence trends in interior architecture and furniture design?** “ (technical aspect)

Research question 3: “**How flexible methods influence comfort conditions of occupants in limited spatial contexts?** “ (social aspect)

Research question 4: “**How flexible methods influence living patterns?** “ (social aspect)

Goal 2:

IDENTIFICATION OF FUTURE DIRECTIONS

⇩

This research aims to analyse flexibility and comfort in limited dwelling interiors, by providing updated considerations referring to the period of 1970s and focusing on technical possibilities, trends and impacts on contemporary living. These results can contribute to understanding today’s occupants intimate comfort conditions in everyday living, as a direct response to the rapid development and popularity of flexible interior methods in nowadays’ residential architecture. Furthermore, the aim of this research is to find a model for the future developments of flexibility methods and comfort conditions in dwelling, which could be helpful to identify the appropriate target market for such type of living options in the future. Consequently, the research outcomes might be a base for further discussion on how these types of dwellings can be considered an appropriate “way of living in the future”, as recent literature sources and viewpoints of professionals are predicting.

3. Historical background

Flexible dwellings have existed throughout history and have had significant developments in various periods and cultures. For example, if we consider the early age, the tents, the first examples of dwellings and the most widespread in the nomadic populations living in the desert, take the roots of architecture back to the period from 6000 B.C. to 850 B.C. and are connected with the agricultural and pastoral groups that have inhabited North Africa, the Arabian Peninsula and the Middle East.

If looking at the contemporary age, the situation is instead more complex: indeed, besides the architectural approach, we have to consider the strong interconnection between different fields like engineering, design, art, sustainability and new materials development. This is actually a relatively new field which has its origins in recent history, especially in the period between the two World Wars, with the dramatic development of wartime technologies. This is when this branch of architecture found its application in the housing context and when different economical and social living conditions appeared, particularly during the Great Depression and after WWII.

Firstly, it is important to clarify the meaning of the term "flexibility" in the field of dwelling, as it may have different acceptations depending on the context. We can have flexibility in terms of dwelling's *portability* and flexibility as related to the *adaptability to change* within a given living space. More specifically, in the field of architecture this term could be applied to portable dwellings which are constructed so as to be easily transported, assembled, disassembled or modified. In industrial design, flexibility could be connected to the linkage between house concepts and vehicles. Finally, in interior design it indicates the various possibilities of functional arrangements inside a space, while in furniture design it could be understood as the various functional transformations of a single furniture object.

Fig.3.1. Bedouin tent. Source:[http://www.mcdonough.com/speaking-writing/a-new-geography-of-hope/#!lightbox/1/ (accessed 19th Sept 2013)]

Fig.3.2. Nomad Dome-shaped House of Atr Tribe, Eritrea. "Afar people are nomad living in Great Rift Valley. Their house is called Bulla which is transferable compact dome shaped house. The house is made of straw which is easy to carry". Source: [http://www.hgpho.to/wfest/house/house-e.html (accessed 19th Sept 2013)]

Looking more closely on timeline of flexible dwelling solutions (see Fig. 3.3.), we can notice that all this contexts were in parallel developed in period till 1960's. From then on, we can notice rapid expansion of flexible techniques which resulted with three separate fields that were further developed independently – 1) flexible architecture (mainly related to various techniques of prefabrication in dwellings); 2) travel homes (dwelling approaches in close relation with vehicles); and finally, 3) we can notice the relatively new approach related to beginnings of flexible arrangement of interior spaces (that is in close relation with new approach to furniture design). Therefore, the following historical background subchapters will try to encompass all the above options together due to their influence on development of future flexible dwelling interior techniques that will be further investigated in this Thesis.

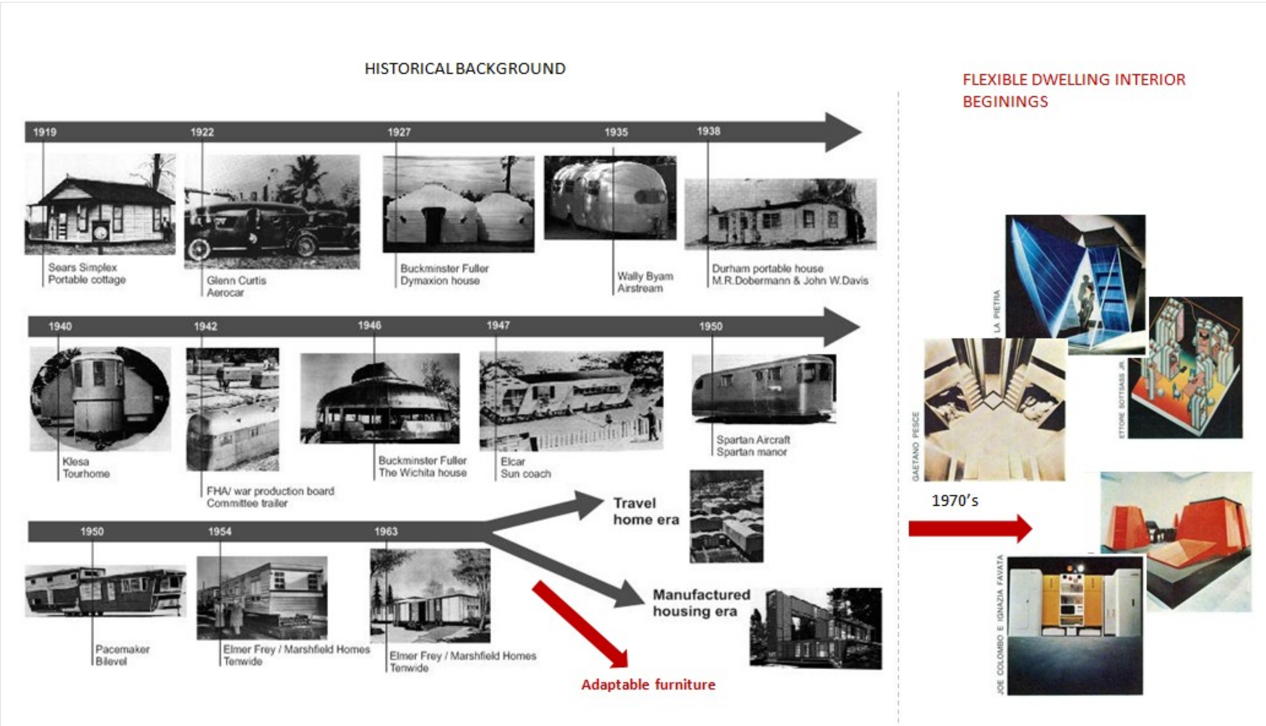


Fig.3.3. Timeline of flexible dwelling solutions showing the turning point around 1960's when flexibility start to be separated in three directional development fields (travel home era, manufactured housing era, and begining of adaptable furniture solutions). Source: personal archive.

3.1. Flexible dwelling architecture

Beginnings

From the long period of traditional dwelling structures common for nomadic societies all over the world, the significant step forward in the history of portable dwellings began at the times when industrialization took its part in developing new building techniques. The industrial production was very progressive and during the passage of time more and more capable to facilitate some issues with which people in global colonial era in the 16th and 17th century could hardly deal with.

Headed at the first place with British, building process in far countries like India, Australia, New Zealand, Canada, Africa and United States became a problem since the British were not familiar with local materials and local building techniques. In order to simplify the construction process at the distant sites, they start to produce building components in factories in England and shipped them to the various locations worldwide. One source is mentioning such case in early 1800s in Australia, where the first settlements such as prefabricated hospitals, storehouses and dwelling cottages in New South Wales were shipped to Sydney.[54] ”These simple shelters were timber framed and had timber panel roofs, floors, and walls. Speculations also suggest that infill material could have been canvas or a lighter timber frame infill system with weatherboarding. A similar system is reported to have been unloaded and erected a couple of years later in Freetown, Sierra Leone, to build a church, shops, and several other building types.”[55] To concentrate more on dwelling solutions, we have to mention the role of John Manning, a London carpenter and builder. In 1830 he constructed first timber cottage for Australian immigrants (“Manning Portable Colonial Cottage”) which components could be packed, transported and assembled together on the construction site. “These houses resembled cabins, with the interior not differing much from the exterior.”[56]Construction components of these first dwelling systems were very simple, based on in advance prepared, dimensioned and sub-assembled wooden parts necessary for assembling a building construction on the site. Later, based on same model, *Sears, Roebuck and Co* developed the whole palette of different dwelling types in South America between 1895 and 1940. In their mail-order Modern Homes program they offered even 447 different housing styles divided in three main lines: Honor Built, Standard Built, and Simplex Sectional. One of the distinct advantages used for construction was based on “balloon style” framing which did not require a team of skilled workers and made construction time faster than in standard methods.

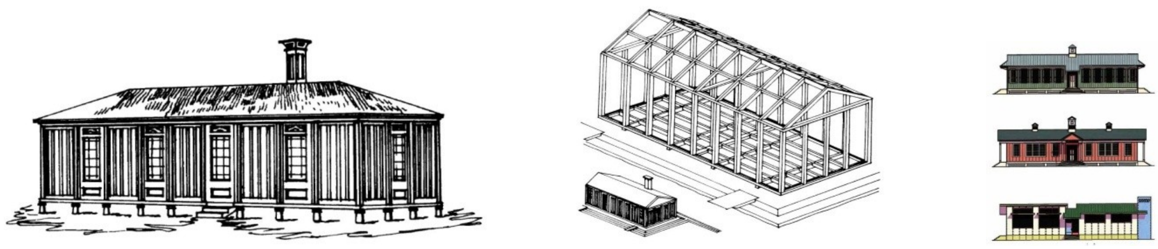


Fig.3.1.1. Manning portable colonial cottage, around 1830s

[54] Smith, Ryan, E. “Prefab Architecture”. New Jersey: John Wiley & Sons, 2010, p5.
[55] (Smith, 2010)
[56] Schneiderman, Deborah.“Inside Prefab: The Ready Made Interior“. New York: Princeton Architectural Press, 2012.

"Pre-cut timber, fitted pieces, and the convenience of having everything, including the nails, shipped by railroad directly to the customer added greatly to the popularity of this framing style."[57] So general advantages in this approach were significant time, work and cost reduction in comparison with standard building methods, which were the decisive factors that stimulated wide acceptance on the market between 1930s and the 1960s. In United States, companies like General Homes, The Marlette Company, Lustron Homes and lots of others emerged, and each of them had developed its own types of houses based on same principles.

Except timber, with the rise of industrial revolution, also other materials like iron start to be used in the same manner. First iron components which were prepared in factories and brought to the sites were initially used for bridge building. One of the early examples was *The Coalbrookdale Company Bridge* from 1807, which was "almost entirely prefabricated and erected in pieces onside. This was followed by a host of the bridges in England that progressively streamlined the process of production and erection."[58] By the passage of time, elements of construction start to be standardized, with easy-understandable assembly methods which were suitable also for unskilled workers and laypersons. In Staffordshire (England), the *Horseley Ironworks* was one of the significant manufacturers in iron prefabricated constructions. Except working on bridge constructions all over England, they were most famous for constructing the first iron steamer, *The Aaron Manby*, in 1821.[59] It was the first example of prefabricated boat construction made by Captain Napier, Aaron Manby (the owner of the company) and his son Charles Manby. It is constructed "of heavy plates riveted together to form units" which could be "assembled, dissembled, and reassembled"[60] again. This technology was soon transferred to iron plate buildings, especially suitable for lighthouses in 19th century. "Cast iron was lighter than stone or brick, relatively inexpensive, capable of being shaped, watertight, and had a slow rate of deterioration."..."The first cast-iron lighthouse in the New World was designed by Alexander Gorden, built in England and erected in Jamaica in 1840. The United States was quick to follow Gorden's concept when in 1844 it built a cast-iron tower on Long Island Head, Boston Harbor. Cast-iron plates were prefabricated offsite, numbered, and easily assembled into towers on site. The cast-iron plates were either segments of a cone or a flat surface, depending on the design chosen. The plates have flanges on all four sides which were fastened together by bolts. The interior of the tower was often lined with brick for added stability and insulation. In areas where shifting and eroding beaches were present, cast-iron-plate towers were designed so they could be disassembled and re-erected as needed. Cape Canaveral Lighthouse (1868), Florida, and Hunting Island Lighthouse (1875), South Carolina, are examples of this design; both having been successfully moved."[61]

Therefore, we can detect already well developed level of iron structures. In parallel, research considering metal performances also improved. One of such improvements is corrugated iron. The main benefit of these corrugations is that it increased the bending strength of the sheets in the direction perpendicular to the corrugations. After the solving problem of corrosion of metal in late 1830s with galvanization, this type of material showed its full potential especially for shelters during the First and Second World War. *Quonset hut* used by United States army and *Nissen hut* used by the British were the representative examples. These half-cylindrical shaped shelters were flexible considering the floor space and its open interior allowed use for different purposes (barracks,

[57] Sears archive [http://www.searsarchives.com/homes/index.htm (accessed May 16th 2013)]
[58] Smith, Ryan, E. "Prefab Architecture". New Jersey: John Wiley & Sons, 2010. p7
[59] Source: [http://en.wikipedia.org/wiki/Horseley_Ironworks (accessed 15th May 2013)]
[60] (Smith, 2010)
[61] Source: Lighthouse construction types [http://www.nps.gov/maritime/constype/cast.htm (accessed 15th May, 2013)]

latrines, offices, hospitals, housing, etc). After the war time, this type of huts has found its application mainly for industrial halls and storage facilities.

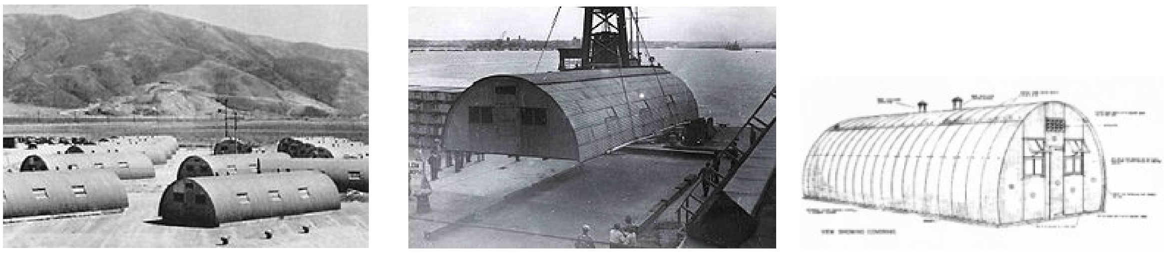


Fig.3.1.2. Quonset and Nissen hut, by Peter Norman Nissen, WWI and WWII time period.

Modern techniques

Thanks to the standardization of the manufacturing process, many new ideas appeared in the building field. One of the earliest examples was based on creating a repetitive system of standardized components in order to build the structure. The most significant example of this system is the Crystal Palace by Joseph Paxton, which was first presented in the London Great Exhibition in 1851. The whole building skeleton was made of prefabricated iron modules. This example is important as it influenced later generations of architects, leading them to explore the various possibilities of iron constructions, and the further developments in engineering, fabrication and assembly processes.

Consequently, an increased interest in standardization techniques is evident in the *Fordism* era, when many engineers and architects realized that assembly line manufacturing could be also applied to building techniques, so as to make the process simpler and the final product cost more affordable. For example, with the Citröhan concept, Le Corbusier tried to create a type of house which could be built in series applying the perspective of “machine for living”. He was literally recreating the concept of assembly line manufacturing for cars, ships and planes. Gropius and Wachsmann made a joint project known as “Packaged House”, a proposal for the American market of war and post-war housing. The project consisted in a wooden house that could be easily assembled from standardized elements and “five untrained workers were all that was needed to put the house together, and that in just nine hours.”[62] Jean Prouve’s contribution to prefab systems lies in minimizing waste and maximizing benefits.[63] In 1949 he designed the experimental houses known as Meudon Houses in the suburban area of Paris. These standardized houses were planned on one interchangeable module which allowed 14 variations on two unit types.

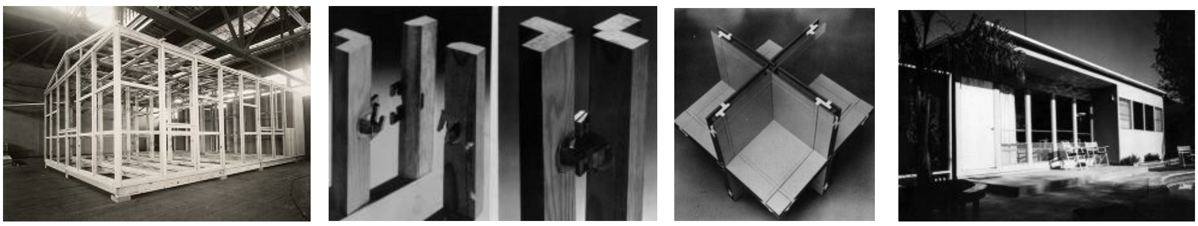


Fig.3.1.3. Gropius and Wachsmann, “Packaged House“.

[62] Zimmermann, Jorg. “Build it in the morning, move in in the evening“. Source [http://www.stylepark.com (accessed 25th May 2013)]

[63] Smith, Ryan E. *Prefab architecture*. New Jersey: John Wiley & Sons, 2010.

However, we also have to notice that many of these prefabrication experiments failed, as they were based on too complicated and too expensive methods. One of the main problems was that they were unable to face the possible developments of the interior conception over time. Furthermore, these constructions techniques were difficult to apply to individual living patterns or to the styles and technologies to come.[64] "Solutions like Fuller's Dymaxion house were technically advanced but would have required a continual stock of supply in order to mantain the building systems during their lifecycle. Especially in the case of service pods, systems are updated frequently enough that the near entirety of the home is outdated after its first decade or two of life."[65] Proposals like "Safdie and the Metabolist projects are rarely, if ever, change because of the sheer cost of demounting a module in order to update the technology or replace the model altogether. This modules usually rely on heavy infrastructure which can not be manipulated without deep, invasive and expensive intervention, what is difficult to justify in the lifecycle costs of the building…"[66]

Functionality

Except all mentioned building techniques based on assembling standardized parts together, it was shown that even more simple strategy consist of ready-made structures which could be transported in one piece and ready to use instantaneously. One of these examples was the 20 m^2 (8 x 2,5 m) completely outfitted home by the Wingfoot Homes Company. The whole house was completely built in the factory, along with built-in furniture, kitchen cabinets, a factory installed gas stove, icebox, sink and the bathroom facilities. Since such structures have size limitations in order to be suitable for transportation, these types of ready-made dwelling were initially considered as a short-term living solution, suitable for most of the families during and after the WWII period. As such, they were not predicted to allow adaptability for some possible future contexts or needs of the occupants.

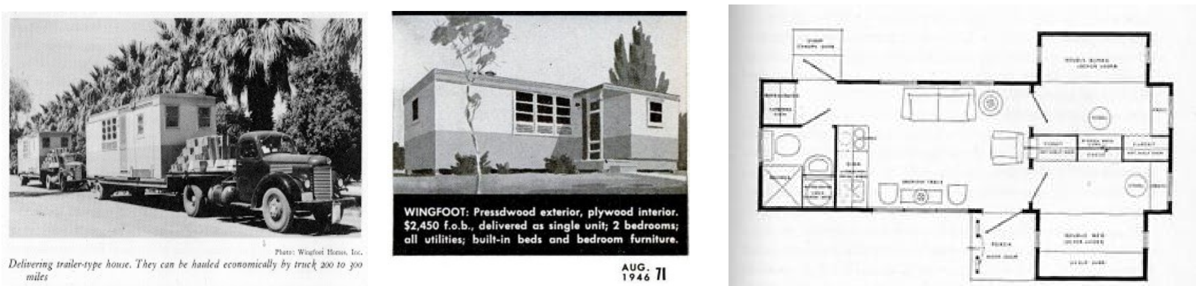


Fig.3.1.4. Wingfoot House by Wingfoot Homes Company, post WWII period.

However, this aspect turned out to be a great disadvantage throughout the years. As a consequence, dwelling constructions with less spatial limitations and based on modular parts or units started to be employed, whose mutual combinations supported the maximum flexibility for adaptation to different layouts. Some examples of this new trend can be found in Skidmore, Owings and Merril's (SOM) 1942 "Flexible space", according to which "a basic housing unit consists of a Vocabulary (shell, utility units, wall units – exterior and interior, and mobile units – thing & body furniture), a Grammar (the functional relation of Vocabulary: shell + utilities = space) and a Composition (the final plan). Plans

[64] Smith, Ryan E. *Prefab architecture*. New Jersey: John Wiley & Sons, 2010.
[65] (Smith, 2010)
[66] Davies, Colin. *The prefabricated home*. London, UK: Reaktion Books, 2005.

were developed so as to allow for progressive changes in the composition of the families and so that utilities could be replaced when obsolete."[67]

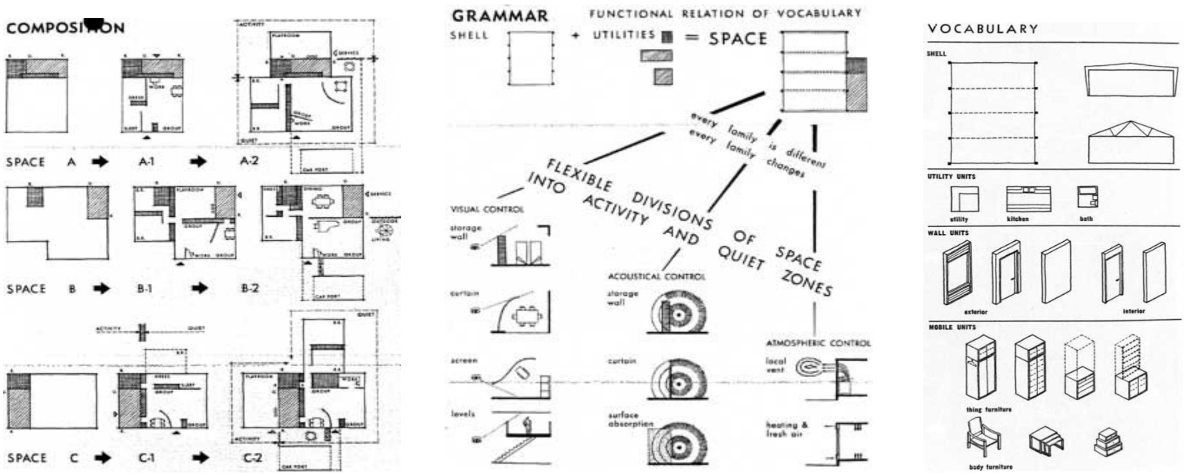


Fig.3.1.5. Skidmore, Owings and Merril's (SOM) "Flexible space", USA, 1942.

Walter Bogner's proposal was also based on a similar concept: his "Prefabrication" realized a concept of house that should be "adaptable to different needs resulting from changes in the family composition as the family grows older."[68] It was composed by four divisions: "groundwork, shell assembly, installations unit and accessories and interchangeable parts. The shell assembly consists of the enclosing walls and a roof, with subdivisions measuring 8 feet - horizontally as well as vertically, which can be further subdivided into three parts - but without the need for interior support. The division within this shell is made with interchangeable panels, which can be solid or have a window, or can be external or internal. These accessories and parts are considered like furniture and include wall partitions, wardrobes, cabinet storage, doors and windows, roof shades as well as a heater and utility room, a laundry and quick freeze room, a garage or car port and a porch or play room. All of which can be bought at any time or rearranged periodically to suit changing family needs. To illustrate the concept: in a first step, the user would have a basic unit of 24 feet by 24 feet – amounting to around $53m^2$. The only space-defining element in this shell is a prefabricated bathroom unit with attached kitchen. By adding partitions, still within the same shell, the plan can be subdivided to form up to two bedrooms, an enclosed kitchen and a living and dining room. By adding further 8 by 8 feet modules, the basic plan can be enlarged for greater comfort or changes in the composition of its users"[69].

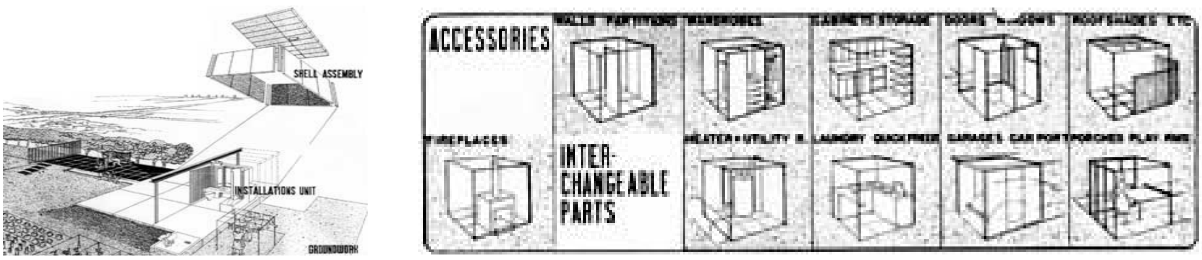


Fig.3.1.6. Walter Bogner, *Prefabrication*, USA, 1942.

[67] Flexible Housing [http://www.afewthoughts.co.uk (accessed 1st October 2013)]
[68] [Flexible Housing]
[69]Flexible Housing [http://www.afewthoughts.co.uk (accessed 1st October 2013)]

Another similar approach is developed by Harry Seidler and Associates in Australia where a “160 m^2 house is constructed with a minimal steel frame which stands on four columns, 10 metres by 8 metres apart. Diagonal hangers support the raised floor, which projects five metres at each end. Apart from the suspension members and columns the plan is free of load bearing elements, allowing the plan to be adapted over time.”[70]

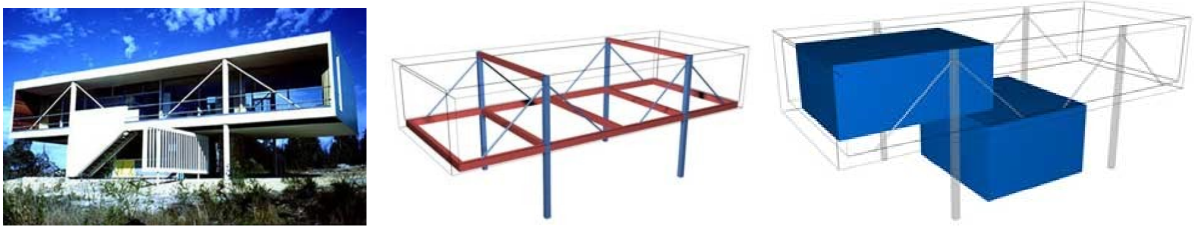


Fig.3.1.7. Rose House, Harry Seidler and Associates, in Turramurra, Sydney, 1950.

Another example is the Van Broek and Bakema’s 1963 project “Extendable house” designed for future possible expansions. “The smallest functional unit is designed to be expanded by pushing out horizontally to the front and back, and vertically upwards. Towards the front, on the site of the front yard, an additional room can be built, which might be a garage, a small shop or a guest room. Towards the back, the entire rear garden can be transformed into a series of rooms that are organized around the courtyard – which almost doubles the usable space on the ground floor. Finally, planning permission allows for an additional room to be built on top of the first floor flat roof. Together these changes allow for the initial house of 85 m^2 to be transformed into one of 130 m^2.”[71]

With the development of these types of flexible strategies in dwellings, two main classifications in the architectural approach appeared which were based on structural “softness” or “hardness”. “*Soft* refers to tactics which allow a certain indeterminacy...” (like the mentioned example of Rosa House) ... “whereas *hard* refers to elements that more specifically determine the way that the design may be used” (like the mentioned example of Bogner or SOM). “Soft schemes generally work in the background whereas hard schemes, both visually and technically, tend to foreground their flexibility. In terms of use it may appear a contradiction that flexibility can be achieved through being either very indeterminate in plan form and/or technology or else very determinate, but historically both approaches have developed in parallel throughout the twentieth century.”[72]

Quality and aesthetics

Popularity and wide acceptance of prefab dwellings initiated the new social trend especially in post-WWII period (mid 40’s - 60’s) when prefab house start to be not necessary the matter of temporary “need” but the element for permanent and at the same time desirable life-style in already well established Mid-Century modern society. Considering that, some improvements in initial concepts of war period houses in terms of raising the level of quality, comfort condition and visual appearance start to be developed. Based on emerging technologies and materials like concrete, glass and steel, the style was supporting “functional beauties”.

[70][Flexible Housing]
[71]"NextGen Housing." [www.nextgenhousing.wikispaces.com/file/view/05_On+Flexible+Spaces+%26+Modularity.pdf (accessed October 22, 2013)].
[72] Flexible Housing [http://www.afewthoughts.co.uk (accessed 1st October 2013)]

Fig.3.1.8. Joseph Eichler house model 1224, post WWII period.

For example, Joseph Eichler was one of the most influential builders of modern homes who raised value of prefab dwellings among the middle-class Americans. His company, Eichler Homes, constructed from 1949 till 1974 around 11 000 houses mainly in California. The approach he used was typical Modernist, with open floor plans and glass walls, what is actually original style assigned to Frank Lloyd Wright and Mies van der Rohe. Eichler houses were comfortable and airy, and among most mass produced middle-class cramped post-war houses at that time, that was an approach which made a great distinction. Although prefabrication building methods and materials remained almost unchanged, we can notice that war concept of “shelter like” modest dwelling was totally abandoned.

Among professionals, comfort and aesthetics of prefab-dwellings was even more evident and it “gained its largest ground during the period of the modern revolution, beginning with the works of Behrens and his followers Walter Gropius, Mies van der Rohe, and Le Corbusier; and later with the American, Frank Lloyd Wright.”[73]Although their houses were not sold in large quantities like Eichler’s, their work made a great impact on prefab-dwelling.
Unlike Gropius and Waichmann, Mies van der Rohe’s passion for steel and glass created the architectural approach which was anything but affordable. He strove toward architecture “with a minimal framework of structural order balanced against the implied freedom of free-flowing open space. He called his buildings *skin and bones* architecture. He sought a rational approach that would guide the creative process of architectural design, but he was always concerned with expressing the spirit of the modern era. Mies’s contribution to industrialized dwellings do not lie in searching for suitable building methods, new technologies or developing module systems like for example Gropius did. He managed to impose to society and profession new aesthetic in architecture based on open space planning, simple steel skeletons and glass volumes. Considering Frank Lloyd Wright, he had his own vision for affordable low-cost dwelling that average American could buy. He despised compact living “boxes” and was sceptical of prefabrication considering the quality. Therefore he developed the modules which “were a kit-of-parts and could be added to and taken from”[74] but still with some level of handcraft intervention in order to reach the acceptable quality. These houses were known under the name Usonian houses which were built between 1930s and 1940s. In these houses he actually did not use any of previously mentioned prefabrication methods, but his main contribution was rational and logical approach to construction. Regular grid and standardized materials used had a great potential for prefabrication.

[73] Smith, Ryan E. *Prefab architecture*. New Jersey: John Wiley & Sons, 2010. p27
[74] Smith, Ryan E. *Prefab architecture*. New Jersey: John Wiley & Sons, 2010. p31

3.2. Flexible dwelling vehicle

Vehicle and dwelling

Besides the various architectural techniques mentioned so far, which tried to support easy relocation, adaptability and satisfactory aesthetic levels, the rise of industrialization and the development of the automotive industry at the beginning of the 20th century also had a great impact on flexibility in living.

The advances which prefabricated system in architecture brought to the building methods start to be useful also in industrial mass production of goods. At the early beginning of 20th century, the goods in general which need to be produced start to be the subjected to standardization and mass production, which encouraged lower production costs because of decrease of labor and reduction of production time. This model found its application especially in car production and Ford Motor Company was the representative example. Henry Ford's Model T was "generally regarded as the first affordable automobile, the car that opened travel to the common middle-class American; some of this was because of Ford's innovations, including assembly line production instead of individual hand crafting."[75] Lots of companies start to follow Ford's model in production of goods, but by the passage of time this kind of approach resulted with two types of problems: 1) it undermined the value and variety factor of the produced goods – values were based on assembly lines, by strictly specialized machines, and main consequence was that previous wide labor skills became very limited. In other words, the workers become unskilled and product very standardized without any individuality; 2) this kind of progressive mass production by the passage of time exceeded consumption – there were more manufacturers then customers.

In the middle of the 1920s, General Motors with Harley Earl and Alfred Sloan at the head were the first who start to confront *fordism* by emphasizing growing demands for style. They encouraged annual model changes and branded products in industrial design. Also the first industrial design professionals start to appear. This kind of approach recovered the market saturated with mass production, low consumption and fierce competition. T model, always available only in black colour, became a prototype of rigid standardization of design; an un-desirable result of mass production with lack of comfort and convenience; and, not least important, a symbol for lower social status.
The *style* component became desirable refreshes, a sort of added "value" to the goods, and the automotive industry was at the forefront of this new wave. The reversal year was 1927 when Henry Ford was forced to stop production of the T-model entirely, and replace it with completely new, more *stylish*, model A. In parallel, Alfred Sloan and Harley Earl in General Motors already applied the new strategy in order to stimulate consumption. They start to create gradual hierarchy and more expanded variety of products which could be able to cover all levels of market. For example, *La Salle* model was developed when Alfred Sloan "noticed that his carefully crafted market segmentation program was beginning to develop price gaps in which General Motors had no product to sell. As originally developed by Sloan, General Motors' market segmentation placed each of the company's individual automobile into specific price points. The Chevrolet was designated as the entry level product. Next, (in ascending order), came the Oakland, Oldsmobile, Buick, and ultimately, the

[75] Source:Henry Ford 's Model T[http://en.wikipedia.org/wiki/Ford_Model_T (accessed 17th May, 2013)]

Cadillac. However, during the robust 1920s, certain General Motors products began to shift out of the plan as the products improved and engine advances were made."[76]

In order to ensure wide market acceptance, the search for new trends seems to be the most important factor in progressive development of automotive industry. One of the potential niches was growing desire for American weekenders to ensure some alternative solutions to standard hotel accommodation during vacation. Glenn Curtiss in 1919 responds by inventing his trailer known under the name "Aerocar". It was a vehicle attached to the car, created for having "a home away from home". From the conception point of view that was actually a modern inspiration of 19th century horse drawn covered wagon, where horse is replaced with automobile, and wagon upgraded with better-standard structure intended not mainly for carrying the goods but also to live in. This fact has drastically raised the level of comfort and trailers like "Aerocar" with integrated Pullman-style berths, wardrobes, running water and latest technology like telephone, [77] were actually an example of luxurious accommodation which an average American could not afford. This is the reason why an entire industry developed around manufacturing more affordable types, known as folding trailers and car-tents (e.g. Combined camping outfit by A.D. & L.S. Campbell, US Patent 1,185,981; 1916). These tent-solutions were usually "packed" on a separate trailer and served as a provisional dwelling for leisure time. Around the 1920s, one of the most popular tent models was the prairie schooner type produced by the Warner Auto Trailer Company.

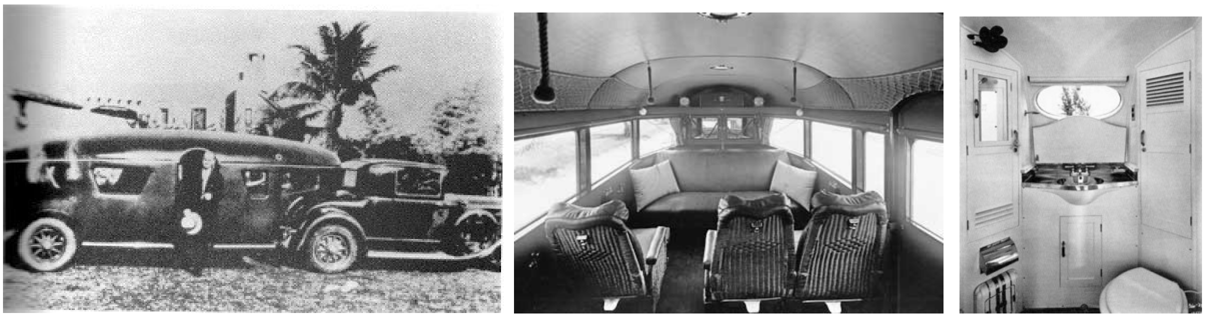


Fig.3.2.1.(Left/Middle/Right) Aerocar, by Glenn Curtiss, USA, 1919.
Source [http://www.coachbuilt.com/bui/c/curtiss/curtiss2.htm (accessed 2nd October 2013)]

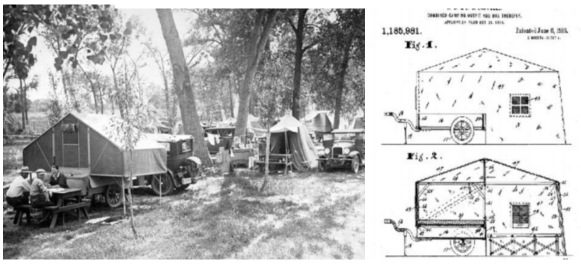


Fig.3.2.2. Example of first patented tend structures later developed in car trailers. US Patent 1,185,981. By A.D. & L.S. Campbell , 1916.

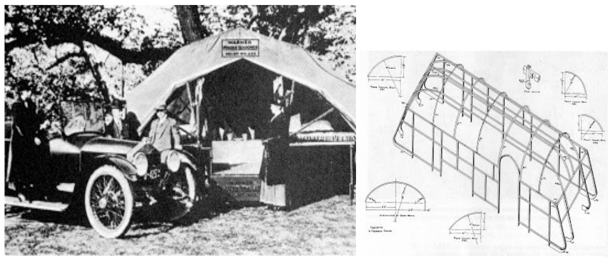


Fig.3.2.3. Example of prairie schooner, produced by Warner Auto Trailer Company, ca 1920.

Consequently, the growing popularity of such various structures (especially in post WWII period in America) ended in switching initial purposes of trailers: people start to use the trailer as a permanent home. The result of this condition caused even greater expansion of the "flexible home" market.

[76] Source[http://en.wikipedia.org/wiki/LaSalle_(automobile) (accessed 20th May 2013)]
[77] Instant house. Source [http://instanthouse.blogspot.it/2011_09_01_archive.html (accessed 20th May 2013)]

Dwelling structures with different names appeared: travel trailers, house trailers, mobile homes, manufactured homes, and the only common feature was that they were suitable for highway transportation. Trailers start to be bigger, instead 8-foot-wide they expanded to 10-foot-wide models allowing more comfortable dwelling. As such, the trailer was not trailer anymore, but a house, intended to be transported to the site and remain. In period between late 1960s and late 1970s, they expanded even more – from 10 foot-wide to 12-foot-wide and even 14-foot-wide trailers.

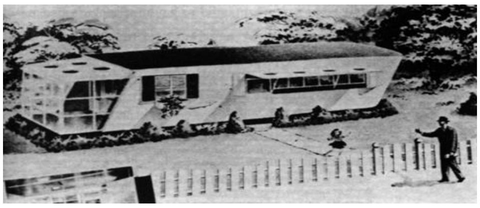


Fig.3.2.4. Sun Coach, by Elcar, late 1940's.

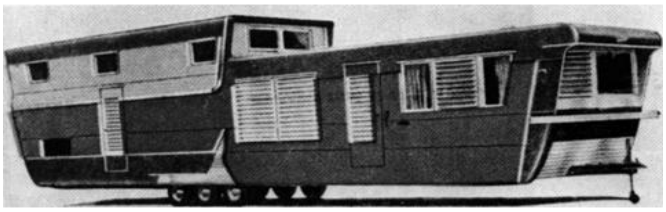


Fig.3.2.5. Pacemaker Bilevel, by Pacemaker, 1950's.

Conception and functionality

Along with "travelling home" progress, for the first time the approach to interior conception become more and more demanding. Factors like reduction of living area and multi-functional use of interior elements become main points for experimentation. Therefore, traditional approach to interior with freestanding furniture starts to be replaced with precisely fitting and built-in elements where the reduction of size and concern about the interior weight were the most challenging factors. The cutaway in Fig. x shows the typical layout of the Spartan Manor trailer from 1946. We can notice that the development of the airline industry during the Second World War greatly contributed to constructive methods of the trailer shell, as well as in the use of aluminum as the base material. As for the concept of space, all the necessary living units are present to accommodate at least two persons, but in a very compact manner. Average dimensions of the trailer were between 24 - 50 feet in length (approximately 7-15 m), a width of 8 inches (approximately 2 m) and the height of 9 inches (approximately 220 cm). Therefore, all necessary furniture and appliances for kitchen, bathroom, storage, sleeping room and living room are optimized in order to accommodate the space of ca 14-30 square meters. For example, the lack of working areas in the kitchen is compensated with a telescoping pull-out (or folding) surfaces which at the same time can be used as a dining table; sanitary facilities are situated in wardrobe-sized elements; and sofa in the living area is usually intended as an additional bed for two more people.

Fix.3.2.6. (Left) Spartan Manor, 1946, 3d section. Source [http://www.spartantrailer.com/restoration.html (accessed 4th July 2013)]; **Fig.3.2.7. (Right)** Kitchen cabinet/dining table in closed (40 cm x 71cm /h73) and open position (132 cm x 71 cm /h73 cm) Spartan Manor, from 1946. Source [http://www.spartantrailer.com/restoration.html (accessed 4th July 2013)]

Target group

Considering the wide variety of trailer models existing on the market, the progress of trailers can be classified in three main categories:

1) In the early 1920's, trailers were affordable leisure-time products for high-level society members. They were considered as a status symbol and one of its most representative examples after Glen Curtiss's "Aerocar" was the "Airstream" by Wally Byam, presented in the early 1930's. The Airstream was classified as a luxury brand of recreational vehicles which had the longest history among trailers, and the only one which survived the years of the Great Depression. Using the newest techniques at that time, which were also common to aircraft manufacturing, it was the first aluminium-based trailer. The interior was equipped with a telephone and with amenities like ice boxes, gasoline stoves and water pumps, in order to ensure as much home-like comfort as possible. Trailers represented a new way of travelling but although they were marketed for a broad audience, most of the models were not so affordable for the masses.




Fig.3.2.8. Airstream exterior, source [http://www.architecturaldigest.com/celebrity-homes/2008/matthew-mcconaughey-airstream-slideshow_slideshow_item6_7 (accessed 2nd October 2013)] ; **Fig.3.2.9.** Airstream's aluminium ribs structure, source [http://www.boston.com/yourlife/gallery/071207_airstream?pg=9 (accessed 2nd October 2013)]; **Fig.3.2.10.** Airstream's aluminium shell structure, source [http://www.boston.com/yourlife/gallery/071207_airstream?pg=9 (accessed 2nd October 2013)]; **Fig.3.2.11.** Life-style, source [http://www.boston.com/yourlife/gallery/071207_airstream?pg=9 (accessed 2nd October 2013)]

2) During and after the WWII period, with the increased need for housing solutions, the situation drastically changed. In this period the trailer industry experienced a significant growth, as it was able to provide the most suitable living options thanks to trailers' mobility, affordability and availability. The "house trailer" suddenly became the instant war shelter economically affordable for everybody.

Fig.3.2.12. Trailer park in Baltimore, 1943. Source [http://www.bbc.co.uk (accessed 4th October 2013)]

3) Since income conditions of most of the families did not improve after the war period, trailers became in most cases a permanent home solution. They were often located in single installations or situated in trailer parks where they remained immobile. Such trailer parks were extremely popular in America and represented lower-cost living solutions in comparison with the traditional "house concepts" of living. Despite all the advances in the trailer technology, this kind of living, especially in the American culture, was "stereotypically viewed as lower income housing whose occupants live at or below the poverty line, have low social status and lead a desultory and deleterious lifestyle."[78] From a hygiene and health perspective, the living conditions in trailers were of very low level and the deprivation of essential living services was often compared with the shantytown settlements (or squatters) in the suburbs of the big cities.

Fig.3.2.13. Trailer park in Thermal, California. [http://www.bbc.co.uk/news/magazine-24135022 (accessed 4th October 2013)]

[78] Trailer park [http://en.wikipedia.org/wiki/Trailer_park (accessed 2nd October 2013)]

3.3. Flexible dwelling interior

Methods

As mentioned before, flexibility in the field of architecture is defined as a method which relies on modular parts or units whose mutual combinations support the maximum flexibility for adaptation to different layouts. This strategy's goal is to contribute to the functional durability of a living space in terms of changeability of this space's floor area.

If we consider the concept of increased functional durability as related to interior, the term flexibility acquires a bit different meaning. In this case flexibility depends on interior elements which are capable to make various functional transformations within the same spatial context. Particularly, one of these methods can be found in the 1924 Schröder House by Gerrit Rietveld, with its sliding and revolving panels form different spatial scenarios of the rooms. As described in source *Flexible Housing*, "the house is organized on two storeys around a central core that contains the staircase. Whilst the ground floor plan is subdivided in a conventional way into separate rooms: kitchen/dining, a reading room, a studio room (plus adjacent dark room) and a bedroom - the hinged sectional moveable screens of the first floor allow"[79] the transformation of a single continuous open space into more separate and closed functional units.

Similarly, but with more options available, Fred J. Mac Kie Jr. and Karl F. Kamrath showed in the 1942 "Movable Space Dividers" that the modular grid of one large open space can be divided into many more combinations of smaller functional areas by using movable partition walls, which, if not used, could be stored in closets.[80]

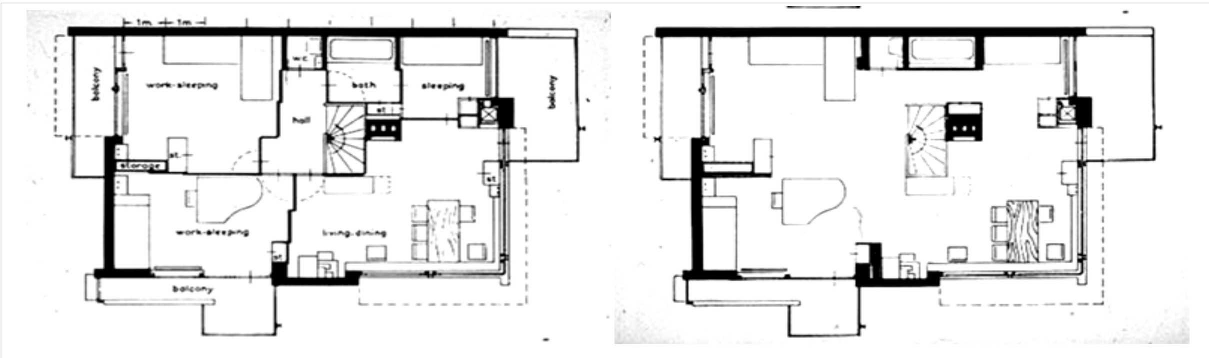


Fig.3.3.1. Gerrit Rietveld, Schroeder house layout transformation, 1924.
[http://www.studyblue.com/notes/note/n/slide-id/deck/846283 (accessed 4th October 2013)]

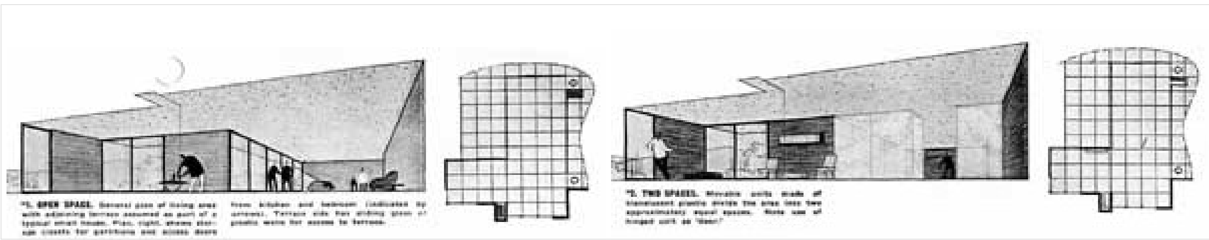


Fig.3.3.2. Fred J. Mac Kie, Jr. and Karl F. Kamrath, Movable space deviders, 1942. Source: [http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=26&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=2 (accessed 4th October 2013)]

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[79] Flexible Housing [http://www.afewthoughts.co.uk (accessed 1st October 2013)]
[80] [Flexible Housing]

Furthermore, Gio Ponti with his “Single Space House for Four People“ developed a similar idea “of a single space that is surrounded by the essential minimums of services - kitchens and bathrooms that are pushed to opposite sides of the single large space. A series of angle sections of wall provide the connecting point for concertina panels. These walls allow the creation of different connections between different areas and keep their multi-functionality intact. The flexibility is one of use, heavily dependent upon its user to follow the directions given through the positioning of walls and moveable panels. Areas can be connected with each other as well as isolated, though never acoustically. The architect determined that the openness of the apartment has to be shared by each occupant. If applied, however, the various areas within the space create a set of special relationships both within the flat and with its surrounding“[81].

Besides movable or sliding walls, another approach to achieve flexibility in interior could be based on furniture components in the form of “boxes” containing different functional units like kitchen, closet or sanitary, that could be positioned inside the living space as desired by the inhabitants. This approach was developed in Yona Friedman’s proposal called “Movable boxes” (1949). “Based on the architect’s experiences during the Second World War, where two or more families had to share a single room that was commonly divided with furniture, this project is based on a shell whereby the interior layout of the home was left to the inhabitants to determine. The designed structure could be used to build houses of one or more floors and consisted of two party walls, two end walls with window and door openings, and a roof. All sanitary and kitchen units and closet partitions in the house were lightweight boxes”[82] that could be moved.

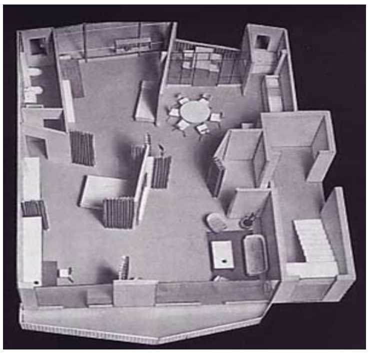


Fig.3.3.3. Gio Ponti, Single-Space House for Four People, 1957. Source:[http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=32 (accessed 4th October 2013)]

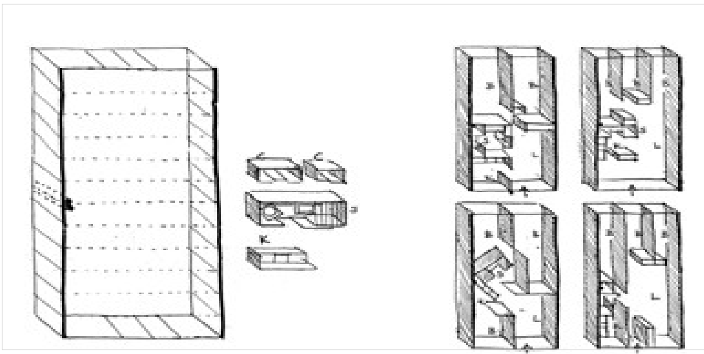


Fig.3.3.4. Yona Friedman, “Movable boxes“, 1949. [http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=163&number=&total=&action=&data=&order=&dir=&message=&messagead= (accessed 4th October 2013)]

[81]Flexible Housing [http://www.afewthoughts.co.uk (accessed 1st October 2013)]
[82][Flexible Housing]

Furniture

The modern era – the era of transportation, skyscrapers, radio, movies and mass-media – required a particular approach to living conditions. This powerful technological revolution was based on increasing the level of speed and comfort, which in turn influenced the increase in leisure behaviours and the development of new attitudes towards life-style[83]. At the same time, there was also a demand for distinctive products in order to face the unstable trend in market during the Great Depression.

Herman Miller, notable as one of the first manufacturers who produced modern furniture, considered that there was an incongruity between the period and the style and that the new style should be consistent with the circumstances of the new age, based on a machine which could produce affordable modern design.[84] "In the modern era, people needed efficient storage in minimum space, compact and multi-use furniture for new smaller living spaces and surfaces unencumbered by high-maintenance dust-catching carved mouldings"[85]. To support this idea he hired Gilbert Rohde, Modernist furniture and industrial designer who designed over the 1930's and 1940's "many lines of modular furniture, promoted for its flexibility, functionality, and suitability for apartments and small homes".[86] One of his greatest achievements was the Executive Office Group (EOG) line which represented a systematic approach to office furniture, where 137 individual elements like drawers, drawer pedestals, tabletops, and other items, could be configured according to individual work requirements.[87]

After his death in the mid-1940's, the architect George Nelson replaced him and continued with much greater support by also involving new talents like Isamu Noguchi, Charles and Ray Eames, Robert Propst and others. For example, the "Storagewall", a product which he devised with his fellow architect Henry Wright, "was designed to take the place of the traditional walls between the rooms in a home, and offered storage tailored to the function of the room. Their concept for the multi-functional wall was presented in the 1945 *Life* article *Storage Wall*—the first in a series of articles on the unique design challenges of what would soon be the postwar American home. *[...]* The article documented the many ways the Storagewall could be used to provide structure, space delineation, and storage for any room..."[88]. This could be considered as a turning point, where for the first time the strict boundaries between architectural and interior approach were blurred and which laid the groundwork for later experiments with flexibility.

[83] Ross, P.. "Merchandising The Modern: Gilbert Rohde At Herman Miller."*Journal of Design History* 17, no.4 (2004): 359-376.
[84] (Ross, 2004)
[85] (Ross, 2004)
[86] Gilbert Rohde [http://en.wikipedia.org/wiki/Gilbert_Rohde (accessed 5th October 2013)]
[87] [Gilbert Rohde]
[88] "Solving the storage problems" [http://www.hermanmiller.com/discover/page/4/ (accessed 6th October 2013)]

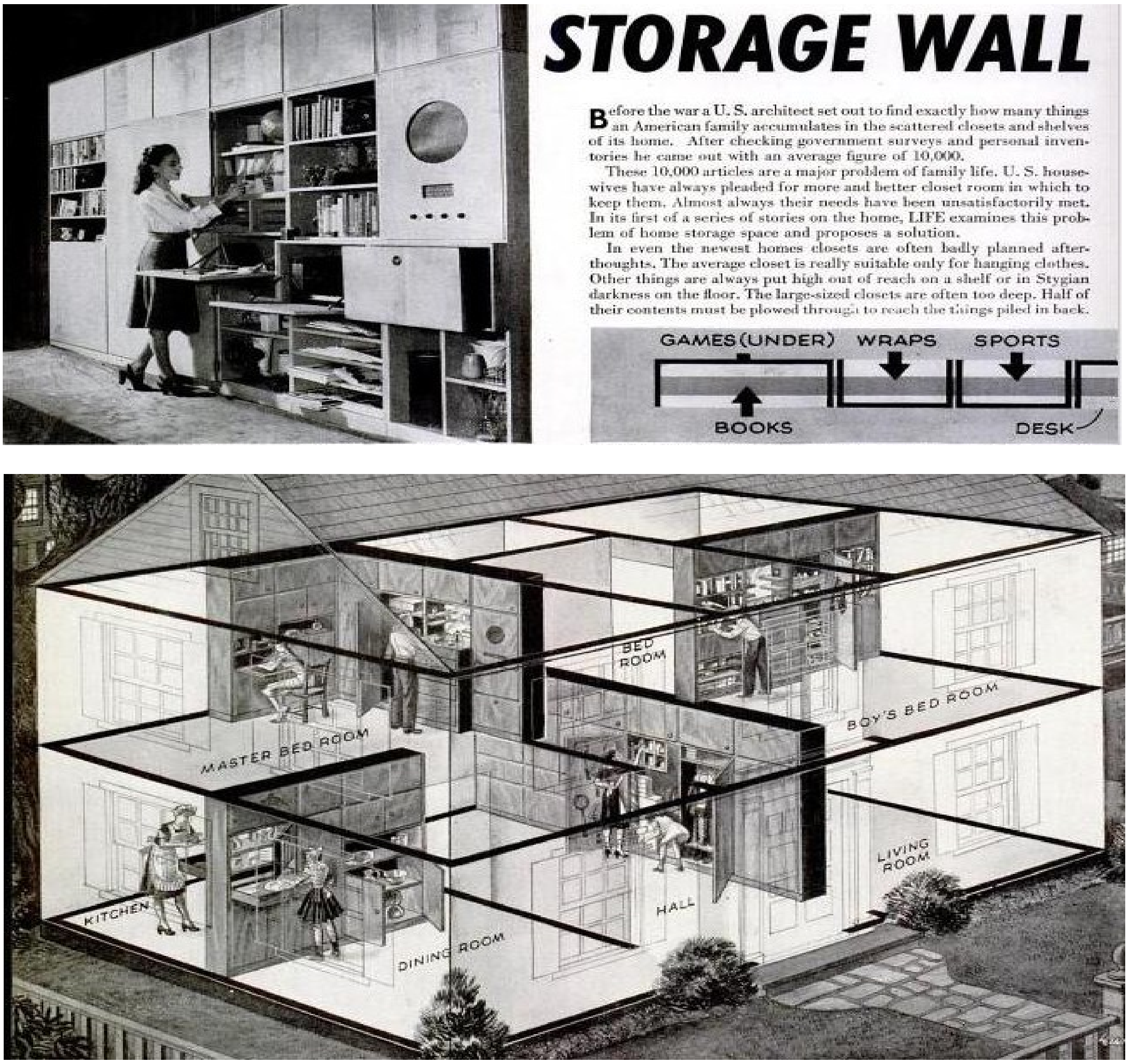


Fig.3.3.5. Storage wall presented in *Life* magazine, by George Nelson and Henry Wright for Herman Miller, 1945. Source[http://books.google.ca/books?id=KVMEAAAAMBAJ&pg=PA38&dq=life+magazine+1945+22+jan&hl=en&ei=wXVeTfKHLIS8lQfs0MieDA&sa=X&oi=book_result&ct=book-thumbnail&resnum=2&ved=0CD0Q6wEwAQ#v=onepage&q&f=false (accessed 4th October 2013)]

Architects and designers started to transform “traditional” furniture into complex structural elements in order to reply to the flexible architectural concept of space. Therefore, solutions like “wall concept” became the most inspiring “furniture element” for further experimentation. Indeed, it was widely used in office environments, whose most important examples were the 1950’s Storage Units by Charles and Ray Eames, or the Robert Propst and George Nelson’s “Action Office I and II” (mid-1960’s), where a combination of various basic elements created an infinite range of possible space arrangements.

Furthermore, single pieces of furniture, like tables and beds in particular, also started to be designed for possible multi-functional contexts. In these cases the modular approach, when repeated, was used as basis for creating various spatial and functional scenarios. One simple example is Eames’s Wire Base Low Table which can be used in home or in office environments, as a single piece or as part of the custom made composition. “

Fig.3.3.6.(Left/Middle/Right) Wire Base Low Table by Ray and Charles Eames.
Source [http://www.hermanmiller.com/discover/page/4/ (accessed 4th October 2013)]

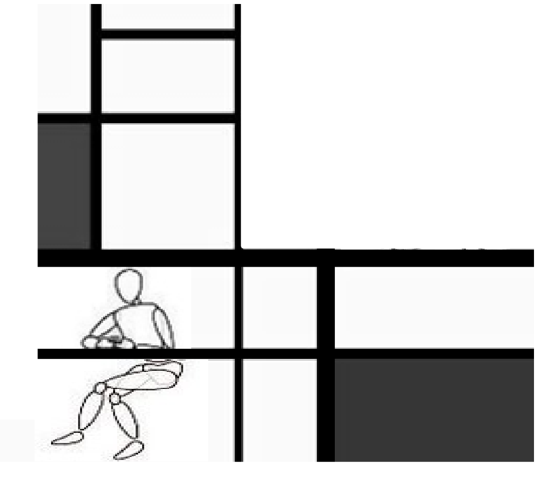
Additionally, organizing various furniture elements into compact ready-made unit components was shown also as one more alternatives how to achieve greater freedom in space organization. For example, already in architectural approach we could notice some methods of “grouping” various functional areas like kitchen, bathroom or storage into independed structures or “boxes” which could be added or moved as desired. In context of furniture this method starts to be present especially in the case of kitchens where one single object was housing all necessary kitchen storage facilities along with appliances. When closed, these units appeared to be a simple closet, but when opened, it revealed a working area of kitchen.[89]

Fig.3.3.7. Lilly Reich, *kitchenette, 1931.*
Source [http://wanafoto.blogspot.it/2010_11_01_archive.html (accessed 4th October 2013)]

In all mentioned concepts we can notice that, unlike traditional perception of furniture with the fixed form and purpose, the essence of flexible approach in furniture is that it allowed consumer to create its own interior composition according to personal desires, or functional and social requirements.[90]

[89] Schneider, Tatjana, and Jeremy Till.*Flexible housing*. Oxford, UK: Architectural Press, 2007. p21
[90][http://www.jstor.org/stable/3527000?seq=10&Search=yes&searchText=interior&searchText=compact&searchText=living&list=hide&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Dcompact%2Bliving%2Binterior%26Search%3DSearch%26wc%3Don%26fc%3Doff%26globalSearch%3D%26sbbBox%3D%26sbjBox%3D%26sbpBox%3D&prevSearch=&item=25&ttl=2306&returnArticleService=showFullText&resultsServiceName=null (accessed 5th October 2013)]

FIELD OF INVESTIGATION



4. General classification and selection of case studies

By analysing the general historical background of flexible approaches in architecture, transportation, interior and furniture design, this research aims to narrow down and further specify the target area to be investigated.

Accordingly, the next three chapters will focus on three main areas with the related case studies (100 case studies overall). This classification is the result of reviewed concepts which are strictly related to a flexible organization of interior spaces and to furniture design. More specifically, the guiding criteria of selection are based on examples which are able to arrange functional changes over time and in the space without destroying partition and/or exterior walls. Therefore, the first typology represents case studies with changeable interior separations; the second typology represents homes in form of capsules whose layout can be upgraded or "reduced" according to the need; finally, the third typology represents multiple-use furniture structures.

This classification represents the initial field of investigation of this work, which will be further deepened and analysed and will lead to obtain the results and exposed in the following chapters.

4.1. Typology 1: Multi-purpose layout

Fig.4.1.1. Gerrit Rietveld, *Schröder House*, Utrecht, 1924. Picture source: personal archive.

This typology relates to projects which are flexible in terms of functional re-arrangements of one single space that doesn't change its total floor area during those transformations. This refers mainly to case studies with movable and sliding walls or hinged partitions, which support a variability of spaces that can be divided, separated, integrated or opened according to the needs and wishes of the occupants[91]. With this in mind, such solutions may be considered as open-plan environments but at the same time could be further divided into series of physically separated living zones.

If we consider *the screen* as the simplest and most basic element which allows this type of spatial flexibility, we can find the early roots of this typology in the Japanese *tatami* and *shoji* – a traditional interior system of floorings combined with sliding screens, doors or windows made of paper and dating to as early as 200 BCE[92]. The case studies for this typology could be numerous. However, if focusing on more recent history, one significant example in the Western tradition can be found in the *Schröder House* by Gerit Ritveld built in Utrecht in 1924. Inspired by the Japanese tradition, this residence represents a highly flexible modernist living space. As described in *Flexible Housing* by Tatiana Schneider et al*.,* "the house is organized on two storeys around a central core that contains the staircase. Whilst the ground floor plan is subdivided in a conventional way into separate rooms: kitchen/dining, a reading room, a studio room (plus adjacent dark room) and a bedroom – the hinged

[91] Schneider, Tatjana, and Jeremy Till.*Flexible housing*. Oxford, UK: Architectural Press, 2007, p. 152.

[92] Schneiderman, Deborah. *Inside Prefab: The Ready-Made Interior*. New York: Princeton Architectural Press, 2012, p. 11.

sectional moveable screens of the first floor allow”[93] the transformation of a single continuous open space into more separate and closed functional units[94]. Going further in the timeline, the next similar example that could be mentioned here is Eileen Grey’s small studio apartment in Rue Chateaubriand in Paris constructed in 1931. In this irregularly shaped space of around 32 m^2, “Gray applied the principles of planning, multi-functionalism and storage that she had developed during the creation of E.1027” [...] and “created the space for all the varied needs of the apartment's occupant with a certain level of luxury and comfort through several means. She used metal mesh screens and sliding metallic curtains in curved tracks, as well as furnishings and decorative elements to designate separate functional spaces”[95]. Furthermore, more drastic examples of flexible layouts can be found in the period between 1960s and 1970s. Among the most significant examples we must highlight the building structures based on the modular grid, one of the most inspiring tools for implementing flexible concepts. A grid organized by rows and/or columns can contain the same or various repetitive modules which allow for the re-organization of functional units in the interior into structurally independent elements (e.g. various space separators – doors, walls or even furniture elements). This method contributes not only to “saving-space” contexts, but it may also improve the efficiency of space over time and give the possibility of modifying various spatial scenarios more than in the past. Some remarkable examples are *Wohnhaus Kronsberger Straße* by Benhard Binder and Stefan Polónyi, in Berlin, from 1969; or *Flexibo* by Fællestegnestuen, in Følfodvej, Amager, Copenhagen, from 1976; etc.

Related case studies

1970’s

CS 1. Ugo La Pietra, *Unbalancing system*, Italy, 1973.
CS 2. Fritz Haller, *Wohnhaus Schärer*, Switzerland, 1969.
CS 3. Fællestegnestuen, *Flexibo*, Denmark, 1976.
CS 4. Bernard Kohn, Georges Maurios, *Les Marelles*, France, 1975.
CS 5. Ernst Plischke, *Frey Haus*, Austria, 1973.
CS 6. Benhard Binder, Stefan Polónyi, *Wohnhaus Kronsberger Straße*, Germany, 1969.

1990’s

CS 39. Shigeru Ban Architects, *Nine-Square Grid House*, Kanagawa, Japan, 1997.

2000+

CS 46. Kent Larson and MIT School of Architecture and Planning, *CityHome*, USA, 2012.
CS 47. Modern Office Systems llc, *LifeEdited Apartment*, USA, 2012.
CS 48. studio_01, *Barcode Room*, 2012.
CS 49. Mima Architects, , Marta Brandao & Mario Sousa, *Mima House*,

[93] Flexible Housing [http://www.afewthoughts.co.uk (accessed 1st October 2013)]
[94] [Flexible Housing]
[95] “Inventory of the Eileen Gray architectural drawings”. Online archive of California. Source: [http://findaid.oac.cdlib.org/findaid/ark:/13030/c828090m/dsc/ (accessed 30th June 2014)]

Portugal, 2011.

CS 50. arch.Sandra Mestrovic, *38m2 Home/Office*, Zagreb, Croatia, 2009.

CS 51. arch.Damir Spoljar, *Garage project*, Zagreb, Croatia, 2009.

CS 52. Michael Chen Architecture, *Unfolding Apartment*, New York.

CS 53. Michael Chen et al., *Partywall*, New York.

CS 54. Luigi Colani and Hanse Haus, *Rotorhaus*, Germany, 2004.

CS 55. José Miguel Reyes and Students of the Departamento de Proyectos Arquitectónicos, ETSAM, *domino.21*, Spain, 2004.

CS 56. Studio Aisslinger, *Loftcube*, New York, 2003-2010.

4. 2. Typology 2: Micro-living "capsule"

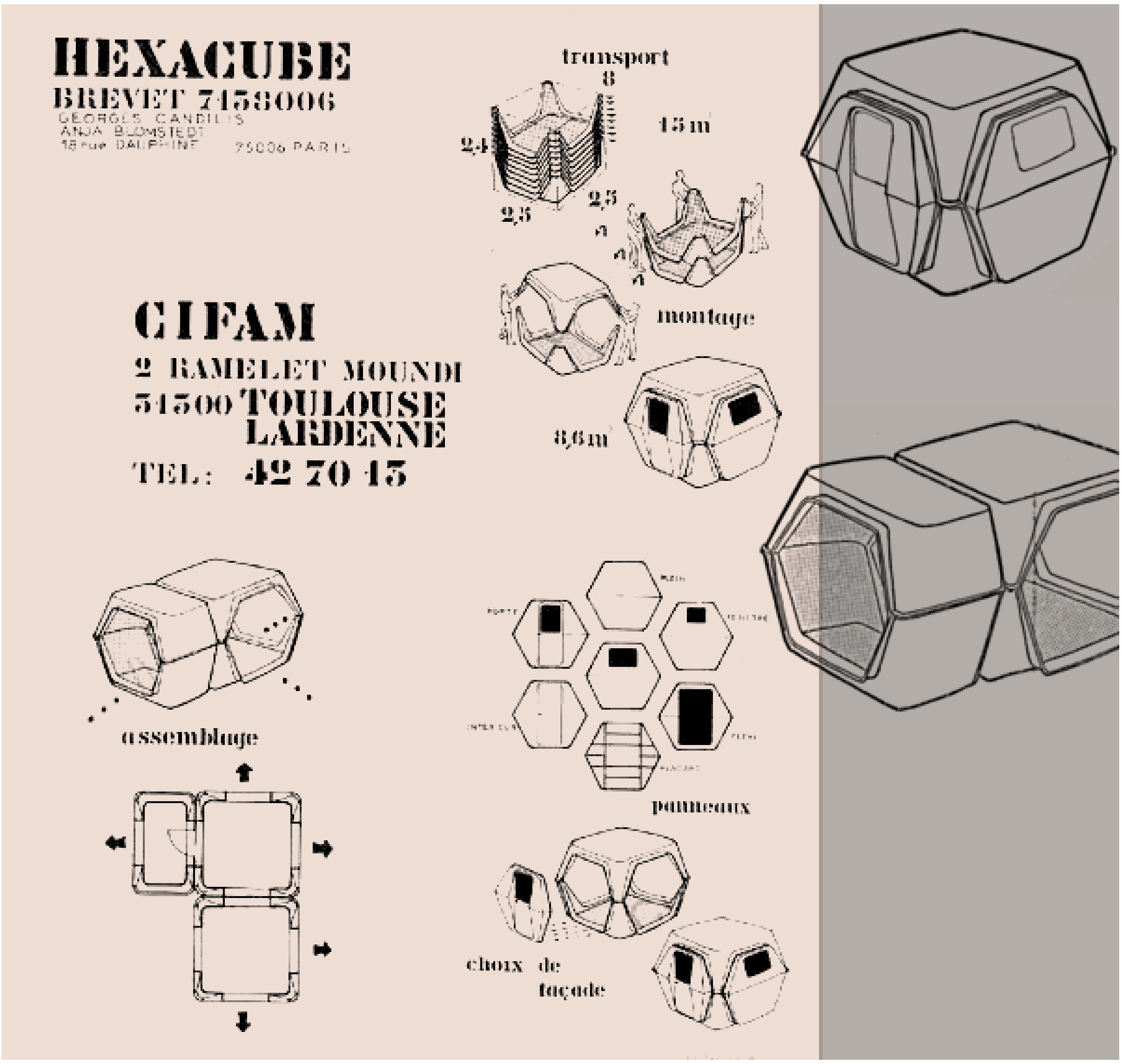


Fig.4.2.1. *Hexacube* by Georges Candilis and Anja Blomstedt, 1972.

This typology is related to structures in form of capsules (or modules or units) which can be upgraded or "reduced" according to the current need. The main intention of such approach is to predict a possible extended functionality of interior spaces and to improve spatial efficiency on a long-term. Due to that, this solution is one that most fruitfully contributes to achieving the flexible transformation of interior spaces.

The early experiments applying such approach mainly refer to architecture and urbanism and date back to the mid-1960s, when new architectural responses were given as a reaction against the obsolescence of style which had marked the post WWII period – homes in the form of living capsules, expandable buildings which were incorporated into macro structures which represented a view of total urbanism. Some of these interpretations were presented in projects like "Capsule Home" by Warren Chalk (1964), "Living Pod" by David Green (1965) or group projects like the "Plug-in City" (1964) where the whole structure had the size of a city and contained "plugged-in" units for a wide variety of uses. Their work found like-minded followers in Italy with the groups "Archizoom" and "Superstudio" as well as in the "metabolist" architecture in Japan.

Although these solutions are mainly related to the field of architecture, they still have to be taken into consideration, as this view of dwelling allows functional variability of interior spaces, which is actually one major focus of this research. As such, these structures are based on autonomous cells representing the same or different functional units which can be organized together in infinite variations and could "grow" or get smaller as desired. Unlike the previous typology, in this case the floor area of living structures is changeable and is not defined by the external walls.

Additionally, the reason why this typology is interesting to the purpose of this thesis is that, since these capsules (or modules or units) are usually very small and spatially limited, the approach to functional organization of interior for each separate unit usually relies on optimized and compact solutions. In other words, interior settings try to integrate here all the necessary elements in a more compressed way as opposed to standard architectural or ergonomic regulations – what may eventually result in the development of more complex or more innovative interior solutions, suitable for spatially limited dwellings. Therefore, many optimization techniques could be considered as significant contributions to flexible interiors in limited spatial contexts useful to improve spatial efficiency.

Related case studies

1970's

CS 7. Jean Maneval, *Six Shell Bubble House*, France, 1968.
CS 8. Ekuan Kenji, *Yadokari with GK Industrial Design Associates*, 1972.
CS 9. Kisho Kurokawa, *Living Capsules*, Tokyo, Japan, 1972.
CS 10. Orges Candilis, Anja Blomstedt, *Hexacube*, 1972.
CS 11. Matti Suuronen, *Futuro*, Finland, 1970s.
CS 12. Matti Suuronen, *Venturo*, Finland, 1972.
CS 13. Kisho Kurokawa, *Nakagin Capsule Tower*, Japan, 1972.
CS 14. Alberto Rosselli, *Ambiente Mobile*, Italy, 1972.
CS 15. Marco Zanuso, Richard Sapper, *Habitation Unit*, Italy, 1971.
CS 16. Kristian Gullichsen and Juhani Pallasmaa, *Moduli 225*, 1969/1971.
CS 17. Paul Rudolph, *Oriental Masonic Gardens*, USA, 1970/71.

1980's

CS 37. Richard Horden / Horden Cherry Lee Architects, *Yacht House*, UK, 1983.

1990's

CS 40. Joep Van Lieshout, *Master and Slave Unit mobile home*, Otterlo, The Netherlands, 1995/96.
CS 41. Allan Wexler, *Habitation unit*, USA, 1999.
CS 42. Willi Ramstein, *Habitation unit*, Switzerland, 1999.

CS 43. Kaufman 96, *Fred*, Austria, 1999.

2000+

CS 57. Studio Liu Lubin, *Micro-house*, China, 2012.
CS 58. Richard Horden and Institute for Architecture and Product Design at Technical University Munich, *Micro-compact home*, Germany, 2005.
CS 59. Adam Kalkin, *Pushbutton house*, USA, 2005.
CS 60. Andrea Zittel, *A_Z Cellular Compartment Units*, USA, 2001.
CS 61. Jordi Lopez Aguilo, *Micro House*, 2012.
CS 62. 55 architects, *Walking house*, Denmark, 2008.
CS 63. Renzo Piano, *Micro Home*, Italy, 2013.
CS 64. N55 architects, *Tiny house*, Denmark, 2008.
CS 65. Betillon / Dorval-Bory, *appartement spectral*, France, 2013.
CS 66. Marc Baillargeon and Julie Nabucet, *130-Square-Foot Apartment*, France, 2012.
CS 67. Monadnock Development, the Actors Fund Housing Development Corporation and nArchitects, *MicroUnit* – winners of adAPT NYC competition, New York, 2012.
CS 68. SPOT- STUDIO POLENTA TECCO ARCHITETTI ASSOCIATI, *Box2*, Italy, 2006.
CS 69. LOT-EK Architects, *Mobile Dwelling Unit*, New York, 2003.
CS 70. Michael Katz and Janet Korne, *L41home*, Vancouver, 2008.
CS 71. arch. Marco Colombo, *Pack’n go House*, Italy, 2006.

4. 3. Typology 3: Furniture/ units/modules in interior settings

Fig.4.3.1. Joe Colombo, *Total Furniture Unit*, 1972.

This typology is focused on solutions where many different needs are implemented in one particular furniture object with a multifunctional use. Therefore, this typology is more related to furniture-design conceptions.

Unlike the traditional ("non-flexible") method, where each sample of furniture has its unambiguous function, the flexible approach supports the fusion of furniture elements. In other words, such elements are usually "compressed in function", minimized or composed in parts in order to fit to combinations with other furniture or to adapt to other functions so as to achieve the final goal, which is improving spatial efficiency. More specifically, it relates to furniture such as chairs which could be transformed in armchairs, armchairs transformable into beds, tables transformable into beds, even cupboards on castors in moveable kitchens, etc. This changeability of elements is interesting to analyse and relevant to the scope of this Thesis, as such transformations are achieved in most cases by eliminating physical distances and optimizing or even reducing standard ergonomic principles to essential needs, which in turn changes and forms new ergonomic trends and new behaviours in contemporary dwelling culture.

Significant experiments applying such approach to furniture can be found in the concept of *Total furniture unit* by Joe Colombo dating to the late 1960s. Its main focus was an organization of living environment aimed to create compact functional forms whose mutual combinations or transformations could support different living contexts. More specifically, the *Total Furnishing Unit* was an example of a compact "furniture" structure made of plastics which contained various "functional stations" like the "central unit" (for daily activities), the "night unit" (containing sleeping arrangement), the "bathroom unit", the "cupboard" and the "kitchen box" which could also be transformed into a dining area. Later on, a similar approach was adopted by many other professionals such as Allan Wexler's *Crate House* or *Parsons Kitchen* in 1990s; etc.

Additionally, by further experimenting furniture optimization and spatial efficiency, it was shown that such approach could also contribute to "space-saving". Therefore, another direction and a source of inspiration consisted in elements which could be folded, "packed-in", easily assembled and disassembled and light in weight so as to be easily removed (e.g. *Plia* by Giancarlo Piretti, Italy, 1969; *Plano* by Giancarlo Piretti, Italy, 1970/71; etc.).

Related case studies

1970's

CS 18. Luigi Colani, *Kitchen Satellite for PoggenPohl*, Germany, 1971.
CS 19. Alberto Rosselli, *Bathroom Unit*, Italy, 1972.
CS 20. Bruno Munari, *Abitacolo ("Cockpit") habitable structure*, Italy, 1971.
CS 21. Internotredici (Carlo Bimbi, Gianni Ferrara, Nilo Gioacchini), *Tuttuno*, Italy, 1969 (1971).
CS 22. Alberto Salvati and Ambrogio Tresoldi, *Tavoletto*, Italy, 1967 (1969).
CS 23. Alberto Seassaro, *Central Block*, Italy, 1968 (1970).
CS 24. Ettore Sottsass, *Furnishing Concept*, Italy, 1972.
CS 25. Virgilio Forchiassin, *Spazio vivo*, Italy, 1968.
CS 26. Joe Colombo, *Total Furniture Unit*, Italy, 1972.
CS 27. Joe Colombo, *Total Furniture Unit - bathroom*, Italy, 1972.
CS 28. High-Tech, *Loft bed (Hopkins house)*, UK, 1970's.
CS 29. Hennessy & Papanek, Urban Nomads movement, *Resource Tower*, 1970's.
CS 30. Hennessy & Papanek, Urban Nomads movement, *Living Cubes*, 1970's.
CS 31. Giannantonio Mari, *Modular system,* Italy, 1972.
CS 32. Joe Colombo, *MultiChair*, Italy, 1971.
CS 33. Joe Colombo, *Recliners*, Italy, 1971.
CS 34. Giancarlo Piretti, *Plia*, Italy, 1969.
CS 35. Fritz Haller, USM modular system, Switzerland, 1963/69.
CS 36. Gae Aulenti, *House Environment*, Italy, 1972.

1980's

CS 38. Allan Wexler, *Bed/sitting rooms for an Artist in Residence*, 1988.

1990's

CS 44. Allan Wexler, *Crate House*, New York, 1991.
CS 45. Allan Wexler, *Parsons Kitchen*, New York, 1994.

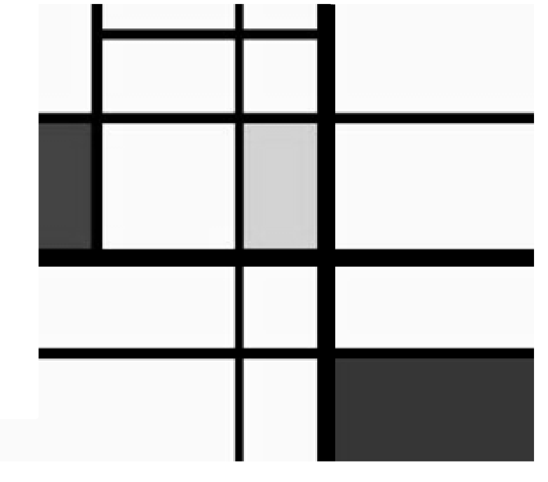
2000+

CS 72. OMA, *Rache kitchen box*, The Netherlands, 2006.
CS 73. Lowrien Kaptein, *90Â° Flatpack Furniture*, 2008.
CS 74. Crowd productions, *Cirrus MVR*, 2008.
CS 75. Rolands Landsbergs, *Boxetti*, Latvia, 2010.
CS 76. Behles & Jochimsen, *2Raumwohnung*, Germany, 2006.
CS 77. Colab architects, *Co-Pod*, Nelspruit, South Africa, 2010.
CS 78. Andrew Kline, *The Interior Living Unit*, Michigan, 2010.
CS 79. Design Odyssey Co, *Vertebrae vertical bathroom*, United Kingdom, 2008.
CS 80. Stefan Eberstadt, *Rucksack house*, Germany, 2004.
CS 81. Alleswirdgut, *Turnon*, Austria, 2005.
CS 82. SpaceFlavor, *Mobile Living Space*, San Francisco, 2012.
CS 83. CLEI Srl, DOC – SOFA INTO BUNK BED, Italy.
CS 84. CLEI Srl, ULISSE DESK – DESK TO BED AND BACK AGAIN, Italy.
CS 85. CLEI Srl, NUOVOLIOLA 10 – SOFA WALL BED DESIGN, Italy.
CS 86. RESOURCE FURNITURE, *Goliath*, New York, 2012.
CS 87. RESOURCE FURNITURE, *Voila*, New York, 2012.
CS 88. RESOURCE FURNITURE, Scala Zero, New York, 2012.
CS 89. atelier OPA, *Kenchikukagu*, Japan, 2008.
CS 90. Johannes Häuser, HOJ studio, *Klopf Klopf*, Germany, 2013.
CS 91. It Design, *Itbed*, Switzerland, 2006.
CS 92. Studio NL, *'1.6 SM Of Life' Desk Turns Into A Compact Bedroom*, New York, 2013.
CS 93. Sakura Adachi for Campeggi, *Trick*, Italy, 2010.
CS 94. Tetran, *Tetran Infinite Living System*.
CS 95. Vestal Design, *DoubleSpace Kitchenette*, 2006.
CS 96. Shin Yamashita, *Land Peel*, Japan, 2010.
CS 97. Emanuele Magini for Campeggi, *Sosia*, Italy, 2011.
CS 98. Till Konneker, *The Living Cube,* Switzerland.
CS 99. Resource Furniture, *Stealth Kitchen*.
CS 100. Sturm-Wartzeck, *Apartment in Berlin*, Berlin, 2008.

