
Adaptable dwellings



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In loving memory of Roxine.

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Introduction. The intent of this thesis is to critically examine past practices of housing design and to propose new approaches that take into consideration the vast societal and technological changes of our times. As new needs and preferences from different households arises, it becomes apparent that our society and its lifestyle's trends have been morphing at an increasing pace. Despite those facts, architecture has, apart from singular and often theoretical experiments, been slow to adapt and forcing the users to adapt instead. Housing needs a flexible structure and flexible spatial configuration to meet those rapidly changing demands.

The research will start by discussing the changes and characteristics of this new society being shaped around us. Revealing some of the impacts expected to happen on the housing market, followed by analysing Swiss statistics on housing and construction for discrepancies. Illustrated with Hardau II to show the complexity and efforts needed to modify buildings created with Rigidity in mind. Ending with a proposal for a new adaptable paradigm, based on the lessons of past attempts. Illustrated by six cases believed to have interesting ramifications and exemplify certain aspect of flexibility and adaptation interesting for our own concept to replace the rigid one actually in use. A paradigm bolstered by digital enablers to help housing in being more connected to our transient society.

A. Millennial living: Societal changes

Drivers of change. Society is transient, altered by time and in turn impacting architectural housing design. Before discussing an adaptable paradigm, it is important to have a clear picture of society today and its possible evolutions. Starting by a study on the main drivers or symptoms of societal changes. Today, family structures have evolved, a new generation is making its marks and different living accommodations have surfaced.

1. Household Evolution




























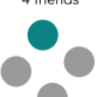

















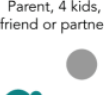


Timeline

Spirit of the past age. The rules of society have always been in a transient state of affair and architects have tried to represent those changes in buildings. Coined by the German's as "Zeitgeist", the Spirit of the age has had far reaching consequence throughout all society and refers to the general intellectual, moral and social climate of a specific era¹. Impacting the composition of families, the arrangement of our living units and up to the design of architecture. Prominent examples feature Art deco in its attempts to express the aesthetic of modern innovations such as the automobile and Brutalism linked with the turmoil of Post-second world war period and the fast-paced urbanisation².

Architecture expresses our society. Yet, it is our belief that the majority of architecture follows an old approach to housing design as our society has moved on. The changes have accelerated exponentially in the last decades with many factors such as the widespread use of social network and increased connectivity, the western political decline and the increased awareness on sustainable design³. Mainstream architecture has a tendency of running behind and is having problem adapting itself to those factors.

The "Zeitgeist" has a wide impact and our interest lies primarily in the housing's evolution, as such, concentrating our first part on societal changes with the greatest impact: the household composition.

Common family types

ONE-PERSON One-person household 	NUCLEAR Married couple 	NUCLEAR Married couple, kid 	NUCLEAR Married couple, 2 kids 	NUCLEAR Parent, 1 kid 	COMPOSITE Householder, friend or partner 	NUCLEAR Married couple, 3 kids 
NUCLEAR Parent, 3 kids 	COMPOSITE Householder, non-relative 	EXTENDED Householder, sibling 	COMPOSITE Parent, 2 kids, friend or partner 	EXTENDED Householder, parent 	EXTENDED Parent, kid, grandkid 	EXTENDED Householder, grandkid 
COMPOSITE Group of 3 friends 	COMPOSITE Parent, 3 kids, friend or partner 	NUCLEAR Married couple, 5 kids 	NUCLEAR Parent, 4 kids 	EXTENDED Married couple, grandparent 	COMPOSITE Householder, friend, non-rel. 	COMPOSITE Parent, kid, non-relative 
EXTENDED Married couple, 1 kid, 2 grandkids 	EXTENDED Married couple, 2 kids, relative 	EXTENDED Householder, kid, parent 	COMPOSITE Non-related group of 3 	COMPOSITE Married couple, non-relative 	EXTENDED Married couple, kid, parent 	COMPOSITE Group of 4 friends 
EXTENDED Married couple, relative 	EXTENDED Married couple, sibling 	EXTENDED Married couple, 2 kids, parent-in-law 	EXTENDED Parent, kid, sibling 	NUCLEAR Parent, kid, stepkid 	EXTENDED Householder, 2 parents 	EXTENDED Married couple, kid, parent-in-law 
NUCLEAR Parent, 2 kids 	NUCLEAR Married couple, 4 kids 	COMPOSITE Parent, kid, friend or partner 	EXTENDED Married couple, 2 grandkids 	EXTENDED Parent, kid, 2 grandkids 	EXTENDED Married couple, relative 	EXTENDED Married couple, 2 kids, grandkid 
EXTENDED Married couple, grandkid 	EXTENDED Married couple, kid, grandkid 	EXTENDED Householder, relative 	COMPOSITE Parent, 4 kids, friend or partner 	EXTENDED Parent, 2 kids, grandkid 	EXTENDED Parent, kid, grandparent 	COMPOSITE Married couple, kid, non-relative 

Present evolution. Traditionally, the majority of households' compositions in the last century (Post-industrialization) consisted of two married parents with one to three children. The OECD or "Organisation for economic co-operation and development" published in 2011 a study showing that worldwide, most notably in Europe, Japan, Australia and the United-States, this was no longer the case.

Since 1960, family structures have undergone significant changes with deep impact to housing and most importantly those transformations are accelerating.

The average household size has declined, falling from 2.8 persons in 1980 to 2.6 persons in 2010. Marriage rates fell from 8 marriages per 1000 people to 5 marriages per 1000 people and the average divorce rate has doubled to 2.4 divorces per 1000 people in the same time period. There are no children anymore in over half of those households. Those born out of wedlock have seen their numbers triple, passing from 11% in 1980 to 33% in 2007. Meaning that today 10% of all children live in reconstituted households, 15% with single-parents and even 6.5% living with their grandparents. [OECD, 2011]

It is vital to keep track of those changes in household and family structures as they have a direct impact on the housing needs, both with the type of accommodation and the housing stock. As seen, before planners were primarily concerned with the needs and preferences of families with children. Today, they have to take in account the needs and preferences of several different types of households. One of them being the much higher demand for smaller living units caused by the growth in the number of single-person household, many of them elderly.

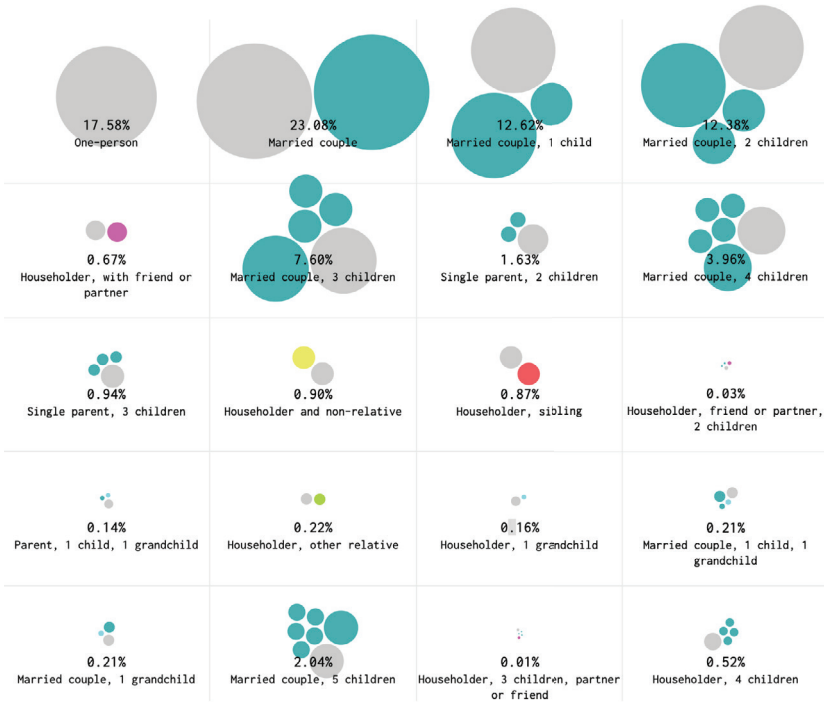
Some general trends show also higher rates of female participations in the labour market, rising and longer enrolment in education, growing numbers of elderly, higher number of foreign-born population and so forth.

Future implications. An increase in networks of loosely connected family members from different partnerships and generations is expected to emerge, with a new approach to cohesion and solidarity. Intergenerational transfers taking different forms and in consequences changing social services, welfare and fiscal management and helping instil family values in mainstream society.

Fast-moving technologies and innovations in social networking are expected to continue to revolutionize society, even if its future impacts remain to be seen.

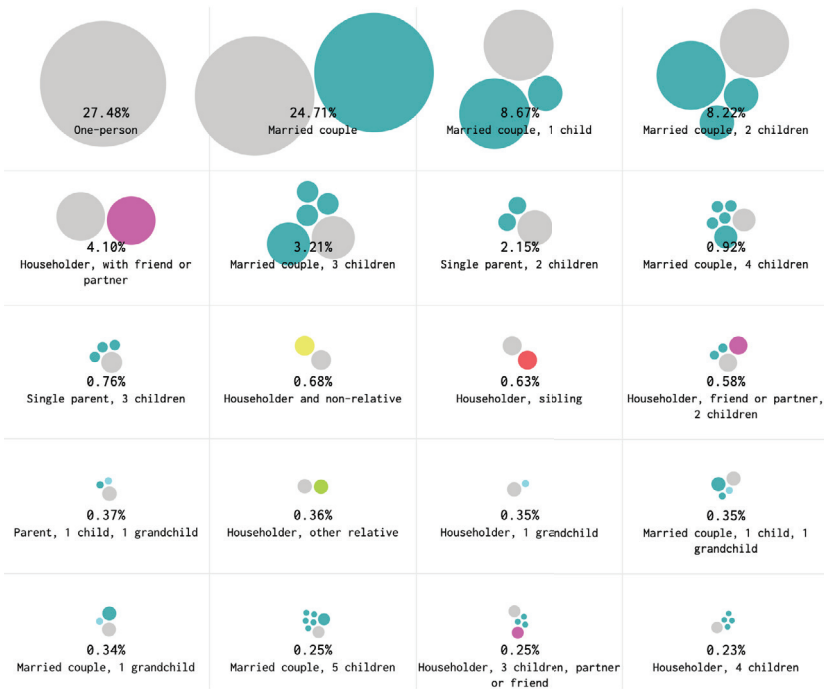
Mobility will be increasingly important for family cohesion as more single-person households, more divorces and reconstituted families, a growing share of elderly "ageing in place" in rural and suburban areas, point to long distances between family members.

The OECD report proposes that: "*In housing policy, there is considerable scope for public authorities to influence family formation and intergenerational solidarity, for instance through the encouragement of a sufficiently large rental sector, through making home-ownership more accessible for young couples, by encouraging communal forms of living such as shared housing, co-housing, multi-generational housing etc, as a means of fostering family interaction and supportive networks between generations, and delivering innovations in the design and equipment of homes more suited to ageing in place. For low-income groups, mixed generation communities offer considerable potential for informal care for children and the elderly, at low direct and indirect cost. For example, by allowing informal carers to better split their time between care shifts and part-time work. In shared housing and neighbourhoods' communities, informal care settings for non-family elderly and children can be supported with smart ICT (Information and Communication Technologies) programmes to manage care schedules.*" [OECD 2011]



Household distribution 1970

Household evolution 2016



2. Millennial Generation

As time passes, major households composition shifts and generations changes. A new generation is having greater influence on Western way of life, as they are also arriving at an age where they will have important impacts on housing. This generation is nicknamed the "Millennials" and this chapter will be studying our own idiosyncrasy and the impacts they have on today's societal structure.

Megatrends

Population category. As of 2018, the population can be categorized in five different groups: The Silent Generation (65+ y/o), the Baby Boomers (50-64 y/o), the Generation X (35-49 y/o), the Millennials (21-34 y/o) and the Centennials (15-20 y/o). Each having different ways of life. For understanding Millennials, it is also important to understand that our 21-34 y/o definition still covers a huge range of the population, and the youngest of the group isn't identical with the oldest one.

As such, the characteristics defining Millennials are a complex interaction between their life stage and the period of history they reside in. Two core causal factors seem nonetheless fundamental in defining this generation, their economic and technological context.

Economy. Western Millennials have matured in a context of economic uncertainty and stagnation. The employment struggle and financial strain is delaying important phases of adulthood, with visible symptoms over various characteristic. Effects such as later marriage, later child-bearing age and staying longer with parents and longer in education. The economy is of course not the only causal factor behind those delays, as cultural reasons, such as the decline in societal pressure to marry, also have an impact.

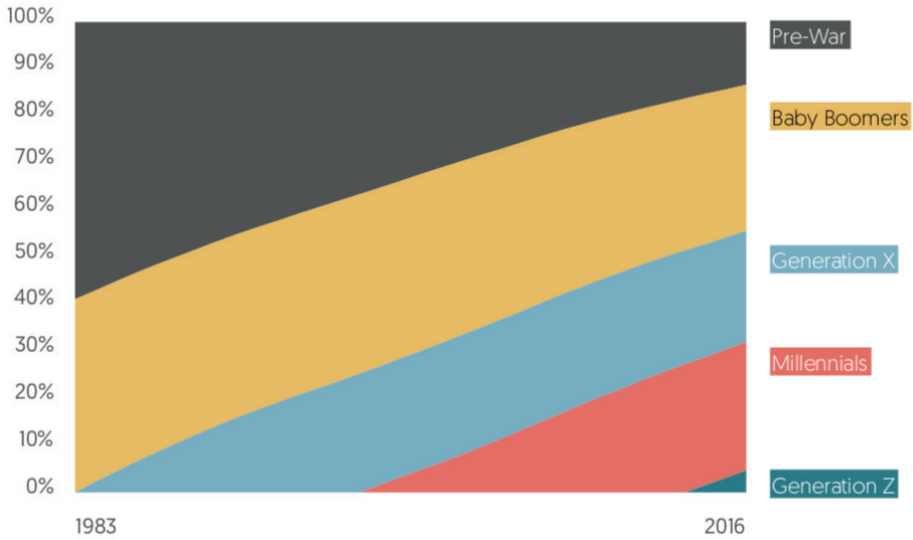
Technology. The changes in pace experienced in the last thirty years have made digital tools and connectivity more commonplace and more advanced for millennials than the previous generation at the same age. Technology, so important in everyday life, has helped shaped a different generation entirely. Nonetheless, there is no clear "Native vs Original" separation, but instead a steady gradient of differences. This leads to breaking the generation into sub-divisions, based on their relationship with technology, with for Millennials: Digital Natives (up to 24 y/o), Digital Guinea Pig (25-30 y/o) and Original Millennials (31-34 y/o).

Importance of Millennials. All of them have entered adulthood; making them as big, if not yet as economically imposing as the precedent generations. Worldwide, this importance is due to the growing presence of emerging markets with a population of much younger profile. In established economies, Millennials match the demography of the Baby Boomers and by including the emerging markets, with African adults being half (49%) composed of Millennials, they easily supplant them.

The UN projection of 2015 states that the Millennials are the largest adult generation worldwide, with 36% of the global adult population aged between 20-34 y/o, exceeding the Generation X, the Baby Boomers and the Silent Generation.

