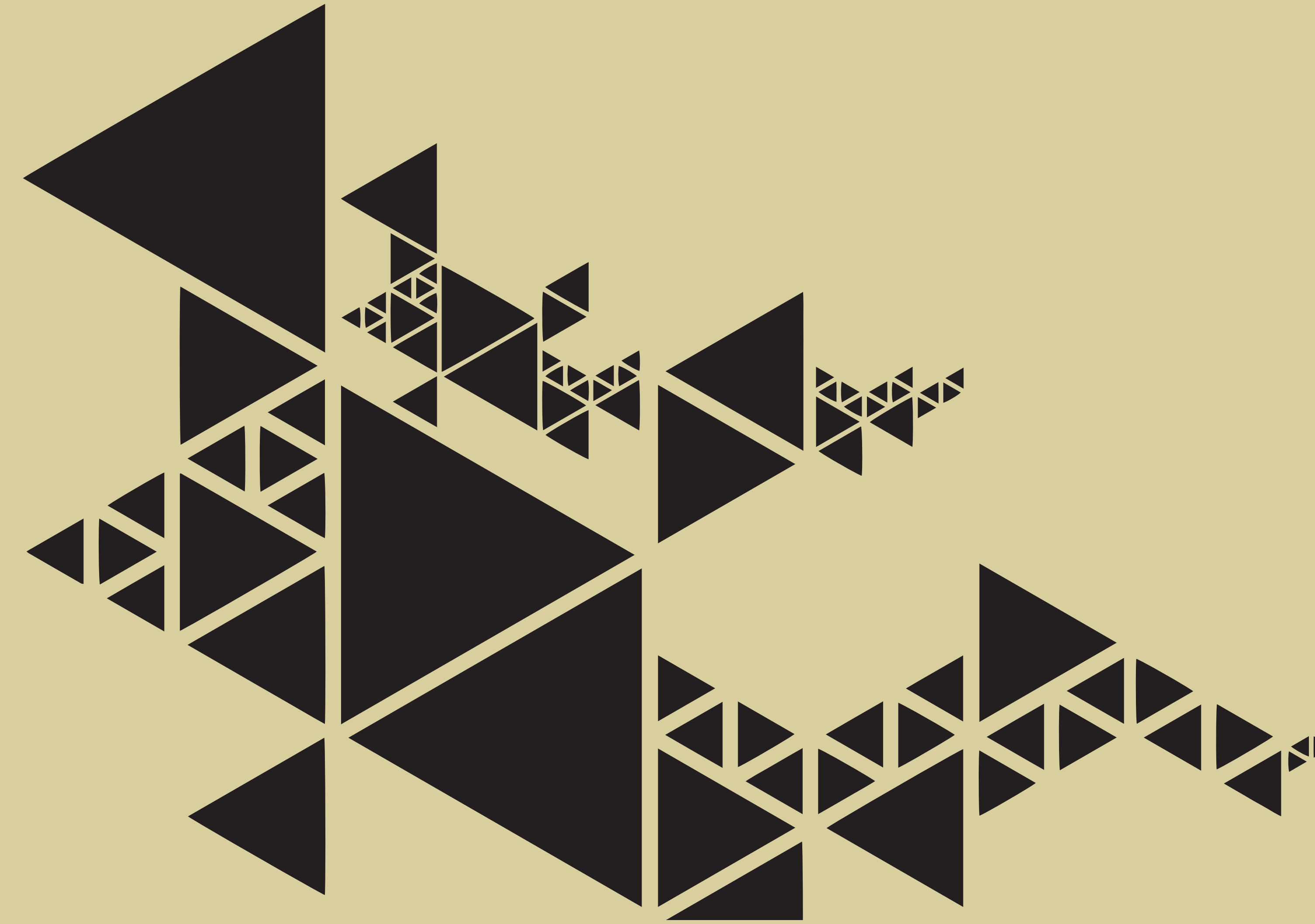

António Alberto Lopes Fernandes Duarte Correia

FABRICATING ARCHITECTURE
From Modern to Global Space

VOLUME II (ANNEX)

Tese de Doutoramento em Arquitectura, orientada pelos
Professor Doutor Luís Simões da Silva e Professor Doutor Vítor Murtinho e apresentada ao
Departamento de Arquitectura da Faculdade de Ciências e Tecnologia da Universidade de Coimbra

Dezembro de 2017

· U C ·

UNIVERSIDADE DE COIMBRA

António Alberto Lopes Fernandes Duarte Correia
VOLUME II (ANNEX)
FABRICATING ARCHITECTURE From Modern to Global Space
UNIVERSIDADE DE COIMBRA

Bolsa SFRH/BD/65732/2009:

PD F PROGRAMAS DE DOUTORAMENTO FCT

POPH PROGRAMA OPERACIONAL POTENCIAL HUMANO

QREN QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL

UNIÃO EUROPEIA Fundo Social Europeu

António Lopes Correia

FABRICATING ARCHITECTURE
From Modern to Global Space

VOLUME II (ANNEX)

PhD thesis in Architecture, advised by
Prof. Dr. Luís Simões da Silva and Prof. Dr. Vítor Murtinho
and presented to the Department of Architecture of the
Faculty of Sciences and Technology of the University of Coimbra

December 2017

Table of Contents

I A Mechanistic Inheritance

COMPLEMENTARY TEXTS

1 ARCHITECTURE: AN ETYMOLOGICAL DRAFT

Everything starts with a name. That could well be an ontological motto for this dissertation, for in structuralist terms there is an invisible linguistic bridge between us and the world—or, as Heidegger formulated, the *Dasein* (i.e. the *being there* or *existence*)[1]. Accordingly, intertwined within a quintessential social nature of the human endeavoring, there is a linguistic sphere locating architecture among the things of the world, engaging it among the production processes underlying the come-to-being of human artifacts. As the world moves on, our frames of reference move with it, shifting as we shift throughout, as too languages evolve. Thus, any attempt to observe the unfolding matters of what we can assume as being *architecture*, will always be incomplete. But it is also from that point of departure that we can arguably aspire to the production of some meaningful sense, i.e., knowing beforehand that no ends are achievable, but endless paths of possibilities, with an end and a beginning in *architecture*.

In western culture, etymologically, *architecture* seems to be derived from the Latin, *architectura* and ultimately from the Greek, *arkitekton* (αρχιτεκτων), roughly meaning master builder or director of works, from the combination of *arkhi-* (αρχι), a *chief* or *leader*, and *tekton* (τεκτων), a *builder* or *carpenter*. In turn, *tekton* comes from the Sanskrit *taksan*, denoting to the use of the axe and the craft of carpentry. Vestiges can also be found in Vedic, referring again to carpentry. In ancient Greece, it would appear in Homer, alluding to the art of construction in general. A poetic sense is first noted in Sappho where the *tekton* impersonates the poet. The meaning would further evolve, as the term went from referring to something physical and specific—carpentry—to a more generic notion of making—poetic sense. In addition, *architecture* can be related with the notion of *arkhé*, that is, the knowledge or engagement towards the *origin*, which is the root of words such as *archetype*, *archeology*, or *archive*. Such can be observed in the sense of what the ancient western philosophers called the Demiurg, the unattainable original architect, an ontological God-like figure, the seemingly one and only to have access to the *genuine essence*[2].

In a common sense, *architecture* stands for creating, planning, coordinating, and for building, to refer the characteristics of what is built, and so forth. Accordingly, the term is frequently applied to describe works related with the built environment. In addition, it has been used via other connotations, such as in explicitly *artificial* things (e.g. software, hardware), characteristically *natural* things (e.g. biological structures, geological formations), or in implicitly *abstract* things (e.g. music, mathematics). In each, broadly we can regard it as a mapping to the elements or components of a structure or system, to understand them better and/or to creatively re-combine them towards new meanings. Indeed, the term has also been associated to a wider notion that implies the métiers of creating or devising a thing or a system, addressing some sort of problem, to be implicitly or explicitly applied—

e.g. through the own hands, through others', through machines', to build a logical frame, and so forth.

In this perspective, in a modern sense, it can be understood from Immanuel Kant's (b.1724–d.1804) broader notion of *architectonic* and its correlated notion of *systematicity*[3]. Before Kant, other thinkers, such as Aristotle[4] (b.384BC–d.322BC) or Leibniz[5] (b.1646–d.1716), had implied such notion. In common, all these authors place it close to a sense of system construction, via *Idea* (mental) and through devising combinatorial *ars logica*, and finally, as an ontological structure by itself. For the XVIII[th] century Kant, human reason is by nature architectonic because it regards all our knowledge as belonging to a possible system, a notion that has since been reinforced[6]. Anyhow, it must be noted that this is a double-edged notion. On the one hand, it is in agreement with the need for attaining frames of reference which underlays any knowledge construction—architecture included. On the other hand, if neglecting an emanating *real*, when it appears to us out of any aprioristically conceived frame of reference, and/or if taking those frames as a sort of immutable entities, it may also lead to what potentially is a methodologically (and ideologically) dangerous assumption of totality. That can lead to an also likely treacherous (and unlikely accurate) idea of full accomplishment, or of a kind of super-human universalism. In the least, that can be suggested through an *arkhé* etymological perspective, which brings it a sense of full-proof solidity, since based in a sort of historical soundness, even if not confirmed or confirmable. However, that idea of universal truthiness has also been refuted, namely by the epistemological repercussions raised out of the scientific notion of relativity[7].

Overall, it is hard to picture architecture has being just about a discourse, or just about a set of techniques, or just about a pure mental setting, or just about any single isolated thing. It is generally a blend of multiple things, something with, say, an unspecified specificity. Moreover, it is about delivering-through-praxis *artifacts* in a space-time set, being that real or virtual (assuming the latter is conceded) or any other. That implies there is a visible, perceptive or practical side to it, which can be seen more as of an organic and dynamic nature, and that is hardwired to engage with the available reality that is being addressed. That also necessarily suggests there is a subjective (thus ideological and/or aesthetical) *way of seeing*[8] implied, which is responsible for bounding *form* at some point (i.e. making options in a limited time span), which unavoidably extends beyond purely rational, rhetorical or technical considerations, or in the least brings about a minimum set of constraints. Thus, there is too a dimension of circumstantiality and chance, which renders useless any attempt of instilling an unyielding, tout-court rationality.

Since the vast majority of contemporary architects are formed in architecture schools, it seems reasonable to consider that an architectural *way of seeing* (or its equivalent *thinking*) may be linked with an academic formatting, regardless the differences that may exist between schools. Nevertheless, throughout history, there are also those that gained an outstanding architectural reputation, to the point of reshaping the profession, without going through (or completing) a formal architectural education and/or considering themselves architects.

Among these, figure XXth century acknowledged masters such as Frank Lloyd Wright, Mies van der Rohe, Le Corbusier, Buckminster Fuller, or Jean Prouvé. As free creative spirits, their curiosity came from multiple sources, not limited to architectural references alone. Their forming years did not exactly follow an academically straight path, and some have not even gone through academia. In the least, it is believable that the openness to the things of the world, which they manifested in their life path, contributed for their affirmation. Anyhow, it is unquestionable that, by devising new *ways of seeing*—i.e. their own ways—they have extended the vocabulary of architectural language, from which new and different meanings could thereon be produced. In this sense, they have raised the bar, becoming themselves referential, setting trends and thus creating a retinue of followers, and with it contributing to a reconfiguration of the profession. They did it foremost by bringing their own subjectivity to the stand, not exclusively their rational or rationalizing spirit. These are evidence that more than a link to any establishment (academic, political, economic, and so forth), architectural production can essentially be considered as an act of human intelligence over space-time.

The example of these non-conformed masters also illustrates a process by which the evolution of the architectural field has proceeded not only from within, but also by fetching elements externally. As in any other product of human intelligence, such kind of process can be observed from different angles and arising from different contexts. In any case, to enable such a rich and vivid contamination can point towards the existence of some sort of basic structure laying beforehand. It can be presumed that there is a matrix to an architectural way of understanding the world resting in common principles, or entities, such as space-time. However, such notions are also vague, subjectable to different interpretations, and far from undisputable. Nevertheless, although those may not be directly intelligible, whatever the human activity considered, the way these are understood necessarily shapes the way we look to the world, and unavoidably informs and constrains the modes in which architecture is produced and understood, shaping an architectural *way of seeing*[9], whatever that may be.