RESULTS ANALYSIS

RESULTS ANALYSIS

PART 1 – TECHNICAL ASPECT



PART 1 – TECHNICAL ASPECT

In this section the specific results based on the analysis of some case studies will be presented. These results will be strictly related to the technical considerations obtained from the analysis and will lead to highlight the answer to the **first two research questions** listed at the beginning of this Thesis (see chapter 2.5.).

5. Flexible interior methods noticed from 1970s to the present

"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete". Buckminster Fuller (1895-1983), architect, systems theorist, author, designer, inventor, and futurist.

In architecture, the avant-garde group Archigram launched a new interpretation of living as a reaction to the obsolescence of style which had marked the post WWII period. The main concern was to create an architectural response to an ever-changing environment through people participation and flexibility. And this response was drastic: homes in the form of living capsules, expandable visions of buildings incorporated into mega structures which all together represented a vision of total urbanism. Some of these interpretations were presented in projects like "Capsule Home" by Warren Chalk (1964), "Living Pod" by David Green (1965) or group projects like "Plug-in City" (1964), where the whole structure had the dimension of a city and contained "plugged-in" units for a variety of uses. Their work found like-minded followers in Italy with the group "Archizoom" and "Superstudio", as well as in the "metabolist" architecture in Japan (e.g. Kenzo Tange's *Shizuoka Press and Broadcasting Center*).

Influenced by the same dynamic principles, 1972 represents another important watershed for interior and furniture design. One ambitious exhibition took place in MoMa, New York, which also indicated a change in the lifestyle and a shift to more flexible and mobile trends. Under the name "Italy: New domestic landscape", Italian designers illustrated some of the living concerns of industrialized societies by using a new approach: they believed that an object could no longer be designed as a single isolated entity and they conceived their design as environment-oriented, aiming at flexible purposes and allowing multiple modes of use and arrangement". Among them were the "Ettore Sottsass' micro-environments in plastic, each of whom was built on casters so that occupants could easily re-arrange them to fit their needs; Joe Colombo's fixed plastic units for bath, kitchen, sleeping, and storage that could be put into any existing space; Gae Aulenti's molded plastic elements which could be combined to create architectural multi-purpose environments; Rosselli's aluminum mobile house which expanded from 7 x 14 feet (ca 213 x 426 cm) to 20 x 29 feet (ca 610 x 880 cm) ; Zanuso-Sapper's house, an aluminum container made of two molded plastic shells housing bedroom and bathroom/kitchen units; Mario Bellini's glass-walled "exploration" car which could also expand when stationary, etc.

Consequently, it is sure that from those times to the present a wide variety of new flexible concepts have been developed. Nevertheless, a common guiding principle for all of them can be identified which is related to the fact that flexible methods generally rely on the deviation, optimization or even elimination of physical distances based on standard ergonomic approaches aimed at fitting spatial limitations. Furthermore, functional units with determined, static and fixed purposes become variable, movable, extendable entities which can free the spaces from fixed and limited functions through their flexibility.

With this in mind, the various techniques of furniture optimization and compressed functionality become one of the main sources of inspiration for achieving the maximum functional variety of spaces (e.g. *Oma's Rache* by Melanie Olle and Ilja Oelschlägel, 2006; *Parsons Kitchen* by Allan Wexler Studio, 1994; etc). Additionally, movable and sliding walls or hinged partitions, which support a fluid space that can be divided, separated, integrated or opened according to the needs and wishes of the occupants, represent only a small part of all the applicable concepts (e.g. *CityHome* by Kent Larson and MIT School of Architecture and Planning, 2012; *LifeEdited* Apartment by Modern Office Systems llc, 2012; etc). Furthermore, today we are witnessing examples of kitchens whose dimensions are decreased to those of one element (e.g. "Kenchikukagu" kitchen cabinet by Atelier OPA, 2008) in which people can store only basic belongings; examples where the whole house is not bigger than a parking place for one car ("Ultra Small House" by Junichi Sugiyama, Side Architects, Tokyo, 2010) or where the whole functional units (like kitchen, bathroom, sleeping room, etc.) in which one dwelling is "packed" inside a wheeled box can be "moved", "re-moved" or "opened" and used depending on the need (e.g. "The Interior Living Unit" by Andrew Kline, 2010).

All this considered, we could claim that flexibility was continuously used as a successful "tool" for inexhaustible experimentation applied in infinite forms and for infinite living contexts. However, the main intention of the next chapters is to detect those varieties and classify them according to different methods that use flexibility as the main tool for experimentation. Accordingly, these methods will be classified on the basis of three related contexts identified during the case studies analysis. These contexts refer to: spatial organization, compact solutions and flexible joints.

Finally, the main aim of this investigation is to eventually classify all the existing flexible techniques in order to have a clear overview on the evolution of this particular field under a technical perspective from the 1970s to the present. Thereby, the answer to Research question 1 -"**How has flexibility been implemented in limited spaces from 1970s to the present?** " – will be provided.

5.1. Spatial organization

5.1.1. Grid concept

As Alison Smithson (2001) explains, the "space is total and society is universal. These realities must be reflected in our planning and building". In order to follow this principle, spaces should "grow" along with our needs giving us maximal support according to current requirements. "The more flexible the building is, the more able it is to react to different patterns of use over several generations of users and the better its overall ecological as well as economical balance"[96].

Applied in interiors, skeletal structure houses based on a modular grid approach can be considered as one of the most inspiring tools for implementing various flexible concepts. A grid, organized by rows and/or columns, can contain dimensionally the same/or various repetitive modules which allow the re-arrangement of interior functional units into structurally independent elements (like wall panels or sliding doors). This method contributes not only to "saving-space" contexts, but it may also improve the efficiency of space over time and give the possibility to modify various spatial scenarios.

In order to achieve this flexibility of layout, the structure should be designed at the first place with as less internal load-bearing supports as possible (Friedman, 2002). That is usually not from particular problem in the context of small dwelling structures. Such open floor layout allows having the maximum functional changeability[97]. The simple model translated into practice is shown in the Case Study no. 49 (Mima *House* by Mima Architects, Marta Brandao & Mario Sousa, Portugal, 2011). A thirty-six square meters interior divided by regular modular dilatations of floor and ceiling define the possible functional separations of the space. As such, this space could represent a dwelling for one person, but at the same time it could accommodate possible future additional occupant/s by re-arranging the layout for one more sleeping room, or by reducing the working room in order to enlarge the bathroom, or simply by expanding the kitchen or storage elements to be functional and appropriate for two persons.

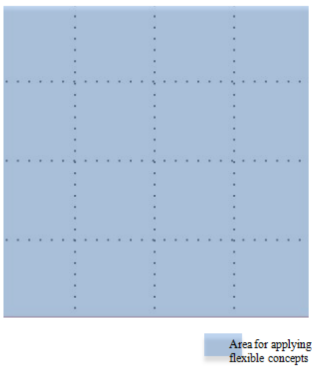


Fig.5.1.1.1. Open floor layout most adequate base for applying flexible concepts.

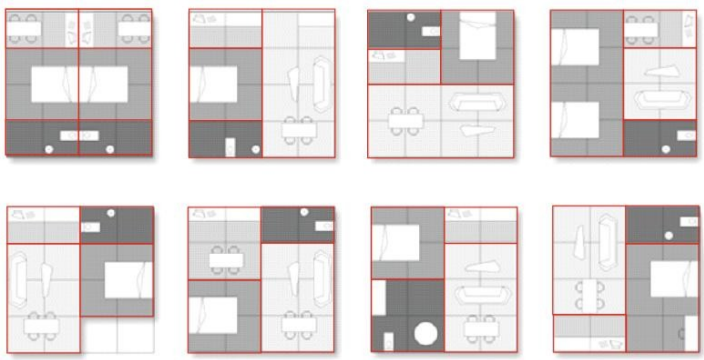


Fig.5.1.1.2. Possible variations of layout. Case study no. 49 (*Mima House* by Mima Architects, Marta Brandao & Mario Sousa, Portugal, 2011).

[96] Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010.

[97] Friedman, Avi. *Innovative houses: concepts for sustainable living.*. S.l.: Laurence King Publishing, 2013.

In the second case – for structures which inevitably need internal structural supports – these latter should be grouped with the only immobile units of the living space, such as kitchen and bathroom (e.g. Case study no. 51: *Garage project* by Damir Spoljar, Zagreb, 2009). However, this approach is at once advantageous, as the relocation of wet functions may require a complicated and expensive method.

Fig.5.1.1.3. Functional changeability of layout where kitchen and bathroom units are immobile.
Case study 52: *Garage project* by Damir Spoljar, Zagreb, 2009.

Fritz Haller, Wohnhaus Schaerer, Switzerland, 1969.

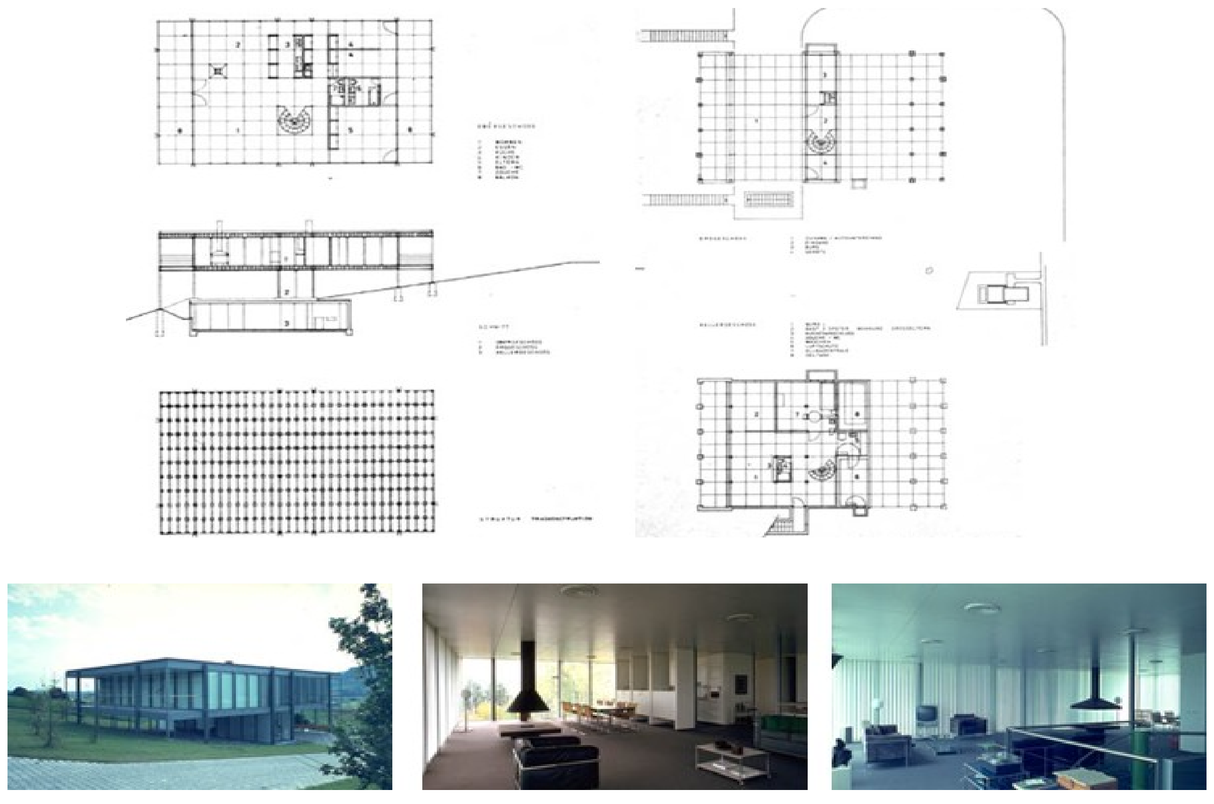


Fig.5.1.1.4. Layout and interior appereance. Source: “Flexible housing“ [/http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=46&number=15&total=175&action=all&data=Japan&order=type&dir=ASC&message=all%20projects&messagead=ordered%20by%20type&photo=6(accessed 30th June 2013)]

Project description:

-*General notes:* Fritz Haller (1924-2012) is considered as one of most important Swiss architects but also distinguished by his experiments in industrial constructions which he implemented in architecture as well as in furniture design. Along with the company USM he developed extendable and repeatable quadratic modular systems of furniture where he, trough structures of steel tubes, steel panels and chromium plated brass ball, embodied artistic, technological and scientific approach altogether. Furthermore, in architecture he formed industrial aesthetics based on the integration of Buckminster Fuller and Konrad Wachsmann’s concepts, as well as on Max Mengeringhausen’s structural solutions (e.g. “Mero” space frame).[98] In early Sixties, “Münsingen-based metal processor, Schärer, had commissioned him to design their new production facility, the components for which would be manufactured in the company’s own workshops. The commission gave rise to the *Maxi* modular system, to be followed by the smaller *Mini* and *Midi* systems.”[99] Later on all his work was based on these three systems - *Mini* for residential houses and offices, *Midi* for taller buildings and *Maxi* for industrial complexes.

-*Methods of flexibility:* Wohnhaus Schärer house construction was based on *Mini* modular system. Steel framework consists of elements based on a modular measurement of 120/60 cm, and features like doors and windows could be dismantled and moved within the modules.

[98] “Modern systems” by Jörg Stürzebecher [http://www.stylepark.com/en/designer/fritz-haller/contributions (accessed 15th October 2013)]

[99] [Modern systems]

Flexibo by Fællestegnestuen, Følfodvej, Amager, Copenhagen, 1976.

Fig.5.1.1.5. (Left) Relation between "area for applying flexible concepts" and "immobile units". Picture source: "Flexible housing" [/http://www.afewthoughts.co.uk (accessed 30th June 2013)]. **Fig.5.1.1.6.** (Right) Method for flexible re-organization of the space. Picture source: "Flexible housing" [/http://www.afewthoughts.co.uk (accessed 30th June 2013)].

Project description:

-*General notes:* "With the works of Team X and dutch structuralism the concern for adaptable structures and rough materials rised, and resulted with number of dense, low-rise housing developments during the 1970s. One of the most notable was Fællestegnestuen's *Flexibo* housing development, which incorporated a system of structure and light partitions that allowed residents to adapt the location of the walls to their particular way of living."[100]

-*Methods of flexibility:* This case study represents approach to flexible dwelling in which the whole concept is partially designed and partially adopted by the residents according their personal needs. The basic frame of the building consists of prefabricated components made of concrete and laminate timber, and its structure cannot be altered. On the other hand, the possibilities of interior organization are numerous due to implementation of modular wall system that allows easy reconfiguration of functional units inside the space. As it is further mentioned in description of relevant source the architects drawing are clearly showing the principle of flexibility. "Parallel walls of concrete provide the dividing perimeters of each house. After these walls are placed, flooring elements are laid on concrete joists and roof and deck elements on timber beams. The facades are closed with light elements. Bathrooms and kitchens are placed along one of the partitions as the only fixed elements. Subsequently, internal partition walls can be laid out. These partitions consist of two types of wall elements of 1 metre and 0.45 metre, a door element of 1 metre, cover board, guide strips, and assembly fittings. Within the given modular grid system, determined by the rhythm of the laminated timber beams as well as some further guides, rooms can be formed at will. Additional pieces of wall can be acquired from a central wall depot. Whilst flexibility in the Flexibo scheme is implemented at the project stage, it is also possible after occupation and when somebody else moves into the house. The construction system allows walls to be moved around very easily, so any layout can be adapted to different needs and requirements at any point in time."[101]

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[100] "Denmark: Page 2 of 3 | Architect Age." Architect Age. http://architectage.com/node/71822/page/0/1 (accessed October 18, 2013).
[101] "Flexible Housing" [http://www.afewthoughts.co.uk (accessed 15th October 2013)]

Wohnhaus Kronsberger Straße, by Bernhard Binder and Stefan Polónyi, Berlin, 1969.

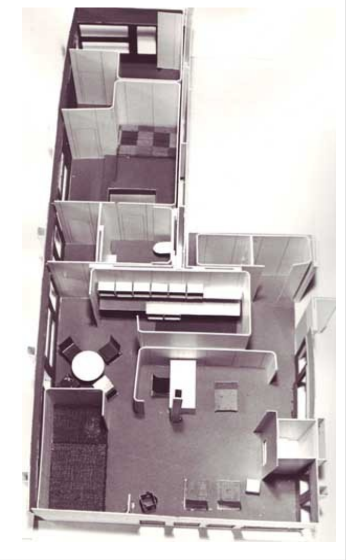


Fig.5.1.1.7. Layout model.
Source:
[http://www.afewthoughts.co.uk
(accessed 2nd July 2013)]

Project description: This residential building is designed in the way to have capacity for change due its type of construction - that is able to support various expansions and contractions of each separate dwelling within the same structure. As such, the base structure is designed by using a grid system in combination of reinforced concrete frame. Main central staircase separates the building in two parts and contains only few structural columns and a service duct. Each of these parts has a common hallway with the organization of doors that allows each floor to have two, three or four differently sized apartments. Additional extended possibilities include variety of possible layout arrangements, in order to support long-term flexibility. According to the plans, spatial divisions are able to be organized into ten units, but therefore the number of apartments could be as low as six or as high as twelve. "The advantages in this form of flexibility lie not only in its potential to respond to its user's periodic changing requirements but also in the long-term adaptability offered by the dwelling within a changing market situation."[102]

[102] "Flexible Housing" [http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=60&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=6 (accessed 15th October 2013)]

5.1.2. Variable walls and doors

The approaches based on grid concepts launched the development of more sophisticated and advanced versions of dividing elements such as doors and sliding panels (walls). This variety ranges from simple single-leaf panels till many variations of segmented sliding options. These approach in spatial flexibility is usually used either in contexts of small and affordable housing (e.g. Case study no.3: *Flexibo*) or even in open space dwellings where spatiality is not so limited (e.g. Case study no.2: *Wohnhaus Schaerer*).

In reviewed case studies most usual options are “single/double leaf” sliding panels whose movement is rectilinear and guided by the rail (see Fig.5.1.2.2; Fig.5.1.2.3; Fig.5.1.2.4; Fig.5.1.2.5). Starting with *Schroeder House* as a forerunner example (1924), such methods are the most common and simple ones. Another variation based on the same sliding principle is where the rail is not necessarily rectilinear, but follows a specific trajectory (e.g. *Schröder* House by Gerit Rietveld, 1924), or where the panels are segmented into three or more pieces (e.g. Case study no.39: *Nine square grid house* by Shigeru Ban Architects, 1997).

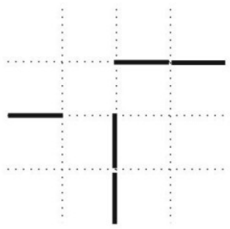


Fig.5.1.2.1. Demountable panels whose mobility is dependent on the structure skeleton

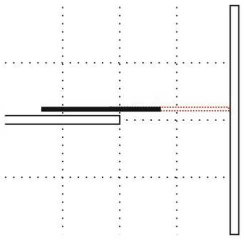


Fig. 5.1.2.2. “Single leaf” panel; linear sliding.

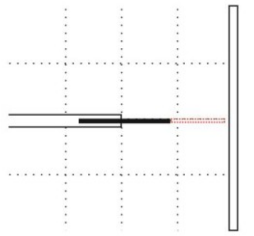


Fig.5.1.2.3. “Single leaf” panels, hidden in the fixed partition; linear sliding.

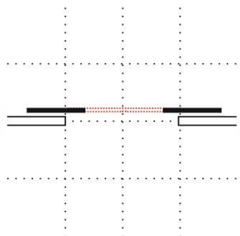


Fig.5.1.2.4. “Double leaf” panels, linear sliding.

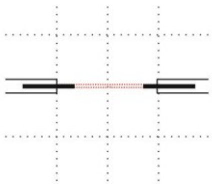


Fig.5.1.2.5. “Double leaf” panel, hidden in the fixed partitions, linear sliding.

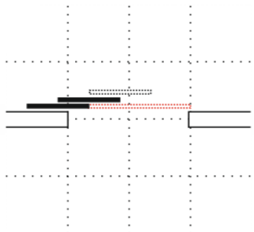


Fig.5.1.2.6. Variation of segmented sliding

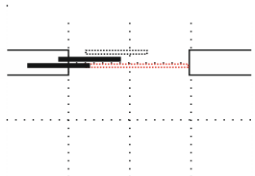


Fig.5.1.2.7. Variation of segmented sliding

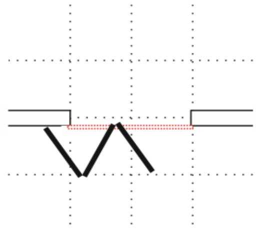


Fig.5.1.2.8. Variation of segmented sliding

Finally, more complex solutions should also be mentioned where elements, besides maintaining their original dividing function, are also used as storage furniture (see Fig.5.1.2.9) or even contain rooms (which will be discussed in the following chapters). Such systems allow complete configurations of the dwelling concept where maximum flexibility is achieved. These “storage dividers” are also able to form different rooms with most of the necessary furniture elements compressed along the “wall”. These rooms are usually “slid out” when needed and “removed” when no longer useful (e.g. Case Study no.48: *Barcode room*).

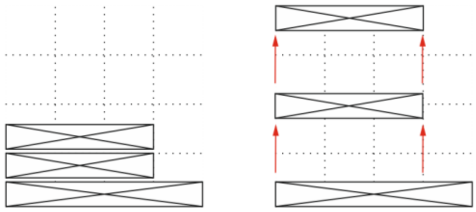


Fig.5.1.2.9. Dividing elements with additional function (e.g. storage, or even integrated rooms)

All the mentioned examples are actually not a novelty, but while the 1970s case studies were just starting to experiment such solutions, contemporary examples are in some cases more technologically advanced. Today, manual transformations of layouts are replaced with more sophisticated rails or even automatic systems. For example, this can be noticed at first glance if we compare the “static blocks” of Joe Colombo’s 1972 *Total Furnishing Unit* with, for example, the easy-sliding space dividers containing also similar concepts with folding beds, kitchen cupboards or storage elements in *Graham Hill’s Apartment* by Modern Office Systems llc (Case study no.47) or in *Multifunctional dwelling* by Gary Chang (Hong Kong, 2010).

Home office #1 by arch. Sandra Mestrovic, Zagreb, Croatia, 2008, 38m^2.

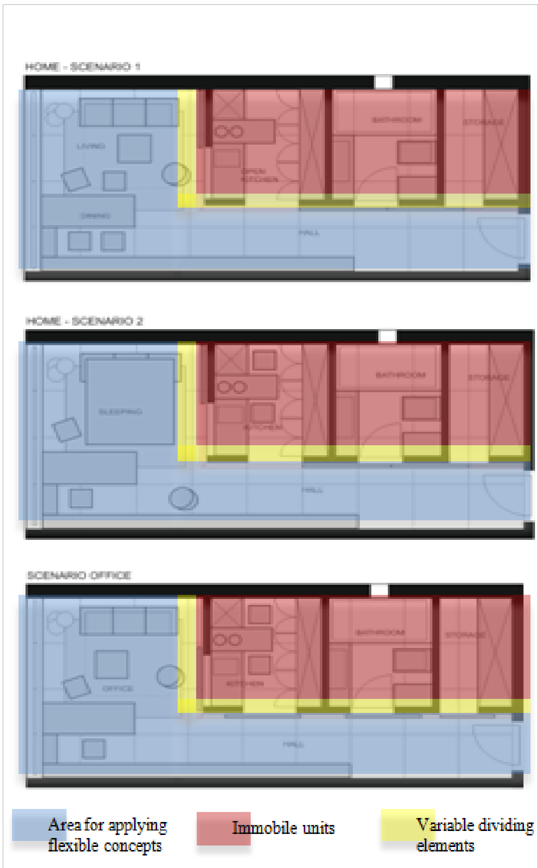


Fig.5.1.2.10. Functional transformations of layout. Source: personal archive.

Fig.5.1.2.11. View on the "daily office scenario". Source: personal archive.

Project description: Home-office #1 by arch. Sandra Mestrovic we can describe as living and working residence. This 38m^2 space host two-person-household where one of the occupants uses this environment as an architectural-studio as well. The internal structural supports of the space are grouped within the units such as wardrobe, kitchen and bathroom which in whole flexible scenario represent "immobile" units of the living space. The central space of the apartment is "daily-zone area" which is flexible in its function - it can be transformed into traditional living room for spending leisure-time afternoons; then dining room which can accommodate 4-6 people around the dining table; sleeping room for two persons; or office. The important contribution to all these functional transformations is visual appearance of the space achieved by sliding panels. Units like kitchen, bathroom and wardrobe could be "exposed" or "hidden" depending on circumstances or desires. For example, in the "office scenario" the only "visible" environment from the entrance door could be the hall which leads to the main space – the office. The rest of the space, if hidden with panels, is giving the illusion as it does not exist. Space as such completely fulfills common office appearance: working desk, shelves for professional literature and area with sofa for meeting purposes with the clients. On the other hand, by simple opening sliding doors of the kitchen area and hiding the working belongings (such as laptop, or etc.) into the table-drawers, we are immediately entering into the "private life" of the apartment.

Barcode Room, by studio_01 (Alex Knezo and Akinori Hamada),Tokyo, 2012.

Fig.5.1.2.12. Organization between communication zone, immobile units and variable elements. Layout source: [http://blog.studiozeroichi.com (accessed 10th June 2013)]

Fig.5.1.2.13. Pattern of possible transformations. Source: [http://blog.studiozeroichi.com (accessed 10th June 2013)]

Project description: *Barcode* project is a concept invented for smaller dwelling spaces (e.g. studio apartments). It consist of "furniture-integrated-walls" which are designed so to be easily moved throughout the space, permitting the occupants to personalize the size of space in the way that fit variety of uses. By integrating additional functional purposes into these walls (e.g. storage, folding beds, tables or etc.), this concept is allowing more of the floor area to be used by the occupant and eventual guests. With this on mind, the space is able to offer both comfortable living and entertain a different number of guests, if needed. With such potential, this concept represent a typical studio space made for a single person and with mentioned additional flexible possibilities, allows to be further transformed into a space where one can live and friends can gather. [103] As further explaned in project description – "Each *furniture-wall* is a combination of selection from 12 types of components to make a single *bar*. Depending on the combination of components, various types of *bars* can be created, such as a living *bar*, kitchen *bar*, or sleeping *bar*. Just as each object in a store has it's own barcode, each usage of the apartment has its own layout, or barcode. The composition of the various components into different *bars*, as well as the position of these *bars*, allows the user to create their own unique collection of barcodes for their life. Additionally, when different furniture are unfolded or pulled out of the walls, windows through the space are created as both sides of the wall become connected by large openings. The dynamic quality of the space's changeable size and continuity create a feeling of connectivity through the space which seems to virtually enlarges the small floor area. By utilizing only a ceiling rail to guide movement and wheels below to allow it, this versatile system can be installed not only into new studio apartments, but also in existing apartments as well."[104]

[103] "blog_studio_01: exhibition_02 -- barcode room." [http://blog.studiozeroichi.com/2012/11/exhibition02-barcode-room.html (accessed August 17, 2014)]
[104] "blog_studio_01: exhibition_02 -- barcode room." [http://blog.studiozeroichi.com/2012/11/exhibition02-barcode-room.html (accessed August 17, 2014)]

Graham Hill's Apartment, Modern Office System llc, New York, 2011.

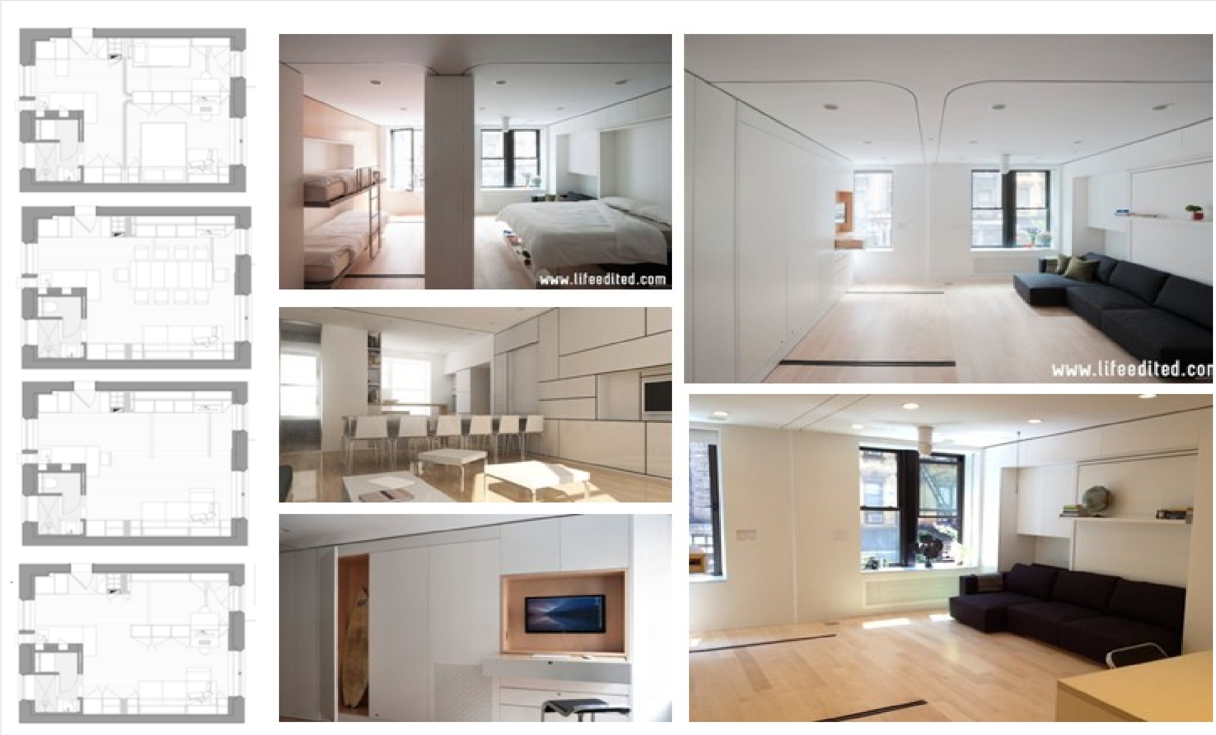


Fig. 5.1.2.14. Transformation options - layouts and interior appearance. Layout source: [http://www.d-a-z.hr/hr/vijesti/sto-sve-stane-u-39-m%C2%B2,2277.html (accessed 2nd May 2014)]; Picture source: [http://www.lifeedited.com/see-full-set-of-official-lifeedited-apartment-photos/ (accessed 10th June 2013)]

Project description: LifeEdited Apartment is again one example of spatial conception based on the "moving walls". This feature is allowing extended functionality how small space could be efficiently used and divided. With such approach, the space is able to transform from typical studio apartment into "a two bedroom apartment–all without adding virtually any additional volume to the overall space. "[105]

Its "daily scenaio" conception consist of a big living room area with open acess to the optimized kitchen zone, and one smaller separated room for bathroom. This conception support comfortable everyday living environment to two-persons houshold. In the case of eventual bigger social gatherings, the multi-functional furniture takes the leading role. For example, the small console table which looks more like decorative sideboard next to the wall (see case study no. 86), can be expanded into the large dining table that can serve up to 12 people. In the case working enviroment is needed, working zone can be folded out from the wall partition. As for the the "night scenario", there are two options available: folding bed system in the main living area that transforms sofa into a bed sufficient for two persons; or second scenario - sliding the flexible wall into the centre of the main living zone in order to form two separate bedrooms. In this case, the "new emerged" sleeping room can serve up to two additional people or guests.

[105] Friedlander, David. "See Full Set of Official LifeEdited Apartment Photos." LifeEdited RSS. January 22, 2013. Accessed June 10, 2013. http://www.lifeedited.com/see-full-set-of-official-lifeedited-apartment-photos/.

Multifunctional dwelling by Gery Chang, Hong Kong, 2010.

Fig. 5.1.2.15. Flexible transformation of functional zones inside apartment. Source: http://www.archdaily.com/59905/gary-chang-life-in-32-sqm/ (accessed 12th Aug 2014)].

Project description: The adequate living space became hardly reachable commodity in Hong Kong. The system that architect Gary Chang created in order to improve various functionality in spatially limited dwellings is based on more sliding walls. Concept as such, allows accommodating 24 different room scenario's in an area of just 32 m2. "The various uses and furniture are concealed within wall modules which can be moved along two axes. The bed is simply folded up into a vertical position, moved to the other side of the room and you are already in the kitchen, the TV room, the library or the spacious bathroom that even has room for a bathtub."[106] Additionally, such system covers range of daily actions dedicated also to zone adequate for seasonal storage, and even to zone for obtaining laundry cleaning and ironing.

[106] "References Categories Live + Work Apartment Gary Chang." Duravit. http://www.duravit.com/website/homepage/references/categories/live__work/apartment_gary_chang.com-en.html (accessed August 17, 2014)

5.1.3. Light as a dividing element

Besides the usual space separation elements like doors and wall systems covered in the previous chapter, the contemporary age shows examples where light is also used as a tool for visual separation of different functional units (e.g. Case study no.65: *Appartement spectral*). That method is particularly functional to very small dwellings where all or almost all of the living functions are organized in one single space.

Although not being a physical method, this different illumination may change the visual perception of spaces on different levels. For example, spaces may change their proportions – by adding more light some areas may look bigger, more important or more prominent. On the other hand, by reducing light intensity we could “hide” some parts that we do not want to be conspicuous. This hierarchical approach gives different zones a specific dominance, which actually deceives on the real size of the whole space.

A similar approach of different intensity or even colour diversity of light may be used to distinguish gathering and private zones of dwelling. For example, stronger or vivid colour light in the kitchen or living may emphasise the social area of the dwelling, while more muted or soft colours may create a visual distance between those and the night zones. In this way the degree of intimacy could be controlled but also changed very easily according to different emotional impressions. In fact, such techniques are already very common in theatre, dance, opera and other performing arts where different light effects on the same stage can evoke different experiences of the play.

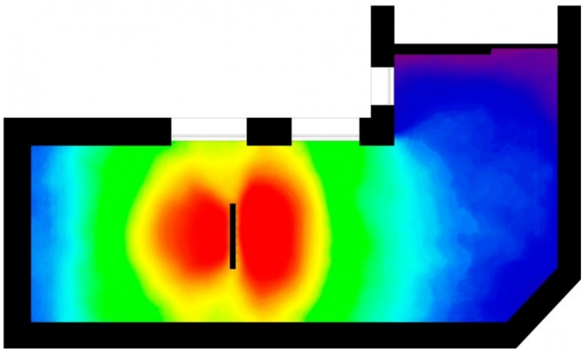


Fig.5.1.3.1. Organization of functional units by light
Picture source: [http://www.homedsgn.com (accessed 2nd November 2013)]

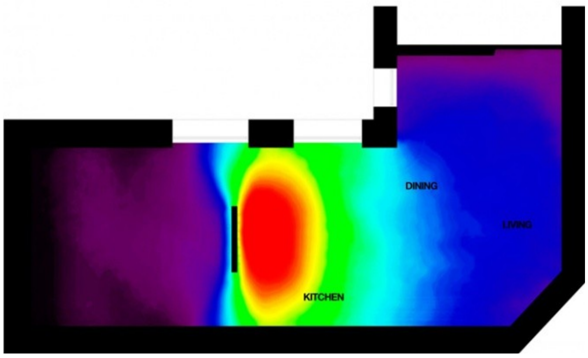


Fig.5.1.3.2. Organization of functional units by light
Picture source: [http://www.interiordesign2014.com/home-design-ideas/modern-apartment-in-paris-appartement-spectral-by-betillon-dorval-bory/ (accessed 2nd July 2013)]

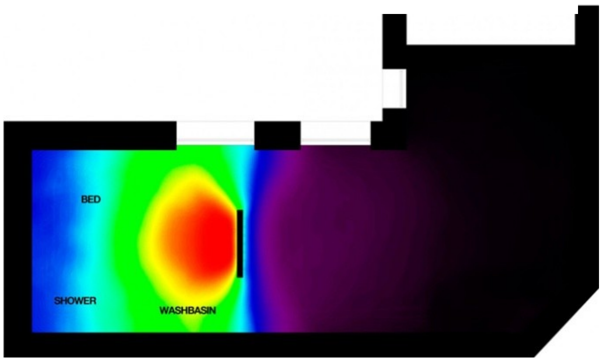


Fig.5.1.3.3. Organization of functional units by light
Picture source: [http://www.interiordesign2014.com/home-design-ideas/modern-apartment-in-paris-appartement-spectral-by-betillon-dorval-bory/ (accessed 2nd July 2013)]

Additionally, it is worth it to mention some new technological improvements based on light implementation in domestic spaces that may be considered relevant for possible future directions in spatially limited and flexible dwellings.

For example, according to the article *Light Matters: Creating Walls of Light*, in ArchDaily, today's trends in lighting are moving towards invisible light sources that fill spaces with a purer light. Techniques of lit walls are starting to be used to define the rooms and to structure the space architecture[107]. More specifically, "contemporary LED technology has led to a new light typology for walls: the self luminous wall with integrated LED pixels. The appearance of LEDs ranges from clear visibility to emphasize the technical character up to sophisticated design solutions, where the LEDs are concealed behind a translucent plane. Innovative options have emerged from the combination of colour changing LEDs, video control systems and sensors. These walls have left behind the pure white wall-washing of the rational international style and established a new generation of animated architecture with software programmable and responsive planes"[108]. (see Fig.5.1.3.4.).

Further upgrades based on the same principle which can be beneficial in flexible dwellings are LED wallpapers. According to the article *"Luminous LED Wallpaper Lends a Low-Energy Glow to Any Room"*, in Inhabitat, Philips company just teamed up *Kvadrat Soft Cells* to unveil a completely new breed of luminous wallpaper that could forever change the field of mood lighting[109]. These wallpapers are based on the combination of textiles with sound-absorbing properties and with integrated LED lights[110]. Accordingly, wallpapers are capable of displaying a broad range of LED colours and can therefore be used for variable mood ambiences of one single dwelling space.

Fig.5.1.3.4. (Left) Example of luminous walls systems. Source: "Light Matters: Creating Walls of Light." ArchDaily. http://www.archdaily.com/522257/light-matters-invisible-light-sources/ (accessed July 14, 2014). **Fig.5.1.3.5. (Right)** Example of luminous wallpapers. Source: "Luminous LED Wallpaper Lends a Low-Energy Glow to Any Room." Inhabitat Sustainable Design Innovation Eco Architecture Green Building Luminous LED Wallpaper Lends a LowEnergy Glow to Any Room Comments. [http://inhabitat.com/luminous-led-wallpaper-lends-a-low-energy-glow-to-any-room/ (accessed July 14, 2014)].

[107] "Light Matters: Creating Walls of Light." ArchDaily. http://www.archdaily.com/522257/light-matters-invisible-light-sources/ (accessed July 14, 2014).
[108] [Light Matters: Creating Walls of Light]
[109] "Luminous LED Wallpaper Lends a Low-Energy Glow to Any Room." Inhabitat Sustainable Design Innovation Eco Architecture Green Building Luminous LED Wallpaper Lends a LowEnergy Glow to Any Room Comments. [http://inhabitat.com/luminous-led-wallpaper-lends-a-low-energy-glow-to-any-room/ (accessed July 14, 2014)].
[110] [Luminous LED Wallpaper Lends a Low-Energy Glow to Any Room]

'appartment spectral' by Betillon / Dorval-Bory, France, 2013.

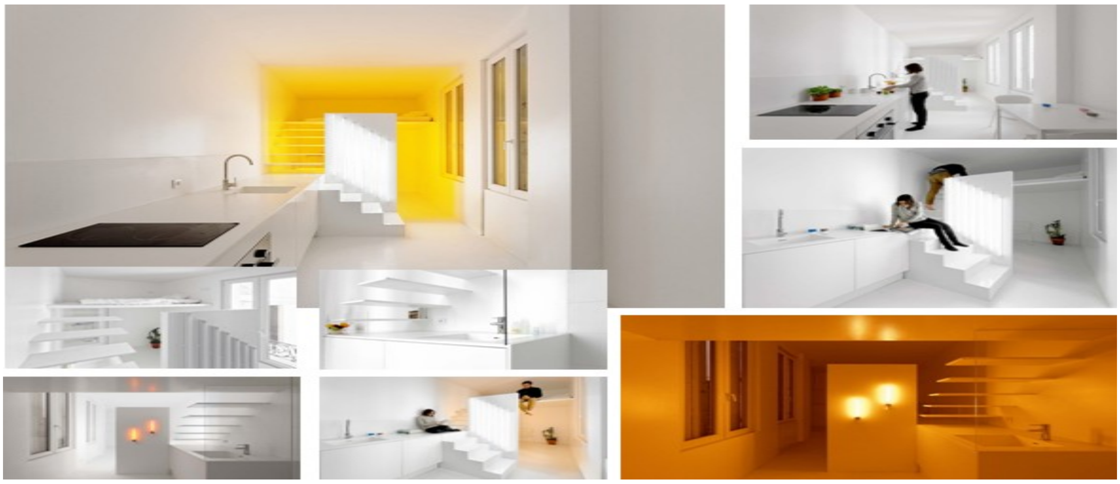


Fig.5.1.3.5. Light transformations inside space. Source: [http://www.designboom.com/architecture/betillon-dorval-bory-appartement-spectral-paris// (accessed 1 June 2013)].

Project description: This project conception is based on experimentation with color rendering index (CRI), which is considered as one of the fundamental criteria for evaluating light. To be more precisely, it is quantitative measure of the ability of a light source to reveal the colors, and depends on power of the spectral distribution of light. As such, color rendering index has ability to reflect accurate color of the surface. According to scientist JP Bourma, who identified the importance of CRI in 1948 (and then later qualified by the International Commision on Illumination), a "light with high CRI, close to 100, can render the colors properly (homogeneity in the spectral power distribution), while a low CRI is synonymous with loss of color range, so a disappearance of colors." [111]
Following this principle this project at first consists of an organization of space according on the spectral needs (e.g. which areas insist higher color rendering, and which one can be content with a very low color rendering). In that way also hierarchy of space is established: on one side is the kitchen and the living room, where distinguishing colors is required; and on the other side - the bed and the shower where monochromatic light suffices. As further explained in offical project description: "…this bipolarity between high and low CRI becomes the crucial element of space composition. Holding two separate light sources, a simple 2m high wall divides the studio and generates this composition. On one side an over 90 CRI lighting (940 fluorescent tubes) with a neutral color temperature (4000K), on the other side a warm light from low-pressure sodium lamps with zero CRI. Each of the two light sources produces about 16,000 lumens. The accurate analysis of the distribution of light in space then indicates the positioning of uses. Since there is no other source of artificial light in the studio those spaces are arranged in a form of free plan. As both sources can be switched independently, different lightning patterns appear, giving rise to unforeseen uses in particular areas of the apartment. The apartment is designed in a simple and neutral expression, without color or particular detail, annihilating any architectural expressiveness or narrative to leave only the logic of composition generated by light."[112]

[111] "Appartement Spectral / BETILLON / DORVAL-BORY" 07 May 2013. ArchDaily. Accessed 13 Nov 2014. [http://www.archdaily.com/?p=369075]
[112] "Appartement Spectral / BETILLON / DORVAL-BORY" 07 May 2013. ArchDaily. Accessed 13 Nov 2014. [http://www.archdaily.com/?p=369075]

5.1.4. Soft dividers and curtain walls

The development of new fabric technologies and the intelligent approach to structure composition brought various possibilities for more innovative space organizations with deformable building elements. In this case, "formal and spatial transformations are not the product of different specific and temporal constellations of essentially rigid, unchanging building elements [...] but instead result of movement within the element or the material itself"[113]. Therefore, this subchapter is dedicated to flexible elements that integrate two important factors in their development approach:

a) Use of new fabric composites (in order to develop additional properties of materials);
b) Creation of unconventional structures (in order to extend the flexible properties of a form).

With this in mind, people could rely on objects whose aim is to facilitate a greater freedom in adjusting the object to various forms that could best fit to their temporary functional (or even aesthetic) requirements inside the space.

a. Use of new fabric composites

If we want to approach the issue by firstly considering the new fabric improvements occurred nowadays, we must highlight that the experimentation of different fabric components joined together in order to extend or improve the efficiency of material properties has become an important research topic for many fields. Special achievements based on this issue relate to industries whose final product affects goals such as speed efficiency, balance efficiency, weights, etc. Therefore, among the main related industries that are carrying out researches in fabric technology there are the automotive industry, the train industry, the airplane industry as well as structural engineering in the field of product design and architecture. For example, in the car industry many researches focus on studying the lightweight fabric such as the *Carbonskin* developed by Lamborghini, which became the main tool to achieve a lighter weight of the vehicle's interior finishings (e.g. seats, upholstered parts in the interior of the car, or etc.). Besides being lighter in comparison with the usual and already widespread "pure" leather materials, this substitute material made of woven carbon fibres is more flexible and can be more easily cut into complex shapes. Additionally, this material can replace any other fabric and can be useful in the building and fashion industry as well.

In architecture, especially in fields relevant to the scope of this Thesis, the main purpose is to explore materials with supple properties. Therefore, all those materials made of combined textiles or ropes of natural or sinthetic origins, either woven or knitted, are having a great popularity: materials obtained from cellulose like papers or cardboards; other high-strenght fibrous composites made of glass, carbon, aramid, synthetic resin, elastomer, or thermoplastic; meshes made of brass, copper, bronze, aluminium, nickel, titanium, silver; and so on. That said, is important that such composition

[113] Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010, p. 47.

of fabrics has adequately strong directional material properties and that shows adequate stiffness and stability, as well as allowing easy deformation like strecthing, rolling or bending (see Fig.5.1.4.1.)[114]. In practice, these characteristics in fabrics can be useful if applied to flexible dividers between different functional zones inside and outside the dwelling.

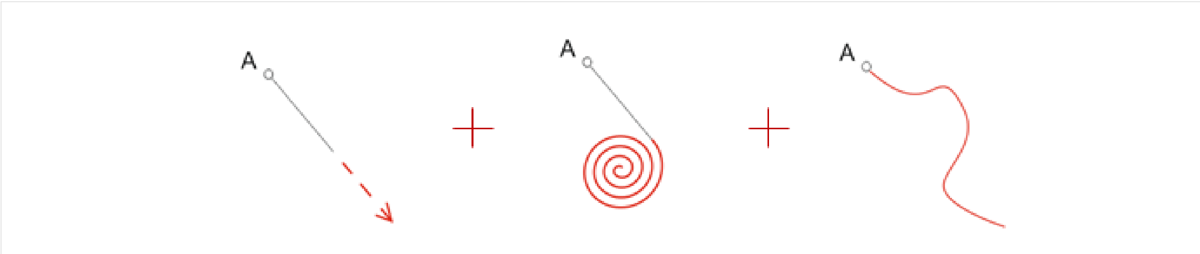


Fig.5.1.4.1. Desirable material properties in interior architecture: stretching + rolling + bending.

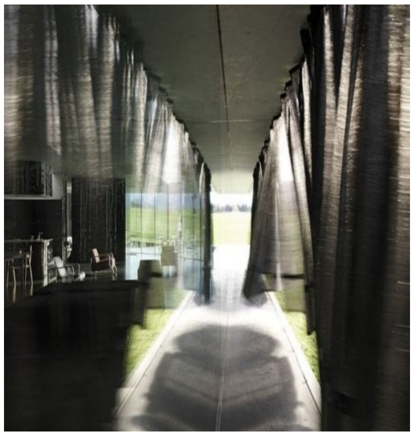


Fig.5.1.4.2. (Left) Metal textile curtain. *Houses on Hohenbühlstrasse*, by agps.architecture, Zurich, 2004. Source: Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010, p231; **Fig. 5.1.4.3. (Right)** Metal textile curtain as substitution of rigid walls. *47°40'48"N/13°8'12"E House* by Maria Flöckner and Hermann Schnöll, Salzburg, 2007. Source: Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010, p233.

[114] Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010.

Mesh fabrics by AlphaMesh company, Germany

Fig.5.1.4.4. (Left/Middle/Right) Various aplication of mesh fabrics, by AlphaMesh. Picture sources: [http://www.alphamesh.de/index.php?page=spielerisch-neues-entwickeln-2 (accessed 12th November 2013)]

Fig.5.1.4.5. Fabric created by weaving technology with finely spun stainless steel yarns lending the fabric a restrained elegance for unique moulding and shaping properties, by AlphaMesh, Germany. Picture source: [http://www.alphamesh.de/index.php?page=seda-2 (accessed 12th November 2013)]

Fig.5.1.4.6. *Phenomena* fabric made of combination of stainless steel + copper, by AlphaMesh, Germany. Picture source: [http://www.alphamesh.de/index.php?page=vision-2 (accessed 12th November 2013)]

Fig.5.1.4.7. (Left/Right) Stainless steel curtains made of rings, by AlphaMesh, Germany. Picture source: [http://www.alphamesh.de/index.php?page=Steffel-department-store (accessed 12th July 2014)]

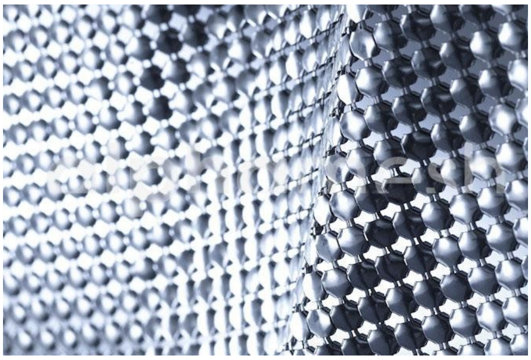


Fig.5.1.4.8. Various fabric products by AlphaMesh. Picture source: [http://www.alphamesh.de/index.php?page=scale-mesh (accessed 20th July 2014)]

"SCALE MESH **Alphamesh: the scale mesh.** Alphamesh scale mesh defines a new quality of material for metal meshes utilised in architecture and design. The flexible mesh resolved the heaviness and coldness of conventional metallic surfaces. Light forms and exclusive structures in elegant radiance suggest the association with sequins of ornate clothing. And many fashion designers have already discovered alphamesh scale mesh for their collections.

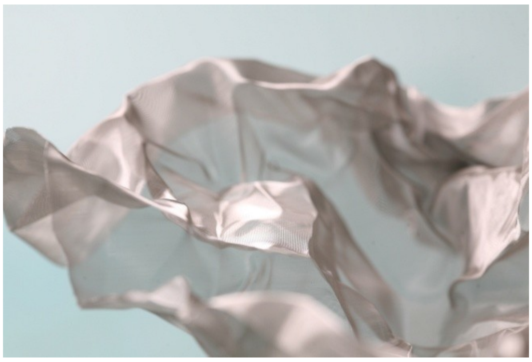
Qualities
Alphamesh scale mesh is available for architects, interior designers and designers in two different material versions, brass or aluminium. The capsule (scale) diameter of 5.8 mm and the number of capsules per square metre (27,750) is the same for both variations. Every capsule combines four ring elements in a mesh grid of 6 mm to one unit. Naturally the weight per square metre of both scale meshes is different: here the brass scale weighs twice as many kilos as the mesh made of aluminium scales.

Manufacture
Alphamesh scale meshes are produced with a specially developed manufacturing process. The scale mesh is available as delivered goods in the maximum dimensions of 3 m (height) x 6 m (width). Individual dimensions can be manufactured on request.

Characteristics
Alphamesh scale meshes are design-oriented, formative elements of architecture, interior design and creative applications. Flexibility, lightness and the special structure of the mesh underscore the high measure of stand-along appearance. The material acquires individuality through the possibility to design the typical capsules/scales in colour.

Inside or outside?
Alphamesh scale mesh is predestined for applications inside a building. But this does not preclude application in outdoor areas. In order to be able to guarantee the valuable appearance and integrity of the scale mesh, the separate scrutiny of any outdoor application is advisable."[115]

[115] Description of the product taken from official webpage of Alphamesh, Germany. Source: [http://www.alphamesh.de/index.php?page=scale-mesh (accessed 20th July 2014)]



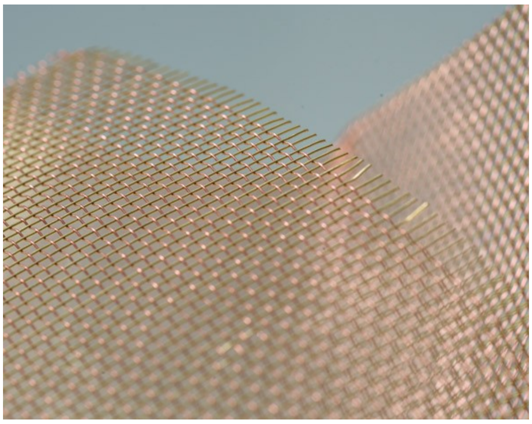


Fig.5.1.4.9. Various fabric products by AlphaMesh – *SEDA* (up picture), *IGUANA* (picture in the middle), *TESORO* (picture down) *fabric.* Picture source: [http://www.alphamesh.de/index.php?page=fabrics-2 (accessed 20th July 2014)]

"Such fabrics, as dreams are made on.
alphamesh fabrics present an assortment of fabrics for architectural uses and impressive interior design application capabilities. The particularity of these fabrics are enhanced by the weft yarns which are all in 100% metal. *alphamesh* fabrics are produced using stainless steel, brass, copper and aluminium yarns resulting in materials providing the haptic feedback and the appeal of fabrics, yet featuring the properties of metals.

Materials and weave constructions.
weft yarns combined with re-engineered weaving techniques result in the individual *alphamesh* fabrics weave constructions. *seda* and *iguana* are woven implementing a stainless steel yarn with a diameter of barely 0.05 millimetres. Although the metal thread is four times thicker than a silken thread, this has no effect whatsoever on the fabric's fine surface ductility.

iguana is extraordinarily enhanced by a vibrantly embossed reptile-motif surface structure.
tresoro and vision showcase a play of surface weaves engineered using a dynamic combination of different warp and weft metal yarn counts. The golden glow typical of *tresoro* is provided by a genial interplay of brass and copper, whilst vision gets its fiery hue from the artful merging of stainless steel and copper, enhanced by the lacquered copper yarn. *cubo* showcases a traditional cubic weave construction highlighted by the aluminium yarns providing an especially compelling surface effect.

2 or 3 dimensional.
A consistently malleable formability is ensured by the unique metal yarn properties. Properties that alphamesh fabrics simply highlight and magnify. Meaning that not only do the alphamesh fabrics provide spectacular surface effects, but they can also be moulded into permanent sculptures or three-dimensional objects. Whilst the freeform alphamesh fabrics surface structures make them ideal for use as extremely delicate room partitioning membranes or as a three-dimensional spatial cladding solution in structured-space interior decorating solutions.

Indoors or outdoors?
Wherever and whatever their use, the especially hardy metal fabric properties by alphamesh fabrics remain constant over time. Although they are extremely light, these metal properties allow them to be particularly resistant in any climate. With the added benefit that in as far as safety issues are concerned, the alphamesh fabrics are virtually non-flammable and flame-retardant. Making *seda*, *iguana*, *tresoro*, *vision* and *cubo* the best option for versatile design highlights.Be it indoors or outdoors."[116]

[116] Description of the product taken from official webpage of Alphamesh, Germany. Source: [http://www.alphamesh.de/index.php?page=fabrics-2 (accessed 20th July 2014)]

NYA NORDISKA Company, Germany.

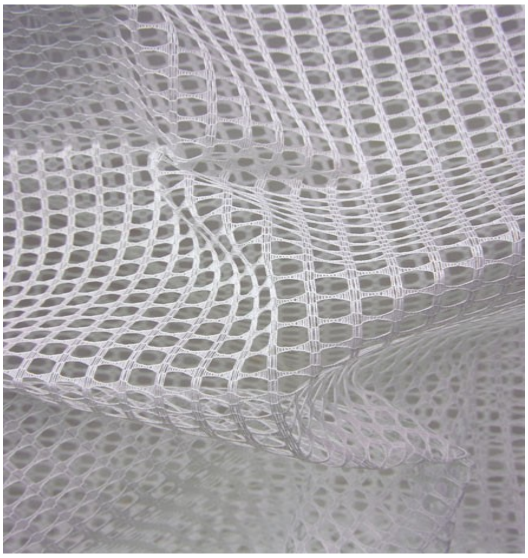


Fig.5.1.4.9. *Ypsilon CS* fabric product. *Ypsilon CS* is a knit fabric, produced on a knitting machine. Made of 100% Trevira CS, Ypsilon CS is an ideal fabric for architects because it can be easily applicable as room dividers and as screen panels.
Source: [http://www.nya.com/product/ypsilon-cs (accessed 12th August 2014)].

b. Creation of unconventional structures

When fitted with the additional material properties described in the previous subchapter, objects can have a possible extended usability in terms of form or purpose. For example, *Flake* is a product developed by Woodnotes Company in Finland. It could be used as a screen on door and window openings, but also as a room divider inside the space, carpet, or table decoration. Its specific structure is made of interlocking snowflake-like pieces of flash spun high-density polyethylene fibres known as Tyvek. This material is very strong; difficult to tear, but at the same time it can be easily cut with scissors or a knife. Additionally, it has the capability to hold liquid water, while water vapour can pass through it[117].

Fig.5.1.4.10. *Flake* curtain made of snowflake like pieces joined together by slipping the point of a flake through the hole of another flake. Such structure can be created as compact or a net-like, loose surface. Additionally, three-dimensional forms are also possible. Design by Mia Cullin, for Woodnotes Company, Finland. Source: [http://www.woodnotes.fi/product_range/accessories/interior_elements/ (accessed 22th July 2014)].

Furthermore, in the context of use of cellulose materials, we could mention the example of *Paper Softwall* by Stephanie Forsythe and Todd MacAllen, made of paper with translucent characteristics. The structure itself is made of repetitive layers of honeycomb shapes that help strengtheing the fragile paper material. “The partition’s many paper layers are bound together at each end by wool felt covers, which fold to create handles for manipulating the wall while it is stretched open and create a protective covering when the wall is collapsed to be stored“[118]. Lightweight and flexible, the freestanding wall can be arranged in numerous ways, empowering users to reconfigure open space into more intimate provisional enclosures“[119]. […] It represents a “delicate material composition, but it also refers to its structural capacity to be stretched and compressed to create a range of forms not possible with more rigid, fixed partitions. In addition, the multiple accordion folds of translucent paper in the wall’s surface absorb light and emit a hazy glow, imparting a subtle softness to interior space“[120].

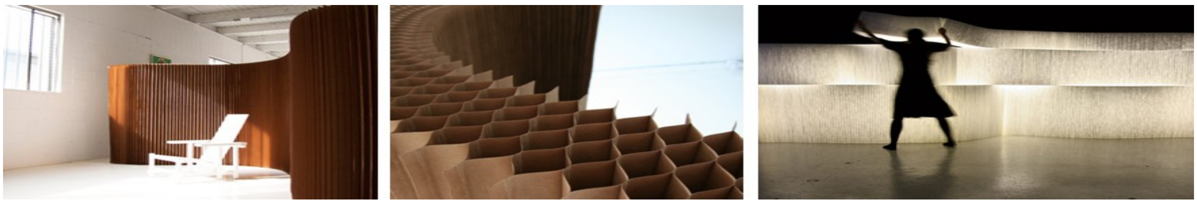
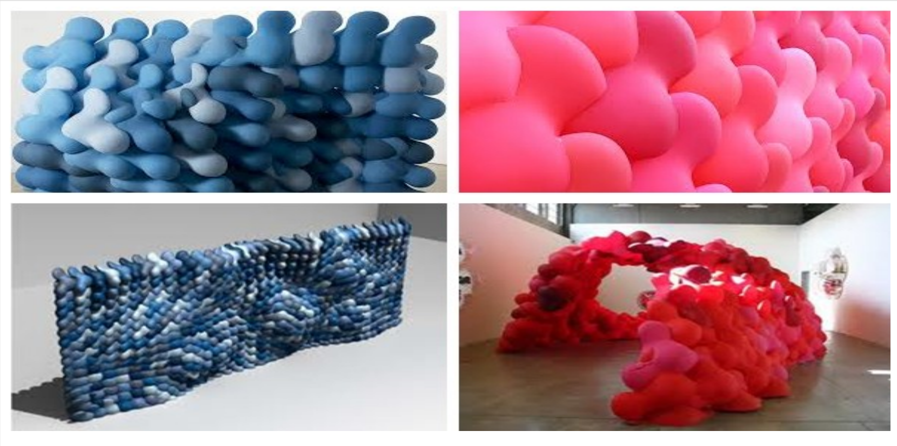


Fig.5.1.4.11. (Left/Middle/Right) Flexible wall structure made with brown and translucent white paper structure. *Paper Softwall* by Stephanie Forsythe and Todd MacAllen. Source: http://www.architonic.com/pmsht/softwall-softblock-natural-brown-kraft-paper-molo/1069017 (accessed 20th July 2014)]

[117] “Tyvek”. Source: [http://en.wikipedia.org/wiki/Tyvek (accessed 19th July 2014)]
[118] *MoMA Highlights since 1980,* The Museum of Modern Art, New York: The Museum of Modern Art , p. 216. Source [http://www.moma.org/collection/object.php?object_id=94960 (accessed 12th June 2014)].
[119] [MoMA Highlights since 1980]
[120] [MoMA Highlights since 1980]

Blobwall by Greg Lynn



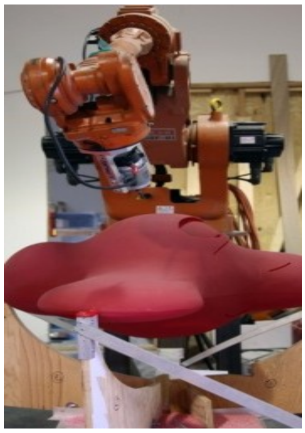


Fig.5.1.4.12. Variable forms made by partitioning system built up of large individual "blobs". Source: [[http://www.iconeye.com/news/news/greg-lynns-blob-wall (accessed 21st March 2014)].

Fig.5.1.4.13. Production proces of a single unit. Source: [http://www.iconeye.com/news /news/greg-lynns-blob-wall (accessed 21st March 2014)].

Project description: *Blob Wall* could be considered as system built up of individual parts (or *blobs*) joined together. Blobs are rotationally moulded from recyclable plastic. The capabilities of such system allow construction of variable forms that can be used in interiors as freestanding walls, screens, or even as freestanding furniture (e.g. sofa). As such, functional uses may be adjusted to various volumes that can be easily assembled, disabled and modified according to the need.[121]

Modular Amass Curtain system by Benjamin Hubert

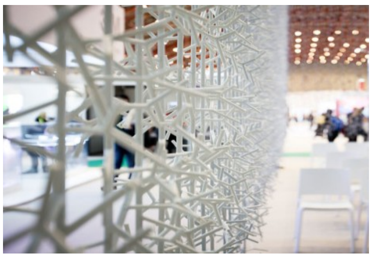


Fig.5.1.4.14. Curtain structure; **Fig.5.1.4.15.** Curtain detail; **Fig.5.1.4.16.** Strructure partitions. Source: [http://inhabitat.com/benjamin-huberts-modular-amass-system-creates-nature-inspired-curtains-and-walls/ (5th Dec 2013)]

Project description: "Inspired by the controlled randomness found in nature, Benjamin Hubert's three simple, reusable modules are evocative of tree branches or the structure of cells. When clipped together they can form curtains, dividers and walls of varying thickness as well as adaptable 3D structures.The modules are fashioned from injection moulded polypropylene, and they come in a variety of colors. At London's 100% design trade show during the London Design Festival they took center stage – Hubert's team used the Amass system to effectively define presentation spaces, without excluding passers-by from seeing and hearing what was going on inside. With its subtle and futuristic good looks, we expect the scalable Amass system to even pop up in interior spaces such as offices and even homes."[122]

[121] [http://www.iconeye.com/news/news/greg-lynns-blob-wall (accessed 21st March 2014)].

[122] [http://inhabitat.com/benjamin-huberts-modular-amass-system-creates-nature-inspired-curtains-and-walls/ (accessed 5th Dec 2013)]

Soft House by Stephanie Forsythe and Todd MacAllen , Forsythe + MacAllen Design, Vancouver, 2003.

Fig.5.1.4.17. thinwall is a flexible paper space partition. Measuring only 8.75cm (3.5”) wide, it offers diverse new applications such as an acoustic, sculptural interior space liner for solid walls, columns, and ceilings; a flexible wrap for closet/storage areas, reception desks, and other millwork; or a partition for shaping more intimate areas within any larger space. Source: "The Velvet Highway." [http://www.velvethighway.com (accessed 15th August 2014)].

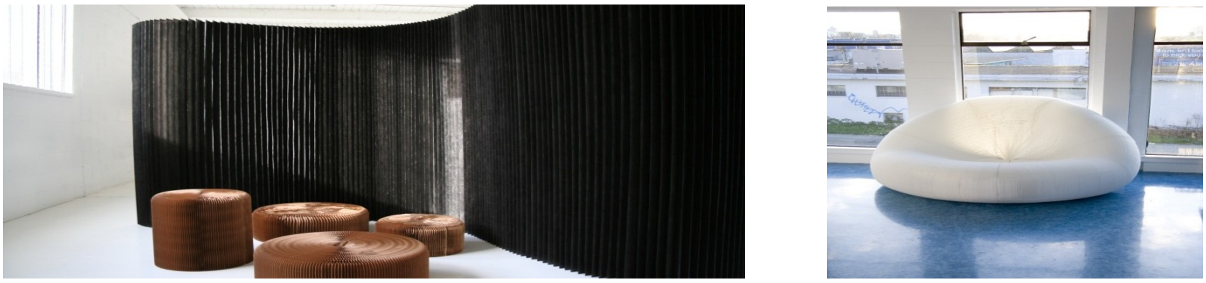


Fig.5.1.4.18. vertical panels (soft walls/ blocks) of various heights for various additional purposes like dining chairs, sofa’s, coffee tables, and etc. Source: "The Velvet Highway." [http://www.velvethighway.com (accessed July 22, 2014)].

Project description: Initial motivation of authors to develop various interior elements based on unconventional approach to structure and functionality, is dissatisfaction with so far noted creative limitation in using accordion pleats. Through they work they wanted to examine extended possibilities of these kind of similar structures by creating furniture objects and various interior elements (e.g. such as space dividers or screens). Consequently, by improving and exploring the structural strength inherent in the honeycombed construction they manage to achieve a solid base element that can allow creation of entire range of interior and design products. The result was called *Soft Products* – the wide range collection of lighting elements, seating furniture, vertical panels of various dimensions and potential uses (e.g. room divider, bar, coffee table, etc.). As it is stated in more detailed official project description by authors, the elements are made from “brown craft paper or a non-woven polyethylene fibre textile in white or stained with a bamboo charcoal ink that creates a rich lively black that allows the texture of the fibre to show, the colour palette is limited. Yet due to its open honeycomb structure and the thinness of the layers a light source in proximity does effect colour change and was very much considered within the original concept.

Made from simple lightweight sheets of humble materials such as paper and non-woven textiles, the honeycomb geometry lends these structures high strength and flexible resilience, with an economy of material resource. […] *Soft* is a product line conceived of the desire to dynamically shape and redefine open space into more intimate and ephemeral surroundings, in a flexible and temporal way. Utilizing flexible honeycomb structures that can expand, contract, and flex to form a sculptural space or seating topography, *Soft* is an evolutionary, materials research driven exploration of possibilities. The elements of the *Soft* collection have been designed to be used and re-used in a flexible and dynamic way, replacing the need for more costly and inflexible alternatives for partitioning and arranging space. “[123]

[123] "The Velvet Highway." The Velvet Highway. [http://www.velvethighway.com/joomla/index.php?option=com_content&task=view&id=78&Itemid=78 (accessed July 22, 2014)].

Joyn by Hyroshi Tsunoda, 2007.


Fig.5.1.4.19. Hexagon shaped structure for multiple uses.
Source: [http://www.yankodesign.com/2007/06/13/joyn-divider-curtain-wall-art-by-hiroshi-tsunoda/#3cFyZSkjoTig66O8.99 (accessed 12th November 2013)]

Project description: *Joyn* are hexagon shaped pieces that can easily be attached to one another to form an object with multiple uses. It's perfect divider for all types of spaces, both for private and professional use. There is no need for a standing structure; it's connected and swiftly hung up, on a steel cable using the accompanying attachment pieces, or directly to the wall using a number of fixation methods. *Joyn* can be put together in countless aesthetic and functional ways.[124]

[124] Design, Yanko. "Categories." Joyn – Divider, Curtain & Wall-art by Hiroshi Tsunoda » Yanko Design. July 13, 2007. Accessed November 11, 2013. http://www.yankodesign.com/2007/06/13/joyn-divider-curtain-wall-art-by-hiroshi-tsunoda/#3cFyZSkjoTig66O8.99.

5.1.5. Plug-in/out capsules

The idea that a small unit could be multiplied in order to design the structure in bigger scale become common with the appearance of Archigram in the 1960s and projects like Moshe Safdie's *Habitat 67* (1967), or Kisho Kurokawa's *Nakagin Capsule Tower* (1972). Usually created as affordable living solutions, these interiors are based on autonomous cells representing different functional units that can be organized together in infinite variations and could "grow" and be reduced as desired. Although being based on a very flexible interior method, these solutions were shown to be not so adequate for long-term living. The main problem is maintenance over time because of the sheer cost of disassembling a module in order to update the technology or replace the model altogether"[125]. These modules usually "rely on heavy infrastructure which can not be manipulated without deep, invasive and expensive intervention, what is difficult to justify in the lifecycle costs of the building".[126] Along with these technical problems, some of these solutions became soon outdated because aesthetic preferences also changed over time and because they represented ideas, styles and constructions difficult to change and adapt to individual living patterns or new styles and technology in coming[127]. Anyway, to support short-term living they should be taken in consideration as an option.

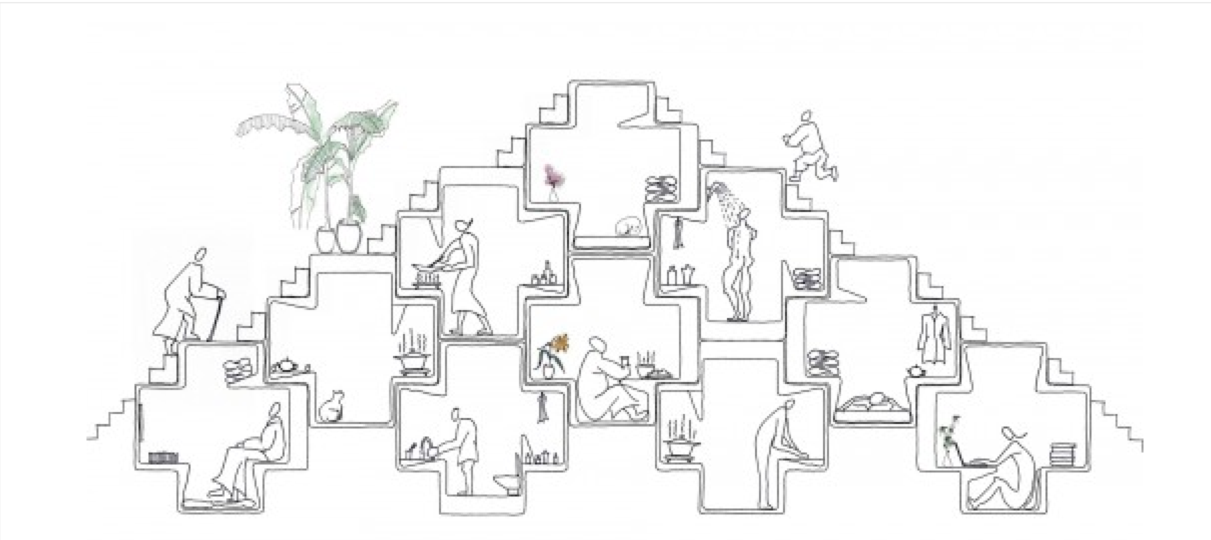
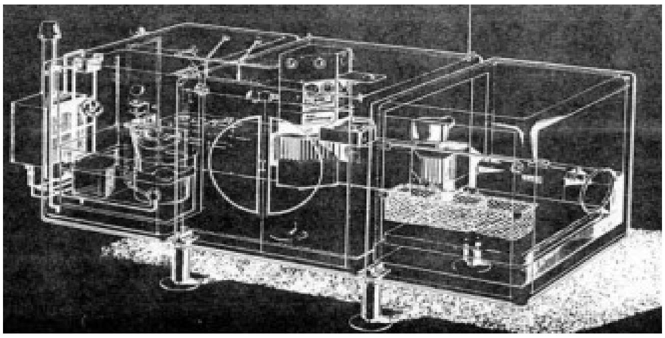


Fig.5.1.5.1. Micro-House, by Studio Liu Lubin. Source: [http://www.archdaily.com/379927/micro-house-studio-liu-lubin/51a6c905b3fc4b39ee00032a_micro-house-studio-liu-lubin_-png/ (accessed 12th November 2013)]

[125] Smith, Ryan E.*Prefab architecture: a guide to modular design and construction*.Hoboken, N.J.:John Wiley &Sons,2010,p40
[126] (Smith, 2010. p40)
[127] (Smith, 2010)

Living capsules by Kisho N. Kurokawa, 1972.



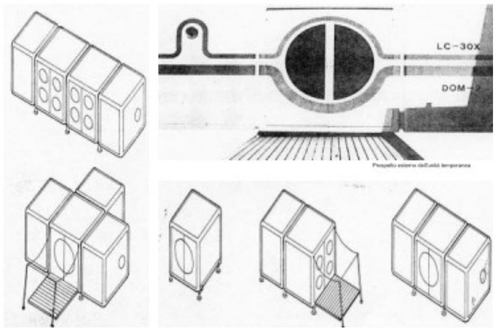


Fig.5.1.5.2. (Left) View on the interior organization divided by modules.; **Fig.5.1.5.3.** (Right) Combination of modules. Source: “Abitazioni ed Aspetto Morfologico “[http://www.b3b6b.it/_arredo0405/NuoviFile/Repertorio3.pdf (accessed 12th May 2014)].

Hexacube by Gorges Candilis, Anja Blomstedt, 1974.

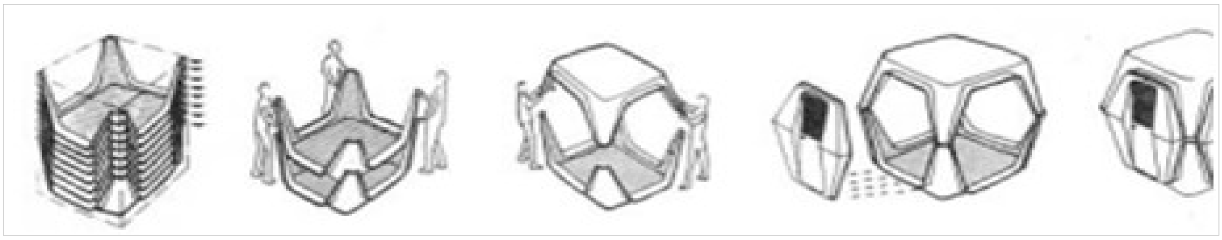


Fig.5.1.5.4. Assembly phases of a module. Source: “Abitazioni ed Aspetto Morfologico” [http://www.b3b6b.it/_arredo0405/NuoviFile/Repertorio3.pdf (accessed 12th May 2014)].

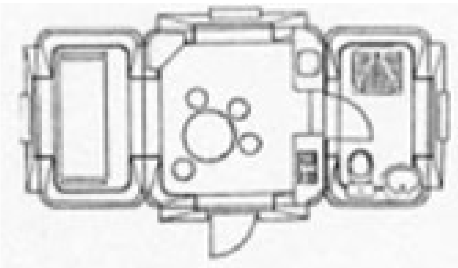


Fig.5.1.5.5. Example of layout of three modules joined together.
Source: “Abitazioni ed Aspetto Morfologico” [http://www.b3b6b.it/_arredo0405/NuoviFile/Repertorio3.pdf (accessed 12th May 2014)].

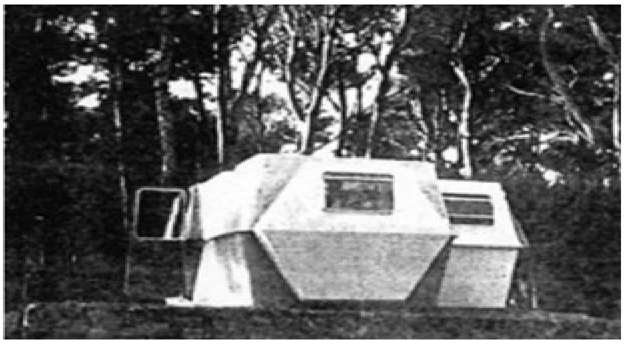


Fig.5.1.5.6. Example of assembled modules. Source: “Abitazioni ed Aspetto Morfologico” [http://www.b3b6b.it (accessed 12th May 2014)].

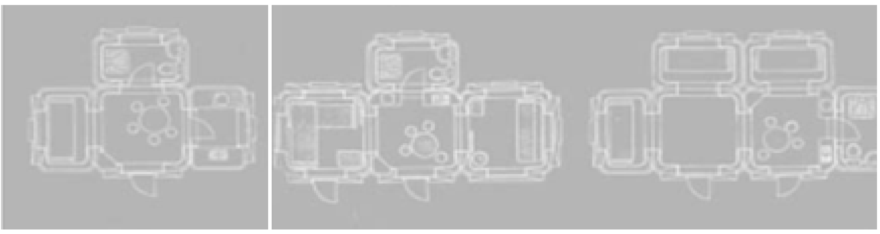


Fig.5.1.5.7. Example of various layout combinations.
Source: “Abitazioni ed Aspetto Morfologico” [http://www.b3b6b.it (accessed 12th May 2014)].

EcoPod by Howeler + Yoon Architecture, 2013.