THE GENERATIONAL MAKE-UP OF THE UK

Proportion of UK adult (18+) population from each generational grouping



GLOBAL MILLENNIAL POPULATION

Proportion of global adult (+20) population from older age groups

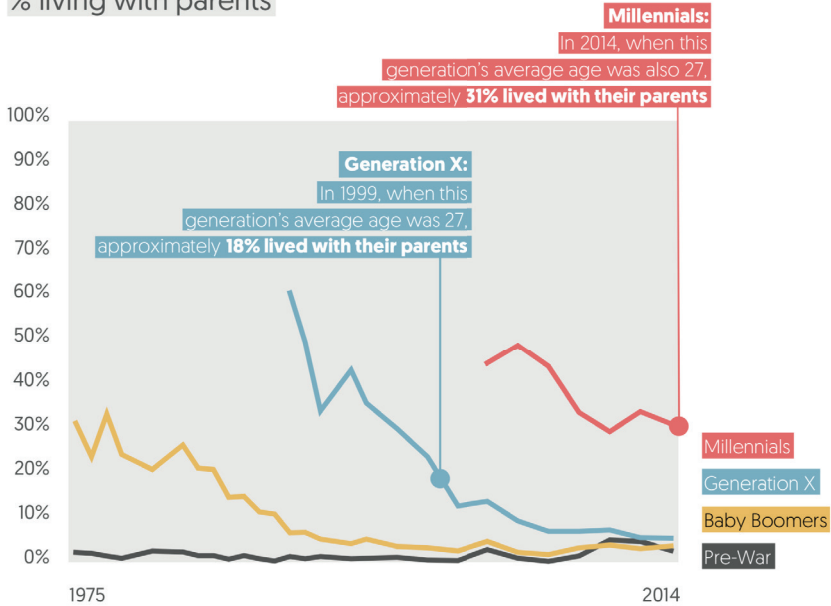
2015 ADULT POPULATION	WORLD	EUROPE	NORTH AMERICA	OCEANIA	LATIN AMERICA/ CARIBBEAN	ASIA	AFRICA
MILLENNIALS (AGED 20-34)	36% 1.8bn	25% 147M	28% 75M	32% 9M	38% 157M	37% 1.1bn	49% 284M
OLDER (AGED 35+)	64% 3.1bn	75% 438M	72% 193M	68% 18M	62% 258M	63% 1.9bn	51% 294M

Implications. As seen, Millennials are going to have a major impact on our society with important differences from previous generations linked to those two megatrends:

- In established market, their disposable income and pay haven't increased as fast and, in certain places, shrunken compared to the previous generations, making them financially worse off.
- Due to increase opportunities such as traveling and a greater need for self-reliance with the lack of help from the state, they're not saving enough for retirement.
- They live well into adulthood with their parents
- They do not move into home ownership as fast as previous generation
- They have a better education, with impact on tolerance, expectations and openness, yet less trusting of people.
- Different view of ownership especially in the case of media.
- They are not more connected than other generations, but spend more time online and have a bigger variety of activities online, in particular for creating their own content.
- More identify as LGBT

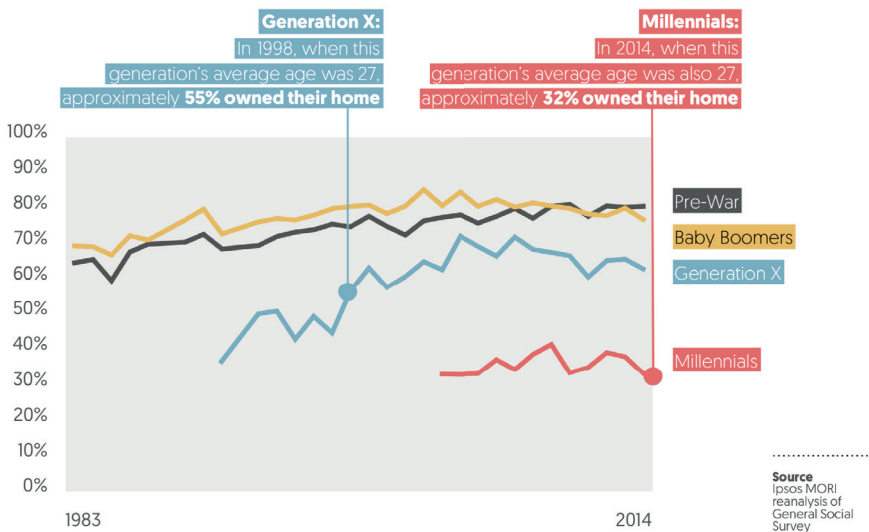
MILLENNIALS IN THE US ARE MUCH MORE LIKELY TO LIVE AT HOME

% living with parents



MILLENNIALS IN BRITAIN ARE MUCH LESS LIKELY TO OWN THEIR OWN HOME

% living independently who own their own home/paying off a mortgage



Money

Income stagnation. The OECD report has shown us that Millennials in established economies are worse off than their parents. Other reports go as far as calling them “the Unluckiest Generation”^{xx} and as being “financially screwed”.^{xx} Partially caused by a mix of structural explanations (Long term stagnation of the west and the shift of power towards the East) and cyclical effects (2008 crash impacting their first career positions), yet with real impacts.

An analysis by the LIS (Luxemburg Income Study), shows that income for those ages 25-29 y/o have stagnated since the seventies compared to the incomes of older people. The salary progression of Millennials has even been stunted in comparison to Generation X and the Baby Boomers,^{xx} with an average decrease of 10'000.- CHF in their twenties in comparison.

Assuming this bad start will impact lifetime earnings, Millennials are at risk of being the first generation to earn less than their parents over their working lives. An optimistic projection, professes the average Millennial would earn a 7% increase in comparison to Generation X, who themselves has a much bigger increase in comparison to the Baby Boomers. A more pessimistic projection professes a decrease of 1% in comparison to Generation X over their lifetime.

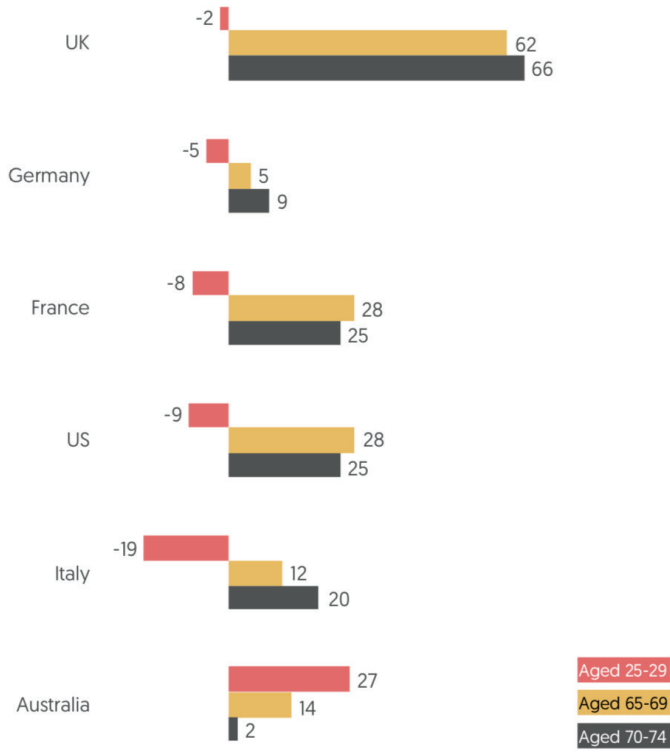
The Intergenerational Foundation^{xx} attributes this increase in the financial gap between old and young since 2008 to:

- an ageing population and the resulting increase in the cost of pensions
- increasing government debt
- increased housing costs
- higher youth unemployment
- underweighting of public policy that may help them, due to lower levels of voting turnout.

Implications. The financial context is both tougher and more complicated than for previous generations. Millennials are much less optimistic on the future compared to their predecessors. There is a feeling that the best is behind and the worst is just waiting to come. The economic impacts on Millennial's housing can already be felt.

MILLENNIALS' DISPOSABLE INCOME HAS SHRUNK

Growth in disposable income above or below national average %



.....
Source
 Guardian
 analysis of
 Luxembourg
 Income Study
 data

Housing

Frozen out of housing market. Homeownership tends to express a social identity, mostly depending on the future owners' financial position and as we've seen, the Millennials generations is really badly placed. Whatever the cause this new trend has earned them the new nickname as "the Rent Generation." ^{xx}

The decline in home ownership is clearly visible in younger adults, over different countries. In previous generation, the pattern usually showed a marked increase in property possession as they grew older; yet it is not the cause for ours. By the age of 27, more than half (55%) of the Generation X had ownership. Nowadays, just a third (32%) of Millennials do.

Home working. Another factor is also the way Millennials work. Firstly "Job-hopping", even if not as rampant as imagined with only 38% of this generation desiring frequent job change, the instable market with the help of social communication favours trying different companies before settling in. This reinforces the renting decision as stability is uncertain on the long run.

As Millennials become more and more fluid in their relation with work, staying for shorter times employed in the same company, another trend is rising. More and more Millennials in the study (75%) find working from home more appealing than staying in the office. Even if this decision can raise questions of its effects on working environment, it is also a factor that impacts housing design. Incorporating a small office for an employee, isn't the challenge, but in bringing in clients and separating private from public is.

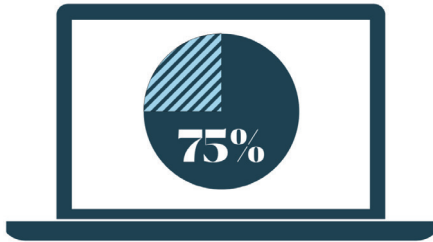
Bespoke Identity. The desire to customize and to express one's identity, is spreading to housing design. As objects owned influence our identities as well as expressing it to others, consumerist have latched on this need for uniqueness with acquisition of goods for the purpose of developing and enhancing one's self-image and social image. When housing is seen as a consumer good, it also causes the same desire to express oneself.

In addition, Ikea has shown that mass produced elements still permit expression of oneself by clients as long as there is enough choice to create a combination they believe is theirs. A trend accelerated by the digital technologies, as discussed later:

Implications. Profound shifts have been seen in housing with this generation, as staying longer with their parents and being pretty much locked out of ownership, has impacted greatly the way they live and how they will develop. As in short-time it has already impacted consumption and financial behaviours and, in the long-run, might change the traditional pattern of lifecycle for established societies.

In different countries around the world, exists different approach to living accommodations and looking elsewhere, for places where having home ownership isn't the norm, will offer other perspectives

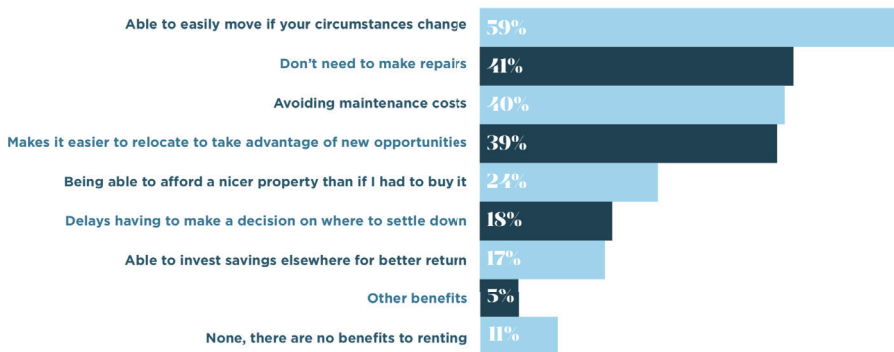
Millennial opinions on housing



MILLENNIALS THAT WOULD LIKE TO WORK FROM HOME AND RISK "NOT INTERACTING WITH PEOPLE IN PERSON"



57% OF MILLENNIALS CONSIDER INVESTING IN PROPERTY OVER THE NEXT FIVE YEARS WHERE THEY LIVE TO BE 'HIGH RISK'.



IN YOUR OPINION, WHICH OF THE FOLLOWING ARE BENEFITS TO RENTING INSTEAD OF OWNING THE PROPERTY YOU LIVE IN?

3. Living accommodations

With a general idea of societal shifts and evolution, it is interesting to peak in the offers for living. With new trends, there are various way to inhabit a home, various typologies and each impacts the inhabitants and their lifestyles in different ways. It is also correct to believe that certain households are better suited for particular typologies, may that be economically or social.

Ownership

Buying. Ownership of his home is one of the marks of success in Western society. It can be ownership of different typologies, but generally considered to be that of an independent housing. As presented earlier, buying a house is becoming increasing difficult for the millennial generation.

Renting. Costing less than outright buying, renting as known by the act of paying for a temporary use, has the other advantage of offering much more flexibility to the users. As such, this has been appealing to a majority of millennial, earning them the nickname "The rent generation"

Guest room/ Nesting. Living with family or friends is an alternative that more and more millennials are resorting to. Be it staying with the parent for longer periods as education continues to lengthen or returning home, as the boomerang generation, unable to sustain a household.

Housing typologies

Detached and semi-detached housing. Generally present in the suburbs, they represent the western ideal of living. It requires a lot of maintenance and high cost, yet offers more liberty to express oneself

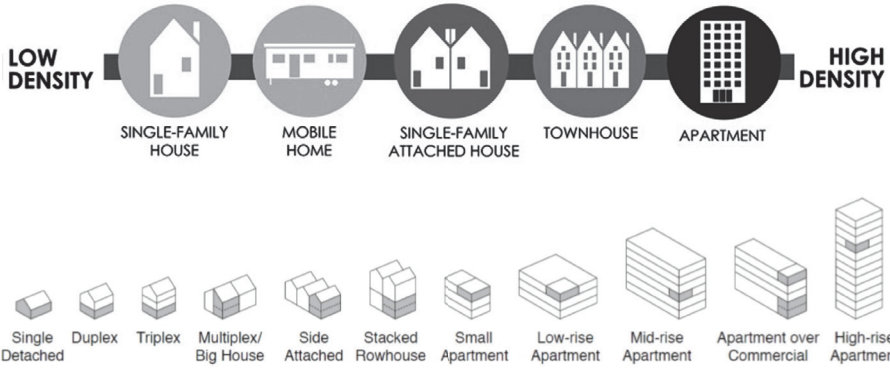
Multi-residential. Single units in larger buildings or community shared with others. Few opportunities for expression, yet less costly and sometime offers other amenities.

Co-Housing

An interesting trend has appeared, or more precisely reappeared, in the Millennials way of live. Co-housing has found a new development. It is not entirely unsurprising, if the trends discussed previously are taken in consideration. As more and more people chose or are forced to live alone, co-housing appears as an interesting alternative to single apartments. Driven by young professionals in cities, who may be more digitally connected yet feel lonelier than ever:

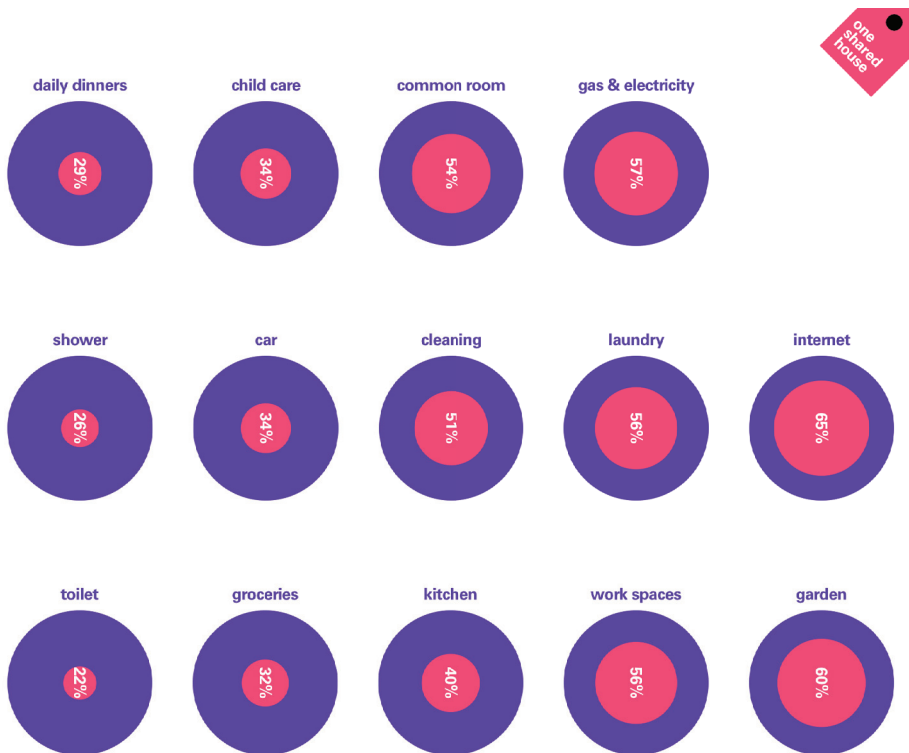
One Shared House. A research was made on the subject, specifically showing the desire of younger generation with 85% of respondents being 18–39 y/o. Below is the list of points they believe should be implemented inside a co-housing community based on the survey's they made:

- city based
- access to multiple homes that could easily be move between
- co-living community designed by people with a design background
- common areas to come furnished and private space to be bespoke
- private and communal spaces with clear boundaries of use
- shared internet, self-sustainable garden and workspaces
- communal kitchen for more flexible private space
- open to pets
- 4-10 as the right amount of people for a community
- 10-25 people for communities of couples with children
- energy costs expenses based on the amount of energy used per person
- extra pay for a service layer to manage all house related items



Housing typologies

One shared housing, sharing tolerance



Socially, it would mean:

- members share equal ownership of the house
- new house-members to be selected by a consensus vote
- House-members qualities: neat and tidy, honest and socially at ease
- composed of single women, single men and couples
- most worry is to deal with other people's mess
- conflicts settled by talking privately
- house-members from different walks of life
- no previous co-living experience needed

Implications. At first, the main advantage of co-housing would seem to be a splitting of the bills permitting to live in otherwise unaffordable neighbourhood and saving spending money, as students do when in university dorms. Yet this survey clearly shows the biggest benefits for people would be the social life it creates. As discussed before with the societal changes, single-occupancy households are increasing in low, middle and high-income countries creating more loneliness than before.