The seemingly ordered world of an architect's vision creates a reality that only in his own mind can aspire to be set perfectly clear—eventually, with greater or lesser degree, the (in)congruencies of the *real* take care to mismatch it from its original source. In this sense, the architectural projection (*mental*) implies a creative search of an unattainable and only ideal perfection, regardless the more or less complex and/or contradictory that perfection may be—ontologically, *perfection* is unavoidably dated and contextual. Additionally, in a design stage, as in a construction stage, or in any stage or combination of stages so-considered, architecture is most frequently the result of multiple minds. Finally, all this implies an architectonic to the very architecture, which results from an age-old human process of construction, of building significance out of things, answering to human problems or aspirations, and from which the architectural artifact intrinsically results from.

Indeed, architecture is not usually a one-man job, but implies a chain of actors—a communal job—that enables the architectural artifact to come to life. In this sense, and like in any other human activity, architecture is primarily a social process, but generally with an important distinction regarding other creative forms. That is, the distance from an original thought to the final product is bigger than, say, in writing or painting, where the creative process is more likely to be depending of a single subject. As this distance increases, with more subjects and hence more communication channels involved, it also increases the probability of noise, distortion or of manipulation of what was originally set forth—distorted or mistranslated language. It can be argued that that is a matter of control, and how to manage that control, where architecture can be regarded as mode of attempting to exert some sort of control over a certain space-time context—but even so the unexpected is to be expected[10]. Indeed, the establishment of different levels of control, towards the spatial conformation or the user, seems to be key to define the architectural production itself.

It is also clear that architecture involves a complex fabric of multiple fields—aside a broader social or cultural, also the technical, economical, legal, and so forth—under the (subjective) scope of the architect. Within such frames, directly or indirectly, the subject-architect (and regardless it is a single person or a collective) will inevitably reveal his own background—e.g. in aesthetic preferences—in the devising process conducting to the advent of the artifact. In a process of such nature, it is unlikely that a scientific method is exclusively pursued, nor an exclusive artistic approach, and so forth. And again, it is a process that inevitably involves a receiver, users that will be experiencing it. Furthermore, it involves a life span of occurrences. In this sense, the *total architectonic* of the architectural artifact in space-time can be regarded as its (final) constructed *artifact*, or how its conception-made-*artifact* (*mental*-to-*executive* sphere) shows itself to the user—i.e. outside viewer, inhabitant, and so on—and through it *lives* and *breathes*, (de)generating in time.

In the face of an indelible evolution of the human signification processes and, with it, of the complexity and intricacy of the artifacts of our world, it seems that some of the enchantment surrounding architecture that we have inherited from modernity may have forever been lost. In a way, modern architecture seemed to convey a sense of control over space-time that was somewhat reassuring—echoes of a positivist, techno-optimistic age that currently is no longer conceivable in the terms that it once may have been.

Ascribing to its *poetic* etymological inheritance, architecture resides in what yet remains untold, undone, that is, in a creative sphere, in going beyond some sort of replication realm or the like. As in the classical tale of Sisyphus, which everyday repeated the same task of pushing a boulder up a mountain, only to see it roll down again, it seems that architecture too aims to an unreachable ideal—that of perfecting the unfolding (and imperfect) *artifact*. Its job, although permanent, is never complete. That can be regarded as a warning, to not underestimate certain realities or to settle, but also as an assurance of its disciplinary relevance. As the world progresses, architecture must continually reinvent itself, otherwise risking losing its relevance, or ultimately its sense at all, thus imprinting itself a positive sense of conflict, permanently bouldering up the mountain. On the other hand, such reinvention is only conceivable within a humanistic frame, for without a purpose or belief, for faded that may be, architecture is in the least doomed to a sort of void aesthetical stance, stylistic replication, lost or dead language.

2 THE FRAGMENT EXPERIENCE OF SPACE-TIME

From a phenomenological perspective, space-time can be regarded as what is implied in the elements that involve (or are perceived as involving) man[11]. In the psychology of space, what fundamentally matters is limited to the current perception moment, non-homogeneous and non-isotropic[12]. Indeed, more than a mere scenery to physical, social or cultural forms, space-time seems to participate in those forms, as they are embodied and understood via that same embodiment. For instance, human behavior, does not simply seem to happen in space-time, but to have its own forms—encountering, avoiding, interacting, building, teaching, eating[13]. In a way, these are not merely activities that happen in space-time, they are themselves space-time, and are deeply rooted in fundamental human needs[14].

On a common use, often the idea of space will be transcribed to expressions such as *use of space*, *spatial perception*, *space production*, *concepts of space*, and so forth. In each of these expressions, a meaning is attributed to the idea of space, linking it directly to human behavior or intentionality. Spatial concepts common to the social sciences, as *sensory space*[15] or *space appropriation*[16], also imply the human agent, and do not recognize its existence as independent of it. However, in architecture, where, by the rationalization of the intervened object, the concepts of space often get disconnected from the direct human agent through notions such as *spatial hierarchy*[17] or *spatial scale*, we verify that in the end space is rarely described as being totally independent[18]. Architectural functionalism, and its historical discussion[19], stands out as a critical example of such detachment. Behavioral patternizations, such as those developed by Alexander Klein[20] (b.1879–d.1961), as spatial qualities classifications, such as light, air, color, and so on, are among the key aspects to understand the functional developments that are indelibly associated with the advent of the Modern Movement in architecture[21], as is its subsequent critique[22].

Rediscovered in the Renaissance, Vitruvius' work also inputs new information to a centralization on the individual, which in itself fundamentally configures a spatial concern with multiple shades. In the first chapter of the third book, he begins to describe the proportions of the human figure as a model for the architectural proportions. The harmony of the body is, in its turn, assured by the geometric harmony of the perfect figures, such as the circle and square. The problem of the corporal measure, or of the body as a model of measurement, varies from the demonstration of its accurate dimensions to a demonstration of the commensurability of man and space, between a subjective order of body and an objective, mathematical, order of natural or celestial harmony.

The famous interpretation of the Vitruvian description by Leonardo da Vinci values this conception, affirming the human figure using a visual device of geometrical order, placing it in a circle and square. The theme of da Vinci's sketch is not only the demonstration of the body proportions, but also implies the quest of a higher level of harmony which gathers, simultaneously, the objectivity of numbers, law and measure, and the subjectivity of the body, vision and being. It thus points to a path on the resolution of the conflict between an individual dimension of consciousness, and a collective dimension of reason and science. This can be described as the corporeal base of a 'perspectival paradigm', i.e. the paradigm of the body that looks to the world through mathematical eyes, the idea of an objectivity principle inscribed in the subjectivity of the soul. However, this idea came from the assumption of a universal man, redemptory of harmony and perfection among things[23]. This would later collide with the implicit idea of the Cartesian rationalism, in which ultimately man, by rationalizing the world, is self-excluding from it[24].

The famous Descartes sentence *cogito ergo sum* (I think, therefore I am)[25] can, on the one hand, be understood as a sort of 'starting point' of the objective knowledge of reality, but is also the motto of the new position of thought and of being according to which reality exists for us as a network of thought constructions. In an Enlightened world, mathematics became the methodic ideal of philosophy and of the all quest for knowledge, of even God[26]. Nature was the primordial source of such quest, if observed as a matter determined only casually according to norms. The ideal of perfection, represented by God, is confronted with the chaos of creation, from which the imperfect Man chases reason on the basic, but ever unraveling laws of Nature created by the very same God[27].

The immediate unit between Man, Nature and the Cosmos, as it had earlier been idealized in the Renascence, was abolished. As perspective converged to an inscrutable viewpoint[28], revealing an unexplored figurative potential, the Cartesian dualism between mind and body, its postulation of the body autonomy as machine or sensorial organ, indirectly inaugurates a new logic of body as logic of the senses, in which the eye replaces reason[29], and the sensorial organ, the ability of comprehension[30]. The original idea of body as a formal measurement reference model was in due course replaced by the idea of body as a perception system[31]. In our times, the technological eye penetrates matter and space, allowing a simultaneous vision of things[32]. In a world were technology is developing more and more in a multi-mediation fashion, it is also verifiable that the audition, or the touch, has joined the vision in the technologically mediated experience. Simultaneously, the technical development somewhat discarded other senses, given the difficulty to transport them digitally. *Space* is *human space*, with a body, a breath, eating, sleeping or thinking.

Architects in the baroque faced the task of agglutinating the space of drama action with the space of the audience, achieving it with the *proscenium*, a brilliant and thereon widespread architectural invention. Such enabled the stage to be illuminated without interfering with the audience, and through it offering the audience the convincing illusion that they were alone in the dark, spying characters through an invisible wall. High-definition sound and sight, which current technologies enable, dizzies us in an intense fog of images, where the screen experience, by its enormous dissemination, is less and less *proscenic*, losing its apparent depth[33]. Instead, if a parallel can be stated, their multi-mediation, increasing capabilities and links with multiple other devices, somewhat resemble more and more the archetypal 'flexible theatre'[34], and one that we now carry in our pockets or that is integrated in our homes, cars or clothes. Daily objects are ever more mediators to a ubiquitous virtual world, and although connecting us to an immense collective construction, they seem to have the intimacy of underwear, as denoted by the objects of the so-called *internet of things*. Conversely, the abundance of imagery and information is so great, that it may paradoxically make it disappear[35].

Using pure Cartesian terminology, in 1923, Le Corbusier was telling us that the plan was the generator, and that without it there is disorder, randomness, that the plan is the essence of sensation[36]. In our days, there is a growing tendency for architecture to leave this extruded plan, opening up to the algorithmic complexity provided by the digital era. On the one hand, that finally enables the visualization and calculation of the shapes generated by the complex math of the non-Euclidian geometry, which had been long remaining extraordinarily difficult to proceed. On the other hand, it somewhat 'democratizes' design, making its production seemingly more accessible to a larger share of the population, as in the least noticeable by the customization enablement provided by multiple brands in different businesses. Anyhow, no matter how sophisticated the technological development, the best option may at cases be, rather than detaching the design to the point of a complete abstraction with no referential to tangible elements, to keep the design in closer contact with the designer's reach, perpetuating an analogical sense to it[37]. In a way, the *analogical* has been underestimated by modernity, and the *digital*[38] is so hardly separable from the concrete, as the conceptual thought is from our sensibility. As neurology seems to confirm, the spiritual and the corporeal doing are referred to one another and are interdependent[39], definitively shredding the Cartesian dualism apart.

Historically, through successive technological breakthroughs—*inventions* as some may call it—such as the optical instruments, the perspective, photography, television, internet, and so on, our civilization has progressively transited from a sort of *realist space*, objective, coordinated, in apparent control by the observer, to an immersion in seemingly virtual spaces, which are simultaneously personal and shared to the point of no distinction[40]. As space was becoming *objectivized*, from the infinitely small to the infinitely big (to the point of escaping common imagination and having to be expressed in mathematical formulas), our culture has also dematerialized it, making us constantly dive in ever more diversified (and *specialized*) spaces[41].

In a prevalent perspective of our technologically based material culture, to measure, register, account, predict, and so forth, come as requisites for the superlative idea of constantly achieving an ever more efficient pace that will likely lead us to somewhere better. We may easily assume this positivist idea of *progress* without even remembering to question the cornerstones of such paradigm[42]—Jacques Tati's movies have remarkably satirized it. However, the rational positivism of the sciences, has somewhat been giving place to relativism in people's minds and habits. In a sense, we live the paradox of what we can call the *relativist positivism*. The once unitary idea of space (as in Le Corbusier's *sensation generated by a plan*), which characterizes the Modern culture narrative, has been fragmented, leading us to witness to the increased visibility of a reality where there is an endless a proliferation of space-times in a space-time only apparently common.

Aside the fireworks, if we recall Henry David Thoreau's retreat to the woods, some things seem to have not changed that much. We are still rooted to basic stimulate as the beauty of a landscape or of a place, the noises of the city, the smell and flavor of the food we taste, the comfort of a chair, the cosines of a bed, or the warmth of a body[43]. We experience, remember, compare, feel. Diffusely (and inaccurately), we rebuild remembrances of space-times from our body-image. Our comfort sensations, protection and shelter, rooted in our genes and experience, strengthened and articulated in the interaction with the surrounding, and that will constrain our re-conformation of space-time by the architectural action. The architectural experience is multi-sensorial, absorbs qualities of space-time and matter[44], dynamically mapping and recalibrating them towards us, involving several states of sensorial experience that interact and merge with each other. Beyond the modernist functionalism, or any kind of abstraction, there are human bodies, living, experiencing, …errant beings. Beyond an inebriating barrage of images and rhetoric's, there are people with their own space-time experiences, and there can be architecture too. Space-time is the place and occasion of our needs and dreams, of our senses and emotions[45]. The body contributes with content that is part and parcel of the workings of the mind. The mind is embodied, in the full sense of the term, not just embrained[46]. It is not just *me*, as fully embodied with and within space-time. It is *me* with my world, both finally undistinguishable within the spiral of one's existence.