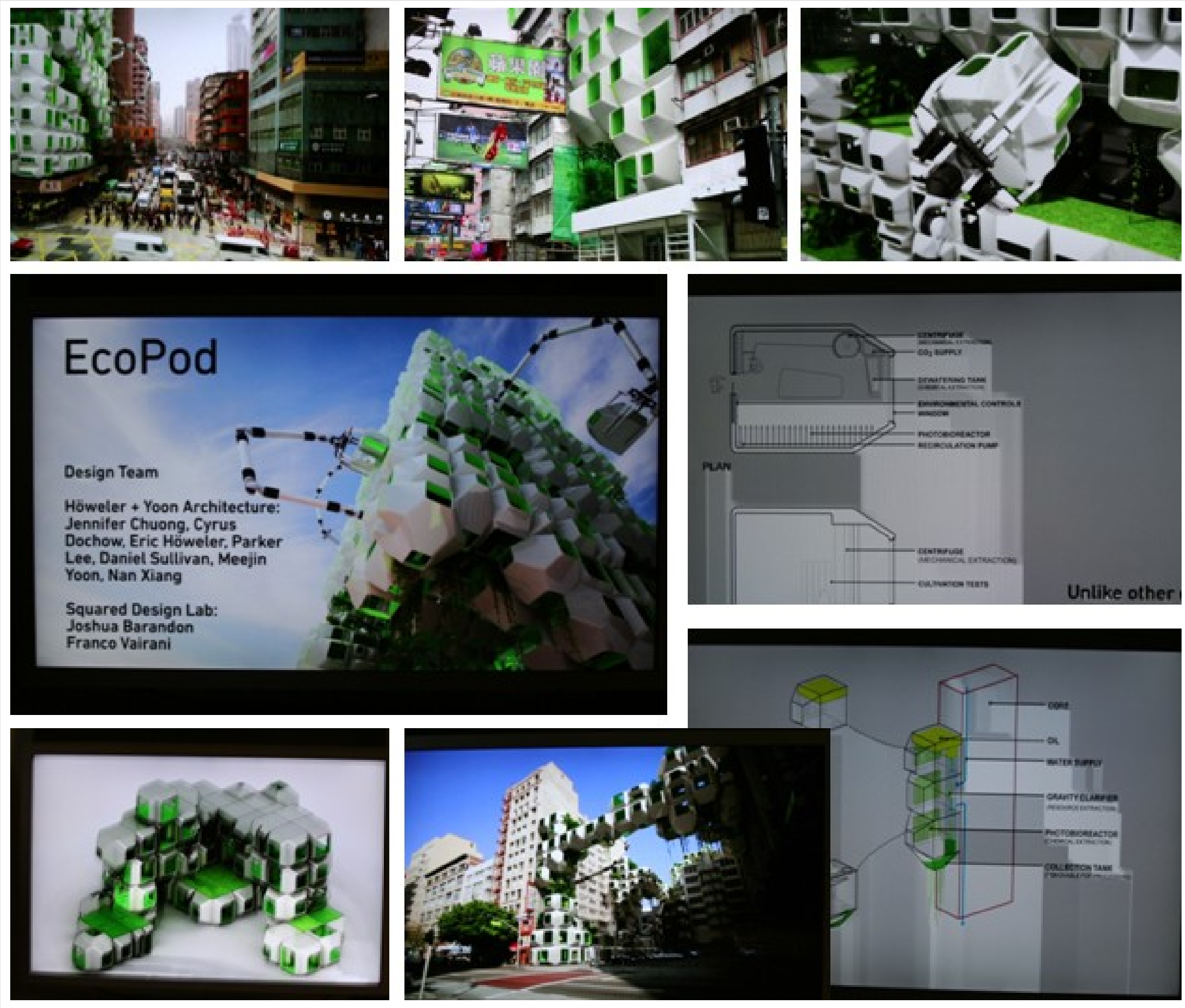


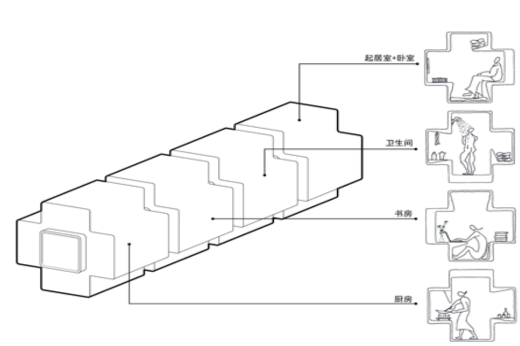
Fig.5.1.5.8. Eco Pod concept. Source: Pictures taken on exhibition in Het Nieuwe Instituut in Rotterdam, 2013.

Project description: This project represents a conceptual residential structure made for city of Boston. This concept is based on building with not strict dimensional boundaries but on capability to be expanded and spread either in horizontal and vertical directions. As such, it contains capability to be formed in the way which is most adaptable to any of eventual changes that are about to happen in surrounding urban context. A basic structure is made of modular pods that are constructed in the way to be continuously rearranged by robotic arms (see the Fig.5.1.5.8.) to ensure the functionally efficient structure both for occupants and surrounding environment.[128]

[128] "Eco-pods by Howeler + Yoon Architectureand Squared Design Lab - Dezeen." Dezeen Ecopods by Howeler + Yoon Architecturebrand Squared Design Lab Comments. [http://www.dezeen.com/2009/10/02/eco-pods-by-howeler-yoon-architectureand-squared-design-lab/ (accessed July 22, 2014].

MicroHouse by Studio Liu Lubin, Beijing, 2012.

Fig. 5.1.5.9. *MicroHouse* concept – view on exterior and interior. Source: "Micro-house / Studio Liu Lubin." ArchDaily. [http://www.archdaily.com/379927/micro-house-studio-liu-lubin (accessed August 19, 2014)]



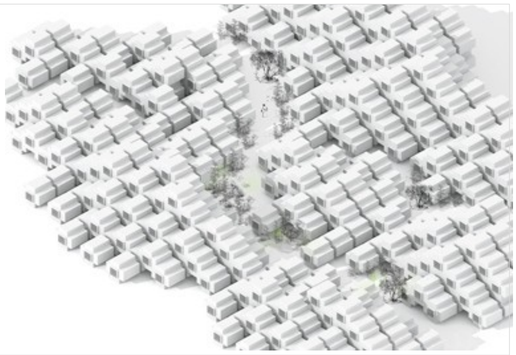


Fig. 5.1.5.10. (Left) *MicroHouse* concept – functional concepts of the modules; **Fig.5.1.5.11.** *MicroHouse* city. Source: "Tetris-Like Micro House Can be Stacked to Form Expanded Housing Suites." Inhabitat Sustainable Design Innovation Eco Architecture Green Building Micro House by studio Liu Lubin Comments. [http://inhabitat.com/tetris-like-micro-house-can-be-stacked-to-form-expanded-housing-suites/micro-house-by-studio-liu-lubin-21/ (accessed August 19, 2014)].

Project description: This micro living concept created by Chinese architect Liu Lubin represent cross-shaped modules that can be attached together, and as such, have capability to "grow" in infinite forms. The basic motivation is to provide a compact private space for obtaining strictly essential living activities for the people (e.g. work space, sleeping space, bathroom and dining room). With such flexible possibilities, these modules can be organized as a basic dwelling. For example, three module house can contain a bedroom, a bathroom and a small office; four modules joined together can contain two bedrooms, a bathroom and dining room, and etc. Furthermore, the modules are designed to fit into shipping containers and therefore can be transported easily to different locations if necessary. Finally, such compact volume of modules allows them to bypass current restrictions governing private homes that are currently present in China.[129]

[129] "Micro House in Tsinghua by Studio Liu Lubin." Dezeen Micro House in Tsinghuabr by Studio Liu Lubin Comments. Source: [http://www.dezeen.com/2013/06/29/micro-house-in-tsinghua-by-studio-liu-lubin/ (accessed July 22, 2014)]

5.1.6. Expandable structure

Flexibility of interior settings could be achieved also with structures that can change and expand their floor area when needed. In this case the load-bearing structure is usually made in a way to support linear and reversible motion of certain parts of the space. Besides linear transformation, vertical space changeability might be another option to consider, but the case studies related to this type of flexibility apply to either larger-space dwellings or public spaces, for which they are out of the scope of this thesis (e.g. *Villa in Bordeaux* by Rem Koolhaas, 1998; *LaboShop* by Mathieu Lehanneur, Paris, 2008; *Cocobello mobile studio* by Peter Haimerl, Vienna, Munich, Rotterdam, 2003; etc).
In fact, such “expandable” design is mainly due to the fact that these structures are meant to be transported, therefore the whole structure has spatial restrictions. The positive consequence is that when the structure is unloaded on its position and expanded, it offers additional functional units (e.g. an additional sleeping room) or simply gives the occupants more qualitative and comfortable options to use the space.

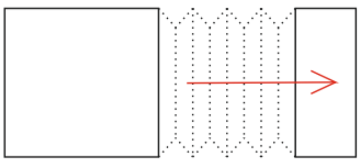


Fig.5.1.6.1. Method of expansion of floor area based on stretchable model

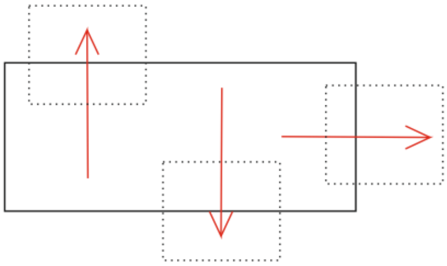
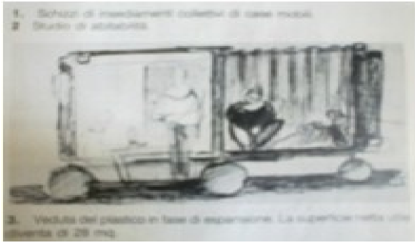


Fig.5.1.6.2. Method of expansion of floor area based on disassembly model

Ambiente Mobile / Mobile House by Alberto Rosselli, Italy, 1972.



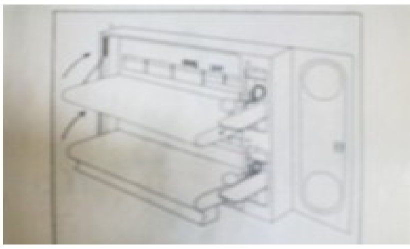


Fig.5.1.6.3. (Left) Sketch of expandable unit; **Fig.5.1.6.4.** (Middle) View on the foldable bed partitions; **Fig.5.1.6.5.** (Right) Expansion towards exterior space. Source: Ottolini, Gianni, and Vera Prizio. *La casa attrezzata: qualità dell'abitare e rapporti di integrazione fra arredamento e architettura*. Napoli: Liguori, 1993. p245.

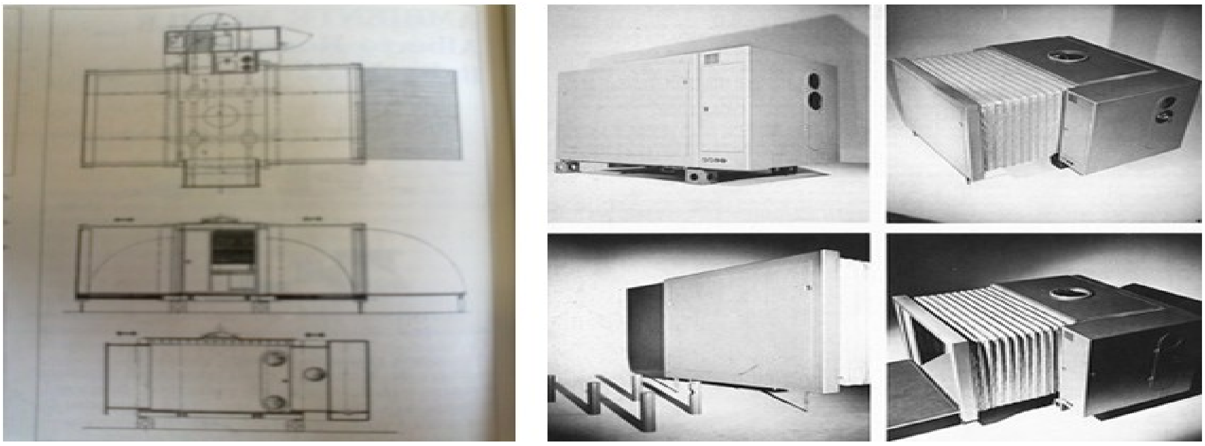


Fig.5.1.6.6. (Left/Right) Possible expansions of basic module. Source: Ottolini, Gianni, and Vera Prizio. *La casa attrezzata: qualità dell'abitare e rapporti di integrazione fra arredamento e architettura*. Napoli: Liguori, 1993. p245.

Habitation Unitby Marco Zanuso / Richard Sapper, Italy, 1971.

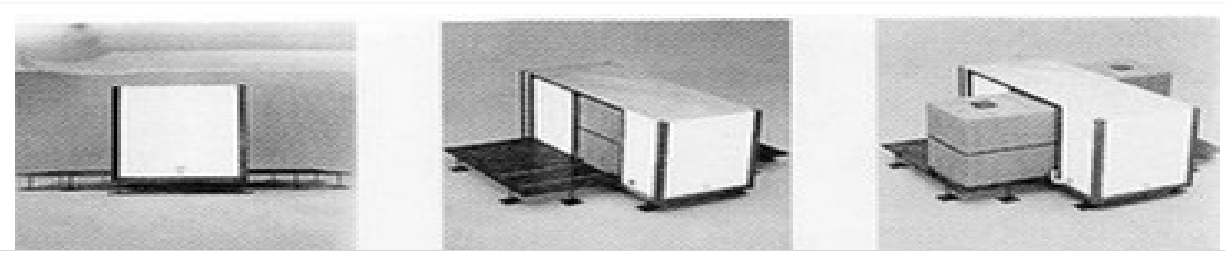


Fig.5.1.6.7. Possible expansions of basic module. Source: Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.* New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972. p133.

Fig.5.1.6.8. View on interior spaces. Source: Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972. p198.

Joep Van Lieshout, Paris, New York, Los Angeles, 1995/96.

Fig.5.1.6.9. View on the external expandable partitions. Source: "Abitazioni ed Aspetto Morfologico" [http://www.b3b6b.it/_arredo0405/NuoviFile/Repertorio3.pdf (accessed 12th November 2013)].

Fred by Kaufmann 96, Austria, 2000.

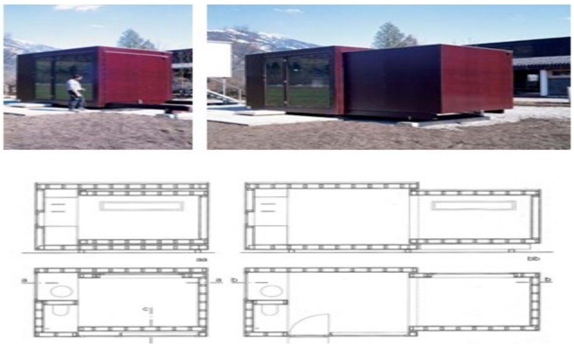


Fig.5.1.6.10. (Left) View on the external expandable partitions; **Fig.5.1.6.11.** (Right) View on the interior. Source: [http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=126&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=4 (accessed 2nd July 2013)]

Project description: Fred is one of the few projects to explore the idea of built in expandability. It is a timber container that consists of two boxes: one outer box of 3 by 3 by 3 metres and one which is slightly smaller that slides inside the bigger one. In its retracted state, it provides an interior area of 8 m2; when pulled out it has a total area of 15 m2. Kitchen and bathroom, a small room with WC and integrated shower, are in the fixed part, with the remaining area is open for interpretation. Delivered on the back of a lorry, Fred can be assembled within the space of two hours. The box sits on six steel feet: four feet support the larger outer volume and two further feet carry two bearers, extended from the large box, on which the sliding box can rest. To be entirely independent as a unit, Fred would have to be connected to the sewage system, but could then be used as an office, guest room or additional living space. Whilst not designed as a long-term dwelling, Fred introduces a new aspect to flexible design. [130]

[130] Source: [http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=126&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=4 (accessed 2nd July 2013)] and 'Mobiles Haus - Fred', *Detail*, 2001, pp. 408-11.

Box2 by SPOT - STUDIO POLENTA TECCO ARCHITETTI ASSOCIATI, Italy, 2006.

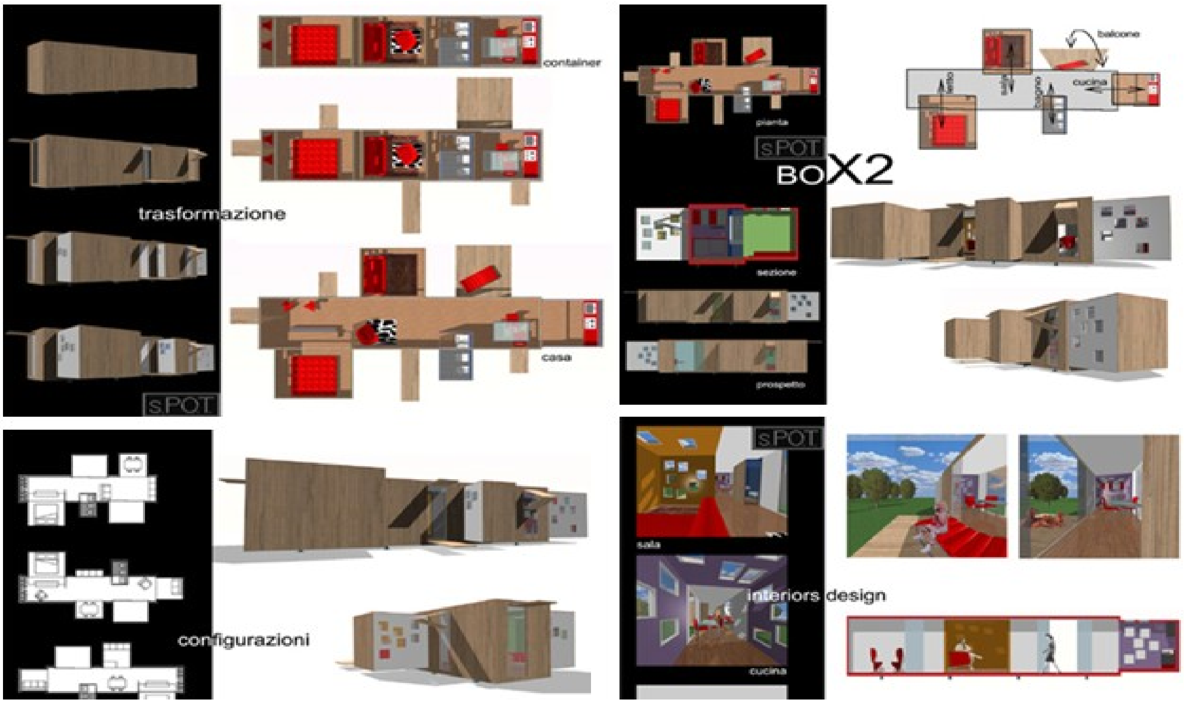


Fig.5.1.6.12. Project presentation posters. Source: [http://europaconcorsi.com/projects/20865-Box2/images/656177 (accessed 3rd July 2013)]

Pack'n go House by Marco Colombo, arch., Italy, 2006.

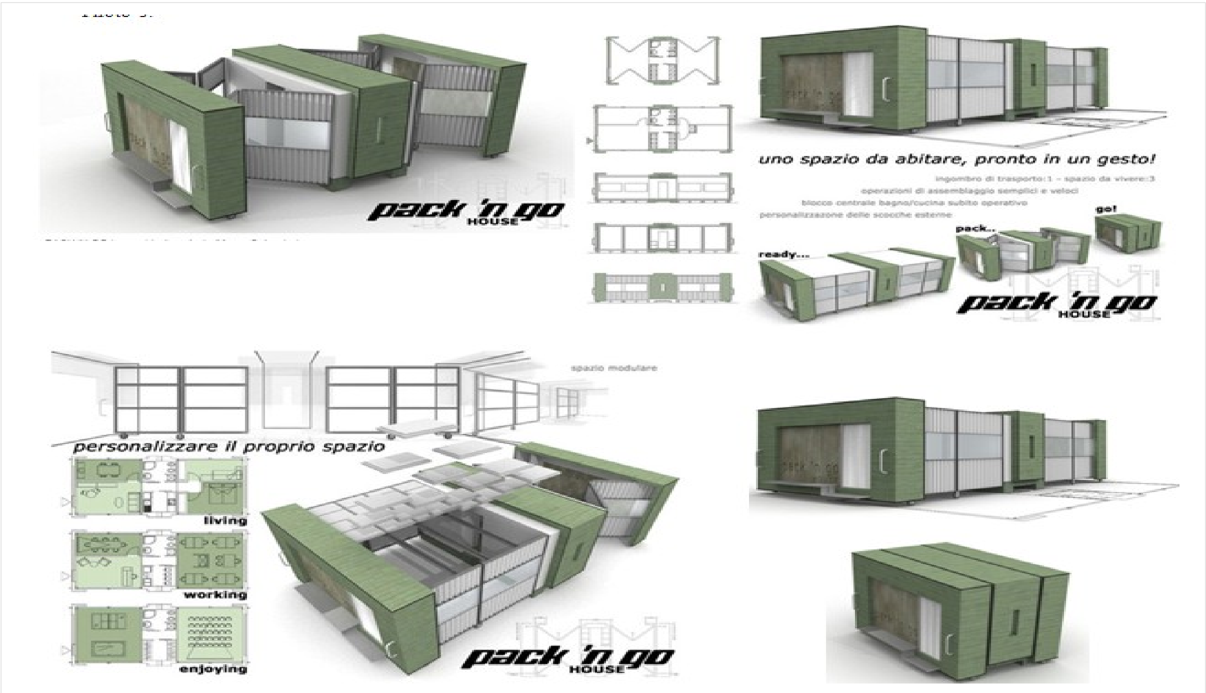


Fig.5.1.6.13. Principle of expansion of a basic unit. Source: [http://europaconcorsi.com/projects/20875-Pack-n-Go-House-design-Arch-Marco-Colombo- /(accessed 30th June 2013)]

Mobile Dwelling Unit by LOT-EK Architects, New York, 2003.

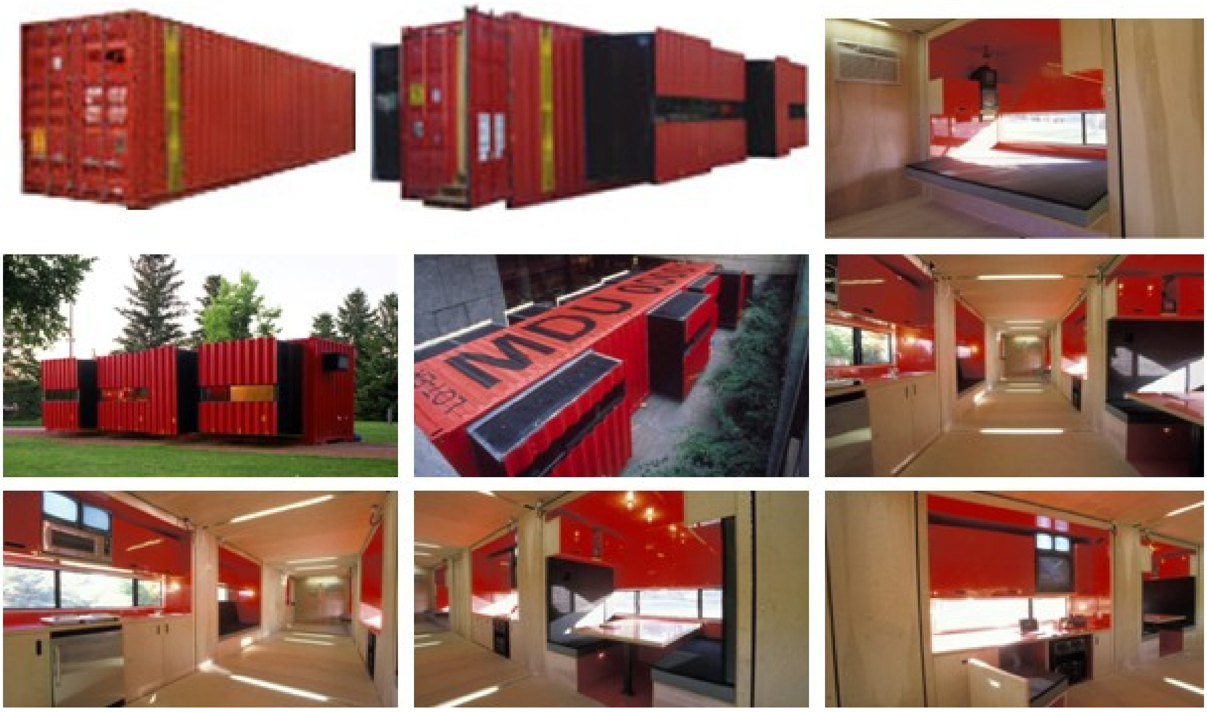


Fig.5.1.6.14. Exterior and interior of expandable container-unit. Source: [http://www.lot-ek.com/MDU-Mobile-Dwelling-Unit (accessed 3rd July 2013)]

Project description: The base of this dwelling structure is a shipping container. It is designed in the way that the metal wall-panels of the container can be extended in order to provide additional niches for living, working or for storage. In the case of relocating the dwelling unit, these extensions can be pushed in, in order to fit adequate dimensional requirements for transportation. When in use, this "extension niches" can be closed, or pushed out, leaving open possibility to the residents how to transform the space according to their daily needs. The whole interior and the structure is fabricated entirely out of plywood and plastic coated plywood, including all fixtures and furnishings.[131]

[131] "MDU (Mobile Dwelling Unit) - LOT-EK Architecture & Design." MDU (Mobile Dwelling Unit) - LOT-EK Architecture & Design. January 1, 2003. Accessed July 13, 2013. http://www.lot-ek.com/MDU-Mobile-Dwelling-Unit.

5.2. Compact solutions

5.2.1. Micro-living interior

Reducing living spaces to only essential needs is a direct consequence of the unstable economic condition of the middle class society on the long term, as well as of the rising of living costs and expenses of households maintenance. Subsequently, the increased demand for “studio apartments” represent one of the most adequate solutions for people who chose to become homeowners and at the same time want to live in urban area where living costs are higher. Another alternative for suburban contexts are small-sized and “ready-to-use” prefabricated dwellings, which also respond to the requirements of nowadays’ middle class society because of lower building costs compared to those of the traditional building techniques, as well as lower property taxes and general households’ costs.

Flexibility in this model of interior is achieved by selecting unavoidable functional elements in our daily life and giving them various multiple meanings so as to achieve some extra functions. For example a wardrobe: besides being used for storing things, it could also serve as a space for placing basic kitchen appliances needed for cooking. A bed could be used for sleeping but also transformed into a daily sofa, etc. Therefore, the elements of special attention are mostly related to bed design, kitchenette, dining area and bath area. Spatial organization can also be achieved by reducing the space to only one or maximum two areas, where most of these units are functionally interconnected and support each other. For example, dining and living room are usually organized as a single space and also a sleeping area can be “hidden” somewhere (e.g. Case study no.58: *Micro Compact Home* by Richard Horden et al.).

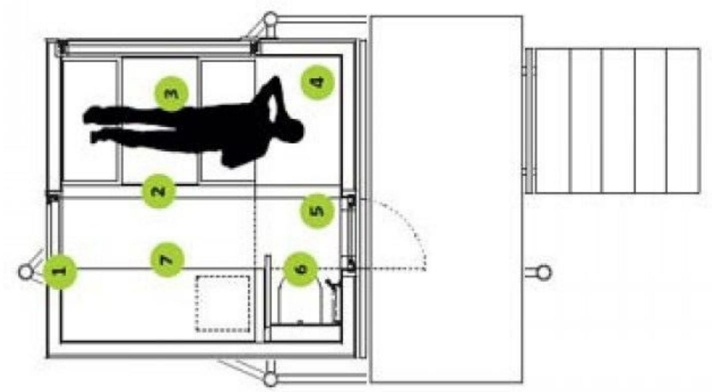


Fig.5.2.1.1. *Micro Compact Home* by Richard Horden et al., 2005.
Source: [http://www.microcompacthome.com/ (accessed 4th July 2013)]

Six Shell Bubble House, Jean Maneval, 1968.

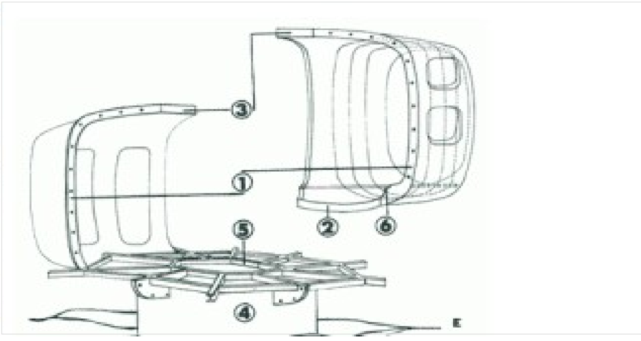
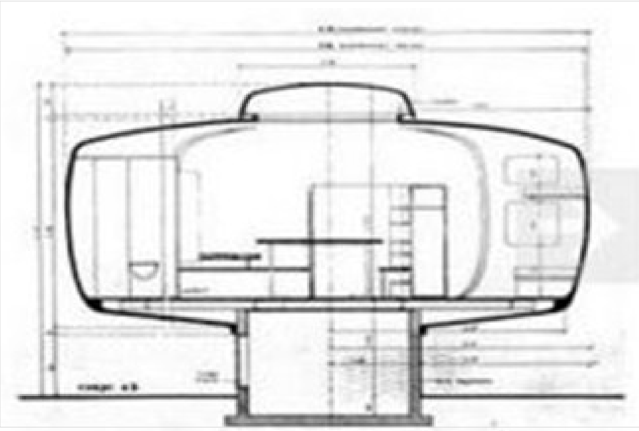


Fig.5.2.1.2. (Left) Exterior appearance of dwelling; **Fig. 5.2.1.3. (Right)** Assembling parts of a dwelling shell.
Source: [http://www.socialdesignmagazine.com/en/site/architettura/jean-maneval-the-six-shell-bubble.html (accessed 13th June 2013)]



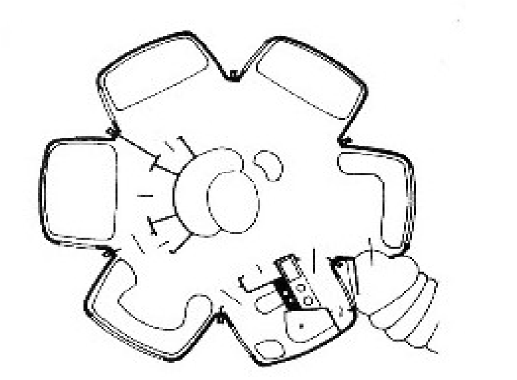


Fig.5.2.1.4. (Left) Section of the shell; **Fig. 5.2.1.5. (Right)** Layout of a dwelling shell.
Source: [http://www.socialdesignmagazine.com/en/site/architettura/jean-maneval-the-six-shell-bubble.html (accessed 13th June 2013)]

Nakagin Capsule Tower by Kisho Kurokawa, 1972

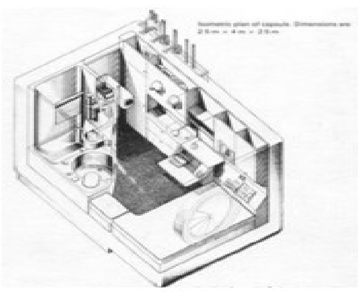


Fig.5.2.1.6. (Left) Section of the shell; **Fig. 5.2.1.7. (Middle)** View on multifunctional wall element; **Fig.5.2.1.8. (Right)** View on interior from the entrance. Source: Ottolini, Gianni, and Vera Prizio. *La casa attrezzata: qualità dell'abitare e rapporti di integrazione fra arredamento e architettura*. Napoli: Liguori, 1993. p242.

Micro-compact home by Richard Horden et al, Germany, 2005.



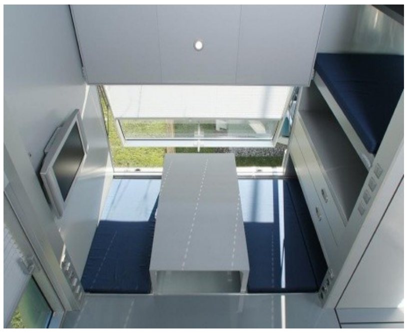
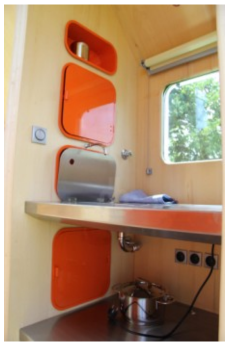


Fig.5.2.1.9. (Left) Exterior of compact home; **Fig. 5.2.1.10. (Middle)** View on multifunctional interior; **Fig.5.2.1.11. (Right)** View on dining/living area. Source: [http://www.microcompacthome.com/ (accessed 4th July 2013)].

Project description: The key objectives of the authors while designing *Micro compact home* is to focus on essential living needs – "less is more". Therefore, the interior of this compact unit is focused on smart organization of functional zones and combining the interior methods already well known in interior of aircrafts, yachts, trains, cars and micro apartments. It contains compact kitchen, bathroom, storage elements that are efficiently distributed, and dining area that can be easily transformed into sleeping room. [132] As it is further explained in official project description - "*the micro compact home* is a high quality compact dwelling for one or two people. Its neat dimensions of a 2.66m cube adapt it to a variety of sites and circumstances, and its functioning spaces of sleeping, working/dining, cooking and hygiene make it suitable for everyday use."[133]

Micro Home by Renzo Piano, 2013.



From Left to Right: **Fig.5.2.1.12.** Exterior of compact home; **Fig.5.2.1.13.** View on dining/working area; **Fig. 5.2.1.14.** View on living/sleeping area; **Fig.5.2.1.15.** View on kitchen/bathroom area.
Source: "designboom." [http://www.designboom.com (accessed August 21, 2014].

Project description: This project represents a concept of living space of two by two meters. As such, the author wants to emphasize the initial motivation trough the statement "the beauty of enough". As a result, this micro living environment consists of a minimal space for bed, a chair and a coffee table. Equipped like this, this interior represents essential living needs for one person and minimum

[132] "m-ch." micro compact home | About the company. [http://www.microcompacthome.com/company/ (accessed August 21, 2014)].
[133] http://www.microcompacthome.com/ (accessed August 21, 2014)].

required layout area for normal performance of daily activities. As further explained in official project description: "...the home is equipped with a highly considered sustainable system- a feat of small-scale engineering, what with a system of photovoltaic cells, solar panels, a rainwater tank, bio-toilet, natural ventilation and triple glazing that guarantees total environmental synthesis and autonomy from the grid. The home is a tectonic effort to live deliberately, satisfying only a program of foundational human needs with a simple partition between a living space with a sofa bed and a small kitchen with an adjacent shower. Interiors are tactile and warm with meticulously joined planes of wood while the gabled roof and exteriors are humanized with round vertices and a protective skin of riveted aluminium. Technical perfection meets a philosophy of 'Walden'-sized proportions, with a small footprint, autonomously generated current and recycled water unit. Although the project is a prototype that will be tested by a real inhabitant at Vitra, the overarching goal is to optimize the complex product for mass production. An accompanying exhibit showed the incredible volume of work, thought and iterations generated for the small building; but not without a multicolored model with a plethora of future units over a green site. This is an architecture that teaches through time and draws from those who dwell in its walls."[134]

[134] "Renzo Piano's Micro-home 'diogene' Installed on Vitra Campus." Designboom Architecture Design Magazine Renzo Pianos Microhome Diogene Installed on Vitra Campus Comments. June 14, 2013. Accessed August 21, 2014. http://www.designboom.com/architecture/renzo-pianos-micro-home-diogene-installed-on-vitra-campus.

5.2.2. Multi-functional furniture elements

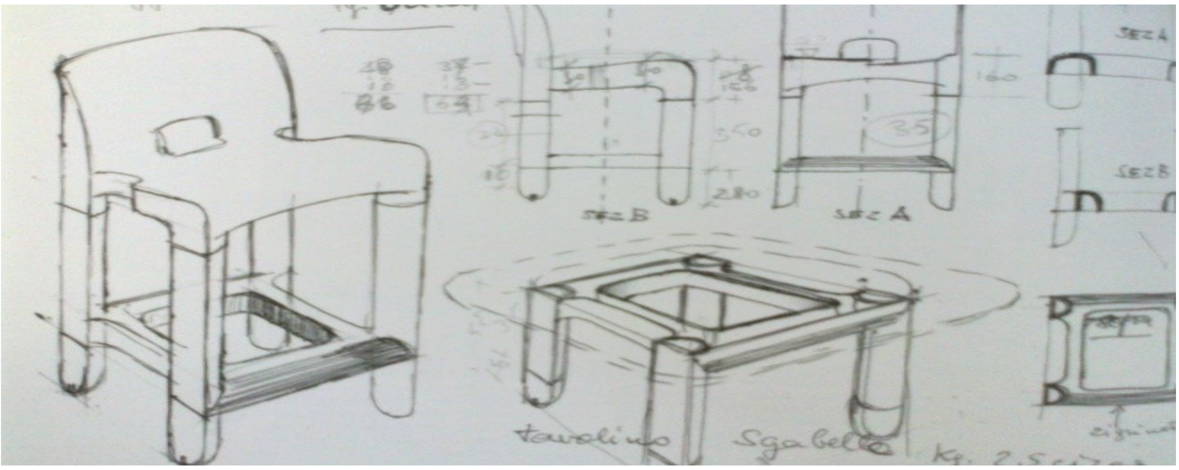


Fig.5.2.2.1. Sketches for Universale chair by Joe Colombo. Picture source: Barnwell, Maurice. *Design, creativity & Culture: An orientation to design*. London: Black Dog Publishing, 2011, p102.

Unlike the traditional method, where each functional unit in dwelling has its own separate meaning and each sample of furniture its unambiguous function, the flexible approach supports the fusion of elements. In other words, such elements are usually “compressed in function”, minimized or composed in parts in order to fit to combinations with other furniture or to adapt to other functions so as to achieve the final goal, which is improving spatial efficiency. In furniture design this method relates to furniture such as chairs which could be transformed in armchairs, armchairs transformable into beds, tables transformable into beds, even cupboards on castors in moveable kitchens, etc. Such changeability of elements is achieved in most of the case studies here analyzed by eliminating physical distances and optimizing or even reducing standard ergonomic principles to essential needs, which can improve and update the general ergonomic regulations according to the general trends and behaviours in contemporary dwelling culture.

Fig.5.2.2.2. (Left/Right) *Mini kitchen on castors* by Joe Colombo, for Boffi, 1963. In MOMA, New York. Picture source: personal archive.

One of the first forerunner examples designed to support spatial efficiency is the compact kitchen by Margarete Schütte-Lihotzky (1926) known as *Franfurt kitchen*, where a different approach to space utilization was adopted for first time. “The functions in the small, fully-fitted working kitchen were optimised so effectively that it could be described as a *command centre*. There was a room only for one person, the housewife. [...] The compact organization of a standardised functional kitchen was meant to improve the efficiency and satisfaction of the housewife and to reduce the amount of non-creative housework so as to give her more time for creative activities”[135]. With the passage of time, especially from the 1960s and 1970s, more drastic examples appeared where this optimized efficiency of the whole space was reduced to the size of only one furniture element (e.g. *Mini kitchen on castors* by Joe Colombo, for Boffi, 1963). Besides in kitchens, this approach is also evident in the combination of the functions of different living areas (such as living room furniture and sleeping room furniture into one object (e.g. *Tuttuno* by Carlo Bimbi, Gianni Ferrara, Nilo Gioacchini, 1969/71). Over the years, these furniture solutions have expanded and have become more compact and multifunctional by adding more and more living functions. In most cases they included dining-room elements along with kitchen, sleeping room, living room and bathroom elements altogether (e.g. *Central Block* containing bed, table, wardrobe, toilet, shelves, by Alberto Seassaro, 1968/1970). These solutions will be discussed more in detail in the next subchapter.

Fig.5.2.2.3. (Left/Right) Chair transformable into table by Allessandro Mendini, for Zanotta, Italy, 1984. Source: **(Left picture)**: Postell, James Christopher. Furniture design. Hoboken, N.J.: John Wiley & Sons, 2007, p70. Retrieved from [http://books.google.it (accessed 22 August 2014)]; **(Right picture)** "marinni." marinni. http://marinni.dreamwidth.org/507482.html?thread=11471962 (accessed August 24, 2014).

[135]Schittich, Christian. *Small structures: Compact dwelling, Temporary structures, Room models*. Munich: Edition Detail, 2010.

Tuttuno by Internotredici (Carlo Bimbi, Gianni Ferrara, Nilo Gioacchini), Italy, 1969 (1971).

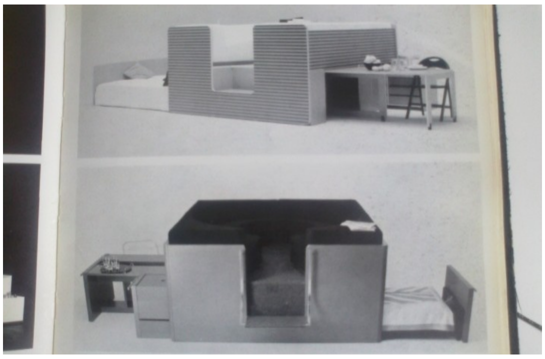


Fig.5.2.2.4. (Left) Tuttuno. Source: Ambasz, Emilio. Italy: the new domestic landscape; achievements and problems of Italian design.. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972. p133; **Fig.5.2.2.5. (Right)** Tuttuno at Moma, New York. Source: personal archive.

Fig.5.2.2.6. (Left/Middle/Right) Various functional possibilities for various contexts. Source: "CARLO BIMBI DESIGN”. [http://www.carlobimbidesign.it/en/contact/tuttuno_moma02.htm (accessed August 22, 2014)].

Multi-functional kitchen - House, by Tomoyuki Utsumi (Milligram Studio), Kamakura, Japan, 2005.

Fig.5.2.2.7. (Left/Middle/Right) Multifunctional kitchen element in various phases. Source: Brown, Azby. *The very small home: Japanese ideas for living well in limited space*. Tokyo: Kodansha International , 2005.

Tavoletto by Alberto Salvati and Ambrogio Tresoldi, Italy, 1967 (1969).

Fig.5.2.2.8. (Left /Right) Table transformable into bed. Source: "von Zezschwitz Kunst und Design." [http://www.vonzezschwitz.de/detail.php?restanten=1&chapter=4&objectid=12140&refBack=adx&id=23&language=englisch&action=language (accessed August 22, 2014)].

5.2.3. Hybrids

According to the previous chapters, compact elements can be found in furniture design - in the form of multi-functional elements; and in interior architecture - in the form of micro-living structures. However, due to their increasing conceptual complexity it is difficult to classify some of these examples into certain fields (architecture, furniture design, etc.) or in specific functional groups (space-saving elements, space dividers, etc). One of the first examples of this were Joe Colombo's *Total Furnishing Units* (1972), whose blocks containing complete kitchens, bedrooms and other functional units could be defined "compact furniture elements" but could also contribute to spatial organization as dividing elements (what is more related to the architectural approach). An even more remarkable case is the Alberto Seassaro's *Central Block* (1968/1970) containing bed, table, wardrobe, toilet, shelves, etc.. When opened in certain positions, this box provides the whole spatial and functional organization of the dwelling. So how could we classify it? It could be definitely considered as a compact piece of furniture, as it contains multiple functions, but at the same time it contains also the whole spatial organization "packaged" inside one cube. It is a sort of "instant dwelling box" that only needs to be positioned in the centre of any empty space to be used. These kind of elements we can call "functional boxes", "spatial separators", "cabinets" or even "instant rooms", all of which at the same time, but maybe the best description could be "interior inside interior". They can be closed when not in function and moved away in order to give space to some other functional unit, or even to allow replacing the dwelling-function of the space with something else (e.g. office, shop, etc.).
This method, along with the method of "variable walls and doors" systems previously mentioned, allows a complete reconfiguration of the dwelling concept and the achievement of its maximum flexibility.

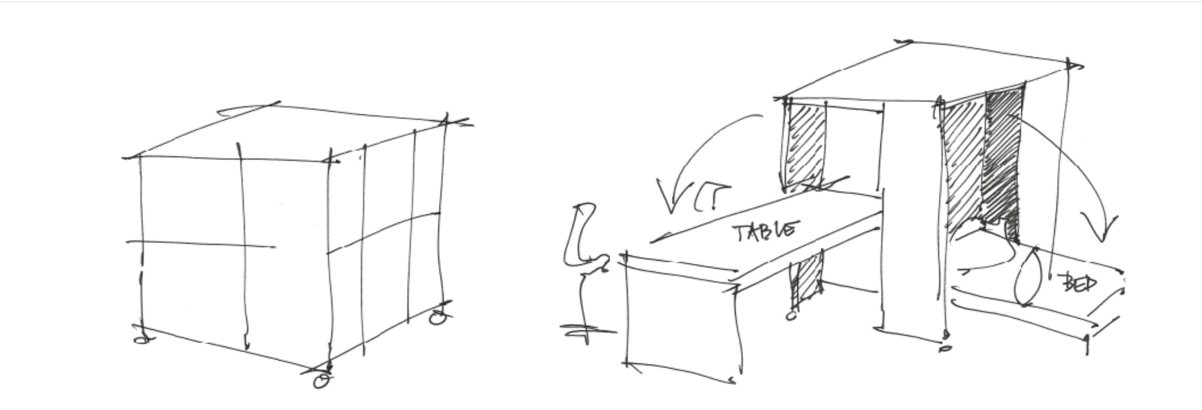


Fig.5.2.3.1. Complex flexible structures: "interior inside interior". Picture source: personal archive.

Central Block by Alberto Seassaro, Italy, 1968 (1970).

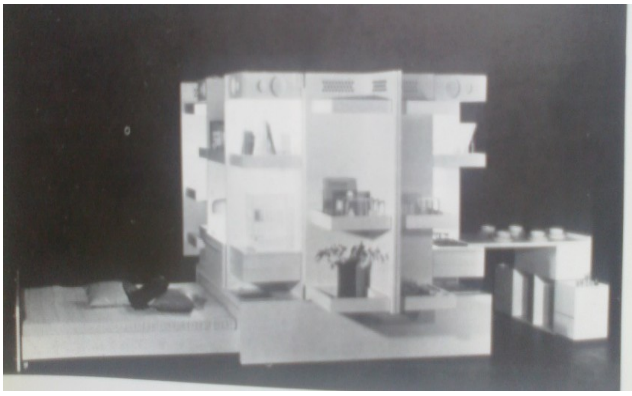


Fig.5.2.3.2. (Left) Functional unit in the closed position; **Fig.5.2.3.3. (Right)** Functional unit in "open" position. Source: Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972.

Modular ODA Room, by ODA-Architecture,New York, 2012.

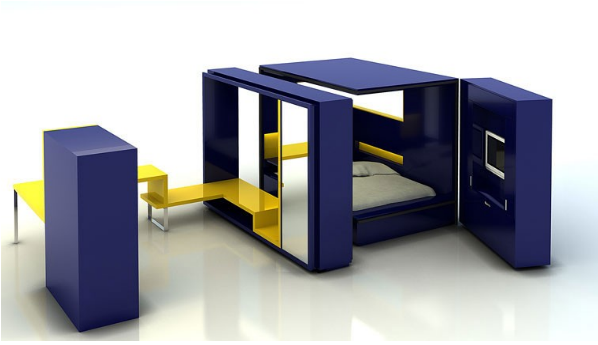


Fig. 5.2.3.6. (Left/Right) Various functional transformations of a unit. Source: "ODA-Architecture ODA Room." ODA-Architecture ODA Room. [http://www.oda-architecture.com/projects/ODA_Room.html (accessed August 22, 2014)].

Project description: This concept is created as a transformable functional box that can be placed into any type existing space (e.g. abounded industrial buildings, unequipped apartments, offices, and etc). It consists of three transformable zones – elements for sleeping, working, and for storage. This concept is targeted for users of all ages, and the appearance and arrangement can be adjusted to fit within rooms of all sizes. [136]

[136] "ODA-Architecture ODA Room." [http://www.oda architecture.com/projects/ODA_Room.html (accessed August 22, 2014)].

The Interior Living Unit by Andrew Kline, 2010.

Fig. 5.2.3.7. Various transformation of Living Unit. Source: "Interior Living Unit by Andrew Kline - Dezeen." [http://www.dezeen.com/2010/06/13/interior-living-unit-by-andrew-kline (accessed August 22, 2014)].

Project description: The initial motivation of the author was to design a compact unit for transforming disused industrial spaces into temporary homes. Titled as Interior Living Unit, the project contains a place for kitchen, bathroom, bed and storage that all fold away into one compact red box. As explained in official project description: “When folded away the surrounding room could be used as a work space or for public functions. The cube breaks down into nine pieces for easy transportation to a new space. The Interior Living Unit is composed of 9 pieces, sized to fit through standard doorways and be combined in the space within. Centralizing the program requirements of a home, The Unit allows the surround space to be used for other purposes, such as workspace. The Unit folds (closed) and unfolds (open) to reveal different functions when needed: a wardrobe, bed, kitchen, and bathroom. When the Unit is folded the private program requirements of a home are removed and the surrounding space can be transformed for public uses. These Units, utilized in vacant buildings, can build communities in hollow urban areas of post industrial cities, such as Detroit. Once taken apart, the Unit is easily transported in a moving van and can be re-installed in another space, allowing the owner to take their home with them if they move. This project challenges current platforms of living bringing the transportability of a trailer to the urban fabric; existing buildings in multiple cities can be readied for Units allowing owners to rent space for their home.”[137]

[137] Etherington, Rose. "Interior Living Unit by Andrew Kline - Dezeen." Dezeen Interior Living Unit by Andrew Kline Comments. June 13, 2010. Accessed June 13, 2013. http://www.dezeen.com/2010/06/13/interior-living-unit-by-andrew-kline.

Mobile Living Space by SpaceFlavor, San Francisco, 2012.

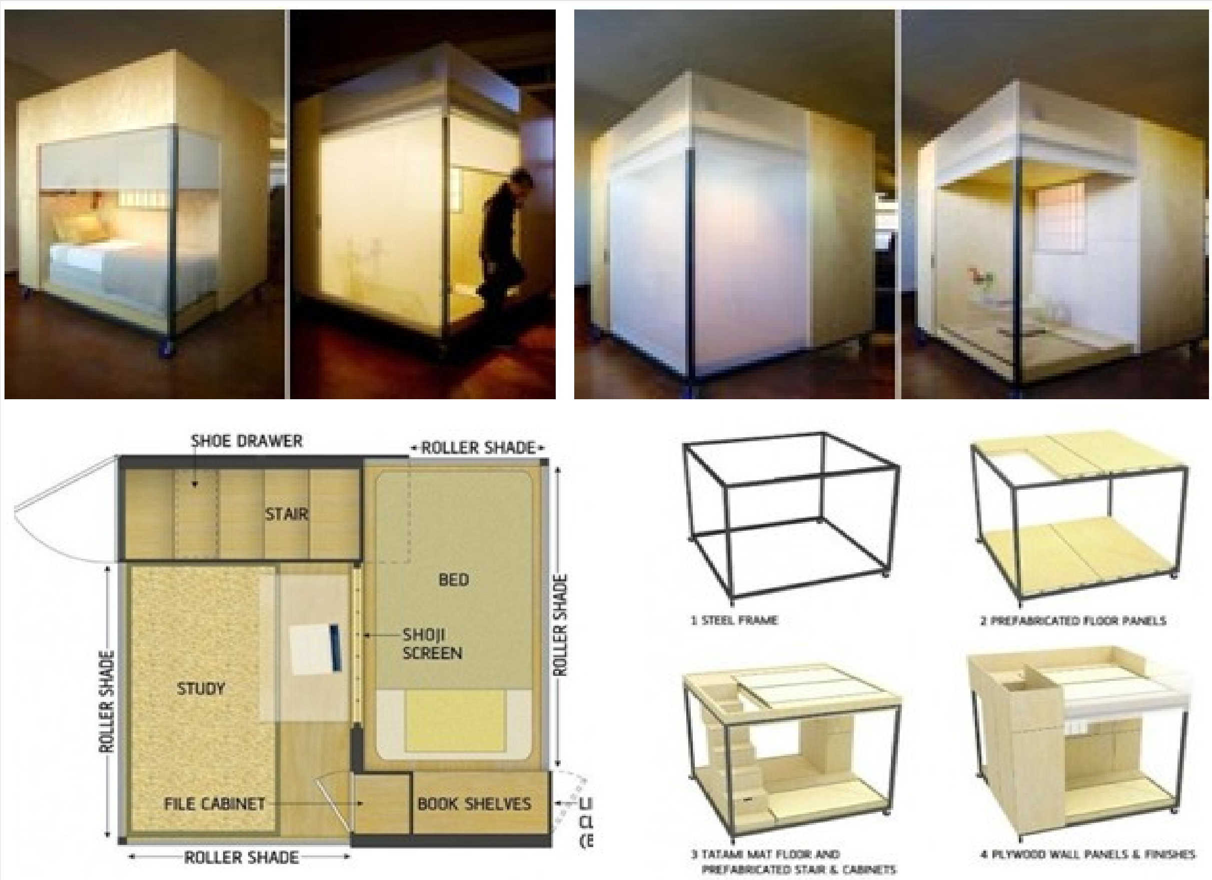


Fig.5.2.3.8. Various transformation of mobile living box. Source: "The Art Of Micro-Living." Architizer. [http://www.architizer.com/en_us/blog/dyn/49473/the-art-of-micro-living/ (accessed August 22, 2014)].

Project description: *SpaceFlavor* is a prefab movable living “box”, designed according to certain principles of feng shui. The simple cubic structure can be easily dissembled or rotated along its base in order to create different interior arrangements. This eight-foot cube made of plywood contains an area to accommodate the office space, a bed, space for storage and space for meditation. The modular approach in design of the “box” allows the user to reconfigure his loft while ensuring that his personal space is kept intact. As further explained by official project description: “… to minimize space and allow for easy relocation, the steel frame and plywood pieces were prefabricated to fit through a standard 3-foot wide door and designed to be assembled on-site with regular DIY tools. The cubic form conceal two sliding doors/walls, translucent roller shades, and casters that allow Ming to orient the cube in relation to the Chinese lunar calendar.” [138]

[138] "The Art Of Micro-Living." Architizer. September 5, 2012. Accessed August 19, 2014. http://www.architizer.com/en_us/blog/dyn/49473/the-art-of-micro-living/.

5.2.4. Space saving furniture

With the rise of the new idea of flexibility in living contexts, also supported in the exhibition “Italy: New domestic landscape” which took place in the early 1970s, the use of space acquires another dimension that is closer to furniture design and outside the borders of architecture. This mainly includes free-standing furniture components like chairs, tables, etc. that can be disassembled and are compact in form and convenient for storage (e.g. they do not occupy a large space area when removed). This furniture can save living space and keep room for other items and other functional concepts.

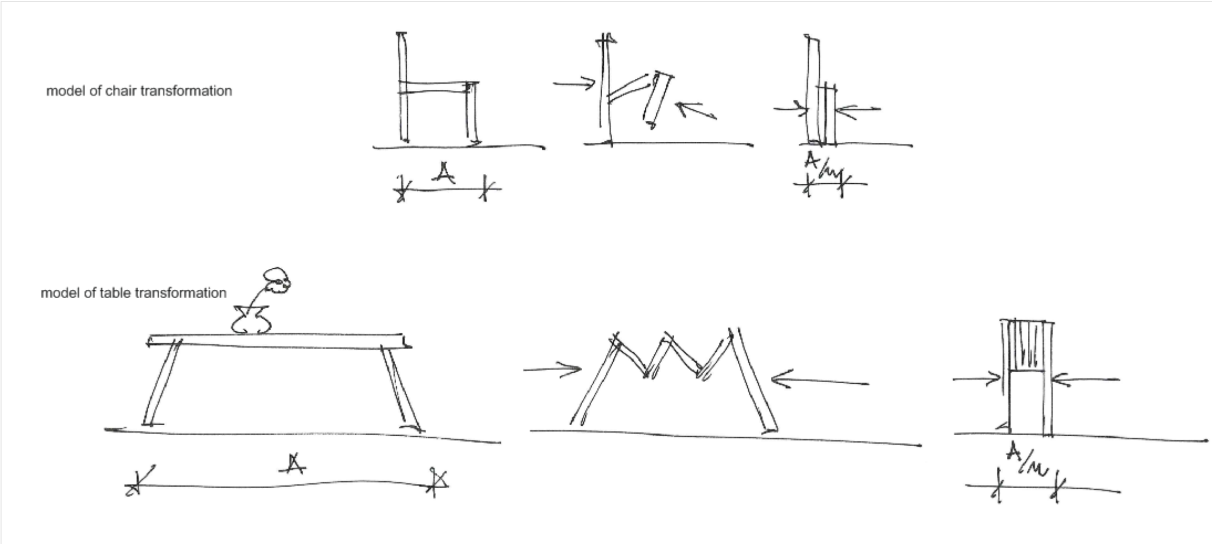


Fig.5.2.4.1. Model of transformations applied on the example of chair and table. Picture source: personal archive

Plia by Giancarlo Piretti, Italy, 1969.

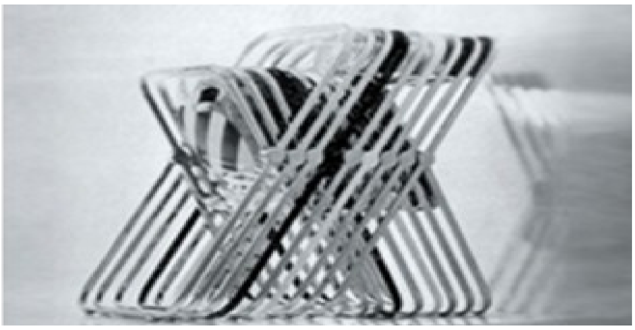



Fig.5.2.4.2. (Left) Different view on the chair when "opened" and "closed"; **Fig. 5.2.4.3. (Right)** Possibility for spatially efficient storage of the chair. Source: "Plia - Giancarlo Piretti - Vitra Design Museum." Informationen - Vitra Design Museum. [http://www.design-museum.de/en/collection/100-masterpieces/detailseiten/plia-giancarlo-piretti.html (accessed October 18, 2013)].

Project description:

• *General note:* Designed in 1968; production since 1969 till nowadays; manufacturer Anonima Castelli s.p.a., Ozzano near Bologna; chair size 75 x 47 x 50,5 (when opened) with the seat height 45,5 cm; material: polished die-cast aluminium, oval tubular steel, plastic.

• *Methods of flexibility*:"Lightness, flexibility, and technical precision are the obvious advantages of this design by Giancarlo Piretti. The folding mechanism of the chair was completely novel in its day. The chair rests on a joint made of three metal disks which connect the back, legs, and seat in such a way that they can be folded up into a flat compact form barely five centimeters thick. The elegant chair, which is also suitable for outdoor use, has clear rounded forms, an oval-insection tubular steel frame, and transparent plastic surfaces. When folded up, it can be hung on a wall hook made especially for this purpose, but can also be stacked when folded out."[139] The same methodology is applied also on other models like Plona chair, Pluff stool, Platone desk, Planta coat rack and Pluvium umbrella stand. [140]

Platone Folding Desk, by Giancarlo Piretti, Italy, 1971.



Fig.5.2.4.4. Platone Folding Desk in different positions. Source: "THE COLLECTION." MoMA.org. http://www.moma.org/collection/browse_results.php?criteria=O%3AAD%3AE%3A4638&page_number=2&template_id=1&sort_order=1 (accessed August 22, 2014).

[139] "Plia - Giancarlo Piretti - Vitra Design Museum." Informationen - Vitra Design Museum. [http://www.design-museum.de/en/collection/100-masterpieces/detailseiten/plia-giancarlo-piretti.html (accessed October 18, 2013)].

[140] [Plia - Giancarlo Piretti - Vitra Design Museum]

Plano folding table by Giancarlo Piretti, Italy, 1970/71.

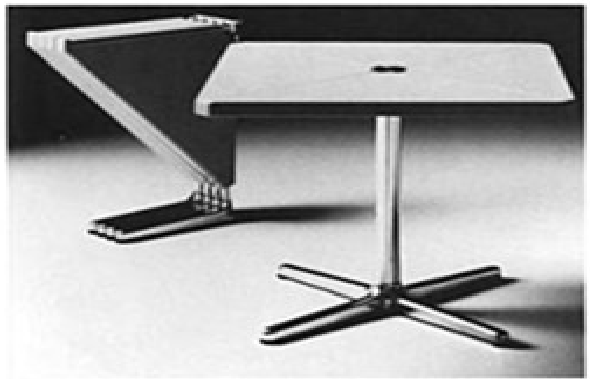


Fig. 5.2.4.5. (Left) Plano folding table (round-shaped) while transforming. Source: "OBJECT <> PLASTIC." Plano table. http://www.objectplastic.com/2010/02/plano-table-giancarlo-piretti-anonima.html (accessed August 24, 2014); **Fig.5.2.4.6. (Right)** Plano folding table (rsquare-shaped) in "open" and "closed" position. Source: Habegger, Jerryll, and Joseph H. Osman. *Sourcebook of modern furniture*. 3rd ed. New York: W.W. Norton & Co., 2005., p218.

Project description:

• *General notes*: Designed in 1970; production started in early 1970's; manufacturer Anonima Castelli s.p.a., Ozzano near Bologna; in round version table diameter is 96 cm; in square version the dimensions are 85 x 85 cm, with the height 71,5 cm; material: aluminium base, polyester tabletop.

• *Model of flexibility:* Loaded mechanism allows folding tabletop into four smaller interconnected sections that make up a compact form suitable for storage.[141]

[141]"OBJECT <> PLASTIC." Plano table. http://www.objectplastic.com/2010/02/plano-table-giancarlo-piretti-anonima.html (accessed August 24, 2014)

5.3. Flexible joints

Although in a smaller scale, a joint can be considered a supportive element which allows further flexible variations in a bigger scale. More specifically, an intelligent approach to joints can give a significant contribution to flexible interior organization in terms of modularity of interior elements (e.g. *USM Haller modular system* by Fritz Haller, Switzerland, 1963/69.) and space-saving furniture (e.g. *Plano* folding table by Giancarlo Piretti, Italy, 1970/71.)

5.3.1. Modularity systems

USM Haller modular system, by Fritz Haller, Switzerland, 1963/1969.

Project description: The USM Haller modular system, named after the Swiss architect Fritz Haller that co-created the furniture in the 1960s alongside with Paul Schaerer (one of the founders of the company USM MöbelSystem), is carefully proportioned, aesthetically "clean", and supportive in various scenarios furniture system. The key of the system is not only its simplicity of design, but also the ease with which the modules can be assembled, disassembled and reconfigured if necessary. The base of the system lies only in three elements which were all made of metal - a ball joint, connecting tubes, and panels – and which mutual combination revolutionised the way how to approach to flexible interior organization.



Fig.5.3.1.1. A ball joint; **Fig.5.3.1.2.** A ball joint connected with structural tubes; **Fig.5.3.1.3.** The basic module made with ball joint, connecting tubes and metal panels.
Picture sources: Klemp, Klaus. *Das USM Haller Möbelbausystem*. Frankfurt am Main: Verlag form, 1997. and "USM Modular Furniture" [http://www.usm.com (accessed 12th November 2013)]

Fig.5.3.1.4. (Left/Middle/Right) Possible combinations.
Picture sources: Klemp, Klaus. *Das USM Haller Möbelbausystem*. Frankfurt am Main: Verlag form, 1997. and "USM Modular Furniture" [http://www.usm.com (accessed 12th November 2013)]

X-FILES system, by MG prototypes, Zagreb, Croatia, 2009.

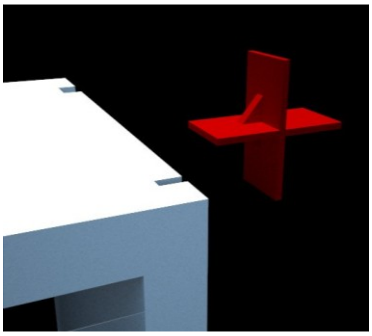
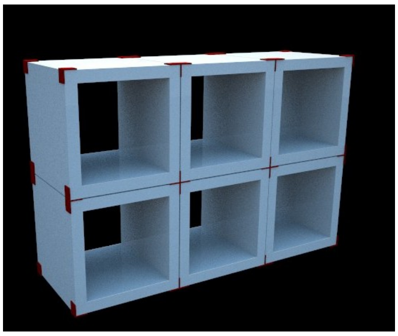
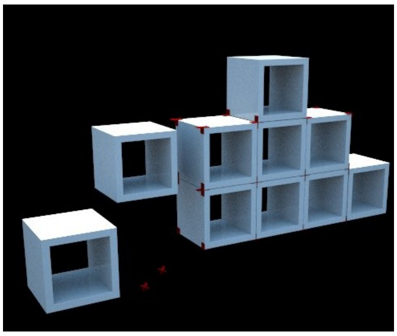
  

Fig.5.3.1.5. A cross-like joint; **Fig.5.3.1.6.** Example of modularity 1; **Fig.5.3.1.7.** Example of modularity 2. By MG studio, Zagreb, Croatia, 2009. Picture source: personal archive.

UG2Fab2

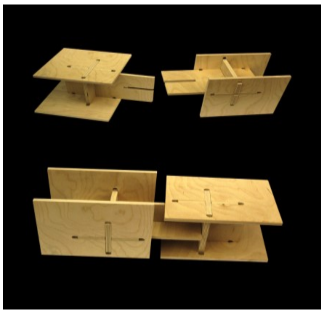
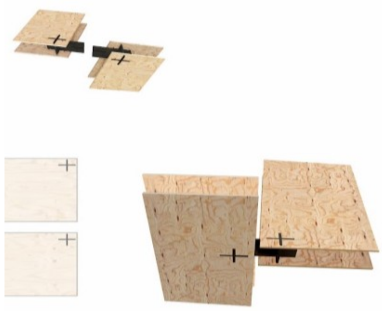
  

Fig.5.3.1.8. Joining elements; **Fig.5.3.1.9.** Possible forms 1; **Fig.5.3.1.10.** Possible forms 2. Source: [http://ug2fab2.blogspot.it/2014/03/furniture.html (accessed 12th Aug 2014)]

Project description: With this concept the authors wanted to explore the range of possibilities of this specific structural system. As authors are further explaining:

“A pattern of gap and overlap between two parallel concrete masonry unit walls varies to organize light by spread and intensity. These two qualities were evaluated in many study models, light studies, and eventually became a sculptural aspect of our final design for the Saco Lake Bathhouse. A *Cagian* method of letting the CMU walls fall into place was used to cement our desire for the inmaterial/ the ephemeral to play an integral role in determining the form. Using grasshopper to randomize points in a landscape, placing center-points and quickly iterating through scalar variables with the use of "sliders." This method of designing and evaluating moved beyond plinth, wall and canopy and was used to determine the location and rotation of "floating plywood planes": bunk beds and panelized screen walls. As we iterated through these wooden sculptures, we looked for thresholds, a geometry that invoked haptic potential and inconvenient spaces. The word attach usually holds a functionalist, positivist weight that we fought in the construction of our furniture joint. A simple half-lap construction, two steel plates slip into each other and allow for three dimensional, 90 degree rotations between plywood planes. The simplicity and modularity of the joint avoids the elitist curvature of contemporary architecture and injects references to the De Stijl.”[142]

[142] "UG2Fab2." : Furniture. March 4, 2014. Accessed August 15, 2014. http://ug2fab2.blogspot.it/2014/03/furniture.html.

MoModul, by Xavier Coenen, 2012.

Fig.5.3.1.11. MoModul – basic elements. Source: [http://xaviercoenen.eu/ (accessed 16th August 2014)]

Fig.5.3.1.12. MoModul – various combinations. Source: [http://xaviercoenen.eu/ (accessed 16th August 2014)]

NOOK, by Sebastian Reymers

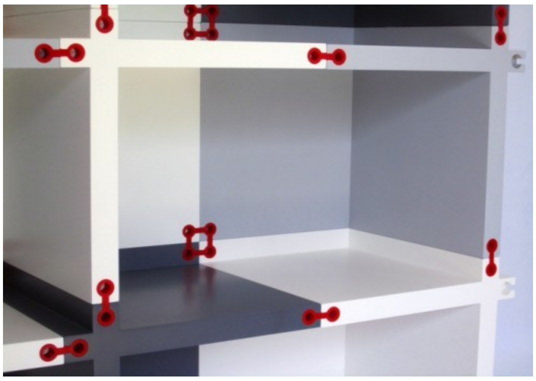


Fig.5.3.1.14. (Left) Detail; **Fig.5.3.1.15.** (Middle) Joint; **Fig. 5.3.1.16.** (Right) Possible combination. Source: "NOOK : Sebastian Reymers Design." NOOK : Sebastian Reymers Design. [http://www.sebastianreymers.com/index.php?/project/nook/ (accessed August 16, 2014)].

Chidory furniture, by Kengo Kuma and associates, 2011.

Fig.5.3.1.17. (Left) Structural parts; **Fig. 5.3.1.18. (Middle)** Basic construction; **Fig. 5.3.1.19. (Right)** Possible forms. Source: "Chidori Furniture by Kengo Kuma and Associates - Dezeen." Dezeen Chidori Furniture by Kengo Kuma and Associates Comments. http://www.dezeen.com/2011/11/07/chidori-furniture-by-kengo-kuma-and-associates/ (accessed August 22, 2014).

NV01, by Noir Vif, Paris, 2013.

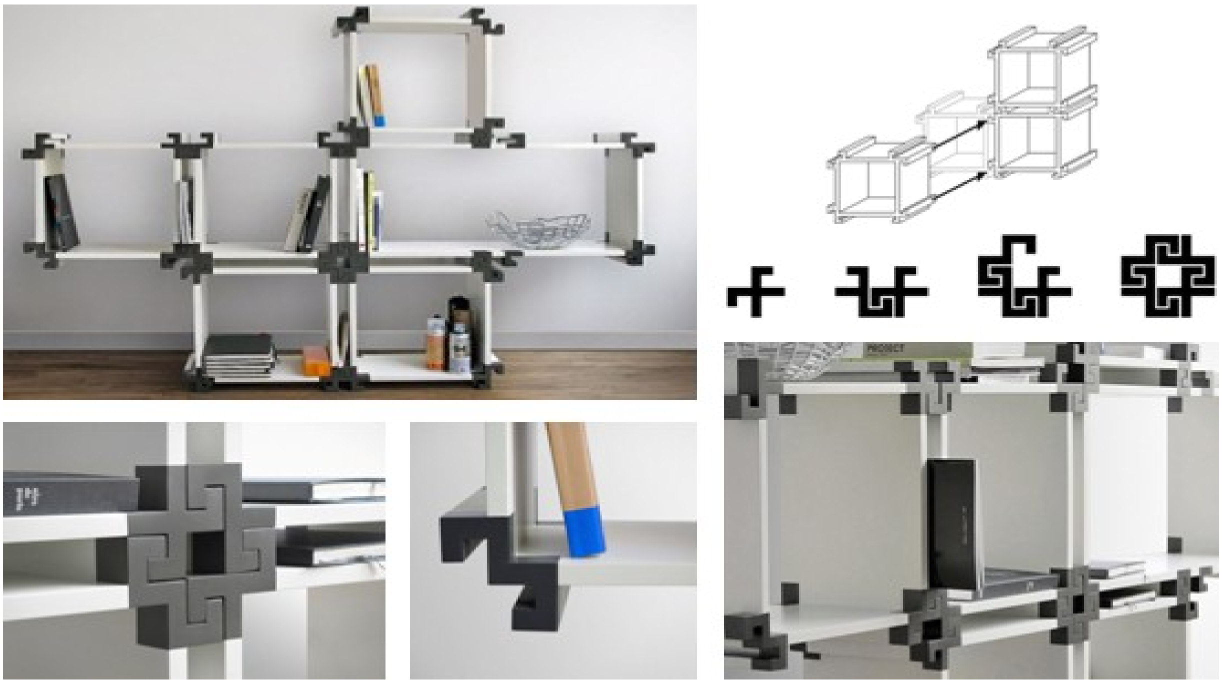


Fig.5.3.1.13. Basic elements, joints and combinations. Source: "Noir Vif | NV01." Noir Vif | NV01. [http://www.noirvif.com/en/projects/NV01.php (accessed August 16, 2014)].

Project description: NV01 is a shelving system designed in the way to allow flexible dimensional arrangements in order to fit the available space in any room. Its construction allows both horizontal and vertical expansion. The key element that support such flexible rearrangements of elements is the corner joint for each module. As author explained for the interview with Gizmag: "…the concept emerged from the wish to make furniture that can fit almost any kind of housing, is simple and cheap to manufacture, and provides playful and creative options for the user. The number of possible combinations is very high. *You can make a small bookcase by piling two or three modules or cover a whole wall with modules to suit your needs*, says Lehoux. *There are also 'double' modules that can be integrated vertically or horizontally [to] extend the storage possibilities and disrupt the overall look of the 'grid'*. NV01 is at present just a prototype hand-crafted from wood, but Noir Vif is keen to bring the system to market and is actively seeking a manufacturer to produce the modules. The final cost of NV01 will depend on the materials and manufacturing processes employed. Lehoux suggested that the relatively simple shape of each NV01 module means an extruded polymer could be used in order to keep costs low."[143]

[143] "NV01 modular bookcase fits together like a giant jigsaw." NV01 modular bookcase fits together like a giant jigsaw. http://www.gizmag.com/nv01-modular-bookcase/26663/ (accessed August 16, 2014).

5.3.2. Space-saving joints

Giancarlo Piretti system by Gaincarlo Pireti, Italy, 1970/73.

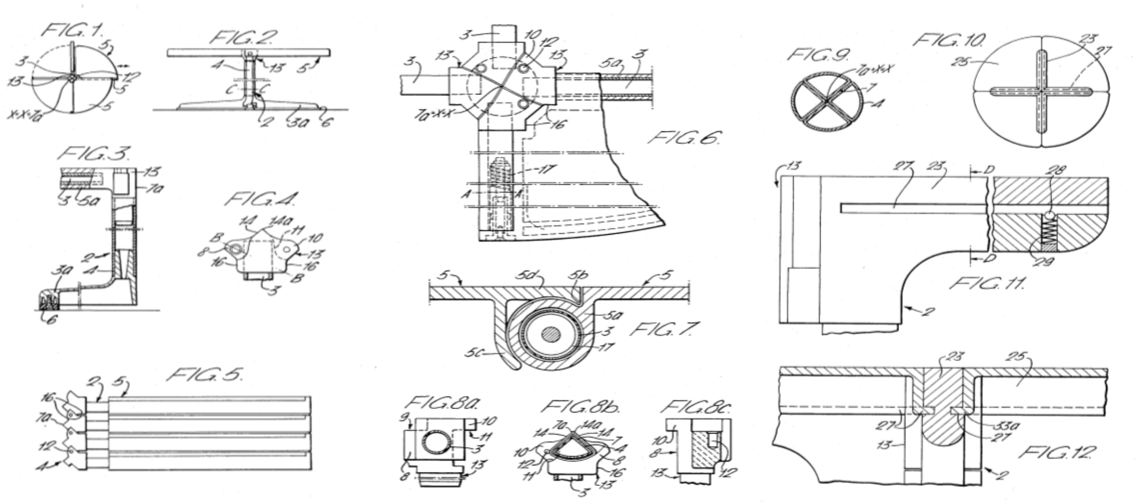


Fig.5.3.2.1. Folding table Plano, patent no. US 3779176 A, by Giancarlo Piretti. Picture source: http://www.google.com/patents/US3779176?printsec=description (accessed 12th November 2013)]

Fig.5.3.2.2. (Left/Middle/Right) Folding table Plano, patent no. US 3779176 A, by Giancarlo Piretti. Picture source: http://www.google.com/patents/US3779176?printsec=description (accessed 12th November 2013)]

Patent description: "A folding table comprising a carrying structure which is constituted of a plurality of C-shaped metallic frames and of a plurality of plates designed to form in combination the bearing plane of the table, said C-frames being pivotally connected to each other, one excepted, by means of hinge devices having vertical pivot axes and arranged at the sides of each vertical members of the C-frames, said vertical members being so shaped as to form in the use position of the table a single central composite post for the table, while the upper arms of the C-frames in said use position are radially positioned and spaced apart from each other of a same angle and forming the carrying means for said plates, which are designed to be each located between two adjacent C-frames, when in use position, while the lower arms of said C-frames form the radial legs of the table, said C-frames being provided with first and second stop means, wherein the first stop means define the mutual position of the C-frames, where the parts constituting the table occupy the minimum space, while the second stop means define the position of the C-frames in the use position of the table, each of the said plates being so shaped as to be inserted between two adjacent C-frames, when these latter are in their operative position, said plates being associated with means adapted to connect said plates to the upper arms of the C-frames and/or to each other in a disconnectable manner."[144]

[144] Giancarlo Piretti Plano table patent - "Patent US3779176 - Folding Table." Google Books. Accessed November 13, 2014. http://www.google.com/patents/US3779176?printsec=description.

Garage project, by arch.Damir Spoljar for Domus Nobilis, Croatia, 2009.

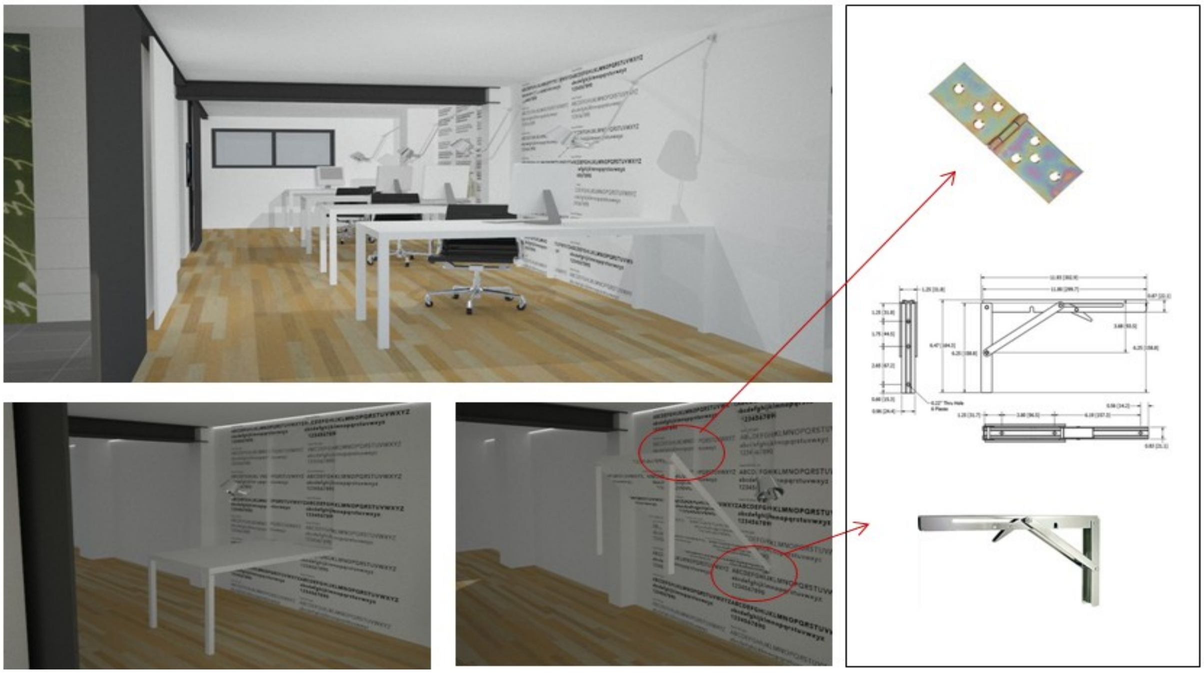


Fig.5.3.2.2. Overview on folding tables integrated into the wall-panel surface. The main purpose of such approach is to transform living space into eventual office. Source: personal archive.

Folding table, by Nils Frederking, Germany, 2008.

Fig.5.3.2.3. Folding phases of the table with a divided table top. Source: "Folding Furniture.." Modern Urban Living. http://modernurbanliving.com/2008/04/folding-furniture/ (accessed August 24, 2014).

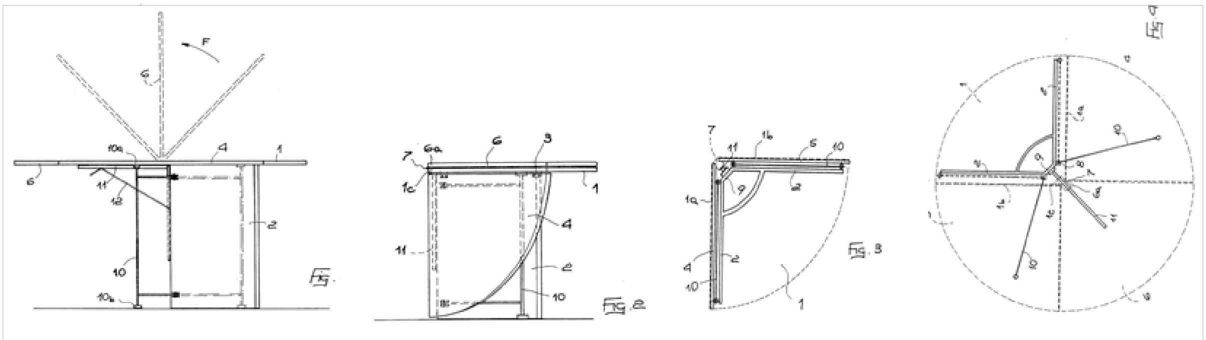


Fig.5.3.2.4. Folding phases - table with divided table top. Source: Folding table with a divided table top , patent no. WO 2008040344 A2.[http://www.google.com/patents/EP0359721A1?cl=de (accessed 21 August 2014)].

Patent description: “Folding tables with a divided table top are generally collapsed with regard to width and height to be somewhat larger than one of the tabletop segments. The invention is based on the object of designing a folding table with a divided table top, which can be collapsed by means of a simple mechanism such that it is very small. Tabletop segments and leg parts of the folding table are connected movably to one another in a joint. The position and the guided movement of the leg parts and tabletop segments with respect to one another is ensured by struts which run obliquely, slide in a guided manner along the leg parts and are fastened to the tabletop segments in an articulated manner. The table is collapsed by being pulled upwards in the vicinity of the articulated connection of leg parts and tabletop segments. The weight of the tabletop segments causes the latter to move downwards and to pull the leg parts with them by means of the obliquely running struts."[145]

[145]Folding table with a divided table top , patent no. WO 2008040344 A2.Source:
[http://www.google.com/patents/EP0359721A1?cl=de (accessed 21 August 2014)].

6. Architectural trends for flexible interiors in current times

After having analyzed various methods of flexibility implementation in limited spaces from the 1970s to the present, the following chapters of this Thesis will focus on the analysis of current trends related to flexible interiors.