In designing co-housing facilities, it is important to note that the majority of people would prefer a distinct separation between shared and private space with the capacity to adapt their private space to their desires, but have common areas furnished by designers, offering architects different ways to plan accommodations.

The desire for homeownership is interestingly still present for co-housing with equal ownership between inhabitants and the right to vote on new members. A model few shared spaces actually offer.

Co-housing seems to be a flexible way to create future housing with shared facilities being rigidly designed and private spaces adapting around to the needs of more transient inhabitants.

4. Conclusion

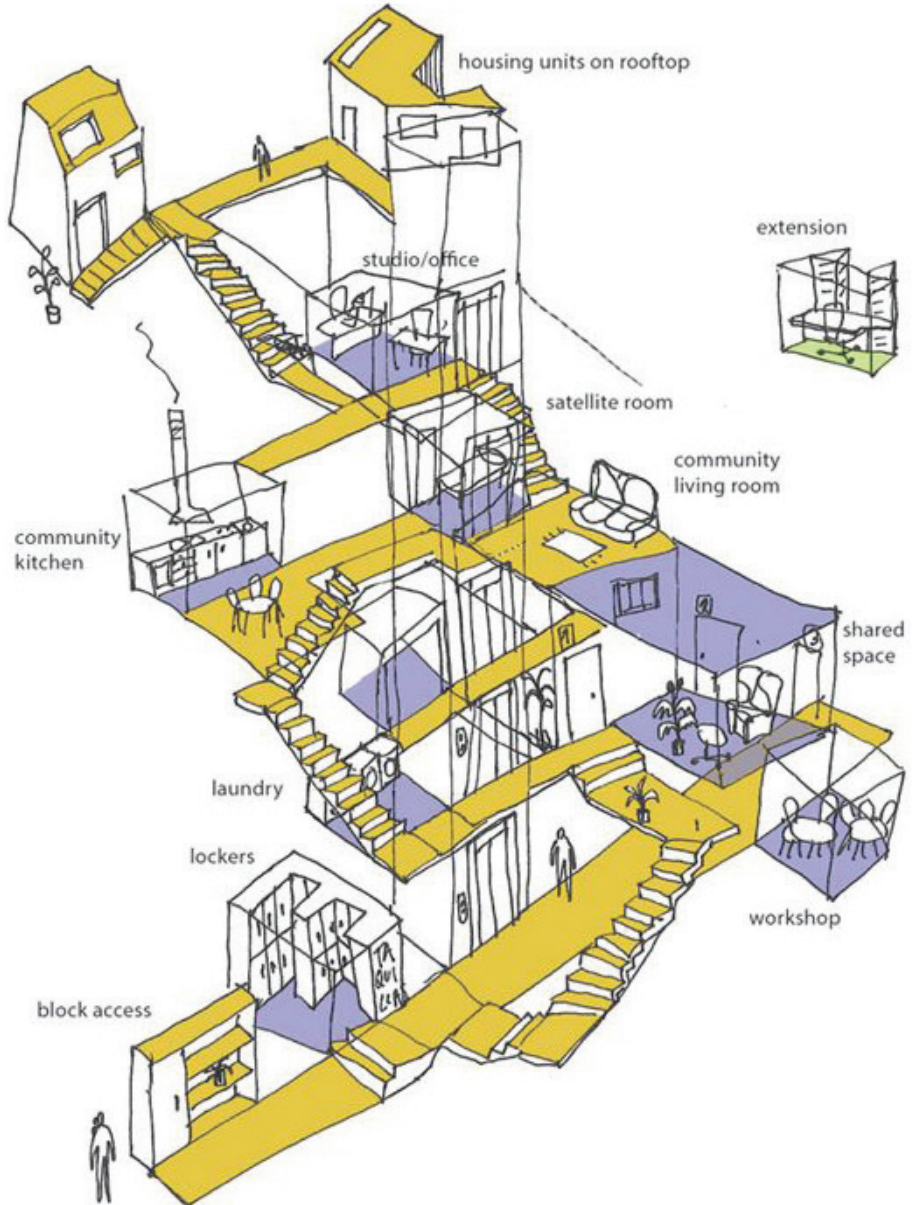
This first chapter has shown us some of the societal changes of this last decades. Household compositions are losing cohesion, recomposing and generally growing smaller, with less and less children and an increase in single-households.

Housing prices are rising and incomes have failed to keep up. Our next generations are getting poorer and spending more time in education with greater uncertainties on what the future holds for them. This leading once again in putting off important life milestone and creating the "Unluckiest Rent Generation" with its renewed interest in co-housing as a mean of homeownership.

Vital issues not only as millennials dictate current and future trends, but as the world adds another 1.2 billion people over the next 12 years, increasing the pressure on the housing market.

The fabric of society is more fluid and diverse than ever, and the question to ask ourselves, is if the available architecture can take in account those accelerating trends for housing. As so, the next chapter will question the way construction is handled and its implications to housing.

Co-housing, public and private separation



B. Swiss Rigidity

As every country has particularly idiosyncrasy, this chapter is moving from worldwide megatrends to single out Switzerland. Firstly, as a wealth of data is available at demand thanks to the Federal Office of Statistic. Secondly as the aim is to propose a project based in Switzerland for next semester:

1. Household Statistics

Megatrends. The general trend in Swiss residency surveys, shows that in 2016, the majority of the population (84.6%) lived in Urban Areas. Half of them living in the five big agglomerations: Zurich, Geneva, Bale, Bern and Lausanne

The age population structure is really important, as its "Pine shape"^{xx} shows that the predominant generation was born between 1950 and 1971. The younger generations having dramatically decreased in size. As so, the part of elderly population (65+ y/o) is expected to exceed 26% in 2045. Which, as explained before, will have a great impact on Switzerland housing composition.

Household Composition

Evolution. The main question pertains to past household organizations, the subsequent evolution and its cause in the Swiss context.

Swiss population has tripled in sized since 1850 (2.4 to 8.3 million inhabitants), yet interestingly enough, in the same time period, the number of households has grown more than seven times higher (500'000 to 3.6 million units). A growth accentuated in the last part of the 20th century and linked to the fundamental structural changes discussed in the last chapter:

In this period, the number of small households has increased, as bigger households have seen stark decline. To be precise, since 1920, household compositions have evolved as following:

- 1-person households, at first the smallest number saw a marked acceleration in quantity between 1930 and 1960 before becoming the most numerous types in 1990.
- 2-person households composed the majority of Switzerland between 1941 and 1980 before stagnating.
- 3-4-person households have been steadily growing while staying relatively in the middle of the pack in quantity.
- 5-person households have slightly grown before stabilizing in 1970
- 6-person households, once the most numerous have been steadily decreasing, with an accelerated decline between 1960 and 1980.

Causality. The cause of these changes outlined above are linked with worldwide megatrends.

Firstly, the diminished size of households was caused by purely demographic factors associated to the decline in fertility and the life-expectancy's increase. Lower fertility means less children being born, so a steady decline in the number of children per couple is seen and increased life-expectancy means more elderly are living with a partner or alone.

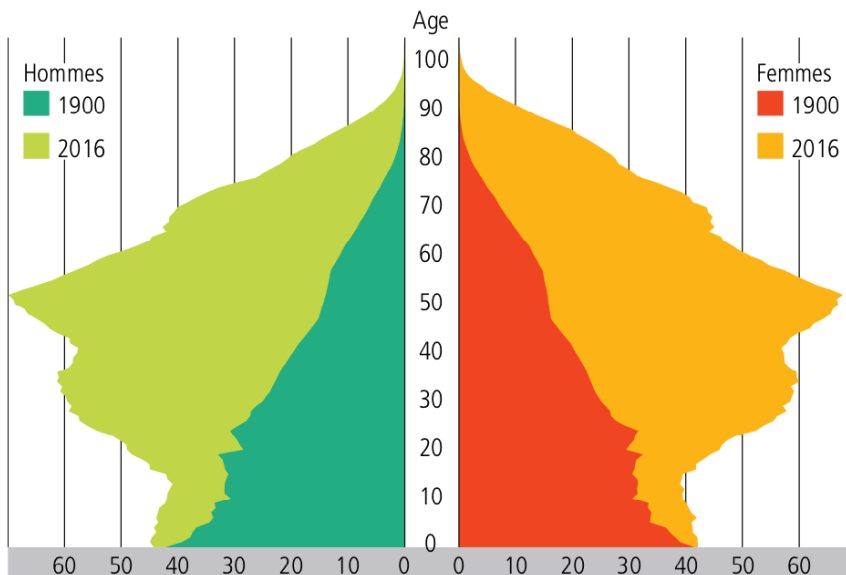
A la fin de l'année	Total en milliers	Etrangers en %	Urbaine en %	Densité par km ²	Croissance 2010–2016 en %
Suisse	8 419,6	25,0	84,6	210,5	7,0
Zurich (ZH)	1 488,0	26,6	99,3	895,9	8,4
Berne (BE)	1 026,5	16,1	74,6	175,8	4,8
Lucerne (LU)	403,4	18,4	63,8	282,3	6,8
Uri (UR)	36,1	11,9	88,4	34,2	2,0
Schwytz (SZ)	155,9	20,7	82,0	183,1	6,2
Obwald (OW)	37,4	14,7	27,4	77,8	5,0
Nidwald (NW)	42,6	14,2	50,7	176,3	3,7

Permanent residents per canton 2016

Permanent city residents in 2016

	Ville		Agglomération	
	en milliers	Croissance en % 2010–2016	en milliers	Croissance en % 2010–2016
Zurich	402,8	8,0	1 354,1	8,4
Genève	199,0	6,1	585,4	7,5
Bâle	171,0	4,8	545,3	4,6
Lausanne	137,8	7,8	415,6	9,6
Berne	133,1	7,0	415,5	6,0
Winterthour	109,8	8,4	140,2	7,9
Lucerne	81,6	5,3	228,3	5,8

Age distribution structure in 2016 per thousands



Secondly, nuptiality and the family founding processes have also seen changes. As visible on the graph, less people are moving through marriage (95% to 55% in 50 years), reducing the percentage of couple with or without children. The family founding average has moved up from 26 to 30 years old in average in the same timeframe, accentuating the change.

Finally, with higher divorce rates (13% to 50% in 50 years), mono-parental families are on the rise.

Implications. In the same trend as worldwide social changes, household are fragmenting and becoming smaller. At the same time, elderly living will start to put pressure on the housing market, as clarified in later chapter.

Household Living conditions

Lifecycle. Household types and lifecycle are related: as a child, one lives with his parents, sometimes with only one of them; Then there is usually a period of solitary living, followed by a consensual couple. Marriage and children precede the "Empty nest" syndrome. Separations, divorces and premature deaths lead to single-parent households, which can lead to familial recompositions. Then comes widowhood and solitary life, mainly concerning elderly women, and finally for some the move to a collective household.

This lifecycle means the housing market needs to offer varied household types to its population. In Switzerland, household types are mainly composed by:

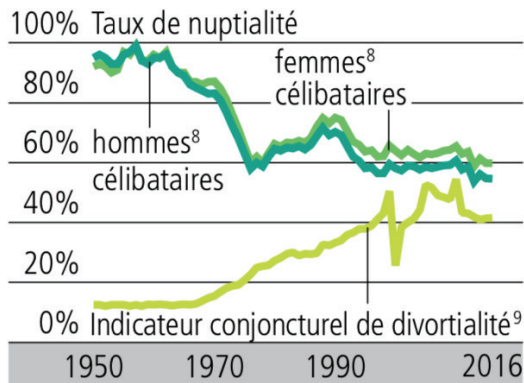
- 47% solitary living
- 30.4% couples
- 17% couples with children
- 4.6% single parent with children
- 2% collective housing

Even if households of single persons make a bigger percentage of households, they only represent 16% of the total population. Families with children represents 51% of the population. By dividing the 51% of population with at least one parent and one child into sub-category, the tally ends with 3/4 of those being married parents living with children, 1/7 being mono-parental and 1/29 living in recomposed families.

In the future, households need will continue to increase, as population continues to grow:

- 31% for the 1-person household
- 26% for the 2-person household
- 12% for the 3-person household
- 10% for the 4-5-person household
- 14% for the 6-person household

But not all at the same rate, as smaller household's will be subjected to bigger increases. The reasons mentioned above will continue to expand the gap between households, reducing, for Switzerland, the median number of people in one household from 2.24 to 2,16 person in 2045.

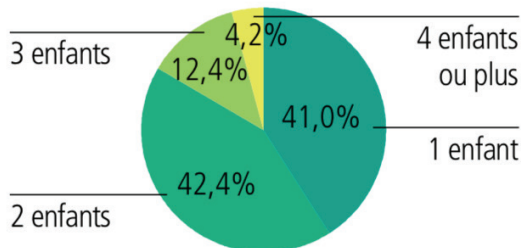


Marriages en divorce in 2015

Private households in 2015 per thousands

Total	3 623,3
Ménages d'une personne	1 273,8
Ménages familiaux	2 323,7
Couples sans enfants	995,9
Couples avec enfants	1 028,4
Pères ou mères seul(e)s avec enfants	218,5
Ménages non familiaux	80,8

Children per household in 2015



Surface per household. Several studies show that the current occupation of housing is neither optimal for the allocation of resources nor representative of the individual preferences.

A study by Tüscher realised, in 2017, that a considerable proportion of dwellings are deemed over-occupied with fewer rooms than occupants and under-occupied with at least two more rooms than occupants. Among the households of elderly people in particular (65+ y/o), 2/3 of dwellings were under-occupied. As a result of population aging, the proportion of under-occupied dwellings will certainly increase in the future.

If 9% of all dwellings are considered over-occupied, this proportion rises to 24% among the 4-person households, and to 51% among the 5-person households. On the other hand, 41% of all dwellings are considered under-occupied, including a majority of 1-2-person households.

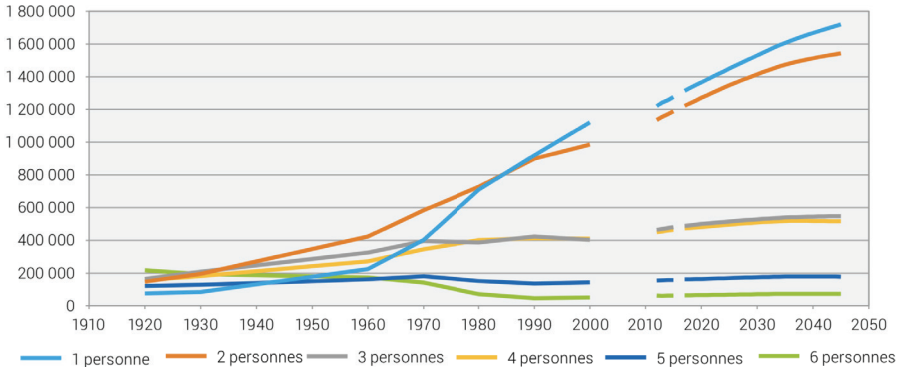
Nearly two-thirds of unattached individuals live in 2-3-rooms dwellings. This is the category with the best surface area per person with an average of 79 m², reaching 88 m² when they are over 65, but falling to 59 m² when they are less than 25 years old.