3 ILLUSTRATING IDEOLOGICAL INCONGRUITIES

The *Weissenhofsiedlung* (Weissenhof Estate) built for the *Deutscher Werkbund* exhibition of 1927, in Stuttgart, became a landmark of the modern architectural spirit. Twenty-one buildings comprising sixty dwellings, displaying a strong consistency in design, with simplified facades, window bands, flat roofs, free plan, and a high level of prefabrication which made their construction possible in a short period of five months. These were designed by seventeen European architects, mostly German-speaking, including Mies van der Rohe, Le Corbusier, J. J. Oud, Walter Gropius, Bruno and Max Taut, Peter Behrens or Hans Scharoun[47], a true architectural stardom fair. However, the pure and crude intentionality expressed in Gropius' words, of form as a result of deep, inner relations, would be seriously questioned in America with MoMA's *International Style* exhibition and book in 1932, under the coordination of Philip Johnson and Henry-Russell Hitchcock. As the formal similarities between the buildings of the *Weissenhofsiedlung* seem to indicate, there seemed to be more to it than inner relations: Gropius' words had avoided it, but after all, modern architecture was a style, was modern-*ist*. In the end, the discarded 'expressionisms' were alive, it was certainly a different thing, but it was alive.

The Great Depression of the 1930s had a disastrous effect. The state sponsorship, required by the high investment of the big social housing blocks, was at a stall. Many estates and projects were postponed indefinitely, while the architectural profession itself became somewhat politically polarized. Among other examples, such would be symbolized by the dismissal, in 1930, of the Bauhaus director Hannes Meyer, who professed a Marxist doctrine, stressing the importance of collective housing for the working class. Meyer's replacement by Mies van der Rohe would cause some controversy. Some accused Mies of being indulgent to the wealthy, since he would proceed in turning the *Bauhaus* into a private school. This fact added to the sort of clientele he had, manifested in the luxury of buildings such as the *Barcelona Pavilion* (1929) or of his *Lange* and *Esters* houses (1930) in an aristocratic quarter of Krefeld (Germany). Nevertheless, such accusations would not avoid the Nazi government to close the school in 1933, under Mies' direction, claiming it was a nest of communist intellectualism. The staff would disperse, spreading their intellectuality all over the world. Regardless Bauhaus' circumstances, it is for a fact that the traumatic war experience, inflation and misery that accompanied the growing urbanization process, allowed a social and political awareness much deeper than, probably, what in normal circumstances would have been produced.

Somewhat in counter cycle with most of the opinions expressed in *CIAM*, the Americanized Richard Neutra would defend an urban philosophy not necessarily dependable in the multi-story apartment building as most of the proposals ended up analyzing and defending. The Austrian-born Neutra had practice based in the USA and often went lecturing in Europe, but he was also one of the few 'non-European' *CIAM* members, and he brought his American insight to the stand. He speaks of a liberal American tradition of individually setting a place to live, and he compares the pros and cons of both individual detached houses and multi-story apartment buildings. It is a reality that is politically very distinct of the European, where state-sponsored housing programs were the rule to face the housing problem, as it was the case in the Berlin or Moscow metropolis.

Neutra's analysis does not focus in political aspects, yet in economic and technical ones, to demonstrate his point of view. Describing the cons of apartment buildings, besides some technical issues, such as fire safety, emergency exits, elevators or access stairs and corridors, he expresses a major concern in the financing issues: "*funding for large buildings finds greater difficulties than small buildings due to the retention of credit*"[48], and *"it is clear that tall buildings with modest public housing rent and intermediate large green spaces should be funded by government agencies or other social organizations. Private enterprise is engaged in the construction of tall buildings only when there is the possibility to set higher rents. The promoter's greatest risk, the greater financial difficulty of the project is, in this case, overcome by a higher profit per unit of surface, precisely what is meant to be avoided in the first place*"[49]. Neutra defends that low-rise seems to be generally more attractive to families. In his opinion, the option between long commute times—to enjoy a pleasant suburban life away from the 'machine' of the workplace—or the option to live in a place where there is not such a obvious possibility to disconnect from work—where the worker both lives and inhabits in a 'machine'[50]—seems to clearly pend for a preference onto the single-family household side[51].

The analysis is certainly reflected in Neutra's architectural path, in which many single-family houses were designed, as is the case of the *Lovell House* (1929, Los Angeles, California) or the *Kaufmann Desert House* (1946, Palm Springs, California). These would decisively influence a *Californian* architectural trend—the region, land of both hope and despair, which had become the Eldorado symbol of a migrant America escaping from the Great Depression[52]. Although Neutra's houses were typically built for an upper-class clientele affording *broadacres* of land, the defense case of low-rise is nonetheless remarkable because no one else in the early *CIAM* meetings seems to question the mass house as solution to the house problem so vehemently. It is almost an obscure statement, in the sense that it is certainly closer to a sort of liberalism, which *CIAM*'s mole, intellectually closer to socialist perspective, did not praise. Nevertheless, as it is known, many of the participants would design low-rise and single-family houses throughout their practices.

In the *CIAM* intervention, Neutra would not mention the potential benefits of an urban life. However, such should not sound strange, as in general the early *CIAM* was foremost concerned with the house problem for the masses, not particularly with the individuals within those masses, as in a sense, given the need for method, human beings were inevitably reducible to a sort of statistical existence. The modern blocks are the exact correspondence of such abstraction. Around the ideal, Cartesian modern block there is nothing but greenery and traffic routes, there is no mix, no density, no (imperfect) life. It is like an architectural miniature model, perfect, ideal. Within there is only ‘function’. In this sense, no wonder Neutra seemed to ignore the benefits of a modern urban life, and instead implying a preference for the ideal of the mythic countryside, or an agrarianism tendency, which would pervade the works of many modern American architects, as was iconically the case of Frank Lloyd Wright. In any case, Neutra also did not refer to the harsh implications of a sprawled, motor depending, oil and overall resources consuming, de-densified territory, has it would become more clearly evident decades later in the aftermath of the 1970’s oil crisis[53].

4 ALDO VAN EYCK'S *ORPHANAGE* SYNTHESIS

4.1 The *Otterlo Circles*

Aldo Van Eyck's *Otterlo Circles* is an allegory for an architecture that has to deal with the '*constancy of change*'[54], with what is different from the past, and what is novelty, but also with what has remained the same. An architecture that has to deal with what is different from an *Other*, but also with what is bonding. Moreover, an architecture dealing with the substance of relationships, that is, an architecture dealing with its structures[55].

In a way, Man was and had been, in all places and all times, the same being, but man has also changed in many ways. According to Eyck, "*we can discover ourselves everywhere – in all places and ages – doing the same things in a different way, feeling the same differently, reacting differently to the same*"[56]. Throughout History, man's basic survival needs have been kept pretty much unchanged, and there are certainly constant aspects related with the sensations of comfort, pleasure, security, happiness or beauty, which span the times and places, although addressed in different forms throughout the different circumstances. Some of these have even become measurable or statistically predictable, such as comfort temperature, correct amount of light to read, and so on[57]. However, man's condition as social and cultural being leads him to understand his inhabited spaces differently. Such varies in the changes obtained via historical evolution, as well as regarding social or cultural differences. Social and cultural aspects are as essential as food and shelter, because it is through them we can make sense of spaces to establish places, affecting notions such as identity, security or privacy: human nature facing culture, the individual facing the collective, difference and change acknowledged, and these ultimately reflected in the built form[58].

From Van Eyck's *Circles* we can interpret that the evolutionary organicism of the vernacular cannot be mimicked. We can only understand its spirit, '*the hearth*'. From this position, there is no point in architecture to pretend it is something it is not, in the sense of simulating the vernacular, since architecture is not vernacular building, although it has most likely been so primordially, and although embedded of its problem-solving authenticity. Hence, it is of no use to fantasize an idealized vernacular, and uncritically borrowing its synchronistic or morphological characteristics to newly designed forms, as such inevitably redounds in a sort of trasvestism, or formalistic heterotopic approach.

The valuable lesson of '*the hearth*' is that architecture is to be inside-out, not outside-in or image-in. Architecture is about form, framing a reality, bounding space-time, setting the potential for place, and it exerts it through implied control mechanisms through design. Architecture is also misogynous and spongy: it combines and absorbs. Architecture's epistemologies also carry its own evolving cultural background, which inevitably involves an academic knowledge of the classical, of geometries, proportions, and so forth. Architects are set to deliver formal, 'determined' responses to habitat problems that cannot simply ignore the academic training. More, they are impelled to provide form. However, somewhere in-between an inevitable formal mimicking and the '*hearth*' of the vernacular there is a rich exploration field. It adds that architects are sometimes requested to solve problems through design, when the real problems are far from being related with design: it is not the architect's job to 'solve society's ills', he is an actor in society, just like any other.

Some, like Coderch, when confronted with the inevitable task of delivering form, refer to the educational, the role-model responsibility of architecture in the everyday dysfunctional territory. In this perspective, architecture represents something like drops of beauty laid in a sea of ugliness, virally contaminating it[59]. Others, like John Habraken, avoid the 'prejudice' of form, sticking up with the concepts, preferring to bind its epistemologies with the ever-changing realities at an analytical level. If form is a frame in a certain moment in time, as soon as present passes it becomes outdated. In this sense, Habraken's conceptual stand is as valid as Coderch's. As it is argued by Stewart Brand[60], if we get more interested in buildings than with architecture it is likely we realize that in many cases architecture is allergic to time, because architects keep being asked to build lasting monuments, frozen in time. Yet buildings have no such presumption, buildings live in time, the same way we do, and as in time we learn, and, in time, buildings learn.

4.2 The *Orphanage*

The *Orphanage* in Amsterdam (1959) is a peak expression of Aldo Van Eyck's synthesis stated in the *Otterlo Circles*[61]. In it, the classical tradition is underlined in the geometrical order of the primary organization. The mode in which it is established a clear support of the 'architraves' in the building's columns also refers to this classical stance. Nonetheless, the 'immutability and rest' of the classical is traversed by a dynamic ordering of reality. Circulation pays no deeds to axial symmetry or any sort of classicist-like cannon. Different floor levels succeed, unfolding in inner streets, which have no bond with central perspective, dynamically shifting, bonding to the unexpected, poised to enact life.

Space is structured, functionally attributed, yet ambivalent. Some critics would regard it as formally suffering from a '*Kasbah*-itis', as it resembled the much in vogue *Kasbah*'s, which were widely scrutinized at the epoch, and therefore criticized as being misadjusted to the Dutch climate, and so forth[62]. In this sense, one may consider that the impressions of the vernacular were literally depicted to form. Certainly, in a planned building such as this, the organicity of a *Kasbah*, with forms added in time according to needs, could only be transcribed as a total and not as scattered additions in time. The building is designed as it appears to sight. Its constructed form is final, not open-ended and additive, although it may resemble so. In a way, its form is final whereas its content is open. Nonetheless, the open-endedness in the consideration of social intercourse aspects, as well as the application of additive principles during the design process, are certainly innovative aspects brought about through this building.

In the *Orphanage*, Van Eyck designed a configuration of places that were simultaneously contained and overlapping. Guiding the design was a concern on the dialectic of opposites, or '*twin phenomena*' (e.g. open-closed, inside-outside, small-big, much-little, many-few). Each unit is designed to work independently, while relating with a larger part containing it. The univocal, isolated relationships of functionalism, privileging the object, do not take place here. Instead, relationships become more important than the objects themselves. With such emphasis in the relationships and in the dialectic of opposites, the (changing) 'place' acquires the potential of multiple significances. Van Eyck uses the term polyvalence to describe such multiplicity of signification within each space. For instance, to enter the complex, one must pass beneath an elevated part of the building, which leads to a patio. Although they all occur in the exterior, these elements, alongside small shifts in the pavement, demarcate the building from the outside world. The whole building can be seen as a succession of transitions, from a public to a private sphere, ultimately leading to the most reserved spaces, i.e. the dormitories in the upper floor.