Considering architectural elements which tend to provide flexible functions inside the interiors, today much attention is paid to the technical improvement of sliding systems, window openings and many other innovations connected with the functional use of floors and ceilings. The following subchapters will review these contemporary solutions, starting from the cases where the whole "external skin" could be opened/or adjusted according to the interior's varying function; where sliding panels inside the space are designed so as to look "invisible" and give the impression of a fixed wall and a feeling of greater spatiality; storage or other functional spaces integrated into the floorings – a recent view for extending functionality of interior; till high-tech adjustable ceiling systems. All the mentioned solutions result from an investigation of recent case studies related to flexible interiors and as such could be considered a fruitful contribution to spatial flexibility in limited dwellings. Furthermore, the next subchapters will also focus on some supporting brand names (companies) who adopted a flexible approach as a business strategy for developing their mass production products.

6.1. Interior doors and sliding systems

Sliding systems could be placed among most important factors which allow flexibility of interior arrangements. Technical improvements which are made in guide rails and rollers allow variety of panel sizes, selection of panel materials and can assure high resistance in frequency of opening and closing. The sliding systems are based on two main principles: top-hanging sliding or bottom-rolling system. Depending on selection of panel material, top-hanging systems can support weights till 250 kg per panel, while those made of steel (usually for industrial purposes) even can carry a weight around 3500 kg (of course, taking in account that load bearing capacity can support such weights). [146] Bottom-rolling systems slide in floor mounted rails; therefore the rollers transfer the weight of the panel directly to the floor. [147] In this case, the walls or ceilings are not weight bearing, but the crucial parameter is the quality of rollers. For weights less than 250 kg plastic-coated ball-bearing rollers or plastic rollers are usually used. The advantage of these rollers is that they can assure quiet movement as well. For heavy panels steel rollers must be used, but the door sliding in this case is not so inaudibly. Considering the rails, they can be "arranged in separate parallel planes or in double or multiple track systems. Telescopic systems offer an alternative in which each element pulls next element out with it, for example by linking them together with a connecting belt. Symmetrical systems allow two elements to be opened simultaneously in a single action."[148]

Advantages	Disadvantages
*Functional variety of spaces	*Usually high cost systems *Costly maintenance

[146] Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010, p105.
[147] (Schumacher, 2010)
[148] (Schumacher, 2010)

Transformer, by Studio Garneau,

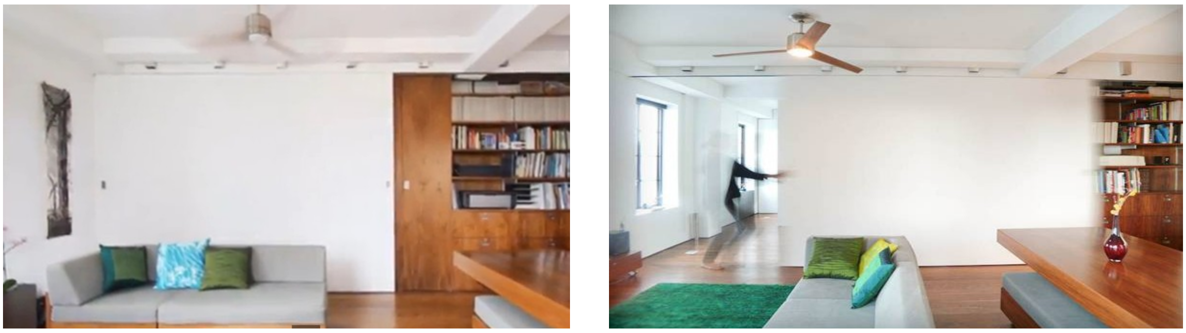


Fig.6.1.1. (Left): Closed view on the sliding door. Picture source: [http://www.youtube.com/watch?v=d1iHzw6wTHM (accessed 21th February 2014)]; **Fig.6.1.2. (Right):** Opening position of sliding door. Picture source: [http://www.studiogarneau.com/ (accessed 21th February 2014)]

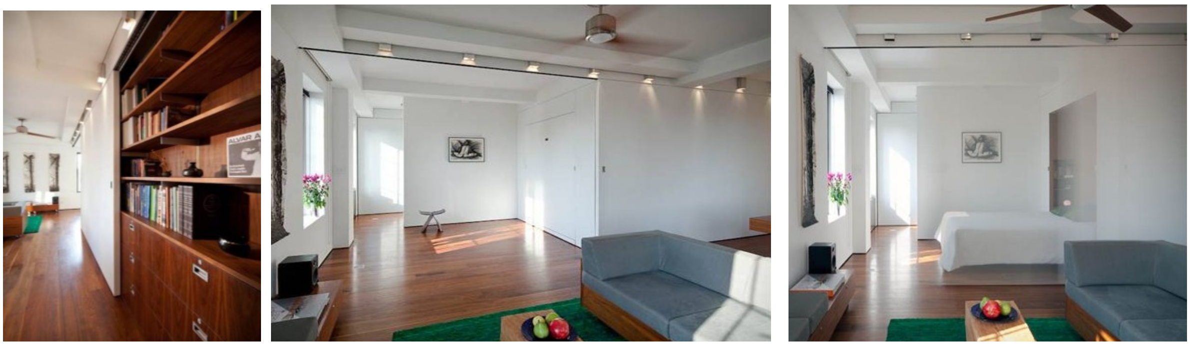


Fig.6.1.3. (Left/Middle): Opening and completely opened view on the sliding door. Picture source: [http://www.studiogarneau.com/ (accessed 21th February 2014)]; **Fig.6.1.4. (Right):** View on the sleeping zone behind sliding panel. Picture source: [http://www.studiogarneau.com/ (accessed 21th February 2014)]

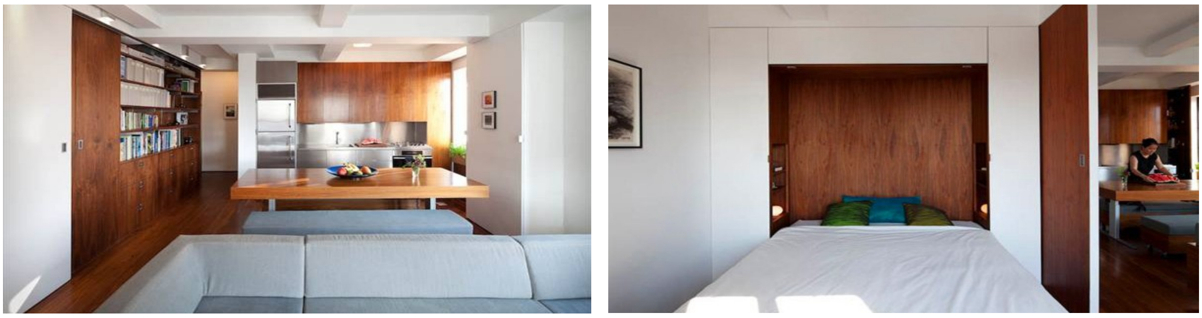


Fig.6.1.5. (Left): View on the closed position of sliding door and rest of the space. Picture source: [http://www.studiogarneau.com/ (accessed 21th February 2014)]; **Fig.6.1.6. (Right):** View on the sleeping zone behind sliding panel. Picture source: [http://www.youtube.com/watch?v=oLwQHd0BYcc (accessed 21th February 2014)]

Fig.6.1.7. (Left/Middle/Right): Sliding system. Picture source: [http://www.youtube.com/watch?v=oLwQHd0BYcc (accessed 21th February 2014)]

Project description: The apartment created under the name *Transformer* presents adaptable organization of activity zones inside interior. As such, this mini-loft space has capability to support variety of functional requirements due to its folding and sliding elements, and furniture with multifunctional uses. As mentioned in official project description, the “centerpiece of the space is a large, track-mounted sliding wall that separates the bedroom from the living and dining areas. When the wall is positioned to enclose the bedroom, it exposes a floor-to-ceiling library wall of filing cabinets and adjustable shelves. And when it’s slid back, covering the library, visual clutter is reduced to create a serene minimalist look.”[149]

$40m^2$ apartment by Sfaro Architects, Tel Aviv, 2011.

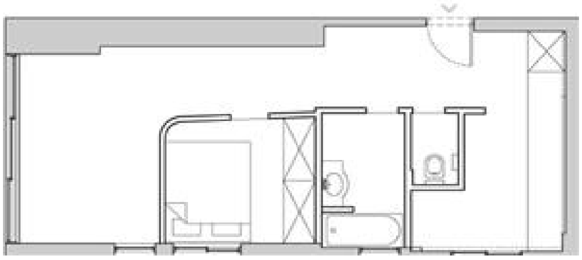
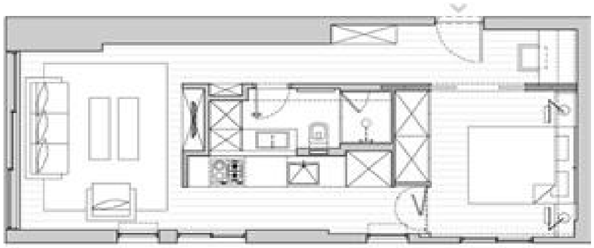



Fig.6.1.8. (Left): Layout of the space before intervention. Picture source: [http://www.sfaro.co.il/ (accessed 23th February 2014)]; **Fig.6.1.9. (Right):** Layout of the space after intervention. Picture source: [http://www.sfaro.co.il/ (accessed 23th February 2014)].


Fig.6.1.10. (Left): View from the entrance to the sleeping area while sliding panels and door is open. Picture source: [http://www.sfaro.co.il/ (accessed 23th February 2014)]; **Fig.6.1.11. (Right):** View from the sleeping area to the rest of the space. Picture source: [http://www.sfaro.co.il/ (accessed 23th February 2014)]

Project description: This initially studio apartment, upgraded with smart centralization of bathroom facilities in the middle of the space and flexible spatial organization with sliding panels, is extended into one bedroom apartment. According to authors words: “we chose to condense all the programmatic functions and storage units into a cube which was centred in the middle of the space, thus dividing the apartments into 4 zones, while maintaining a 360 degree circulation around it, which makes the space seem endless and bigger than it actually is. By adding sliding doors that disappear into the cube, the space can be altered according to the time of day and the various needs of the owner, contributing further more to the sense of a multi-functional and multi-layered space.”[150]

[149] “Transformer by Studio Garneau: a Creative and Flexible Apartment Design”. [http://www.designswan.com/archives/transformer-by-studio-garneau-a-creative-and-flexible-apartment-design.html (accessed 22nd February 2014)]

[150] “Sfaro Architects” [http://www.sfaro.co.il/ (accessed 23rd February 2014)]

6.1.1. Supporting commercial brands

JNF Systems

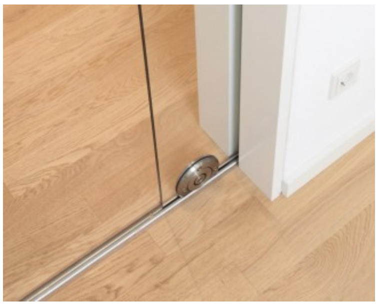
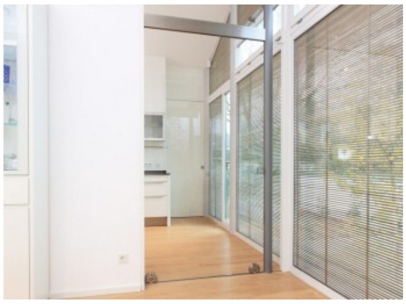
Company profile: This company deals with development of stainless steel hardware specially orientated toward new interior demands for residential and public buildings. Therefore the main company strategy is to follow the trends in architecture in order to support new vision how the contemporary space may be as functional as possible. The result ranges from simple hardware for "single-leaf" sliding door, till large dimensions sliding "walls" with variety of material options and segmented sliding (or opening) solutions. [151]

Range of products

[151] "jnf" [http://www.jnf.pt/index.php?show=familias&id=6 (accessed 17th February 2014)]

MWE Sliding System

Company profile: MWE Company is known by putting the emphasis to develop high quality products with great attention to the details. According to company strategy, their goal is to develop products that fully conform to the spirit of the time. As further mentioned in official company web site: "[we] have to meet the highest requirements of design, quality and functionality know-how. High technology paired with perfect customer relationship management is the right formula for *Quality Built on Passion.*"[152]

System Spider / Protec / Supra



System Twin / Duplex




[152] "MWE" [http://www.mwe.de/en (accessed 12th February 2014)]

Rimadesio

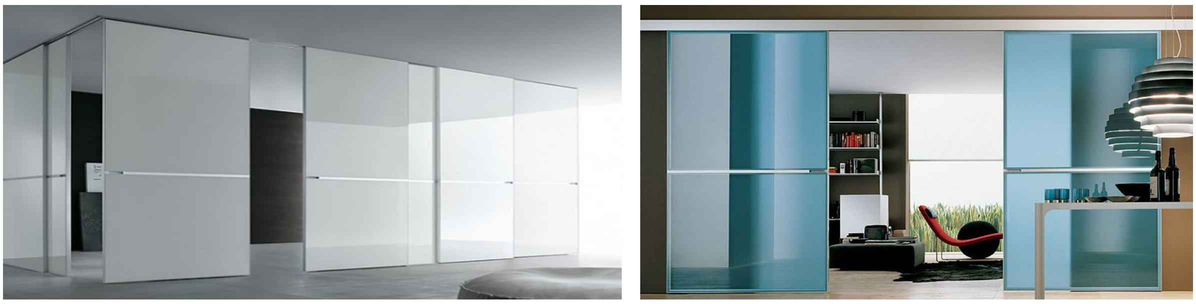
Rimadesio

Company profile: "Rimadesio produces systems for sub-dividing environments and for the architectural definition of internal spaces. Doors, sliding panels, shelving units, walk-in wardrobes and a collection of complementary furniture: an offer which is constantly increasing in size and which is forever evolving its style. Linear and concrete designs wherein the simplicity of a concept is expressed through an exceptional level of technical competence. Highly-stylised objects, made to guarantee a superb look, but which still lend themselves to daily life, to a natural use that corresponds to the concept of contemporary living advanced by the company.
Glass, which is a pure and ecological material, plays the most important part in the collection. All work on it is carried out entirely in the company's production department, this being possible as a result of a technical know-how gained over 50 years' experience in this field.
Rimadesio' s aim is to continue to develop its own design culture and production technology in order to be able to offer functionally innovative ideas which are exclusive from an aesthetic point of view and can ensure maximum reliability over time."[153]

Link+

Stripe

Graphis



[153] "Rimadesio" [http://www.rimadesio.com/eng/company-profile.php (accessed 22th February 2014)]

6.2. Facade openings and screens

In order to liberate indoors from feeling of congestion, but also to give possibility for flexible indoor/outdoor scenarios, it was shown as successful solution to implement as much as possible not only "standard-dimensioned" window openings, but the whole open-able interior surfaces. Such solutions "relate directly through their size, direction, location and manner of opening to the function and usage of the spaces within. [...] In particular the manner in which an element opens along with its size can extend or change the ways in which the interior space can be used."[154]

Such various sliding or raising systems developed especially in last decade show the growing tendency towards high-tech or "clever" solutions which could be either manually or automatically controlled. Materials and level of transparency are dictated most usually by the location or outdoor environment, but also by security to eventually prevent forced access into the space, and personal privacy as well. Quantities and sizes of such systems are usually balanced according to climate conditions of the area, and must fulfil requirements such as wind and rainfall protection, or insulation against noise and heat losses.

On one side, such approaches are beneficial for functional transformations of the interior as already mentioned, but simultaneously, on the other side they create a sort of dynamic-facade appearance of the whole building.

Advantages	Disadvantages
*Functional variety of spaces	*High cost systems *Costly maintenance

[154] Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010, p113.

Nothing Architecture, Av. dels Dolors 27, La Parada, Manresa, Barcelona, Spain, 2008.

Fig.6.2.1. (Left/ Middle/Right) Transformation of the facade of the building. Picture source: [http://www.narch.eu/p7/p7.html (accessed 15th February 2014)]

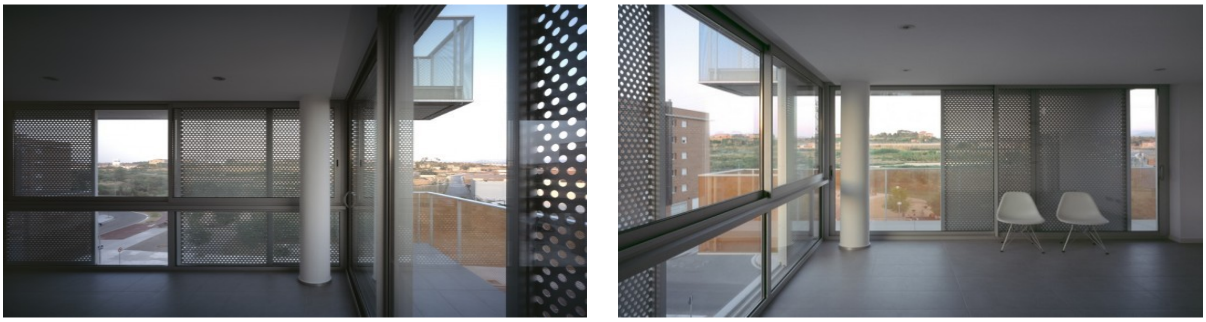


Fig.6.2.2. (Left/ Right) The view from inside to various transformations of the facade of the building. Picture source: [http://www.narch.eu/p7/p7.html (accessed 15th February 2014)]

Project description: Sliding facade system gives to this building dynamic exterior appearance and at the same time variability of interior transformations for its inhabitants. For example, a thin perforated panel on the outside facade works as a sunscreen, but at the same time it gives possibility for occupants to regulate the level of privacy in each separate living zone. As further mentioned in official project description, "...the dwellings are arranged around the central core of communications, leaving all stays in façade an all services inside. The location of the living-rooms in the corner can play with the composition of the façade featuring balconies on either side free and making it disappear on the four planes of enclosure.

Sliding system applies throughout the building from the front where the shutter is replaced by panels of perforated plates to the inner divisions that are integrated sliding doors by Krona. The spatial flexibility, freedom of movement and distribution creates a clean, smooth and flexible space, expanding and extending the area of relationship.

400 panels and perforated aluminum sheet: 3mm anodized matte silver form the second skin of the building, creating an appearance intangible boundaries and porous architecture of becoming imperceptible. The panels slide along the entire façade generates, from the outside, while mobility uniformity in the front, while from inside the panels can come and go as needed, getting a front open system varies according users and not determined by the architect."[155]

[155] "20 Dwellings in Manresa Barcelona / nothing architecture." ArchDaily. [http://www.archdaily.com/139836/20-dwellings-in-manresa-barcelona-nothing-architecture/ (accessed February 16, 2014)].

Glass Shutter House, by Shigeru Ban Architects

Fig.6.2.3. Flexible facade appearance. Picture source: [http://inhabitat.com/metal-shutter-houses-glimpse-of-the-future-and-ode-to-the-past/new-28-4/?extend=1 (accessed 16th February 2014)]

Project description: This residential building in Chelsea neighbourhood in New York City stands to have bigger influence on architecture over time. It is designed by architect Shigeru Ban, and its main significance lies in so called "removable skin" façade that allows the occupants to completely open their loft-like spaces up or to close them in order to make a visual barrier from the outside. As further mentioned by official project description, "...the minimalist building is stripped down to its fundamental elements — the simple boxiness of the 11 story building opens fully to the street, where a series of commercial metal shutters protect the large living spaces inside. Thanks to the twenty foot-wide shutters and operable glass walls the occupants can control their living space to suit their needs — they can let the daylight stream in or, conversely, close the shutter to deflect the hot glare and maintain their privacy. The windows fully open as well, letting the outdoors pour in on a pleasant day. Mr. Ban is known for using simple materials in new ways. The windows use the same technology as folding airplane hangar doors.
The application of outdoor shutters at this scale greatly outperforms even the most advanced glass in terms of energy efficiency. Shutters are a surprising solution — perhaps for their obvious usefulness — but also because of the rarity of external active shading over the last century. Commonly used as a way to control heat gain and glare before the advent of air conditioning and increasingly advanced glazing, the incorporation of shutters in design had virtually disappeared. The Metal Shutter Houses are notable for their use of this simple technology on a large scale, the value it bring to the occupants, and their low environmental profile."[156]

[156] "Gallery: Shigeru Ban's Elegant, ..." Inhabitat Sustainable Design Innovation Eco Architecture Green Building Metal Shutter House Comments. http://inhabitat.com/metal-shutter-houses-glimpse-of-the-future-and-ode-to-the-past/new-28-4/?extend=1 (accessed February 17, 2014).

6.2.1. Supporting commercial brands

Hawa

Company profile: Hawa Company raised the level of outdoor and indoor hardware systems from utilitarian engenering to architectural design elements with facinating possibilities. They goal is to follow the trends in architecture and interior design approach by resolving so far limited possibilities of sliding systems and focusing mainly on implementation of wide palette of different flexible sliding systems; on high load-bearing capability; on characteristically light materials for hand-sliding; and on low-noise running and rattle-proof guides. Additional option for majority of their developed systems is automation techniques, which can be quickly and easily retrofitted by using exactly the same basic components.[157]

Hawa – Frontslide 60/A

Fig.6.2.1.1. Picture source: [http://www.hawa.ch/fileadmin/user_upload/pdf/broschueren_flyer/BPF_EN_Fold_Slide_Laeden_20202.pdf (accessed 22th February 2014)]

Hawa – Frontfold 20

Fig.6.2.1.1. a. Picture source: [http://www.hawa.ch/fileadmin/user_upload/pdf/broschueren_flyer/BPF_EN_Fold_Slide_Laeden_20202.pdf (accessed 22th February 2014)]

[157] "Hawa broschueren" [http://www.hawa.ch/fileadmin/user_upload/pdf/broschueren_flyer/BPF_EN_Fold_Slide_Laeden_20202.pdf (accessed 23th February 2014)]

6.3. Floors

Surface of the floor area can be used as an element which can completely transform the experience of the whole space. In some simple cases we can talk about floor-bunkers on certain positions of the rooms which can be used as storage space for larger seasonal belongings (e.g. *A Home of One's Own* by Peter Gluck, Terri Chiao, Deborah Grossberg Katz, Joseph Vidich, and Leigha Dennis).
However, in more drastic cases, variability of floor altitudes can evoke perception of “separation” of different zones inside one open space (e.g. NA House by Sou Fujimoto in Tokyo, 2010); and even can replace most common horizontal organization of the space into “hidden” functional rooms beneath the floor surface (e.g. Suitcase House by Gary Chang, Hong Kong, 2001). One way or another, such methods contribute to maximum utilization of available space.

Fig.6.3.1. *A Home of One's Own* by Peter Gluck, Terri Chiao, Deborah Grossberg Katz, Joseph Vidich, and Leigha Dennis – showing the section of apartment where storage space is placed below the floor surface. Picture source:
[http://www.domusweb.it/en/architecture/2013/03/05/making-room.html
(accessed 22nd February 2014)]

Advantages	Disadvantages
*Maximum utilization of space	*Clumsy functionality

YO – Home, by Simon Woodroffe, UK, 2012, ca. 24 m²

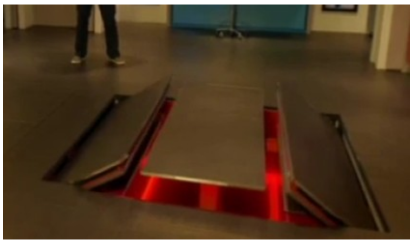




Fig.6.3.2. *Yo-home* concept - using the floor as a source for flexible spatial organization. Source: http://yo.co.uk/yo-home/videos/ (accessed 3rd July, 2014)]

Suitcase House, by Gary Chang, Hong Kong, 2001.

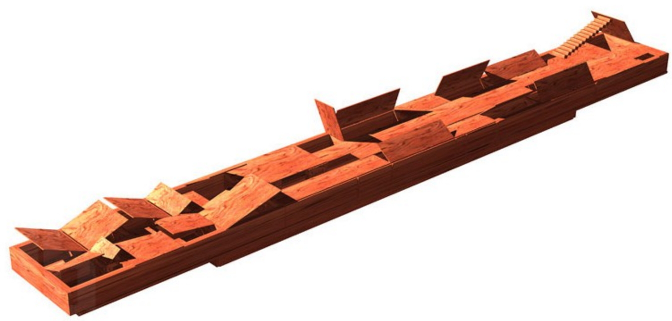



Fig.6.3.3. (left). Concept of flexible floor. Picture source: [http://www.designboom.com/architecture/suitcase-house-by-gary-chang-hides-program-beneath-ground/ (accessed 17th February 2014)]; **Fig.6.3.4. (right).** "Hidden spaces" integrated in floor surfaces. Picture source: [http://www.designboom.com/architecture/suitcase-house-by-gary-chang-hides-program-beneath-ground/ (accessed 17th February 2014)]


Fig.6.3.5. (left / right). "Hidden spaces" integrated in floor surfaces. Picture source: [http://www.designboom.com/architecture/suitcase-house-by-gary-chang-hides-program-beneath-ground/ (accessed 17th February 2014)]

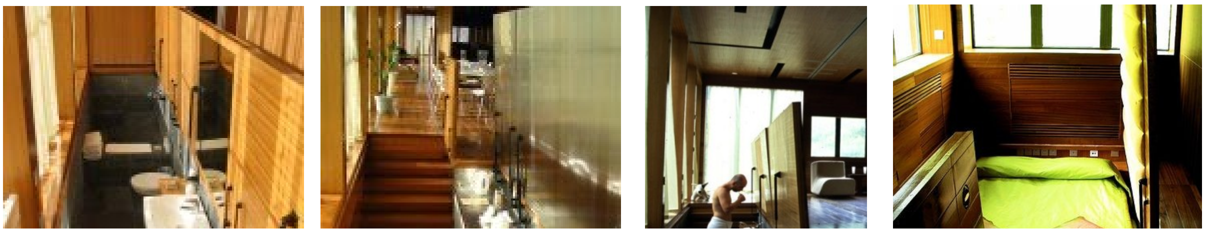


Fig.6.3.6. (left / right). “Hidden spaces” integrated in floor surfaces.
Picture source: [http://www.designboom.com/architecture/suitcase-house-by-gary-chang-hides-program-beneath-ground/ (accessed 17th February 2014)] and [http://www.pinterest.com/pin/366761963374397175/ (accessed 17th February 2014)]

Project description: The main characteristic of this project is that all the internal walls can be shifted and the functional zones of living can be organized in variety of ways. Additional “switch” in approach is that many of the functions inside the space are placed beneath the floor surface. “In effect they are like suitcases let into the floor: flaps open to reveal under-floor spaces – a kitchen, shower tray or a bed – into which one descends down a few steps.”[158]

House NA, by Sou Fujimoto, Tokyo, 85m², 2010.

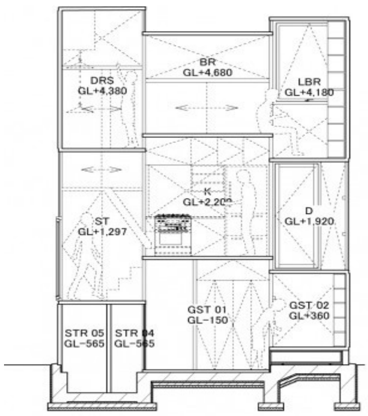


Fig.6.3.7. (left) NA house exterior. [http://www.archdaily.com/230533/house-na-sou-fujimoto-architects/ (accessed 22th February 2014)]; **Fig.6.3.8. (right)** section of the house [http://www.archdaily.com/230533/house-na-sou-fujimoto-architects/ (accessed 22th February 2014)]

Fig.6.3.9. (from left to right) NA house layouts – first floor, second floor, thrd floor and layout of roof [http://www.archdaily.com/230533/house-na-sou-fujimoto-architects/ (accessed 22th February 2014)]

[158](Schumacher, 2010)

Fig.6.3.10. (left) NA house interior. [http://www.archdaily.com/230533/house-na-sou-fujimoto-architects/ (accessed 22th February 2014)]; **Fig.6.3.11. (right)** view on house "terraces" [http://www.archdaily.com/230533/house-na-sou-fujimoto-architects/ (accessed 22th February 2014)]

Project description: This house is designed for young couple in dense residential area of Tokyo. With total floor area of 85 square meters, the interior space is divided on 21 individual floor plates; all situated on different height levels that allow to the occupants to live as nomads in their own house. Accordingly, these varieties of heights participate in perception of whole space both as a single room and a collection of rooms. Each single plate creates a setting for a range of activities that can take place at different scales. The house provides spaces of intimacy if two individuals choose to be close, while also accommodating for a group of guests by distributing people across the house. As such, this concept represents a flexible organization of space without strict definition what is considered as gathering zone, dining area, sleeping area or etc. Residents are allowed to "move" their daily activities from one part of the house to another – or more precisely, from one floor plate to another one. Sou Fujimoto describe this concept as a "tree concept" where each of these functional plates "*are not hermetically isolated but are connected to one another in its unique relativity. To hear one's voice from across and above, hopping over to another branch, a discussion taking place across branches by members from separate branches. These are some of the moments of richness encountered through such spatially dense living."* As further explained in official project description : "Ranging in size from 21 to 81 square-feet, each floor plate is linked by a variety of stairs and ladders, including short runs of fixed and movable steps. Stratifying floor plates in a furniture-like scale allows the structure to serve many types of functions, such as providing for circulation, seating and workings spaces. The short-spans allow for the thinness of the white steel frame. Complemented by the thin white-tinted birch flooring, many wonder where the utilities are hidden. Some floor plates are equipped with in-floor heating to help during the winter months, while strategically placed fenestration maximizes air flow and provides the only source of ventilation and cooling during summer.
The HVAC and plumbing equipment, as well as storage and lateral bracing are located in the thick, north-facing wall at the rear of the house. Additional lateral bracing is provided by a full-height bookshelf and lightweight concrete panels integrated within the side elevations."[159]

[159] "house NA – sou fujimoto architects" [http://www.archdaily.com/230533/house-na-sou-fujimoto-architects/ (accessed 17th February 2014)]

6.4. Ceilings

Functional variability of the ceilings in flexible dwellings contexts could be in most basic manner understood as "integrated bunkers" for furniture (e.g. beds) or storage elements which could be either simply opened or folded down when needed.

Another category, which is more technically demanding, is connected with highly complex and advanced solutions offering a high degree of comfort and safety.[160] Such systems are actually inspired with elevator technology which trough its development found more wide application in general architecture. For example, spectrum of kinetic apparatuses ranges from hydraulic lifting platforms to cranes and complex conveyor systems.[161] In our case, we can talk about "moving platforms" where ceiling become a variable element which changes vertical configuration of the living space. Therefore "the traditional separation of the building into floors is broken down, room heights are not fixed and unusual ways of accessing rooms can result"[162].

Advantages	Disadvantages
*Maximum utilization of space	*High cost systems because of security Requirements and expensive technology *Costly maintenance

[160] Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010, p146.
[161] (Schumacher, 2010)
[162] (Schumacher, 2010. p108)

YO – Home, by Simon Woodroffe, UK, 2012, ca. 24 m^2

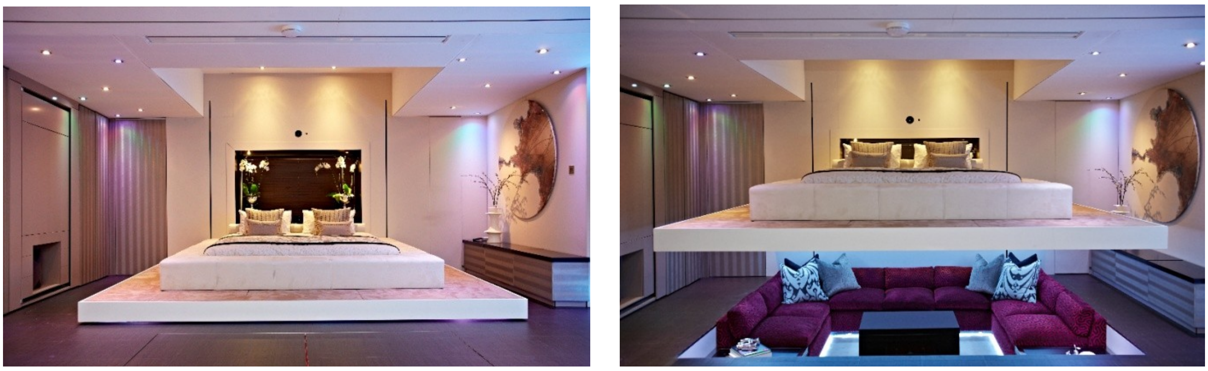


Fig.6.4.1. (Left/Right) Folding "sleeping scenario" from the ceiling. Source: http://yo.co.uk/yo-home/videos/ (accessed 3rd July, 2014)]

Attic apartment, by Elii Architects

Fig.6.4.2. (Left/Right up/Right bottom) Various folding scenarios from the ceiling. Source: http://dornob.com/adaptable-attic-apartment-full-of-secret-compartments/#axzz33gQRZ9WB (accessed 3rd July, 2014)]

Villa in Bordeaux, by Rem Koolhaas, 1998.

Fig.6.4.1. (left) Hydraulically-operated platform in the centre of the living area. Picture source: [http://www.koolhaashouselife.com/html/trailers.html (accessed 17th February 2014)]; **Fig.6.4.2. (middle).** Hydraulically-operated platform in the centre of the living area. Picture source: [http://www.oma.eu (accessed 17th February 2014)]; **Fig.6.4.3. (right).** Hydraulically-operated platform in the centre of the living area. Picture source: [http://storiesofhouses.blogspot.it/ (accessed 17th February 2014)]

Fig.6.4.4. (left/middle/ right). Hydraulically ceiling opening systems.
Picture source: [http://www.koolhaashouselife.com/html/trailers.html (accessed 17th February 2014)]

Project description: Although this project by its dimensional characteristics cannot fit to mentioned standards of compact and flexible living, it is worth to mention one flexible interior method that is implemented. It is related to a hydraulically-operated platform in the centre of the living area. As further explained in project description, the main motivation for this approach was the disability of the owner. Thereby, “the moving floor provides a means of reaching the upper storey and replaces a lift. But it does much more than that: trough its openly visible movement it completely transforms the way the space is experienced.”[163]

Villa in Bordeaux, by Rem Koolhaas, 1998.

Fig.6.4.4. (left/ right). “Hanging bed”. Picture source: [http://inhabitat.com/watch-this-mit-researcher-triple-the-size-of-a-200-foot-apartment-using-minority-report-like-gestures/ (accessed 17th June 2014)]

Project description: Loft bed concepts are usually considered as adequate functional solution for extremely small apartments. However, apartments with standard heights of ceilings may evoke a bit claustrophobic atmosphere and feeling of spatial congestion. Therefore, loft beds can visually clog the space, making it look smaller than it actually is. This case study represents one solution that try to avoid this type of problem. In order to mitigate that claustrophobic feeling, the author decided to create a skylight above the bed, which hangs from the ceiling. [164] “Large windows retract to allow access to a 500 square foot rooftop garden, while the home office below the bed receives additional lighting from the skylight and is discretely separated from the rest of the apartment.”[165]

[163] Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010, p109.
[164] Inhabitat.com [http://inhabitat.com/watch-this-mit-researcher-triple-the-size-of-a-200-foot-apartment-using-minority-report-like-gestures/ (accessed 17th June 2014)]
[165] Inhabitat.com [http://inhabitat.com/watch-this-mit-researcher-triple-the-size-of-a-200-foot-apartment-using-minority-report-like-gestures/ (accessed 17th June 2014)]

7. Furniture trends for flexible interiors in current times

According to the analysis of the case studies carried out in this research, it became obvious that people in limited living contexts think of furniture as of an unavoidable home necessity which is compact in use, easy to store, with multiple functions and suitable for various age-ranges. Consequently, furniture designers and producers had to change their traditional approach to furniture design. Furniture with determined, static and fixed purposes changed into variable, movable, extendable components that could free the space from fixed and limited functions through their flexibility. Techniques like modularity, space optimization and compressed functionality of furniture became one of the main sources of inspiration in order to achieve maximum functional flexibility.

Therefore, today's architects and designers create tables that can be used for dining purposes, but at the same time can be expanded to host more than four people or can be suitable for working as well. We have examples of beds which are completely hidden in the various types of "bunkers" or can be partially exposed in order to be used in daily leisure time, while having all the comforts of a traditional sofa or of a normal bed.

Besides the tailor-made solutions by architects and designers, there are lots of furniture producers who managed to satisfy these trends in furniture mass production. Among the most well-known brands implementing this way of thinking are Ikea, Clei, etc.

On this line, the following chapters will review all the solutions mentioned so far.

Table by Studio Garneau

Fig.7.1. Various functional transformation of the table. [http://www.studiogarneau.com/product/table.html (accessed 22th February 2014)]

Fig.7.2. [http://www.youtube.com/watch?v=oLwQHd0BYcc (accessed 22th February 2014)]

Project description: Table is designed so as to be height adjustable with hydraulic metal legs. Within the tabletop are concealed drawers in different sizes that are distributed on all four sides of the surface. “Electronic controls and power outlets are cleverly out of the sight underneath and accessible via concealed flaps.”[166] With such technical varieties of transformation, this table could be placed in different functional areas of dwelling (in kitchen, in working room, or in living room), or it can represent universal table element (suitable for compact apartments) in which are incorporated functions of dining table, working table or coffee table all together.

[166][http://www.studiogarneau.com/product/table.html (accessed 22th February 2014)]

Sofa-bed in Paris apartment, 16 m2, by Marc Baillargeon and Julie Nabucet, Paris.

Fig.7.3. [http://www.huffingtonpost.com/2013/04/10/small-paris-apartment-photos_n_3054908.html (accessed 18th March 2014)]

Fig.7.4. [http://www.huffingtonpost.com/2013/04/10/small-paris-apartment-photos_n_3054908.html (accessed 18th March 2014)]

Project description: With availability of only 16 m^2 of floor area, we can easily think that this is an adequate measure for a simple dorm room. Instead, two French based architects, Marc Baillargeon and Julie Nabucet, designed an apartment, following the idea that “everything has to be stored in everything else”. For example, the bed slides out from underneath the kitchen and the stairs open up to act as storage.[167]Accordingly, the interior organization is providing its residents appropriate and sufficient space for cooking, dining, working and leisure activities.

[167] Anderson, Christina. "A Small Paris Apartment That Could Fit In Your Dorm Room (PHOTOS)." The Huffington Post. April 10, 2013. Accessed December 8, 2014. http://www.huffingtonpost.com/2013/04/10/small-paris-apartment-photos_n_3054908.html.

7.1. Supporting commercial brands

Ikea

Ikea is well-known brand by its affordability, modularity and adaptability to various life-style contexts which suits middle class standards. This originally Swedish company, developed wide range of ready-to-assemble furniture, appliances and home accessories broadcasted in 40 countries worldwide.
Their business strategy starts with "understanding of people's everyday needs at home, especially the needs of the majority of people, who have limited incomes and limited living spaces. This is how IKEA succeeds in offering well-designed, functional products at prices so low that most people can afford them."[168]

"In response to the explosion of human population and material expectations in the 20th and 21st century, the company implements economies of scale, capturing material streams and creating manufacturing processes that hold costs and resource use down, such as the extensive use of MDF (medium-density fibreboard). MDF, often called "particle board", is engineered wood fibre glued under heat and pressure to create a building material of superior strength which is resistant to warp. IKEA uses cabinet-grade and furniture-grade MDF in all of its MDF products, such as PAX wardrobes and kitchen cupboards. IKEA also uses wood, plastic, and other materials for furniture and other products. The intended result is flexible, adaptable home furnishings, scalable both to smaller homes and dwellings as well as large houses."[169]

The products that are worth to extract, especially in limited interiors which suppose to have flexible functions, are modular wardrobe systems (e.g. Stolmen System) which are not strictly classified as "storage for clothes in bedroom", but can be adopted in other functional zones inside dwelling as well (e.g. in living room, office room, children room, etc.).

Stolmen System

[168] [http://www.ikea.com/ms/en_GB/the_ikea_story/working_at_ikea/work_areas_design_product_development.html (accessed 11th February 2014)]
[169] [http://en.wikipedia.org/wiki/IKEA (accessed 11th February 2014)]

Fig.7.1.1. Stolmen System in house at 36 Boon Teck Road by DP Architects, in Singapore. Picture source: [http://www.archdaily.com/199918/36-btrd-dp-architects/ (accessed 16th February 2014)]

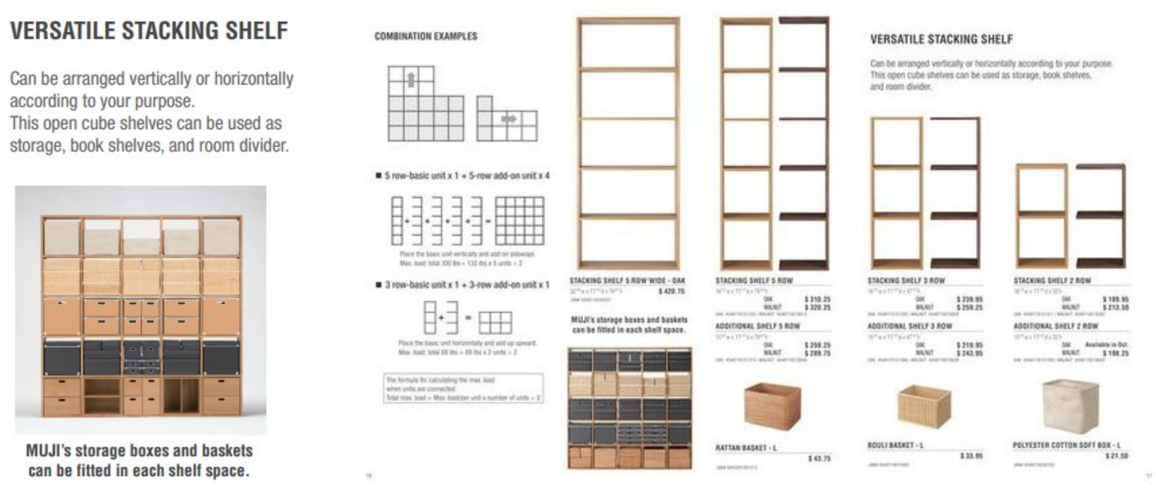
Norden foldable table

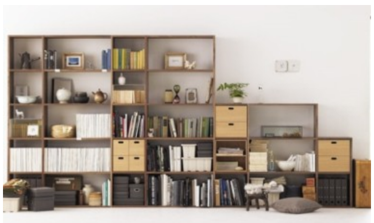
STORÅ Loft bed

Muji

Company profile: "MUJI products vividly embody both our product-design methods and our overall philosophy. Since its birth in 1980, the MUJI brand has attracted a steadily increasing number of consumers, precisely because of our growing understanding and refining of sales principles. Our goal of offering products that excel in quality at lower prices has been achieved by avoiding the waste typical of much product-manufacturing and distribution – in the form of unnecessary functionality, an excess of decoration, and needless packaging."[170]

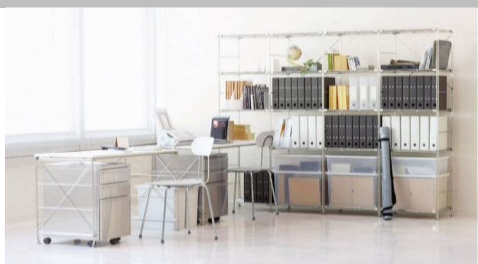
Versatile stacking shelf






Sus-steel unit furniture





170 [www.muji.eu (accessed 17th February 2014)]

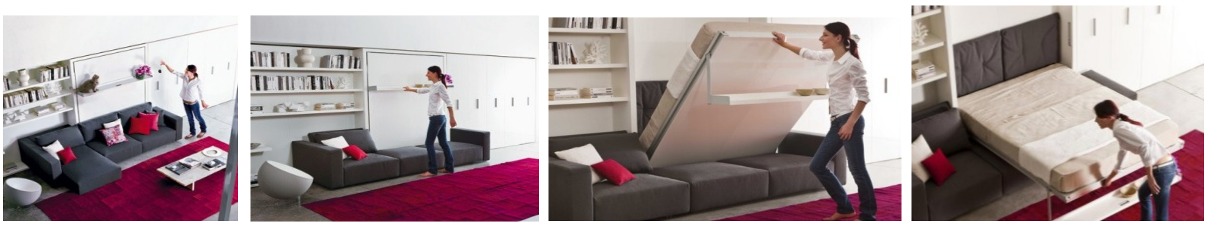
Storage boxes and Units

Clei

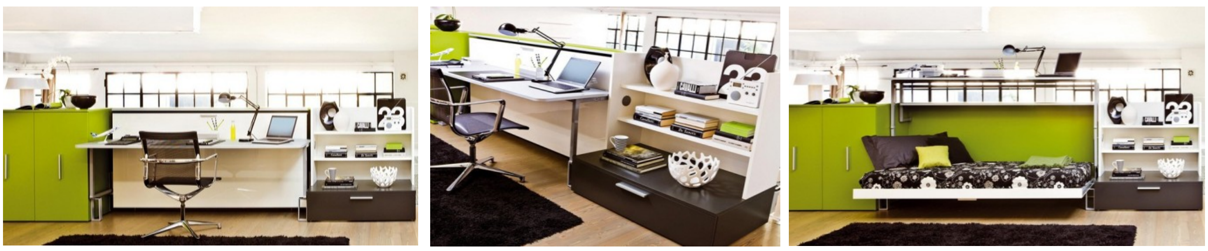
Company profile: "Clei, furnishings industry, is based in Brianza (North of Italy) and boasts origins back in time. The company was established in 1962 with a great propensity for innovation, focusing on design directed to integrate Transformable Systems into modular and versatile furniture collection, for home furnishings, holiday houses and business residences. To the growing market demand for versatile and multifunctional furnishing solutions, able to satisfy the different living requirements, Clei responds with the two furniture collections LIVING SYSTEMS and YOUNG SYSTEMS , integrated to transformable systems for the living area and the young people space . The high technological collections contain research, creativity, innovation and engineering, that are the main lines of CLEI 's philosophy and competitive strategy. Besides the design and the patented technology, an extremely easiness of use : simple movements for multiple functions and performances/solutions, with neither limits nor compromises. Bookshelves, storage units, sofas, tables and desks are combined in one area that is both shared out and shared with, and they transform from living furniture into night elements with comfortable beds in different sizes ready to use, with more advantages than the standard solutions."[171]

Lollisoft

Swing

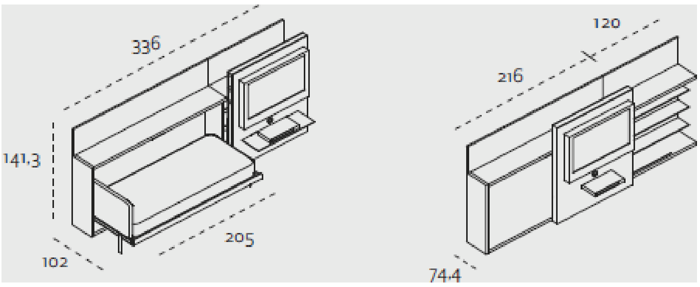


Cabrio In



[171] [http://www.clei.it/# (accessed 11th February 2014)]

Poppi Theatre



Campeggi

Company profile: “In order to avoid boredom of acquired positions, to overcome stillness of static situations,to restart desires and pleasures, Campeggi is imaging a bright and dynamic universe full of objects ready to be moved or trasformed in order to comply with your pleasure of dwelling, living and changing. To speed up before a yawn, Campeggi is proposing you its own dictionary made of Comfort, Agility, Movement, Practicalness, Economy, Gracefulness, Game and always Inexhaustible.

Comfort, namely the use of technologically advanced mate- rials; the results of ergonomic and updated researches; *Agility*, phisically but also mentally speaking of each single piece of the collection; *Movement* as a fundamental rule which allows a trasformability of every single project; *Practicalness* as the result of a corporate tradition which, while dreaming and following new imaginaries, does not venture in “Pindaric flights” within impractical territories; *Economy* as the first target; *Gracefulness* of measure, balance and sobriety, resulting from the strict and knowing co-operation with the best international designers; *Game* as a serious pleasure, sure of the importance given by a smile; *Inexhaustible* as a logic consequence of a corporate thinking which does not put into practice what is obvious and which never sinks into acquired positions. A dictionary as a catalogue, therefore, constantly enriched with unconventionality, freshness, humour, innovation, and lightness.

Objects of the Campeggi’s collection give birth to a catalogue that in the future years will form, with evidence, a point of reference for those in search of a tech-typological innovation and not banality, faintness, luxury, but dynamic intelligence and not static stillness. Stillness prevents and does not register event in the near world. Things that are not changing are bound to dry up; just those that can face a change do not die.

Campeggi, always faithful to itself, is still changing for you.“[172]

Virgola

[172] [http://www.campeggisrl.it/en/company (accessed 11th February 2014)]

Sosia

Concentre de Vie

HomeWork

Resource furniture

RESOURCE FURNITURE
SPACE. REINVENTED©

Company profile: This Company is important to be mentioned, since it is dealing specifically with modern space-saving furniture solutions. Therefore, the main company strategy is to detect and distribute the finest and most innovative furniture products from designers and companies worldwide in this specific field. Accordingly, we can find in their collection various solutions of modular and customizable beds systems (e.g. wall beds, bunk beds, etc.), but also freestanding sofa/wall-bed systems, closets, transforming and space-saving tables, seating and work space solutions.[173]

Goliath



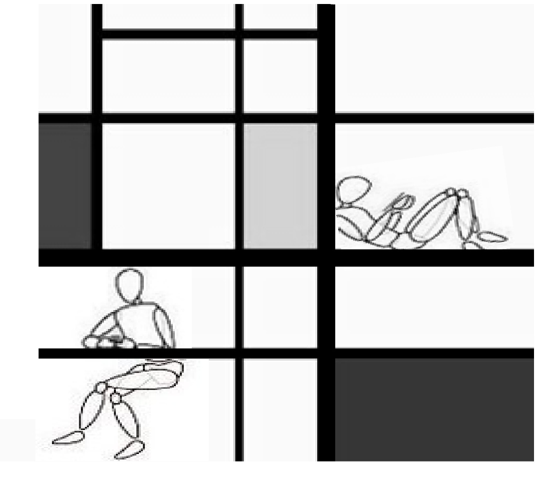

Stealth Kitchen



[173] "Resource Furniture" [http://www.resourcefurniture.com/about (accessed 17th February 2014)]

RESULTS ANALYSIS

PART 2 – SOCIAL ASPECT



PART 2 – SOCIAL ASPECT

As mentioned in *Design, Creativity and Culture* by Maurice Barnwell, "many desired and required changes will come about by design. We have no choice[174]. Despite amazing advances in science and technology "we still live in a world threatened by environmental hazards, by cities infested with social chaos, by an ever increasing divide between the rich and the poor… […] A recent *Living Planet* report shows that the world is facing a natural resources crisis worse than the financial crunch of 2008, and with more dire consequences. […] Humanity's demands exceed our planet's capacity to sustain us"[175].

Therefore, the flexible dwelling methods analyzed in the previous chapters could be considered as adequate tools to raise people's awareness about the future of our planet. These concepts are more and more likely to become unavoidable prototypes of urban homes in upcoming times. But, as also Enzio Manzini mentioned, this transition brings radical change not only in the way how we build, produce or consume, but also in the way how we live.[176] These concepts teach us that we have to live more responsibly and care about global environmental conditions, but at the same time they put us in contrast with the living behavior inherited by the previous generations.

By reviewing flexibility in the analyzed case studies from a technical perspective, we can notice that some solutions impose behavioral patterns which differ from the previous consumer-based perception of living and that some previously adopted "non-flexible" habits connected with comfort are changing. As also Anna Meroni states, we are trying to face "the concept of living well while at the same time consuming fewer resources and generating new patterns of social cohabitation [...] that is diametrically opposed to the one which industrialised society has until now engendered and propagated throughout the world ..."[177].

All this considered, the aim of the following chapters is to highlight what changes in social conditions the flexible approach to dwellings has imposed to people and what kind of comfort conditions people are now obliged to adopt. This analysis is very important as it can offer a deeper view into the living reality of the present time and can provide answers to the **third and fourth research questions** listed at the beginning of this thesis (see chapter 2.5.).

[174] Barnwell, Maurice. *Design, creativity & culture: an orientation to design*. London, UK: Black Dog Publishing, 2011, p. 184
[175] (Barnwell, 2011. p184)
[176] Manzini, Enzio. "Creative Communities in a Network Society", in Cornelis, Jan, Merleen Wynants, ed., *Brand New Interfaces*. Bruxelles: ASP/VUBPRESS, 2008, pp. 89-99.
[177] Meroni, Anna. "Creative Communities. People inventing sustainable ways of living.." Academia.edu. http://www.academia.edu/877752/Creative_Communities._People_inventing_sustainable_ways_of_living (accessed May 11, 2014).

8. Flexible dwelling interior and important comfort categories

"... everything we design is used by people, and people come in many sizes and having varying physical attributes [...] numerous allergies, inhibitions, and obsessions. They react strongly to touch that is uncomfortable or unnatural; they are disturbed by glaring or insufficient light and by offensive colouring; they are sensitive to noise, and they shrink from disagreeable odour." Henry Dreyfuss, "Designing for people", 1955.

The feeling of comfort is an important one that contributes to human satisfaction with the space we live in. Besides the aesthetically pleasant domain of comfort which people can experience inside the spaces and mainly depends on personal taste, there are also some other factors which contribute to people's satisfaction with indoor environment. For example, inside a space people can easily feel too cold or too warm; their daily routine can be disrupted with poor lighting; they can feel uncomfortable when the air is odorous or stale; when the materials on which they sit or sleep are too hard or too soft; or when the selection of colours or amount of volumes inside the spaces are contributing to some negative feelings like congestion, etc. Therefore, crucial factors which detect these unpleasant sensations are connected with our sense organs: eyes, ears, nose, tactile sensors, heat sensors and brain.[178] Taking into account the variable sensitivity of the above mentioned organs, we have to conclude that comfort categories could be challenging to discuss as they depend on subjective standards. However, if we approach the matter from a health perspective, we can distinguish some vital categories based on which comfort conditions can be judged and poorly designed spaces can be identified. These conditions are related to thermal comfort (heating, indoor air quality, ventilation, humidity, etc.), visual comfort, selection of materials, selection of colours, importance of volumes inside the space and respect of ergonomic standards. Additionally, an important starting point which also determines the value of these categories is the state of human body in terms of age, gender or general health conditions. All the previously mentioned parameters are important because they can impact on an occupant's performance in a number of different ways, starting from the effects that can damage the health conditions (e.g. heat stress, musculoskeletal disorders, etc.), effects that reduce the individual's ability to perform a task (poor lighting, distraction), to effects that cause dissatisfaction, resistance to change and uncooperative attitudes[179].

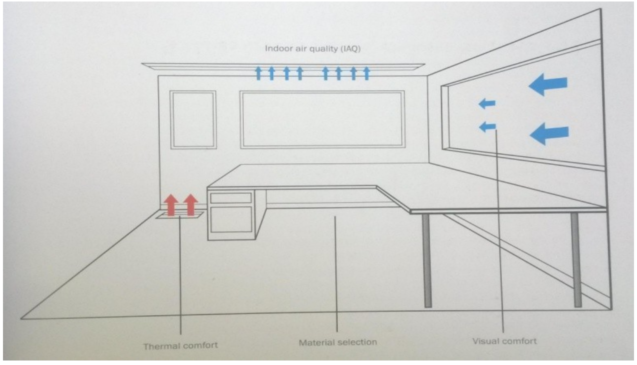


Fig.8.1. Important four key factors (thermal comfort, material selection, visual comfort, indoor air quality) that are affecting indoor environment - according to source "Innovative houses" by Avi Friedman. Source: Friedman, Avi. *Innovative houses: concepts for sustainable living*. S.l.: Laurence King Publishing, 2013, p117.

[178] "Comfort health" [http://courses.washington.edu/me333afe/Comfort_Health.pdf (accessed 12th March 2014)]
[179] "Human factors: Lighting, thermal comfort, working space, noise and vibration." Human factors – Lighting. http://www.hse.gov.uk/humanfactors/topics/lighting.htm (accessed July 8, 2014).

Due to all this, in most countries these factors are deeply examined in order to improve human well-being and are expressed in regulations and standards such as the ones formulated by SIA in Switzerland (SIA e.V. 2008), EBPD in Europe (European Comission 2002) or ASHRAE (ASHRAE 2010) in the United States[180]. Both architecture and design strongly rely on these regulations.

Since this thesis deals with flexible and limited dwelling interiors, where the floor areas of the dwellings are almost always not complying with the proposed standard regulations and where people often have to accept many compromises, the aim of this chapter is to detect the presence of the above mentioned comfort conditions in such dwellings. This observation is very important insofar as it is connected with the occupants' health conditions on the long term. The challenging point is to analyze how these compact and multi-purpose spaces are dealing with the previously mentioned conditions. In addition, another key point is to understand how such spaces can actually ensure that a satisfactory level of comfortable living environment is maintained on the long term.
In this thesis, comfort conditions are regarded mainly in relation to thermal comfort, visual comfort (lighting and colours), space density and ergonomic factors, all of which are considered as crucial factors to answer the **third research question** mentioned at the beginning of this thesis (see chapter 2.5.).

[180] "MODEL-BASED, PERFORMANCE-ORIENTED BUILDING DESIGN EMPLOYING DISTRIBUTED SERVICE SYSTEMS" PhD Thesis by Arno Schlüter, at ETH, Zurich, Switzerland.

8.1. Thermal comfort

8.1.1. In general

"*Thermal comfort* is that state of mind that is satisfied with the thermal environment; it is thus the condition of minimal stimulation of the skin's heat sensors and of the heat-sensing portion of the brain."[181] This "thermal neutrality is maintained when the heat generated by human metabolism is allowed to dissipate, thus maintaining thermal equilibrium with the surroundings. The main factors that influence thermal comfort are those that determine heat gain and loss, namely metabolic rate, clothing insulation, air temperature, mean radiant temperature, air speed and relative humidity. Psychological parameters such as individual expectations also affect thermal comfort."[182]
Relevant researches in this field already set standards based on health requirements, climate zones, demographic factors and personal preferences of the occupants. Therefore, we can in most of the cases predict or avoid some unwanted discomfort conditions. Starting from this point and taking on account also subjective perception, we can conclude that one of the main aspects to assure thermally comfortable environment is to implement instruments which are able to support variable adjustments of mentioned thermal factors. This variability is needed in order to achieve thermal balance according to outdoor conditions, occupants' body sensitivity and personal preferences.

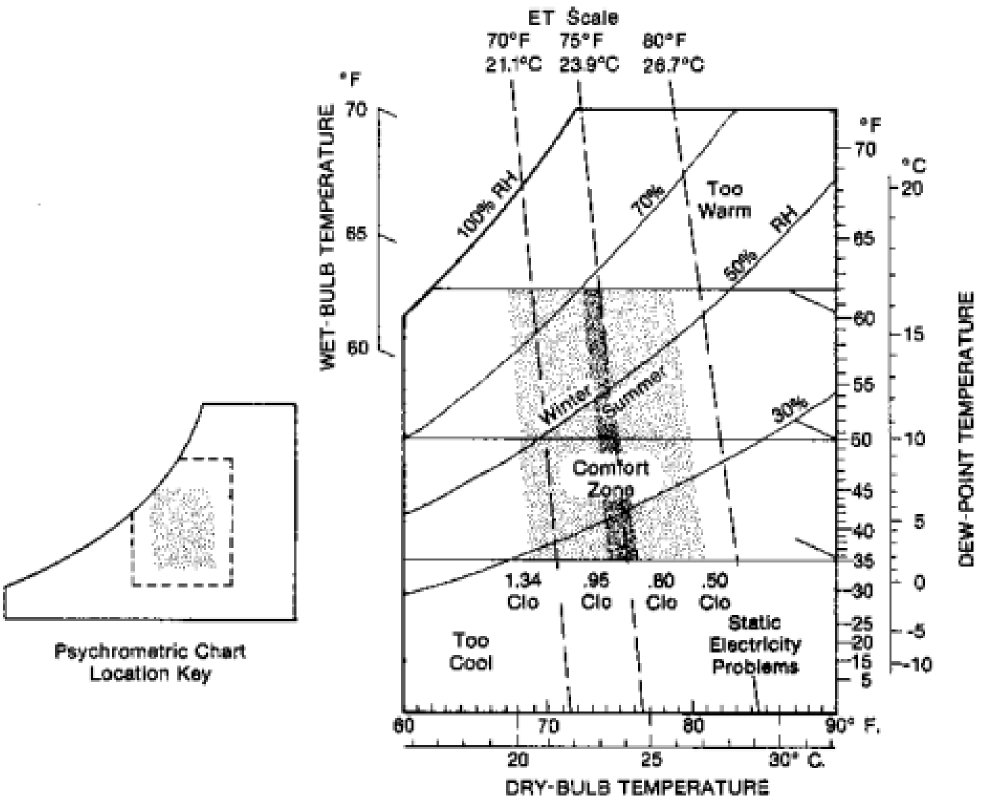


Fig.8.1.1.1. Comfort chart showing range of combined thermal conditions that provide comfort to most people. Source: "Human comfort and health environment" [http://courses.washington.edu/me333afe/Comfort_Health.pdf (accessed 18th March 2014)]

[181] "Human comfort and health environment" [http://courses.washington.edu/me333afe/Comfort_Health.pdf (accessed 18th March 2014)]
[182] "Thermal comfort" [http://en.wikipedia.org/wiki/Thermal_comfort (accessed 11th March 2014)]

8.1.2. In flexible dwellings

All crucial parameters and norms regulated for residential buildings considering thermal comfort are considered also in the case of flexible dwellings. However, such dwellings in the recent times are showing growing tendency towards various technical methods in designing (e.g. large window openings, etc.) and implementing sustainable and energy-efficient concepts (e.g. solar panels, HVAC[183] systems, etc.) which can satisfy thermal requirements, prior to resorting to costly energy consuming technologies.

In context of compact and multi-purpose living spaces we could actually start with very simple manner how to control the level of temperature. Since the floor area is usually very small and contain in majority of cases only one room, the whole space can be easily balanced at once with simple action like opening the door/s or window/s. This method is important to emphasize since all examined case studies rely on it as an unavoidable and basic tool. It should be also mentioned that for some of the case studies this is the only tool for controlling the level of thermal comfort (e.g. Case study no. 57, Case study no. 64).

Furthermore, next relevant factor is properly orientated large window openings which can allow penetration of sun energy inside the space. In order to adjust its quantity, most of the examined case studies implement various types of adjustable sun protectors as well (*e.g. Glass Shutter House* by Shigeru Ban Architects, New York City, 2011). Such approach is appropriate for warm climate locations, while in colder climate areas such approach must have, along with some additional heat source, a strong window isolation in order to prevent unwanted heat escape trough large glass surfaces. In such cases, implementation of "certain window types, such as double or triple glazed insulated windows with gas filled spaces and low emissivity (low-E) coatings, provide much better insulation than single-pane glass windows"[184] (*e.g. Sunset Cabin* by Taylor Smith Architects, Canada, 2004).

Fig.8.1.2.1. Sunset Cabin by Taylor Smith Architects, Canada. Picture source: Schleifer, Simone K.. *Prefab Houses = Fertighäuser.*. Antwerpen: Booqs, 2011, p258-267.

In the case of sustainable and energy-efficient factors in small and flexible dwellings, we could take one representative case study, such as *Micro Compact Home* (Case study no. 58) where the usual approach concepts are implemented. According to its official description, this micro-living

[183] HVAC = Heating, ventilation and air-conditioning systems.
[184] "Sustainable architecture" [http://en.wikipedia.org/wiki/Sustainable_architecture (accessed 3rd March 2014)]

environment “requires a single electrical supply, water and drainage. The electric consumption varies according to the weather condition. In winter it uses no more than 348kWh and in summer it uses approximately 123kWh due to the use of air conditioning. Due to the mall size of the pod, heating and cooling it does not require much time. The pod is also powered by PV solar panels and a vertical wind generator as shown located on the roof of the pod ...”[185] (see Fig.8.1.2.2.). Similarly, in another case of *Micro Home* by Renzo Piano (Case study no.63) we have again highly considered sustainable system - photovoltaic cells, solar panels, a rainwater tank, natural ventilation and triple glazing that guaranties total environmental synthesis.[186]

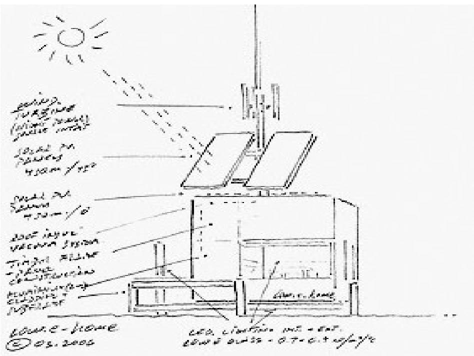


Fig.8.1.2.2. Sketch of solar panels and wind generator on the roof of *Micro Compact Home* (Case study no.58).
Source: "Case studies." LivingPod. http://be1341virtualprojectassignment2pod.wordpress.com/2014/01/11/case-studies/ (accessed July 7, 2014).

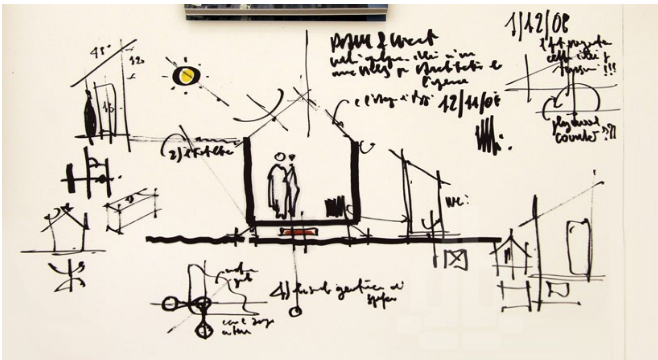


Fig.8.1.2.3. Sketch of energy efficient systems in *Micro Home* by Renzo Piano (Case study no. 63).

Case Study No.	Thermal adjustment by opening/closing windows and doors	Large window openings	Strong window isolation	Curtains/ screens/ sun protectors	Sustainable and energy efficient concepts	Heating appliances	Air-condition appliances	General thermal comfort
47	x					x	x	SATISFACTORY
50	x			x		x	x	SATISFACTORY
51	x			x		x	x	SATISFACTORY
56	x	x	x	x	x			SATISFACTORY
57	x							POOR
58	x	x	x	x	x			SATISFACTORY
63	x	x	x	x	x			SATISFACTORY
64	x							POOR
65	x					x	x	SATISFACTORY
70	x	x	x	x	x			SATISFACTORY

Table 1. Presence of various concepts contributing to thermal conditions in case studies related to Typology 2 (micro-living capsules) from time period 2000+

[185] "Case studies." Living Pod. http://be1341virtualprojectassignment2pod.wordpress.com/2014/01/11/case-studies/ (accessed July 7, 2014).
[186] "renzo piano's micro-home 'diogene' installed on vitra campus." designboom architecture design magazine renzo pianos microhome diogene installed on vitra campus Comments. http://www.designboom.com/architecture/renzo-pianos-micro-home-diogene-installed-on-vitra-campus/ (accessed July 8, 2014).

8.2. Visual comfort - lighting

8.2.1. In general

In order to maximize visual comfort particular attention should be given to the day lighting and different types of artificial light inside the dwelling. As mentioned before, not adequate quantity of lighting inside living space, no matter if it is natural or artificial, can be disrupting circumstance in performance of normal daily routine activities of the occupants. If not properly balanced, it directly affects not only comfort but also have negative influence on the health condition of the occupants. Poor lighting decrease safety in movement inside the space and can cause damage to eye performance on long-term while obtaining some tasks like reading, cooking or working. Other disadvantages mentioned in present researches are connected with low working performance, deformations in posture habits especially while sitting, and can even cause heavy headaches and migraines. In the case of high light intensity, the comfort conditions is decreased because of glare of the surfaces, which at the end causes pretty much the same negative impacts on humans as like in case of poor lighting. Therefore, standards and rules connected with appropriate visual comfort are regulated with norms such as EN 12464-1 (Lighting of workspaces – part 1: indoor workplaces, *CEN, 2002a*), EN 12665 (Light and Lighting – Basic terms and criteria for Specifying Lighting requirements), EN 13032-2 (Lighting applications – Measurements and presentation of Photometric Data of Lamps and luminaries), CIE 117 (Discomfort Glare in Interior Lighting, *CIE 1995*), NEN 2057 (Daylight openings of buildings).[187]

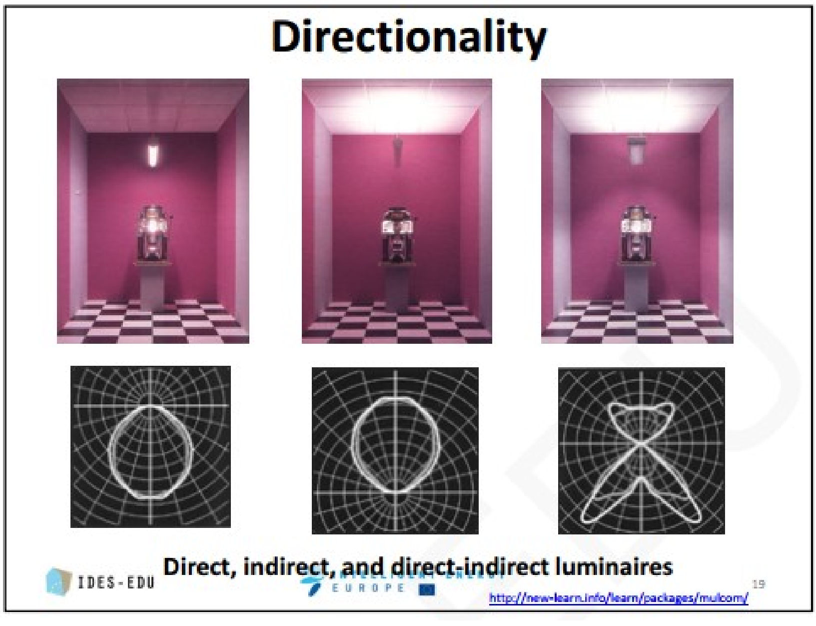


Fig. 8.2.1.1. Directionality of artificial light – direct, indirect and direct-indirect luminaries. Source: Dvořáková, Pavla. "Visual comfort". [http://www.ides-edu.eu/wp content/uploads/2013/04/4-visual-comfort.pdf (accessed July 7, 2014)].

[187] Dvorakova, Pavla et al. "Visual comfort", Faculty of Civil Engineering, CTU, Prague: 2013. [http://www.ides-edu.eu/wp-content/uploads/2013/04/4-visual-comfort.pdf (accessed 17th March 2014)]

8.2.2. In flexible dwellings

In context of the subject of this Thesis, since we are dealing with usually very small and multi-purpose units, such requirements should be carefully examined and implemented in order to support various living activities which require various lighting conditions in usually only one single room. Therefore examined case studies which can be considered as successful in terms of visual comfort are using combination of various techniques in order to achieve balanced light requirements inside variable spatial organizations. Most present and important ones are based on implementation of large window openings with integrated sun screens for adjusting the amount of the natural light as desired (e.g. Case study no.56, Case study no.58, Case study no.69, etc.). As such, presence of natural light is highly valuable category for improving comfort conditions in small and limited spaces because “it is soft, diffused, creates little glare and does not increase the radiant temperature.”[188]



Various examples of big screen openings with integrated sun protectors in order to control the amount of natural light inside the space. **Fig.8.2.2.1.(Left)** Case study 70; **Fig.8.2.2.2.(Middle)** Case study 58; **Fig.8.2.2.3.(Right)** Case study 69.

It is also important considering the fact that it actually psychologically gives impression of grater spaciousness and “extends” the interior layout towards outside environment. Consequently, in majority of related case studies such method is implemented.

In the cases where extremely large window openings are not so applicable solution, artificial up-lighting or directional lighting need to fill the gaps of use of smaller windows. In such cases the attention to light colour, contrast and glare is considered as main point of concern. The light sources must be planned as well in flexible manner so each living scenario could have its adequate lighting functionality.

Usually, based on analysis of case studies, very small capsules suffer from lack of options considering use of different types of lightings. Therefore, majority of such environments are limited to only one artificial light source, or only one natural source of light (very usually without possibility for adjusting its intensity with sun protectors) what puts into the question situations related to qualitative working activities for occupants (e.g. Case study no.57, 63, 64). The main concerns in these cases are related to shadows which this single type of lighting creates. As shown in Fig. 8.2.2.4., such environments need additional artificial light to be focused specially on activities zones related to work, dining or etc.

[188] Friedman, Avi. *Innovative houses: concepts for sustainable living*. S.l.: Laurence King Publishing, 2013, p118.

Fig.8.2.2.4. Example of various combination of use of natural and artificial light (when large window openings are not so applicable solution). Boxhome by Rintala Eggertsson Architects, Oslo. Picture source: Schleifer, Simone K.. *Prefab Houses = Fertighäuser*.. Antwerpen: Booqs, 2011, p202-211. Picture source: [http://www.ri-eg.com/projects/2007/boxhome-/ (accessed 11th March 2014)]

Case Study No.	Natural light without possibility for adjusting its quantity	Natural light with possibility for adjusting its quantity	Artificial – general light	Artificial – directional light	Artificial – indirect light	General lighting comfort
47		x	x	x	x	SATISFACTORY
50		x	x	x	x	SATISFACTORY
51	x		x	x	x	SATISFACTORY
56		x		x	x	SATISFACTORY
57	x			x		POOR
58		x	x	x	x	SATISFACTORY
63		x		x		POOR
65	x				x	POOR
70	x	x	X		X	SATISFACTORY
64	x					POOR

Table 2. Presence of various concepts contributing to visual comfort in case studies related to Typology 2 (micro-living capsules) from time period 2000+

8.3. Visual comfort – colours

8.3.1. In general

"...the best colours work in ways that are, ironically, more difficult to see", Betsky, Aaron. "It Ain't Just (Black And) White: Thoughts on Colour in Architecture".

The power of paint cannot be ignored. Choice of colours inside dwelling spaces may define moods of people and ambiences of living environment. Furthermore, except subjective approach that define individual style of the person, choice of colours have the ability to emphasize "important" and "architectural" decisions such as form, space, materials and dwelling's organization.[189] It helps to clarify various aspects of construction in the way to understand how the structures inside the space are made; but what is more important, it identifies our relation and our position between volumes inside the space which strongly influence proportional aspect of the space we are living in. For the subject of this Thesis this factor is very significant issue since human eye recognises the dwelling's quality based on its proportions in relation to its size. Furthermore, by adding selection of colour tonality, we can play with optical illusions - the proportions could be changed by implementing tone contrasts which will trick the eye in perceiving real depths or heights of the space, or real shapes of the objects, or etc. In that way spaces may seem bigger and more spacious despite of their actual compact or limited floor area. For example, a "room will seem to have a lower ceiling if its walls are painted a bright colour and the floor and ceiling are darker, and it will seem to have a higher ceiling if the walls are darker and the ceiling is bright."

This "manipulation" with colours involves further studies also related to reflective qualities of surfaces inside the space. For example, related literature sources suggest that "the surface of a ceiling should be as white as possible (with a reflection factor of 75%), because light will then reflect from it in a diffuse way, dissipating darkness and reducing the glare from other surfaces. This will also mean a savings in artificial lighting. [...]The surfaces of walls at eye level can produce glare. Pale colours with reflective factors of 50 to 75% tend to be adequate for walls. While glossy paints tend to last longer than matte colours, they are more reflective. Walls should therefore have a matte or semi-gloss finish. [...]Floors should be finished in slightly darker colours than walls and ceilings to avoid glare. The reflective factor of floors should be between 20 and 25%.[...] Work surfaces, machinery and tables should have reflective factors of between 20 and 40%. Equipment should have a lasting finish or pure colour – light browns or greys – and material should not be shiny." [190]

In conclusion, the proper use of colours in the dwelling space influence our well-being; may increase creativity/productivity; have positive impact on living quality; and finally, it support harmony in spatial organization.

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[189] Jacob Reidel. "The Power of Paint: Three Case Studies on Colour in Architecture" 10 Jul 2014. ArchDaily, [http://www.archdaily.com/?p=525647 (Accessed 13 Aug 2014)].

[190] [Jacob Reidel, 2014]

8.3.2. In flexible dwellings

According to the analysis of the related Case studies in this Thesis we can actually state that it become the rule in flexible dwellings to impose the dominance of bright colour finish - no matter if it concerns wall paint, flooring selection or materials for furniture. Approach as such, contributes to greater visual spaciousness and mitigation of feeling of congestion. In smaller amount of examined case studies, the “contrast” colours (e.g. most usually red, black, grey and orange) to the white-base can be noted, but only to emphasize the visual differentiations between various functional zones inside interior. For example, in Case study no. 51 (Garage *project* by arch. Damir Spoljar, Zagreb, Croatia, 2009) dark-grey painted sliding panels when moved in certain positions are used on purpose to make strong visual barriers for certain functional units in white-colour-dominant space. Accordingly, the differentiation between private and social zones of the apartment can be, if needed or desired, exactly defined. In sum, it can be concluded that the use of colour in flexible dwellings has more functional rather than aesthetic purpose.

Case Study No.	Bright wall colours dominance	Dark wall colours dominance	Dominance of light colour furnishing	Dominance of dark colour furnishing	Dominance of light colour free-standing furniture (sofa’s, table’s, chair’s, etc.)	Dominance of dark colour free-standing furniture (sofa’s, table’s, chair’s, etc.)	General colour comfort
47	x		x		x		SATISFACTORY
50	x		x		x		SATISFACTORY
51	x		x		x		SATISFACTORY
56	x		x		x		SATISFACTORY
57	x		x		x		SATISFACTORY
58	x		x		x		SATISFACTORY
63	x		x		x		SATISFACTORY
65	x		x		x		SATISFACTORY
70	x		x		x		SATISFACTORY

Table 3. Selection of colours inside the space in case studies related to Typology 2 (micro-living capsules) from time period 2000+

8.4. Space density

This subchapter refers to the analysis of a dwelling's space and organization of "free zones" – such as *activity zones*, *access zones*, and *passing zones* – in flexible dwellings supposed to allow users to perform normal daily activities. A*ctivity zones* refer to adequate spatiality for carrying out specific activities inside the space; *access zones* refer to the space required to approach to and use a particular element or area; and *passing zones* refer to adequate physical distances between objects inside the space in order to allow normal communication of occupants through the space. The presence of such zones is very important to analyse, as it is usually a critical element in the context of small and compact dwellings due to spatial limitations.

8.4.1. In general

In order to assure mental health and well-being of occupants inside the space, relevant researches suggest various factors which can determine whether a dwelling has satisfactory level for assuring basic internal functionality. Crucial factors are most usually related to: space for furniture and equipment needed for occupants (including occasional visitors); space to access / use the furniture and equipment, doors and windows; space to move around interior among furniture and equipment; space to undertake normal living activities that do not just use furniture (washing, dressing, cooking, eating, playing, socialising); space for storage ("clean and dry"); space for "dirty" storage (e.g. bicycles); space to avoid feeling "cramped" (subjective category) ; and sufficient separation of rooms in order to allow appropriate personal privacy (subjective category).[191]

Looking back in history, according to Neufert from 1930's, standards for adequate spatiality are regulated by the number of inhabitants inside dwelling and, as shown in the Fig. 8.4.1.1., for one person dwelling should be around 40 m^2, while for two persons around 56 m^2.

Dwelling	Area in m^2
1-Person Flat	40,46
2-People Flat	56,47
3-People Flat	80,50
4-People Flat	103,23

Fig.8.4.1.1. Relation between the number of inhabitants per dwelling place and its corresponding area, according to Neufert. Source: "Bauenwurfslehre: Grundlagen, Normen, Vorschriften" (Neufert et al. 2005).

[191] "Housing space standards." www.london.gov.uk. http://www.london.gov.uk/sites/default/files/archives/uploads-space-standards.pdf (accessed April 1, 2014).

Fig.8.4.1.2. (Left) One room flat (40 m^2). Source: "Bauenwurfslehre: Grundlagen, Normen, Vorschriften" (Neufert et al. 2005). **Fig.8.4.1.3. (Right)** Relation between access zone, passing zone and activity zone in one room flat (40m2).

Additionally, later anthropometric data and the furniture schedules set out in the BRE Housing Design Handbook, NHK's Guide to Standards & Quality, and Housing Act from 1985 set their version of minimum space standards needed to meet occupant's requirements. For example, according to Housing Act (Part 10, S.326) minimum size of the sleeping room depending on number of people sleeping in them are: for 1 person room = 6,5 m^2; for 2 person room = 10,2 m^2.

Furthermore, HATC Ltd report "Housing space standards"[192] from 2006 suggest that "qualitative approach resulted in the minimum space requirements for bedrooms and the aggregate amount of space needed for the kitchen/living/dining areas"[193] as shown in Table 4 is 21,75 m^2 for one person or for two person dwelling with an extra 2,5 m^2 for each additional person. Furthermore, data's considering quantitative approach related to minimum floor area of bedroom and kitchen/living/dining area are shown in Table 5 and Table 6. Finally, minimum internal dwelling area (MIDA) is presented in Table 7. and it suggests adequate floor area of 37 m^2 for the case of one-person household, and 44 m^2 for the case of two-person household.