Couples without children have an average of 55 m² per person (57 m² if adults are over 65, 39 m² if under 25) and mostly occupy 3-4-room dwellings (30%).

Couples with children have an average living area of 31 m² per person. Almost half of them living in 5-rooms dwellings, while more than one-third (36%) occupying 4-room dwellings. When divided in sub-categories, the average area of dwellings occupied by:

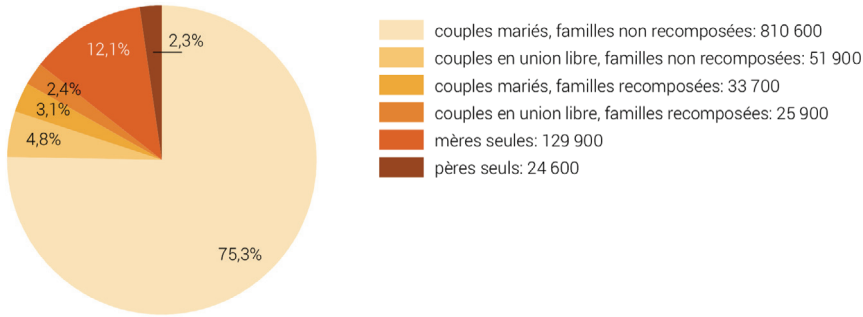
- Couples with one child is 115 m² or 4.3-rooms dwellings,
- Couples with two children is 128 m² or 4.7-rooms dwellings
- Couples with three or more children is 137 m² or 5.4-rooms dwellings.
- Single-Mothers with children occupy less space with dwellings averaging between 96 m² (one child) and 123 m² (three or more children).

Implications. Household lifecycles causes a variation in the typical needs in housing. As such, the biggest category in household population are families and the biggest in household units are solitary living. The majority (56%) of the housing units in high demand will have between 3-4 rooms.

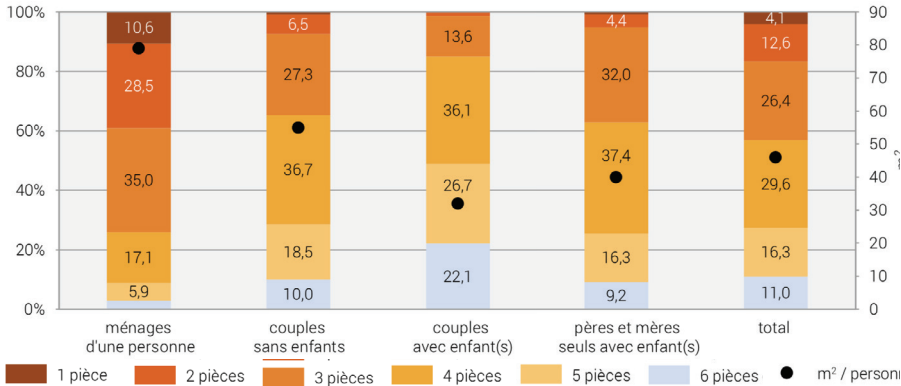


Evolution of private households per size

Households types with children



Distribution of accommodation per rooms and household



2. Construction Statistics

Megatrends

Type of housing. Comparing household statistics with construction statistics reveal discrepancy between needs and availability.

Construction of housing units in Switzerland has been steadily decreasing since 2016. It has only seen an increase in two regions: The Lemanique region (+2.8%) and Zurich (3.9%).

Same downward trend is happening for individual houses and apartments building equally. Apart with Zurich who is having an increase in individual house construction (+10.1%).

Switzerland has a varied catalogue of housing units, yet as seen on the graph, only a fourth of all housing built are multi-housing building (26.4%) with the majority of all construction being between 2-4 floors high (85.4%).

Switzerland shows preference to individual housing with more than half of all construction (57.2%), even though less than one person out of three lives in them (28%).

It is even more interesting to note that most constructions date to the last millennia (85.5%) and only a small part being built after 2000 (14.5%).

Rooms per household. Finally, the housing stock in terms of rooms available is composed mostly of units with 3-4 rooms (54%) with a quarter being bigger units with 5-6 rooms (25%) and a fifth smaller units with 1-2 rooms (20%).

The median units surface size is 99m², mostly due to the fact that most units built last millennia were much smaller than 100m². The considerable number of them impacts the total median since the post millennia median is of 131 m²

Implications. The last chapter revealed the changes of society expected to appear in the following years. It is worrying that such a big amount of those construction will not be up to the standards of living anymore, without even talking about Sustainable design. In addition, the high number of individual low-built housing causes an urban sprawl problem that is worrying urbanists.

	2016	
	absolu	en %
Bâtiments à usage d'habitation	1 730 415	100,0
Maisons individuelles	989 098	57,2
Maisons à plusieurs logements	456 752	26,4
Bâtiments d'habitation avec usage annexe	201 624	11,7
Bâtiments partiellement à usage d'habitation	82 941	4,8
Construits avant 1919	341 300	19,7
Construits entre 1919 et 1945	199 509	11,5
Construits entre 1946 et 1960	190 203	11,0
Construits entre 1961 et 1970	173 646	10,0
Construits entre 1971 et 1980	195 271	11,3
Construits entre 1981 et 1990	201 667	11,7
Construits entre 1991 et 2000	177 620	10,3
Construits entre 2001 et 2010	166 245	9,6
Construits entre 2011 et 2016	84 954	4,9

Sources: OFS – Recensement fédéral de la population 20

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Housing stock per type

Per rooms

	2016	
	absolu	en %
Logements en tout	4 420 829	100,0
1 pièce	280 968	6,4
2 pièces	623 539	14,1
3 pièces	1 186 189	26,8
4 pièces	1 222 704	27,7
5 pièces	675 833	15,3
6 pièces et plus	431 596	9,8
Avec indication de la surface (en m ²)	4 420 829	100,0
moins de 60	787 114	17,8
60 – 119	2 398 563	54,3
120 et plus	1 235 152	27,9
Occupés	3 703 419	83,8
Habités temporairement, vacants ou vides	717 410	16,2

* Les valeurs manquantes n'ont pas été imputées.

Sources: OFS – Recensement fédéral de la population :

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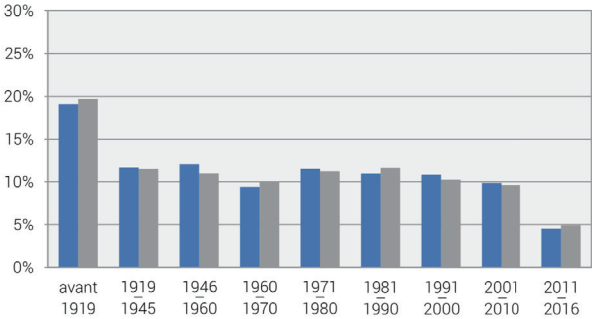
Zurich

Summary. Moving from the mega-trends of Swiss construction to continue zooming in, our interests lies in Switzerland's biggest cities: Zurich, Geneva, Basel, Lausanne and Bern. As cities are densifying, Zurich was singled out as having the biggest numbers of inhabitants (1'475'000) and the most housing construction units (730'000) between all the cantons. It also has the same problems as the rest of the country with the majority of all housing construction being built before 2000.

As seen, Zurich is having an increase in housing construction, yet there is an imbalance towards single house units (52%) at the expense of apartments building (31%). Even though the imbalance is slightly less strong than for all Switzerland.

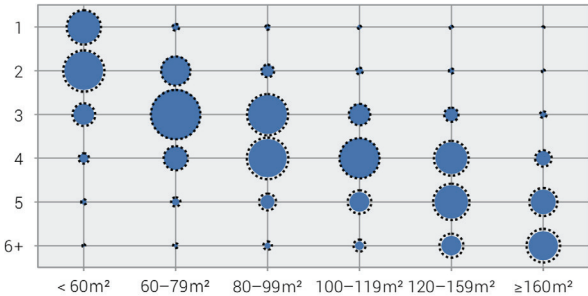
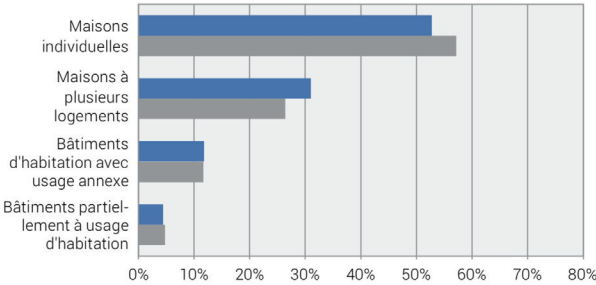
Most of the market seems to be proposing 3-4 rooms units between the size of 60-120 m². The biggest contender being 3 rooms units between 60-79m², which is in line with the rest of the country's market.

It is interesting to note that the majority of Zurich inhabitants live in 1-2 rooms units (68%), when the available market is so skewed towards 3-4 rooms (57%) and only a quarter fulfil the demands for 1-2 rooms (21%).



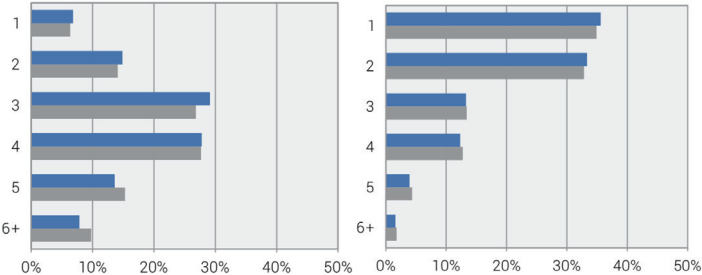
Housing stock per construction date

Per household type



Housing stock per rooms and surface

Per rooms and inhabitants



3. Case study in Rigidity: Hardau II

These numbers should enlighten on how skewed the housing offer is in comparison to the need of users, without even talking about the future trends discussed in the first chapter.

Hardau Tower is used as a concrete example to illustrate some of the problems this discrepancy is going to cause in the future. Constructed in 1976, before being renovated in 2007, it shows the defect of Rigid design.

Hardau II, situated in the Hard district, is one of the dominant landmarks of Zurich's cityscape, composed of four residential towers made out of brown-red concrete. Culminating between 72 and 93 meters high and mostly containing two-and-a-half-room apartments favouring elderly and individuals.

Renovation

Spatially. It had to be renovated after 30 years of use. The renovations were not only necessary to remedy to age-related deficiencies, mostly related to services such as the kitchen, bathroom, heating and water supply.

It was renovated because the city felt that the units spatial design was not fulfilling the needs of tenants anymore.

They combined the due renovation of the building technology with the creation of large apartments by assembling smaller units. In the lowest six floors of the residential towers, housing was created for families with small children who preferred ground-level living. Each 24 two-and-a-half-room apartments and 24 three-and-a-half-room apartments were combined into 24 five-and-a-half-room apartments. Different living spaces were created on the top two floors of the towers. There, 16 two-and-a-half-room apartments were combined to form eight spacious apartments of 130 m² each.

Technically. The total of 573 apartments in the tower blocks and the neighbouring four-storey blocks of flats were refurbished in an inhabited state, which resulted in considerable impairments in the form of noise and dust for the tenants, and for some even temporary relocations. Complaints were often made about the disruption caused by the renovations.

In itself, the entire renovation measures cost around 52 million francs.

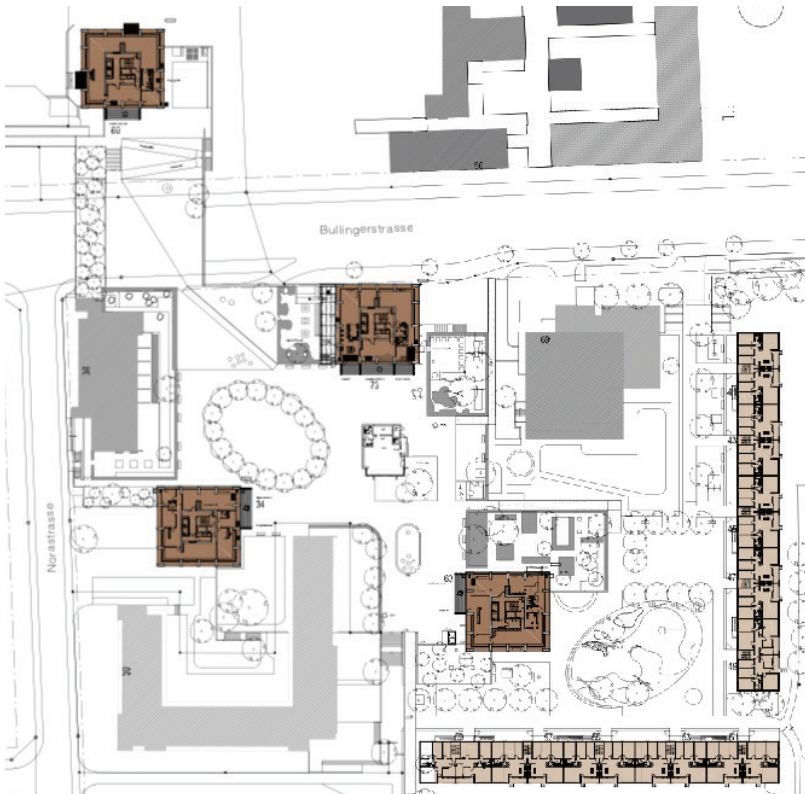
Working from top to bottom, they were able to renovate two floors every four weeks, so that the residents at least on their floor only had a construction site for a foreseeable future. New building material came from the inside with the lifts to the top, the demolition was transported via the construction site lift along the facade down.

The repairs took place without external scaffolding as the facades were not affected.



Hardau, landscape marker

Site plan



Implications

Hardau II shows the complexity and efforts needed to modify buildings created with Rigidity in mind. The cost and nuisances to inhabitants is also an important toll that needs to be taken in account. A building will have to be renovated during its lifetime, yet less complicated and costly renovations should be available.

What is worse in regard to the statistics for Millennials and the most valued units in Zurich, is that the new five-and-a-half-room units created do not fulfil future demands.

The demand will mostly be created by young people and elderly people living alone and with little money available. Currently, the most valued apartment being 3 rooms units between 60-79m² and this is subject to change. Those huge apartments will be difficult to sell, especially since 16.2% of housing units in Switzerland are already left vacant.

If those towers are to continue functioning in the future a new renovation is to be considered.

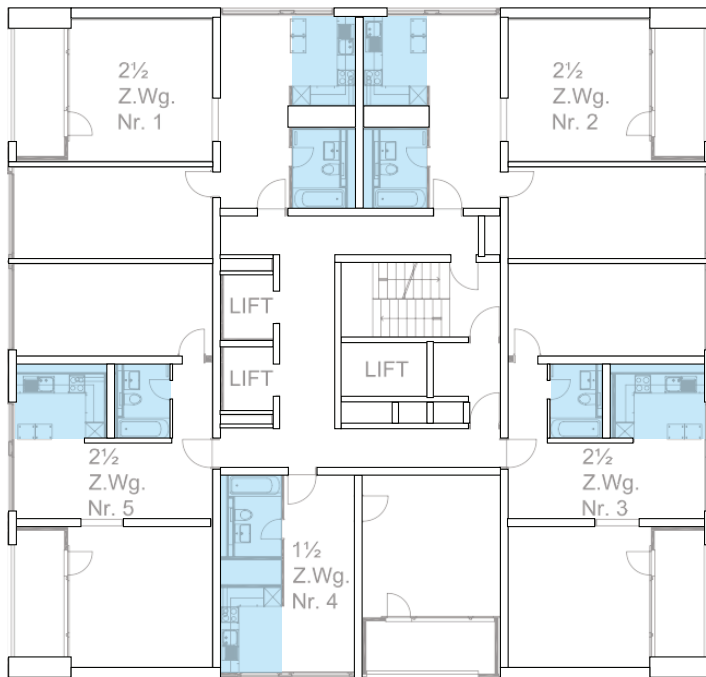
4. Conclusion

Housing units post-2000 are constructed primarily for 5-person families, yet society is moving to a majority of 2-3-person families. The old generation is retiring and a new one, much smaller is taking its place. This new generation has, as seen before, different ways of life with a propensity for 1-person households. Our housing market will soon be saturated with housing units not dimensioned for the needs of the new generations.