Van Eyck's appraised notion of '*aesthetics of number*' is also present, as a limited number of architectural elements compose the building's ensemble. Differences in floor level, concrete stairs, circular roof lights, dome-like roofs and partition walls of brick and glass set in many variations, but with a recognizable underlay. There is a sort of underlying grammar, which is both material and dimensionally regulatory. Similarity strategies prevail, as structural or enclosing functions are assigned the same materials (e.g. stairs in concrete, or walls in glass or brick), or the overall composition is orthogonally regulated. These enable a typification of elements, proceeded in economic principles, which nonetheless enable an overall complex system of polyvalent spaces intended to encourage users to appropriate space.

4.3 Dialectics of control and freedom

How to hierarchize control, allowing freedom is a typical structuralist stance, to which if regarding a long-run time component, where buildings are submitted to change or re-use over time, it may also be included in a sustainability sphere. Aldo Van Eyck's *Orphanage* has seen its use in time been transformed. In 1987, the building became place of learning with the arrival of the *Berlage Institute* to inhabit it, and the building has shown its capacity to withstand the changes of a new occupancy in its stride. When it later became used as an office building, little of the former internal characteristics were left.

Nonetheless, a primary structure withstood the changes. Most of the sensitively crafted interior disappeared, and yet the building managed to endure the changes within, revealing itself as a truly open functional structure.

In any case, this revelation was not premeditated by the architect, he has actually shown some disappointment for that fact to his peers. It was Aldo Van Eyck's influences, his mental immersion on the program requirements, and need of its original inhabitants, that allowed him to initially devise the form, transposing the requirements and needs to spatial qualities. The building was initially designed with the children in mind, on providing them the best possible conditions with the available means. In this sense, the form was deterministic, custom-made, crafted for each purpose.

Hence, there is little surprise in the fact that Van Eyck was not very fond of the change[63]. The architectural 'order' of the building was initially set for open interpretation space-by-space, place-by-place. It was open to a certain speech, but it was not thought of for a language shift as it occurred with a radical change of use. Nonetheless, the building's structure endured such radical language shift, gutted from its original dialectics. Part of the original is still there, but the building inevitably acquired a very different character. The structural elements and all the outer shell, including external walls and roofing, are what most outstandingly remained.

Regarded from a life-cycle point of view of the constituent parts of the building, the stronger elements endured the passage of time, while the more perishable or easily replaceable have proven to have a shorter expectancy. The changes in the *Orphanage* also highlight the difficult congruence between the theoretical arguments and the practice. In Van Eyck's case, answering the emotional needs, as he had so remarkably expressed in the *Otterlo Circles*, was a motive that he attempted to fulfill, yet forgetting that, as in most buildings that endure, is quite common for the initial purposes to change over time.

5 DOWN MAGRITTE'S RABBIT HOLE

The legacy of the painter René Magritte brilliantly illustrates the questioning of signs, and it certainly illustrates the games of appearances in which meaning can be diluted. Magritte aimed to create paintings that would, in his words, "*challenge the real world*"[64]. He achieved such questioning by challenging us with different visual expressions of displacements and mismatches of the objects (their 'reality', labelling or truthfulness).

With the *The Treachery of Images* (*La trahison des images*, 1928-29) a pipe is pictured with a caption saying 'this is not a pipe' (*Ceci n'est pas une pipe*). In the same year, Magritte publishes a less know article in the journal *La Revolution Surréaliste*, generally exposing his doctrine and showing that what he had playfully portrayed in the painting was only a part of a larger set of problems he was working on, dealing with different aspects of the relation between words, images, and reality[65].

Concordantly, Magritte would eventually say that such was not a pipe, but a mere representation of one, and if he had written otherwise, that he would be lying. Indeed the painting is an image of a pipe, not a real one. Alfred Korzybski similarly remarked, "*the map is not the territory*"[66], also noting the difference between the abstraction and the thing in itself and their dependency on a similarity relation.

The latter is an argument particularly visible in contemporary engagement of meaning/becoming within a context as brought about through electronic digital media. Maps can induce territories as if hyper-real, virtual landscapes. That also stands for diagrams, architectural models or sketches, as they embed the potential to project the real (or the hyper-real) environments. Electronic digital media brings not only the possibility to visualize or manipulate the virtual-hyper-real, authoring models using the computer code (binary, elemental difference), or navigating through representations enabled by those. It changes fundamental space and time notions, bringing them closer together, to the point of no more distinguishable substance, to the point of meaning and representation to be hardly recognizable from one another[67].

Magritte's would further develop the theme of image and meaning in the *Interpretation of Dreams* (1930). As in a child's reading primer, the painting pictures six different elements (egg, shoe, hat, candle, glass and hammer) and their respective captions. Yet, none of the captions corresponds to what should be the expected description of the image above: the shoe is captioned as 'the moon', the hat as 'the snow', the hammer as 'the desert', and so on. With this, Magritte draws attention to a certain arbitrariness of language. There is seemingly no real connection between the picture and its caption, but there is no reason for it not to signify something else instead.

Indeed, when learning a new thing, we are implicitly instructed on how to establish some connections (how to frame this and that, what and where, and so on) and, by such, to make meaning out of it. By reading Magritte's painting we are invited to make our own connections between the sets of signifiers. The painting explicitly keeps options open, preserving the secret of its final signifier. Such sorts of mechanisms are certainly not exclusive of painting, being also found in other forms of expression. They are eminent in poetry, where, by proposing parallels, the reader is invited to make his own connections between apparently distinct signifiers. Nonetheless, in a way, Magritte is also implying that beyond words there are just empty signifiers.

In *Not to be reproduced* (1937), a similar theme reappears. The painting depicts a man seemingly looking to what it seems like a mirror, facing his back towards us, the painting's observer. Yet, where we would expect to see his face staring at us through the reflection in the mirror, we again see his back reproduced.

In the painting portraying a pipe, beyond the words '*ceci n'est pas une pipe*', we were lead (invited) to realize that the image was fake. In *Not to be reproduced* we are lead to realize for sure that the very same words of the pipe were images themselves, and not only because they were carefully drawn and, by that, resembling images of words in themselves. In it, we do not see the man's face, we see his back again, and immediately we are confronted with the existence of both backs as images. Moreover, we can even realize we are behind that back, becoming ourselves images of us, as if we were that very man, as if we would ourselves be representations. Such would not be 'truth', but it would not either be 'false'. Here something leads us to think we are seeing a mirror. Yet, Magritte shows that something much more important is there. On the one hand, the mirror (or what is represented as a mirror), and the whole representation (or the painting as a whole and the very seeming reality beyond it) can be deceiving. Conversely, everything is ultimately a mental representation whose bond to a sense of real (as in Abbot's *Flatland* where we cannot perceptually imagine more dimensions than those we experience) is constrained by an outstanding 'otherness', an invisible 'otherness' we cannot reach.

Finally, with paintings such as *Son of a Man* (1964), everything is inevitably hidden inside of another thing, like a *matryoshka*, or so it may appear. This painting portrays what it appears to be a man behind what it appears to be an apple, and what appears to be the face of what it appears to be a man is hidden behind of what it appears to be an apple. With it, we can no longer be conformed at all to what we see. We want to see what can be the face of a man that seems being behind the apple that we seem to see. Appearances, games, shades, conspiracies, possibilities, is it the artist trapping us, or what else is going on? We may think there is nothing there, there is no apple, no man, and no face: there is an image, empty. Still, we want, we wish, we desire to see.

We, humans, are curious, and so we want to see behind what we see, to the point there is nothing else to see, and still, unresigned, we will want to see more – how long is the coast of Britain?, asked Benoît Mandelbrot. We can go there and scratch the surface of the painting. But most certainly there is nothing behind the apple (except probably the materials of the canvas and the frame that holds them behind, and so forth). There is only the apple itself, or rather the image of the apple, which is not an apple at all, but is not also the image of an apple: it is all, so it seems, a conspiracy of the mind.

Yet it appears also not to be empty, it looks like there is something, something we can relate to, or more precisely, something we can relate with a reproduction of some possible similar other (because the image is reproduction of yet another), and produce (non)sense of an image of an image. We, humans, are curious and we, humans, build meanings, and that is a standpoint that in language terms only humans can subscribe. Conversely, we can build meanings even if language is absent, or signs undecipherable, or even if we cannot express them to others.

With '*ceci n'est pas une pipe*', as Foucault notes in an essay on this painting, there is the presence of the calligram, ideogram, or the image-text and text-in-image[68]. With it, we enter in a tautological set of remembrances, of spaces within spaces. The eye (mind) deciphers, but the mind (eye) is equivocal. To erase the signifier, we have to do more than that. To erase the signifier, we have to erase the graphical set of the text, we have to erase the frame of the painting, voiding the void, and still, remarkably unparadoxically, it is unattainable because the signifier is within, we are it. The pipe, while denying, is denied of its denial, it becomes a calligrammatic cyclic redundancy. Ultimately, it is a verbal game, a language game (isn't everything?), but a very serious one. It outstandingly evidences the trap of language, which is also the trap of the (human) subject behind the (human) organism. As in William Blake's words in *The Marriage of Heaven and Hell* (1908): "*If the doors of perception were cleansed every thing would appear to man as it is, infinite. For man has closed himself up, till he sees all things through narrow chinks of his cavern*".

The pipe is nowhere. The real is 'mine' and, as present tense, keeps escaping, wrapped by ever-treachery reference points, shattered, fragmented, but ever instantaneously re-assembled, ever ready to, again, and again be built, meaningfully. Anyhow, this is just an interpretation, and it seems reasonable to presume that there are multiple other readings out there.

6 ALBERT FREY'S NATURE AND INDUSTRY SYNTHESIS

6.1 A living architecture

Albert Frey (b.1903-d.1998) was born in Switzerland, and had a life path that took him, in 1928, to Le Corbusier's atelier where, among other projects, he collaborated in the *Villa Savoye*. Soon he would become the first architect in America to have worked with Le Corbusier, with whom he would keep close contact. It seems it was his innermost desire to embrace and explore developments related with the unveiling of a new architecture—"*I went there because I had seen his books, his architecture, and some of his published works: I decided that I had much to learn with him*".

It was this restless desire, added by his own travels and life experiences, which would lead him to later develop the 'new' in his own terms. This would happen after moving to the USA, in 1931. The early times there where spent in New York, working with A. Lawrence Kocher. Together, they design the *Aluminaire* house (1931), built in a lightweight structure of steel and aluminum and embodying a prefabrication philosophy. The house would be chosen to incorporate MoMA's *International Style* exhibition in 1932.

The Great Depression was striking, and in that same year, Frey travels through the USA, making photos of industrial constructions—metallic gas containers, bridges, electrical towers and the desert landscape. This new country delivered him a wonderland of new materials, and industrial types of constructions, but it also brought a fascination for the mesmerizing landscapes, most notably the immense of the desert, with its contrasts of heat and cold, flat and mountain, dust and rock, heart and sky, death and life…, and its shapes, shades, textures and feelings. The material gathered from his journeys would result in the book *In Search of a Living Architecture*, posteriorly published in 1939, where he sets a programmatic tone for his own architecture, manifesting an appraisal for the forms of nature and placing them in dialogue with the industrial forms of man. In his journeys he would also visit Neutra and Schindler, which he recognizes as influences alongside Le Corbusier and Mies Van der Rohe: *"(they helped with) the idea of expanding the house in the landscape"*[69].

From his words, architecture is originated in nature, and hence it must be drawn back to it. The splendor of nature is the ever-unreachable model of man's artifacts. Its perfection is greater than architecture can ever aspire to. Engaging with architecture is also being aware of what surround us all the time, both natural and human (made) landscape. Accordingly, he writes the following: "*observe carefully how things come about in nature (…). See lots of architecture… get full of it*". The new, modern, architecture must be a synthesis of these spheres, economy, efficiency, and beauty taught by the natural forms, allied to the possibilities and limitations of man-made materials, of which the industrially produced are the highest example. In addition, it is not only the haptic properties that one should observe from nature, but the very principles of spatial and formal composition, as altogether they enrich the new architecture: *"it is by studying the forms of nature, which have always inspired* *mankind, and those of traditional architecture, which have induced beyond practical usefulness, for theories of ideas and structure that we will discover the basic principles which guide the creation of shape, space, and composition and be able to build a living architecture that not only provides us with physical comfort but with spiritual joy as well (…). I studied forms, industrial and natural, and then I analyzed what the form meant (…). Two fundamental elements of composition are combined in one structure, an illustration of the way modern methods enrich visual experience*".