Bedrooms:	**7m² for a single bedroom and 12m² for a double or a twin bedroom**
Kitchen/dining/living:	**21.75m² for a 1 person or 2 person dwelling with an extra 2.5m² for each additional person**

Table 4. Qualitative space requirements. Table taken from HATC report "Housing space standards" [http://www.london.gov.uk/sites/default/files/archives/uploads-space-standards.pdf (accessed March 26, 2014)].

	Bedrooms *from Guide to Standards & Quality / BRE Housing Design Handbook*		
	Single	Double	Twin
Calculated	7.2	11.7	12.1
Rounded	7	12	12

Table 5. Quantitative space requirements for bedrooms. Table taken from HATC report "Housing space standards" according to Guide to Standards & Quality / BRE Housing Design Handbook [http://www.london.gov.uk/sites/default/files/archives/uploads-space-standards.pdf (accessed March 26, 2014)].

[192] "House Space Standards" [www.london.gov.uk. http://www.london.gov.uk/sites/default/files/archives/uploads-space-standards.pdf (accessed March 26, 2014)].
[193] [House Space Standards]

Basic Requirements & Incremental Increases in m² from Guide to Standards & Quality / BRE Housing Design Handbook						
	Kitchen	Living		Dining	Increment	Total
	units & access space	furniture, access, activity & passing	layout allowance	seats, table, passing		
			20%			
1p	No distinction drawn between 1-person and 2-person dwellings					
2p	6.4	9.6	1.9	4.2	0.0	**22.2**
3p	0.6	0.6	0.1	0.5	1.9	**24.1**
4p	0.0	1.5	0.3	0.7	2.5	**26.5**
5p	1.0	1.2	0.2	0.7	3.2	**29.7**
6p	1.8	1.0	0.2	0.5	3.4	**33.1**
7p	1.0	1.0	0.2	0.5	2.6	**35.7**

Table 6. Quantitative space requirements for kitchen/living/dining. Table taken from HATC report "Housing space standards" according to Guide to Standards & Quality / BRE Housing Design Handbook [http://www.london.gov.uk/sites/default/files/archives/uploads-space-standards.pdf (accessed March 26, 2014)].

MINIMUM INTERNAL DWELLING AREA (MIDA) m² (25%/30% add-on)							
	K/D/L	Beds	K/D/L/B	Add-on	Storage	Total	Rounded Total
1p	22	7	29	7	1	37.3	**37**
2p	22	12	34	9	1.25	43.9	**44**
3p	24	19	43	13	1.5	57.5	**57**
4p	27	24	51	15	1.75	67.4	**67**
5p	30	31	61	18	2	80.9	**81**
6p	33	36	69	21	2.25	92.0	**92**
7p	36	43	79	24	2.5	104.8	**105**

Table 7. Minimum internal dwelling area. Table taken from HATC report "Housing space standards" [http://www.london.gov.uk/sites/default/files/archives /uploads-space-standards.pdf (accessed March 26, 2014)].

8.4.2. In flexible dwellings

There are two important observations which are crucial in order to evaluate the density of the space in flexible dwellings. These observations allow insight analysis of factors which are crucial for further evaluation of the quality of flexible methods in context of living comfort.

a) First important observation

As mentioned in previous chapter, proposed minimum living area according to three different researches and standard regulation sources should be for one person not less than 37 m^2 and for two persons approximately 44 m^2. Therefore we can consider adequate spatial area for small household (of 1-2 persons) between 37 – 44 m^2. Although these results are not related to specific field of flexible dwellings but to dwellings in general, still it can give us some guiding criteria for evaluation of comfort quality.

Mentioned data's, if compared with analysed case studies, guide us to following consideration: relevant case studies selected in this thesis are focused only on dwellings with flexible spatial organization, and their floor areas vary from 7m^2 – 45m^2. This means that, if referring to mentioned standards, only case studies above 37 m^2 could satisfy standard spatial requirements (e.g. case study no. 54, 55). In all other cases, we can say that people are put in situation to adopt on limitations; therefore we could state that comfort conditions are in some level reduced, denied or completely excluded. Accordingly, we could state that the great majority of selected case studies in this field do not fit mentioned standard criteria (look at Fig.8.4.2.1.).

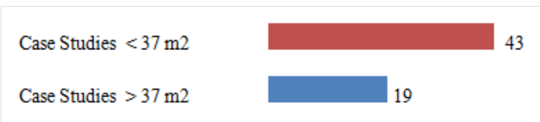


Fig.8.4.2.1. Floor area of case studies selected from Typology 1 and Typology 2.

However, now we have to ask ourselves the question which leads us to second important observation: what is the role of flexibility in this context? More specifically - how can flexible interior methods make contribution in improving comfort conditions in spaces which are less than 37 m^2?

b) Second important observation

Important consideration during analysis of case studies shows different approach in organization of “free zones” inside flexible dwelling interiors than in “non-flexible” dwellings as shown previously on the Neufert’s example (see Fig.8.4.1.2. and Fig.8.4.1.3.). Since in flexible dwellings most critical part are zones connected with obtaining *activities*, *passing* and *access zones* – if the whole space is less than 37 m^2 - it is noted that “free zones” are becoming more complex. This complexity is related to overlapping of different functional zones together. In conclusion, as shown also in Fig. 8.4.2.2., we can state that flexible interior practice make fusion of these three functionally different zones into only one: *passages,* intended to improve communication trough space become at the same time *zones of activities*; *access zones*, reserved for adequate space that is required to approach to and use a particular element or area become at the same time zones for obtaining certain *activities*, or etc.

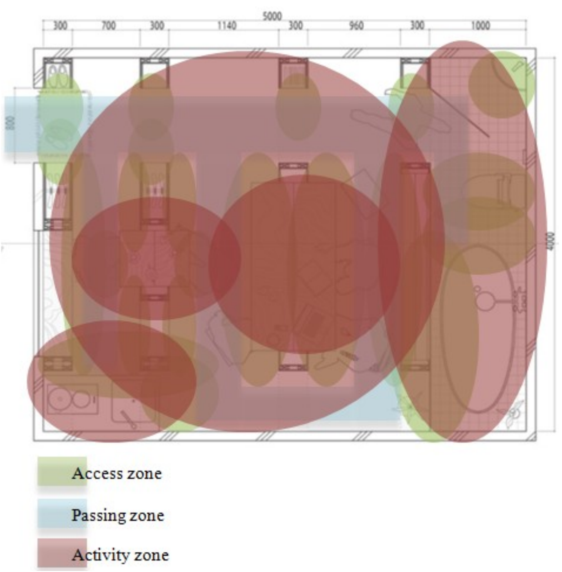


Fig.8.4.2.2. Zones overlapping - example of case study where flexible dwelling interior is less than 37 m^2.

Case study no.48 – example of complex space density (floor area less than 37 m²)

Hall	√
Kitchen	√
Living	√
Sleeping	√
Working	√
Storage	√
Sanitary	√
Dining	√

	m²
Total floor area	20
Communication zone	11
Immobile units	3,6
Variable elements	5,4

Fig.8.4.2.3. Relation between communication zone, immobile units and variable elements.

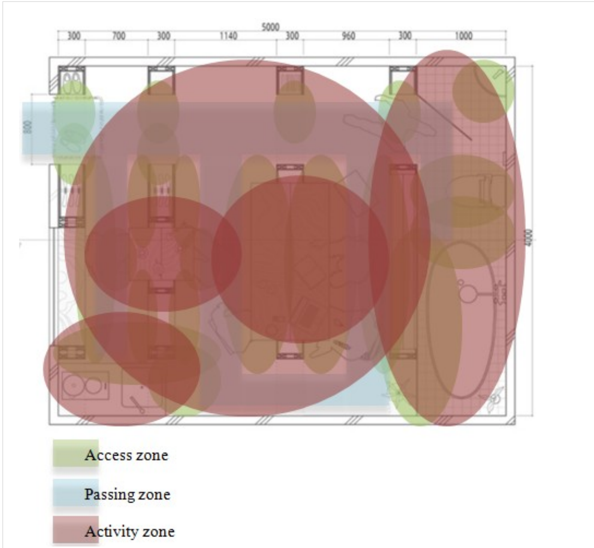


Fig.8.4.2.4. Relation between access, passing and activity zones.

Multi-functional dwelling by Ghary Chang, Hong Kong - example of complex space density(floor area less than 37 m²)

Hall	√
Kitchen	√
Living	√
Sleeping	√
Working	√
Storage	√
Sanitary	√
Dining	√

	m²
Total floor area	32
Communication zone	17,8
Immobile units	6,9
Variable elements	7,3

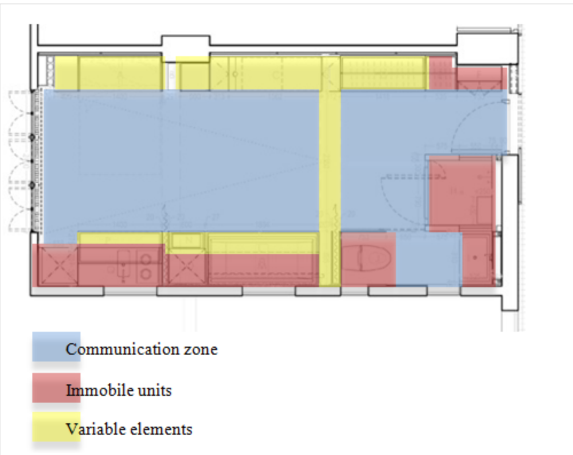


Fig.8.4.2.5. Relation between communication zone, immobile units and variable elements.

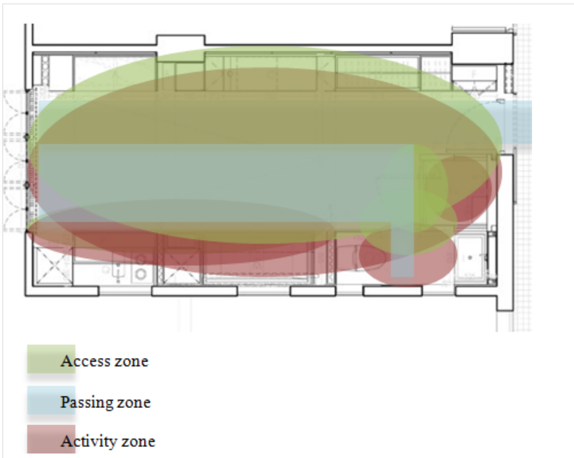


Fig.8.4.2.6. Relation between access, passing and activity zones.

Case study no. 58 - example of complex space density(floor area less than 37 m^2)

Hall	√
Kitchen	√
Living	√
Sleeping	√
Working	√
Storage	√
Sanitary	√
Dining	√

	m^2
Total floor area	7,1
Communication zone	1,7
Immobile units	1,7
Variable elements	3,7

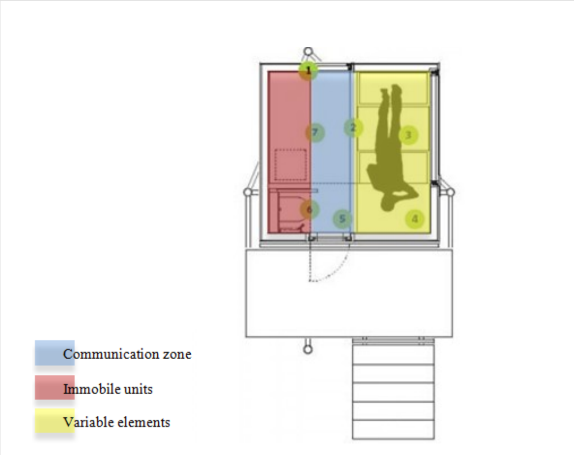


Fig.8.4.2.7. Relation between communication zone, immobile units and variable elements.

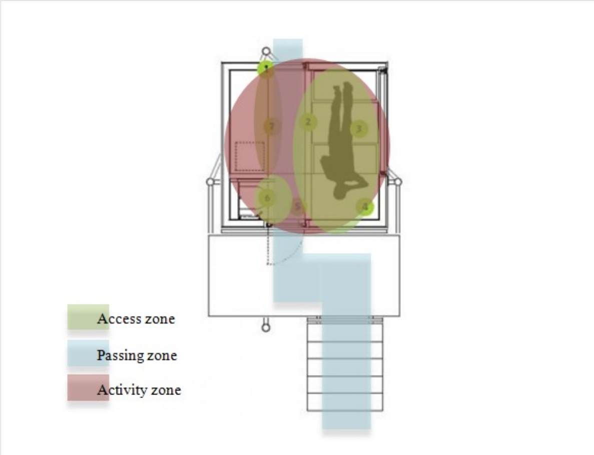


Fig.8.4.2.8. Relation between access, passing and activity zones.

8.5. Ergonomic factors

"It must be borne in mind that the object being worked on is going to be ridden in, sat upon, looked at, talked into, activated, operated, or in some way used by people individually or en masse. If the point of contact between the product and people becomes a point of friction, then the designer has failed. If, on the other hand, people are made safer, more comfortable, more desirous of purchase, more efficient – or just plain happier – by contact with the product, then the designer has succeeded." Henry Dreyfuss, Harvard Business Review, November 1950.

In order to go deep into the topic of comfort conditions in flexible dwellings, it is important to investigate also some crucial ergonomic factors which go against the standard perception of comfort. Broadly speaking, the most important ones refer to comfortable dimensional adjustments in seating (e.g. chairs, armchairs, etc.), sleeping (e.g. beds) and working elements (e.g. various tables, cooking and working surfaces).

However, since there is no significant dimensional difference in sleeping and sitting furniture between standard-regulated interior arrangements and flexible interior arrangements, the following subchapters will focus on the analysis of work surfaces in flexible dwellings such as kitchen worktop, dining surface (e.g. dining table), and working surface (e.g. working table). This selection is made based on the fact that these specific domains have a wide dimensional variety in flexible interior arrangements and sometimes drastically differ from the recommended standards.

8.5.1. In general

Under the term "working surfaces" we can understand various elements inside our home which support at the first place activities like dining, cooking or working. For example, according to Neufert, *dining table* represents central point of organization inside interior because it supposes to fulfil dining, communication, social and prestige functions within a home. Accordingly, appropriate minimal standard needed for one person is approx. 60x40 cm of table area (see Fig. 8.5.1.1.).[194]

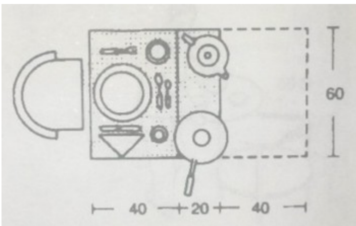
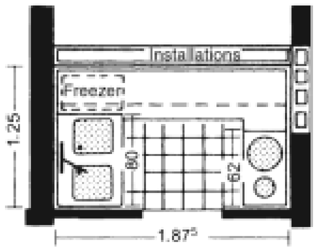
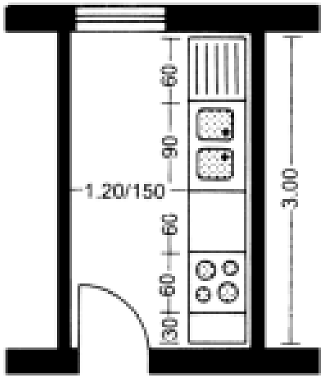


Fig.8.5.1.1. Spatial requirements for one person while dining. Source: Neufert, "Architects data", p150. [http://books.google.it/books?id=6N68sMtqXSUC&pg=PA163&lpg=PA163&dq=one+room+flat+neufert&source=bl&ots=B7Izn_tsRk&sig=U61dsd87co_SzSEtZ_Dubad7RCk&hl=en&sa=X&ei=F3o-U7-tNM_MsgaCxoCIDg&redir_esc=y#v=onepage&q=one%20room%20flat%20neufert&f=false (accessed 4th April 2014)]

[194] Neufert, "Architects data", p154. [http://books.google.it/books?id=6N68sMtqXSUC&pg=PA163&lpg=PA163&dq=one+room+flat+neufert&source=bl&ots=B7Izn_tsRk&sig=U61dsd87co_SzSEtZ_Dubad7RCk&hl=en&sa=X&ei=F3o-U7-tNM_MsgaCxoCIDg&redir_esc=y#v=onepage&q=one%20room%20flat%20neufert&f=false (accessed 4th April 2014)]

Considering minimal *kitchen worktop*, we have to take in consideration minimal kitchen standards because they are the closest representative examples to kitchens present in small and flexible dwelling interiors. According to Neufert, such kitchens (also known as *compact kitchens* or *kitchenettes*) are actually suitable for holiday flats and (student) apartments. They do not normally require their own separate space and can be placed as part of the corridor or passages. “The kitchen equipment is functionally arranged in the smallest possible area as a one-row, two-row or U-shaped configuration, normally as a fitted kitchen. The location of the appliances and worktops are optimised for rational working. This results in practical working spaces on a floor area of between 5,5 m^2 and 9,5 m^2.”[195] Summarizing various proposed minimal standards, total running length of the elements, no matter if one-row, two-row or U-shaped configuration, should be not less than 3 m in order to support minimum required functionality.





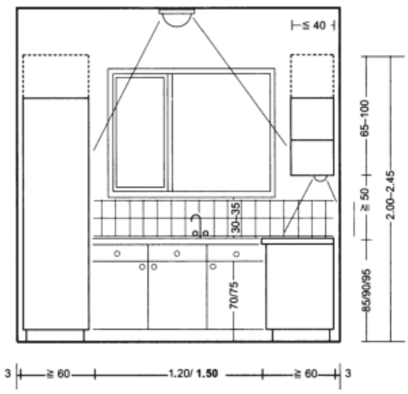


Fig.8.5.1.1. (Left) Very small kitchen – kitchenette; **Fig.8.5.1.2. (Middle)** Minimal single-row kitchen; **Fig.8.5.1.3.** Minimal dimensional requirements for kitchen.
Source: Neufert, “Architects data”, p150.
[http://books.google.it/books?id=6N68sMtqXSUC&pg=PA163&lpg=PA163&dq=one+room+flat+neufert&source=bl&ots=B7Izn_tsRk&sig=U61dsd87co_SzSEtZ_Dubad7RCk&hl=en&sa=X&ei=F3o-U7-tNM_MsgaCxoCIDg&redir_esc=y#v=onepage&q=one%20room%20flat%20neufert&f=false (accessed 4th April 2014)]

Considering dimensional standards for *working tables*, recommended surface for one person should be approx. 120 cm – 150 cm in length, and 70 cm – 76 cm in depth. This surface area is adequate for placing personal belongings related to working (e.g. personal computer, books, papers and etc.).

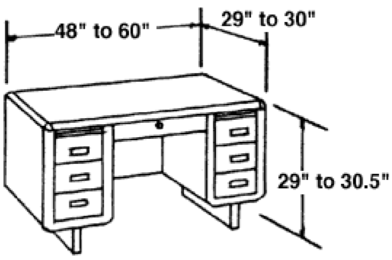


Fig.8.5.1.4. Recommended dimensions of working table (in inches). Source: [http://www.fas.harvard.edu/~loebinfo/loebinfo/Proportions/furniture.html (accessed 4th April 2014)]

[195] Neufert, “Architects data”, p150.
[http://books.google.it/books?id=6N68sMtqXSUC&pg=PA163&lpg=PA163&dq=one+room+flat+neufert&source=bl&ots=B7Izn_tsRk&sig=U61dsd87co_SzSEtZ_Dubad7RCk&hl=en&sa=X&ei=F3o-U7-tNM_MsgaCxoCIDg&redir_esc=y#v=onepage&q=one%20room%20flat%20neufert&f=false (accessed 4th April 2014)]

8.5.2. In flexible dwellings

a) Dining surfaces

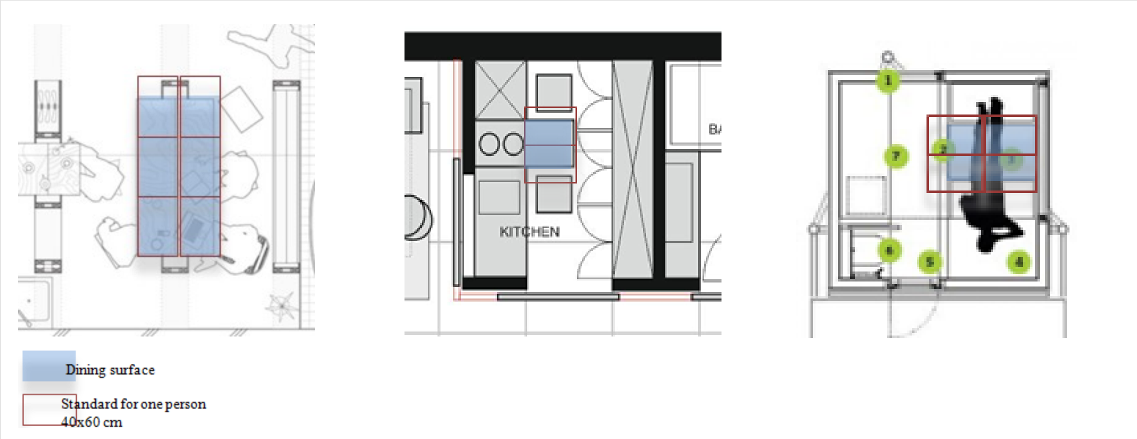


Fig.8.5.2.1. (Left/Middle/Right) Comparison analysis in some case studies – overview on standard dimensions of dining surfaces vs. dimensions of dining surfaces present in flexible dwellings (Case studies taken from Typology 1 and Typology 2).

Out-of-standard dimensions of dining surfaces/tables are present in majority of collected case studies. If we exclude those examples that have ability to linger (extend), tables in flexible interiors intended to accommodate two persons - according to recommended ergonomic standards - actually can offer satisfactory comfort to only one person (e.g. Fig.8.5.2.1. Middle). Such lack of standard length and depth towards more compact dimensions entail further deviations which are usually connected with form of dining chairs (see Fig. 8.5.2.2., Fig. 8.5.2.3. and Fig. 8.5.2.4.) or selection of tableware for dining. Not less important is to mention that such conditions affect level of comfort in sitting posture and in eating habits. For example, as shown in Fig.8.5.2.3., in order to fulfil flexible requirements of the kitchen and dining altogether, table height deviate from standardized recommended measure (75 cm), and instead is adjusted according to the height of cooking worktop (which could be according to the standard measurements between 86 -92 cm). As a consequence, seating level of dining chairs is not in balance with standard ergonomic regulation (42 cm) but much above this measure.

Fig.8.5.2.2. Case study no.96 - Dining surface which dictate floor level sitting position.

Fig.8.5.2.3. Case study no.72 - Dining surface whose out-standard height dictates the chair-height other than standard recommendation.

Fig.8.5.2.4. *Fusion* dining table with chairs by Ikea: Space-saving approach to dining which changes standard form considering arm- and back-rest of the chair.

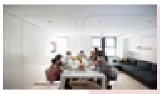
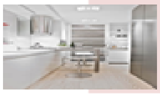
Case Study No.	Fix. dimension (in cm)		Variable dimensions (in cm)				Max. number of persons	Overall comfort
	Lenght	Widht	Min. lenght	Max. lenght	Min. widht	Max. widht		
	-	-	43	295	80	80	10	SATISFACTORY
	-	-	165	165	40	80	6	SATISFACTORY
	55	48	-	-	-	-	2	POOR
	80	140	-	-	-	-	6	SATISFACTORY
	110	65	-	-	-	-	4	POOR

Table 8. Dimensions of surfaces for dining in case studies related to Typology 2 (micro-living capsules) and Typology 3 (furniture unit/ component / module) from time period 2000+.

b) Surfaces for preparing food and cooking

As mentioned at beginning, proposed minimal standard for kitchen worktops should be not less than 3 m of running length (no matter if one-row, two-row or U-shaped kitchen configuration) in order to support minimum required functionality. Nevertheless, in flexible dwellings very often we can find variety of dimensions which again deviate from those standards. For example, as shown in Fig.8.5.2.6., these deviation always refer to deviation to less dimensions than required what at the end puts in the question the matter of real usefulness on long-term.

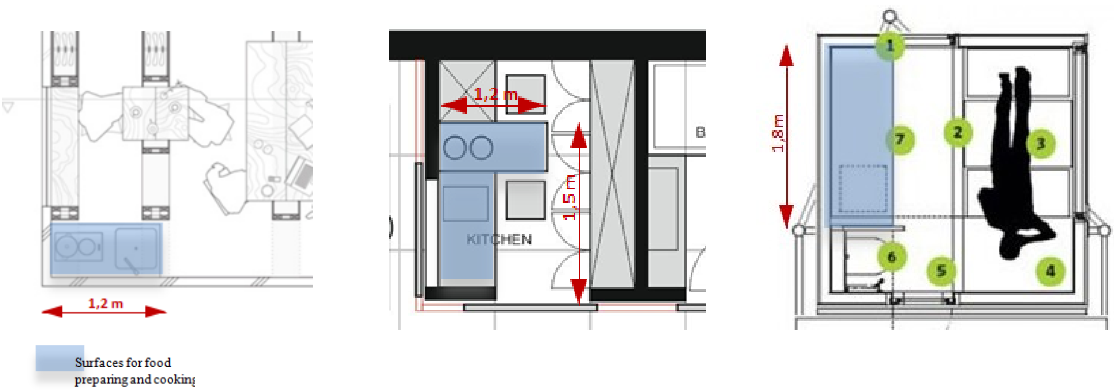


Fig.8.5.2.6. Overview in some case studies on amount of surfaces for preparing food and cooking present in flexible dwellings (Typology 1 and Typology 2).

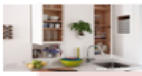
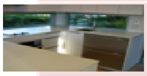
Case Study No.	Running dimension of whole kitchen worktop (in cm)	Overall comfort
	250	POOR
	120	POOR
	270	POOR
	300	SATISFACTORY
	180	POOR
	300	SATISFACTORY
	200	POOR

Table 9. Dimensions of surfaces for preparing food and cooking in case studies related to Typology 2 (micro-living capsules) and Typology 3 (furniture unit/ component / module) from time period 2000+.

c) Surfaces for working

Surfaces to working in most of analysed cases do not refer to standards. Work tables are usually not autonomous elements inside space. They are related to elements which functions are not strictly and exclusively related only to working activity, but - because of spatial limitations - refer also to fusion of activities such as preparing food, dining and working altogether. That is why in related case studies we can find great variety of out-standard dimensions which deviate according to its heights, lengths and depths.

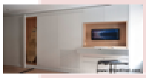
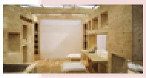
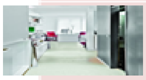
Case Study No.	Dimension (in cm)		Overall comfort
	Lenght	Depth	
	80	60	POOR
	60	45	POOR
	165	40/80	SATISFACTORY
	110	65	POOR
	180	80	SATISFACTORY
	50/90	28/56	POOR

Table 10. Overview on surfaces for working present in flexible solutions (Typology 1, Typology 2 and Typology 3).

9. Flexible dwelling interior and human body

A fundamental feature of flexible interiors is that we are surrounded by objects that are able to support variable functions according to our variable needs or desires. No matter if we are talking about sliding panel constructions, foldable furniture systems or some other flexible method – each daily-routine action carried out in such interiors in most cases requires occupants to have adequate physical abilities. In other words, each functional transformation depends on our mind and body force, as elements could be repetitively slid, folded, opened or removed more than once during the day, in order to successfully accomplish even the most banal daily activities.

To have a more precise visualization of this concept, one good example is the "Lego style apartment" in Barcelona by the architect Barbara Appalloni. As mentioned in the article *Lego-style apartment transformations into infinite spaces* , when the occupant "of this space isn't cooking, dressing, sleeping or eating, his 24 m^2 apartment is an empty cube. To use a piece of furniture, he has to build it. To sleep, he rolls his bed out from under the balcony, his stairs become bedside tables and he can even swing his tv out from the wall. To dine, he lowers a plank from the wall, his flower-stand becomes a support and his stairs become a bench. To cook, he clicks a spot on his vast wall of click-able furniture, and a spring-loaded door swings up to reveal an instant kitchen…"[196]. Similarly, in the case of the "LifeEdited apartment" in New York by Graham Hill, the occupants' body force is again actively participating in the layout transformations of the whole apartment by, for instance, sliding wall on tracks that can "enclose the bedroom and create a second sleeping space with bunk beds, a work zone, and lots of storage behind" [197]; or by expanding a dining table that stows away within the kitchen island when this is not in use [198], etc.

The above described behaviour highlights how the occupant firstly needs to "build" the environment before using it and is actually an essential condition of flexible interiors (e.g. *LifeEdited apartment* by Graham Hill in New York; *Extreme transformer home* by Ghary Chen in Hong Kong, *Unfolding apartment* by Michael Chen in New York, *Partywall* by Michael Chen et al., etc.). There is no flexibility without motion, and objects motion cannot change unless it is acted upon by a force, as described by Newton's first law. Consequently, in order to use the force for interior's flexibility, there are three crucial factors which are related to motion:

- *Simplicity.* The type of demanded motion must be easily understandable for the user. In order to provide the adequate flexible solution, a holistic image of the object must be offered. The users have to understand different statuses, and only if different alternatives are comprehended, she or he can make the use of the various options available[199]. On the other hand, complex solutions could insist much more on time, patience and body energy.

[196] "Lego-style apartment transforms into infinite spaces". Source: [http://faircompanies.com/videos/lego-style-apartment transforms-into-infinite-spaces/ (accessed June 3, 2014)].
[197] "LifeEdited Graham Hill's tiny apartment". Source: [http://www.apartmenttherapy.com/lifeedited-graham-hills-tiny apartment treehugger-171768 (accessed June 17, 2014)].
[198] ["LifeEdited Graham Hill's tiny apartment"]
[199] Barnwell, Maurice. *Design, creativity & culture: an orientation to design*. London, UK: Black Dog Publishing, 2011, p139.

- *Weight.* In order to be moved, structures must be balanced with the human ability to "transport" weights (e.g. to slide, fold, rotate, etc.).

- *Health condition.* The living circumstances in which structures need to be "built" and consequently used clearly require a selection of a specific target group of occupants who are able to fulfil such conditions. As such, the described conditions necessarily lead us to *young and healthy* occupants. With this in mind, the problems which might arise could be in contrast with some already widespread literature-based interpretations about flexible dwellings considering temporal benefits. In other words, flexibility in this context cannot be considered as a method able to ensure a sort of "life-time dwelling" where the "obsolescence" of spaces can be prevented through spatial transformations. Therefore, although flexible, such interior conception is appropriate only for short-term life periods, those in which occupants are in such physical conditions that they can actively participate in layout transformations. Consequently, this fact can be considered a significantly limiting factor for a wider target of users and on the long term.

Fig.9.1. (left) Approaching to the kitchen elements; **Fig. 9.2. (middle)** Adjusting dining environment; **Fig.9.3. (right)**. Preparation of bedroom scenario. Picture source: "Lego-style apartment transforms into infinite spaces" by Christian Schallert. Video by Faircompanies.com [http://www.youtube.com/watch?v=juWaO5TJS00 (accessed 5th May 2014)]

Fig.9.4. (left) Wall in the sliding position; **Fig.9.5. (middle)** Preparation of sleeping scenario; **Fig.9.6. (right)**. Preparation of sleeping room for the guests. Picture source: "LifeEdited Apartment"by Graham Hill. Video by Faircompanies.com [http://www.youtube.com/watch?v=XYV0qATsyts (accessed 5th May 2014)]

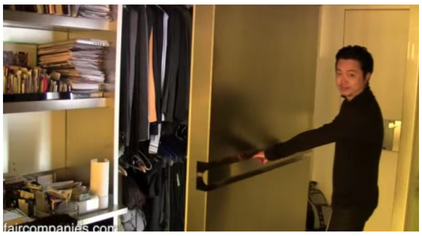




Fig.9.7.(left) Wall in the sliding position; **Fig.9.8. (middle)** Approaching the wardrobe; **Fig. 9.9. (right)**. Preparation of sleeping scenario. Picture source: "Extreme transformer home in Hong Kong: Gary Chang's 24 rooms …" by Gary Chang. Video by Faircompanies.com [http://www.youtube.com/watch?v=WB2-2j9e4co (accessed 5th May 2014)]

10. Flexible dwelling interior and noticed forms of living

Houses are getting smaller and smaller. According to the analyzed case studies in the last forty years people have been changing their living habits drastically. As it seems, they are starting to adapt to limitations and learning to choose personal belongings not based on their preferences, but always with this question in mind: “Do I have enough space for this in my home?” Similarly, with the decreased affordability of comfortable living spaces, in most cases those who decide to become homeowners choose “affordable option” instead of “comfortable option”. In addition, such choices today are commonly becoming life-long living solutions which will probably house two, three or more generations of the same family in the future. Furthermore, the average age of population is continuously rising in several nations all around the world, which indicates that “those aged 65 and over have more than doubled since the 1970s”[200]. This fact also created a new market demand for adaptable interiors to support senior occupants’ needs particularly[201]. In parallel, digital revolution opened possibilities for home-based working and the International Data Corporation in U.S.A. estimates that “nearly 2 million home-based businesses will be added by 2015”[202]. These are all common circumstances which launched not only transformable home solutions but also new behavioral patterns in living.

The aim of the following chapters is to review such living patterns and give an answer to the **fourth research question** mentioned at the beginning of this thesis (see chapter 2.5.).

[200] Friedman, Avi. *Innovative houses: concepts for sustainable living*. S.l.: Laurence King Publishing, 2013, p. 9.
[201] (Friedman, 2013)
[202] (Friedman, 2013. p10)

10.1. Living with minimal needs

"Some people assume all living rooms need a sofa and all offices need desks." Tara Roscoe, Senior Designer at Conant Architects, New York.

As mentioned in "*Beyond the walls"* by Adrianne Rewi, "The physical aspects of being human — the need to eat and sleep — will never change, but there are global challenges to the prescriptive notion that a home must have a kitchen, a living room, a dining room. All aspects of what traditionally formed a home now are being challenged"[203]. Consequently, confronted with reduced spatial affordability, this perspective tries to find some new ways how to implement all this necessaries despite of limitations of available space. Following example represents most common approach to this context.

"Ultra Small House" by Junichi Sugiyama, Side Architects, Tokyo, 2010, $30m^2$

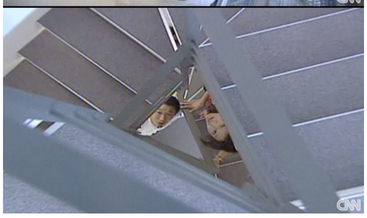


Fig.10.1.1. (above left) Overview on the "daily" area of the house; **Fig.10.1.2. (bellow left)** Staircases connecting "daily room" with the "night room" of the house; **Fig.10.1.3. (right)**. Overview on the window openings in the "daily" area of the house. Picture sources: "Ultra-small is beautiful for Japanese homeowners" [http://edition.cnn.com/2010/WORLD/asiapcf/11/12/japan.ultra.tiny.home/(accessed 20th January 2014)]

Fig.10.1.4. (left) Inhabitant showing amount of dishes able to be stored inside kitchen element **Fig.10.1.5. (right)** The space on the upper floor - transformation into sleeping room. Picture sources: "Ultra-small is beautiful for Japanese homeowners" [http://edition.cnn.com/2010/WORLD/asiapcf/11/12/japan.ultra.tiny.home/(accessed 20th January 2014)]

[203] Rewi, Adrienne. "Beyond wall" in *Perspective*, Winter: 2004. Source: [http://www.iida.org/resources/category/9/4/1/documents/0104beyond.pdf (accessed May 12, 2014)].

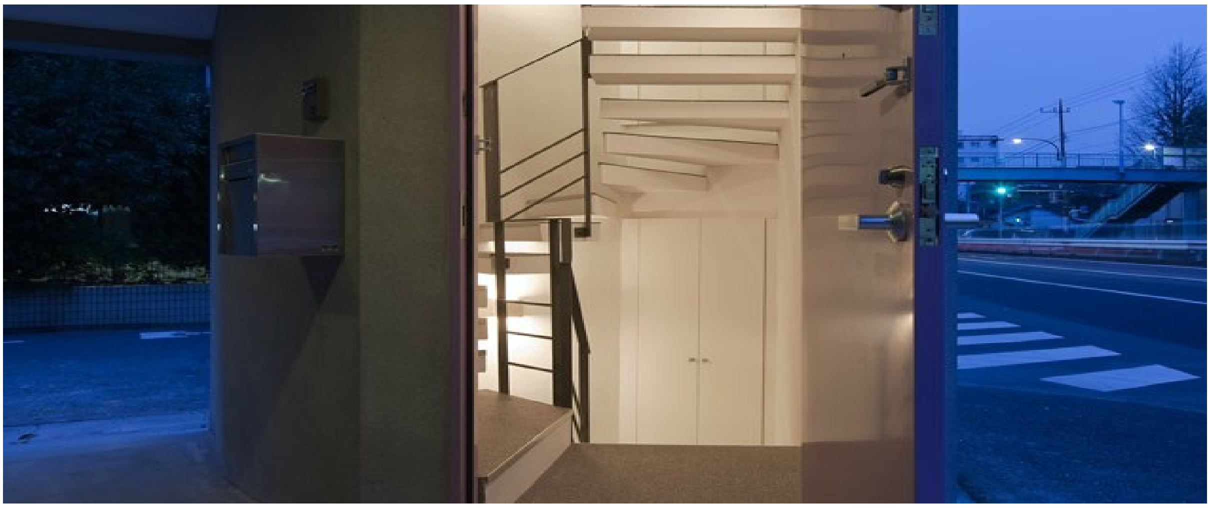


Fig.10.1.6. Entrance of the house. Picture source: "Ultra-small is beautiful for Japanese homeowners" [http://edition.cnn.com/2010/WORLD/asiapcf/11/12/japan.ultra.tiny.home/(accessed 20th January 2014)].

At the first glance we can hardly see an interconnection between micro-architecture and flexible way of living. But if we explore deeper into interior arrangements and lifestyle in such micro-environments, we can notice elements which follow flexible living principles if perceived from behavioral point of view.

To satisfy the functional usefulness of the space as much as possible, most micro-architecture dwellings are based on the concept of "neutral rooms" which are able to increase the functional variety of the space. For example, the "Ultra small home" by Junichi Sugiyama represents the household of two people living in 30 m^2. The space is arranged vertically on three levels and consists of the following four spaces, which are organized on top of each other:

- one space supporting all the inhabitants' daily actions (like cooking, living, dining and working)
- another separate space representing the "night zone" and storage area
- bathroom and
- staircase - which is also the linking area between the spaces and where additional storage elements are implemented.

The concept of "daily space" is on the first floor and contains only the kitchen (which at the same time can serve as a dining table or as a working desk) and two bar chairs (primarily for dining, but also for working and as a "replacement for the sofa" when watching television). To carry out all the necessary living routines during the day in such space, occupants can only use these three interior elements. With this in mind, we can say that this space dictates adoptive living behavior from occupants. Furthermore, considering personal belongings which need to be stored inside available elements in these circumstances, the freedom to choose *whatever we like* is becoming a challenging factor. On the contrary, this household is based on the concept of storing only unavoidable belongings for cooking or appliances inside the kitchen elements, as this is the only place where inhabitants can also store some personal belongings for working (like printer, computer, papers, books, etc.). In sum, since we are dealing with a two-people-household, this means that the kitchen is probably equipped with only two cups, two plates, two sets for eating and maximum two pots – in order to give some "extra" space for other belongings which are traditionally not intended to be stored inside the kitchen elements.

We can assume that the same situation is present in another "neutral space" on the second floor of the house which is meant for sleeping, living, storage and also for housework (e.g. clothes drying or ironing). Here we have an empty room with only one built-in closet and one smaller cabinet on which the television is placed. Since space limitations are again more than obvious, placing the fixed bed element in the centre of the room would only limit the essential functional extension of the space. Instead, elements like a foldable bed, a desk for ironing or similar objects are placed inside the wardrobe (probably along with the clothes) and need to be taken out only when used. In that way we can have a sleeping room during the night and a living or facility room during the day.

According to what was described so far, we can conclude that space transformations in such context do not completely allow a level of living comfort in which every action can have its own place and privacy, without unwanted interfering other actions and other people's privacies. In other words, carrying out different spatial functions at once is hardly possible. For example, in hypothetically scenario, if one occupant wishes to cook, the other one cannot work nor dine at the same time. The actions which generally need to be done in this type of interior must follow a "one by one" procedure. Therefore, an organization of the daily routine between the inhabitants is necessary.

This scenario also raises another problematic issue related to this type of spaces. Limited spatial contexts can force occupants to close proximity and a feeling of crowding can easily occur (3). One of the strategies used in this case study is to improve the perception of spatiality by using big window openings in order to increase the amount of natural light in the interior, so as to mitigate this feeling of an overcrowded and claustrophobic atmosphere in daily life. Therefore, a small and flexible space should be one with large window openings in order to respect human well-being.

Driving forces	Interior strategy	Living behavior
*Increased housing costs *High cost of maintenance *Rising heating costs	*Neutral room conception *Implementation of natural light *Multiple functionality of furniture *Various storage solutions *Optimization of free standing furniture elements *Small-sized bathroom sanitary *Space-saving staircase construction	*Managing daily routine with optimized furniture selection *Managing daily routine with optimized personal belongings *Organization of daily routine between occupants must be determined in advance *Limited social engagement inside house

Advantages	Disadvantages
*Lower property taxes *Lower construction costs *Lower maintenance costs	*Lower personal privacy between occupants *Lower possibilities for social life activities *Guests accommodation is not possible *Limited comfort considering personal belongings and furniture

10.2. Multi-generational living

As mentioned before, with the decreased affordability for commodious living space, those who decided to become homeowners in most of the cases choose "affordable option" instead "comfortable option". In addition, such choices today are commonly becoming life-long living solutions which very often have to house two or three generations of the same family as well. "When asked to design such dwellings, architects recognized that the traditional multigenerational models do not fit current needs and lifestyles due to lack of privacy. Therefore, new design concepts, that include spatial arrangements between each generation, need to be adopted. […] Multigenerational dwellings require the separation of family units, so that each household can live independently should they choose to. This also makes the future sale or letting off units possible. It is also recommended that every household have its own street entrance so that members of each generation can leave and enter without disrupting the other."[204]

***L41 Home, by Michael Katz and Janet Corne, Vancouver, Canada, 21m²*.**

Fig.10.2.1. (left) One living-unit model; **Fig.10.2.2. (right)** Combination of more living-units together. Picture sources: "L41 home" [http://l41home.com/L41home.com.html (accessed 21th January 2014)]

Fig.10.2.3. (left) Interior view; **Fig.10.2.4. (right)** Kitchen view. Picture sources: "L41 home" [http://l41home.com/L41home.com.html (accessed 21th January 2014)]

Fig.10.2.5. (left) Interior view; **Fig.10.2.6. (middle)** Kitchen view; **Fig.10.2.7. (right)** Bathroom view. Picture sources: "L41 home" [http://l41home.com/L41home.com.html (accessed 21th January 2014)]

[204] Friedman, Avi. *Innovative houses: concepts for sustainable living*. S.l.: Laurence King Publishing, 2013, p30.

One of such examples is L41 Home by Michael Katz and Janet Corne. The base model is 21 m^2 (studio), but there are also expandable models of 27 m^2 (one bedroom) and 34 m^2 (two bedrooms) which can be used as a self-contained unit, or multiplied in various combinations in the case of multi-generational purposes.
Considering the interior, in contrast to the previous concept of "neutral rooms", here we are dealing with quite defined functional zones where "everything necessary" is included and "everything necessary" has its own place. For example, kitchen organization tries to follow as much as possible conventional full-sized kitchen by including appliances like induction cook-top, dishwasher, a fridge placed under the counter, a convection oven and microwave, a slide out overhead fan and even washing/drying machine. The basic unit of 21 m^2 contain living zone where is a space for a couch that could be converted to bed, then coffee table, dining chairs and a compact working table for placing computer and related belongings. The space is designed with a great amount of natural light in order to improve perception of spatiality and decrease feeling of interior congestion. If desired, blinds on the windows can be used to control the level of privacy in relation to indoor/outdoor, or at the same time they can be used as a backdrop for projections. "A custom-created sliding door that disappears into the side of the unit provides full access to an outdoor deck. Outside, the L41 generates and stores solar electricity on-site through photovoltaic and solar thermal heating and cooling cells on its green roof."[205] Members of each generation can live next to each other but at the same time also independently because separate entrances to the units avoid unwanted disturbance.

Driving forces	Interior strategy	Living behavior
*high cost of housing *working parents depended on older members of the family because of the childcare *conflicts between generations considering various life-styles	*organization of family in separate living units *possibility to reduce/upgrade living units if necessary *large exterior openings *possibility to use outdoor deck as extension of the space *compact furniture and appliances	*continuously maintaining order inside interior *managing daily routine with optimized personal belongings

Advantages	Disadvantages
*affordable *fast construction on site *instant possibility to move-in *possibility to reduce/upgrade living units if necessary *personal privacy among generations respected	*in crowded urban context privacy in relation indoor/outdoor could be problematic during day period because of large amount window openings (- in this case the blinds on the windows during the day should be closed?!)

[205] "L41 house by Michael Katz and Janet Corne" [http://mocoloco.com/fresh2/2011/08/25/l41-house-by-michael-katz-and-janet-corne.php (accessed 21th January 2014)]

10.3. Living & working

Digital revolution opened possibilities for home-based working. In some opinions, this situation leads to a growing tendency for switching from "traditional" office environment to home-based working environment. For example, in United States International Data Corporation estimates that more than 2 million such businesses will appear by 2015.[206] At the same time, such concepts contribute from the point of affordability because renting or buying separate office is often not so acceptable solution for the middle class. These concepts are beneficial from the point of view that they allow flexible working hours without strict schedule and in-between which personal obligations and leisure-time activities could be fulfilled as well. The most important task here is to design a working & living dwelling which could harmonize professional productivity and family life together. The critical factors are most usually visual or personal privacy, light and noise.

Home office #1 by arch. Sandra Mestrovic, Zagreb, Croatia, 2008, 38m^2.

Fig.10.3.1. (left) View on the kitchen zone and multi-functional living room; **Fig.10.3.2. (middle)** Kitchen view; **Fig.10.3.3. (right)** View from the main entrance, with the door opening on the right for bathroom. Picture sources: personal archive.

Fig.10.3.4. (left) View on the kitchen zone with the optimized size of dining table; **Fig.10.3.5. (right)** View from the kitchen area towards hall. Picture sources: personal archive.

[206] Friedman, Avi. *Innovative houses: concepts for sustainable living*. S.l.: Laurence King Publishing, 2013, p10.

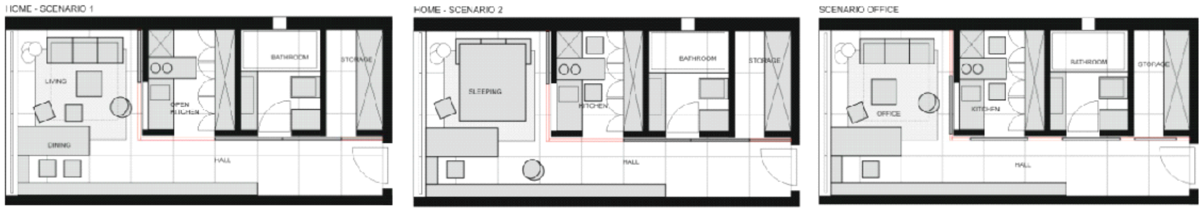


Fig.10.3.6. (left) Home scenario during the day; **Fig.10.3.7. (middle)** Home scenario during the night; **Fig.10.3.8. (right)** Transformation of home into the office scenario. Picture sources: personal archive.

Home-office #1 by architect Sandra Mestrovic we can describe as living and working residence. This 38m^2 space host two-person-household where one of the occupants uses this environment as an architectural-studio as well. The internal structural supports of the space are grouped within the units such as wardrobe, kitchen and bathroom which in whole flexible scenario represent “immobile” units of the living space. The central space of the apartment is “daily-zone area” which is flexible in its function - it can be transformed into traditional living room for spending leisure-time afternoons (Fig.13.3.1.); then dining room which can accommodate 4-6 people around the dining table (Fig.13.3.6.); sleeping room for two persons (Fig.13.3.7.); or office (Fig.13.3.8.). The important contribution to all these functional transformations is visual appearance of the space achieved by sliding panels. Units like kitchen, bathroom and wardrobe could be “exposed” or “hidden” depending on circumstances or desires. For example, in the “office scenario” the only “visible” environment from the entrance door could be the hall which leads to the main space – the office. The rest of the space, if hidden with panels, is giving the illusion as it does not exist (as shown on Fig.13.3.8). Space as such completely fulfills common office appearance: working desk, shelves for professional literature and area with sofa for meeting purposes with the clients. On the other hand, by simple opening sliding doors of the kitchen area and hiding the working belongings (such as laptop, or etc.) into the table-drawers, we are immediately entering into the “private life” of the apartment.

Driving forces	Interior strategy	Living behavior
*development of digital technologies *high costs of renting/buying working space	*sliding panels for visual separation of “private” and “public” areas *multi-functional “daily zone”	*flexible maintenance of daily routine

Advantages	Disadvantages
*flexible working-time management *economical benefits	*work can interfere family-life routine *family-life routine can lead to distractions and decreased productivity in working

10.4. Aging in place - Life-time homes

Terminologies such as “Aging in place” or “Life-time homes” are commonly used phrases in referent literature as one of the possible potentials of flexible dwelling interior spaces in future. “It typically refers to the ability to remain in your own home as long as possible rather than being forced into an assisted living facility because home can no longer support your evolving physical or mental well-being. Aging in place isn’t a new concept, but it’s certainly gaining traction under the broader heading of senior living, partly because a *silver tsunami* of Baby Boomers keeps flowing deeper into this demographic.”[207]
“In the next 20 years, the number of adults in the US age 65 and older will nearly double, which means the elderly are the fastest growing demographic in the country. Today, people are living longer than ever before, with more medical assistance and higher healthcare costs. This presents an unprecedented financial, emotional and ethical challenge for families and caregivers. How will we provide for the health and well-being of the aging Baby Boomers? The reality is that many of them will reject high-priced institutional care and instead, will choose to continue living in their homes, despite chronic conditions and disabilities.”[208]

“Ageing in place concept” insist complex approach because the designer of the interior have to base the spatial concept with prediction of all of the conditions that young occupant while reaching the senior life-phase might encounter as difficult.[209]Accordingly, flexible interior solutions are in majority of cases focused on creating various mechanisms which allow easier accessibility to elements and spaces. Therefore, furniture has to be prepared in advance for the later transformation although at the current phase it does not represent the actual occupant’s need. Described in simplest context - “a young couple will not want grab bars in their bathroom, but could wisely plan the means for their installation at a later stage.”[210]



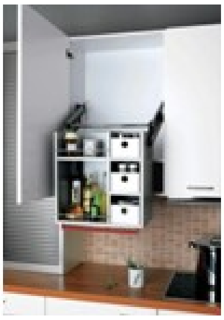



Fig. 10.4.1. “Accessible kitchen”. Source: Universal kitchen [http://ia2studio.wordpress.com/ (accessed 1st June 2014)]; **Fig. 10.4.2.** Rotating mechanism inside kitchen cupboard. http://www.livingwellwithadisability.org/2011/12/are-there-tax-incentives-for-home-modifications/e00003897/ (accessed 1st June 2014)]; **Fig. 10.4.3.** Foldable mechanism inside kitchen cupboards. Source: Universal kitchen [http://ia2studio.wordpress.com/ (accessed 1st June 2014)]; **Fig.10.4.4.** “Magic corner” in kitchen elements.

[207] "Aging in Place, Redefined - Urban Planning and Design - Gensler." Aging in Place, Redefined - Urban Planning and Design - Gensler. http://www.gensleron.com/cities/2014/2/24/aging-in-place-redefined.html (accessed June 4, 2014).
[208] “Aging in Place With the Internet of Things“ by Eric Baczuk. [http://schedule.sxsw.com/2014/events/event_IAP20166?utm_source=linkedin&utm_medium=social&utm_content=4047218 (accessed 1st June 2014)].
[209] Friedman, Avi. *Innovative houses: concepts for sustainable living*. S.l.: Laurence King Publishing, 2013, p23.
[210] (Friedman, 2013. p23)

Driving forces	Interior strategy	Living behavior
*declining birthrates	*flexible mechanisms which can be added to basic structures in order to improve accessibility	*living behavior common to conditions of reduced mobility or poor vision.

Advantages	Disadvantages
* Life-time living in one dwelling	*Some flexible methods related to spatial transformation (e.g. sliding walls) can not fit in this criterion at all. The elements which are beneficial are related only to upgrading existing furniture conception.

Haefele's Transformable Kitchen & Dining Spaces, Holz-Handwerk fair 2014, Germany

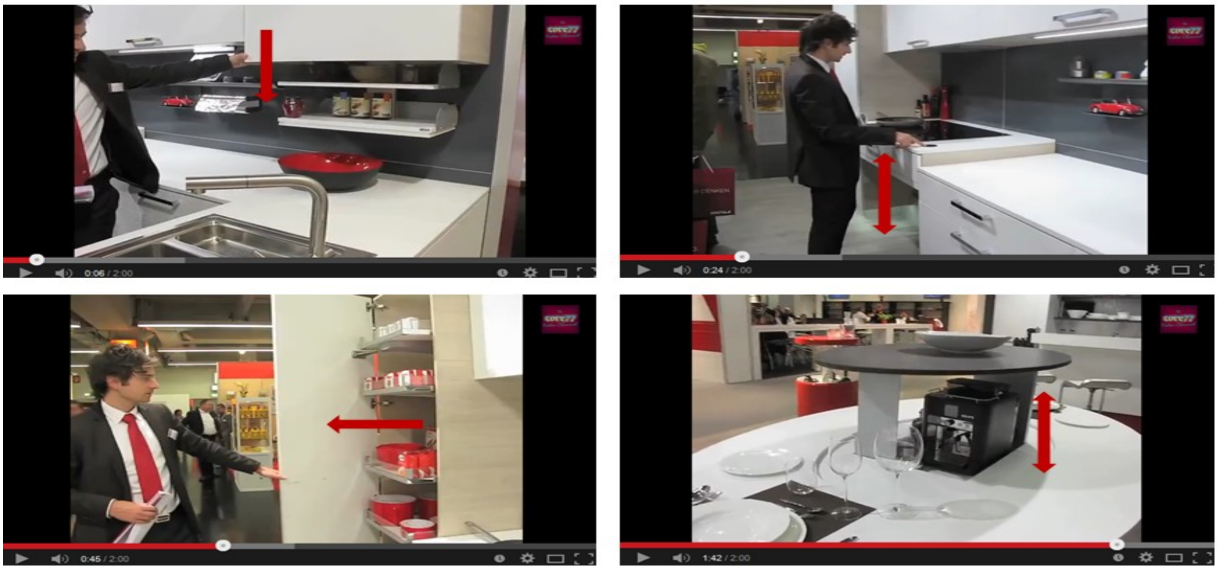


Fig.10.4.5. Adjustable kitchen elements. Source: Noe, Rain. "Haefele's Transformable Kitchen & Dining Spaces.

Project description: One of the contributors to the concept of "life-time homes" is Häfele Company with their new improvements in furniture design, especially in kitchens. With innovative and more sophisticated approach to furniture hardware they try to meet the highest individual requirements for various functional contexts as well as for ergonomic standards. More specifically, such improvements are specially targeted for wide variety of users – from younger population till people with physical disabilities. For example, among more significant examples are kitchen worktops which height can be easily adjusted in most appropriate working position for the user. Additionally, the cabin elements can slide or lower down to a better hand-reach with a simple push-button function. In sum, all these improvements prevent the actions in which the user has to bend down or "climb over", in order to reach certain contents.[211]

[211] Noe, Rain. "Haefele's Transformable Kitchen & Dining Spaces." YouTube. April 10, 2014. Accessed November 25, 2014. http://www.youtube.com/watch?v=ujs98Bo4lsY.

10.5. Urban nomad

“Our society is transforming itself into a mobile society, where interaction itself is mobilised... but the most powerful aspect is the mobilization of our inter-personal interactions. The mobilisation of interaction redefines our sense of time, space and context”.
Barnwell, Maurice. Design, creativity & culture: an orientation to design. London, UK: Black Dog Publishing, 2011, p189

“In “Nomads at last”, an article in *The Economist*, Andreas Kluth observed that, “wireless communication is changing the way the people work, live, love and relate to places”.[212] Furthermore, this claim he supported by one commonly seen situation of everyday life: “At the Nomad Café in Oakland, California, Tia Katrina Canlas, a law student at the nearby university in Berkeley, places her double Americano next to her mobile phone and iPod, opens her MacBook laptop computer and logs on to the café's wireless internet connection to study for her class on the legal treatment of sexual orientation. She is a regular here but doesn't usually bring cash, so her credit-card statement reads *Nomad, Nomad, Nomad, Nomad*. That says it all, she thinks. Permanently connected, she communicates by text, photo, video or voice throughout the day with her friends and family, and does her *work stuff* at the same time. She roams around town, but often alights at oases that cater to nomads.” Furthermore, he gave his modern interpretation of such behaviour significant actually to Bedouin people in history: “
“Urban nomads have started appearing only in the past few years. Like their antecedents in the desert, they are defined not by what they carry but by what they leave behind, knowing that the environment will provide it. Thus, Bedouins do not carry their own water, because they know where the oases are. Modern nomads carry almost no paper because they access their documents on their laptop computers, mobile phones or online. Increasingly, they don't even bring laptops. Many engineers at Google, the leading internet company and a magnet for nomads, travel with only a BlackBerry, iPhone or other “smart phone”. If ever the need arises for a large keyboard and some earnest typing, they sit down in front of the nearest available computer anywhere in the world, open its web browser and access all their documents online.”[213] This kind of reality raises up the question what are the boundaries of our privacy today and what actually represent our most intimate environment which we were used to call “home”?

Since people are able to fulfil only basic daily needs in spatially limited and flexible dwellings, the fact with which we are dealing today is that in most cases some additional comfort conditions which are missing in home contexts are transferred to public spaces. A strong support to this approach came from the development of information technologies, especially wireless communication systems which “changed the way the people work, live, love and relate to places”[214] . Consequently, if we turn outside of “home concept” to other segments of daily life, we can see that great attention is given to many other forms of lifestyles and that other industries used this opportunity and already set very high levels of standards. For example, a lot of attention is focused on a constantly changing

[212] Barnwell, Maurice. *Design, creativity & culture: an orientation to design*. London, UK: Black Dog Publishing, 2011, p189
[213] Kluth, Andreas. “Nomads at last” from *The Economist.*[http://www.economist.com/node/10950394 (accessed 11th may 2014)]
[214] (Barnwell, 2011. p189)

technology which allows people to experience a greater comfort in communication in various public locations. A high ergonomic comfort in transportation, no matter if it is a private car, a public train, a boat or an airplane, is offered in order to promote final destinations in a fast and relaxing way. High quality accommodations in hotels accompanied with various additional facilities and services have started to be important competitive factors in the hotel industry; rental companies start offering working spaces (e.g. offices) according to occasion-based needs; bars and restaurants have become meeting points for family or friends gatherings, etc. Therefore, limitations in dwelling contexts have encouraged a rapid development of consumer-oriented services which apply the strategies based on the idea of "home replacement".

Fig. 10.5.1. Starbucks coffee house , gathering zone of the store. Source: "Starbucks"[http://www.starbucks.com/coffeehouse/store-design (accessed May 15, 2014)].

Fig. 10.5.2. *Sleepbox* by Arch Group for various public locations.Source:[http://www.dezeen.com/2011/09/12/sleepbox-01-by-arch-group/ (accessed May 15, 2014)].

Fig. 10.5.3. *Park-bench-house* by Seangodsell. Source: http://www.seangodsell.com/park-bench-house (accessed May 19, 2014)].

Fig. 10.5.4. *Bus station-bench-house* by Seangodsell. Source: http://www.seangodsell.com/park-bench-house (accessed May 19, 2014)].

CONCLUSION

Identification of future directions

11. General considerations

Flexible environments can be easily understood as products of technology, play, space transformation, art sculpture or some other imaginary interconnection combined all together. Their usefulness is made of construction or connection parts that are usually adaptable, transformable and that insist on various models of behaviour. That is the reason why they insist on a complex design approach from both the technical and social point of view.

There is no flexibility without some kind of motion, and dealing with motion in architectural or design objects means creating objects that are often unpredictable and surprising to a wide audience at first glance. These objects present unconventional solutions for “conventional” things and extend the network of necessary knowledge to other sciences and disciplines, trying to contribute to their high-level achievements. The results always need to be judged simultaneously in conceptual, functional, economic, “clever” and aesthetic terms and over a time which is not only now, but rather **is going to come**. In other words, dealing with such objects and spaces means being capable to combine, for example, recent innovations for the future of IT technologies, natural sciences, mechanics, engineering and so on, but also showing appropriate aesthetic design skills. By implementing flexibility as an element of creation, we are extending the standard approach of creative thinking to one more level. We are starting to think how to save energy; how to optimize materials, functions and spaces; how to make lightly constructions that can be easily re-moved by humans and so on. As such, the results can be revolutionary, extraordinary and beyond expectations. Flexibility changes our perception of things and their meanings in standard contexts: based on that, we are entering into the world of possibilities other from those we inherited as standards; we are developing approaches capable to be useful in the future. Our living objects suddenly acquire multiple purposes, can be used in different contexts, more complex contexts, give people greater freedom in functionality and in general change the static picture of home into a more dynamic context. In parallel, all these considerations open new habitation patterns which people are starting to adopt as adequate for recent and upcoming times.

However, regardless of all the mentioned potentials, we have to be aware that this approach has its own specific rules of technical development, its trends and its own desirable target group of users capable to fulfil required flexible patterns. Therefore, according to the results of this research we can state that the flexible approach in interiors is developing towards specific directions which still need to be monitored, focused on and intelligently upgraded in order to allow adequate comfort and usefulness to wide audience in living conditions which are already appearing and are about to come.

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11.1. Technical aspect - overview on the chapters

With a drastically opposite attitude towards all the previous common practice in interior architecture, flexible interior from its beginnings in 1970s to the present time has become a significant tool because of its bypassing the previous, deeply embedded habits imposed by the rapid growth of industrialized societies. These significant "deviations" are reflected in the deconstruction of the fixed foundations of traditional living; in the emphasis put on arbitrary constructions of social relations by making restrictions loosened; and finally – with its incorporated dynamic nature – in the *victory* over time and space obsolescence. In more practical terms, it represents the initial guiding principle for Italian designers and architects in the year 1972 (exhibition "Italy: New domestic landscape", New York), who made their first step towards the belief that "an object can no longer be designed as a single isolated entity" and "their reaction is to conceive of their designs in terms of environments and to purpose that are flexible in function and permit multiple modes of use and arrangement". With such potential, it could be expected that technical variations based on flexibility can be developed in infinite forms for infinite contexts. However, by reviewing relevant case studies over the period of the 1970s we can distinguish some technical patterns that show how these solutions were accepted in society and how they evolved in continuous changes and demands of surrounding.

Therefore, if focusing only on the technical aspect, the first aspect to highlight is a general basic statement – flexible methods contribute to better spatial organization and functional efficiency of the dwelling space (see Fig. 12.1.1.).

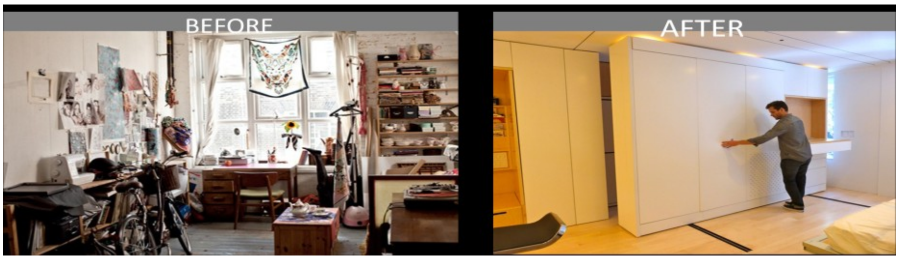


Fig.12.1.1. Differentiation between "non-flexible" (*picture on left*) and flexible (*picture on right*) spatial organization of dwelling space.

Furthermore, by analysing a wider perception of flexibility and selecting focus areas related to micro architecture, interior architecture, and furniture design, three mayor approaches to the implementation of flexibility in dwelling interiors are identified. The first one refers to spatial organization (with 6 different subcategories); the second refers to compact solutions (with 4 different subcategories); and the third approach refers to flexible joints which allow further flexible variations in bigger-scale (2 subcategories).
Taking into account the influence of improved technical possibilities and the development of new technologies in recent times, among the mentioned classifications some new methods are identified and deserve to be emphasized, as they were never examined as models of flexibility in the relevant literature until now:

- **The first one** refers to the use of artificial light as a tool for spatial diversity (Chapter 5.1.3). Although not being a physical method, this different illumination may change the visual perception of spaces on different levels. For example, spaces may change their proportions – by adding more light some areas may look bigger, more important or more prominent. On the other hand, by reducing light intensity we could "hide" some parts that we do not want to be conspicuous. This hierarchical approach gives different zones a specific dominance, which actually deceives on the real size of the whole space. This method may be useful for contexts where placing physical dividing elements (e.g. walls, storage furniture, or curtains) is not a feasible solution. Therefore, it should be highlighted here that a new perception of flexibility not based on **physical** principles**,** but rather on **visual** ones can also be used in limited dwelling interiors as a tool for further spatial experimentation.

- **The second one** is related to "soft dividers and flexible curtain-walls" which rely on new fabric technologies which brought various possibilities of space organization with deformable building elements (Chapter 5.1.4.). For example, for the scope of this thesis the most popular ones are the combinations of fibrous materials which have strong directional material properties, can have required levels of stiffness and stability and at the same time allow deformation like strecthing, rolling or bending. Furthermore, interesting examples are the textiles or ropes of natural or sinthetic origins which are usually woven or knitted; materials obtained from cellulose like papers or cardboards; high-strenght fibrous composites made of glass, carbon, aramid, synthetic resin, elastomer, or thermoplastic; meshes made of brass, copper, bronze, aluminium, nickel, titanium or silver; plastics foams produced either chemically, physically or mechanically; etc.

Furthermore, in this Thesis, the **trends** in flexible dwelling interiors are considered from two main perspectives. The first one is related to a more architectural approach where the analysis is focused on elements like interior doors, sliding systems, façade openings, screen protectors, floors and ceilings constructions; the second one is more related to furnishing elements such as free standing tables, beds, sofas, etc.

In all the mentioned contexts it is important to emphasize the growing trend of developing "smart" structures and various movement typologies supported by the recent innovations in the field of automatization, high-tech systems and sensor technology. Despite their technical advances such fusion results in technically impressive and innovative flexible solutions that often go beyond their functional need. The way the structures are made and the transformations they are able to achieve are contributing to astonishing functional and aesthetic experiences which, as such, could also be regarded as "objects of art". Such attitude goes beyond the limits of only interior spaces. Among such constructions are, for example, the dynamic facade systems which can be programmed to display countless patterns and configurations giving optimized comfort conditions to the users inside the space. As such, the visual appearance of the façade is continuously changing – it turns into a dynamic sculpture (e.g. *Kiefer technic showroom* by Ernst Giselbrecht)[215]. With such potential, we can say that this approach to flexibility has evolved to a new design category which strongly encourages a further development of movement typologies in the building industry from every aspect.

[215] [http://www.architonic.com/aisht/dynamic-facade-kiefer-technic-showroom-ernst-giselbrecht-partner/5100449 (accessed 28th Feb 2014)]

Fig.12.1.2. Approach to flexibility has evolved to a new design category which strongly encourages a further development of movement typologies in the building industry from every aspect.

11.2. Social aspect - overview on the chapters

Since living conditions start to be more and more inspired by various flexible methods in the way how space could be arranged, people also start to follow and integrate such flexible principles in their everyday living behaviour in order to adopt. Accordingly, main focus in social aspect of this Thesis was to investigate this deviations of human comfort conditions in flexible dwelling interiors; forms of daily living influenced by flexible interior principles; and finally, some additional conditions which flexible methods imposed and according to which most appropriate target user for this type of living option could be identified.

General living circumstances which should be mentioned at the first place after summarizing related chapters is that perception of comfort condition under the influence of flexible methods has drastically changed. People have found themselves in a position which requires “adaptation to less“; to share their living space with one more or two generations at the same time; to work and to live inside the same space; to remain in the same dwelling for a life-long period no matter if household expanded or some other functional needs emerged; or to use in some occasions public spaces as “replacement of home“ - which gradually and fundamentally put in doubtful position the right for individual on personal privacy. Such conclusion is based on results of analysing flexible interior methods and case studies in Part I of the Thesis, and they all are developed with the final goal to support one of the mentioned forms of living.

Under such circumstances, people adopt on various living conditions because they have no other more appropriate and more affordable option. They get used to sit, dine or sleep on the surfaces which are not conventional and which dimensions do not fit standard ergonomic requirements. Instead, as observed in Chapter 8.5. (Ergonomic factors), various approaches that try to maximize spatial efficiency resulted with dimensions of dining tables which are, for example, 55 x 55 cm and intended to accommodate two people; heights of seat in dining chairs which are around 60 cm instead standard of 42 cm; size of cooking worktops which are “packed-in” and can be folded or extended to maximum dimension of 150 cm unlike recommended minimal standard of 300 cm, or etc. Such circumstances became today’s living reality and by adapting to it people are gradually losing the sense of importance of ergonomically adequate sitting, sleeping, dining or some other body posture. Further on, as shown in examined case studies, working surfaces can be variable as well: they can be higher or lower, bigger or smaller than standard requirements suggest. They can integrate some additional storage, or they can be folded and moved away. They can fulfil the functional requirements in living room, but at the same time they can be useful in dining or working environment as well. As such, these elements are put in flexible context so people are using them for various actions and on many different ways. In other words, people have on disposal greater freedom to choose their own individual and desirable body posture while obtaining specific actions (e.g. preparing food, working, dining or other) but without questioning if it is recommended by ergonomic, social, psychological or healthy standards as well. As the investigation results show, the main priority is to satisfy as much as possible diversity of actions inside the space.

Consequently, considering the spatial density investigated in Chapter 8.4., living spaces in most of examined cases does not follow strict separation of private or social zones inside dwelling, neither organization of “free zones” – such as *activity zones*, *access zones*, and *passing zones* which suppose to allow users to perform daily activities in adequate and comfortable manner. Instead, all mentioned factors show different approach in organization than in “non-flexible” dwellings and are definitely more complex. This complexity is related to overlapping of different functional zones together: private and social areas of the dwelling are merged; *passages,* intended to improve communication trough space become at the same time *zones of activities*; *access zones*, reserved for adequate space that is required to approach to and use a particular element or area become at the same time zones for obtaining certain *activities*, or etc. In sum - the greater this fusion is present, the spaces become more complex and consequently lower comfort is offered.

Furthermore, a fundamental feature of flexible interiors is connection with human body (see Chapter 9). We are surrounded by objects that are able to support variable functions according to our variable needs or desires. No matter if we are talking about sliding panel constructions, foldable furniture systems or some other flexible method - each daily-routine action carried out in such interiors in most cases requires occupants to have adequate physical abilities. In other words, each functional transformation depends on our mind and body force, as elements could be repetitively slid, folded, opened or removed more than once during the day, in order to successfully accomplish even the most banal daily activities.
Consequently, such condition emphasises importance of occupant’s health condition. The living circumstances in which structures need to be “built” and consequently used clearly require a selection of a specific target group of occupants who are able to fulfil such conditions. As such, the described conditions necessarily lead us to *young and healthy* group of occupants. With this in mind, the problems which might arise could be in contrast with some already widespread literature-based interpretations about flexible dwellings considering temporal benefits. In other words, flexibility in this context cannot be considered as a method able to ensure a sort of “life-time dwelling“ where the “obsolescence“ of spaces can be prevented through spatial transformations. Therefore, althought flexible, such interior conception is appropriate only for short-term life periods, those in which occupants are in such physical conditions that they can actively participate in layout transformations. Consequently, if not replaced with some more advanced method, this fact can be considered a significantly limiting factor for a wider target of users and on the long-term. More advanced techniques, such as developing “smart” structures and various movement typologies supported by the recent innovations in the field of automatization, high-tech systems and sensor technology, start to be more explored and implemented only recently (since 2010 onward).

12. Evolutional stages regarding implementation of flexibility in limited dwelling interior since 1970's

As said throughout the chapters in this Thesis, from this first experimental phase until the present day, a wide variety of flexible concepts has been rapidly developed. Nevertheless, a common guiding principle for all of them can be identified which is related to the fact that flexible methods generally rely on the deviation, optimization or even elimination of physical distances based on standard ergonomic approaches aimed at fitting spatial limitations. Furthermore, functional units with determined, static and fixed purposes become variable, movable, extendable entities which, due to their flexibility, can set the spaces free from fixed and limited functions.

However, regardless of all diversity of approaches, evolutional stages of flexible techniques during time period of 1970's till nowadays could be identified and classified as following:

- *"Instant interior" (emerged in period in 1970's)*
- *"Neutral interior" (emerged in period in 1990's)*
- *"Stage interior" (start to be noted in period since 2010's onward)*

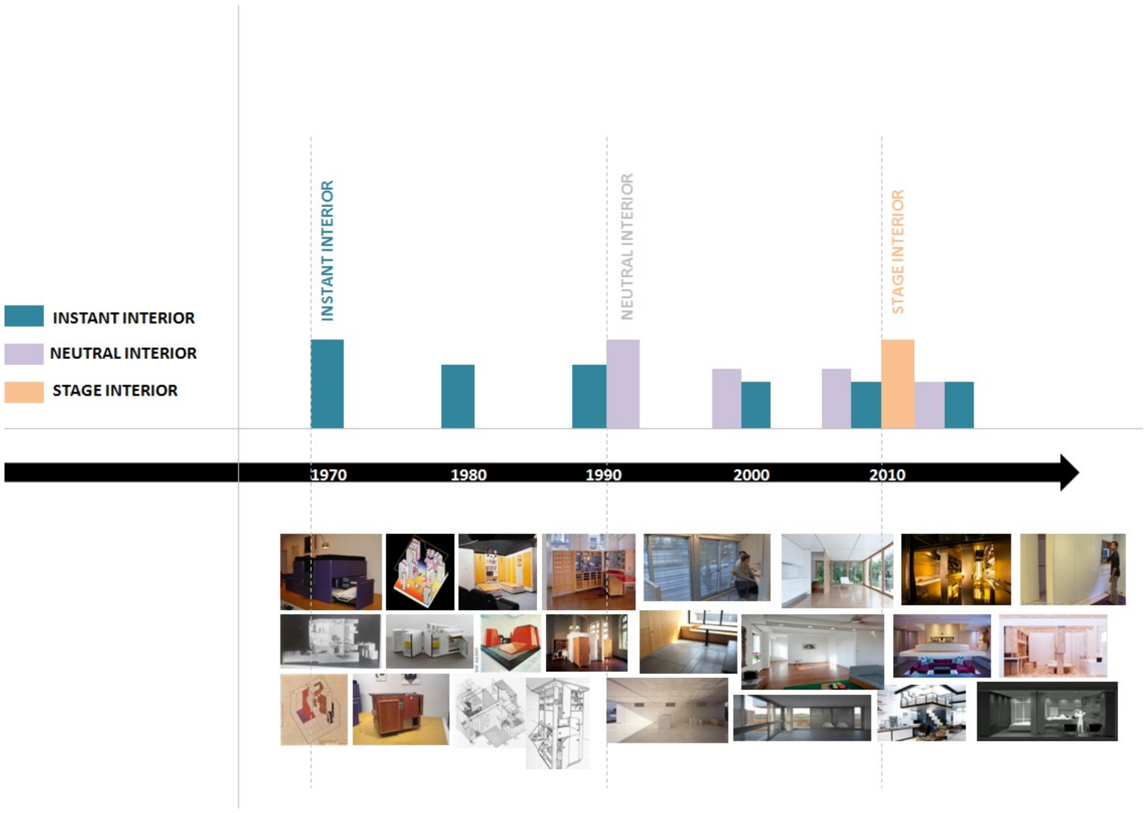


Fig. 12.1. Timeline of evolution of flexible dwelling techniques from 1970's till nowdays

12.1. *"Instant interior" (emerged in period in1970's)*

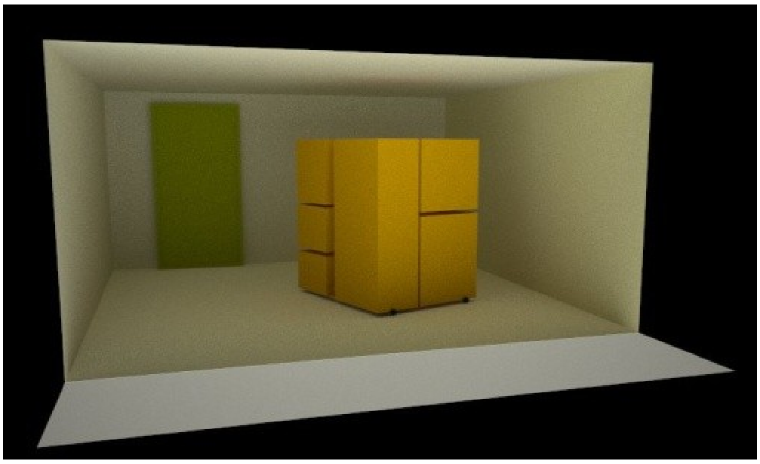


Fig. 12.1.1. *Instant interior* model.

The appropriate form of this type of flexibility could be described as a "compact piece of furniture", as it contains multiple functions, but at the same time it dictates also the whole spatial organization "packaged" inside one structure. As such, this approach represents a sort of "instant dwelling box" that only needs to be positioned in the centre of any empty space to be used. These kind of elements we can call "functional boxes", "spatial separators", "cabinets" or even "instant rooms", all of which at the same time, but maybe the best description could be "interior inside interior". They can be closed when not in function and moved away in order to give space to some other functional activities inside the space. They can be placed on any location, regardless if it is related to private or public context. One of the first examples of this type of approaches to flexibility were Joe Colombo's Total Furnishing Units (1972), whose blocks containing complete kitchens, bedrooms and other functional units could be defined as "compact furniture elements" but could also contribute to spatial organization as dividing elements. An even more remarkable case is the Alberto Seassaro's Central Block (1968/1970) containing bed, table, wardrobe, toilet, shelves, etc. When opened in certain positions, this box provides the whole spatial and functional organization of the dwelling. Furthermore, as a more recent example, it could be mentioned Andrew Kline's Interior Living Unit (2010) (see Fig.12.1.2), where "the Unit folds (closed) and unfolds (open) to reveal different functions when needed: a wardrobe, bed, kitchen, and bathroom. When the Unit is folded, the private program requirements of a home are removed and the surrounding space can be transformed for public uses. […] Once taken apart, the Unit is easily transported in a moving van and can be re-installed in another space, allowing the owner to take their home with them if they move."[216]

Consequently, such types of solutions go even beyond the limits of strictly private interior spaces. Especially for nowadays rapidly developed consumer-oriented services, such approach is considered as potential niche for applying new brand strategies based on idea of temporary "home replacement". As an example it could be mentioned the Sleepbox concept by Arch Group (architects: M. Krymov, A.Goryainov), designed in 2009. This concept is developed primarily in order to support eventual unforeseen circumstances for the travelers who need to spend a night safely and inexpensively; or simply to "kill" a few hours without leaving the luggage[217]. As such, its range of

[216] Etherington, Rose. "Interior Living Unit by Andrew Kline". Dezeen - Interior Living Unit by Andrew Kline. June 13, 2010. Accessed November 7, 2014. http://www.dezeen.com/2010/06/13/interior-living-unit-by-andrew-kline/.
[217] Frearson, Amy. "Sleepbox 01 by Arch Group - Dezeen." Dezeen - Sleepbox 01 by Arch Group. September 12, 2011. Accessed November 7, 2014. http://www.dezeen.com/2011/09/12/sleepbox-01-by-arch-group/.

applicability can be used primarily at airports or rail stations, but additionally also in the contexts such as fairs, big events (e.g. Olympic Games or concerts), public and shopping centers, and some other accommodation facilities.

Example of INSTANT INTERIOR

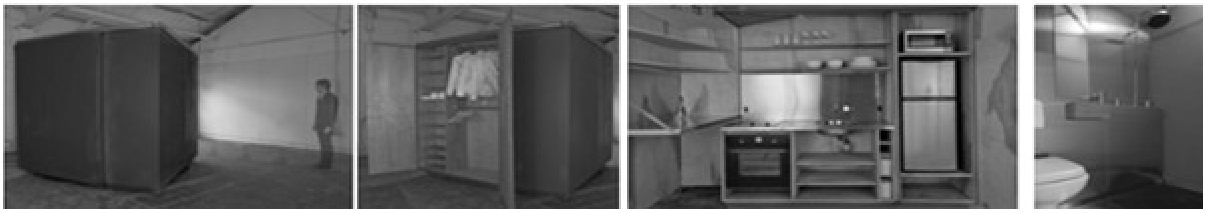


Fig. 12.1.2. (from left to right) Interior Living Unit, by Andrew Kline, 2010. Picture source: [http://www.dezeen.com/2010/06/13/interior-living-unit-by-andrew-kline/ (accessed 5th November 2014)].