The case of Hardau II is a good example of what will happen in the majority of Switzerland. What's more the plans being made now, may not be relevant for succeeding generations.

Housing tries to create perennial architecture in a situation that is always transitional. It is not supposed to be building monuments to stand the test of time and generation, but to create housing fulfilling the needs of individuals at specific times for specific periods.

As such a new paradigm is needed for housing architecture.



Typical floorplan, 1976

Floorplan after renovation, 2007



C. Adaptation Paradigm

1. Architectural Paradigm

Our culture has entered an age of obsolescence where ever-changing environment and consumerism reigns. Yet architecture has stayed fixed in the old model with rigid systems design.

Limits of current paradigm: Rigidity

Modification of family organisation. Up to a point this system works. It creates affordable residences for many, but more and more people are falling off the way-line as residence no longer fill their needs.

Mainly because the classical family composition is falling apart. Different compositions of relationships are appearing and since 1970, the social background in Switzerland has moved away from nuclear families.

Nuclear family was a singular arrangement for families that took place in a period when it was easy for Westerner's young adults to find a good paying job and affordable housing. As the first chapter showed, Millennials don't have the same opportunity anymore.

Nonetheless, as the second chapter has shown us, the majority of housing fulfil the needs of this nuclear family of 4-5-persons. In addition, constructing for nuclear families is not only in the number of rooms made available but also in the way they're designed. In a simple example, most designs have a master bedroom with smaller bedrooms, which works perfectly for parents with children of younger age, but in other situations, not so well.

- Young adults living with their parents
- Elderly returning to live with children
- Recomposed families
- Shared housing
- Single dwellings
-

Societal obsolescence. In addition, housing architecture is mostly thought of as a perennial system. Perennial in its construction, rarely in its use.

Our relationship with housing is analogue to the relationship the hermit crab has with its shell. When our home has been outgrown, forced to run around to try and find another one hoping it would fit us.

In the past, permanence of architecture made sense due to a lack of change. Changes happened slowly over the course of generations and most modifications needed could be done by the owner itself with or without help from the community. Nowadays technologies, social media, mobility and environmental changes have sped up those changes. Often the design and technologies used in housing become obsolete long before the construction's lifespan is, and rigid design complexify any change possible.

New paradigm: Adaptability

Intent. This thesis' aim is to propose another direction to investigate. Not proposing a Panacea, to cure all our problems, simply another vision with other opportunities and problems to question housing and living, that can be more in touch with the new paradigms of today's society. By putting precedence on transient lifestyles cycles over the perennity of architecture, the proposal creates housing design that will more easily follow those cycles instead of forcing us to adapt.

As such, a study of adaptable and flexible architecture design is proposed as an alternative to rigid architecture design.

Transient system. House types forms over time, adapting to slightly constant environmental factors such as climate, topography and available building materials, as well as more transient factors such as social, cultural and economic conditions. The introductions of technological innovations such as renewable energy and smart systems, as well as new legislations and digitalisation also changed house types at the same time than its lifestyles. These factors are exterior influences, creating deep transformation taking places over generations of builders and users.

Housing is more than a construction reacting to outside factors. It is a place of living, from birth to death, a space for human activities, by day and night and all years long, and as such must cover all of a human's lifecycles steps.

So, a housing unit cannot be considered as rigid building, but closer to a system of ongoing activities.

The wide variety of human activities, as well as the wide range of time spent in the house emphasis on the necessity of flexibility in housing design. All of these changes affect the space requirements and predicting their changes with rigid planning is impossible. Only a flexible system is able to adapt to predictable and unpredictable changes.

Adaptability to long term factors, as mentioned can already be done, to an extent, by actual housing units. Therefore, our biggest challenge is short term adaptation with rapidly changing needs and requirements. Housing needs a flexible structure and flexible spatial configuration to meet the rapidly changing demands of today's and tomorrow's society.

Adaptable design has other advantages, as Sebastian Moffatt and Peter Russell argue that adaptable designs and materials can improve the environmental performance of buildings in at least three ways:

- *"More efficient use of space as adaptable buildings is likely to use the same amount of space and materials more efficiently, on average, over their entire life."*
- *"Increased longevity as adaptability extends the total lifetime of buildings."*
- *"Improved operating performance" [8, pp. 4-5]*

It is an opportunity of change, not by implying a new start from scratch, as it is possible to modify existing old buildings towards adaptability.

2. Concepts through case study

Six aspects. As previously mentioned, adaptable ideology is an already existent system, with different variants created other time and born from different visions on architecture.

To clarify the terms, adaptability is defined as capable of different social uses and flexibility as capable of different physical arrangements.

Trying to invent a completely new way to create adaptability is possible but it makes more sense to study what was done in the past. Synthesizing the thought processes, the advantages and inconveniences as well as verifying if those propositions could be relevant in our society and using the useful parts to create a proposition of modern adaptability at the end of our thesis.

For this, six cases believed to have interesting ramifications and exemplify certain aspect of flexibility and adaptation interesting for our own concept will be analysed.

- Sugimoto House as an example of Undefined Flexibility
- Eames House and the prefabrication approach
- Nakagin capsules tower for the Plug-in Megastructures
- Elemental and the Incremental Building
- "Home" as a study in Exquisite Corpse
- Davidsboden for its analysis on adaptable people



Undefined Flexibility: Sugimoto House - Japan

This first concept studies the Sugimoto House. A kyo-machiya townhouse of Kyoto believed to represent the mindset of the Japanese people. Built in 1743 and analysed by Arte architecture in 2007, It was recognized as National important cultural property in 2010.

It is a large town house of over 15 rooms, with a complex organization linked to the family's activities and perfectly preserved by the different family generations.

Belonging to the kimono fabric salesmen of the Sugimoto family, the building follows the "omoteya-zukuri style", therefore containing a shop with a long facade on the street, a family living-quarters and the employees' living-quarters.

The house occupies 435m² of the 1,200m² plot, (less than 2/5 of the land, as tradition calls for). With storages rooms, small gardens and courtyards filling the remainder and creating a collection of 21 roofs. Making it the largest surviving merchant house in Shimogyo ward.

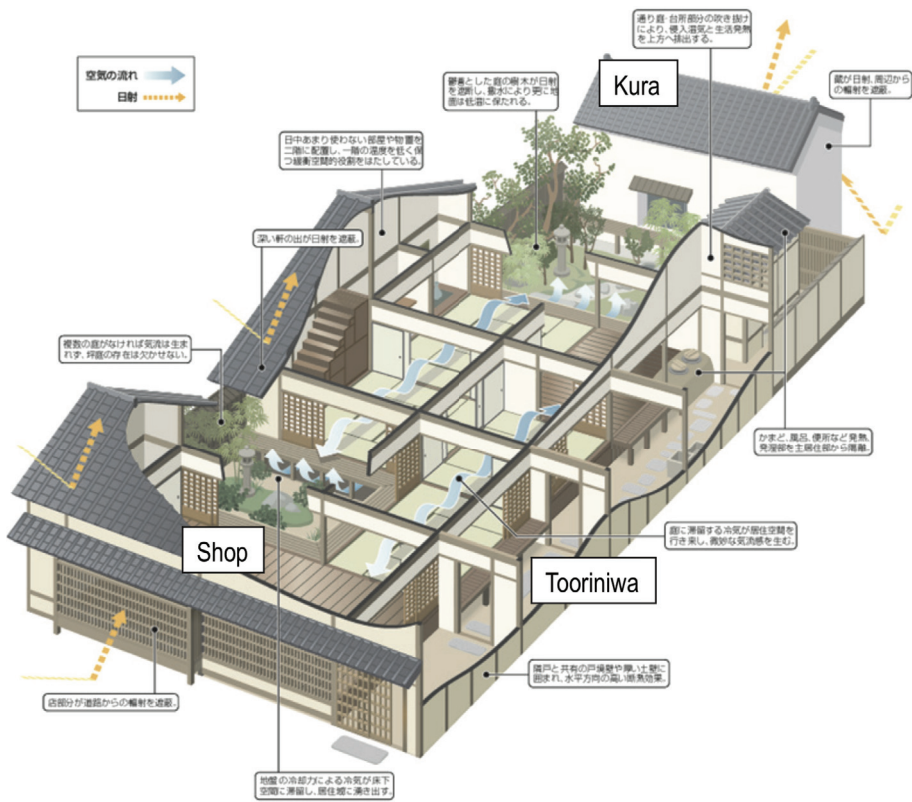
A Japanese house was chosen as our first example for two main reasons. Firstly, Japanese traditional structure inspired enormously modern western architecture and especially founding architects such as Frank Lloyd Wright and Le Corbusier. Secondly, it's principles on space, important to ruling flexibility have more hidden depth than what is available in western philosophy such as the 5 points of architecture.

- The house a wide wooden skeleton built with pillars supporting the roof structure (Yane). All is assembled with intricate woodwork permitting flexible change (sukiya-daiku).
- Tatamis (straw mats), Shoji (translucent divider) and Fusuma (opaque divider) are flexible elements in the standardization of structure and space. Based on human's dimension, the combination of them creates different space compositions.
- There are no rigid walls but sliding panels (shoji and fusuma). Built with paper frames that slide along grooves in the floor and beams, they facilitate change in spatial organisation and permits seasonal changes. It is simple to take one off and insert a new one more adapted to the weather and social situation.

This concept is coined "Undefined Flexibility". The structural elements discussed creates flexibility, yet undefined mainly come from the way space is expressed and used.



Shoji as spatial organiser
Typical machiya axonometry



Spatiality. Space is defined differently here than in Western civilization. For westerners, space is closer to a hollowed cave, the emptiness surrounded by solid. For Japanese, it is called Ma, the void and emptiness between two solids. Be it the space between two pillars or the pause between two notes to create a rhythm.

There are no walls, no windows, rooms are simply placed side by side. Not always of the same size, but with no distinctive features and no qualifications.

The space is defined only when furniture is present, and in the same day, each space can change its function. The dining room, defined by the low table, can become the bedroom. The table is stowed and a futon is simply brought out from the cupboard.

Functions of space are undefined but not without meaning. Underlying the space, appears invisible codes that hierarchies the use of space. This space becomes flexible and fluid, a transitional space.

Those invisible codes follow a strict hierarchy over space, determined by the nature of the ground and the cardinal points. Mostly based on Zen Buddhism which states the North-East as being unlucky and West as the staying place of paradise.

This logic forms two main axes perpendicular to one another:

- East to West (Ke to hare) as a progress from the mundane to the sacred. It positions in succession the kitchen, the dining room, the receptions area and the sacred altars.
- North to South (oku) as a progress of depth, from public space to private space. It scales the nature of the area and measures the importance of visitors. The biggest and most important space being at the rear and open on the garden. Customers staying in the front shop and eminent guests are invited to the rear of the house.

Thresholds are of importance as the interspace that dialogues between the house and the surroundings. They are created by the veranda (engawa) as well as the crisscross of translucent and opaque screens.

Key elements. Japanese have a long tradition in adaptability, or to be precise in the appreciation of transience expressed by time and season. It is even more visible in the art of tea and gardens, yet still intrinsically tied to housing architecture.

From this concept, the skeleton structure closed in by transient sliding panels is of interest, as well as the intricate woodwork that permits a flexible assembling without rigid fixation.

What is needed to be worked upon is the composition of the sliding panels. Acoustically and thermally, they perform poorly under any Swiss regulations, yet clipping in place interior separations is an action that lends well to flexibility.

It is also needed to find a way to make the art of wood joinery much more streamlined, efficient and less costly if it is to be integrated it into modern architecture

Undefined space works well for small housing units with needs for efficiency in usage. For it to work for bigger units, where normally each room is specialized would depend on tenants.

In addition, underlying the space with invisible rules would help in organizing rooms, especially for concepts such as "Elemental" discussed later. Even though Zen Buddhism traditions rarely applies to Western Interior design, the act of codifying movement through space will help in designing harmonious architecture.



Sugimoto house, entrance courtyard

Undefined floorplan



Prefabricated: Eames House - California

Engineers aesthetic. Modern architects, impressed by the possibilities of industrial technologies, embraced a new, modern aesthetic. Ushering a new era characterized by "the aesthetic of the engineers", an architecture embracing the aesthetic of industrial materials and production techniques. They believed in a house that was economical, functionally efficient and conducive to modern living standards.

It is of note that this led to a particular style of construction: prefabrication, where buildings are treated as a factory product. Each piece fabricated in factory before being shipped on site. This created a disconnect with the majority of architects as it transformed their timeless art into a factory produce product.

Californian Modernism. Charles and Ray Eames' design is linked with "Californian modernism", also called "Mid-century Modernism". It opposes the Bauhaus style of "social conscience" by being more expressive and with warmer design, as well as being more in touch with the reality of local commerce [Hawthorne, 2011].

According to the article, "Mid-Century Modern", "*This style emphasized creating structures with ample windows and open floor-plans with the intention of opening up interior spaces and bringing the outdoors in. Warmth was emitted with the consideration of color, texture, and other materials utilized in the construction and expression of the Eames' designs. Moreover, this design style illustrates the concept of "form follows function" both in materials and space planning, as there was an emphasis of addressing the needs of the average American family*" [Mid-century Modern..., n.d.]

As such, prefabrication is a system enabling rapid constructing of parts for a housing unit. Speed of creation and reduction of costs are a key part of anything linked to adaptability.

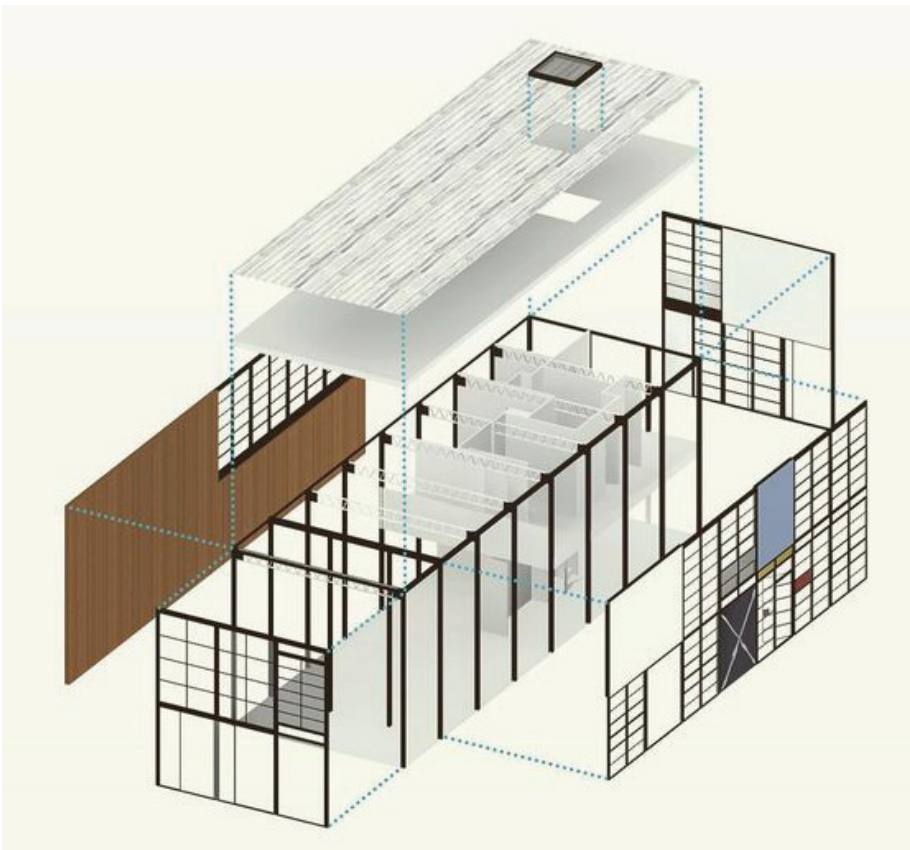
As such prefabrication mainly appears under those types (Gibb, 2001):

- Stick and Panel; processing of industrial elements to reduce site labour.
- Panelized; complex assemblies fabricated into panels for ease of transportation, including elements such as services and insulation, reducing work on site.
- Modular (or volumetric); structurally self supporting or load bearing volumes enclosing whole sections of buildings, typically fitted-out with services, fittings. Modular construction is often combined with panelization.