Frey considers that there is not an inevitably to attain a continuity solution between nature, needs and human work: "*I try to have a preconceived idea about the building, without seeing how the location is, and by that I try to compose and to make architecture out of it with the functions and all the rest. I try to work with nature… I do not aggresse it, I respect it. Nature is beautiful. After all, we come from it. We have grown for millions of years in contact with it (…). You must also have fantasy working out. After all, that is life. When you think in what is happening in nature, in fantastic forms, in birds and animals and all. That is where creativity comes in*". Anyhow, he ends up analyzing every bit of the site, as it was the case of *House Frey II*, where he spent months just to analyze the sun position along the year until finally deciding the exact location and orientation, and where he surveyed every inch to fit the building with the rocky plot. Therefore, his perspective is not about not a dichotomous relation nature *vs* (man)machine, but a dialectical one, where each has its own space, but each has to be aware of the space of other.

Work would lead Frey to Palm Springs, in 1933, to supervise the construction of a joint project with Kocher, the *Kocher-Sampson* house (1934). Since the 1920's, the desert around Palm Springs, became a rest and winter vacations area for rich and bohemian people – the desert as a safe haven for the realities of daily life. In less than two decades, the desert also became an experimentation field of modern architecture, as exemplified by the *Popenoe Cabin* (Rudolph Schindler, 1922), or the *Miller* house (Richard Neutra, 1937), embryo of what would follow years later with the masterpiece *Kaufman* house (Richard Neutra, 1946).

6.2 *House Frey I*

After constructing the *Kocher-Sampson*, Frey decides to stay in Palm Springs, where, in 1941, he builds the central nucleus of his *House Frey I*. Experimentation is visibly the greatest driver, in a house that started as a minimum *bachelor pad* house, in 1941, and ended as a family house in 1953. That is reflected both in the formal language and in the design philosophy, with its additive and transformative approach. The building began with the design of horizontal planes elevated by vertical walls, which are either transparent or opaque. Initially, these recalled a tridimensional neoplasticist interplay, with planes extending towards the exterior, somewhat resembling Mies Van der Rohe's archetypal *Barcelona Pavilion* (1929). Experimentation is also extended to the use of concepts such as growth and adaptability, since the house went through different stages, which would follow an intention and expression through ruled or modular architectural elements. Finally, these make use of industrially borrowed materials, which further enhance the underlying general theme of man (artifice) facing nature.

The *bachelor pad* is a wise composition of elements that make a powerful play of contrasts. One of these occurs between the aluminum as external coating, the rose color used in the internal walls and the orange tones of the furniture. There is also the contrast between the machine-like character of the house and the desert where it sits. The original house is of 16×20ft (4.9×6.1m) and is composed of a main room, which works as a living room at day and bedroom at night, a toilet and a small kitchen. The walls extend towards the outside, and the flat roof creates small porches in all four sides (one of which bigger than the others in order to park the car). Although relatively small, the vertical plans expand the house towards to the exterior, which increases the perceptual sense of space. It is a dot in the desert, from where any direction is possible, limitless.

The ensemble is articulated through a module of 4×4ft (1.2×1.2m), which is doubled in height to 8ft (2.4m), which is based on the dimensions of the asbestos roof plates that are used in the building. Sliding doors are thoroughly used, enabling multiple spatial configurations. Finally, there seem to be a special cherishing on showing technical apparatus, as both the car and the air conditioning are often visible elements in the photographs.

From the bachelor house (1941), to the final family house (1953), there were five recognizable stages of construction. The first is the house unit with main room, toilet, kitchen, and outside porches, beginning with the 4ft (1.2m) modulation, interior delimitation of 16x20ft, roof covering of 28×28ft (8.5×8.5m), and 8ft height. In stage two, a swimming pool, with concrete pavement and furniture, was added in the south, extending the house modulation, measuring 31x28feet (9.4×8.5m). In stage three, a pergola is added around the swimming pool, with lightweight stainless steel supports, and white coated glue-laminated wood shades (which would not resist the Palm Springs sun); in addition, a discreet landscaping was implemented, by adding some palm trees to the ensemble. Finally, in 1953, the house goes through two main changes. One is the horizontal extension, including the interior patio, construction of a new metallic and glass-fiber pergola, and colored (yellow, rose, green) corrugated glass-fiber wall panel. The other is the vertical extension, with the construction of the room in a new superior floor, with circular plan and eight, hatch-like, round windows.

About the superior volume, Frey said: *"Thomas Jefferson had a second floor (in its house in Monticello) which was more octagonal, but also had circular windows. Then I remembered a Mayan astronomic observatory which I had seen in Chichen Itza, called the Sun Tower, a round building with just a few windows. The bed was in the middle and had a 360º view. The visors protected the openings from the sun. They were cut in angle and its depth varied according to the side they were at".* In the interior, the walls were covered with a yellow coated cushioning, to produce a cozy effect to the room, *"the curtains (…) were in a sort of midnight blue, so that by night, when you would close them, you would feel it was good to sleep with"*[70].

On the constructive solutions to the patio, Frey said: *"(The curved thin wall) was in fiber-glass, which could be in rose, green or yellow. It was a structural challenge… it is like a water tank, it is corrugated and sel-sustained thanks to the curves. Therefore, one can say it is a wall of only a 1/16inch thick, instead of a heavy wall of some kind. It only had a pair of braces…, two tubes, …(…). I like to make things with the least material possible. Speaking in economy… I am much more interested in achieving the maximum by the minimum of money. It is a challenge by itself. It is very easy to scatter and spend a lot of money, but that's not very interesting. After all, the economy controls many things"*[71].

The house reflects its authorship, revealing a pragmatic mode of thinking, allied with a particularly ecological view of the world and a certain desert mystique. Technically, industrialization is thoroughly used, with adaptation of new materials and industrial techniques applied to architecture and an overall philosophy of economy in the approach to architecture, its space, and its materials. Artistically, early works suggest a more abstract approach, with a neoplasticist base and the use of industrial and natural landscape as references. Later, it is also observable a certain tendency on a sort of pop approach. Overall, it reflects tendencies of liberty, of no constraints to pre-established paths, economy and ecology, of experimentation and zeitgeist, but fundamentally on a path in the search of the commons between machine and nature with man.

7 THE ADDITIVE ARCHITECTURE OF JØRN UTZON AND THE ESPANSIVA SYSTEM

7.1 Vernacular and natural influences

Somewhere around 1965, while working in a little site office in the *Sydney Opera House*, Jørn Utzon gets up and with his 6B pencil writes the words '*ADDITIVE ARCHITECTURE*' on the wall, adding that '*we have now broken through the sound barrier*'. The sudden epiphany was in fact the result of a long, slow and laborious development, retrieved from each design, each of his extensive travels, each reading, each experience, all synthesized in a brief concise expression and subsequently in a homonymous manifest[72].

As his documentation attests, Utzon cherished and shared an open view towards the world. In 1948 he writes: "*To understand all the inspiration present in every one of Man's countless means of expression, to work on the basis of our hands, eyes, feet, stomachs, on the basis of our movements and not of statistical norms and rules created on the principle of what is most usual—this is the way forward to an architecture that is both varied and human*"[73]. Early on, in 1949, he had visited the pre-Columbian sites of Chichen-Itza, Uxmal and Monte Alban, where he became seduced by the magnificence of the methodically built rock buildings and the dialogue they established with their setting. From the XIIth century China, Li Jie's *Ying Tsao Fa Shi* technical treatise on architecture and craftsmanship, Utzon was impressed by the power of a flexible *kit of parts*. Likewise, the Japanese domestic architecture, as for instance depicted by Tetsuro Yoshida in *The Japanese House and Garden* (1955), with its apparent but intricate simplicity, would also leave its imprint; namely, in the use of a constructive philosophy based in a lightweight tectonic-like approach, integrating modularity principles, and finally, all peacefully resting in a precise relation with a surrounding *nature*, which is also often a construction. The observation of natural structures, as depicted in Karl Blossfeldt's photographies or D'Arcy Thompson's writings, was one of his most prized subjects. The formal cohesion of villages such as Ait Benhaddou, which he had visited in a trip to Morocco in 1947, his study of Chinese Buddhist monasteries, or his fascination in Islamic art, how its exceptional buildings coexisted with the medina underneath, are examples of the importance given to the vernacular structures[74].

7.2 An *Additive Architecture*

The kind of dialogue undertaken between the built structure and its surroundings, artificial and natural, would become remarkably visible in buildings such as the *National Assembly Building* in Kuwait (1968) or the *Sydney Opera House* (1957). This dialogue is in both these cases also a dialogue between heavy and light—the *gravitas* and *levitas*—acting as propellers to technological development. Indeed, the play of inside-outside transparencies, dialoguing with the surroundings is remarkable in the first, with the heavy elements framing the transparency screens towards the outside. As in the pre-Columbian plateau buildings, the *Sydney Opera House* conveys a feeling of being firmly tied to the ground. Simultaneously, above the masonry plinth, the white shells seem to be lifting in the air, as sails of a vessel ready to depart from the harbor at any time.

The shape of the shells incorporates a research that evolved towards simplicity, arising as both a way of technical problem-solving and overall design philosophy. In the early designs, the shells required a calculus with non-Euclidian curvatures, which was virtually impossible to compute without digital methods, non-existent at the time. Instead, as it evolved, the apparent complexity of the shells' curvature became in fact derived from the segments of a sphere, the simplest sort of curvature. By simplifying and thinking modularly, it was enabled a greater control and rationalization of the building process. That occurs up to the tiniest elements, from the sphere-derived structural curvature conception, up to the modular development of the components of the white skin. These are also evidence that a modular approach is not necessarily opposed to, say, an organic approach. Rather, it is evidence that these can be effective means, regardless of the intentioned form and its degree of complexity[75].

In Utzon's architecture there is a sort of grammar that became progressively recognizable, where every component of the building is interrelated, both conceptually and tectonically. Utzon's *Additive Architecture* manifesto is the utter expression of this mind-set[76]. With the manifesto, there is an implicit appraisal to the virtues of mass production set towards formal freedom. A strong underlying idea is that is possible to devise architecture from a limited set of elemental components of shared similarity, which nonetheless enable to attain apparently complex shapes. This can be achieved as straightforwardly as by juxtaposing the components with nuanced repetitions, varying with no more than simple geometrical operators (e.g. translating or rotating). The concept thus entails a kind of repetition that does not necessarily lead to uniformity, but ultimately to an apparent organicity. It acquires its fundaments in a fascination by nature's structures, or on the vernacular built forms, and aims a return to it, retrieving spaces and shapes that although artificial, aim to achieve an ever-more balanced relation with their settings. The cases of the *Farum's Town Center* (1966), the *Herning College Campus* (1969), the housing *Skåne* schemes (1954)—realized in the *Kingo Houses* (1957) and the *Fredensborg Houses* (1965)—or the *Espansiva Housing System* (1969), are remarkable examples of Utzon's efforts to incorporate *Additive Architecture* principles as an overall building philosophy in his works.

The realizations of the *Skåne* scheme are remarkable examples of taking the additive principles to their ultimate consequences, embracing it both in the public and in the private sphere of the houses and their ensemble. The *Kingo Houses* master plan denotes a unity of similarities. In a closer scale, the designs are based in a one-story square atrium house, whose boundary changes either accordingly to the relative positioning to the next square, to the topography of the terrain or to the customization of the lot by its inhabitants. With the same configuration, the master plan could have been more rigid. Instead, option was to codify it spatially to establish a dynamic dialogue with the setting and in time. As consequence, the subtle changes that occur, either by topographical differences or by the customization of the units, transform the entire house complex in a vivid and by no means monotonous ensemble. Both the public dimension of the exterior gardens, and the private dimension of the open-ended courtyards, is bonded by a multi-scale approach where the unity of the system is perceived in the diversity of its appearance.

7.3 The *Espansiva System*

The ability to individualize home in a flexible way would be the core of the building concept *Espansiva*, which was also developed under the *Additive Architecture* principles. The initial goal of *Espansiva* was to develop, produce and combine components for single-family houses with wood as the predominant structural material. It envisioned the use of standardized, low-cost components, based in a single floor modular composition. Aside conceding individual clients the ability to plan, as well as to alter or extend in time, it also had the potential to be extended towards larger complexes. Whatever the case, the system endured the potential to retain a formal uniformity (or resemblance) in diversity. The components were to be put together in a very large number of spatial combinations, be easy to assemble and produced at a competitive price. Combined they could potentially meet different programs and space sizes requirements—houses, schools, motels, and so forth.