12.2. “*Neutral interior” (emerged in period in 1990’s)*

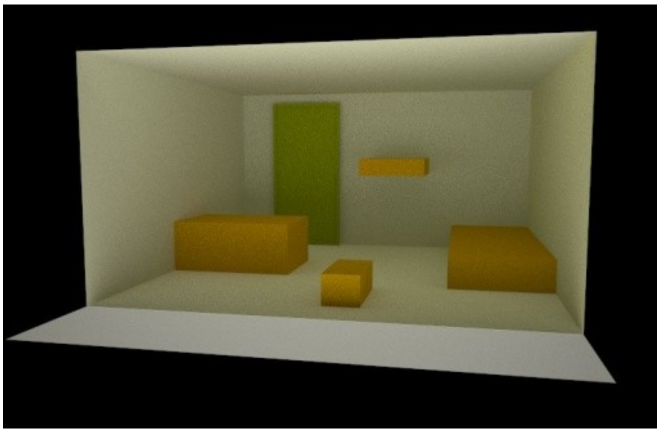


Fig. 12.2.1. *Neutral interior* model.

To satisfy the functional diversity of small-floor-area spaces as much as possible, flexible approaches can be “hidden” inside “neutral base” of the dwelling. Such neutrality refers to the shapes and volumes inside the space that do not have strictly defined function. Instead, flexibility in this model of interior is achieved by selecting unavoidable functional elements in our daily life and giving them various multiple meanings so as to achieve some extra functions. It that way, for example a built-in wardrobe: besides being used for storing things, it could also serve as a space for placing kitchen, foldable bed for sleeping, daily sofa, or even the toilet. To have a more precise visualization of this approach, one good example is the “Lego apartment” in Barcelona by the architect Barbara Appalloni (see Fig. 12.2.2 Left). As mentioned in the article “*Lego-style apartment transformations into infinite spaces*”, when the occupant “of this space isn't cooking, dressing, sleeping or eating, his 24 m2 apartment is an empty cube. To use a piece of furniture, he has to build it. To sleep, he rolls his bed out from under the balcony, his stairs become bedside tables and he can even swing his tv out from the wall. To dine, he lowers a plank from the wall, his flower-stand becomes a support and his stairs become a bench. To cook, he clicks a spot on his vast wall of click-able furniture, and a spring-loaded door swings up to reveal an instant kitchen…”[218] According to analysis, these type start to rapidly emerge around 1990’s.

Examples of NEUTRAL INTERIOR

Fig. 12.2.2(Left). Lego apartment, by Barbara Appolloni, Barcelona, 2008-2009. Picture source: [http://barbaraappolloni.com/en/lego-apartment/ (accessed 5th November 2014)]; **Fig.12.2.3. (Midle)** Transformer, by Studio Garneau. Source: [http://www.youtube.com/watch?v=d1iHzw6wTHM (accessed 21th February 2014)]; **Fig.12.2.4. (Right)** “Ultra small home” by Junichi Sugiyama, Japan, 2010. Picture sources: “Ultra-small is beautiful for Japanese homeowners” [http://edition.cnn.com/2010/WORLD/asiapcf/11/12/japan.ultra.tiny.home/(accessed 20th January

[218] "Lego-style Apartment Transforms into Infinite Spaces." Exquisite Home Designs Room Design Ideas Decorating Ideas Classic Interior Designs Bathroom Designs Small Room Decorations RSS. March 1, 2013. Accessed November 7, 2014. http://exquisitehouse.com/lego-style-apartment-transforms-into-infinite-spaces/.

12.3. *"Stage interior" (noted in period since 2010's onward)*

12.3.1. Technical definition - "Stage space" model of flexibility

"All the world's a stage,
And all the men and women merely players..."
By William Shakespeare, As You Like It,
between 1599-1600.

As a conclusion to all the above considerations and according to the results of the analysis of the all flexible interior methods and related trends, one schematic model can be identified which starts to emerge in recent times as an experimental prototype for future developments in the field of flexible dwellings.

Titled by the author of this Thesis as the **"*Stage space*"** concept of dwelling flexibility, this model of flexibility is strongly influenced by scenery movement systems in stage-design technology – initially a very commonly used technique for performing arts and entertainment industry (e.g. theatre plays, dance performances, concerts, etc.). Such systems are usually developed to provide a wide range of stage flexibility in order to support requirements, ambiences or some special effects for specific artistic performances (see Fig. 12.3.1. and Fig. 12.3.2.).

According to the mentioned patterns of such type of flexibility, this concept fits with the techniques already widespread in theatre, dance, opera and other performing arts where different environmental effects on the same stage can evoke different scenario experiences of the play. Therefore, the final conclusion is that the theatre design practice is the most reliable ground for developing small contemporary dwellings with flexible functions in upcoming times.

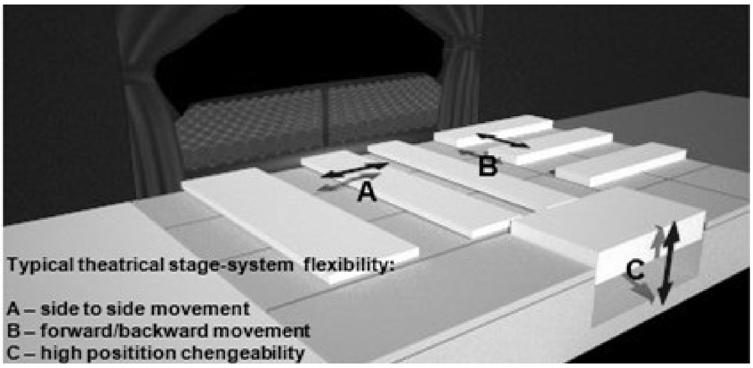


Fig.12.3.1. Scheme of typical scenery movements in theatrical stage systems.

Fig.12.3.2. Example of systems supporting vertical and horizontal changeability of the stage in performing arts and entertainment industry. Source: "Scenery Movement - Silent (SCT) Systems." By SERAPID. Accessed May 12, 2014. http://www.serapid.com/en/stage-equipment/scenery-movement.

Such conclusion is supported by the fact that recent case studies examined in this Thesis (such as the *LifeEdited* apartment by Graham Hill in New York, 2012; the *Multifunctional dwelling* by Gery Chang in Hong Kong, 2010; the *CityHome* project by Kent Larson and MIT School of Architecture and Planning, USA, 2012; the *YO-home* concept by Simon Woodroffe, United Kingdom, 2013; etc.) show an emerging trend based on the idea of creating a basic typology of dwelling space similar to the mentioned stage, where a variety of living scenarios may be implemented. More specifically, a dwelling space as such consists of the following factors (see Fig.12.2.3.): a) geometrically square-shaped empty surface, within which most areas have to be preserved for later applications of flexible interior methods; b) optimized entrance zone; c) optimized immobile units where bathroom fixtures are placed; and d) large window opening which allows extended spatiality towards a terrace or a balcony space. Furthermore, the central area of the dwelling (the so called "*Stage space*") represents the flexible zone of the dwelling where the functional variations of space are shown in two main types: *Type A* - which represents linear interior flexibility (see Fig.12.2.4.), that are noted in case studies like MIT Media Lab *City Home* by Kent Larson et al. (2012), *LifeEdited apartment* by Modern Office Systems llc (2012), or *Barcode room* by Studio_01 (2012) ; and *Type B* – which represents vertical interior flexibility (see Fig.12.2.5.) that are noted in case studies like *YO Home* concept by Simon Woodroffe, London, (2013) and others.

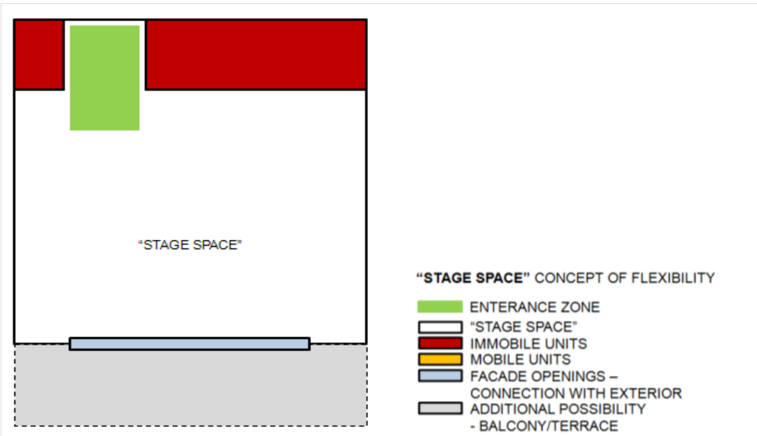


Fig.12.3.3. "*Stage space*" – basic schematic model

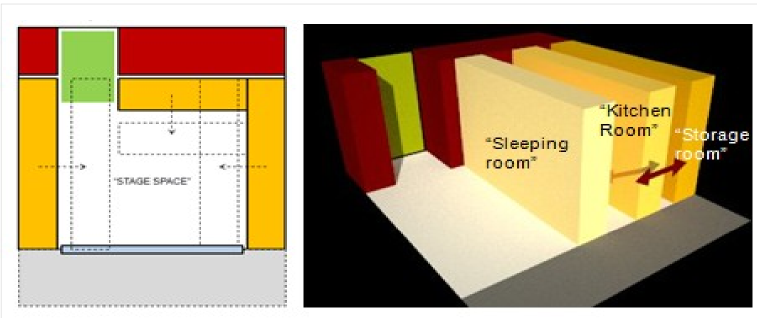


Fig.12.3.4. "*Stage space*", Type A – linear flexibility

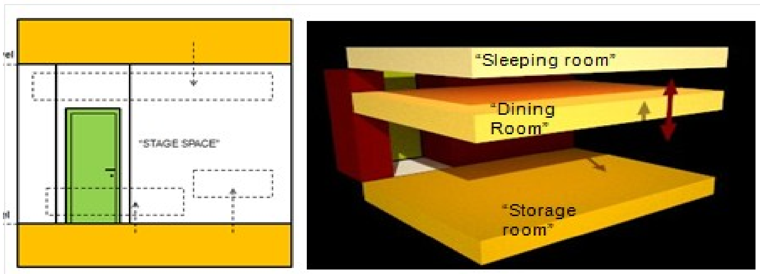


Fig.12.3.5. "Stage space", Type B – vertical flexibility.

12.3.2. Social definition - "Schedule-based" living comfort

According to all described living behaviours in flexible dwellings we can conclude that transformations of the space according to "*Stage-space*" model - which was detected as emerging trend – from sociological point of view do not completely allow the level of living comfort where each action could have its own place and intimacy without interfering other actions and other people's privacies at the same time. In other words, obtaining various functions of the space is hardly possible simultaneously. For example, if one occupant wishes to cook, the other one cannot work nor dine at the same time because the whole space is transformed into the kitchen environment while working or dining area is somewhere "hidden". Even in the case that whole household consist only of one person, situation remains the same because the spatial arrangements usually do not allow simultaneous functionality. Consequently, the actions which need to be done in most of the cases in this type of interior must follow "one by one" procedure regardless of quantity of persons in household (see Fig.12.3.6.). Therefore, organization of daily routine between inhabitants is necessary. In sum, it can be concluded that comfort conditions in flexible dwellings could be on some level achieved only if followed by some organizational agenda.

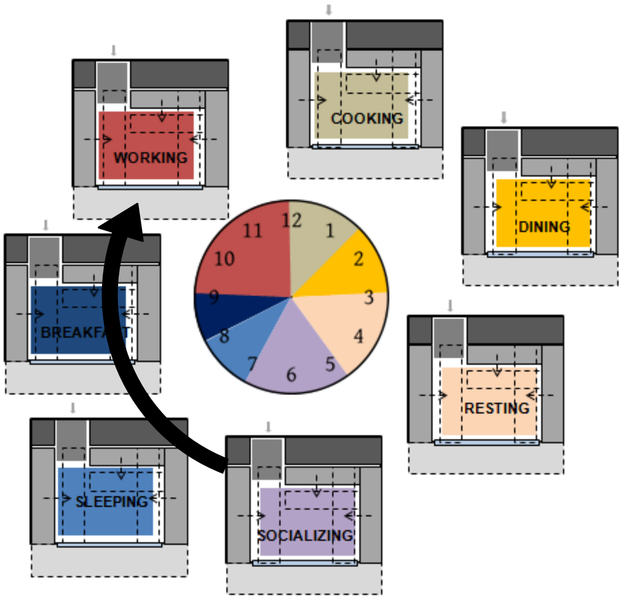


Fig.12.3.6. Hypotetical overview on daily transformation scenarios of flexible dwelling space based on most common daily routine requirements

Example of STAGE INTERIOR

Fig.12.3.7. (Left/Middle/Right) Gery Chang Apartment, Hong Kong, 2010.

13. Proposal for further development

Appirience of “*Stage-space”* flexibility with imposed behavioural living pattern titled as “*Schedule-based”* living comfort invetibly define the target user for this type of dwelling. For the time being, such type of living option is still in early development phase that is only suitible for younger and physicaly healthy population on the short-term basis. However, automation techniques (e.g. sensor technology responding to gestures, touch and voice commands) which start to appear in flexible transformations may be considered a significant improvement for the future because it could expand the target market of users to elderly population as well (e.g. “*Home in a box*”*,* by MIT Media Lab CityHome, USA, 2014).
Aditionally, it should be taken in account more further research regarding intellegent approach to “*Stage-space”* flexibility in the sense of conception of flexible partitions. This step is important in order to improve comfort conditions and therefore to avoid as much as possible ”*Schedule-based”* living comfort which could be considered as limiting factor in obtaining various daily-routine actions inside the dwelling simultaniously. Therefore, flexible partitions should be created in the way to - at least partially - allow the acces to some functions which are temporarly “hidden” because of currently “active” living scenario. Hypotetically speaking, if the dwelling is transformed into *dining scenario*, there should be offered simultanious possibility to at least partially “enter” to some crutial elements from currently “inactive” *sleeping scenario*, or *storage partitions*, or etc. As such, comfort conditions could be improved.

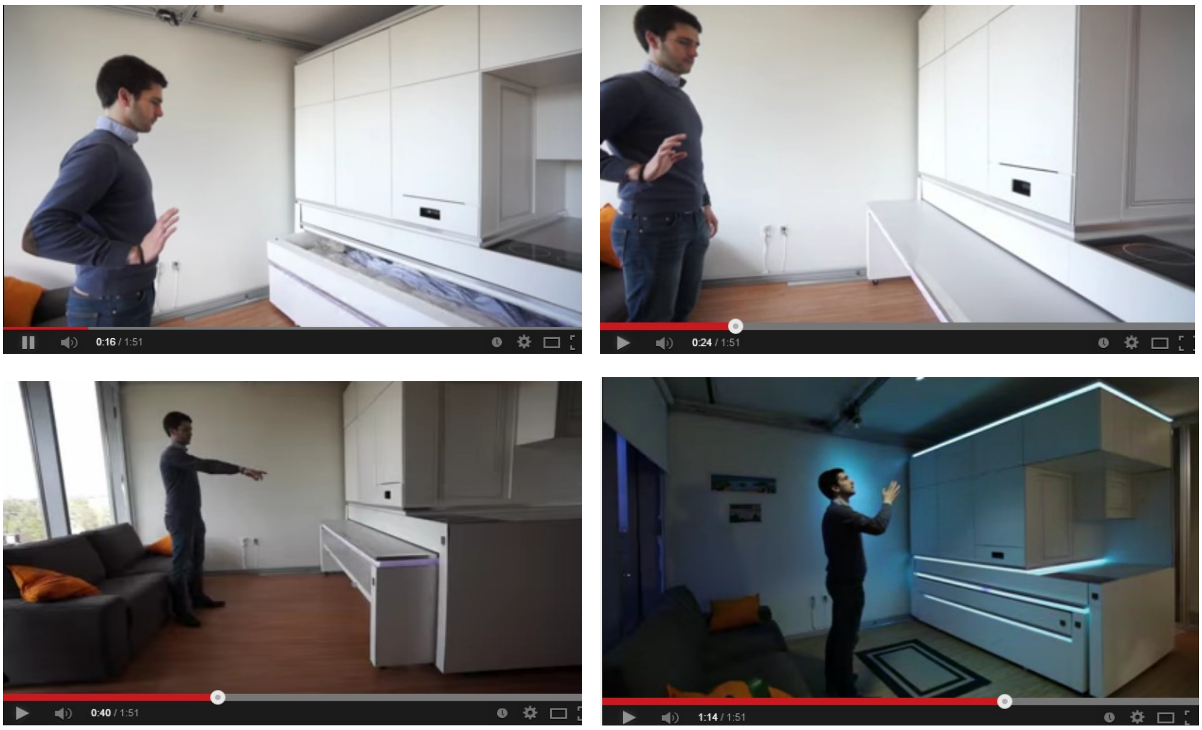


Fig.13.1. Flexibility of the space based on “Minority Report“-like technology which responds to gestures, touch and voice commands. “MIT Media Lab CityHome: What if 200 ft2 could be 3x larger?“ Source: MIT MediaLab. Sections taken from video on Youtube.com [http://www.youtube.com/watch?v=f8giE7i7CAE (accessed 19th June 2014)]

Furthermore, considering further points for improvement, the key factor which should be taken in account while approaching to “*Stage-space”* flexible concept is the target user. First of all it should be mentioned that no matter about which category of users we are talking about, it should be taken in account that very frequent and repetitive functional transformations of the space on the daily basis could cause physical and mental exhaustion on long-term (see Table 11). Therefore, "*Schedule-based"* comfortability, expecially in those examples where transformations are based on manual body force, should be carefully balanced. In other words, some drastic daily transformations that limit simultaneous functionality of the space and encourage more repetetive physical actions should be reduced on minimum. Looking more closely to specific target groups of users (e.g. younger population, middle-age population, erlderly persons or etc.) there are some further particularities which should be taken in consideration for each of them as well (see Table 11). For example, for young and healthy population there are no specific additional factors (except those general considerations previously mentioned related to daily frequency of actions); while for middle-aged or elderly population complex technical solutions or weight of flexible partitions could be already considered as burdening factor.

However - if desired to be targeted for wide audience or like a life-long living solution - flexibile interior approach in dwellings described in this thesis as "*Stage-space*" concept, under condition to improve and incorporate suggested options described in this concluding chapter and listed in Table 11. as well, could be considered as adequate respond to constant and growing problem for functional and affordable dwellings in high-populated urban areas worldwide. Additionally, such typology can be further developed and with some adjustments applied in contexts other than only in dwelling purposes (see Table 12).

<table>
<tr><th>Target user</th><th>Common factors</th><th>Additional specific factors</th></tr>
<tr><td>Young and healthy population</td><td rowspan="6">*It should be taken in account that very frequent and repetitive functional transformations of the space on the daily basis could cause physical and mental exhaustion on long-term. Therefore, "Schedule-based comfortability" should be carefully balanced. In other words, some drastic daily transformations that limit simultaneous functionality of the space should be reduced on minimum.</td><td>*No specific additional factors</td></tr>
<tr><td>Young population with some specific health problems</td><td>*Weight of flexible partitions should be as less as possible, in order to use less body energy in spatial transformations.

*Complex technical systems of transformation which insist more time or patience should be avoided.</td></tr>
<tr><td>Population in the middle ages with no specific health problems</td><td>*Weight of flexible partitions should be as less as possible, in order to use less body energy in spatial transformations.

*Complex technical systems of transformation which insist more time or patience should be avoided.</td></tr>
<tr><td>Population in the middle ages with some specific health problems</td><td>*Weight of flexible partitions should be as less as possible, in order to use less body energy in spatial transformations.

*Complex technical systems of transformation which insist more time or patience should be avoided.

*Possibility for upgrading flexible partitions with automatic systems for future times is advisable to predict in advance.</td></tr>
<tr><td>Elderly population</td><td>*Spatial transformation should be based on automatic systems integrated in flexible partitions.</td></tr>
<tr><td>Disabled persons</td><td>*Ergonomic standards for disabled persons should be respected.

*Spatial transformation should be based on automatic systems integrated in flexible partitions.</td></tr>
</table>

Table 11. Proposal for future improvement of "*Stage-space*" living concept - important factors that need to be taken in account for different target users.

Residential context	Public context
Small private dwellings	Offices
Student dormitory's	
Small holiday houses	

Table 12. Possible applicability of "*Stage space*" concept for other purposes.

REFERENT LITERATURE

List of figures
List of tables

Books:

Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972.

Barnwell, Maurice. *Design, creativity & culture: an orientation to design*. London, UK: Black Dog Publishing, 2011.

Bergdoll, Barry, Peter Christensen, and Ron Broadhurst. *Home delivery: fabricating the modern dwelling*. New York: Museum of Modern Art :, 2008.

Brown, Azby. *The very small home: Japanese ideas for living well in limited space*. Tokyo: Kodansha International , 2005.

Clauss, Mathias, and Alexander von Vegesack. *Living in motion: design and architecture for flexible dwelling*. Weil am Rhein: Vitra Design Museum, 2002.

Davies, Colin. *The prefabricated home*. London, UK: Reaktion Books, 2005.

Douglas, Mary. "The Idea of a Home: A Kind of Space", in Lane, Barbara Miller, *Housing and dwelling perspectives on modern domestic architecture*. London: Routledge, 2007, p.61-67.

Dreyfuss, Henry. *Designing for people*. New York: Simon and Schuster, 1955.

Friedman, Avi. *Innovative houses: concepts for sustainable living*. S.l.: Laurence King Publishing, 2013.

Goytisolo, Juan. *Space in motion*. New York, NY: Lumen Books, 1987.

Habegger, Jerryll, and Joseph H. Osman. *Sourcebook of modern furniture*. 3rd ed. New York: W.W. Norton & Co., 2005.

Heidegger, Martin. "Building, dwelling, thinking" (1954), in Lane, Barbara Miller, *Housing and dwelling perspectives on modern domestic architecture*. London: Routledge, 2007, p.50-54.

Hepworth, Mike. "Privacy, security and respectability"(1999), in Lane, Barbara Miller. *Housing and dwelling perspectives on modern domestic architecture*. London: Routledge, 2007, p150-155.

Herbers, Jill. *Prefab modern*. New York: Harper Design International, 2004.

Klemp, Klaus. *Das USM Haller Möbelbausystem*. Frankfurt am Main: Verlag form, 1997.

Kronenburg, Robert. *Portable architecture: Design and Technology*. Basel: Birkhäuser Verlag AG, 2008.

Kronenburg, Robert, *Transportable environments: Theory, Context, Design and Technology: papers from the International Conference on Portable Architecture,* London; New York, E & FN Spon, 1998.

Kronenburg, Robert, *HOUSES IN MOTION: the genesis, history and development of the portable building,* London, Academy Editions, 1995.

Lane, Barbara Miller. *Housing and dwelling perspectives on modern domestic architecture*. London: Routledge, 2007.

Milner, J & Madigan, R. „Regulation and Innovation: Rethinking Inclusive Housing Design“ in *Housing Studies*, 19 (5), p.727-744.

Moe, Kiel. *Thermally active surfaces in architecture*. New York: Princeton Architectural Press, 2010.

Ottolini, Gianni, and Vera Prizio. *La casa attrezzata: qualità dell'abitare e rapporti di integrazione fra arredamento e architettura*. Napoli: Liguori, 1993.

Pepe, Gian Carlo, and Giacomo Rizzi. *L'alloggio flessibile*. Pavia: Gianni luculano Editore, 1990.

Pople, Nicolas. *Experimental houses*. New York: Watson-Guptill Publications, 2000.

Schittich, Christian, and Peter Ebner.*Housing for people of all ages: flexible, unrestricted, senior-friendly*. München: Edition DETAIL, Institut für Internationale Architektur-Dokumentation GmbH, 2007.

Schittich, Christian. *Small structures: Compact dwelling, Temporary structures, Room models*. Munich: Edition Detail, 2010.

Schleifer, Simone K.. *Prefab Houses = Fertighäuser.*. Antwerpen: Booqs, 2011.

Schneider, Tatjana, and Jeremy Till. *Flexible housing*. Oxford, UK: Architectural Press, 2007.

Schneiderman, Deborah. *Inside Prefab: The Ready-Made Interior*. New York: Princeton Architectural Press, 2012.

Schlüter, Arno. "MODEL-BASED, PERFORMANCE-ORIENTED BUILDING DESIGN EMPLOYING DISTRIBUTED SERVICE SYSTEMS". PhD Thesis (2010) , at ETH, Zurich, Switzerland.

Schumacher, Michael, and Oliver Schaeffer. *Move: architecture in motion--dynamic components and elements*. Basel: Birkhäuser, 2010.

Slavid, Ruth. *Micro: very small architecture*. London: Laurence King, 2007.

Smith, Courtenay, and Sean Topham. *Xtreme houses*. Munich: Prestel, 2002.

Smith, Ryan E. *Prefab architecture*. New Jersey: John Wiley & Sons, 2010.

Smithson, A. (2001) How to Recognize and Read Mat Building, in Sarkis, S., Allard, P. and Hyde, T. (eds) Case: Le Corbusier's Venice Hospital and the Mat Building Revival. New York: Prestel, pp.90-103.

Zuk, William, and Roger Clark. *Kinetic Architecture*. New York: Van Nostrand Reinhold, 1970.

Wright, Frank Lloyd, and Yukio Futagawa.*Frank Lloyd Wright*. Tokyo: A.D.A. Edita, 1984, 1988.

Internet sources:

Bernstein, Levitt. “A new approach to housing standards”. London: 2010. Source: [http://www.housinglin.org.uk/_library/Resources/Housing/Support_materials/Other_reports_and_guidance/A4_Full_proposal_rev5.pdf (accessed 12th May 2014)]

Dvořáková, Pavla. "Visual comfort". Source: http://www.ides-edu.eu/wp content/uploads/2013/04/4-visual-comfort.pdf (accessed July 7, 2014).

Frattari, Antonio. *XXXII IAHS world housing congress: Trento, Italy, September 21-25, 2004 : sustainability of the housing projects : proceedings*. Trento] : [Trento: University of Trento(IS), Università di Trento, 2004.

Friedman, Avi and Maria D. Pantelopoulos. “The Wartime Home as a Paradigm for Today's Affordable Housing Design” *Journal of Architectural Education (1984-)*, Vol. 49, No. 3 (Feb., 1996), pp. 184-195. Source[http://www.jstor.org/stable/1425327?&Search=yes&searchText=interior&searchText=compact&searchText=living&list=hide&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Dcompact%2Bliving%2Binterior%26Search%3DSearch%26wc%3Don%26fc%3Doff%26globalSearch%3D%26sbbBox%3D%26sbjBox%3D%26sbpBox%3D&prevSearch=&item=24&ttl=2306&returnArticleService=showFullText (accessed 7th July 2013)].

Ginthner, Delores (Dee).“Lighting: Its Effect on People and Spaces” , in *InformeDesign*, VOL. 02 ISSUE 02 . Source: http://www.informedesign.org/_news/feb_v02-p.pdf.

“Human comfort and health environment” course materials, University of Washington. Source: [http://courses.washington.edu/me333afe/Comfort_Health.pdf (accessed 18th March 2014)]

Rewi, Adrienne. "Beyond wall" in *Perspective*, Winter: 2004. Source: [http://www.iida.org/resources/category/9/4/1/documents/0104beyond.pdf (accessed May 12, 2014)].

Whiteley, Nigel. "Toward a Throw-Away Culture. Consumerism, 'Style Obsolescence' and Cultural Theory in the 1950s and 1960s." JSTOR. Source[http://www.jstor.org/stable/1360444?seq=13&Search=yes&searchText=archigram&list=hide&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Darchigram%26Search%3DSearch%26gw%3Djtx%26prq%3D%2528modern%2Bmovement%2529%2BAND%2B%2528cty%253A%2528journal%2529%2BAND%2Bty (accessed November 19, 2013)].

Williamson, Jack. "The Grid: History, Use, and Meaning." JSTOR. Source[http://www.jstor.org/stable/1511481?seq=8&Search=yes&searchText=layout&searchText=modular&searchText=grid&list=hide&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Dmodular%2Bgrid%2Blayout%26Search%3DSearch%26gw%3Djtx%26prq%3Darchigram%26hp%3D25%26acc%3Don%26aori%3Da%26wc%3Don%26fc%3Doff&prevSearch=&item=4&ttl=110&returnArticleService=showFullText&resultsServiceName=null (accessed November 19, 2013)].

Wilson, Lindsay. "How big is a house? Average house size by country" in *Housing*, 2012. Source: [http://shrinkthatfootprint.com/how-big-is-a-house (accessed June 6, 2014)].

Videos:

Noe, Rain. "Haefele's Transformable Kitchen & Dining Spaces." YouTube. April 10, 2014. Accessed November 25, 2014.
http://www.youtube.com/watch?v=ujs98Bo4lsY.

"RoomAlive: Magical Experiences Enabled by Scalable, Adaptive Projector-Camera Units." YouTube. October 5, 2014. Accessed December 9, 2014.
http://www.youtube.com/watch?v=ILb5ExBzHqw#t=142.

"Lighting WallpaperTM." Indiegogo. Accessed December 9, 2014.
https://www.indiegogo.com/projects/lighting-wallpapertm#home/share.

Dirksen, Kirsten. "6 Rooms into 1: Morphing Apartment Packs 1100 Sq Ft into 420." YouTube. December 3, 2012. Accessed December 9, 2014. http://www.youtube.com/watch?v=XYV0qATsyts.

Dirksen, Kirsten. "Lego-style Apartment Transforms into Infinite Spaces." YouTube. April 25, 2011. Accessed December 9, 2014. http://www.youtube.com/watch?v=juWaO5TJS00.

Dirksen, Kirsten. "Space Saving Furniture That Transforms 1 Room into 2 or 3." YouTube. June 27, 2011. Accessed December 9, 2014. http://www.youtube.com/watch?v=9nljmEUeLbY.

Dirksen, Kirsten. "Extreme Transformer Home in Hong Kong: Gary Chang's 24 Rooms in 1." YouTube. May 12, 2013. Accessed December 9, 2014. http://www.youtube.com/watch?v=WB2-2j9e4co.

"Resource Furniture: Italian-Designed Space Saving Furniture." YouTube. May 19, 2010. Accessed December 9, 2014. http://www.youtube.com/watch?v=dAa6bOWB8qY.

"25s Transformable Apartment by Kent Larson MIT." YouTube. May 19, 2010. Accessed December 9, 2014. http://www.youtube.com/watch?v=FdROu0dqm8A.

"Transformable Apartment, Kent Larson." YouTube. September 13, 2012. Accessed December 9, 2014. http://www.youtube.com/watch?v=G12hbL0M_ZE.

Dirksen, Kirsten. "House in a Suitcase: Tiny Home 2 Trunks of Furniture." YouTube. December 30, 2010. Accessed December 9, 2014. http://www.youtube.com/watch?v=MQK-CIbvJls.

"MIT Media Lab CityHome - Smart Furniture for Small Apartments." YouTube. June 2, 2014. Accessed December 9, 2014. http://www.youtube.com/watch?v=ODKaMdrgO8o.

Dirksen, Kirsten. "DIY-crafted Seattle Micro Apartment: 8 Spaces Stacked in 182 Sq Ft." YouTube. August 26, 2013. Accessed December 9, 2014. http://www.youtube.com/watch?v=hJkBlqLJLWA.

"Tiny Apartment Design into New York City's - Brilliant Small Apt Fits Everything - Tiny, Eclectic." YouTube. February 28, 2014. Accessed December 9, 2014. http://www.youtube.com/watch?v=zO-E6CTa3Mo.

"Japan's Micro Apartment Boom." YouTube. March 4, 2013. Accessed December 9, 2014. http://www.youtube.com/watch?v=13ssbuyaqZI.

Dirksen, Kirsten. "Tiny Origami Apartment in Manhattan Unfolds into 4 Rooms." YouTube. November 7, 2011. Accessed December 9, 2014. http://www.youtube.com/watch?v=8RbxkrmuQ5E.

"Haefele's Transformable Kitchen & Dining Spaces." YouTube. April 9, 2014. Accessed December 9, 2014. http://www.youtube.com/watch?v=ujs98Bo4lsY.

"HÃ¤fele Functionality Cube (EN)." YouTube. May 2, 2013. Accessed December 9, 2014. http://www.youtube.com/watch?v=kDLzTn5vWe8.

"Living Small in NYC - New York Post." YouTube. January 22, 2013. Accessed December 9, 2014. http://www.youtube.com/watch?v=5ppEOBJigGg.

APPENDIX

Case Studies

Time context: **1970s**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Unbalancing system

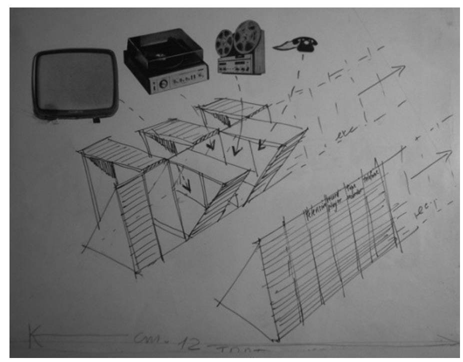
Author: Ugo La Pietra

Location: Italy

Year: 1973

Photo’s:

La Pietra operates on the premise that the designer’s materials are not physical entities but communication bits. Rather than manipulating formally the elements which give meaning to our behaviour, he is more interested in directly dealing with the production, transmission and feedback of meanings trough available communication techniques. His criticism to the present communications structure is that, except the telephone and the rare case of a ham operator, all the communication equipment we have in the house are only one-way in direction. His “stand” is a didactic box, measuring 16’ x 20’, triangular in section, although the shape is not important. Dividing the box is a mesh screen; behind it are stylized present-day electrodomestic and cinema/photographic equipment. The mesh becomes a screen on which, by means of projections, the designer expounds his views.



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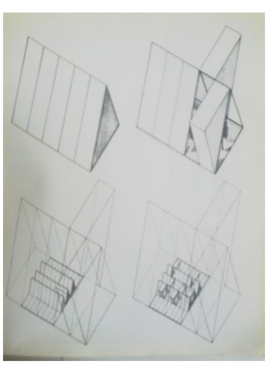
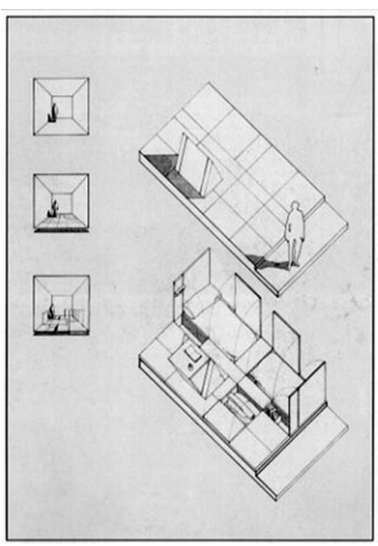
Source:

Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972, p153





Sources:

[http://atcasa.corriere.it/Tendenze/Se-ne-parla/2009/04/10/mostra_new_york_6.shtml#articolo (accessed 10th June 2013)]

Time context: **1970s**

Typology: **MULTI-PURPOSE LAYOUT**

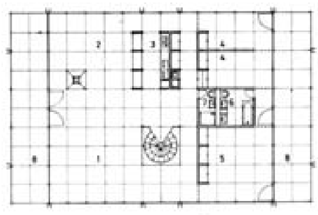
Name: Wohnhaus Schaerer

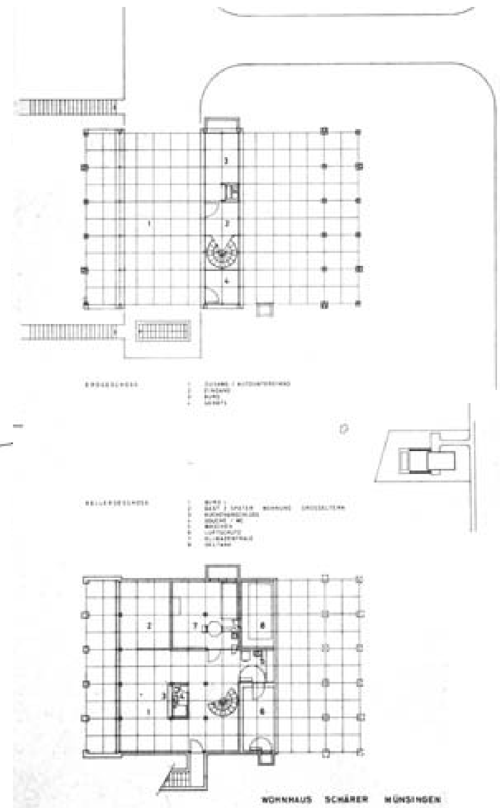
Author: Fritz Haller

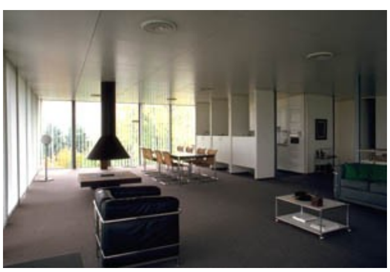
Location: Switzerland

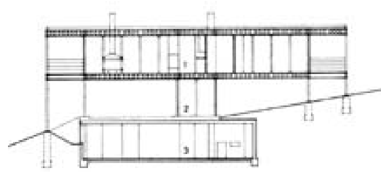
Year: 1969

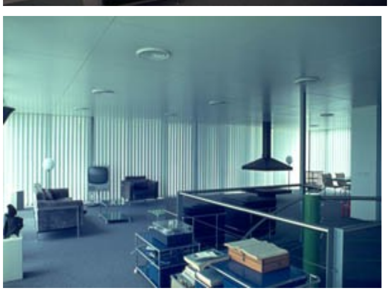
Photo’s:

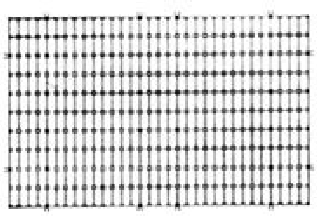












Haller's so-called Maxi architecture was predicated on flexibility: exterior and interior features like windows and doors could be dismantled and moved within a steel framework whose elements were based on a modular measurement of 120/60 cm.

Haller went on to conceive Midi and Mini systems that were used widely for smaller-scale projects, such as the Schärer family's house, which overlooks the Haller’s Münsingen factory.

Sources:

[/http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=46&number=15&total=175&action=all&data=Japan&order=type&dir=ASC&message=all%20projects&messagead=ordered%20by%20type&photo=6(accessed 30th June 2013)]

Time context: **1970s**

Typology: **MULTI-PURPOSE LAYOUT**

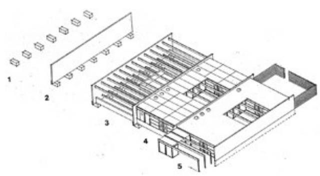
Name: Flexibo

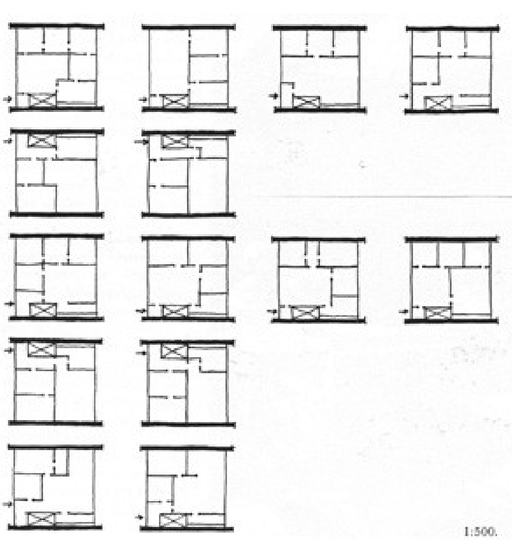
Author: Fællestegnestuen

Location: Følfodvej, Amager, Copenhagen

Year: 1976

Photo’s:





The sixty-eight one- and two-storey dwellings, designed by Fællestegnestuen for Copenhagen’s Public Housing Association (KAB), were partially designed and often also partially built by the residents. Whilst the basic frame of the building, which consists of prefabricated components of concrete and laminated timber, cannot be altered (apart from adding smaller parts such as a pergola), the interior is based on a modular wall system, which can be changed, adjusted or reconfigured by a building's inhabitants.

The architects drawings clearly show the principle of layers in the design. Parallel walls of concrete provide the dividing perimeters of each house. After these walls are placed, flooring elements are laid on concrete joists and roof and deck elements on timber beams. The facades are closed with light elements. Bathrooms and kitchens are placed along one of the partitions as the only fixed elements. Subsequently, internal partition walls can be laid out. These partitions consist of two types of wall elements of 1 metre and 0.45 metre, a door element of 1 metre, cover board, guide strips, and assembly fittings. Within the given modular grid system, determined by the rhythm of the laminated timber beams as well as some further guides, rooms can be formed at will. Additional pieces of wall can be acquired from a central wall depot. Whilst flexibility in the Flexibo scheme is implemented at the project stage, it is also possible after occupation and when somebody else moves into the house. The construction system allows walls to be moved around very easily, so any layout can be adapted to different needs and requirements at any point in time. A study after 3 years of completion showed that various residents had changed the position of doors, added additional rooms and altered room sizes.

Sources:
[http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=60&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=6 (accessed 1st July 2013)]

Time context: **1970s**

Typology: **MULTI-PURPOSE LAYOUT**

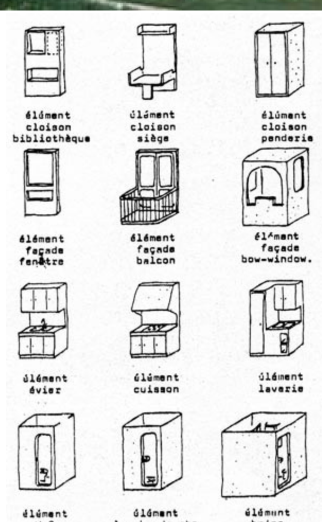
Name: Les Marelles

Author: Bernard Kohn, Georges Maurios

Location: France

Year: 1975

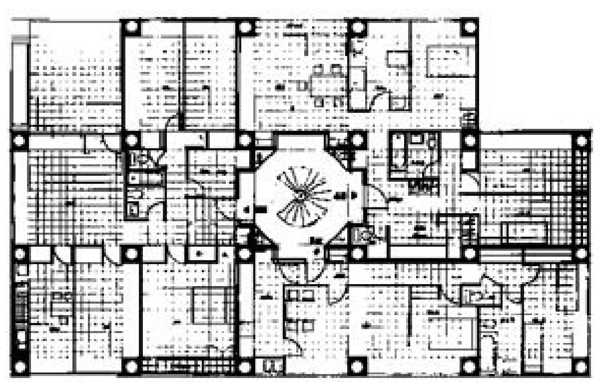
Photo's:



Les Marelles was developed as an experimental housing project of 100 dwellings. Built with the intention to provide a genuinely flexible habitat, the inhabitants were involved in the process of the design of their apartments through the use of 1:10 scale model.

The construction consists of a regular square space frame of 4.65 by 4.65 metres. The u-shaped beams collect and distribute horizontal services which rise or drop in massive hollow columns of 0.75 metres by 0.75 metres. This three-dimensional network allows for kitchens and bathrooms to be located anywhere along the ducts. Kitchens, bathrooms, partitions and facades can be chosen from a catalogue and are designed for interchangeability.

Within this set-up prospective occupants could design their own apartments, the boundaries of which determined by the number of serviced an unserviced space parcels bought. The central staircase of any of the nine buildings, which are grouped into three blocks, can serve up to four apartments. Apart from the column and beam construction system and the vertical circulation system, nothing is fixed. There is no typical plan either: each apartment is different not only through differences in layout but also through the location of its perimeter walls. The only communalities are the use of the same partitions, window panels, kitchen and bathroom units, but they are never in the same place twice.



Sources:

[http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=58&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=5 (accessed 2nd July 2013)]
Georges Maurios, Paris: Editions du Moniteur, 1990.
Herrou, M., and G. Maurios, 'Les Marelles une structure servante irriguée de fluides', *les Cahiers du CSTB*, 1976.
Periàñez, M., *L'habitat évolutif: du mythe aux réalités*, Paris: PCA, 1993.
Rabeneck, A., 'Adaptable Housing by Georges Maurios', *Architectural Design*, 45, 1975, pp. 567-70.
Vernez-Moudon, A., 'Les Marelles : Lessons in Dwelling Design', *Industrialisation Forum*, 7, 1976.

Time context: **1970s**

Typology: **MULTI-PURPOSE LAYOUT**

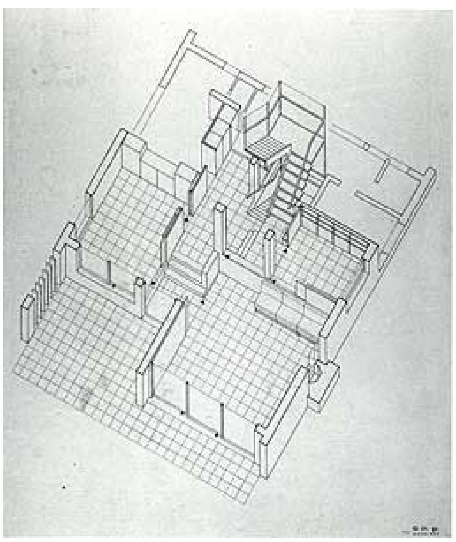
Name: Frey Haus

Author: Ernst Plischke

Location: Graz, Austria

Year: 1973

Photo's:



Large sliding screens open up or close down different parts of the building's ground floor, so that they can be used independently from each other or as one continuous space in order to meet changing requirements and circumstances. When open, each of the storey-high screens is contained within a fixed piece of wall, and, when closed, they always close against a wall or column.

Sources:

[http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=172 (accessed 2nd July 2013)]
Allison, P., 'Mobile elements in social housing in Austria', *ARCH+*, 134/135, 1996, pp. 104-05.

Time context: **1970s**

Typology: **MULTI-PURPOSE LAYOUT**

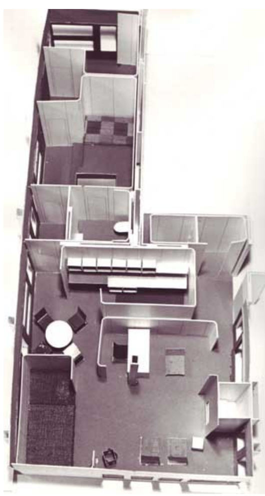
Name: Wohnhaus Kronsberger Straße

Author: Bernhard Binder and Stefan Polónyi

Location: Berlin, Germany

Year: 1969

Photo's:



This three storey apartment building in Berlin provides the capacity for change through its form of construction, which allows the expansion and contraction of individual dwellings within the same structure. The building is designed on a grid using a reinforced concrete frame. A central staircase divides the building into two halves, each of which is unobstructed apart from a few columns and a service duct. The size of one 'half' and design of the common hallway with its multiple doors allows each floor to have two, three or four differently sized apartments. The architects show a variety of possible layouts, testing their design for long-term flexibility. The plans indicate the spatial division into ten units, but the number of apartments could be as low as six or as high as twelve.
At a later stage, two adjoining units could be merged into one large unit (with one of the entrance doors blocked up) or a smaller unit could be enlarged by taking space off another, though the latter adaptation would depend on tenancies. The advantages in this form of flexibility lie not only in its potential to respond to its user's periodic changing requirements but also in the long-term adaptability offered by the dwelling within a changing market situation.

Sources:

[http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=45&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=4 (accessed 2nd July 2013)]
'Berlin, Kronberger Straße 10', *Bauwelt*, 1970.
Deilmann, H., J. C. Kirschenmann, and H. Pfeiffer, *Wohnungsbau. The Dwelling. L'habitat*. 3rd edn, Stuttgart: Karl Krämer Verlag, 1973.

Time context: **1970s**

Typology: **MICRO-LIVING "CAPSULE"**

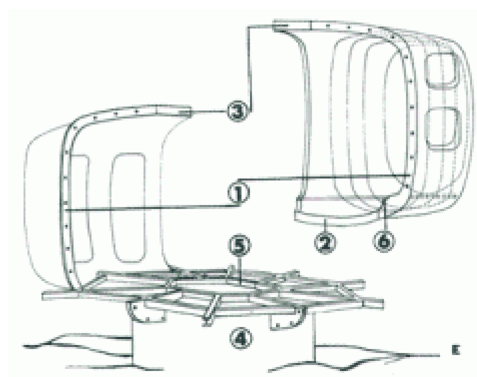
Name: Six Shell Bubble House

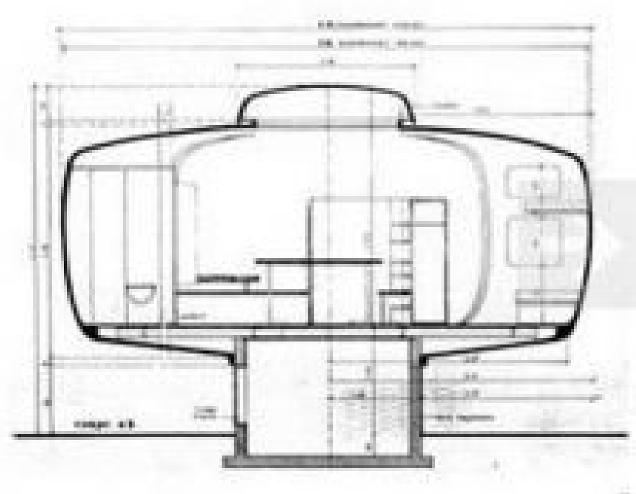
Author: Jean Maneval

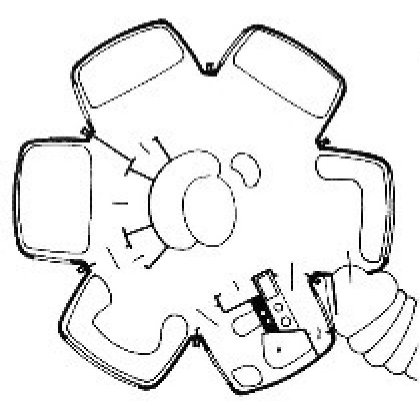
Location:

Year: 1968

Photo's:







Sources:
[http://www.socialdesignmagazine.com/en/site/architettura/jean-maneval-the-six-shell-bubble.html (accessed 13th June 2013)]
[http://davidszondy.com/future/Living/bubble.htm (accessed 13th June 2013)]

Case study no.8

Time context: **1970s**

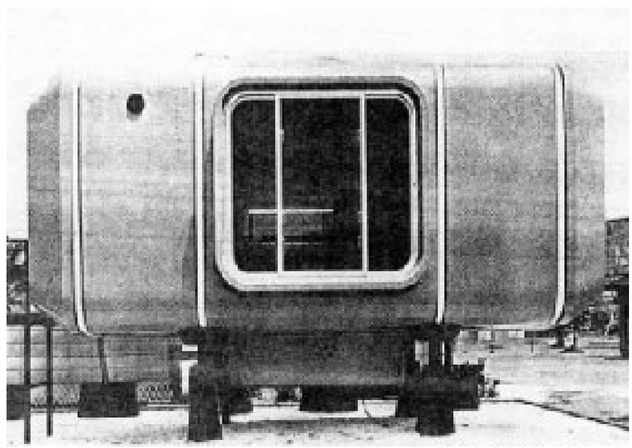
Typology: **MICRO-LIVING “CAPSULE”**

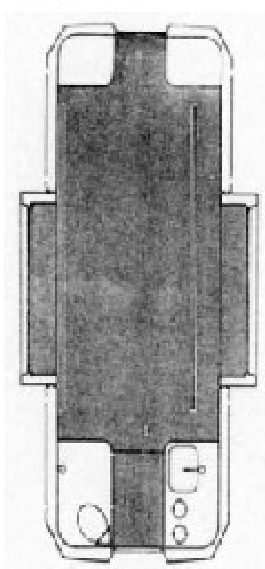
Name: Yadokari

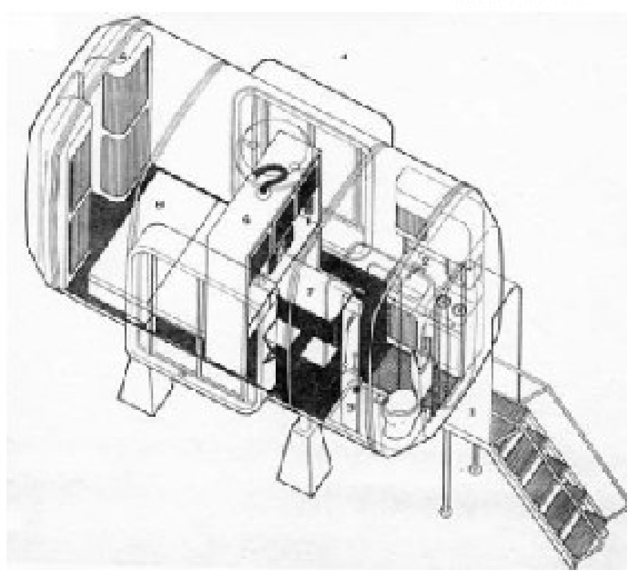
Author: Ekuan Kenji with GK Industrial Design Associates (which later became the GK Design Group)

Location:

Year: 1972







Sources:
[http://farm3.static.flickr.com/2757/4272473802_6e85378f26_o.jpg (accessed 10th June 2013)] and
“Abitazioni ed Aspetto Morfologico “ [http://www.b3b6b.it/_arredo0405/NuoviFile/Repertorio3.pdf (accessed 12th November 2013)]

Time context: **1970s**

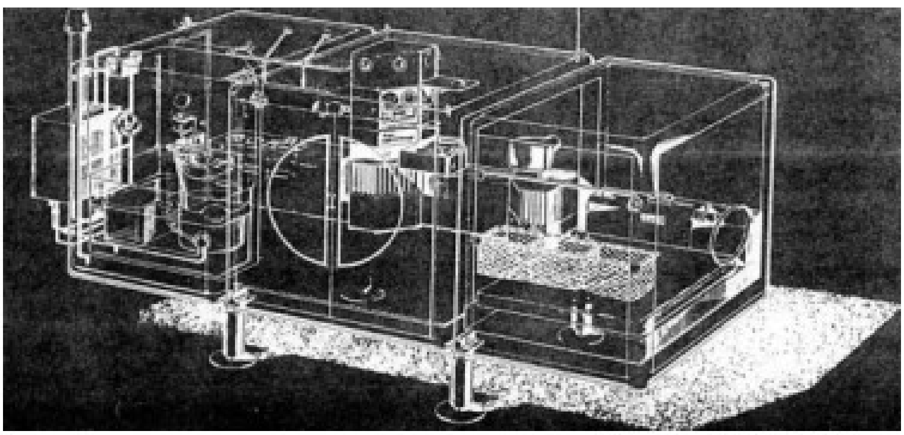
Typology: **MICRO-LIVING “CAPSULE”**

Name: Living Capsules

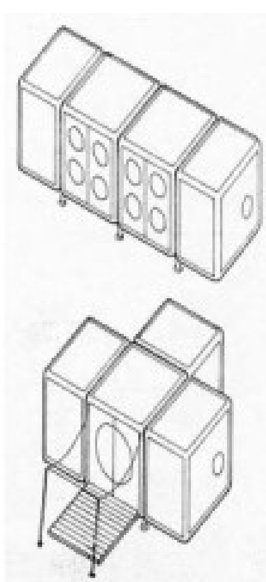
Author: Kisho N. Kurokawa

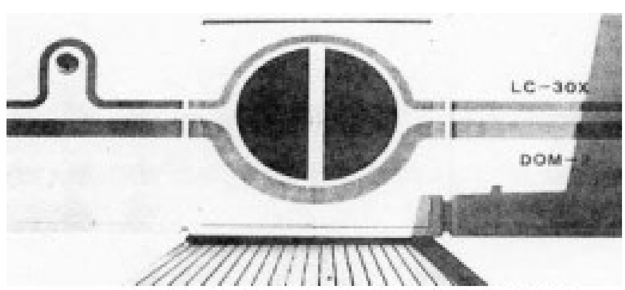
Location:

Year: 1972

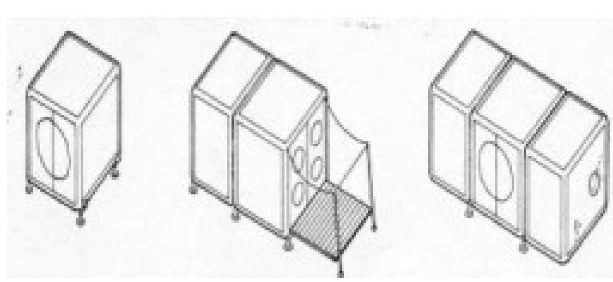


Spaccato assonometrico della struttura e degli impianti





Prospetto esterno dell'unità temporanea



Picture sources: “Abitazioni ed Aspetto Morfologico “ [http://www.b3b6b.it/_arredo0405/NuoviFile/Repertorio3.pdf (accessed 12th November 2013)]

Time context: **1970's**

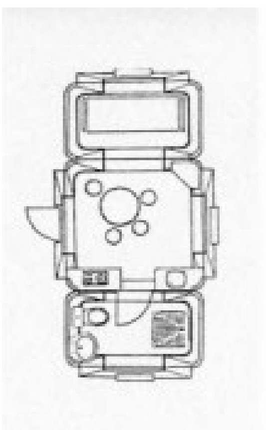
Typology: **MICRO-LIVING "CAPSULE"**

Name: Hexacube

Author: Georges Candilis, Anja Blomstedt

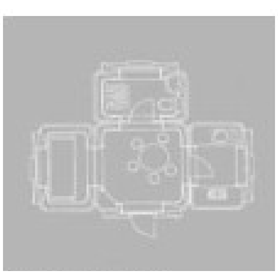
Location:

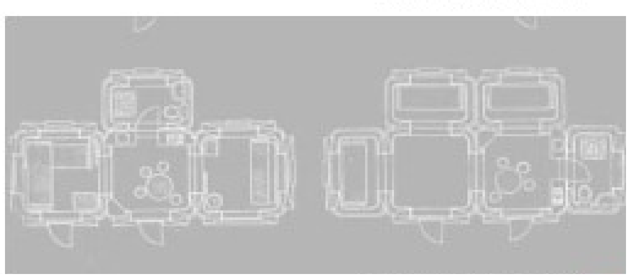
Year: 1974



Pianta di un modulo a tre vani

Immagine di un modulo assemblato





Picture sources:
"Abitazioni ed Aspetto Morfologico " [http://www.b3b6b.it/_arredo0405/NuoviFile/Repertorio3.pdf (accessed 12th November 2013)]
[http://archiwebture.citechaillot.fr/fonds/FRAPN02_CANGE/inventaire?cid=objet-14022 (accessed 12th November 2013)]

Time context: **1970s**

Typology: **MICRO-LIVING “CAPSULE”**

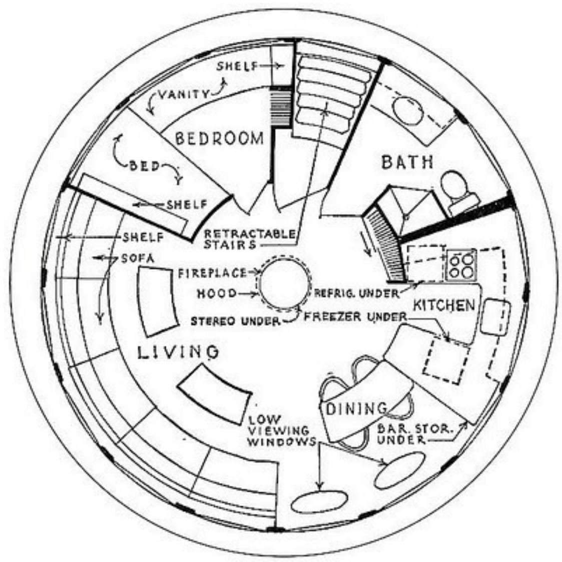
Name: Futuro

Author: Matti Suuronen

Location: Finland

Year: 1968/1978

Photo’s:



Sources:
[http://en.wikipedia.org/wiki/Futuro (accessed 2nd June 2013)]

Time context: **1970s**

Typology: **MICRO-LIVING “CAPSULE”**

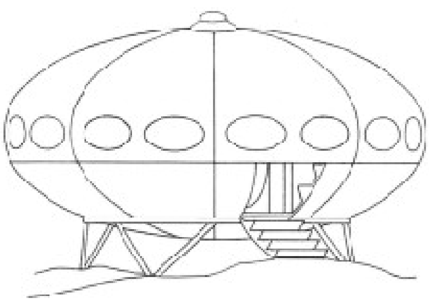
Name: Futuro

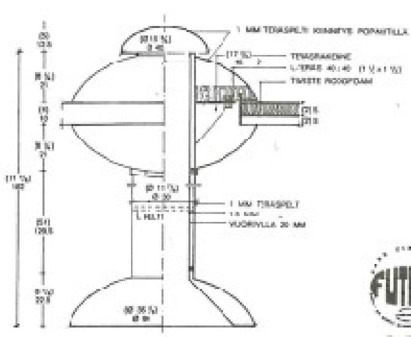
Author: Matti Suuronen

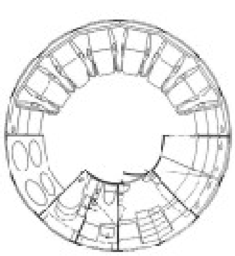
Location: Finland

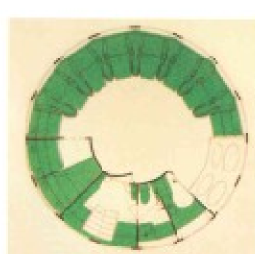
Year: 1968/1978

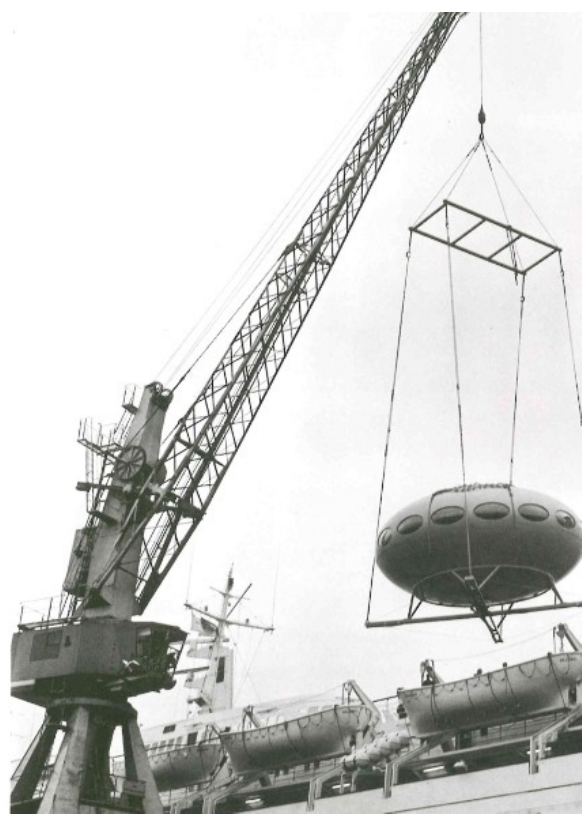
Photo’s:











Sources:
Bergdoll, Barry, Peter Christensen, and Ron Broadhurst. *Home delivery: fabricating the modern dwelling*. New York: Museum of Modern Art :, 2008.

Time context: **1970s**

Typology: **MICRO-LIVING "CAPSULE"**

Name: Venturo prefab

Author: Matti Suuronen

Location:

Year: 1972

Photo's:

Sources:
[http://hookedonhouses.net/2008/01/31/how-mod-the-venturo-modular-home/ (accessed 15th June 2013)]

Time context: **1970s**

Typology: **MICRO-LIVING "CAPSULE"**

Name: Nakagin Capsule Tower

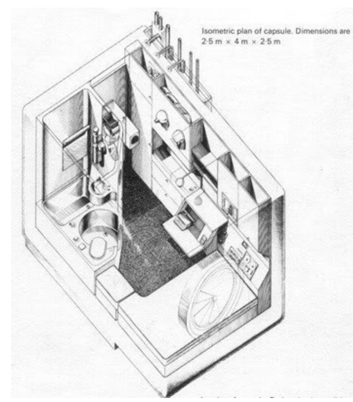
Author: Kisho Kurokawa

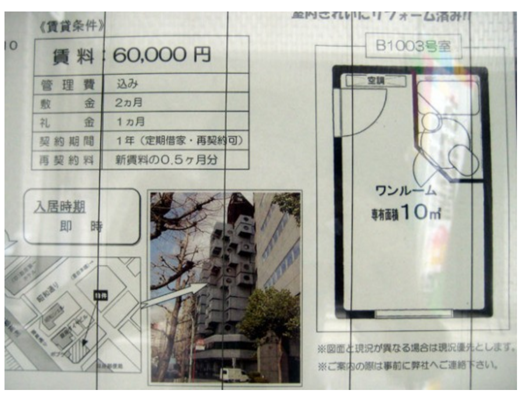
Location: Tokyo

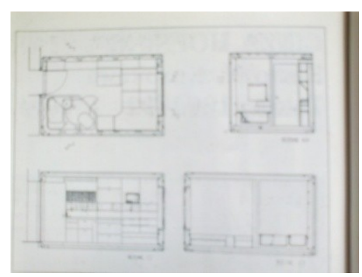
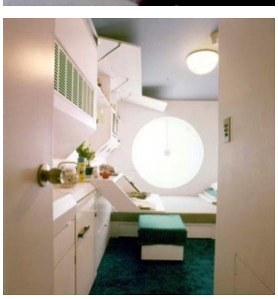
Year: 1972

Photo's:





Sources:
Ottolini, Gianni, and Vera Prizio. *La casa attrezzata: qualità dell'abitare e rapporti di integrazione fra arredamento e architettura*. Napoli: Liguori, 1993. p242
[http://en.wikipedia.org/wiki/Nakagin_Capsule_Tower (accessed 3rd July 2013)]

Time context: **1970s**

Typology: **MICRO-LIVING “CAPSULE”**

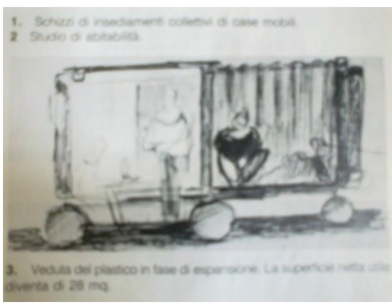
Name: Ambiente Mobile / Mobile House

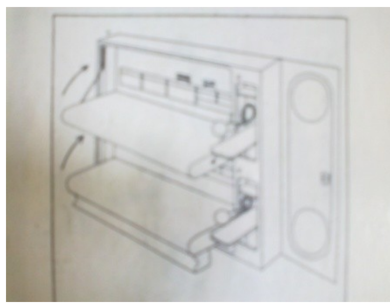
Author: Alberto Rosselli

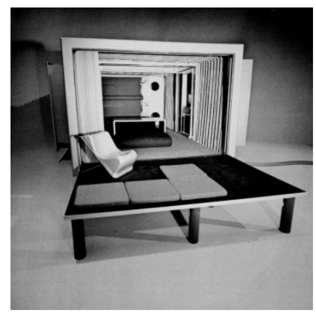
Location: Italy

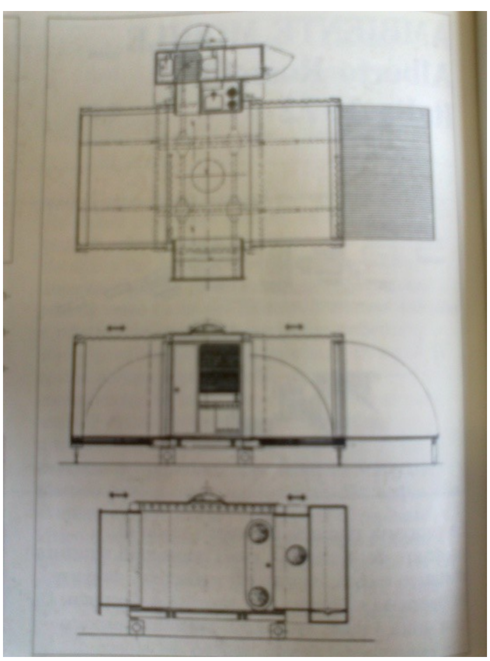
Year: 1972

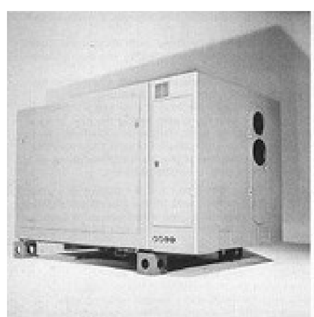
Photo’s:

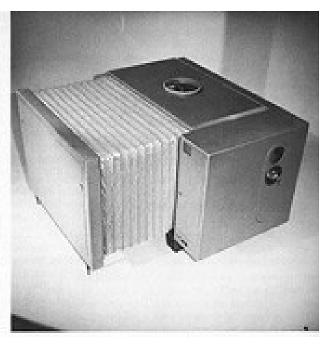


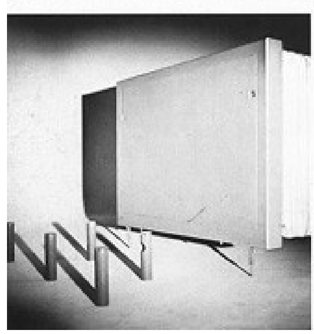


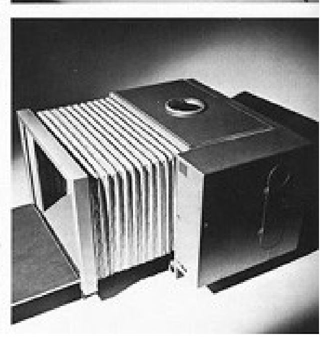












Sources:
Ottolini, Gianni, and Vera Prizio. *La casa attrezzata: qualità dell'abitare e rapporti di integrazione fra arredamento e architettura*. Napoli: Liguori, 1993. p245
[http://primary-yellow.tumblr.com/post/36350606592/1-mobile-house-alberto-rosselli-2-3-total (accessed 14th June 2013)]
[http://www.public.asu.edu/~pjwolf/ind317/NewDomesticLandscape/pages/Contestational05.htm (accessed 14th June 2013)]

Time context: **1970s**

Typology: **MICRO-LIVING “CAPSULE”**

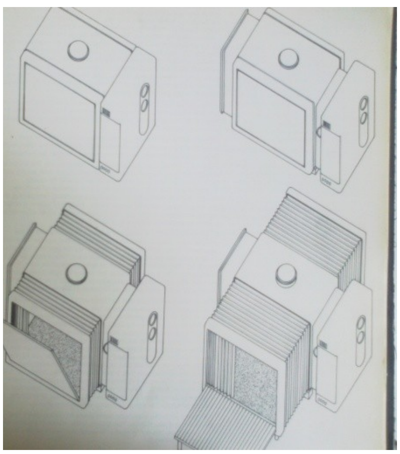
Name: Ambiente Mobile / Mobile House

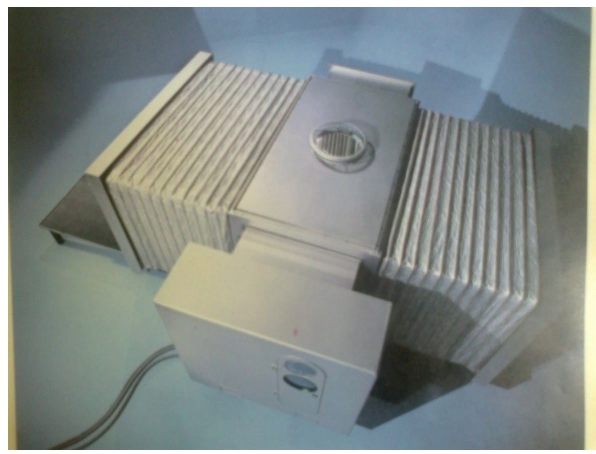
Author: Alberto Rosselli

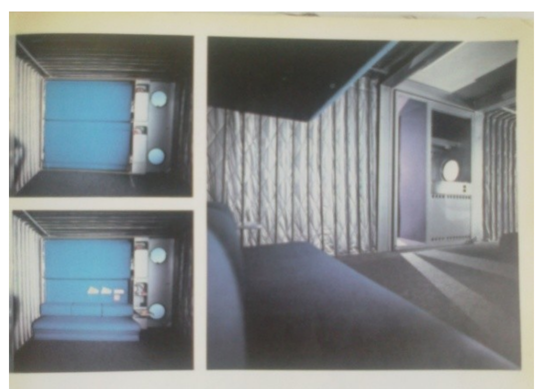
Location: Italy

Year: 1972

Photo’s:







Sources:

Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972. p181-189

Time context: **1970s**

Typology: **MICRO-LIVING "CAPSULE"**

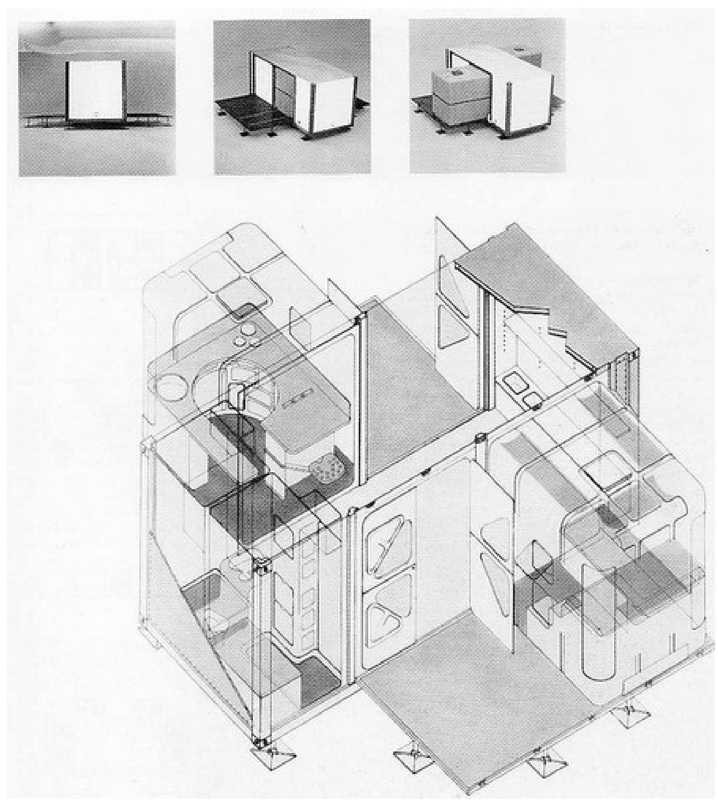
Name: Habitation Unit

Author: Marco Zanuso / Richard Sapper

Location: Italy

Year: 1971

Photo's:



Sources:
[http://www.flickr.com/photos/23605204@N04/3394210197/in/photostream (accessed 14th June 2013)]
Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972. p133.

Time context: **1970s**

Typology: **MICRO-LIVING "CAPSULE"**

Name: Habitation Unit

Author: Marco Zanuso / Richard Sapper

Location: Italy

Year: 1971

Photo's:

Sources:

Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972. p198

Time context: **1970s**

Typology: **MICRO-LIVING "CAPSULE"**

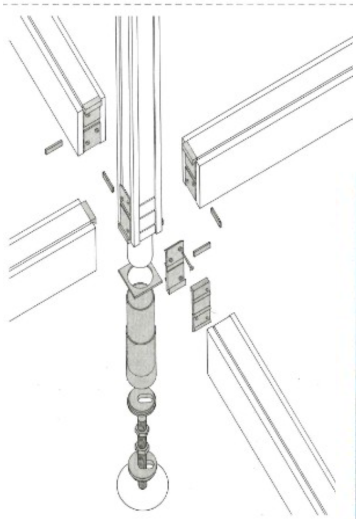
Name: Moduli 225

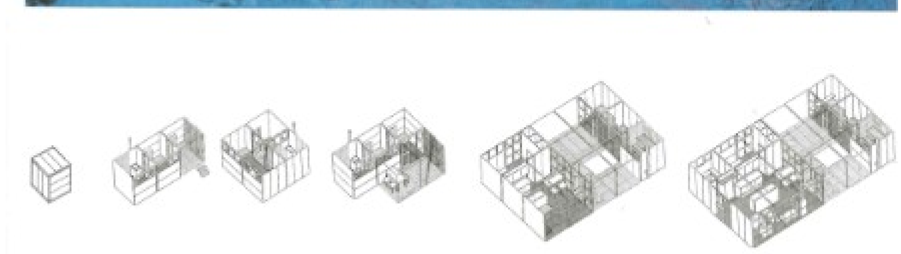
Author: Kristian Gullichsen and Juhani Pallasmaa

Location:

Year: 1969/1971

Photo's:





Sources:
Bergdoll, Barry, Peter Christensen, and Ron Broadhurst. *Home delivery: fabricating the modern dwelling*. New York: Museum of Modern Art :, 2008.

Time context: **1970s**

Typology: **MICRO-LIVING "CAPSULE"**

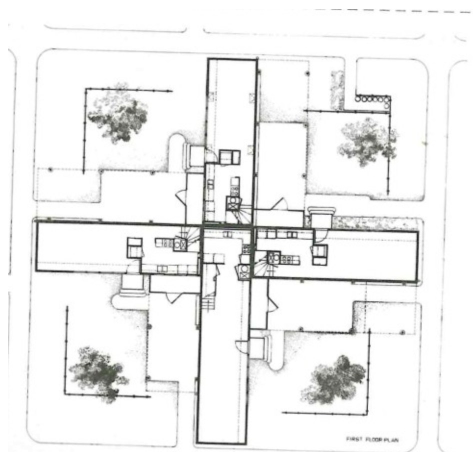
Name: Paul Rudolph

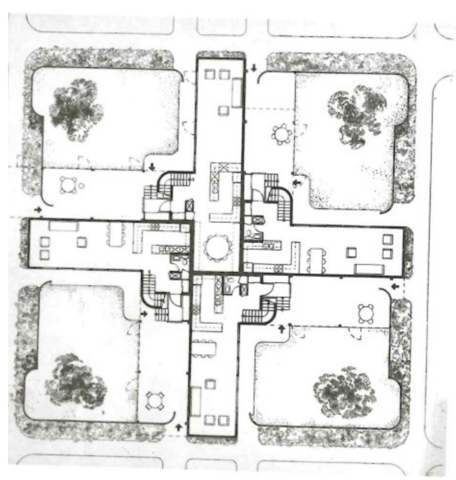
Author: Oriental Masonic Gardens

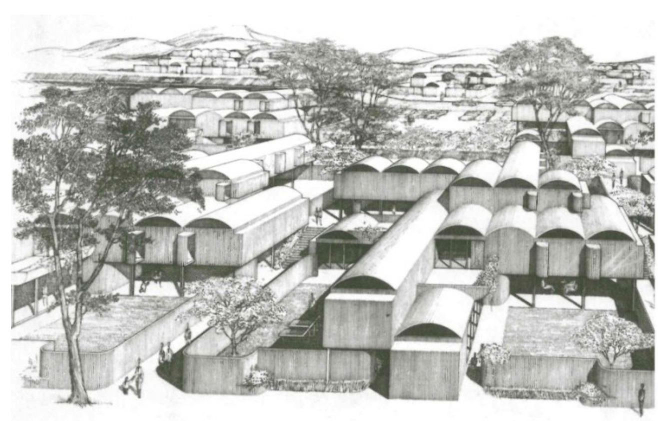
Location: USA

Year: 1970/1971

Photo's:







Sources:
Bergdoll, Barry, Peter Christensen, and Ron Broadhurst. *Home delivery: fabricating the modern dwelling*. New York: Museum of Modern Art :, 2008.