Eames house, exterior

Structural exploded axonometry



The Eames House. Also known as Case Study House No. 8, it is a landmark of mid-20th century modern architecture located in Los Angeles. It is considered one of the most significant experiments in American domestic architecture.

They envisioned a living laboratory that presented a bold development in off-the-shelf housing. Demonstrating that standardized factory-made components didn't mean sterile, endlessly replicated static designs, but instead could result in a flexible kit of parts that could allow architects to more playfully and efficiently explore an endless combination of creative housing options. [Paul J. Armstrong, 2009].

It consists of two glass and steel rectangular boxes: one is a residence; one, a working studio.

The structures are aligned along a central axis with a court between the two structures, and a parking/utility spot on the Studio far side. Each block has a mezzanine balcony overlooking a large central room. Public and private spaces are naturally defined by visibility.

Structure. Industrial materials were used extensively, using an innovative home building system that relied on a standard kit of parts.

Panels resembling Mondrian paintings were attached to the prefabricated materials within the house. At the same time, a Japanese theme is clearly expressed in the construction and spatial opening of the house.

"The facades are essentially black-painted grids (consisting of eight 7.5 foot bays for the House and five for the Studio), with different-sized inserts of glass (clear, translucent, or wired), grey cement panels (both painted and natural), stucco (off-white, black, blue, and orange/red), aluminum (silver or painted) and specially-treated panels (gold-leafed or with a photographic panel). The transparency and translucency of the glass combines effortlessly with the painted colors and wood finishes." [Eames foundation, 2018]

Key elements. The attitude on prefabrication is predominantly about reducing costs. In this example, it not whole building made but part. Discret elements in their size creating a building. Now standardize but more flexible. Separating skeleton from the rest seems to be a descendant of Japanese traditional architecture with addition of technology to help in construction.

Mass produced housing has transformed into mass customization, in response to a qualitative increase in human needs.



Eames house, living room

Floorplan



Plug-in Megastructure: Nakagin capsules tower - Japan

The concept named Plug-in dates from an illustration of Le Corbusier, done in 1950 for his "Unité d'habitation". Even if it wasn't the way the construction was finally done, the Wine Rack inspired successive architects.

In the 1960s, Archigram magazine proposed individual buildings and entire cities made of prefabricated components attached to fixed infrastructures. Plug-in City, designed by Archigram's Peter Cook, had an infrastructure with rail-mounted cranes that would install and replace prefabricated housing and other modules planned for obsolescence.

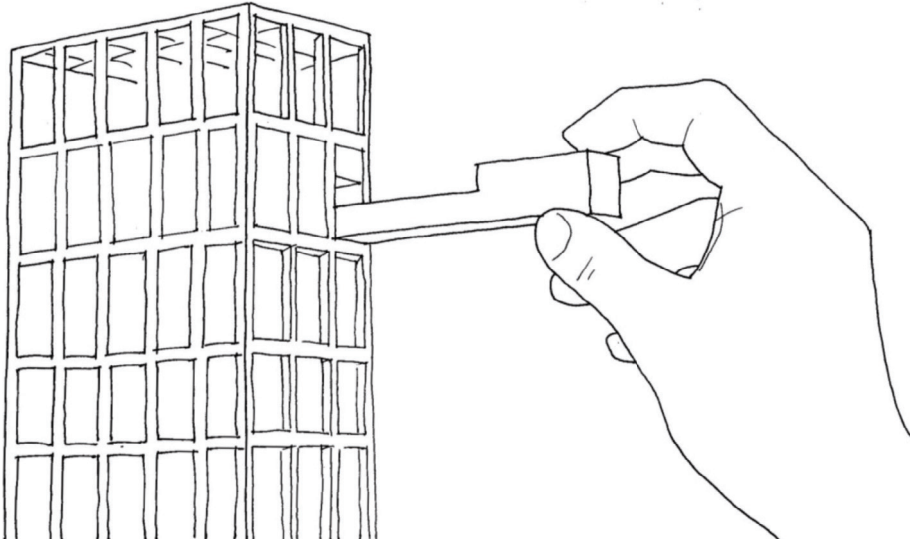
The following building concept comes from the "Metabolism", a parallel movement in Japan sharing many of Archigram's ideas.

Metabolism. It follows the notion of the city as an organic process, a city that grows, transforms and dies like a living organism. For this, they distinguished between permanent elements and transient elements. This metabolic system inspired design characterized by permanent megastructure and transient individual units attached to it.

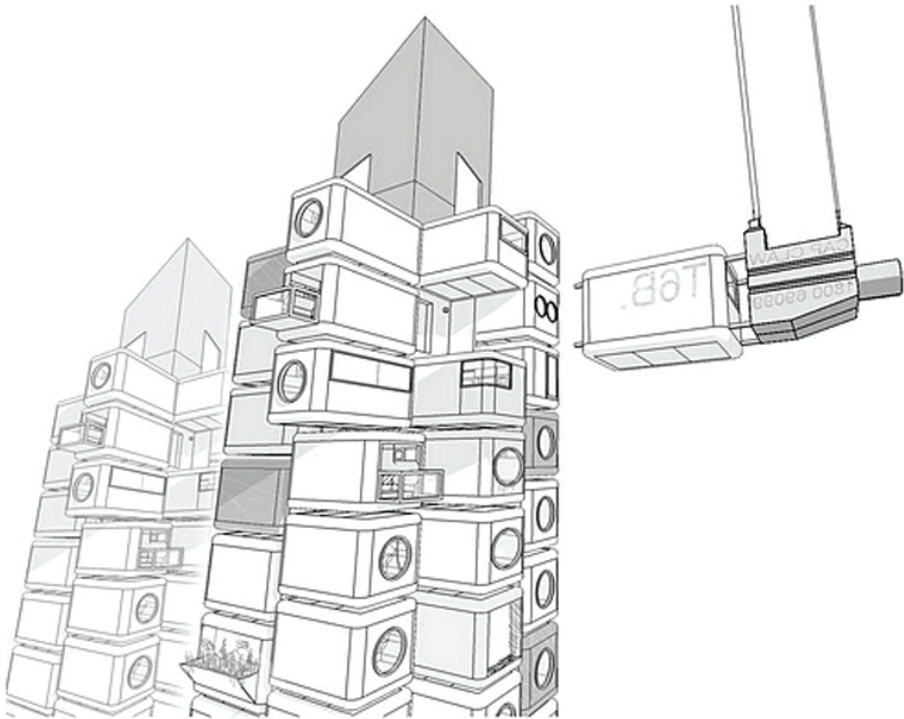
The megastructure or framework generally ended with open joints, giving the buildings an unusual silhouette and suggesting the incompleteness and expandability of the structure. The transient units were often portrayed as being prefabricated boxes.

The concept was originally more inclined towards Urbanism than Housing, yet the themes can be transferred from city size to building size. Personally, the separation between transient and perennial in Housing makes more sense, than trying to solidify urban infrastructure in a 3D grid.

The analyse is on one of the rare buildings created in this period and believed to best encapsulate the metabolism concept.



Wine rack, Le Corbusier
Nakagin tower; capsules installation



Nakagin Capsule Tower. Built by Kurokawa in 1972, it is a symbol of the Metabolism movement, as it showcases their essential idea of adaptability and replaceability.

The building consists of two towers of eleven and thirteen stories covered by 144 capsules. Each capsule, the size of a shipping container, houses a residential unit clipped to the towers with flexible joints.

The metabolic cycles are visible and divide the building in three basic components:

- The permanent structure composed of 2 concrete shafts holds the vertical transportation. Envisioned to last for 60 years.
- The transient and moveable elements composed of 144 capsules holding the living units. Expected to change every 25 years.
- The service equipment holding the utilities. Replaced after 10 years in average.

The incomplete look of the tower, helped by random placement of capsules and the protruding shafts, creates what Kurokawa named the aesthetic of time.

The capsules were prefabricated off-site before being bolted to the shaft. In theory, this permitted to take them out and replace them easily. The lifespan was tied to the changes in human needs and social relationships instead of the mechanical lifespan of the other elements.

The design was aimed for the emerging "urban nomads" and the increasing mobility of the industrial era, which explains the compact size of the capsules (2.5m-4m-2.5m).

The interior was designed as an industrial marvel in technologies. Installation are in-built with an integrated bathroom in the corner, a bed underneath the porthole window and appliances and cabinets along the other wall. The appliances can be hidden in the cabinets when not in use, creating a designer-controlled flexibility.

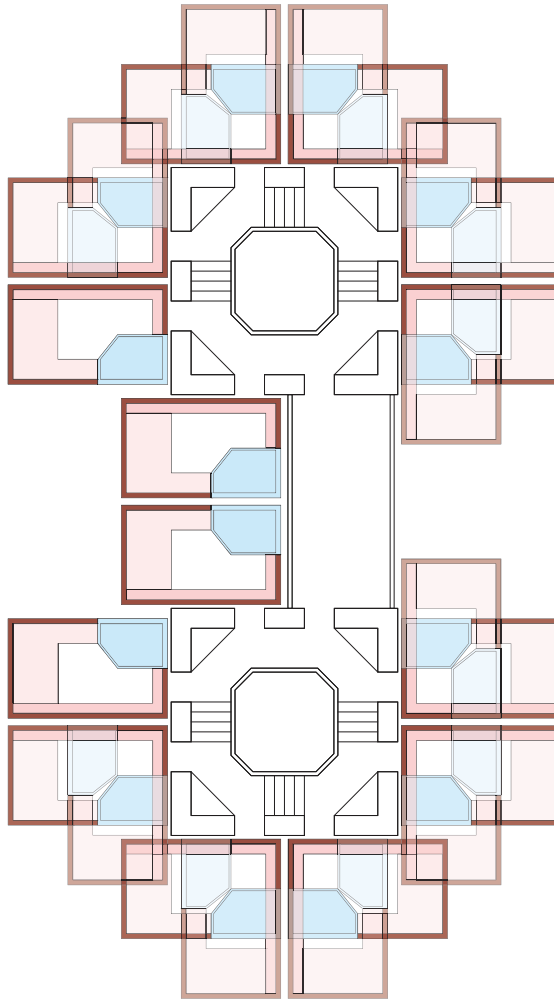
Unfortunately, the capsules were never changed, due to a lack of protocol for the tenants and owners to follow and fixations defects forcing one to remove all the capsules underneath the one being changed.

Key elements. As did Japanese traditional architecture, Metabolic Megastructure expresses the differentiation between permanency and transience by separating open structure and enclosing walls. There is a technological gap between the two periods, yet there are two main differences.

The first difference is in the fact that instead of panels, Megastructure generally installs Capsules/containers. If taking in account the Wine rack analogy, those containers are prefabricated outside of the site with specialised machinery. This streamlines the construction but the best feature is a better isolation capacity.

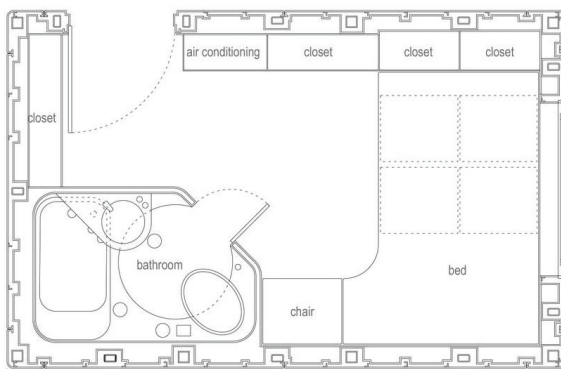
The second difference is that Megastructure tend to work as a 3D grid. There is not only the 4 cardinal's points, there is also up and down. This offers much more possibilities in spatial significance, yet sadly a subject not discussed in Metabolist texts.

In the end, the scope of the megastructure caused serious backlash by environmentalists, and the energy crisis signalled the end of the megastructure ideal by the middle 1970s.



Nakagin tower, all capsules placements

Capsules layout



Incremental Transformation: Elemental - Chile

This chapter marks a change in the process of housing design. Our two first chapters dealt with designer-controlled architecture. The designer, generally the architect, created a flexible and adaptable system by projecting his control into the future of both the building and the occupants.

The following chapters deal with Participatory design, where design decisions are shared between multiple entities, often the architects, the tenants and the owners. This already permits a better appropriation of the space for the users by giving them choices to express themselves.

This integration of a social component in the planning, construction and neighbourhood development allows to create the most appropriate solution to the needs of inhabitants. It also reinforces the sensation of inclusion in the neighbourhood contributing to a more sustainable development.

Step-by-step process. This concept gives better conditions of life for its residents without large upfront costs. It becomes economically more viable by allowing the evolution and improvement of housing in medium to long term.

It generally starts with one element named the shelter, either a bare lot connected to the utilities or a prebuilt kitchen/bathroom unit. The best solutions have a basic multipurpose room with basic kitchen/bath facilities. The inhabitants then have the space to evolve their home units when they have the need or the means.

The various models of evolution use the principles of:

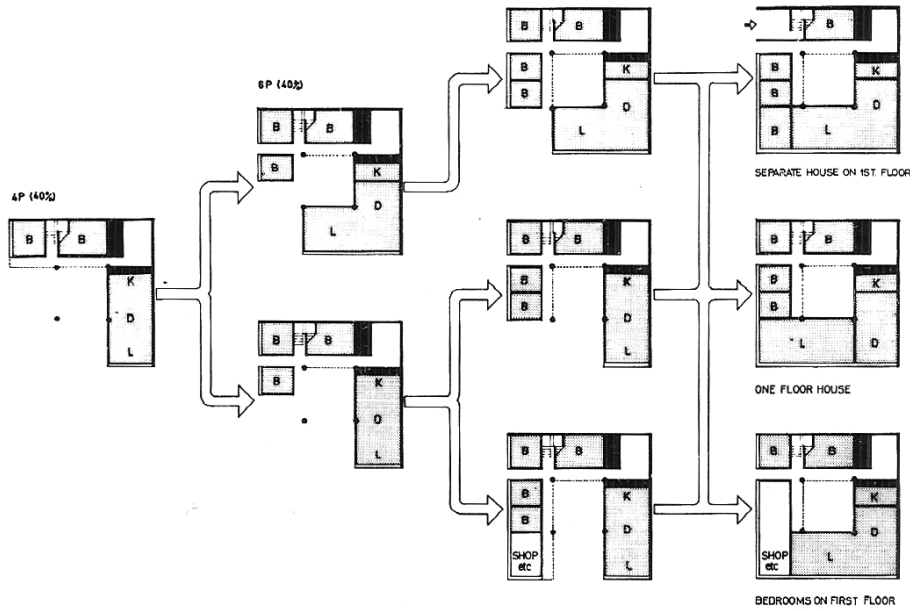
- **Expansion:** Starting from the base unit and expanding in an outdoor area capable of evolving defined in the early plan. Often time it would be a patio, a terrace or a rooftop, enclosed in later phases due to household increase.
- **Aggregation:** If expansion by definition is constructing extension, aggregation is absorbing other units to enlarge the housing surface. The rooms are already existing, simply absorbed into the base unit.
- **Division:** This action generally happens when the children leave. It seems simple to divide, yet accesses and utilities must be taken in account in the planning phase to ensure a total independency of new units from each other.