The modules consist of small pavilions, with a layout with fixed width and variable lengths, with a column in each corner. In a conceptual stage these were set to come in four layout sizes. However, the developed version of the design contains only three layout types: A (201.6×300cm); B (321.6×300cm); and C (501.6×300cm)—measures referring to inside dimensions. The A-type layout allowed a transition space with or without storage space, a small room, a toilet, a small toilet plus a transition space, or other variations. The B-type layout essentially delivered the net dimensions of a basic bedroom, a home office, a kitchen, or a dining area, among other eventual variations. The C-type layout could be used as an open area (e.g. for a living room, normally with two joint C-types), or joining the possibilities of both A and B types together under a single slope of roof (e.g. for a bedroom plus toilet or plus transition area, kitchen plus dining area or plus transition area, and so forth). Regarded in brut, the *additive* philosophy of the system seemingly requires a bigger lot size if compared with a traditional construction system. Nevertheless, its effectiveness enables a spatial rationalization that may counter that very idea.

The main structure, two connected porticoes in laminated wood, rested in four prefabricated concrete beams, which were anchored to concrete foundations. Doors and windows had roughly 2.20m and a minimum floor-height roughly 2.40m, where from runs a standard roof with 17.5º slope following the length dimension. Given the fixed width, but variable length, this means different top heights for each type of module. This meant a great potential in volumetric variability. Allied to the potential variability in the layout combinations, and the possibility of final coating in any kind of compatible material, this meant enormous potential combinations, in layout, volume and renderings.

The project was initiated by the timber industry, and it was intended that the timber dealers would stock elements to enable a faster construction process. In principle, a family could pick up the expansion of their house and carry it on a trailer. Extension, alteration and retraction should be easily possible, as the structure was light and flexible. People would not be tied to specific designers or manufacturers, as a great deal of variability was possible. All kinds of standardized doors, windows, claddings and roofs would be possible to include in the dwelling. Utzon was greatly inspired by Alvar Aalto's thoughts on standardized flexibility of the interwar period, which were ultimately reflected in the development Aalto's *AA System* (1937-45): simple combinations of standardized units would make possible to create a great variety and diversity of expression.

Espansiva concept had several particularities which were somewhat predicting a future of the construction industry, implying themes such as industrial prefabrication, mass customization, system supplies, modularity, user configuration, flexibility, and so forth. For many reasons the project was never realized in a large scale. Among other things, it revealed several technical weaknesses, of which most notoriously a significant waste of material. Additionally, there was still a lot of work on the construction site to put the house together, finishing the façades, of interiors, and so on, which impeded many of the though-of advantages. Furthermore, there was no thought of installations, as these also had to be made on site.

The use of mass produced, generic elements, was embedded in an intention of enabling to build each house regardless their location. In first hand, this may seem to contradict Utzon's concepts of harmony with the natural setting, as it would be eloquently achieved in his later *Kingo Houses*. In any case, the *Espansiva* case should also be seen as a part of an overall effort of providing quality housing at affordable prices while enabling individualization, an effort that throughout modern architectural history has been undertaken by many of its most remarkable figures. *Espansiva* is embedded of a economic spirit that nonetheless embraces configurations that are gradually more elaborate. As in nature or in the vernacular, change is acknowledged, ultimately hardwired in the *additive* philosophy.

8 JOHN TURNER'S NETWORK AND HIERARCHY

The central theme of *who decides what for whom* is an enquiry on how we house ourselves, how we keep healthy, how we learn. It is an enquiry on the control (e.g. political, economic, commercial, institutional) exerted in modern societies. It is also an enquiry on how to regard such control as a means or as the ends, and how to exert our (fundamental) freedoms. Moreover, it an enquire on how to integrate user participation within housing and dignifying living conditions, which should be available for all, as expressed in the *Universal Declaration of Human Rights* (1949), and recognized in many national constitutions.

Although so far never entirely fulfilled, John Turner's views, expressed in *Housing by People: Towards Autonomy in Building Environments* (1976)[77], have been implied in some attempts in Europe to involve residents' participation concerning the built environment. That was the case of the cohousing movement in Scandinava, of the works on self-building and participatory architecture of the 1960's and 1970's, or of the work of architects such as Walter Segal, and the development of the *Segal System*. The latter pioneered a low-cost system of timber-frame building, where anyone who could pick up a hammer could build its own house[78].

Turner departs from an open-ended standpoint, empowering users while advocating the use of short footprint construction products. He writes: "*In historical fact, good housing like plentiful food, is more common where it is locally produced through network structures and decentralizing technologies… these are the only ways and means through which satisfactory goods and services can be obtained, and that they are vital for a stable planet… We have no right whatsoever to tell others to tighten their belts while our own belies protrude so much that we cannot see the poverty we stand on*"[79]. From his work, it can be understood that, in housing, focus must be put in understanding different control strategies. To attain it, typically there are two distinct lines of approach. In one locally self-governed housing systems, as illustrated in the historical, idealized vernacular or in less romanticized forms of vernacular such as the contemporary slums. On the other, policies of central control, ascribing to a deterministic top-down stance. On the one hand, there is autonomy, on the other, heteronomy.

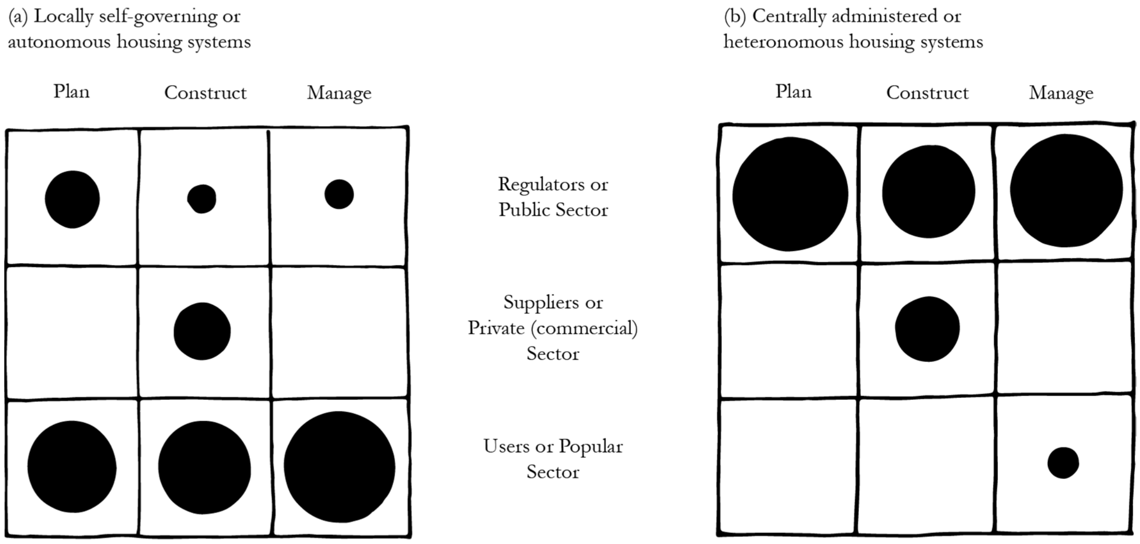

Figure 1. Diagrammatic representation of patterns of decision and control describing two opposite systems (locally or centrally governed) as mirror images.

Turner's diagram-grid eloquently depicts the problematic (Figure 1). Decision-making sets of operations (i.e. planning, construction and management), are crossed with institutions controlling the resources for the process itself (i.e. the users or popular sector, the suppliers or private commercial sector and the regulators or public sector). Provided that the goal is the same (i.e. to deliver proper housing and living conditions), probably the most balanced solutions lay somewhere in between the autonomy and heteronomy poles[80].

In his view, the high and inevitable spiraling cost of hierarchic systems typically creates a disproportionate dependency on borrowed capital. Such ultimately leads to such systems to collapse financially. On the other hand, systems kept by network structures tend to flourish. They only become unstable or disappear because of movements by hierarchic structures. In low-income cases, the investment made by highly hierarchical structures is hardly recoverable. On the other hand, apparently, the closer is a system to the user, the more likely will be that in the long run the system will prove viable. Emotional aspects, such as a sense of belonging, certainly will be reflected in user engagement and responsibility, leading to a closer care with reflex in a long run. Nonetheless, such is not always possible to achieve in architectural solutions, even if incentives are seemingly the right ones.

9 JOHN HABRAKEN'S *SUPPORTS*

Mass housing is an important area on which aspects to streamline user participation have been thoroughly researched. In The Netherlands, *The Foundation for Architectural Research* (SAR) has since 1964 been on the forefront of such research, embedded in a spirit of using prefabricated elements for both the loadbearing elements and the detachable parts. The quintessential conceptualization is due to John Habraken's distinction of *support* and *infill* (or supports theory, as it is also known)[81], which establishes the principle of three autonomous levels: building, subdivisions and furnishings.

Among the core references to the theory stands the *Schröder House*. Influences also came from the Dutch structuralist tradition of Aldo Van Eyck, Piet Blom and Herman Hertzberger. The proposals made a distinction between permanent 'hard core' and flexible and changing interior. A famous precedent for the *Supports*' idea is too the *Plan Obus* by Le Corbusier. Habraken's proposal is based in a fundamental concept: the separation of the collective, permanent components of a residential building (i.e. what strictly corresponds to ordinances, structures, technical installations, and openings: the *support*), from that which could be transformed by the individual dweller (i.e. the interior partitions, closets, bathrooms and kitchens elements, that is, the detachable units: the *infill*).

By establishing clear gradients between public and private, exalting and improving them in transition spaces, and with the possibility of users transforming the base building, the supports theory, applied to residential buildings and neighborhoods, has facilitated the addressing of the typical complexity of high-density housing. The developments were both embedded of a participatory philosophy, and an acknowledgment of the importance of industrialized methods of construction, with the structures conceived through the *support* and *infill* concept.

A durable *support* would be linked to the aspect of housing production that represented communal responsibility, and the *infill* stood for individual control. In the course of the 1960s, Habraken got to know other proponents who designed alternative structures for the city, such as Constant and Yona Friedman, but he considered their plans too utopian. However, he did not make himself drawings of models portraying his supports proposal, because he wanted it to be adaptable to all kinds of formalisms. In the core of his proposal lays the system, the method, and the set of rules.

Amongst *SAR*'s research developments, in *support* may be also distinguished the *bearer* and the *infrastructure*, both retaining a community's responsibility, and individual infill, accompanied by modularized dimensions which intrinsically facilitate the incorporation of prefabrication elements. Another development is the conception of prefabricated service units for kitchens and bathrooms, their inner characteristics and layout position in free plan layouts, in order to enable users to furnish freely their living spaces.

Among other proposals, in *SAR* was developed a *zoning system* in order to ensure an optimization of these aspects. The proposal divides the house in three zones, parallel to the façades. The two zones closer to the outer walls are used for living spaces. Between these and the third, placed inside and containing the services, there is a margin allowing for flexibility in the zones' dimensions. The position of inner partitions and service shafts obeys a modular dimensional system, which sets users' free to adjust the space to their needs according to the underlying system. Therefore, the users were to be engaged in the design process, which gave them a greater freedom, while it was assured an industrial efficiency regardless the choices within the system.

Certainly Hertzberger's *Central Beheer* reflects some of the supports notions, giving it a tectonic sort of sense. The discreet modes of a tectonic approach seem adjusted to constructive elements that can be distinguishable, and such can be paradigmatically ascribed to a Northern European kind of architecture of an industrialized influence. However, these are too fit to a sort of archetypal mass and volume of the *South*[82]. Indeed, by no direct means linked to the supports theory, the example of Alvaro Siza's *Malagueira Quarter* (1977) is an expressive manifestation of an architectural design combining control and freedom, where there is an implied use of structure and infill presupposes, although acting at a different level in a *Southern* architecture.

10 ENACTING FREEDOM IN HERMAN HERTZBERGER'S *CENTRAL BEHEER*

As it has been expressed by Herman Hertzberger, "*(Structuralism) has proliferated in everything in terms of putting things together… All sorts of systems and especially the computer systems are now considered to be Structuralism. I understood it as a way of increasing freedom: by having some things structured you get more freedom, not less. The misunderstanding others have is that they use the idea to keep control*"[83]. However, the idea of an architecture where there is a primary concern in focusing in the individual (how to incentivize participation) has been proven to be hard to put in practice. The set of rules (e.g. economic, legal) that have to be followed to make a building is tighter and tighter, as "*today everything has to be fixed and decided before the work starts*"[84]. However, it is also a more increasingly industrialized architecture, relaying more and more in the catalogue picking, rather than developing elaborate detailing from scratch[85].