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

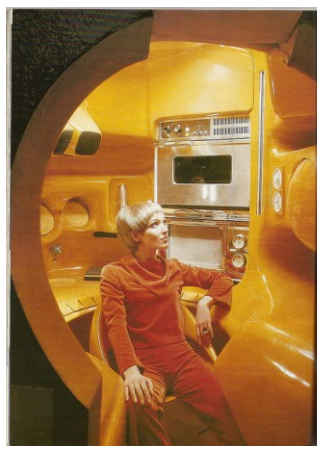
Name: "Kitchen Satellite "for PoggenPohl

Author: Luigi Colani

Location: Germany

Year: 1971

Photo's:



Sources:
[http://tkecnir.blogspot.it/2011/06/luigi-colanis-satellite-kitchen.html (accessed 10th June 2013)]

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

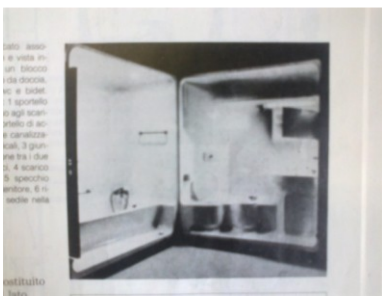
Name: Bathroom Unit

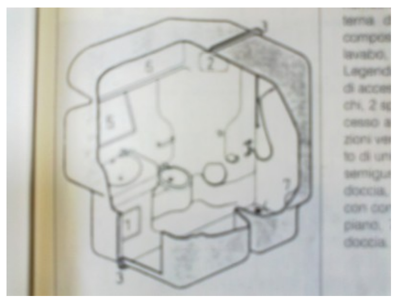
Author: Alberto Rosselli

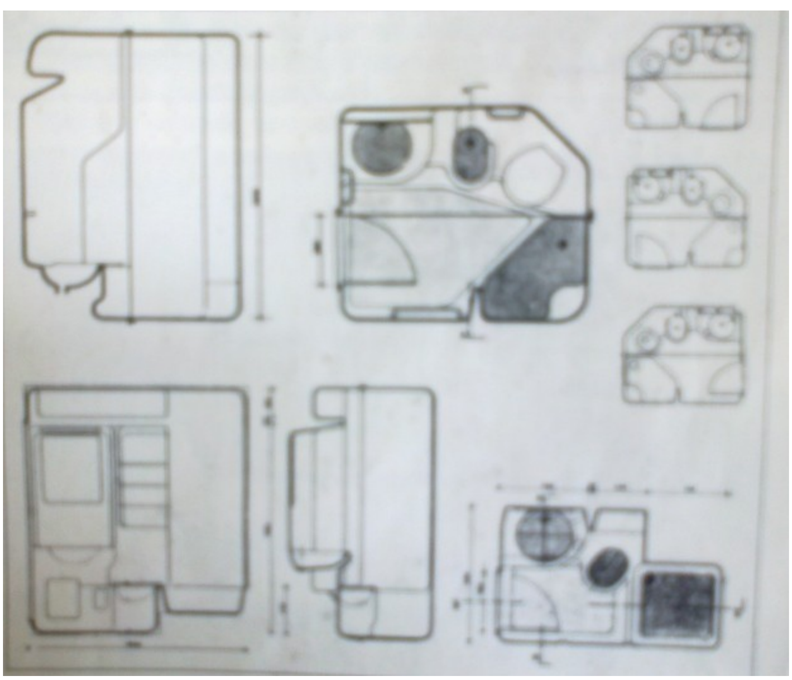
Location: Italy

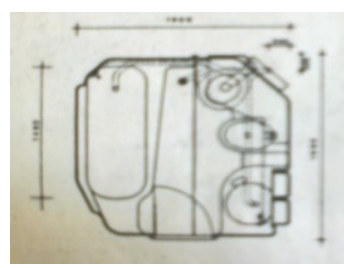
Year: 1972

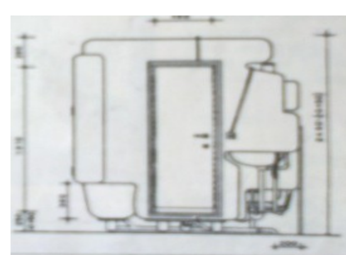
Photo's:











Sources:

Ottolini, Gianni, and Vera Prizio. *La casa attrezzata: qualità dell'abitare e rapporti di integrazione fra arredamento e architettura*. Napoli: Liguori, 1993. p251

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Abitacolo ("Cockpit") habitable structure

Author: Bruno Munari

Location: Italy

Year: 1971

Photo's:

Sources:

[http://atcasa.corriere.it/Design-e-architettura/Oggetti/2009/04/03/convivenza_opposti_12.shtml#articolo (accessed 12th July 2013)]

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Tuttuno (“All-in-one”)single bed unit with bed, table, sofa, drawers, and shelves.

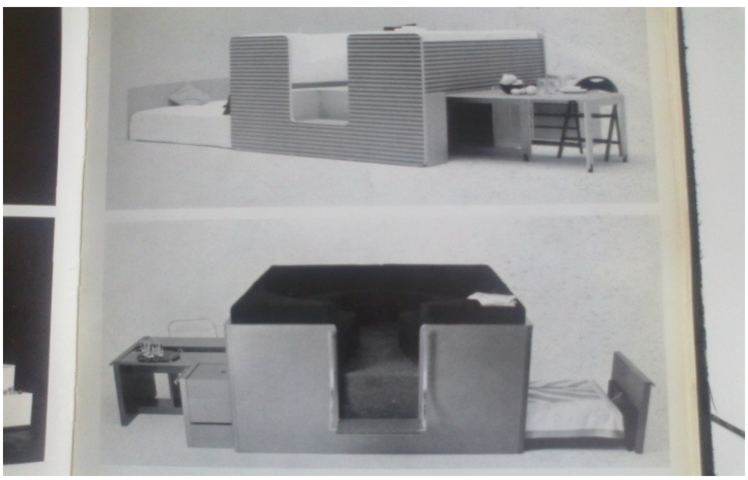
Author: Internotredici (Carlo Bimbi, Gianni Ferrara, Nilo Gioacchini)

Location: Italy

Year: 1969 (1971)

First hand case study

Photo’s:



Sources:
-Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972. p133.
-Personal archive

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Tavoletto

Author: Alberto Salvati and Ambrogio Tresoldi

Location: Italy

Year: 1967 (1969)

Sources:
[http://www.von-zezschwitz.de/detail.php?restanten=1&chapter=4&objectid=12140&refBack=adx&id=23&language=englisch&action=language (accessed 12th November 2013)]

H. Wichmann, Italien: Design 1945 bis heute, Basel 1988, S. 366 u. 370, Kurzbiographien; G. Albera, N. Monti, Italian Modern, New York 1989, S. 90, 'Mianmina'-Stuhl.

Time context: **1970s**

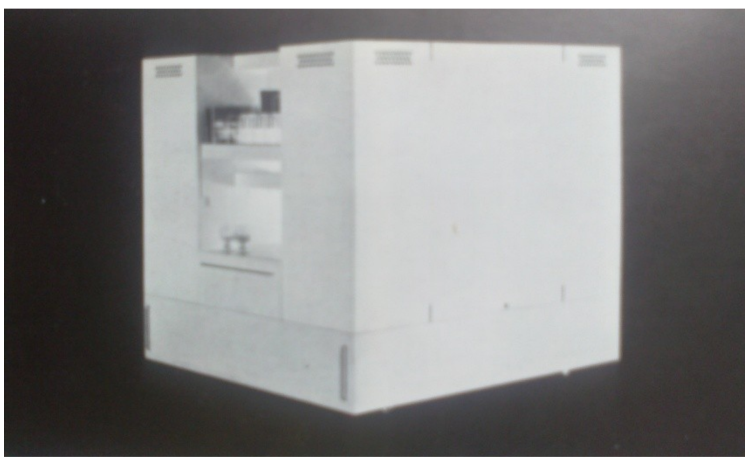
Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Central Block

Author: Alberto Seassaro

Location: Italy

Year: 1968 (1970)



Sources:
Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972. p132

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

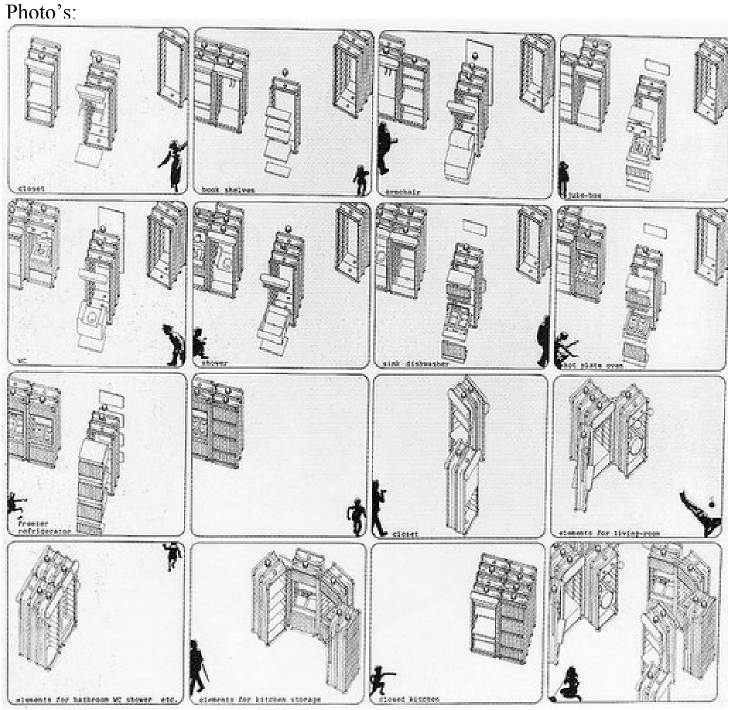
Name: Furnishing Concept

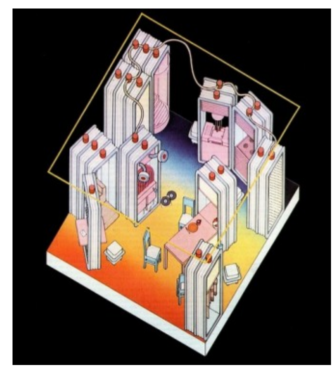
Author: Ettore Sottsass

Location: Italy

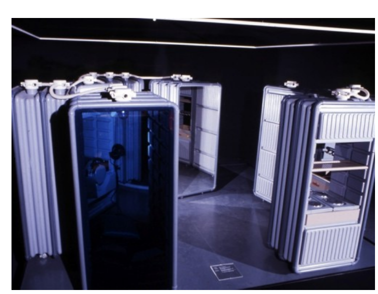
Year: 1972

Photo's:





The basic unit of this environment is a movable closet, a kind of shell on wheels, coloured a natural grey. By the type of its infill this shell, or its multiples, become responsive to the uses it serves, such as kitchen, seat, jukebox, shower, toilet, shelf, closet, etc. By the manner in which these various units are hinged together, or wheeled to new positions, an infinite variety of groupings and spaces may be formed. Acording to this vision, the elements of furniture lose their traditional forms to adopt only one, that of a movable volume. The traditional areas of the house (kitchen, living room, etc) lose their meaning. The space of the house, thus freed, will adopt the changing configurations given by the free arrangement of the modular units. Hierarchies of the house are broken, traditional roles become meaningless. A member of the household, sitting inside seat-closet, looks through the blue-glass wall of the other side of the domestic space which thus becomes transformed into an "exterior landscape".



Sources:

[http://www.interiordesign.net/blog/Cindy_s_Salon/35295-A_Meditation_on_Italian_Modernism.php (accessed 10th June 2013)]

Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972. p133.

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

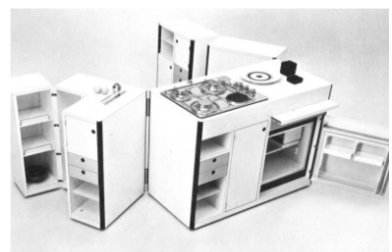
Name: Spazio vivo

Author: Virgilio Forchiassin

Location: Italy

Year: 1968

Photo's:



Sources:
[http://www.paginearredo.it/companynews/a-piu-di-4-anni-di-distanza-la-cucina-spazio-vivo-e-stata-ri-esposta-al-moma-di-new-york-per-le-sue-innovative-soluzioni-stilistiche (accessed 10th June 2013)]
[http://www.moma.org/collection/object.php?object_id=3541 (accessed 10th June 2013)]

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Total Furniture Unit

Author: Joe Colombo

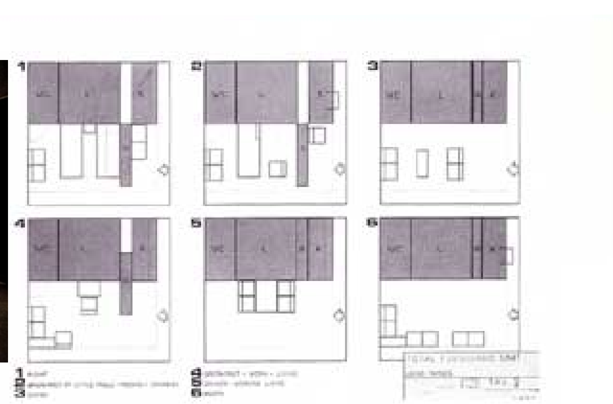
Location: Italy

Year: 1972


General notes. In the late 1960's Joe Colombo starts to work on more experimental ideas. The main interest was based on organization of living environment in terms of creating compact functional forms which mutual combinations or transformations could support different living contexts.

Methods of flexibility. Total Furnishing Unit was example of capsule-like plastic-made structure which contained various "functional stations" like "central unit" (dedicated for daily activities), "night unit" (contained sleeping arrangement), "bathroom unit", "cupboard" and "kitchen box" which could be transformed also to dining area.

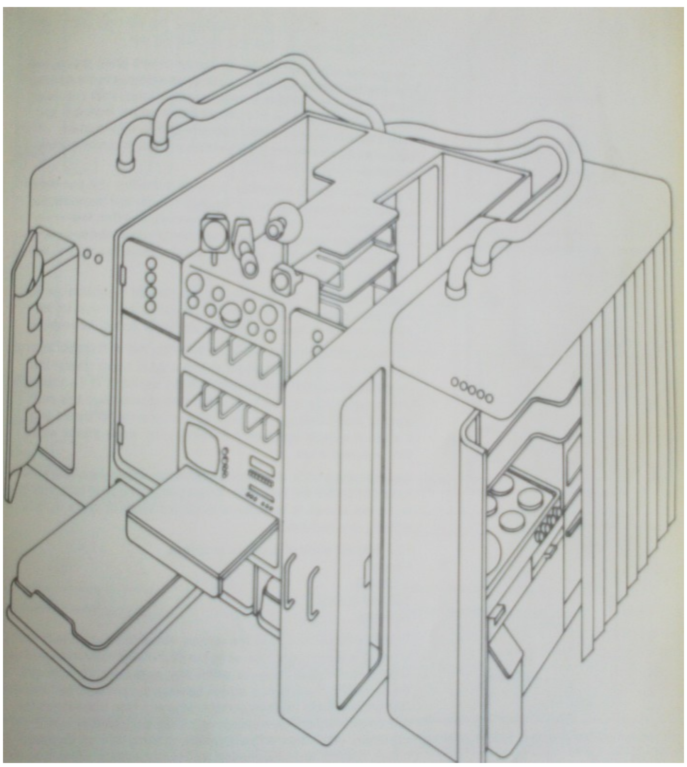


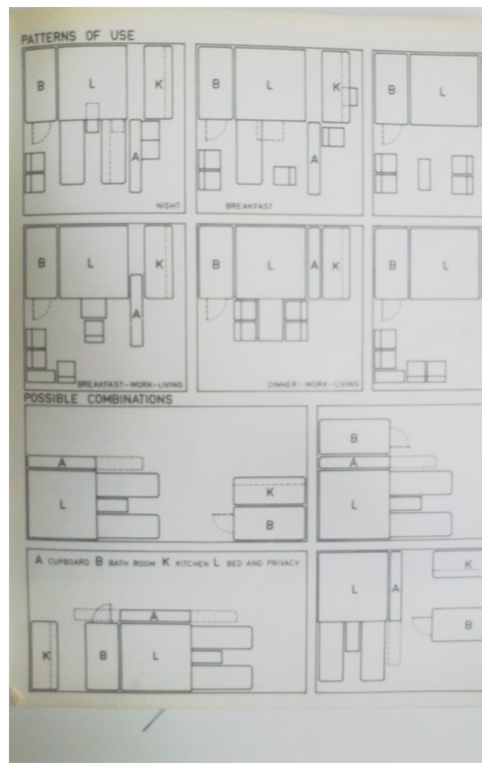


Sources:
[http://www.design-design.it/en/2011/11/07/joe-colombo-un-icona-del-design-italiano/ (accessed 10th June 2013)]
[http://primary-yellow.tumblr.com/post/36350606592/1-mobile-house-alberto-rosselli-2-3-total (accessed 14th June 2013)]
[http://1011etsamunidadruizcabrerop6.blogspot.it/2011/02/1971-joe-colombo.html (accessed 14th June 2013)]

Time context:	**1970s**
Typology:	**FURNITURE UNIT / COMPONENT / MODULE**
Name:	Total Furniture Unit
Author:	Joe Colombo
Location:	Italy
Year:	1972

Photo's:





Sources:

Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972, p171

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

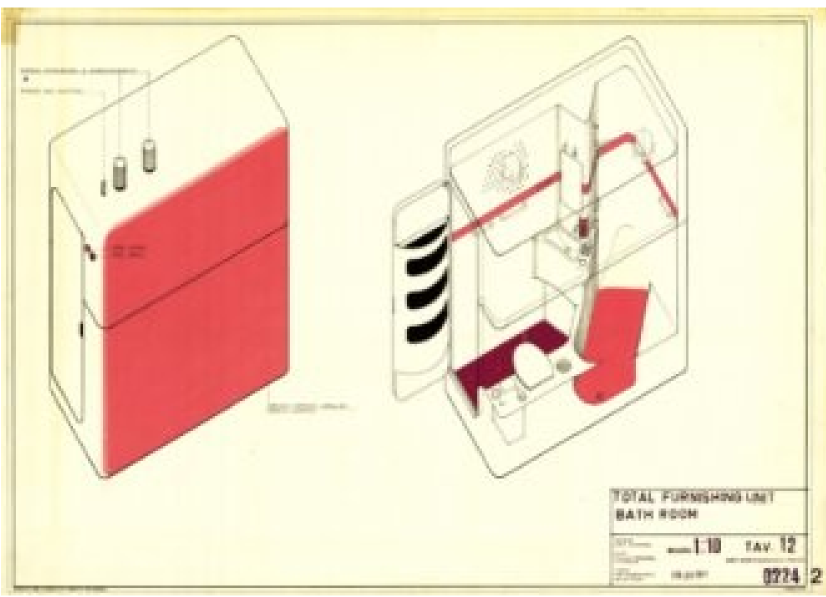
Name: Total Furniture Unit - bathroom

Author: Joe Colombo

Location: Italy

Year: 1972

Photo's:



Sources:
[http://www.ymag.it/schede.asp?id=9186 (accessed 14th June 2013)]
[http://www.goodreads.com/author_blog_posts/3351161-wolf-and-tender-prey-present-brave-new-world (accessed 10th July 2013)]
[http://www.objectplastic.com/2010/01/moma-mia-thats-some-show-rita-reif-new.html (accessed 10th July 2013)]

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Loft Bed in Hopkins house

Author: High-Tech

Location: UK

Year: 1970s

Photo's:

Sources:
[http://radio-weblogs.com/0119080/stories/2003/03/11/galleryUrbanNomadics.html (accessed 15th June 2013)]

Time context: **1970's**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

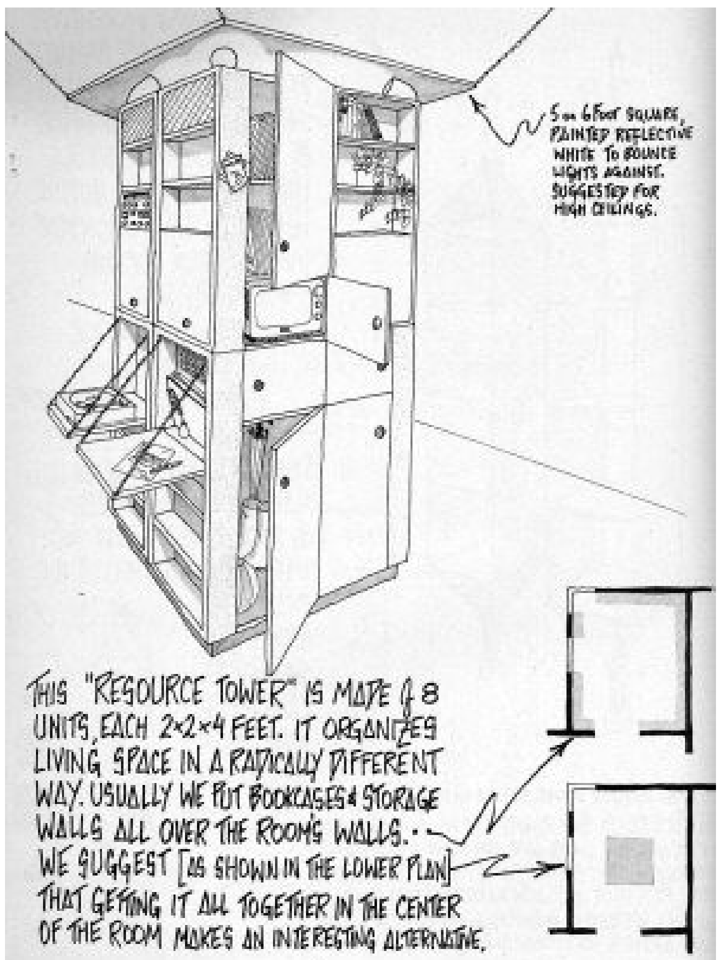
Name: Resource Tower

Author: Hennessy & Papanek, Urban Nomads movement

Location:

Year: 1970's

Photo's:



Sources:
[http://greg.org/2006/06/urban_nomads_21st_centurystyle.html (accessed 15th June 2013)]

Time context: **1970's**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

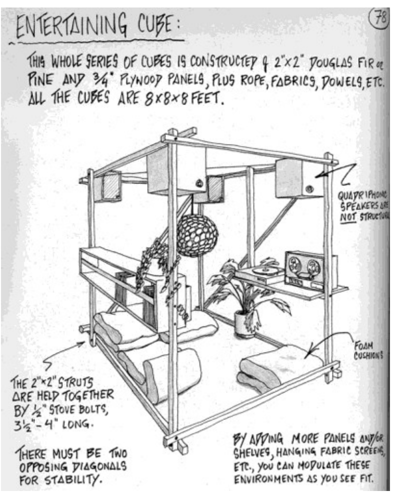
Name: Living Cubes

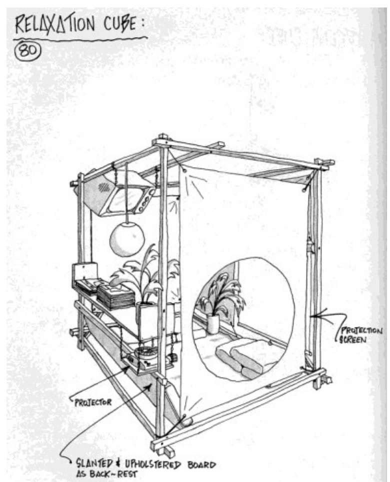
Author: Hennessy & Papanek, Urban Nomads movement

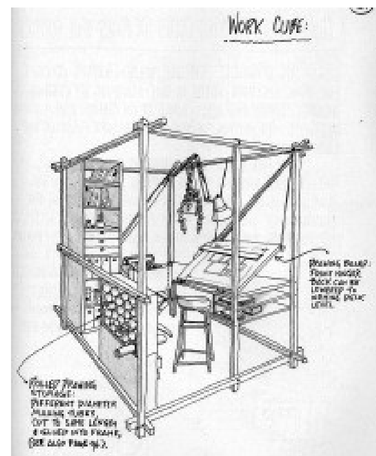
Location:

Year: 1970's

Photo's:







Sources:
[http://greg.org/2006/06/urban_nomads_21st_centurystyle.html (accessed 15th June 2013)]

Time context: **1970's**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

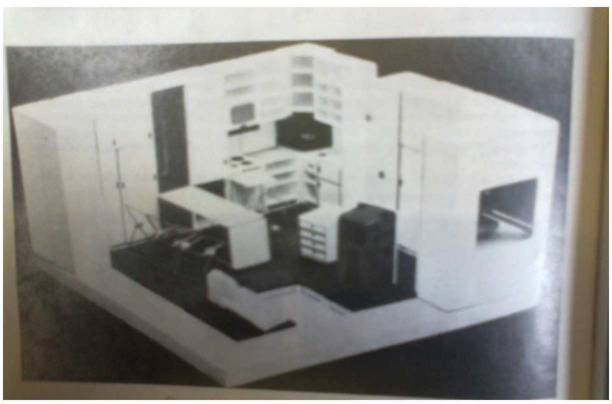
Name: Modular systems

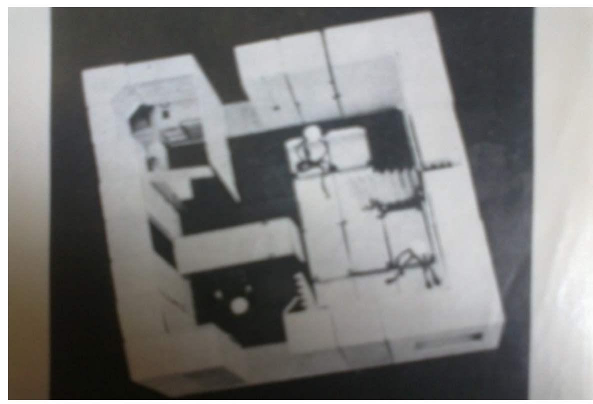
Author: Giannantonio Mari

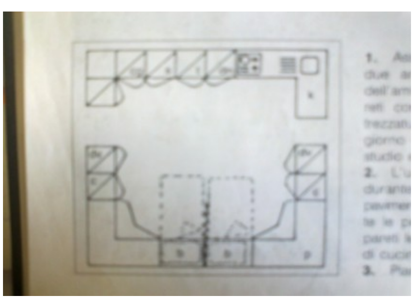
Location: Italy

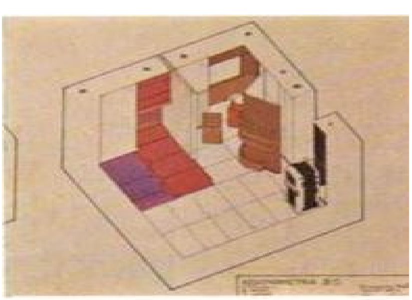
Year: 1972

Photo's:









Sources:
Ottolini, Gianni, and Vera Prizio. *La casa attrezzata: qualità dell'abitare e rapporti di integrazione fra arredamento e architettura*. Napoli: Liguori, 1993. p248

Time context: **1970's**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

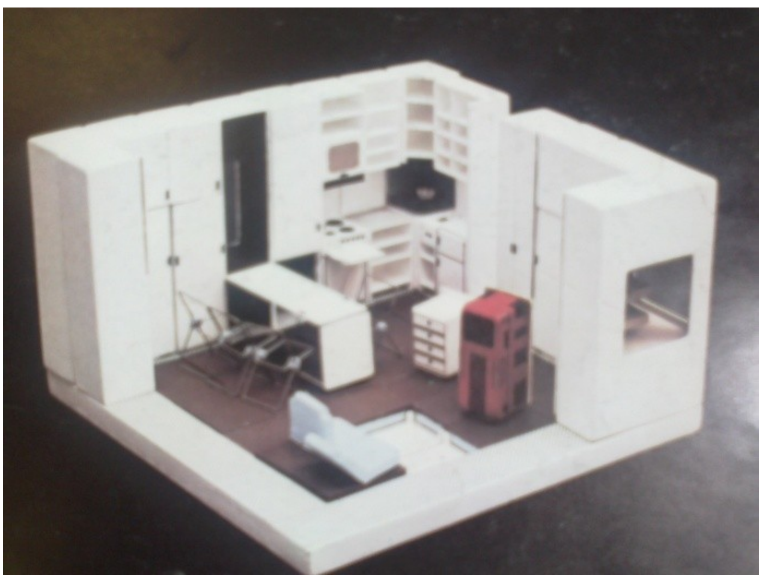
Name: Modular systems

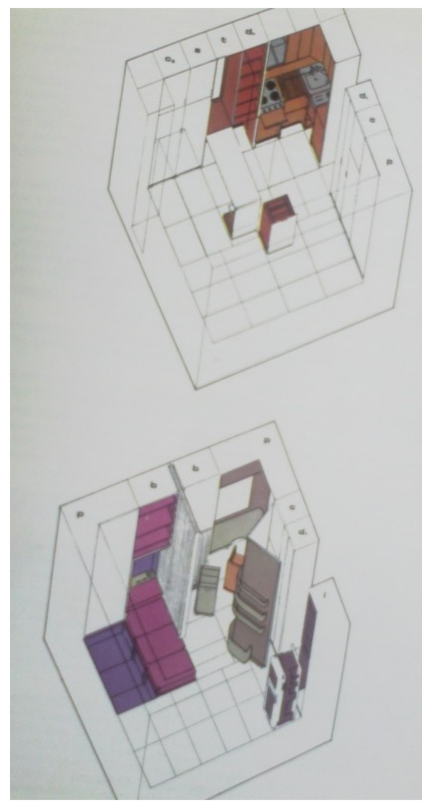
Author: Giannantonio Mari

Location: Italy

Year: 1972

Photo's:





Sources:
Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972, p269-276

Time context: **1970's**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Multi Chair

Author: Joe Colombo

Location: Italy

Year: 1971

Photo's:

Sourceshttp://www.design-design.it/en/2011/11/07/joe-colombo-un-icona-del-design-italiano/ (accessed 10th October 2013)]

Time context: **1970's**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Recliners

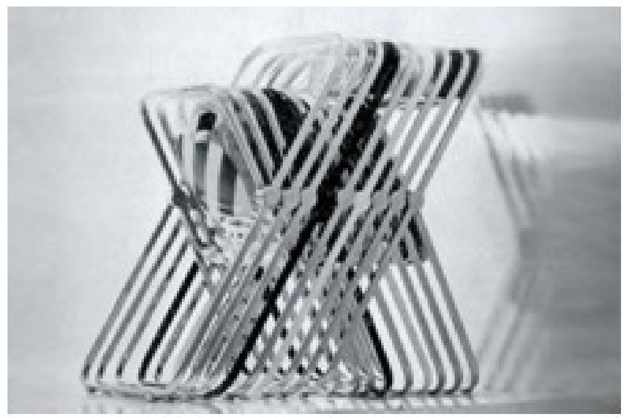
Author: Joe Colombo

Location: Italy

Year: 1971

Sources
[http://www.design-design.it/en/2011/11/07/joe-colombo-un-icona-del-design-italiano/: (accessed 2nd November 2013)]
[http://www.designboom.com/history/joecolombo_recliner.html (accessed 2nd November 2013)]

Time context:	**1970's**
Typology:	**FURNITURE UNIT / COMPONENT / MODULE**
Name:	Plia, folding and stacking chair
Author:	Giancarlo Piretti
Location:	Italy
Year:	1969



General notes.

Designed in 1968; production since 1969 till nowadays; manufacturer Anonima Castelli s.p.a., Ozzano near Bologna; chair size 75 x 47 x 50,5 (when opened) with the seat height 45,5 cm; material: polished die-cast aluminium, oval tubular steel, plastic.

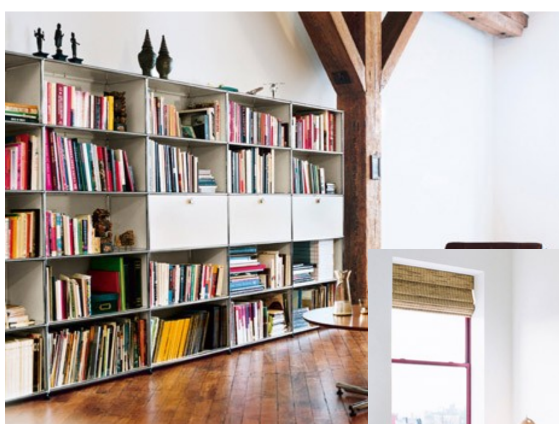
Methods of flexibility.

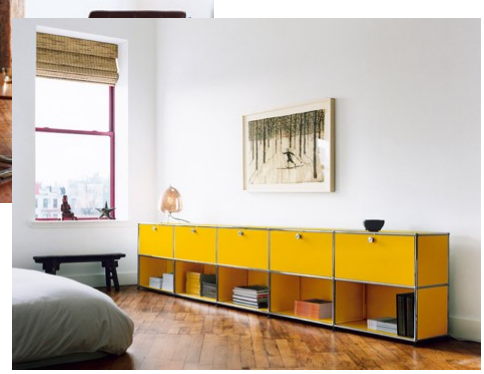
"Lightness, flexibility, and technical precision are the obvious advantages of this design by Giancarlo Piretti. The folding mechanism of the chair was completely novel in its day. The chair rests on a joint made of three metal disks which connect the back, legs, and seat in such a way that they can be folded up into a flat compact form barely five centimeters thick. The elegant chair, which is also suitable for outdoor use, has clear rounded forms, an oval-insection tubular steel frame, and transparent plastic surfaces. When folded up, it can be hung on a wall hook made especially for this purpose, but can also be stacked when folded out."[1] The same methodology is applied also on other models like Plona chair, Pluff stool, Platone desk, Planta coat rack and Pluvium umbrella stand.

[1] "Plia - Giancarlo Piretti - Vitra Design Museum." Informationen - Vitra Design Museum. [http://www.design-museum.de/en/collection/100-masterpieces/detailseiten/plia-giancarlo-piretti.html (accessed October 18, 2013)].

Picture source:
"Plia - Giancarlo Piretti - Vitra Design Museum." Informationen - Vitra Design Museum. [http://www.design-museum.de/en/collection/100-masterpieces/detailseiten/plia-giancarlo-piretti.html (accessed October 18, 2013)].

Time context:	**1970's**
Typology:	**FURNITURE UNIT / COMPONENT / MODULE**
Name:	USM Haller modular system
Author:	Fritz Haller
Location:	Switzerland
Year:	1963/1969





Sources:
USM Modular Furniture [www.usm.com (accessed 1st November 2013)]

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

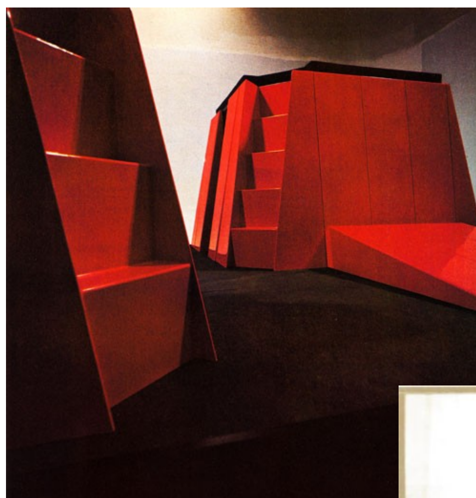
Name: House Environment

Author: Gae Aulenti

Location: Italy

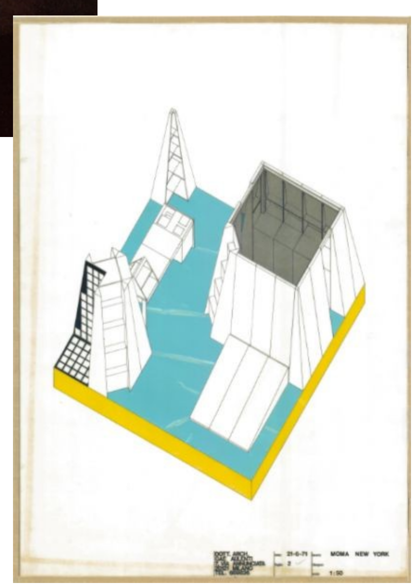
Year: 1972

Photo's:



"system of 3 different elements, of which one is linear and two are angular. By arranging them differently, they can create areas with the following uses: bed, cupboard, bookcase, shelves, seats."

Source:
Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972, p153



This environment is made up of four types of shelf components: The first consists of one planar and two corner elements. In combination they may be manipulated to form a bed, cupboards, either linear or centrally oriented bookcases, inclined seats, etc. In the arrangement illustrated a number of these elements combine to form externally and internally oriented storage units, a small enclosure whose roof is used as a bed, and an inclined plane to rest on. The second, third and forth types of components of this environment are: an extensible table with modular service units, including a sink and two electric burners; a chair with legs and edges corrugated; and a lamp with eight rotating heads. It is in the nature of this design that any combination assumes a volumetric, architectonic quality. In this way the elements of furniture are treated as buildings and the domestic landscape is handled as exterior space.

Sources:

[http://www.moma.org/learn/resources/press_archives/1970s/1972/2 (accessed 10th June 2013)]

Time context: **1970s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

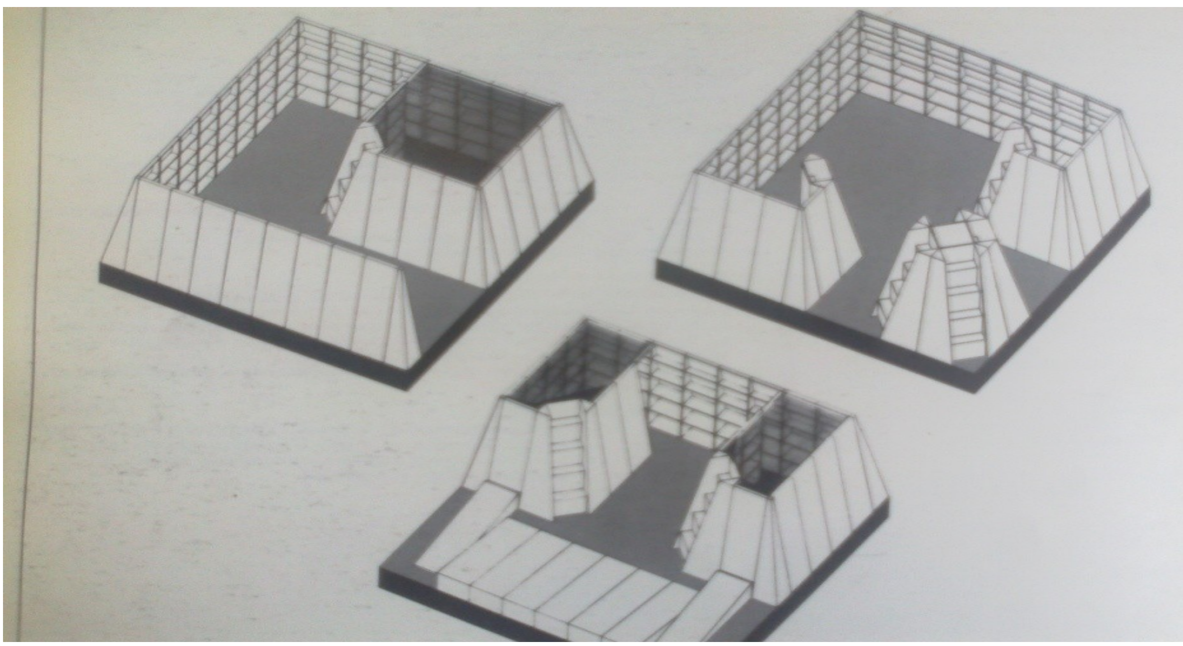
Name: House Environment

Author: Gae Aulenti

Location: Italy

Year: 1972

Photo's:



Sources:

Ambasz, Emilio. *Italy: the new domestic landscape; achievements and problems of Italian design.*. New York: Distributed by New York Graphic Society, Greenwich, Conn., 1972, p154
[http://www.aisdesign.org/aisd/wp-content/uploads/2014/04/AISDSR.03.Scodeller.fig_.3_web.jpg (accessed 20th July 2014)]

Time context: **1980s**

Typology: **MICRO-LIVING “CAPSULE”**

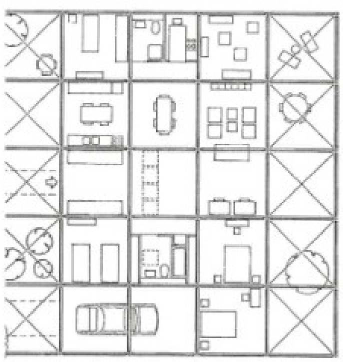
Name: Yacht House

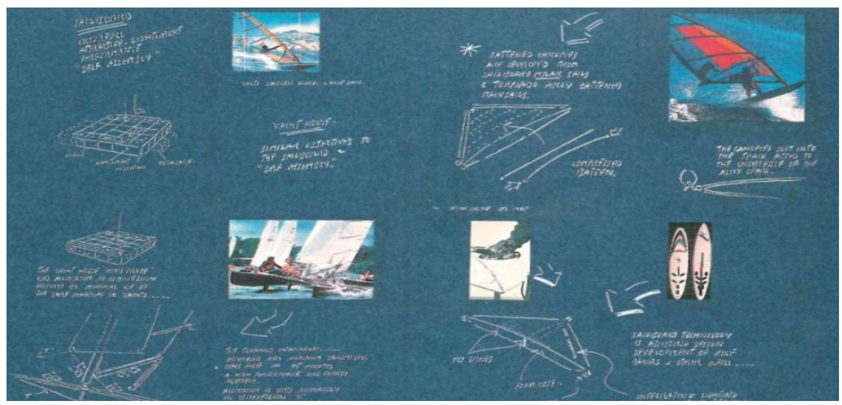
Author: Richard Horden / Horden Cherry Lee Architects

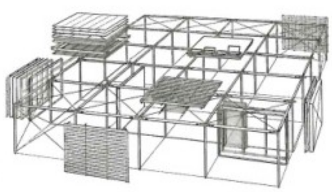
Location: UK

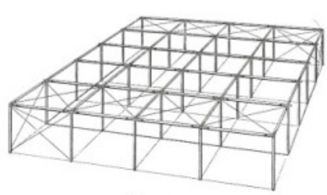
Year: 1983

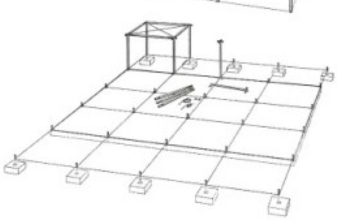
Photo’s:

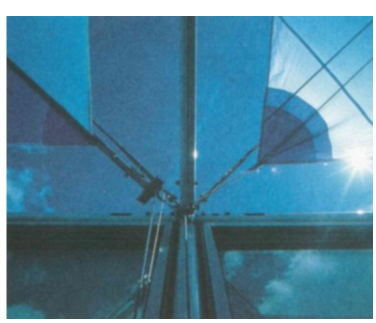


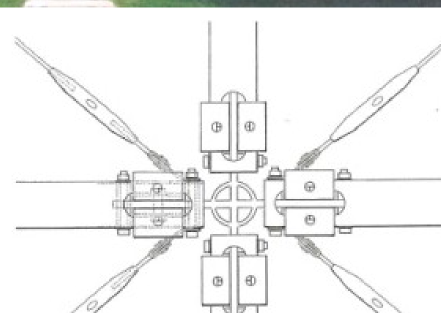












Sources:

Bergdoll, Barry, Peter Christensen, and Ron Broadhurst. *Home delivery: fabricating the modern dwelling*. New York: Museum of Modern Art :, 2008.

Time context: **1980s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Bed/sitting rooms for an Artist in Residence

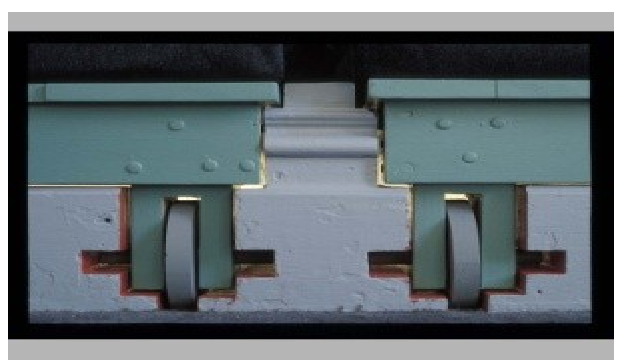
Author: Allan Wexler

Location: Pittsburgh

Year: 1988

Photo's:



Allan Wexler, "Bed/sitting rooms for an Artist in Residence", 1988, Mattress Factory Art museum, Pittsburgh, 1988. "Bed/Sitting Rooms consists of two rooms that function in a variety of ways. For one artist who wants a sitting area in one room and a single bed in the other. A couple who want a sitting area in one room and a double bed in the other. Two people who each want privacy with a single bed and chair in each room. A person who needs an empty room for work and a bedroom. The wall dividing the two rooms has a series of openings through which the furniture components can partially or fully pass through. These transformations are decided upon by the occupant and completed in seconds. The rooms can be redesigned many times a day. Two beds on wheels roll through the dividing wall. Two light bulbs rotate through the wall and can be used in either space. Sofa arms slide through the wall. The sofa's back cushions and the night table swivel."

Sources: [http://www.allanwexlerstudio.com/projects/bed-sitting-room-artist-residence (accessed April 20th, 2013)]

Time context: **1990s**

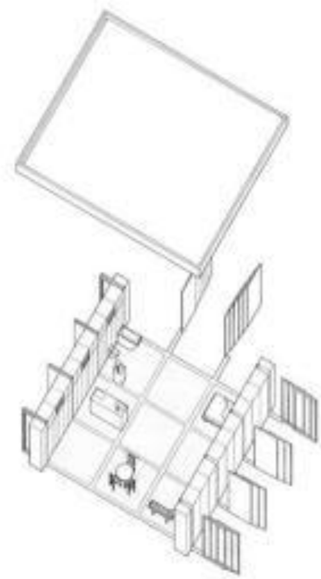
Typology: **MULTI-PURPOSE LAYOUT**

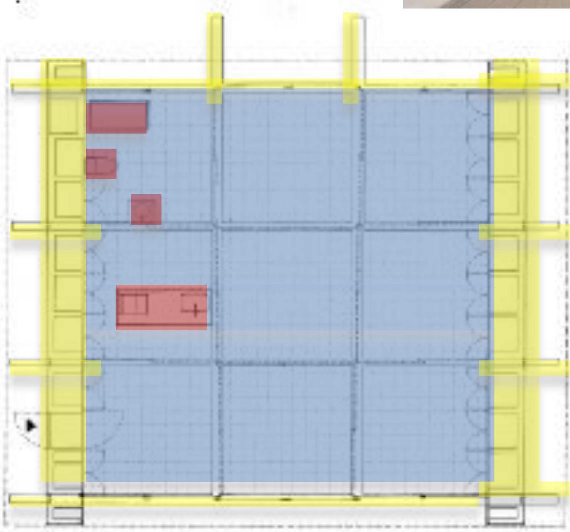
Name: Nine-Square Grid House

Author: Shigeru Ban Architects

Location: Japan

Year: 1997





General notes

“The furniture units of the "furniture house" were made of steel studs. That system can be improved upon, however. For example, it makes possible a simpler and less noisy assembly process on site, avoids condensation by adding urethane-foam insulation during production process, and eliminates annoying vibration.

Area for applying flexible concepts

Immobile units

Variable dividing elements

Methods of flexibility.

The spatial composition combines the systems of two walls and a Universal Floor. A large square floor space, 10.4 meters to a side, can be partitioned by full-height sliding doors into nine square areas. These sliding doors allow a variety of spatial arrangements, adjustable to accommodate seasonal or functional needs.”[1]

[1] “Nine-square Grid House”. http://www.shigerubanarchitects.com/works/1997_nine-square-grid-house/ (accessed 12th October 2013)

Picture sources:
“Nine-square Grid House”. [http://www.shigerubanarchitects.com/works/1997_nine-square-grid-house/ (accessed 12th October 2013)]

Time context: **1990s**

Typology: **MICRO-LIVING “CAPSULE”**

Name: Master and Slave Unit mobile home

Author: Joep Van Lieshout

Location: Otterlo, The Netherlands

Year: 1995/96

Information Stand, Alborg, 1996

Mobile Home per Kroeller Muller, 1995

Picture sources:
“Abitazioni ed Aspetto Morfologico “ [http://www.b3b6b.it/_arredo0405/NuoviFile/Repertorio3.pdf (accessed 12th November 2013)]
Pople, Nicolas. *Experimental houses*. New York: Watson-Guptill Publications, 2000.

Time context: **1990s**

Typology: **MICRO-LIVING “CAPSULE”**

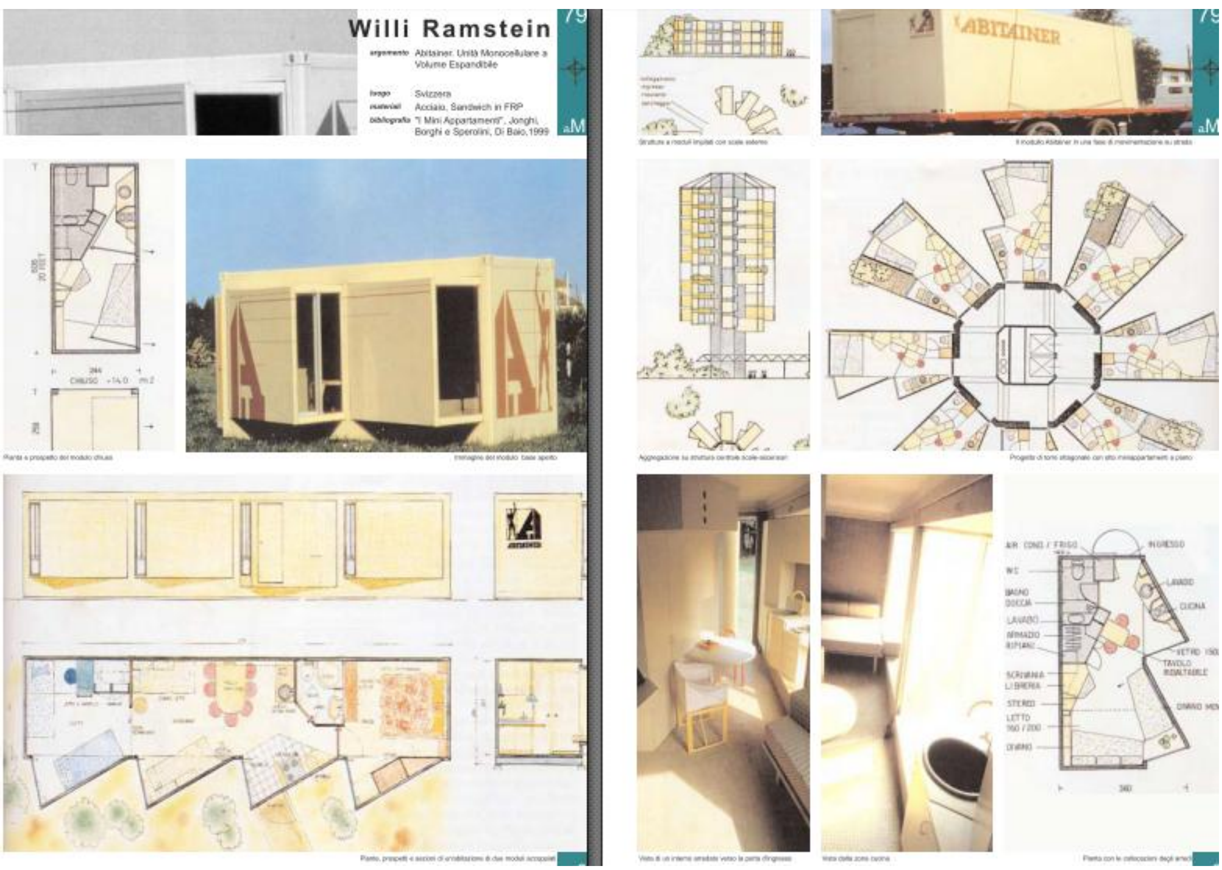
Name:

Author: Allan Wexler

Location: USA

Year: 1999

Time context:	**1990s**
Typology:	**MICRO-LIVING "CAPSULE"**
Name:	Habitation unit
Author:	Willi Ramstein
Location:	Switzerland
Year:	1999



Case study no.43

Time context: **2000+**

Typology: **MICRO-LIVING “CAPSULE”**

Name: Fred

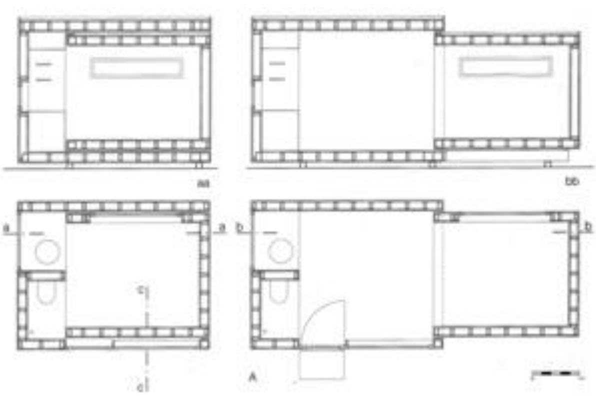
Author: Kaufmann 96

Location: Austria

Year: 1999

Photo’s:

Fred is one of the few projects to explore the idea of built in expandability. It is a timber container that consists of two boxes: one outer box of 3 by 3 by 3 metres and one which is slightly smaller that slides inside the bigger one. In its retracted state, it provides an interior area of 8 m2; when pulled out it has a total area of 15 m2. Kitchen and bathroom, a small room with WC and integrated shower, are in the fixed part, with the remaining area is open for interpretation.
Delivered on the back of a lorry, Fred can be assembled within the space of two hours. The box sits on six steel feet: four feet support the larger outer volume and two further feet carry two bearers, extended from the large box, on which the sliding box can rest. To be entirely independent as a unit, Fred would have to be connected to the sewage system, but could then be used as an office, guest room or additional living space. Whilst not designed as a long-term dwelling, Fred introduces a new aspect to flexible design.



Sources:
[http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=126&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=4 (accessed 2nd July 2013)]
Mobiles Haus - Fred', *Detail*, 2001, pp. 408-11.

Case study no.44

Time context: **1990s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

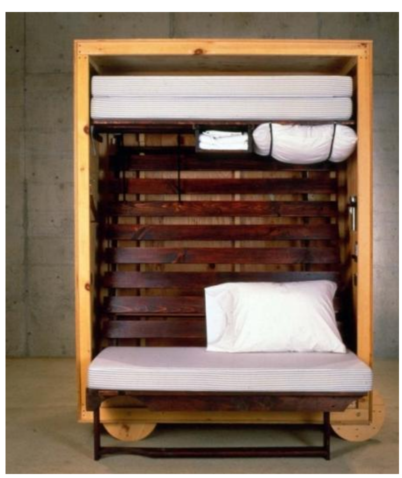
Name: Crate House

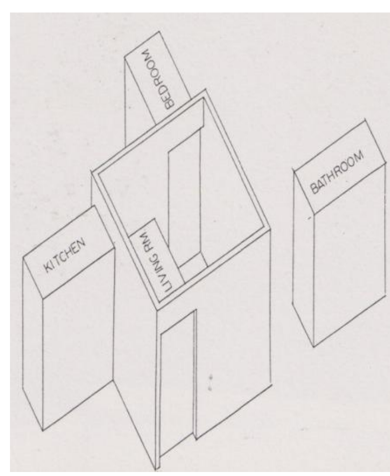
Author: Allan Wexler

Location:

Year: 1991

Photo’s:





Sources: [http://www.allanwexlerstudio.com/projects/bed-sitting-room-artist-residence (accessed April 20th, 2013)]

Time context: **1990s**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

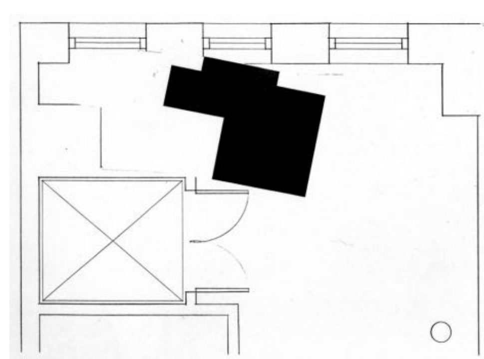
Name: Parsons kitchen

Author: Allan Wexler

Location:

Year: 1994

Photo's:



Sources: [http://www.allanwexlerstudio.com (accessed April 20th, 2013)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

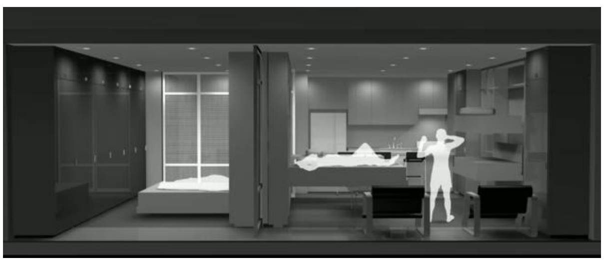
Name: CityHome

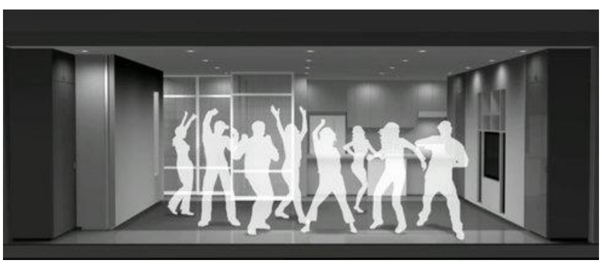
Author: Kent Larson and MIT School of Architecture and Planning

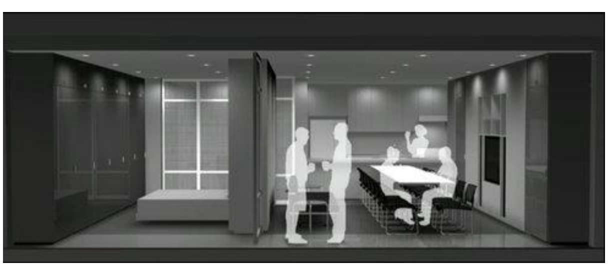
Location: USA

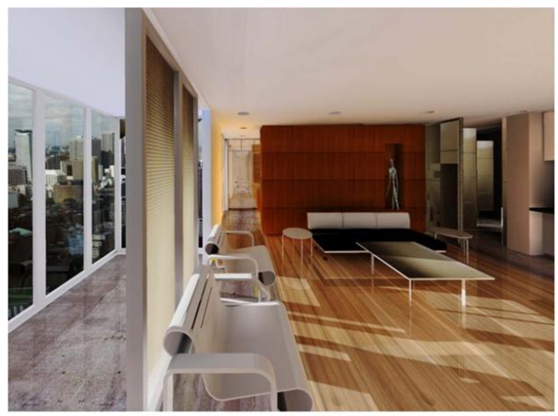
Year: 2012

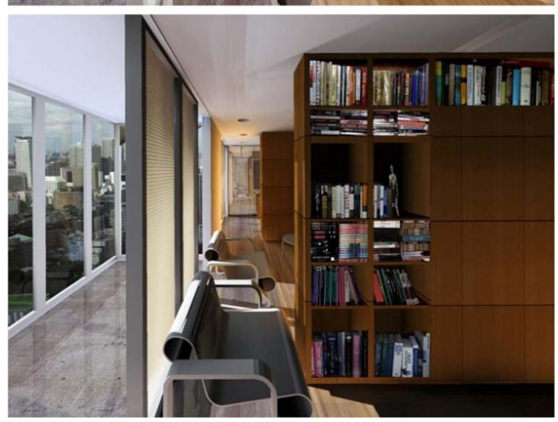
Photo's:











CityHome, has a very small footprint (840 square feet), can function as an apartment two to three times that size. This is achieved through a transformable wall system which integrates furniture, storage, exercise equipment, lighting, office equipment, and entertainment systems. One potential scenario for the CityHome is where the bedroom transforms to a home gym, the living room to a dinner party space for 14 people, a suite for four guests, two separate office spaces plus a meeting space, or an a open loft space for a large party. Finally, the kitchen can either be open to the living space, or closed off to be used as a catering kitchen. Each occupant engages in a process to personalize the precise design of the wall units according to his or her unique activities and requirements.

Sources:

[http://cp.media.mit.edu/research/67-cityhome (accessed 10th June 2013)]

Case study no.47

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

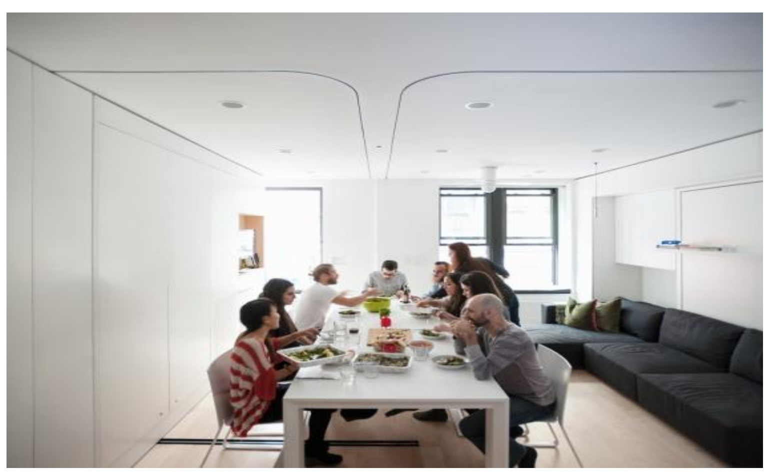
Name: LifeEdited Apartment

Author: Modern Office Systems llc

Location: New York

Year: 2012

Photo's:



Sources:
[http://www.lifeedited.com/moving-wall-makes-rooms-and-sense/ (accessed 10th June 2013)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

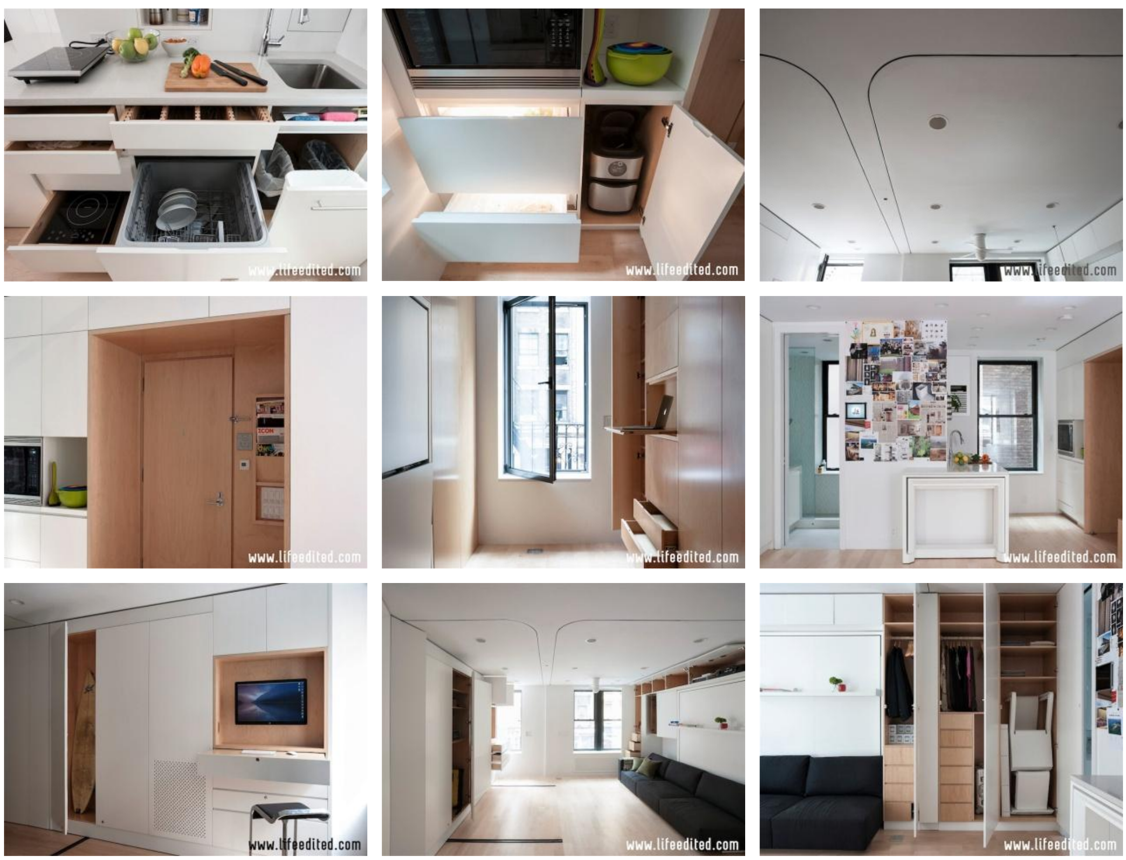
Name: LifeEdited Apartment

Author: Modern Office Systems llc

Location: New York

Year: 2012

Photo's:



LifeEdited Apartment is its moving wall. More than any other feature in the apartment, the moving wall provides a new way of thinking about how small spaces can be used and divided. With it, we are able to transform a studio into a two bedroom apartment–all without adding virtually any additional volume to the overall space.

Sources:
[http://www.lifeedited.com/see-full-set-of-official-lifeedited-apartment-photos/ (accessed 10th June 2013)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

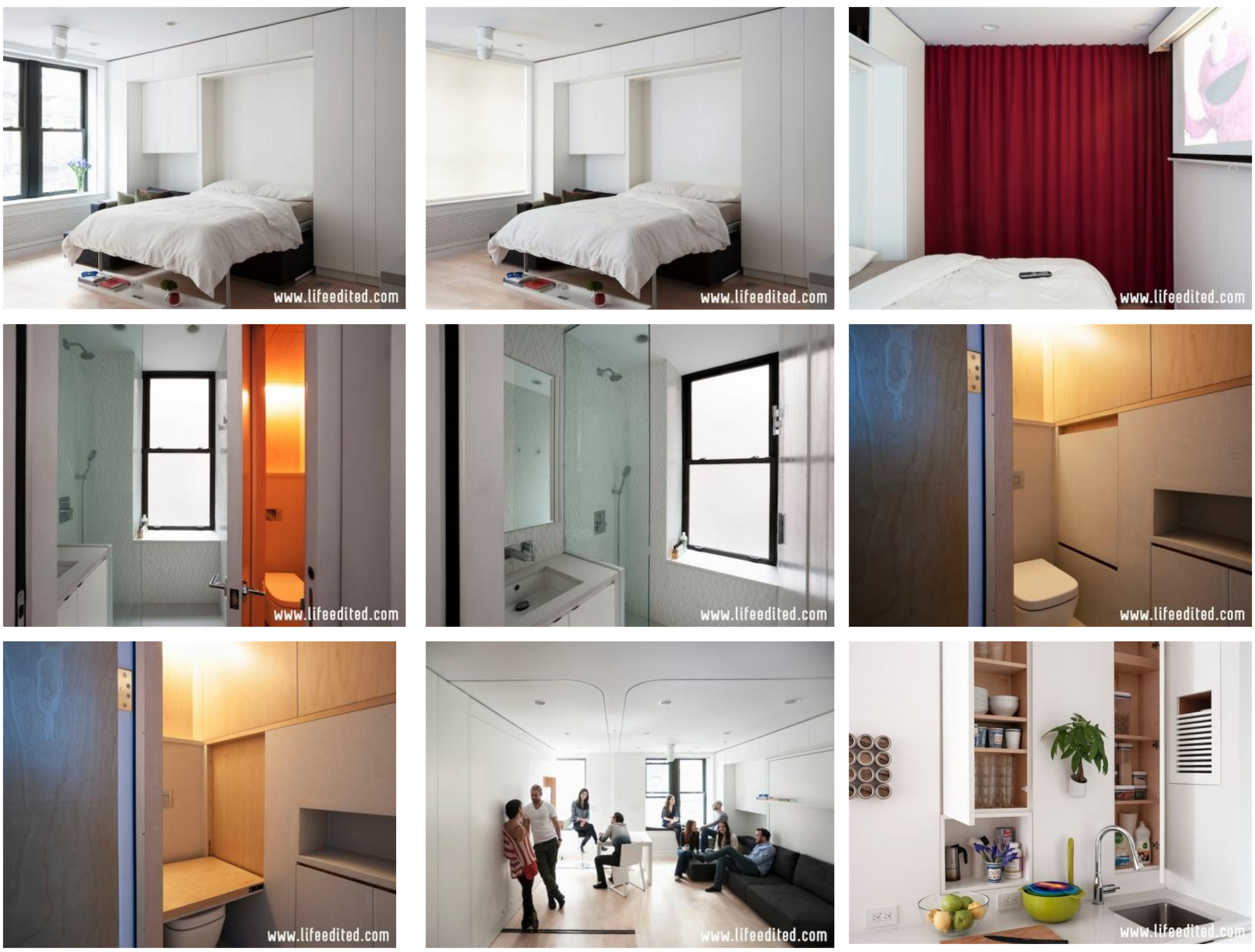
Name: LifeEdited Apartment

Author: Modern Office Systems llc

Location: New York

Year: 2012

Photo's:



Sources:
[http://www.lifeedited.com/see-full-set-of-official-lifeedited-apartment-photos/ (accessed 10th June 2013)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: LifeEdited Apartment

Author: Modern Office Systems llc

Location: New York

Year: 2012

Photo's:

Sources:
[http://www.d-a-z.hr/hr/vijesti/sto-sve-stane-u-39-m%C2%B2,2277.html (accessed 2nd May 2014)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Barcode Room

Author: studio_01

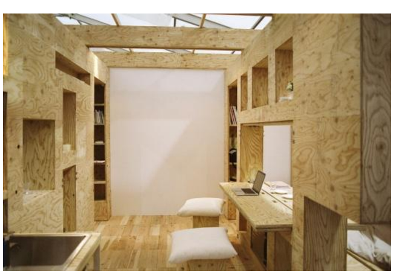
Location:

Year: 2012

Photo's:







Sources:
[http:// http://blog.studiozeroichi.com/2012/11/exhibition02-barcode-room.html / (accessed 10th June 2013)]

Time context: **2000+**

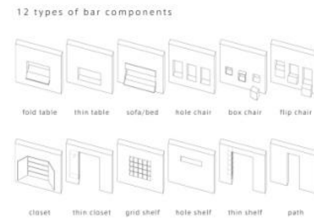
Typology: **MULTI-PURPOSE LAYOUT**

Name: Barcode Room

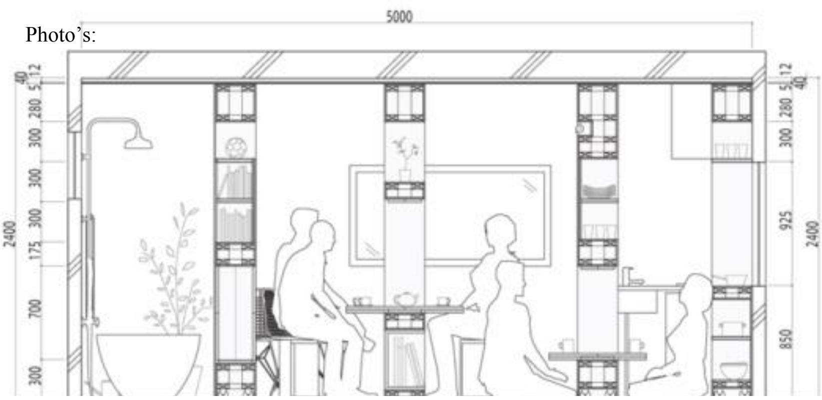
Author: studio_01

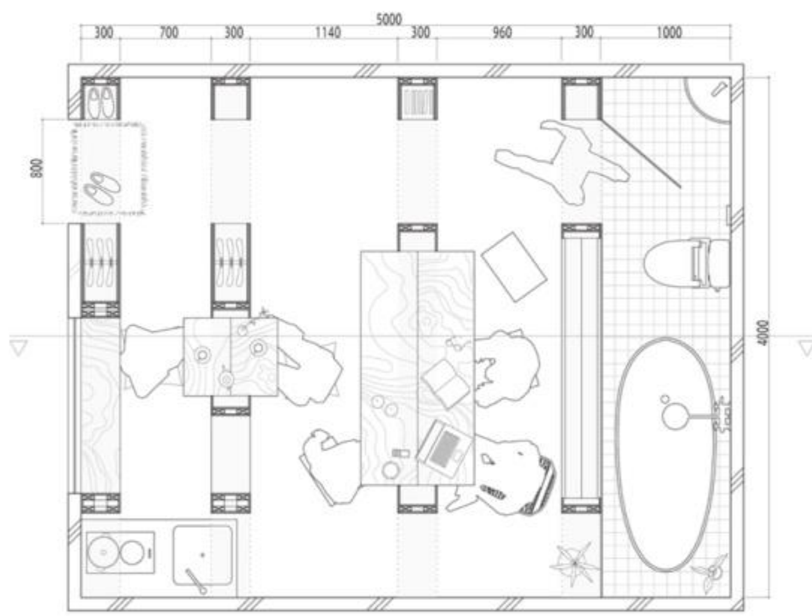
Location:

Year: 2012



Photo's:





barcode room is a concept studio apartment composed of product furniture-walls which move freely from side to side, permitting the resident to customize the size of space to fit a variety of uses. Placing functional elements such as storage and furniture into these walls, only to be pulled out when in use, also allows for more of the floor area to be used by the inhabitant and guests, thus creating a space where one is able to both comfortably live and entertain a different number of guests easily.

Through the use of the furniture-wall, or bars, barcode room takes the typical studio space made for a single resident and allows it to be transformed into a space where one can live and friends can gather. Each furniture-wall is a combination of selection from 12 types of components to make a single bar. Depending on the combination of components, various types of bars can be created, such as a living bar, kitchen bar, or sleeping bar. Just as each object in a store has it's own barcode, each usage of the apartment has its own layout, or barcode. The composition of the various components into different bars, as well as the position of these bars, allows the user to create their own unique collection of barcodes for their life.

Sources:

[http://blog.studiozeroichi.com/2012/11/exhibition02-barcode-room.html / (accessed 10th June 2013)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

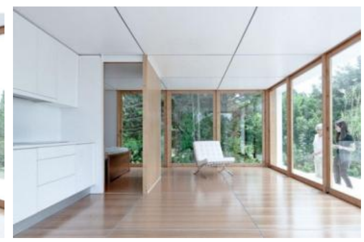
Name: Mima House

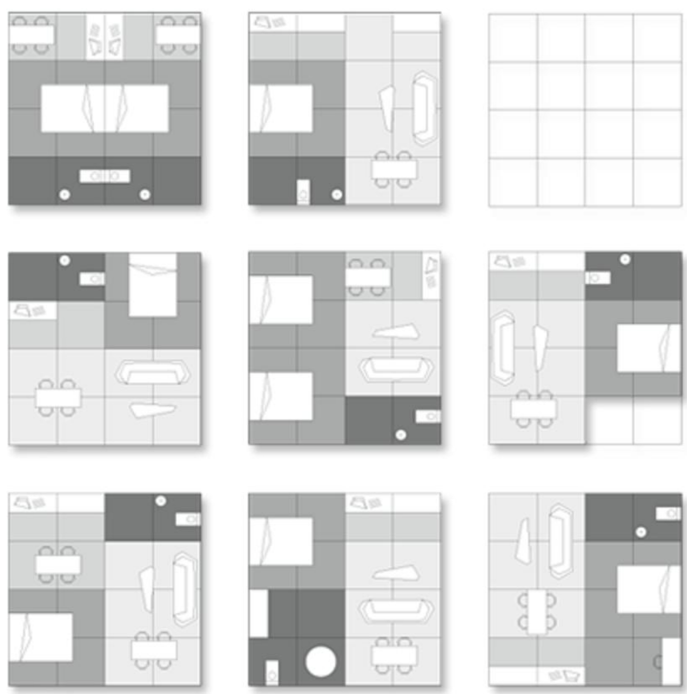
Author: Mima Architects, , Marta Brandao & Mario Sousa

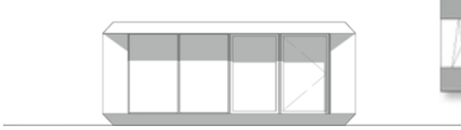
Location: Portugal

Year: 2011

Photo’s:







Sources:
[http://smallhousebliss.com/2012/11/06/mima-house-prefab-by-mima-architects/ (accessed 15th June 2013)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: 38m2 Home/Office

Author: Sandra Mestrovic

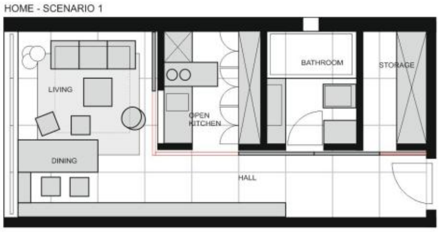
Location: Zagreb

Year: 2009

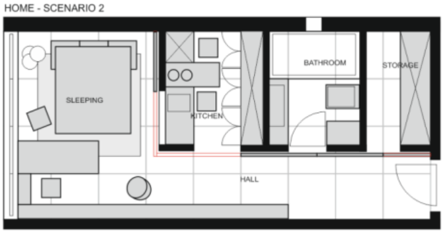
First hand case study

Photo's:

HOME - SCENARIO 1



HOME - SCENARIO 2



SCENARIO OFFICE

Sources: private archive

Case study no.51

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Garage project

Author: arch. Damir Spoljar for Domus Nobilis

Location: Zagreb, Croatia

Year: 2009

First hand case study

Photo’s:

Sources: private archive

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Garage project

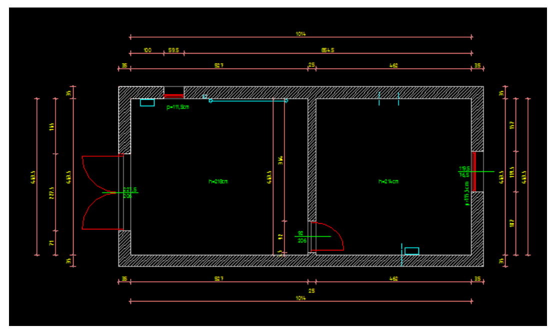
Author: arch. Damir Spoljar for Domus Nobilis

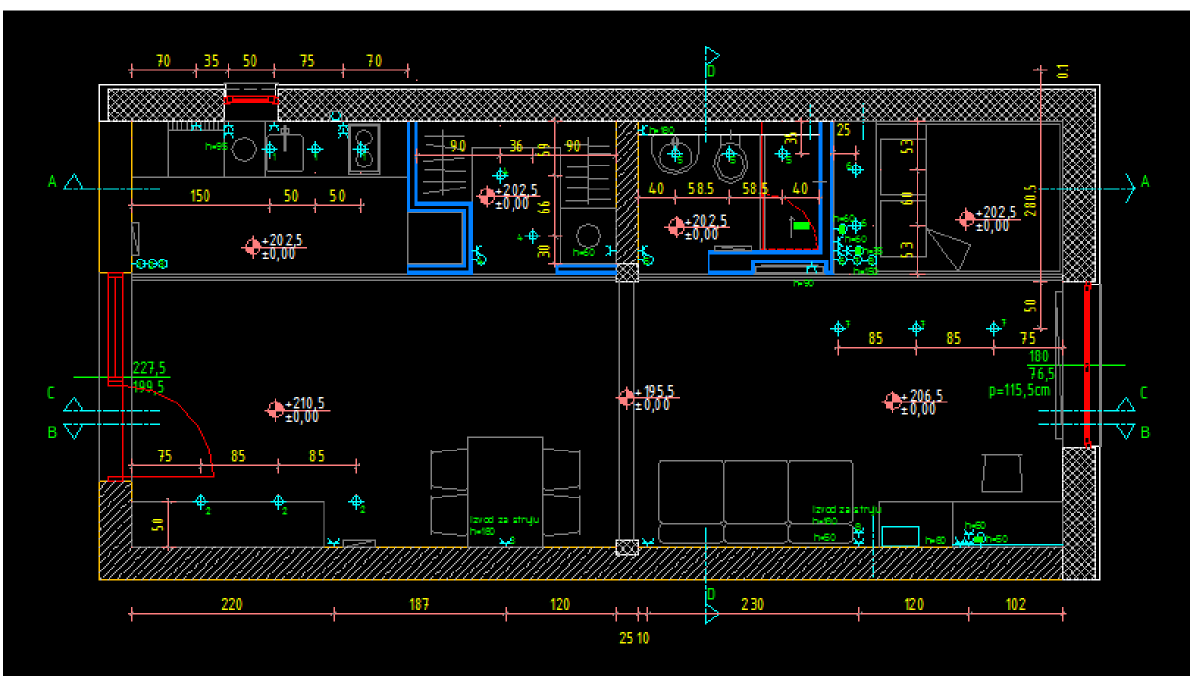
Location: Zagreb, Croatia

Year: 2009

First hand case study

Photo's:





Sources: private archive

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Garage project

Author: arch. Damir Spoljar for Domus Nobilis

Location: Zagreb, Croatia

Year: 2009

First hand case study

SCENARIO 1 – student apartment

Sources: private archive

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Garage project

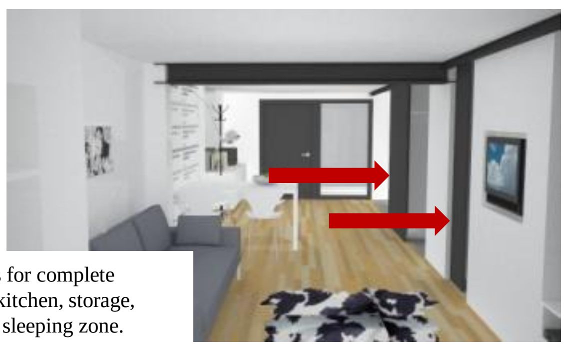
Author: arch. Damir Spoljar for Domus Nobilis

Location: Zagreb, Croatia

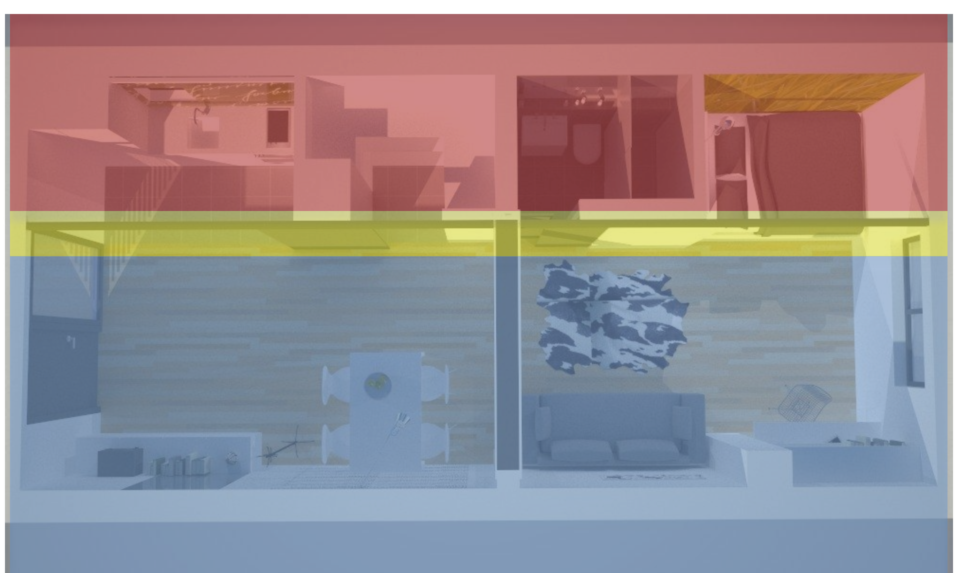
Year: 2009

First hand case study

SCENARIO 1 – student apartment



Sliding panels for complete separation of kitchen, storage, bathroom and sleeping zone.