Nowadays Incremental housing is mainly a system of affordable houses made for poor families, mostly recorded in the slums



Elemental, Quinta Monroy

Incremental transformation., realm of possibility



Elemental. It is a social incremental housing started in 2004, in the neighbourhood of Quinta Monroy (South America), by Alejandro Aravena.

The goal was to settle 100 families with a budget, assuming one house had one family, that could only host 30 families in decent sized homes or settle them all in less than 30m² houses.

The solution proposed was to realize only 50% of the house (the shell, the overall layout, water and electricity), also the hardest part to install, leaving to the occupant the choice to finalize the realization. The final scenario creating a middle-income house of 72m².

The initial structure ensures a certain homogeneity and above all the structural quality of what can be done in the space provided for this purpose. Each subdivision has an easily convertible hollow part between the prebuilt and the free-space. The project thus establishes the basis for a reasoned expansion of the living space.

The design of the extended rooms was left to the inhabitants. This way, users could expand when they had attained the means for it and the time, or simply when the need arises as the family grows. As such the economic burden is distributed over time instead of one big spending. It also permits the house to gain value over time instead of decreasing.

The materials to be used were left to their expressive desire. Instead of blocking inhabitants' need to expand their homes, Elemental offered them space to flourish. This desire and need to transform its habitat are put to contribution: the inhabitant becomes one of the actors of the arrangement of its frame of life.

This economy first permitted to families to stay in a plot that would otherwise been outside their means. Following versions succeeded in showing that the principle works for projects with higher standards.

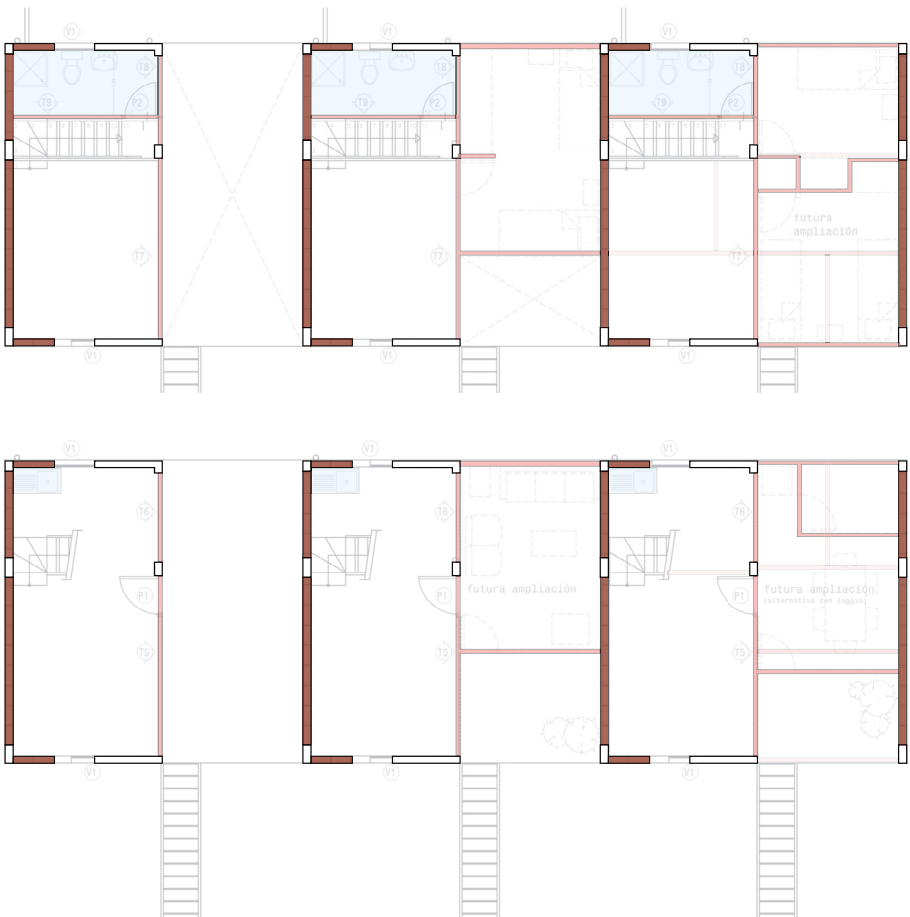
Key elements. It is a system that makes sense economically and reacts well with increasing or decreasing household's composition. As the evolution doesn't need to cover basic needs, such as bathroom and kitchen who are already built in the core, it makes expanding easy. Nonetheless succeeding division must be projected during expansions since dividing must permits clear independence between the old parts.

Incremental seems to be a system best suited for detached or semi-detached housing. In the case of high-rise construction, the question of boundaries between tenants and structure, be it integrity or isolation, makes incremental difficult to manage. It would be interesting to pair it the concept with the concept of Co-housing and the rules set before, as they complement each other well.



Elemental, delivered interior

Incrementing floorplan



Exquisite Architectural Corpse: Home - France

This chapter is based on the book *Home*, written by Pascal Gontier in 2018. It focuses on Participatory design in the context of shared buildings. A position that in the authors mind's morphs in the notion of bespoke architecture. He takes a stand against the standardization of the modern movement and resulting anonymity of vertical housing, dreaming of a return to the soul of the first drawings of towers as seen on the right.

BOB. *"I imagined a model of building capable of offering its inhabitants entirely bespoke housing doted of personalized facades."*

He named his concept BOB (Bespoke Open Building), following Habraken's clear separation between support and infill in Open buildings, with the addition of a prefabricated toolbox to conceptualize the apartments.

The primary architecture creates a canvas in which tenants can express themselves and is composed of four entities:

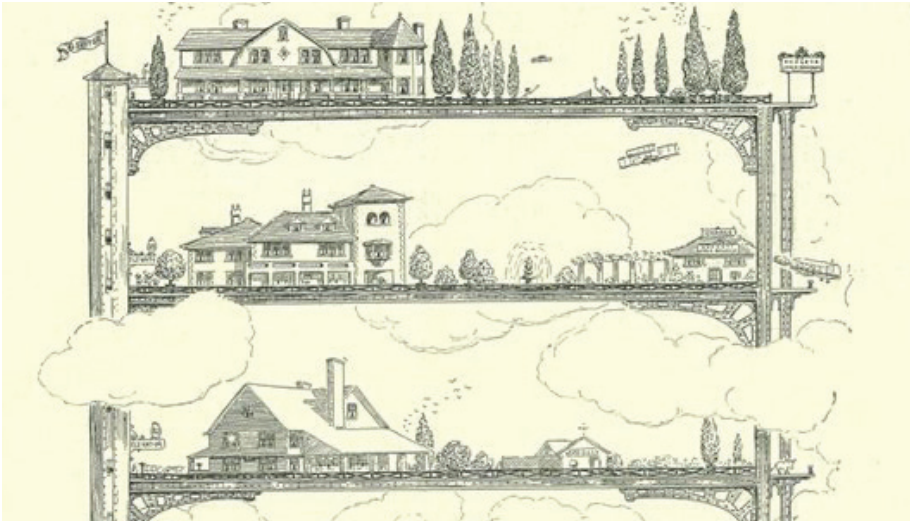
- The primary structure as a beam-post system freeing space
- Distributing organs as staircases and entrance halls
- Structural spaces as communal spaces linking the urban ecosystem
- Ducts as rationale system irrigating the housing units

Wooden beam-post structure, being less expensive than concrete bearing walls lends itself favourably for real implementations of the free plan.

The secondary architecture, or infill, creates housing units with a double process: the division of space in lots and the toolbox aforementioned.

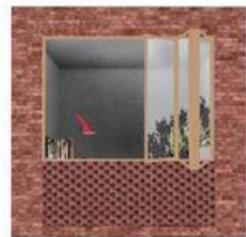
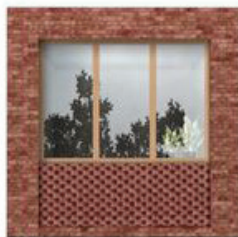
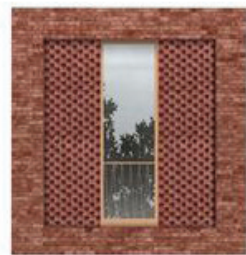
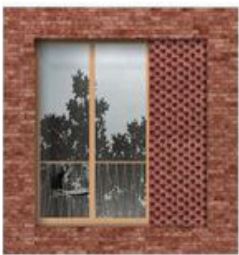
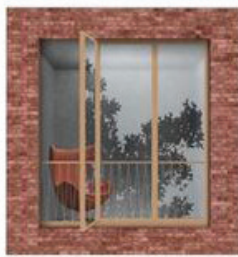
The toolbox expresses the architect and define the general identity of the building, while offering choice to the tenant as shown on the right.

This dialogue between the architect, the tenant and the toolbox permit bespoke units and the creation of an architectural species. As if they were natural phenomenon, all building shares the same "Genome" yet up end expressing different "Phenotypes"



Vertical village

Toolbox, assembling windows



Home. In 2017, Gontier attempted an experimental project for a 14-floor residential tower as if an Exquisite cadaver game.

Exquisite cadaver is a surrealist method of composition. Each collaborator has to add his part in sequence by following a rule and without knowing how the previous person contributed.

The primary architecture is a half-timbered beam-post structure with metal hangers for the balcony. Organized as a rectangular plan (22m X 16m) around a distribution core, with the main ducts along the middle longitudinal length.

The tower is then divided into 3 dimensional lots, sized depending on the desires, means and opportunities of the future tenants (small or large simplex, duplex, triplex and L shaped). As such the tower can end up having between 1 to 60 units, in this case 34 units, as seen on the right axonometry. This action is compared to the plot cutting done in neighbourhoods.

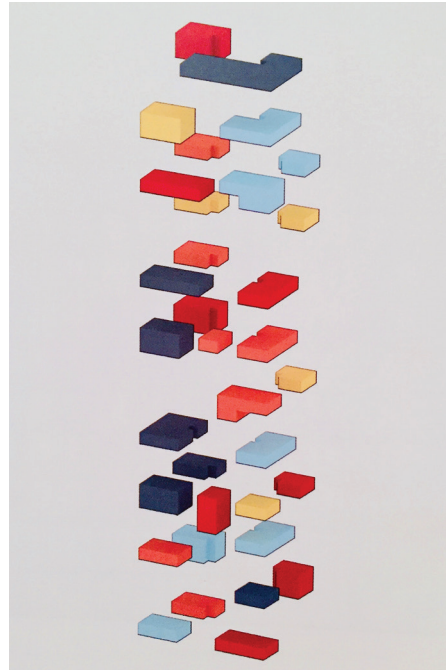
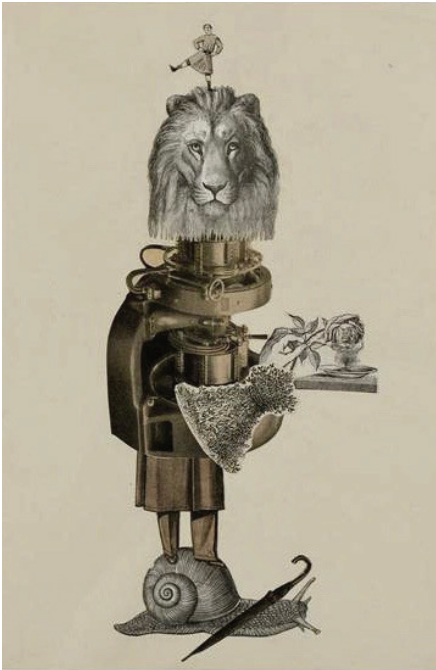
Different toolboxes were made with a selection of elements such as windows, parapets and winter gardens, each with different transparency, colours and materials. Creating a coherent architectural line between all elements and units.

The toolbox and the lots were sent to the participants who assembled their own apartment, as you would an Ikea space. The architects working with each participant to help create the final apartment in auto-cad.

In a real project, the lots would have gradually filled the tower as time passed.

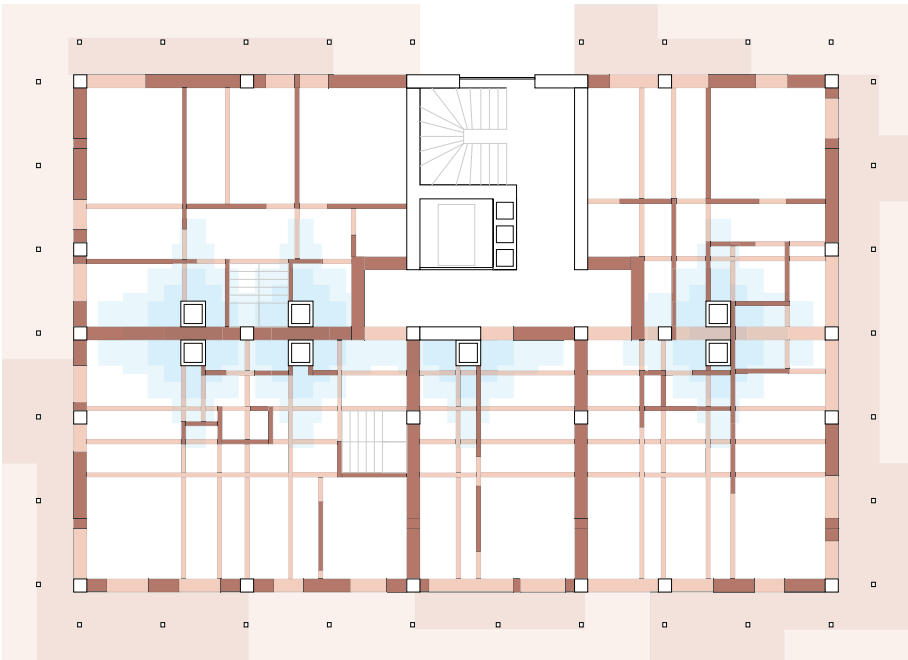
Meanwhile, the architect composed the structural space on the rooftop based on the wishes of all participants/residents, which ended up with a communal room, a greenhouse and a terrace

Key elements. The most important point in our regard is the use of a toolbox that, in the same way as an IKEA do-it-yourself, offers an array of elements. An array, even though design by someone else, permits the tenant to create his own bespoke living space. Nonetheless, the bespoke seems to rigidify future adaptability, forcing new tenants to adapt to in the decision of the first inhabitants. For adaptability to work properly in this context, it should be reversible.



Exquisite Corpse, surrealist drawing and tower organisation

Home, all floorplans



Adaptable people: Davidsboden Housing complex - Switzerland

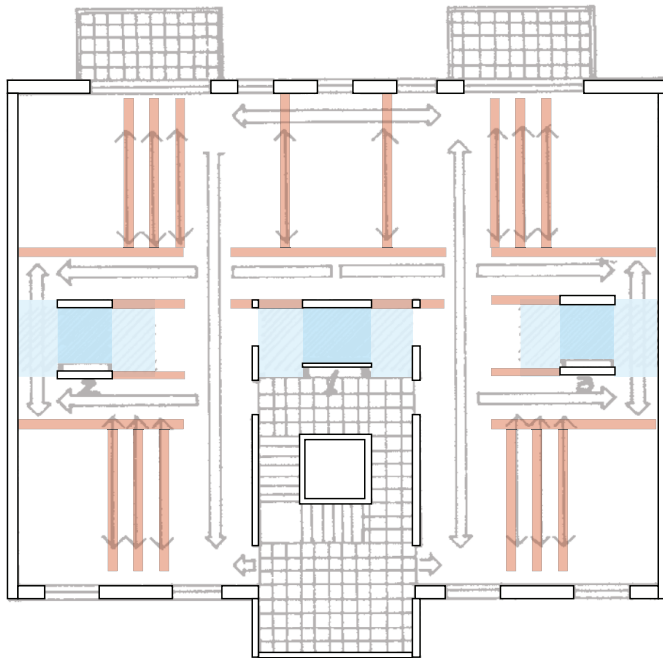
ETHZ Study. This following chapter is based on an article written by Jia Beisi at EPFZ in 1995 for his post-doctorate research project. He analyses and compares 4 adaptable apartment building in Switzerland built between 1970 and 1990 with different ownerships, constructed at different points in time and under different managements, and with different kinds of adaptability. They offer us a clear picture of the Swiss adaptable scene.