In Hertzberger's work there is a philosophy accompanying both his buildings and his writings, which poises a certain freedom in spatial relations. That translates in spatial conceptions favoring appropriation and customization by users. In such, the concepts of *structure* and *filling*, in line with Noan Chomsky's notion of *competence* and *performance*, are essential to understand a reconciliation of the individual with the collective in the architectural production[86]. In fact, Hertzberger's architecture attempts to be structuralist up to the tiniest scale. In a way, he regards form as a consequence, not the design motive or aspiration, in an overall concern in designing spaces that are clear but complex, solid but adaptable. Indeed, Hertzberger's structuralistic approach does not end up in some kind of external form, it goes all the way to the smaller scale, and from within, with an underlying idea of spatial articulation, of providing conditions for people to flexibly occupy space[87].

In that respect, the *Central Beheer* building in Apeldoorn (1968-72) is probably Hertzberger's most eloquent built example. The design brief asked for a building for the headquarters of an insurance group whose activities were not limited to the insurance sector, but which also offered other services. It should also be possible to allocate space, and the building should be able to house one-thousand people. Overall, the building would predictably require frequent changes, which ought to be possible to accommodate within itself, and such meant adaptability was to be a permanent condition.

The building is a sort of archipelago of 56 square-based units of 9×9m, which are subdivided into smaller ones. The spatial design is based on a basic modular scheme of a combined cruciform structure, generically including three types of spaces: basic functional spaces of square base; large horizontal circulation spaces in between the square spaces; and void vertical spaces. The cruciform spatial structure is co-related with the building's primary construction elements, undergoing two complementary principles: a clear structure, which included the structural and infrastructural elements; and an interpretable and variable space, though of to answer any program it could predictably include.

The elements contribute to a perception of the building as an entity made up of smaller ones, underlined by a three-dimensional structural and infrastructural grid. A system of numerous columns defines the positioning of the spatial units and promotes the articulation between spaces. It is an open spatial structure, as highlighted by the polyvalence of its smaller spatial units. The basic spatial units are where primary functions are accommodated. Moreover, the potential different functional layouts of these are extensively thought of in the design stage. These basic spatial units are polyvalent, meaning that, if necessary, they can take over each other's roles, which is key to absorb change. Between each unit and the next lays an ambivalent, interpretable space whose dimensions enable it to work simply as horizontal circulation space or circulation plus extension of the basic units, further expanding their spatial configuration options. The external appearance is directly linked with the inward spatiality. Volume metamorphoses to space and vice-versa, stimulating an heterarchical, open use. Validating such concern in the conception is the fact that, since 1972, the insurance company has undergone great changes, and with it the building's spatial organization. Nonetheless, regardless those changes, the built structure remained unchanged, proof of its polyvalence[88].

11 ALTERITY BEYOND CONTROL THROUGH JEAN NOUVEL'S *NEMAUSUS I*

Jean Nouvel's *Nemausus I*, is an eloquent example on how different levels of constraints may be overcome at the design, limited by budgets or regulations, or at the user level, limited by the architectural impositions. *Nemausus I* is a state-financed social housing built in 1986 in Nimes, France. It consists of two long buildings which border a tree filled inner court. This central element has become the public bond to the project, which both separates and unites two distinct buildings.

Since social housing regulations did not allow underground car park, the issue was overcome by elevating both buildings and digging down the area below. That suffices to accommodate the cars in a protected open-air area underneath the buildings, while keeping a physical and visual relation with the inner court and the other building.

The complex was designed to give people the maximum amount of living area, achieving 30-40% more than usual for equivalent price. Since the apartments are duplexes or triplexes, they also represent large spatial volumes.

During the design stage, a central option had to be made on whether to allocate resources mostly in the exterior or in the interior zones. To build more space with the same budget, besides pondered layout options, efficient construction methods had to be used. Reduced to the simplest level, the buildings of *Nemausus I* are rectangular blocks simplified to the extreme and, in this sense, they cannot be distinguished from other modern social housing answers.

Along a concrete base, at regular intervals, concrete walls are disposed, both separating walls of the apartments and supporting the above floors. These walls regulate the entire construction, constraining the dimensions of the apartments. The gap between the walls is 5m, which is the space needed to park two cars side by side underneath. With the exception of the elevator shaft, everything follows this regulation: the width of the apartments; the space between the beams supporting the walkways; or the screen paneling of the roof. All the collective parts (i.e. stairs, walkways, tree court, and car park) are joined out the façade, ascribing to the needed economy of internal area use, which is thereby released to the apartments. The gains are twofold, expressed in bigger savings and bigger apartments. Walkways are placed in the North, and the private verandas, in the South, adding extra 15m^2 to each apartment.

The 5x12m apartments stretch all the way from walkway to private veranda, façade to façade. Between the two concrete walls, there is a single volume of space. On the lower level, a living room and kitchen separated by a central services block, and the stairs going up. In each apartment, these elements can be combined differently, aligned or perpendicular to the concrete walls. There are no doors, no walls, and no hallway. There is no waste of space, but also there are no privacy filters, as the kitchen links directly to the walkway. However, due to the shortage of storage space or closed private garages, inside the apartments most of the veranda spaces end up being occupied by the user to accumulate their stuff. In the mind of the architect, this was to be a relaxing space, a kind of extension of the living room. Yet, in the mind of the users, this was used as an opportunity to overcome needs that were not otherwise being fulfilled.

The façade wall separating from the veranda can be completely folded back, expanding its space. Industrial materials are thoroughly used in the exterior (e.g. façades, stairs, walkways barriers) and interior (e.g. stairs, toilets), aided by the modulation of the concrete walls. The industrial quality also extends to the interiors, where the concrete is left in a raw state, and industrial stairs and panels are used. However, the choice of materials did not please a large portion of the tenants, which in the meantime have taken the chance to customize it. In some of the flats the 5m bay has been divided into smaller rooms, but in most of the apartments, the full width of the structural bay is kept, and the impression is of a very generous, open loft space.

At *Nemausus I* the design intentions were to build more space for the same price and to offer a living space in line with a modern lifestyle. The apartments were delivered to the tenants in the raw materials, brut concrete on the walls, metal staircases, and so forth. This was a design choice, a deliberate choice of 'non-decoration'. The apartments may seem incomplete to the users, but they are finished. As if a blank canvas, this could be regarded as an invitation for a user free-interpretation of space. However, the architect's intention did not entail an open-ended approach, yet it was uniquely an aesthetical option. Such is confirmed by the building's internal regulation document forbidding tenants to make changes, which evidently they do not meet. For instance, no wallpaper or coating is allowed. Nonetheless, the inhabitants attack with carpets on the walls, paints, wallpapers or adhesive cornices; they have put false walls, locked-off corridors, disguised the staircases and hung curtains; they adapted it according with their means and tastes. In the long run, their will is going to prevail.

In the miracle equation of *Nemausus I* there are serious consequences. The architect won the battle to build apartments 30 to 40% bigger than usual for the same price, but the tenants, whose rents are calculated per square meter, are consequently obliged to pay 30 to 40% more. Bigger, ended up meaning more expensive, and more difficult to rent.

Generally, the blends of regulations and tight budgets reduce design options so much that it becomes extremely difficult to deliver differentiated architectural products. That often leads back to the efficacy of the functionalist models. On the other hand, as when forbidding the decoration of walls as Jean Nouvel did in *Neamausus I*, the architect's temptation to leave a personal imprint, if taken to extremes may well result in an opposite effect, making justice to the saying 'forbidding is empowering desire'.

In a way, the episode recalls the *Farnsworth* house (1951) famous dispute between the client, Edith Farnsworth, and the architect, Mies van der Rohe, where, besides the cost of the house and the heating bills, the client would later complain about the impracticality of a house with no usable walls.

Aldo Van Eyck somewhat professed freedom to the user but failed to deliver it when he saw his *Orphane* being remodeled for a different use than what had initially been conceived. Regardless the doctrine, delusionally, most architects simply want things done their way, exerting control and aspiring for it to prevail in time.

II (Pre)Fabricating Architecture

COMPLEMENTARY TEXTS

1 OUTLINE AND CHALLENGES OF THE HOUSING AND THE CONSTRUCTION SECTOR IN EUROPE

1.1 Introduction

The housing problem in the Western World becomes a central issue with the Industrial Revolution. Mass housing and its related urban planning philosophies are initially a way to provide a concrete answer to an urban overcrowding caused by the rural exodus of workers to the cities. Meanwhile, economic collapses and World Wars further stressed the issue. Finally, the very spirit that gave rise to industrialization was methodologically borrowed to address the housing problem, with a mechanistic approach whose philosophy was imbued of the *Fordist* and *Taylorist* ways.

The assembly line, primarily developed by Henry Ford for the automotive industry sector, soon became a paradigm for all productive sectors. It comprised the synchronized production of standard components and identical products as ideal means to attain economies of scale. These sort of principles would significantly influence the design approaches in high housing demand periods, as they carried the promise of leveraging the bonds of industrial production and construction methods to yet unseen levels. In architecture, eventually such became an important influence for the Modernist founding fathers, showcased not only in the development of functional approaches, but also in the development of formal languages and aesthetical ideas, as well as in the development of production modes of residential buildings.

In the Europe of the XXth century, periods of peak housing demand followed WWI and WWII. Design-wise emphasis sprang from two main sources: rationalization of planning and design, and implementation of industrialization principles to construction. On the one hand, way was made to rationalize planning and design, as are examples the qualitative methodologies developed by Alexander Klein in the early XXth century and the analysis to social housing in *CIAM's Existenzminimum*[89]. On the other hand, the focus was directed to the implementation of industrialized methods in order to increase productivity and gain efficiency, attaining economic advantages. In due course, industrialized construction methods would be introduced at the production and construction stages. The goal is similar in all cases and can generically be put in: saving time on site or, with scaled productions, saving time on factory; with the accomplished economies put at service of financial savings and/or of improving the spatial or material quality of the developments, and so forth.

The most extreme combination of rationalization and industrialization principles occurred in state centralized approaches. In Central and Eastern Europe some of these *tout court* methods kept going as late as the early 1990s (coinciding with key political changes), supported by centralizing planning policies and substantial state funding. These kind of practices no longer have a significant occurrence in Europe but they can still be found in places such as China[90]. In this country, alongside some speculative monstrosities, there is a huge demand for low-cost housing from a migrant rural population overcrowding the urban centers—the producers of the world's consumption goods in factories of global scale. In this respect, the Chinese recent history is evocative of the urban problems occurred with the industrialization of the Western World in the XIXth and XXth century.

In Western Europe, markets would eventually get more liberalized from the 1960s onwards, coinciding with strong social changes. From the time when the post-WWII housing shortage and economic growth incentives through housing programs was overcome, the degree of repetition of some of these solutions became unacceptable for a society increasingly focused on individual freedoms and choices—with the idea utterly illustrated by a new social order introduced by the May 1968. Consequently, the mass approach was progressively abandoned. The changes conducted through a liberal philosophy would enable a more organic kind of development, easing the consideration of renovation, replacement and/or addition philosophies. Nonetheless, some liberalization policies, allied to a deficit in creation, implementation, and/or supervision of regulatory mechanisms, have led to a widespread of speculative real-estate. In many cases such has become economically, socially and environmentally harmful, undermining the built-environment. Signaling such idea are the latter trends in construction research and practice, which have been showing great concern with sustainability issues, with considerable attention paid to energy or environment matters.

1.2 Some numbers

A bubble of real-estate overabundance—which ultimately was the visible igniter of a difficult economic situation publically bursted in 2008 and whose shockwaves are still being felt—could indicate that, at least in part, the housing problem in Europe should be currently solved. However, that is not exactly the case. In 2009, 6.0% of the EU population was suffering from severe housing deprivation, with worse cases found in Eastern European member states, and in countries such as Romania achieving nearly 45%. On the other hand, while population growth is slower than in other continents—and with many cases of critical demographic figures of ageing population—the number of households has increased much more rapidly than the population in the past few decades[91].

A number of factors may contribute to this panorama and different interpretations can be made[92]. It should in all cases be reminded that the housing problem is much more than an architectural or construction problem, having deep social implications. Considering the ratio dwellings/population, it is clear that the housing market in new constructions in Europe is saturated. Exceptions stand in Eastern European countries, where some new building opportunities are still waiting to be found, which can partly be explained by a latter liberalization due to the historical circumstances. As a consequence, the market is currently dominated by refurbishment and maintenance. To some extent this can be explained by a market reaction to the declining in new building, and prospects are for this tendency to be kept in the future.