Area for applying flexible concepts

Immobile units

Variable dividing elements

Sources: private archive

Case study no.51

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Garage project

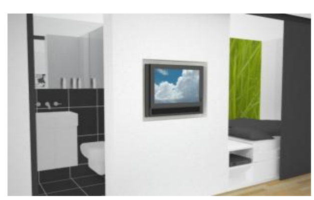
Author: arch. Damir Spoljar for Domus Nobilis

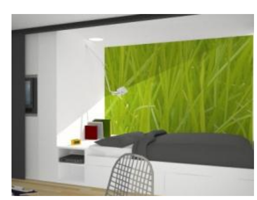
Location: Zagreb, Croatia

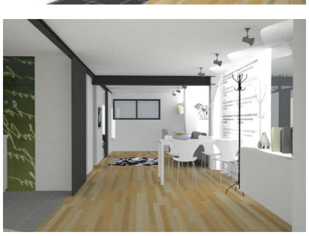
Year: 2009

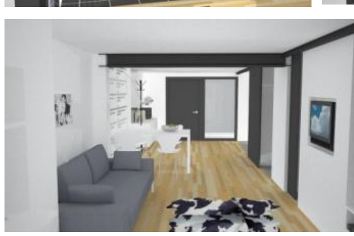
First hand case study

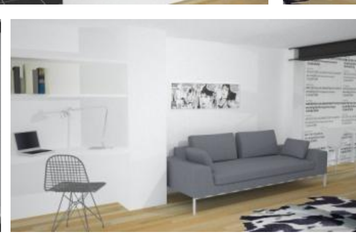
SCENARIO 2 – apartment for couple











Sources: private archive

Time context:	**2000+**
Typology:	**MULTI-PURPOSE LAYOUT**
Name:	Garage project
Author:	arch. Damir Spoljar for Domus Nobilis
Location:	Zagreb, Croatia
Year:	2009

First hand case study

SCENARIO 3 – office

Sources: private archive

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Garage project

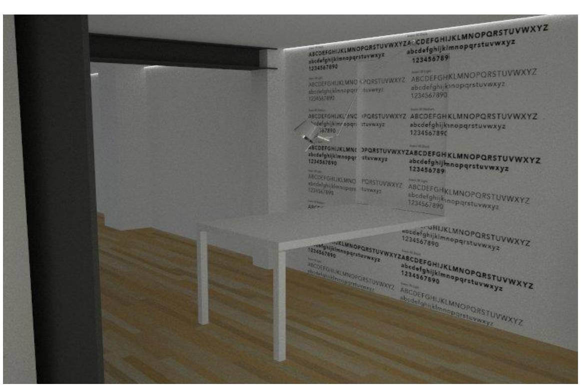
Author: arch. Damir Spoljar for Domus Nobilis

Location: Zagreb, Croatia

Year: 2009

First hand case study

SCENARIO 3 – office

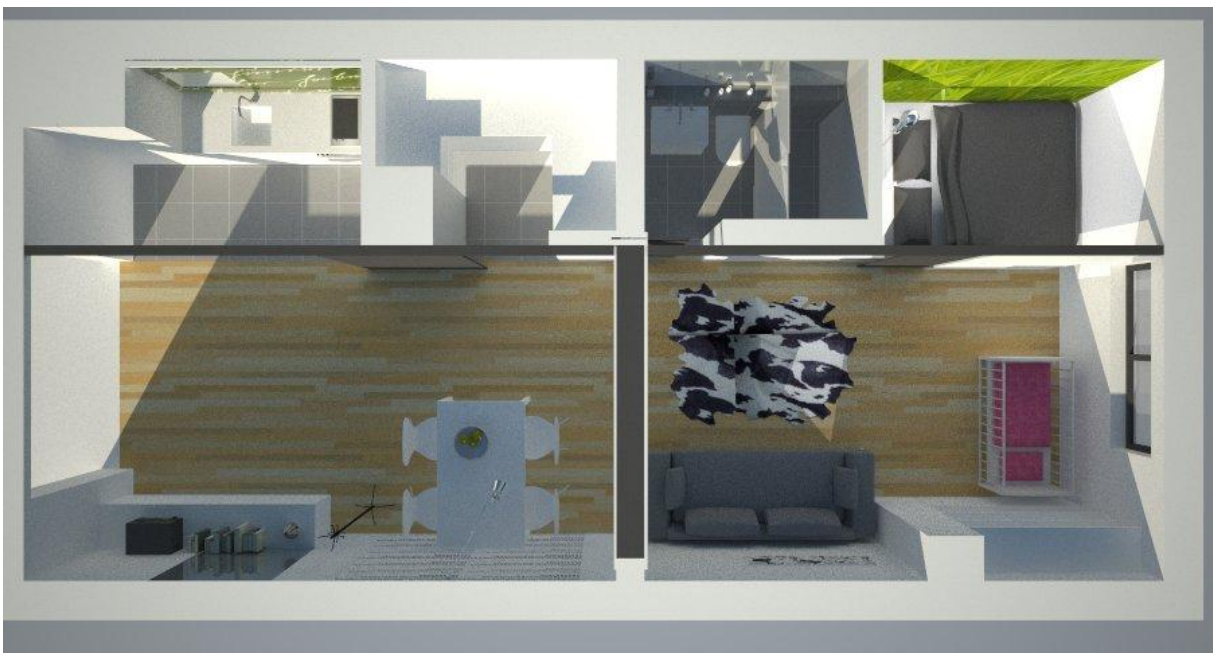


Sources: private archive

Time context:	**2000+**
Typology:	**MULTI-PURPOSE LAYOUT**
Name:	Garage project
Author:	arch. Damir Spoljar for Domus Nobilis
Location:	Zagreb, Croatia
Year:	2009

First hand case study

SCENARIO 4 – apartment for couple with a small child



Sources: private archive

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Garage project

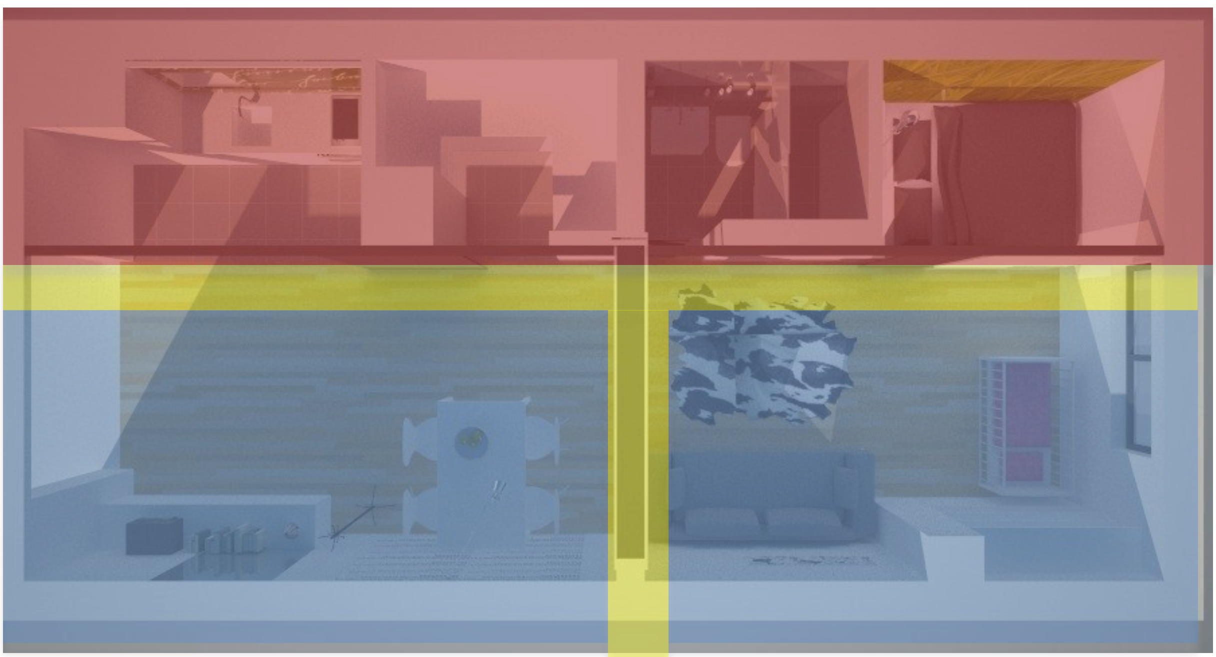
Author: arch. Damir Spoljar for Domus Nobilis

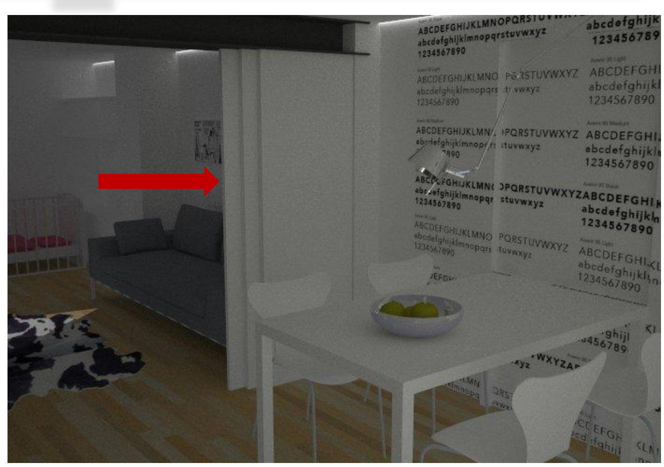
Location: Zagreb, Croatia

Year: 2009

First hand case study

SCENARIO 4 – apartment for couple with a small child





Area for applying flexible concepts

Immobile units

Variable dividing elements

Sources: private archive

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

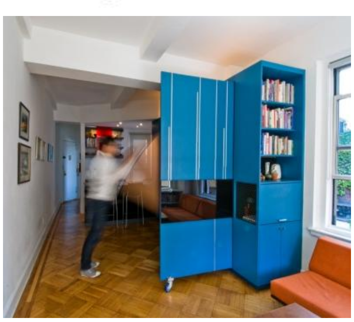
Name: Unfolding Apartment

Author: MKCA // MICHAEL CHEN ARCHITECTURE

Location: New York

Year:

Photo's:



Sources: [http://www.normalprojects.com/unfolding-apartment/#.U48LfHKSzBc (accessed 1st June 2014)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Unfolding Apartment

Author: MKCA // MICHAEL CHEN ARCHITECTURE

Location: New York

Year:

Photo's:






Sources: [http://www.normalprojects.com/unfolding-apartment/#.U48LfHKSzBc (accessed 1st June 2014)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

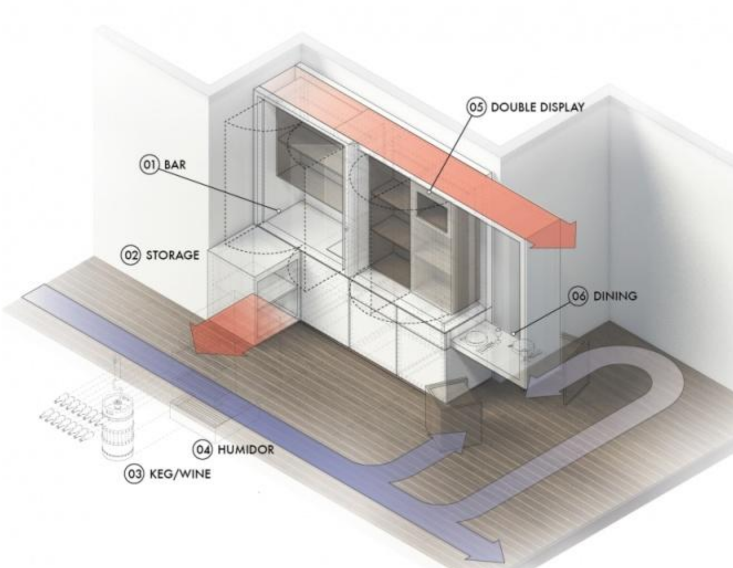
Name: Partywall

Author: Michael Chen, Justin Snider, Brady Caldwell, Alan Tansey

Location: New York

Year:

Photo's:



Sources: [http://www.normalprojects.com/unfolding-apartment/#.U48LfHKSzBc (accessed 1st June 2014)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

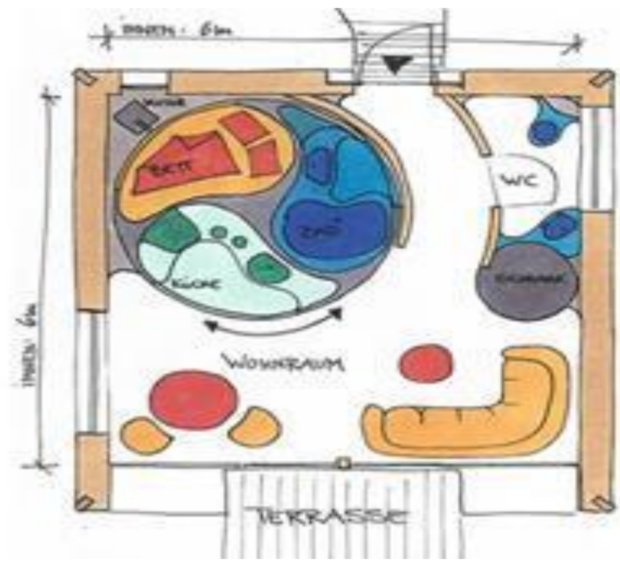
Name: Rotorhaus

Author: Luigi Colani and Hanse Haus

Location: Germany

Year: 2004

Photo’s:



Sources:

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: domino.21

Author: José Miguel Reyes and Students of the Departamento de Proyectos Arquitectónicos, ETSAM

Location: Spain

Year: 2004

Photo's:

Domino.21 is a modular building system, consisting of cubes that can be combined, either vertically or horizontally, to create a unit. Additional modules can be added at a later stage. The basic unit consists of a core space around which other modules or cabins can be arranged. Each unit is separately insulated, but walls as well as insulation are moveable allowing a number of cubes to be spatially and thermally connected to one.
The cost of an apartment is calculated by the number of cubes, which comes to 12,000 Euros each, plus a pro rata sum of 30,000 Euros for structure, stairs and infrastructure.
The system was developed by students of ETSAM, Madrid and a number of Spanish construction firms. Units are prefabricated and then transported to the site. The system, as erected at Construtec, took 15 days to put up. Potential clients are meant to order modules per catalogue, where types of modules and materiality have to be specified (wall elements come in timber, polycarbonate and metal, partition walls are made from PVC).

Sources:
[http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=145&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=6 (accessed 2dn July 2013)]

Time context: **2000+**

Typology: **MULTI-PURPOSE LAYOUT**

Name: Loftcube

Author: Studio Aisslinger

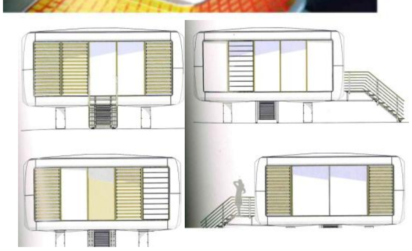
Location: New York

Year:









The LoftCube is prefabricated, which saves energy and material use, and it's designed to have a minimal footprint. The home's 360-degree windows provide ample daylight and natural ventilation while opening up the interior to incredible views. The prefab can be customized with energy-efficient heating and cooling systems, and it can be joined with other units to create a modular LoftCube complex. A LoftCube can be used as a mobile home for the modern nomad, a sky lounge for a modern hotel, a garden house that is close to nature, a beach getaway or a minimalist home. The luxurious yet tiny prefab measures just 420 square feet, and it can expand outdoors with an optional patio. The interiors are customizable as well – the living, kitchen, and bedroom areas can be adjusted according to each owner's needs.

It only takes 5-7 days to set up a LoftCube, and the units can be disassembled in just two days and transported by truck from place to place. The sky is the limit with this innovative prefab that takes small space living to exciting new heights.

Sources:
Friedman, Avi. *Innovative houses: concepts for sustainable living*. S.l.: Laurence King Publishing, 2013.
[http://inhabitat.com/tiny-space-age-loftcube-prefab-can-pop-up-just-about-anywhere/loftcube-aisslinger-bracht-5/ (accessed 12th November 2013)]

Case study no.57

Time context: **2000+**

Typology: **MICRO-LIVING “CAPSULE”**

Name: Micro-house

Author: Studio Liu Lubin

Location: Beijing, China

Year: 2012

Photo’s:

The Micro-house is based on the minimum space people need for basic indoor movement, such as sitting, laying and standing. The form of the Micro-house is designed to act as a combination of furniture and architecture elements. When being rotated, the unit of the Micro house will shift its space which contains all kinds of housing activities, such as resting, working, washing and cooking, etc. The Micro house unit can not only be used as single- functional room, but also can be grouped together as a housing suite, or even residential cluster.

The main material of the Micro-house is the Fiber Reinforced Form Composite Structure, which is light but strong. In this case, the Micro-house unit can be easily lift and assembled by hand. For the convenience of transportation and replacement, the size of the unit is designed as the size of containers.

Sources:

[http://www.archdaily.com/379927/micro-house-studio-liu-lubin/ (accessed 10th June 2013)]
[http://www.designboom.com/architecture/studio-liu-lubin-micro-house-installed-in-beijing-park/ (accessed 245th June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING “CAPSULE”**

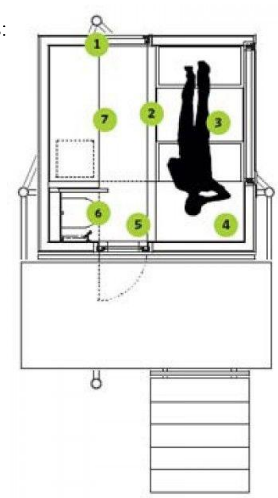
Name: Micro-compact home

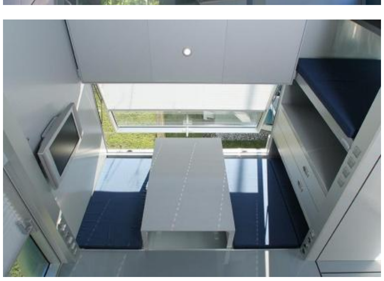
Author: Richard Horden and Institute for Architecture and Product Design at Technical University Munich

Location: Germany

Year: 2005

Photo’s:





Sources:
[http://www.microcompacthome.com/ (accessed 4th July 2013)]
[http://www.dexigner.com/news/8317 (accessed 5th May 2014)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

Name: Pushbutton house

Author: Adam Kalkin

Location: USA

Year: 2005

Photo's:

The Push Button House, is a shipping container that opens up into an entire house. The massive container-turned-home by architect Adam Kalkin opens up to reveal a fully adorned room featuring a bed to sleep on, a couch for lounging, a dining table, a bathroom area, a modest library, and numerous light fixtures. The architectural installation uses hydraulic power to unveil the room in 90 seconds' time.

Sources:

[http://www.treehugger.com/sustainable-product-design/push-button-house-by-adam-kalkin.html (accessed 8th July 2013)]
[http://www.youtube.com/watch?v=cQGd2AlSPh8 (accessed 19th September 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

Name: A_Z Cellular Compartment Units

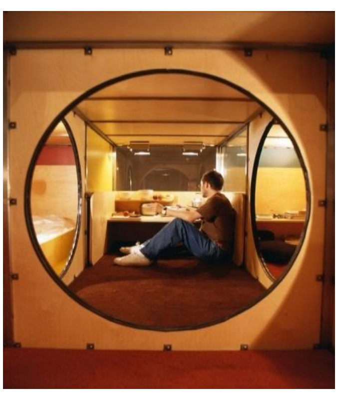
Author: Andrea Zittel

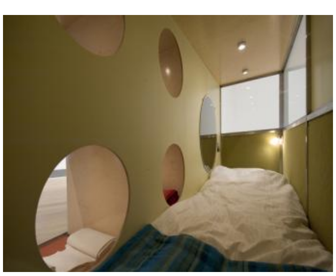
Location: USA

Year: 2001

Photo's:





Sources:
[http://www.zittel.org/ (accessed 10th June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

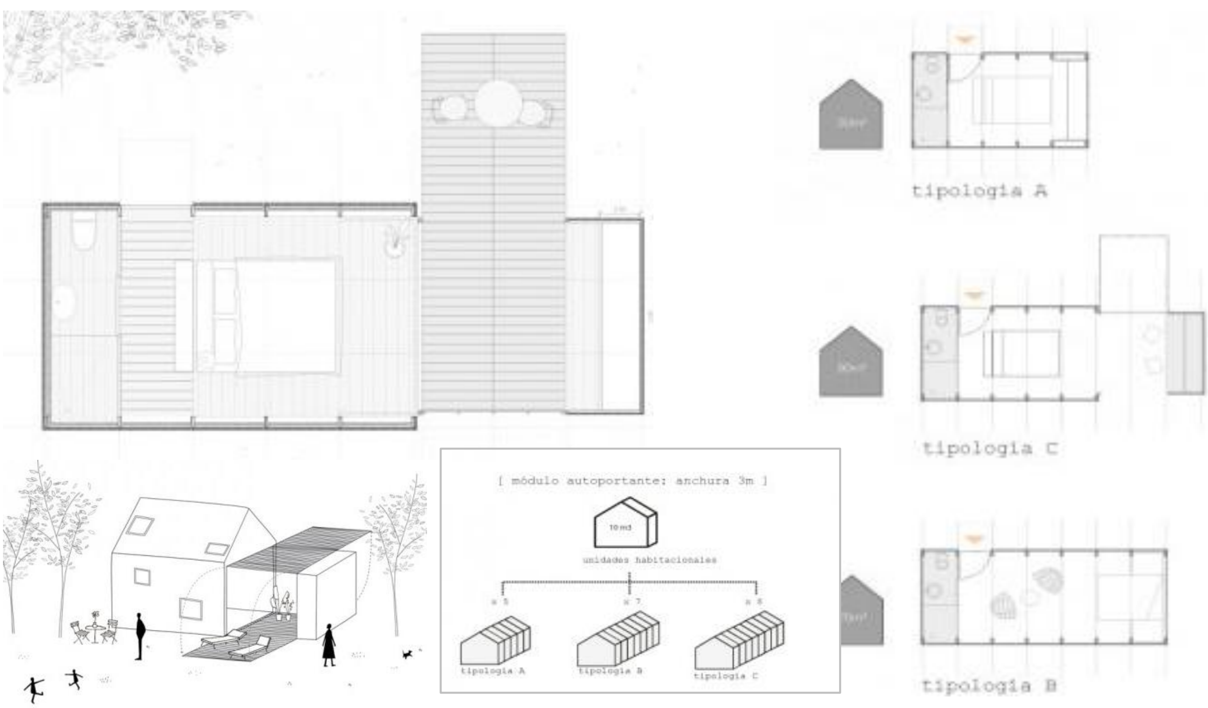
Name: Micro House

Author: Jordi Lopez Aguilo

Location:

Year: 2012

Photo's:



Sources:

[http://www.architizer.com/en_us/projects/view/microhotel/54249/#.UbnrK-fMJG4 (accessed 1 June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

Name: Walking house

Author: N55 architects

Location: Denmark

Year: 2008

Photo's:

WALKING HOUSE is a modular dwelling system that enables persons to live a peaceful nomadic life, moving slowly through the landscape or cityscape with minimal impact on the environment. It collects energy from its surroundings using solar cells and small windmills. There is a system for collecting rain water and a system for solar heated hot water. A small greenhouse unit can be added to the basic living module, to provide a substantial part of the food needed by the Inhabitants. A composting toilet system allows sewage produced by the inhabitants to be disposed of. A small wood burning stove could be added to provide CO_2 neutral heating. WALKING HOUSE forms various sizes of communities or WALKING VILLAGES when more units are added together. WALKING HOUSE is not dependant on existing infrastructure like roads, but moves on all sorts of terrain.

Sources:
[http://www.n55.dk/MANUALS/WALKINGHOUSE/walkinghouse.html (accessed 12th July 2013)]

Case study no.63

Time context: **2000+**

Typology: **MICRO-LIVING “CAPSULE”**

Name: Micro Home

Author: Renzo Piano

Location:

Year: 2013

Photo’s:

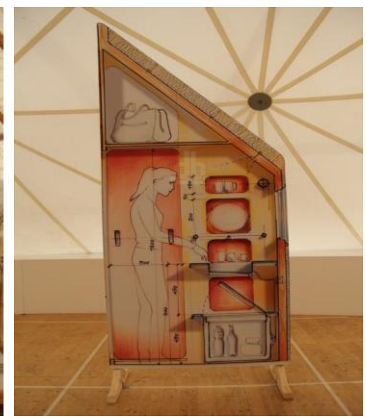
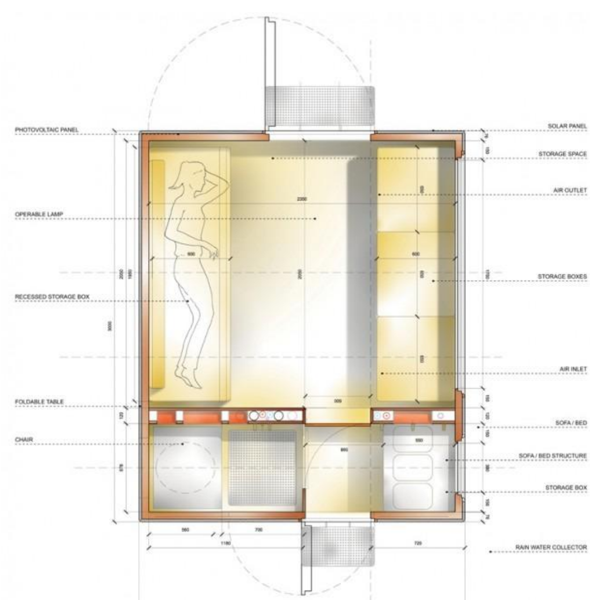
Sources:

[http://www.designboom.com/architecture/renzo-pianos-micro-home-diogene-installed-on-vitra-campus/ (accessed 1 June 2013)]

Time context:	**2000+**
Typology:	**MICRO-LIVING "CAPSULE"**
Name:	Micro Home
Author:	Renzo Piano
Location:	
Year:	2013

Photo's:




Sources:

[http://http://www.designboom.com/architecture/renzo-pianos-micro-home-diogene-installed-on-vitra-campus/ (accessed 1 June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

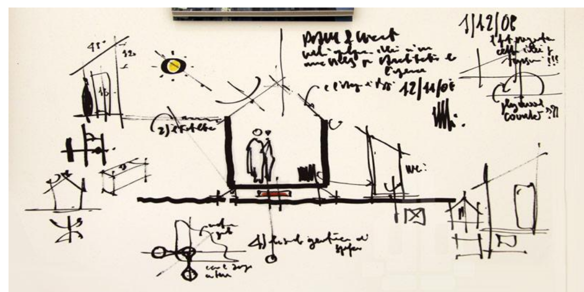
Name: Micro Home

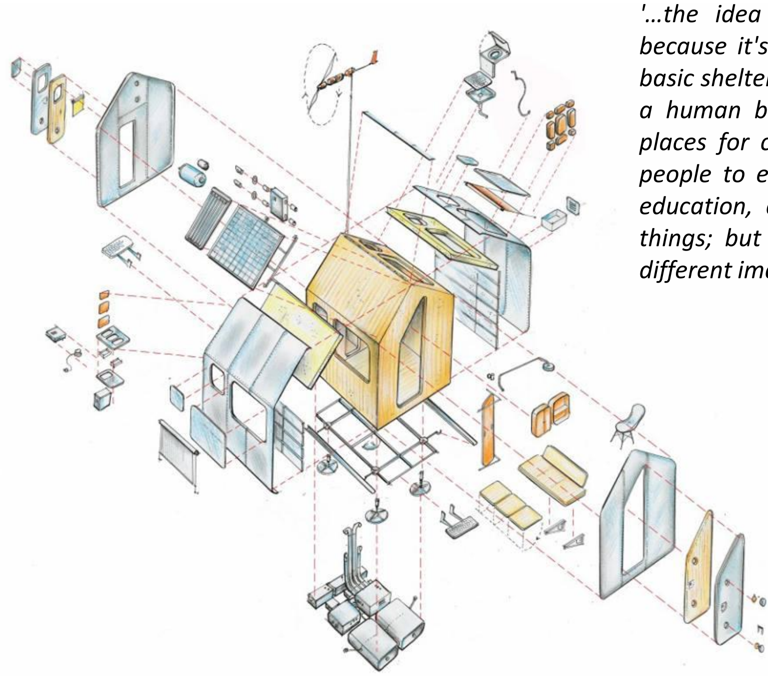
Author: Renzo Piano

Location:

Year: 2013

Photo's:





'...the idea of a small house always came back, because it's kind of a primitive idea. it's the idea of basic shelter-- the minimum living shelter you need as a human being--then you can go and make many places for collective activity. civic places, places for people to enjoy music, to enjoy university, to enjoy education, a civic center. you can do many, many things; but it sticks, this idea somewhere, this one different image-- it's called silence.'

Sources:

[http://http://www.designboom.com/architecture/renzo-pianos-micro-home-diogene-installed-on-vitra-campus/ (accessed 1 June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

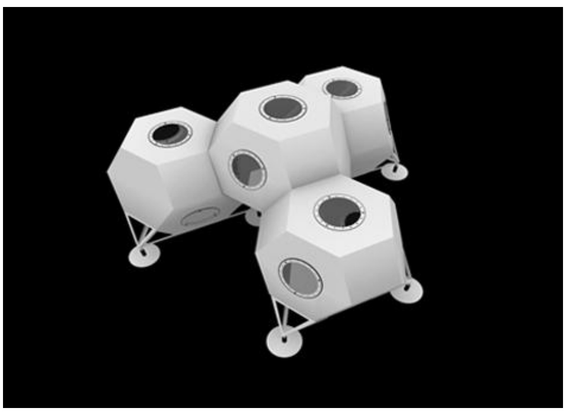
Name: Tiny house

Author: N55 architects

Location: Denmark

Year: 2008

Photo's:



It's a housing system constructed from truncated octahedrons. Due to the perfect symmetry of a truncated octahedron multiple units can be joined to form larger more complex structures. It has 8 regular hexagonal faces and 6 square faces. When assembled these flat faces also form the supporting structure. The size is limited only by the material's size and strength.
This concept is really interesting to me because it provides a simple way of enclosing space with minimal material. Imaging using metal brackets to join 14 plywood sides and insulating with sheets of foam.

Sources:
[http://www.tinyhousedesign.com/tag/n55/ (accessed 1st June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

Name: 'appartement spectral'

Author: betillon / dorval-bory

Location: levallois, france

Year: 2013

Photo's:

Sources:

[http://www.designboom.com/architecture/betillon-dorval-bory-appartement-spectral-paris// (accessed 1 June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING “CAPSULE”**

Name: 130-Square-Foot Apartment

Author: Marc Baillargeon and Julie Nabucet

Location: Montparnasse, Paris

Year: 2012

Photo’s:

Sources:

[http://www.businessinsider.com/architects-create-130-square-foot-studio-2013-4?op=1 (accessed 1 June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING “CAPSULE”**

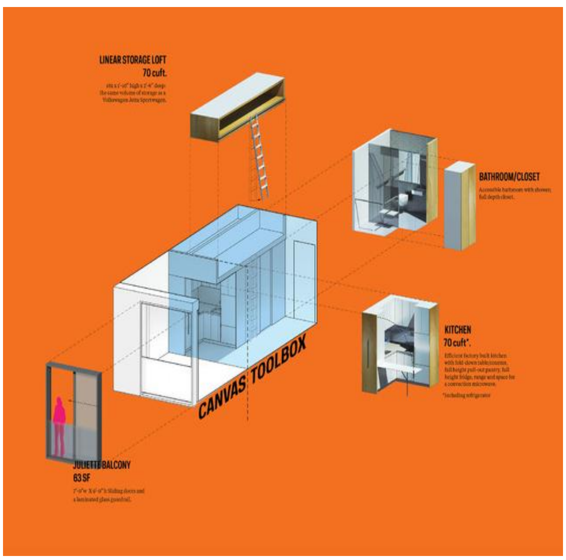
Name: MicroUnit – winners of adAPT NYC competition

Author: Monadnock Development, the Actors Fund Housing Development Corporation and nArchitects

Location: New York

Year: 2012

Photo’s:



Sources:

[http://www.houzz.com/photos/2550141/My-Micro-NY-contemporary-rendering-new-york (accessed 1 June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING “CAPSULE”**

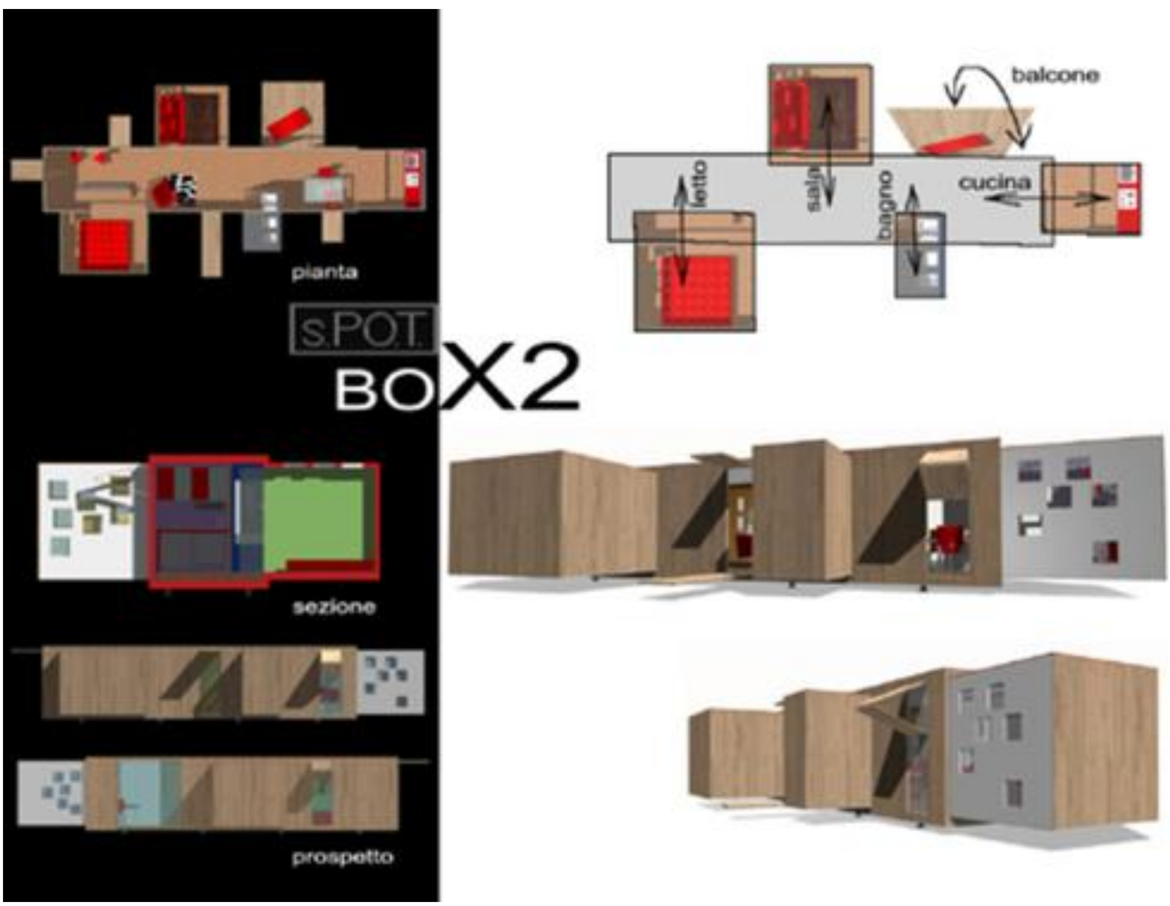
Name: Box2

Author: SPOT - STUDIO POLENTA TECCO ARCHITETTI ASSOCIATI

Location: Italy

Year: 2006

Photo’s:



Sources:
[http://europaconcorsi.com/projects/20865-Box2/images/656177 (accessed 3rd July 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

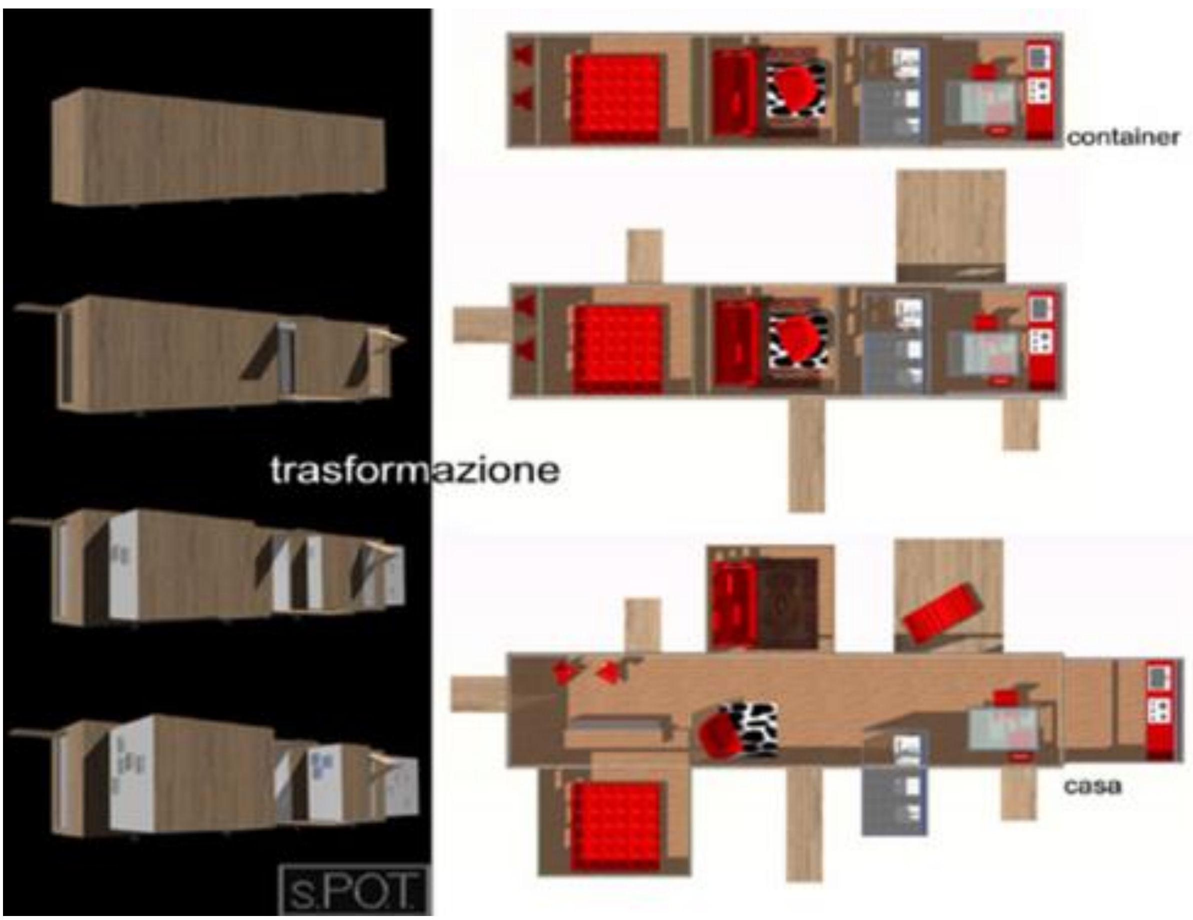
Name: Box2

Author: SPOT - STUDIO POLENTA TECCO ARCHITETTI ASSOCIATI

Location: Italy

Year: 2006

Photo's:



Sources:
[http://europaconcorsi.com/projects/20865-Box2/images/656177 (accessed 3rd July 2013)]

Case study no.68

Time context: **2000+**

Typology: **MICRO-LIVING “CAPSULE”**

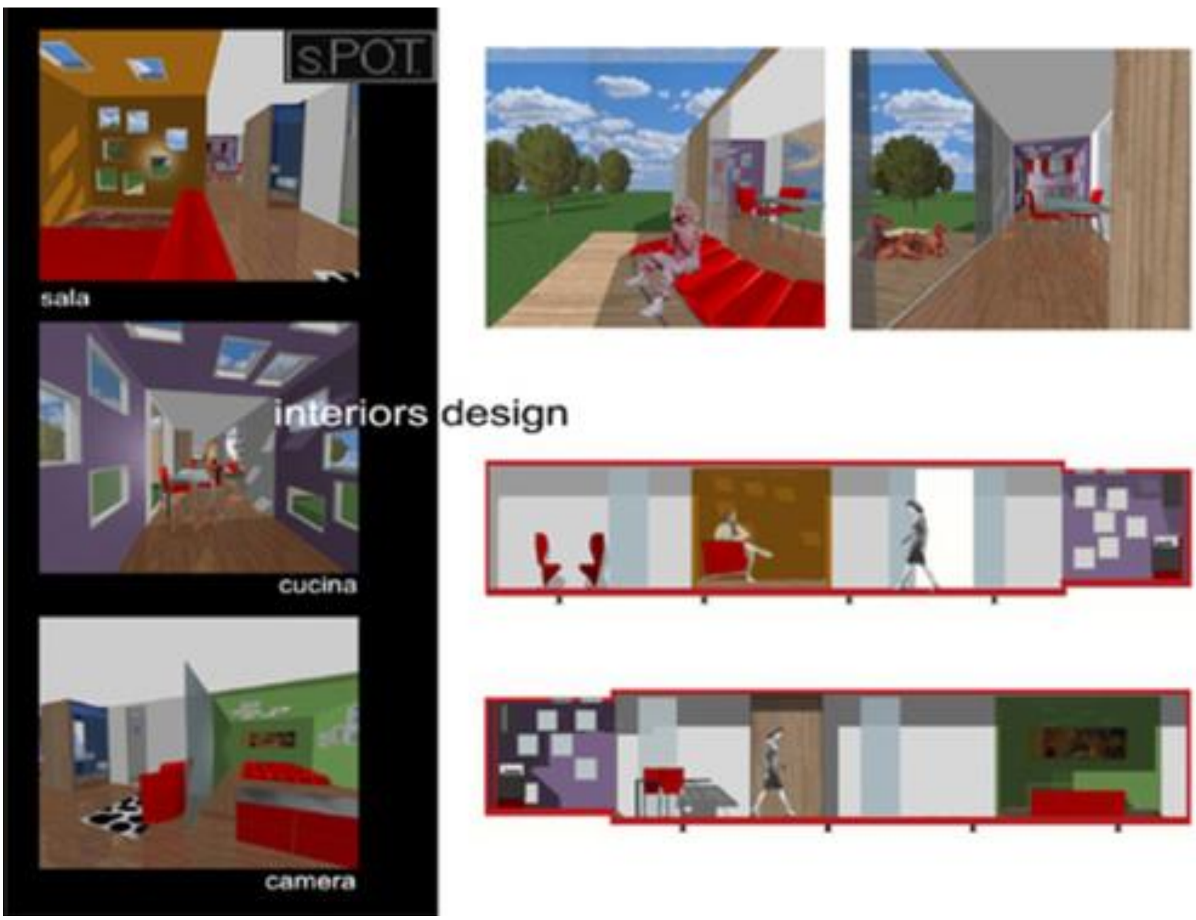
Name: Box2

Author: SPOT - STUDIO POLENTA TECCO ARCHITETTI ASSOCIATI

Location: Italy

Year: 2006

Photo’s:



Sources:
[http://europaconcorsi.com/projects/20865-Box2/images/656177 (accessed 3rd July 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

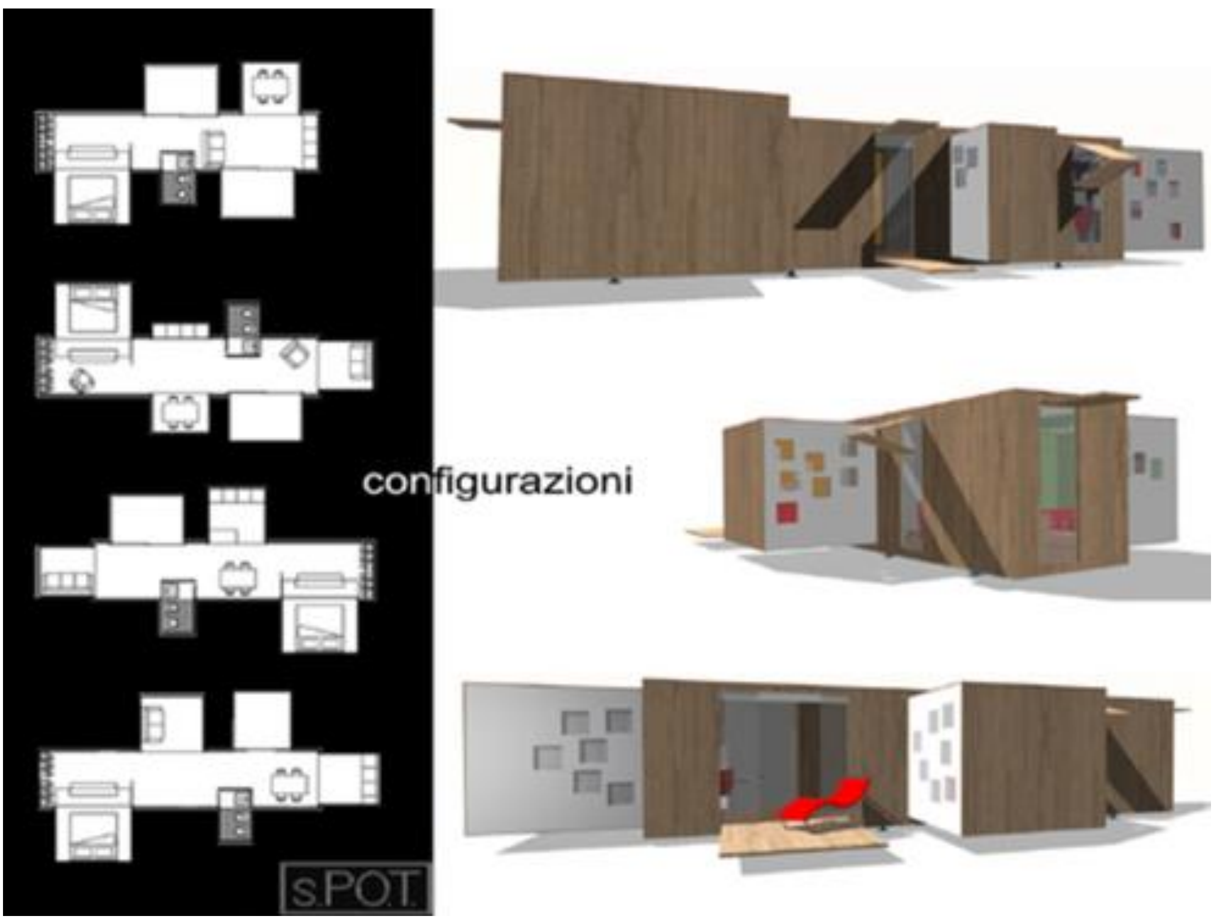
Name: Box2

Author: SPOT - STUDIO POLENTA TECCO ARCHITETTI ASSOCIATI

Location: Italy

Year: 2006

Photo's:



Sources:
[http://europaconcorsi.com/projects/20865-Box2/images/656177 (accessed 3rd July 2013)]

Case study no.69

Time context: **2000+**

Typology: **MICRO-LIVING “CAPSULE”**

Name: Mobile Dwelling Unit

Author: LOT-EK ARCHITECTS

Location: New York

Year: 2003

Photo’s:








Sources:
[http://www.lot-ek.com/MDU-Mobile-Dwelling-Unit (accessed 3rd July 2013)]
[http://www.fabprefab.com/fabfiles/containerbay/059MDU-lotek/UCSB-MDU-webvers/index_UCSB-MDU-webvers.html (accessed 3rd July 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

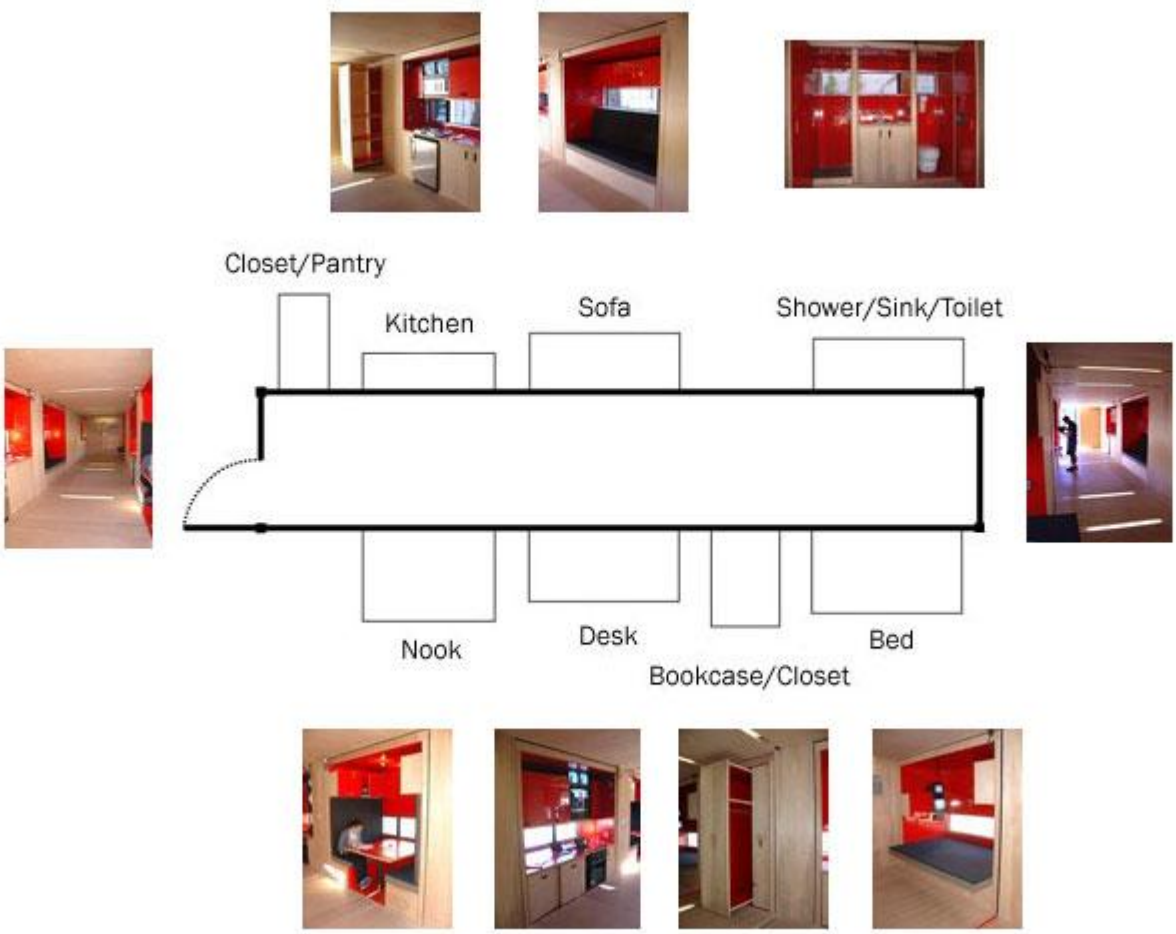
Name: Mobile Dwelling Unit

Author: LOT-EK ARCHITECTS

Location: New York

Year: 2003

Photo's:



Sources:
[http://www.lot-ek.com/MDU-Mobile-Dwelling-Unit (accessed 3rd July 2013)]
[http://www.fabprefab.com/fabfiles/containerbay/059MDU-lotek/UCSB-MDU-webvers/index_UCSB-MDU-webvers.html (accessed 3rd July 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

Name: L41home

Author: Michael Katz and Janet Korne

Location: Canada

Year:

Photo's:





Sources:

[http://www.decoist.com/2012-07-02/tiny-houses-the-best-in-modern-compact-living/(accessed 30th June 2013)]
[http://l41home.com/L41home.com/HOME.html (accessed 30th June 2013)]

Time context: **2000+**

Typology: **MICRO-LIVING "CAPSULE"**

Name: Pack'n go House

Author: Marco Colombo, arch.

Location: Bari, Italy

Year: 2006

Photo's:

Sources:

[http://europaconcorsi.com/projects/20875-Pack-n-Go-House-design-Arch-Marco-Colombo- /(accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Rache kitchen box

Author: OMA

Location:

Year: 2006

Photo's:

Sources:

[http://www.designboom.com/project/grandmas-revenge/ (accessed 15th June 2013)]
Schneiderman, Deborah. *Inside Prefab: The Ready-Made Interior*. New York: Princeton Architectural Press, 2012.p52

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

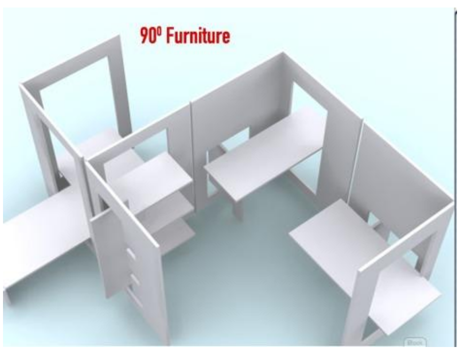
Name: 90Â° Flatpack Furniture

Author: Lowrien Kaptein

Location:

Year: 2008

Photo's:



Sources:
[http://www.designbuzz.com/10-best-cardboard-designs-green-and-beautiful/ (accessed 30th June 2013)]

Case study no.74

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Cirrus MVR

Author: Crowd productions

Location:

Year: 2008

Photo's:





Sources:

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Boxetti

Author: Rolands Landsbergs

Location:

Year: 2010

Photo's:

Sources:
[http://www.furnishburnish.com/furniture/boxette-multifunctional-furniture/ (accessed 30th June 2013)]
[http://freshome.com/2012/06/06/super-space-saving-furniture-by-boxetti/ (accessed 10th July 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

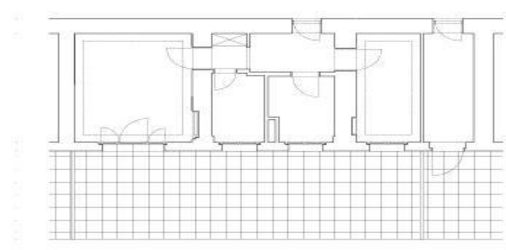
Name: 2Raumwohnung

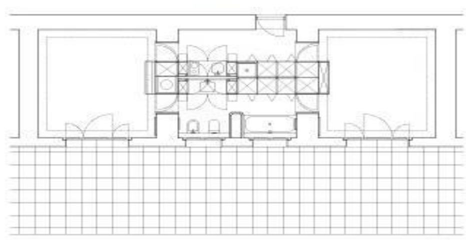
Author: Behles & Jochimsen

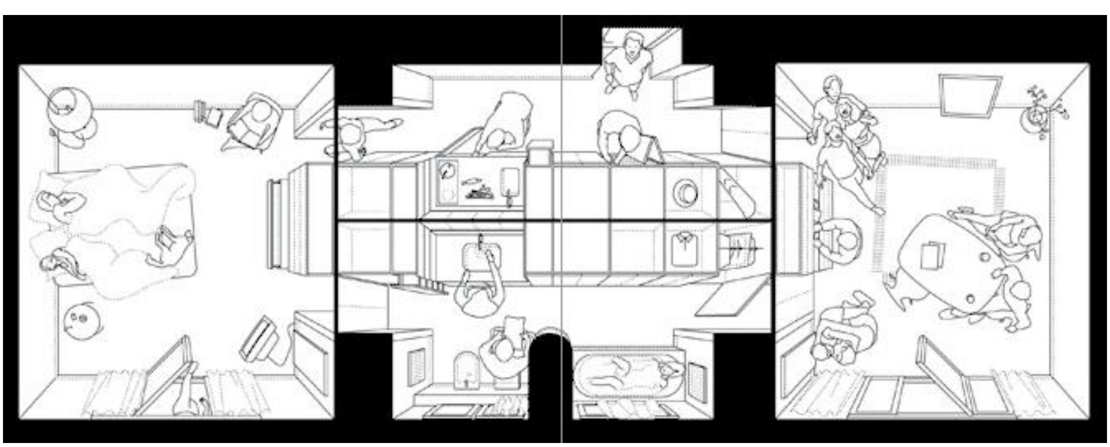
Location: Berlin

Year: 2006

Photo's:







Sources:

[http://behlesjochimsen.de/en/projects/2raumwohnung/3/ (accessed 10th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Co-Pod

Author: Colab architects

Location:

Year: 2010

Photo's:

Sources:
[http://www.co-labarchitects.com/copod/Products.html (accessed 20th August 2013)]

Time context: **2000+**

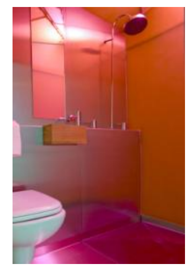
Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: The Interior Living Unit

Author: Andrew Kline

Location:

Year: 2010



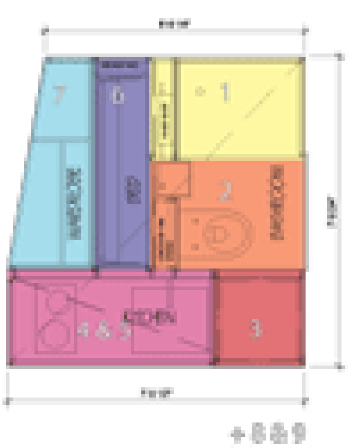


diagram of individual pieces

Michigan designer Andrew Kline has designed a compact unit for transforming disused industrial spaces into temporary homes. Called Interior Living Unit, the project comprises a kitchen, bathroom, bed and storage that all fold away into a cubic red box. When folded away the surrounding room could be used as a work space or for public functions. The cube breaks down into nine pieces for easy transportation to a new space. The Interior Living Unit is composed of 9 pieces, sized to fit through standard doorways and be combined in the space within. Centralizing the program requirements of a home, The Unit allows the surround space to be used for other purposes, such as workspace. The Unit folds (closed) and unfolds (open) to reveal different functions when needed: a wardrobe, bed, kitchen, and bathroom. When the Unit is folded the private program requirements of a home are removed and the surrounding space can be transformed for public uses. These Units, utilized in vacant buildings, can build communities in hollow urban areas of post industrial cities, such as Detroit. Once taken apart, the Unit is easily transported in a moving van and can be re-installed in another space, allowing the owner to take their home with them if they move. This project challenges current platforms of living bringing the transportability of a trailer to the urban fabric; existing buildings in multiple cities can be readied for Units allowing owners to rent space for their home.

Sources:

[http://www.dezeen.com/2010/06/13/interior-living-unit-by-andrew-kline/ (accessed 13th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

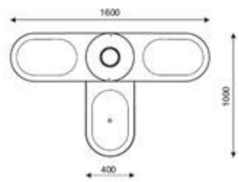
Name: Vertebrae vertical bathroom

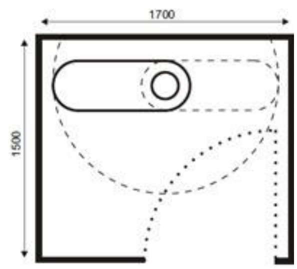
Author: Design Odyssey Co

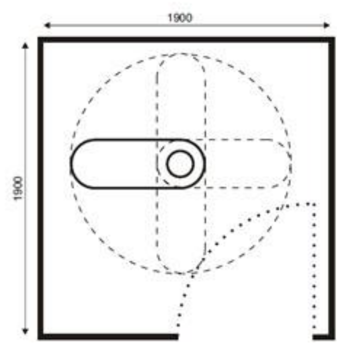
Location:

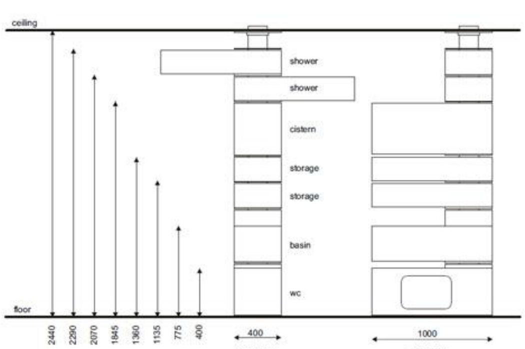
Year: 2008

Photo’s:









Sources:

[http://www.apartmenttherapy.com/verterbrae-vertical-bathroom-h-67578 (accessed 12th June 2013)]
[http://dornob.com/7-functions-1-fixture-modular-metal-bathroom-design-idea/#axzz2W6lfMpsI (accessed 13th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

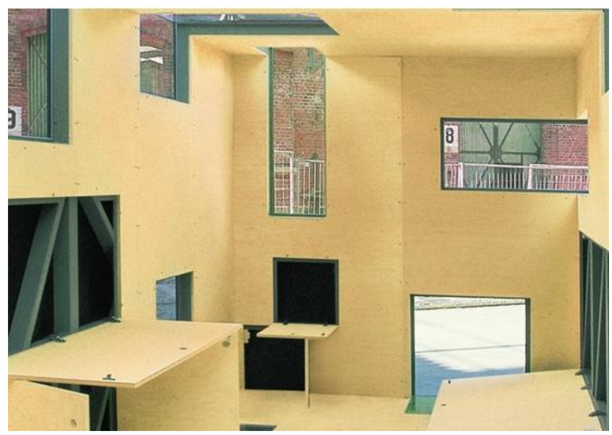
Name: Rucksack house

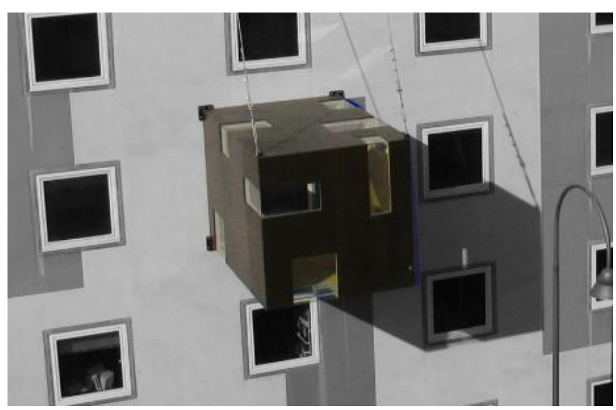
Author: Stefan Eberstadt

Location: *Leipzig and Cologne*

Year: 2004

Photo's:





Sources:

[http://inhabitat.com/stefan-eberstadts-rucksak-house-provides-instant-space-light-for-a-cramped-apartment/rucksack-house-stefan-eberstadt-7/ (accessed 12th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

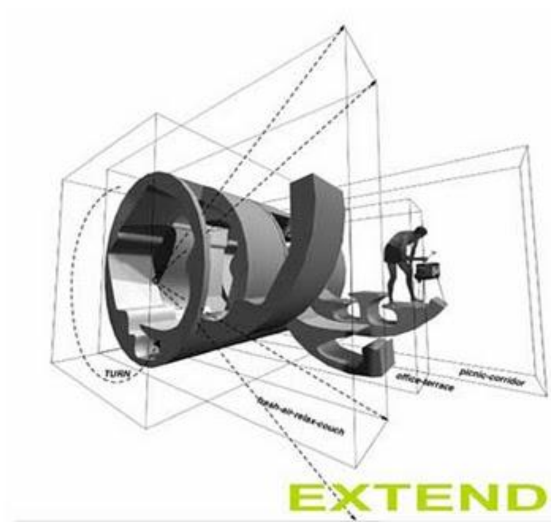
Name: Turnon

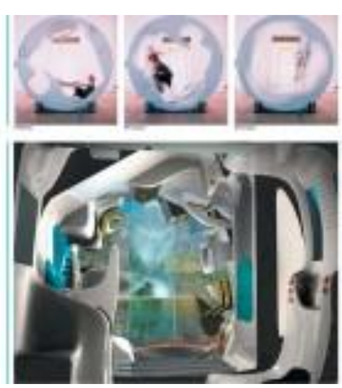
Author: Alleswirdgut

Location: Austria

Year: 2005

Photo's:





Sources:
[http://blog.kineticarchitecture.net/2011/05/turnon/ (accessed 1st August 2013)]

Time context: **2000+**

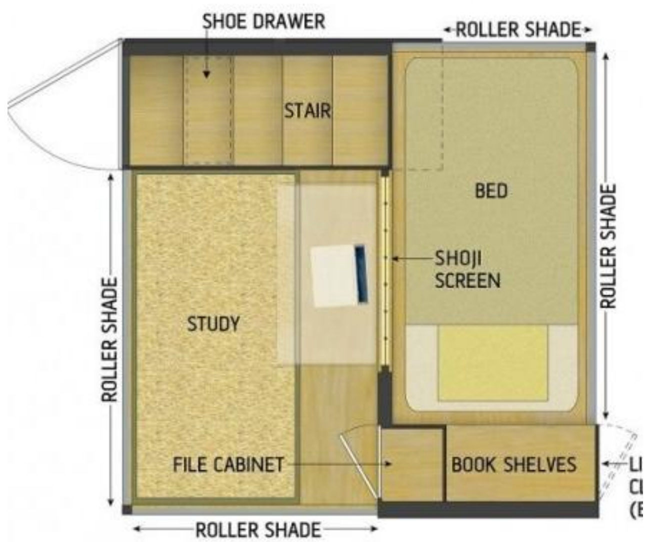
Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Mobile Living Space

Author: SpaceFlavor

Location:

Year: 2012



San Francisco architectural firm SpaceFlavor has gone zen for their latest project, a prefab mobile living space that's designed to correspond with certain principles of *feng shui*. Like a matryoshka doll, the modest cubic structure can be easily partitioned or swiveled along its base to creates sub-rooms within a larger, encompassing living area. Commissioned by Bay Area feng shui expert, Liu Ming, the eight-foot plywood cube has room to accommodate an office, a bed, storage and a meditation space. The modular design allows Ming to reconfigure his loft while ensuring that his personal space is kept intact. To minimize space and allow for easy relocation, the steel frame and plywood pieces were prefabricated to fit through a standard 3-foot wide door and designed to be assembled on-site with regular DIY tools. The cubic form conceal two sliding doors/walls, translucent roller shades, and casters that allow Ming to orient the cube in relation to the Chinese lunar calendar.

Sources:
[http://www.architizer.com/en_us/blog/dyn/49473/the-art-of-micro-living/ (accessed 13th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: DOC – SOFA INTO BUNK BED

Author: CLEI Srl

Location:

Year:

Photo's:

Sources:

[http://www.superconsciousness.com/topics/environment/space-saving-furniture-design / (accessed 30th June 2013)]
[http://www.clei.co.uk/ (accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: ULISSE DESK – DESK TO BED AND BACK AGAIN

Author: CLEI Srl

Location:

Year:

Photo's:

Sources:

[http:/ http://www.superconsciousness.com/topics/environment/space-saving-furniture-design / (accessed 30th June 2013)]
[http://www.clei.co.uk/ (accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: NUOVOLIOLA 10 – SOFA WALL BED DESIGN

Author: CLEI Srl

Location:

Year:

Photo's:

Sources:

[http:/ http://www.superconsciousness.com/topics/environment/space-saving-furniture-design / (accessed 30th June 2013)]
[http://www.clei.co.uk/ (accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Goliath

Author: RESOURCE FURNITURE

Location: NEW YORK

Year: 2012

Photo's:




Sources:

[http://www.resourcefurniture.com/space-savers/space-saving-tables/goliath (accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Voila

Author: RESOURCE FURNITURE

Location: NEW YORK

Year: 2012

Photo's:

Sources:

[http://www.resourcefurniture.com/node/488 (accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Scala Zero

Author: RESOURCE FURNITURE

Location: NEW YORK

Year: 2012

Photo's:






Sources:

[http://www.resourcefurniture.com/seating/dining-chairs/scala_zero (accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Kenchikukagu

Author: atelier OPA

Location: Japan

Year: 2008

Photo's:

Sources:

[http://clickobra.com/design/moveis-multifuncionais-para-aproveitar-ambientes-pequenos (accessed 30th June 2013)]
[http://www.spoon-tamago.com/2008/09/19/kenchikukagu-by-atelier-opa/ (accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Klopf Klopf

Author: Johannes Häuser

Location:

Year: 2013

Photo’s:




Sources:

[http://inhabitat.com/klopf-klopf-multifunctional-furnishing-turns-into-a-kitchen-unit-desk-bookshelf-or-wardrobe/klopf-klopf-johannes-hauser/(accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Itbed

Author: It Design

Location: Zurich

Year: 2006

Photo's:

Sources:
http://inhabitat.com/itbed/ (accessed 3rd July 2013)]

Time context:	**2000+**
Typology:	**FURNITURE UNIT / COMPONENT / MODULE**
Name:	‘1.6 SM Of Life' Desk Turns Into A Compact Bedroom
Author:	Studio NL
Location:	New York
Year:	2013

Photo’s:







Sources:
[http://inhabitat.com/studio-nls-transforming-1-6-sm-of-life-desk-turns-into-a-compact-bedroom/ ˙(accessed 3rd July 2013)]

Case study no.93

Time context: 2000+

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

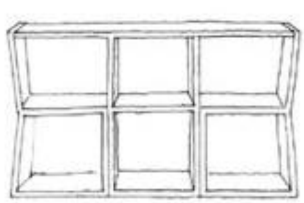
Name: Trick

Author: Sakura Adachi for Campeggi

Location: Milano

Year: 2010

Photo's:



Sources:

[http://www.furnime.com/multifunctional-furniture-for-small-spaces-trick-by-sakura-adachi-for-campeggi-003026.html (accessed 30th June 2013)]
[http://www.sakurah.net/collection/trick.html (accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

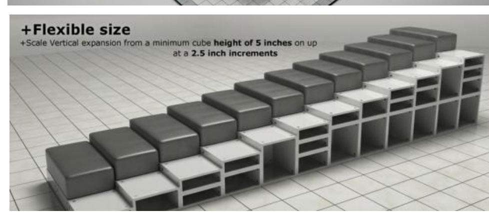
Name:

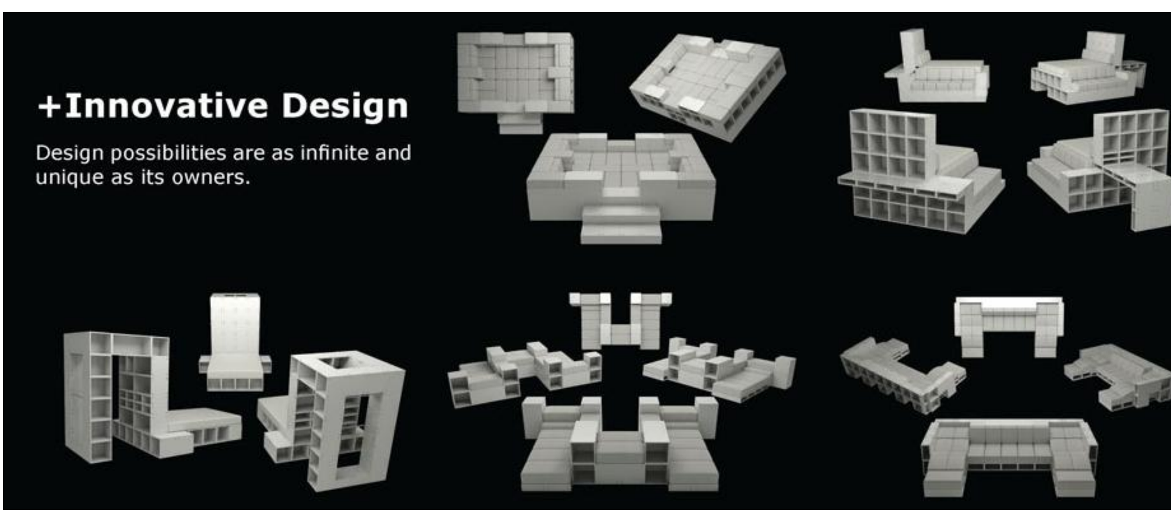
Author: Tetran Infinite Living

Location:

Year:

Photo’s:





Sources:

[http://decoholic.org/2012/11/25/multi-functional_furniture_designs/ (accessed 30th June 2013)]
[http://tetranliving.com/ (accessed 30th June 2013)]

Case study no.95

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: DoubleSpace Kitchenette

Author: Vestal Design

Location:

Year: 2006

Photo's:

Sources:
[http://inhabitat.com/vestal-designs-convertible-kitchenette/ (accessed 3rd July 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

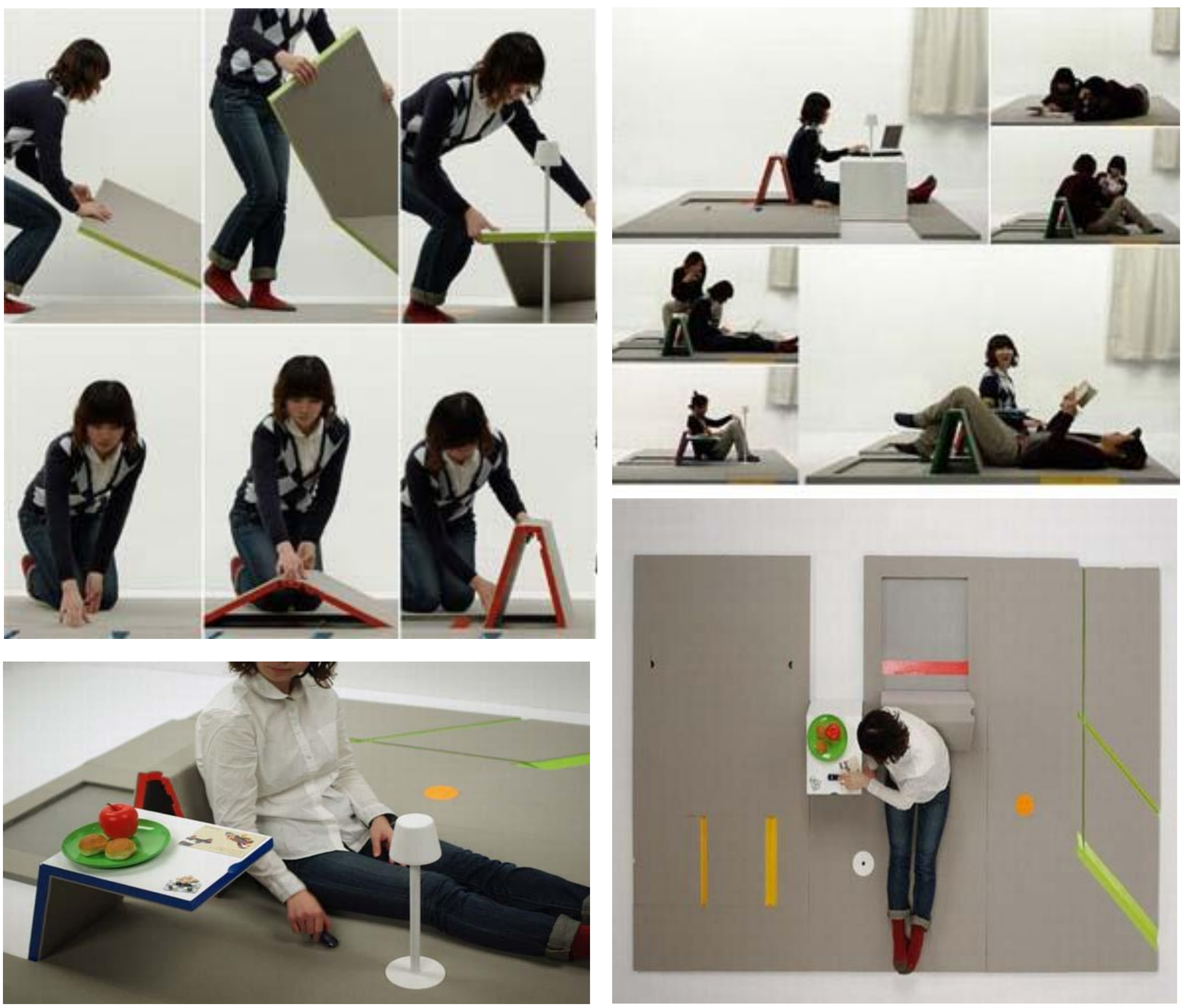
Name: Land Peel

Author: Shin Yamashita

Location:

Year: 2010

Photo's:



Sources:

[http://www.creative-furniture.com/versatile-mat-called-land-peel-by-shin-yamashita/ /(accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Sosia

Author: Emanuele Magini for Campeggi

Location: Italy

Year: 2011

Photo's:

Two armchairs, a sofa, a sheltered and covered bed, but also a proto-living room or a hidden den.Emanuele Magini's (2011) Sosia is an object for different relaxing moments, comfortable and dynamic, fitted for everyday's life. All you can desire from a seat can be wrapped in one piece, where design plays a continuous metamorphosis game that separates, doubles up and puts together shapes and functions.

Sources:

[http://pinterest.com/pin/380061656023221406/ (accessed 30th June 2013)]
[http://www.pinterest.com/diybazaar/multifunctional-love-for-furniture-and-design/ (accessed 30th June 2013)]
[http://www.campeggisrl.it/ (accessed 30th June 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: The Living Cube

Author: Till Konneker

Location:

Year:

The Living Cube designed by Till Konneker for apartment studio without storage room. He made a minimalistic cube design with a shelf for vinyl collection, TV, Clothes and Shoes. On the cube is a guest bed and inside the cube is a lot of storage space. A house is not really flexibly but we can re-think the space and furniture inside. Useful furniture must be adapted to the needs of the user.

Sources:

[http://welldonestuff.com/living-cube-till-konneker/ / (accessed 25th November 2013)]

Time context: **2000+**

Typology: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Stealth Kitchen

Author: Resource Furniture

Location:

Year:

Sources:

[http://www.youtube.com/watch?v=Zbm43YKeH78/ (accessed 25th November 2013)]

Time context: **2000+**

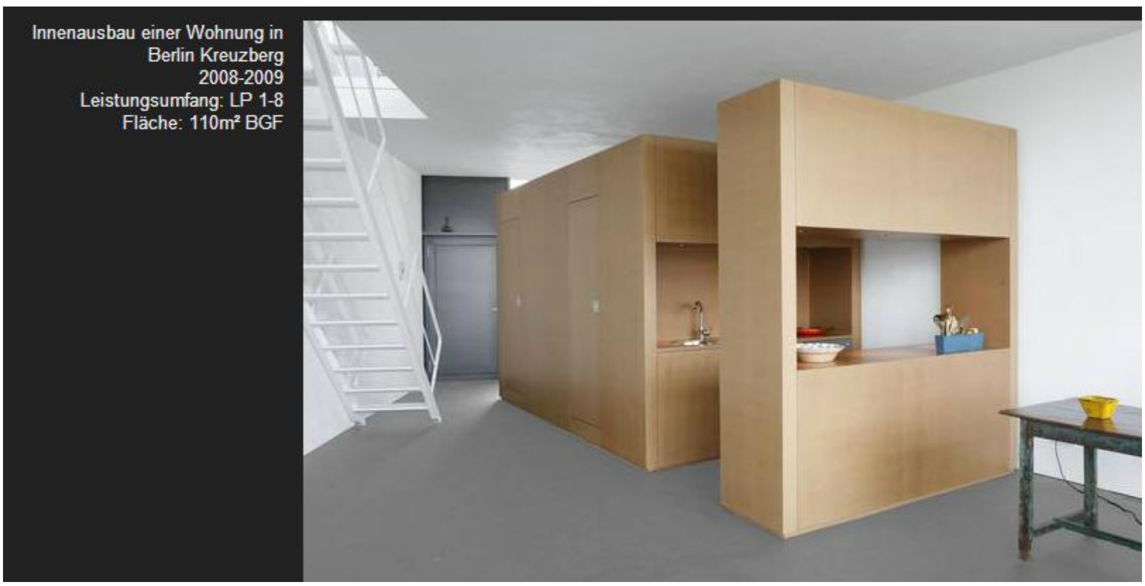
Type of analysis: **FURNITURE UNIT / COMPONENT / MODULE**

Name: Apartment in Berlin

Author: sturm-wartzeck

Location: Berlin

Year: 2008



Das umgebaute Loft ist Teil einer Wohnanlage auf dem Dach eines historischen Gasometers in Berlin/Kreuzberg. In zwei Holzkisten werden alle notwendigen Funktionen für die Nutzung der Wohnung untergebracht: Küche, Bad, Schrankraum, Bett, Regale, Hauswirtschaftsraum. Die neu erstellte Treppe verbindet als Gangway die 2 Wohnebenen und die Dachterrasse.

Sources:
[http://www.sturm-wartzeck.de/index.php?id=312 / (accessed 22th Feb 2014)]