Most importantly it highlights something that has been lacking up to now, focusing on the experiences of the architects, owners and tenants on the real use of adaptable housing through time, of its pitfalls and impetus.

Recommendation. Along the study, it is explained that most of adaptable housing fails to use their potential. Generally due to a lack of follow up, as in their opinion, for adaptability to function on the long-term, certain guidelines must be followed:

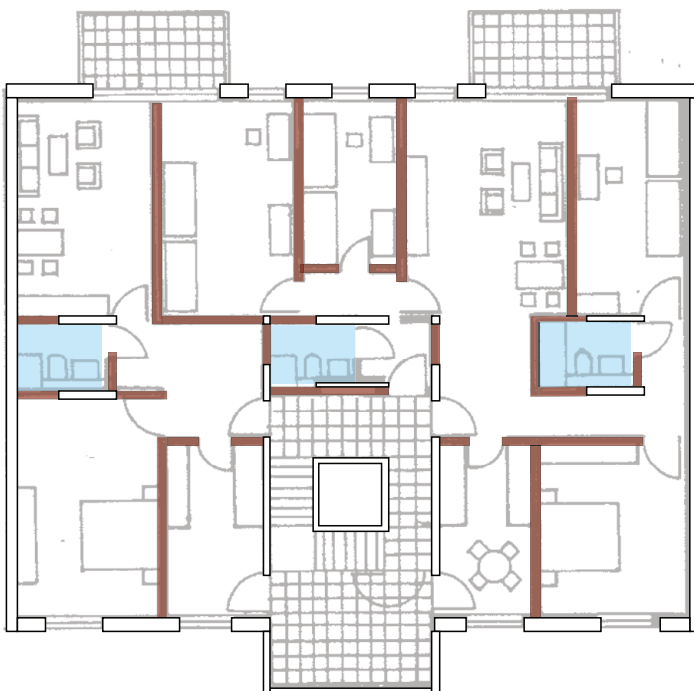
- Adaptability must be developed early in the design phase and take in account the following points in the thought process:
 - Defining users
 - Time-period of usage
 - Possibilities and constraints: Material and costs
 - Level of technicality needed (complexity of used systems)
 - Management style of system
- Several approaches of adaptability should be used over the various states of the project (construction, inhabitancy and lifecycle).
- Adaptability must be easy and do-it-yourself
- Individualization of apartments through initial tenants' participation must be limited as personalized units makes succeeding changes more difficult.
- Management must be cleared on who has ownership on the flexible elements between owners and tenants. Appropriate management must put restrictions on those and also give proper introductions and technical assistance.
- Cooperation between architects, owners, managers and tenants is vital in applying adaptability
- The success of adaptability depends on the owner's attitude and as such, must serves the owner's interests.

Key elements. Architects , when working on the intricacies of adaptability tend to focus on technical modularity This part puts the focus on the transfer of information between layers (various actors involved) and through time (from inhabitants to inhabitants), as well as reminding that one adaptability solution doesn't need to cover all. Various approaches used at different phases work best to create good adaptability. It also reminds that adaptability really works only if changes are reversible, easy to use and rapid in action.



Davidsboden, spatial rules

Typical floorplan

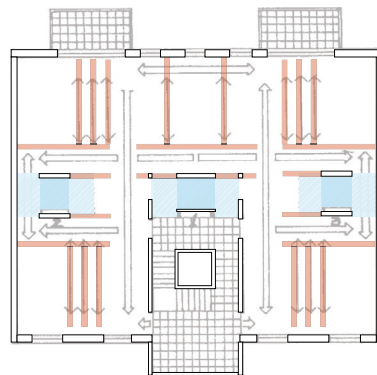
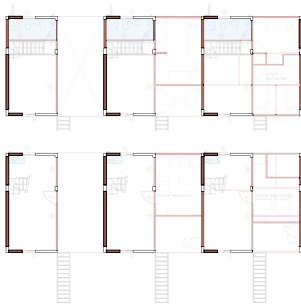
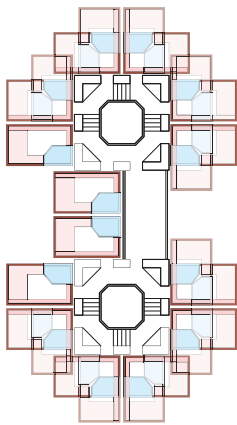
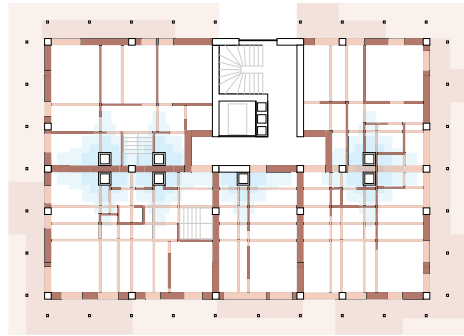


3. Conclusion

As more flexibility is needed, adaptability is our proposal as a new paradigm. Those five approaches have given us themes of adaptability to inspire us:

- Underlying rules as guided placement linked to systems.
- Skeleton as rigid structure with adaptable walls
 - Not solid fabrication, yet not shoji (prefabrication)
 - Time as variable in elements
- Co-Housing as important factor of living (small communities)
- Starting small to growing (Expansion/agglomeration) before retracting (Division)
- High-rise over independent housing.
- Toolbox by the architect for the inhabitants to use
 - Same style, yet variable in cost and form
- Importance of communication

All case study comparison



D. Digital Adaptation

1. Digital Enablers

The attempts of our predecessors were studied and separated into what works and what needs work. The changes expected to happen in our society have been clarified. Before proposing our own version to be continued as a building in the next semester, it is also interesting to explore what new tools can help us.

Technologies have been progressing rapidly in the last decades and is slowly integrating into the construction systems. As such, it is useful to see if some of those would help adaptability become more mainstream. Simplifying the processes, reducing the costs, speeding the construction/ demolition and helping better connect the different actors.

Construction techniques

Artificial Intelligence. Machine learning is expected to accelerate design automation, by making the machines learn from mistakes. It would permit them to create new behaviours in solving problems without the need to recode it. It would impact all of the following construction techniques.

Robots. Robotic arms permit rapid construction. In our opinion it is most interesting in creating complex assembling cuts such as needed for a traditional Japanese house. Instead of a slow and expensive artisan, a robot arm could do it quicker with more complex shapes. Helping create adaptable structure at a fraction of the costs

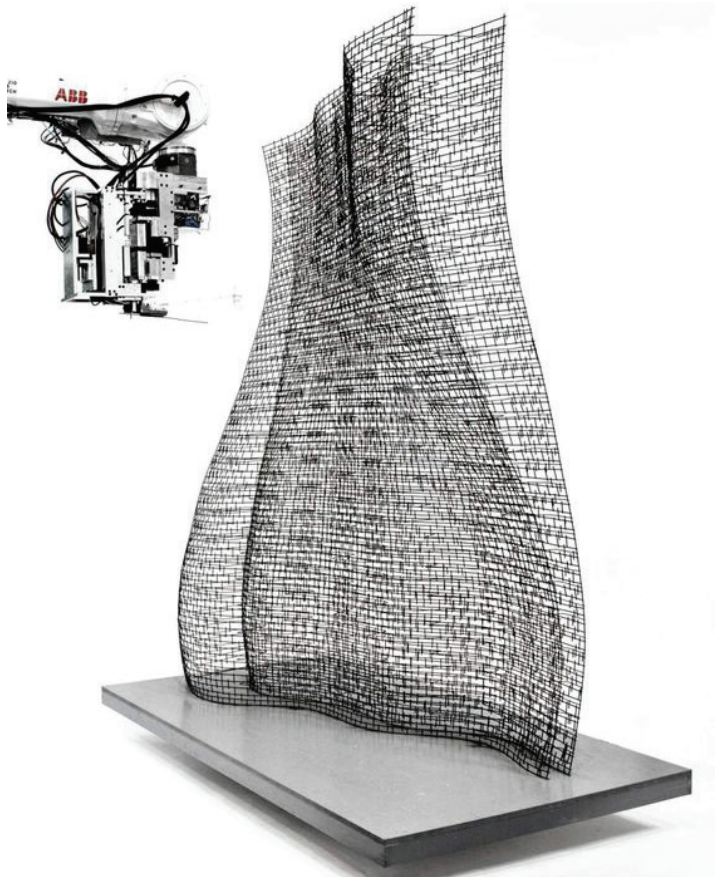
Others technological evolution like " Robot Assembled Construction" try to respond to the shortage of resources to validate the possibility in increase productivity and address the labour shortage. The importation of robots to the construction site is studied, yet prefabrication still seems to be their strong suit.

Drones. Used mainly for mapping, visualisation and surveying work progress on site. In adjunction to other autonomous vehicles, they are experimented as a way to assemble building blocks. As of now, drones have a limited use in constructing for adaptability.

3D Printing. One which seems more actual is the 3D Printing. Even though several companies are testing this approach, there is still a long way to go especially 3D printing building as the calculation of resistance in time are difficult and the industry is not convinced in the solidity of printed structures supposed to last.

Another research is done by Space10, the furniture giant Ikea's lab for testing prototypes and ideas for better and more sustainable ways of existing. Also exploring "open-fabrication", where designs are shared online and goods are made or printed locally using machines that follow digital patterns.

Another direction for 3D Printing, is not to print the walls directly, but to print moulds in which concrete can be poured. Used in the case of historical restoration, it permitted to replace and continue stonework details that would have been carved by hand at cost.



Separation, Robotic welder
Bridge, 3D printing



Digital tools

BIM. One of the most interesting technology usages for this project is the Building Information Modelling (BIM), especially the Next Generation 5-Dimensional (5D) representation, which not only provides 3D but includes Time and costing. The sharing of information it enables will create better links between the actors involved.

The main value is in providing a better visualization of the impact of change – one of the potential evolutions would be also to link the visualization using augmented reality devices – some would even be able to map the physical environment using sensor within an existing building – which will provide a “mixed – physical and virtual Reality”. (Imaging Construction’s digital future Mc Kinsey)

VR/AR. Virtual reality, enables constructors and users to step into the new building to visualize choices and changes in work.

Augmented reality permits us to see our choices in space directly, helping construction and accelerating the decision-making process. A 3D engineering models is overlaid on site, linked with BIM, it facilitates information transfer between parties.

Software’s enabling resident to study quickly the layout without having to engage a specialist, are being perfected for mainstream construction [Dexter Lilley, 2016]

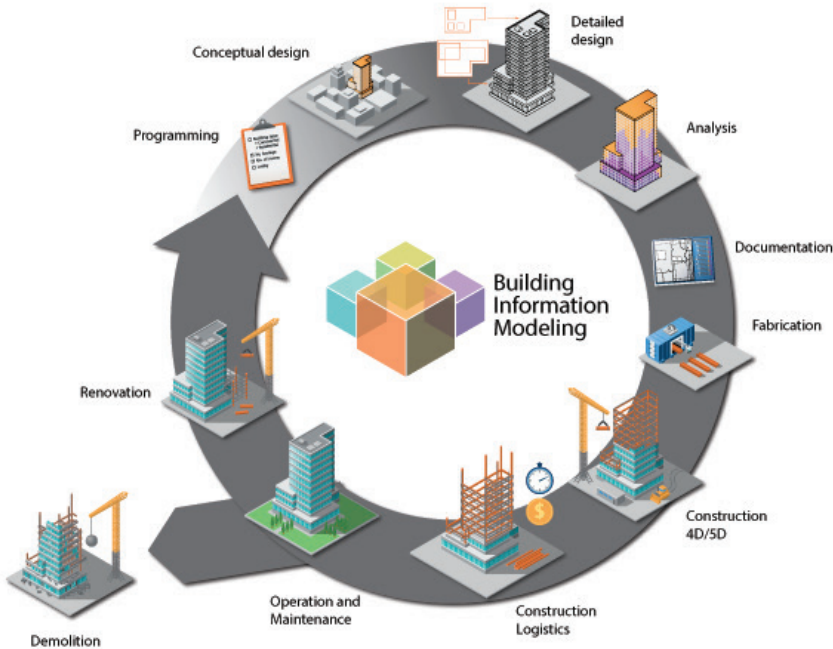
Internet of things. Internet of things, is a network of objects or things linked to the house and discussing data between each other to inform future decisions. In construction it is used to remote control construction, monitor, resupplying construction materials and following repair needs. Big data is one key to perfect adaptability since the flow information permits rapid knowledge of what is working and what needs work, leading to more efficient and more responsive housing environment.

Open source (architecture). It is a concept using advances in technology, such as 3D printing, combined with the internet of things and the era of information to create architecture design that is a collective and collaborative endeavour. [Unit 19, 2018]

In practice, it means inhabitants have access to a building program to create parts of their future housing units. Forms and construction details downloadable from the internet or private servers.

Open source focuses on the potential of action in peoples to create this environments instead of a top-down solution coming from the architect.

The smart house doesn’t really link with adaptability, even if it is an interesting research sector, as it can be seen as a new layer of control in the building but it doesn’t impact much of an adaptability that tries to impact the lifecycle of inhabitants.



BIM as unifier
VR/AR as work accelerator



2. Final observations

Highlighting the lessons of this research and the concepts to be used for next semester's project.

Key elements

This first chapter has shown us some of the societal changes of this last decades. Household compositions are losing cohesion, recomposing and generally growing smaller, with less and less children and an increase in single-households.

Housing prices are rising and incomes have failed to keep up. Our next generations are getting poorer and spending more time in education with greater uncertainties on what the future holds for them. This leading once again in putting off important life milestones and creating the "Unluckiest Rent Generation" with its renewed interest in co-housing as a means of homeownership.

Vital issues not only as millennials dictate current and future trends, but as the world adds another 1.2 billion people over the next 12 years, increasing the pressure on the housing market. The fabric of society is more fluid and diverse than ever, and the question to ask ourselves, is if the available architecture can take in account those accelerating trends for housing. As so, the next chapter will question the way construction is handled and its implications to housing.

Housing units post-2000 are constructed primarily for 5-person families, yet society is moving to a majority of 2-3-person families. The old generation is retiring and a new one, much smaller is taking its place. This new generation has, as seen before, different ways of life with a propensity for 1-person households. Our housing market will soon be saturated with housing units not dimensioned for the needs of the new generations.

The case of Hardau II is a good example of what will happen in the majority of Switzerland. What's more the plans being made now, may not be relevant for succeeding generations.

Housing tries to create perennial architecture in a situation that is always transitional. It is not supposed to be building monuments to stand the test of time and generation, but to create housing fulfilling the needs of individuals at specific times for specific periods.

As such a new paradigm is needed for housing architecture.

As more flexibility is needed, adaptability is our proposal as a new paradigm. Those six aspects have given us themes of adaptability to inspire us:

- Underlying rules as guided placement linked to systems.
- Skeleton as rigid structure with adaptable walls
 - Not solid fabrication, yet not shoji (prefabrication)
- Co-Housing as important factor of living (small communities)
- Starting small to growing (Expansion) before retracting (Division)
- High-rise over independent housing.
- Toolbox by the architect for the inhabitants to use
 - Same style, yet variable in cost and form
- Importance of communication

Digital enablers permit mainstream complex creation and facilitating links between all actors involved speeding construction and reducing costs. Giving more option for tenants and architects to adapt housing to their needs.

Future process

It is our belief that high-rise construction and not independent housing makes more sense in regard of the needs of Switzerland in housing. As such, the of the Master's thesis project part is to use the lessons from this book to create a multi-residential building incorporating th adaptability to follow the inhabitants lifecycles. The design will rest mainly on three aspects covering the scope of adaptable construction:

- A Megastructure as a skeletal tower with underlying spatial organisation (shared space and plot cutting).
- A Toolbox of style, taking in mind the themes of reversible, do-it yourself and reuse (library of parts to create personnel self-built apartments).
- Guidelines, as a need to prepare living rules in regard to the adaptable parts and co-housing segments with a transmission through time and actors, helped by big data and technological enablers



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