The idea of decline is also confirmed by the predominance of certain types of houses over others: in 2009, 41.7% of the EU population lived in flats, 34.3% in detached houses and 23.0% in semi-detached houses[93]. Comparing overall numbers, this reveals a slightly bigger propensity for European citizens to live in cities than, for instance, in the US (around 80% in detached or mobile-homes, according to 2000 census figures) or Japan (56.5% in detached houses, according to 2003 figures). Socially and culturally these figures should not be disregarded and indicate that the historical Europe may be more appealing to an urban lifestyle. This can also disclose a certain standstill, to which an atomized fabric of construction companies does not bring a positive contribution to the stand[94].

1.3 The construction sector

The enormous range of systems and products which characterizes European construction industry has many reasons. One of the strongest is linked to a solid local anchoring of the construction industry to national contexts, and the structural traditions of the building crafts of the local construction industries[95]. The 'idea of Europe' works here only in the sense of defining a common market, in which, simplistically, the construction industry is merely a sort of embryo of project, a business sort of project. This is also a reflex of the idiosyncrasies and convulsions of the grand European project whose basis, regardless its remarkable virtues, has first been laid *ideal* and only later *real*, triggering convulsions and questionings of the very project. Some of these virtues are in setting clear and ambitious milestones, which at least have the merit of making affairs moving. Indeed, main production mechanisms have been questioned and challenged, as it is the case at the highest level with *Europe 2020* strategy and its derivative documents such as *Directive 2009/28/EC*[96]. These are embedded of a flagship initiative spirit for a shift towards a resource-efficient, low-carbon European economy to achieve sustainable growth and therefore impelling to practices and methodological shifts affecting all sectors, and evidently also the construction sector. However, solid answers to these challenges seem yet to come and the construction sector is typically slow to adjust[97].

The value of this sector is nonetheless quite relevant. According to Eurostat figures published in 2013, around 10% of the European GDP was construction-induced, representing 7% of all employment and about 30% of industrial employment. It adds that the majority of the construction companies are SMEs, of which only 3% have more than 20 employees[98]. Although eventually with advantages in a sort of neighborhood-like proximity, this sort of atomized company profile, allied to an often doubtful quality-delivery, undermines response capacity to greater challenges, as those implicitly involved in prefabrication. With automation, industrial production of construction components does not necessarily imply a great number of employees, nonetheless it may require a great deal of investment which may not be accessible to the bulk of SMEs. It adds the sovereign debt crises, allied to an uncertainty in the Eurozone, which are likely to keep constraining construction investment in many Western European markets for the years to come[99]. The benefits of economies of scale associated with mass produced constructions are already quite well established in other economic regions, as it is the case of Japan, whose overall construction sector represents almost 13% of GDP, and in the US, with a compared 7.9%. Overall, the construction industry in Europe suffers from many weaknesses, which can be generally put in fragmented responsibilities, lack of concern on the final consumer (speculative), competition mostly price-oriented, suffering still of unfit-regulation, still high labor intensive, high resource consumptive, and cause of major local environmental effects.

Attempts to mass produce construction exist already for a quite long time. However, the current production methods can still primarily be characterized has of a prevalence of crafted one-of-a-kind sort of buildings, and/or of following a modernist tradition of typological repetition. It adds a tendency in using minimum batch size[100] production principles, remarkably noticeable, for instance, in the extreme example of the brick by brick layout in building masonry walls enrooted in many southern European countries constructive cultures. Exceptions do exist, but a true paradigm shift requires still plenty of work in some core issues. The need for such shift has become inextricably visible in countries such as Spain or Portugal, whose economic dependence on the construction sector for the overall GDP, allied with a stagnancy or cut of investment in the sector, turned the economic development into a very difficult equation—a theme that has been making the headlines the past few years. Additionally, despite the quality work being developed, many businesses in the construction field still lack a true innovative insight.

1.4 Prefab innovation and business as usual in the Portuguese case

The case of prefab houses companies operating in countries such as Portugal is clear in terms of the lack of an innovative insight. It is elucidative on a sort of installed *business as usual* culture, where most of the operating companies just mimic or directly import building methods and often sell them as state-of-the art constructive achievements. Based on information accessible online from the companies' websites, from an analyzed universe of 98 companies operating in Portugal in this sub-sector in 2013, only 56 had a minimum of available data from where to drive some possible conclusions. From the 56, only about half seemed to have R&D concerns (Figure 2. Portuguese prefab houses companies' profile. and the remaining were apparently only seller, or intermediates of imported systems (Figure 2c, organization: *seller* '*s*').

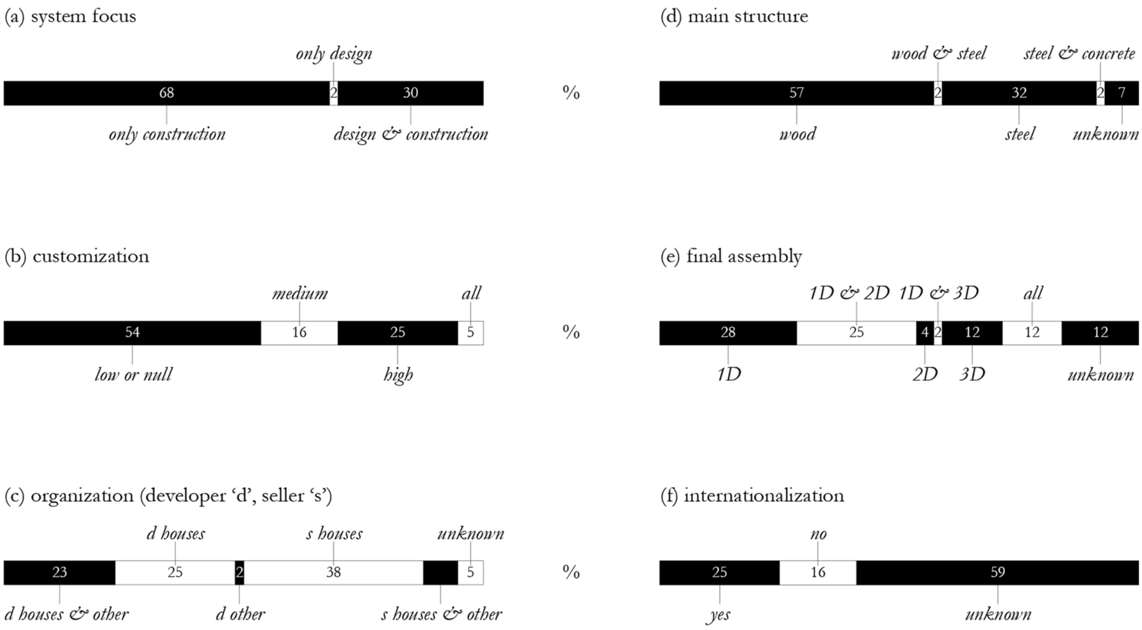

Figure 2. Portuguese prefab houses companies' profile.

It is among the R&D half that those with architectural design concerns can be found (Figure 2a: *design & construction*). The companies with stronger architectural design concerns also seem to be more flexible to adjust their constructive systems to the client's needs, reflected on the achievable level of product customization (Figure 2b, customization: *high*). In terms of technology, the majority uses wood construction (Figure 2d, main structure: *wood*), which is linked to the *seller* figures (Figure 2c, organization: *seller* '*s*'), since most of the non-R&D firms sell imported wood systems. Technologically it is of notice a non-existent percentage of exclusive concrete based prefab in this research. Prefab based companies do exist in the Portuguese pool, but they were discarded given a preliminary verification of their relative secondary role in the overall panorama. The research was hence more focused in lightweight construction in wood or steel based structures.

As to the kind of final assembly, figures are more diversified, and generally a bondage can be made between companies with stronger design and customization concerns, as these are more prone to offer differentiated final assembly methods. As one could expect, the more flexible a *design system* is, the smaller is likely to be the minimum batch size used by a company (Figure 2e, final assembly); and the break-even between a minimum batch size and industrialized construction methods is in a very thin threshold, as with smaller batches more human labor can be implied, reducing potential overall gains. Nonetheless, it is unclear from such an analysis any conclusions on a definitive relation of these principles with commercial success. This is further emphasized by the lack correlation of any of the research insights with national or overseas company's operations (Figure 2f, internationalization).

From these figures of the Portuguese case, given a number of factors such as the country's small size and a late industrialization when compared with many other European countries, it is not possible to establish a broader parallelism towards other realities. Nonetheless, although with its own idiosyncrasies, there are reasons to believe that some of the behaviors observed in the Portuguese case are not exclusive of this country alone. For instance, for several motives and in many cases throughout Europe, the house prefabrication industry has become associated with *low quality* or architecturally undemanding reputation. There are historical reasons for that fact, but there are also reasons related with a vast amount of companies which mostly have constructive concerns, and/or are simply selling constructive systems and their related building services, and/or have do not have integrated design or other R&D concerns. Nonetheless, there are remarkably positive examples, found mostly in Northern European construction cultures, which set optimistic prospects on a beneficial, more massified use of prefab related methods in some circumstances.

1.5 Thinking of a future possible

As the world population continues to grow, demanding for new buildings or renovation of existing ones is responsible for a great deal of use of available resources, particularly in what concerns to our energy consumption. There is a strong consensus that this issue as to be tackled, reflected in several institutional documents produced, as is for instance the case of *Agenda 21* or the *Urban Strategy 2004*[101]. The ways to do it, however, are not consensual. Sustainable practices in construction include not only environmental impact of buildings during their lifecycle, but economic, social, and cultural considerations as well. Some aspects of sustainability, namely economic and environmental are already quite well underway, while other, namely the social field, are harder to grasp.

Prefabrication does not necessarily mean sustainable building, nor does sustainable building imply the use of prefabrication. However, the promise of a greater efficiency (economic, or other) that appears to steam from it, is seemingly advantageous. Besides visible benefits regarding labor conditions, its ability to meet environmental and especially social goals is, as in other areas of study, difficult to consider. Given our positivist inheritance, accountability is an issue that is difficult to contour. Yet, while a reasonable accounting model does not come around, alternatives must be put in sight so that discussion can be increasingly informed. This gains even more relevance as it is acknowledging that socio-cultural aspects are crucial and often impose choices that contradict the better environmental and economical solution[102].

The dawn of the XXIth century has been witnessing a quantity and quality boost in the field of prefabrication. The seemingly less favorable economic circumstances that are being verified make construction speed and efficiency even more necessary. In some cases, this can be improved by optimizing and improving traditional methods, for instance via the increasing integration of processes via digital aided methods, in others only prefabrication can really offer more competitive ways[103]. Additionally, requirements are increasingly demanding in what concerns 'making green', not only regulation wise, but also in the very social acceptability worldwide. The potentially greater control achieved by prefabrication methods in comparison to traditional construction methods, can too be an advantage in an environmental perspective. The material advantages are well known, as, in theory, prefab construction allows a better material optimization, minimizing waste, and reducing the carbon footprint. Besides, its characteristics potentially enhance the possibilities of quality control and deconstruction for eventual lifecycle-end reduction, reuse or recycling. This lifecycle can be of the entire building or of some of its components—in the latter case with the possibility of extending building's useful life through maintenance. Additionally, the building's life can be prolonged by allowing change and extension, of the built form and of its components, by easing the tasks of disassembly and reuse. Some of these possibilities are far from being specific of prefab, but if set on an adequate study of relation between constructive components, prefabrication can enhance environmental and economic viability of the construction: the design leading to a prefab construction simply has to be constructively accurate, as tolerances are minimal in relation to ordinary, less industrialized construction methods.

Despite globalization, there are yet social and cultural aspects of a regional order, that constrain the prevailing building culture of each place. In fast-moving, fast-changing societies, housing is, has it has been, in a permanent crisis, which is currently typically visible in true quality and diversity deficits. Such state of permanent crisis is increased by the globalization challenges which our contemporary societies face, with expression in core aspects deeply affecting dwelling, such as employment or family structures. In an interview to the Portuguese *Negócios* newspaper published in June 27, 2014, Wolfgang Schäulble, the German Minister of Finances, affirmed: "*The globalized economy is changing at an astonishing speed, the technological advances are killing numerous jobs each year. If we want to fight unemployment in the XXI*st *century, we have to make structural reforms – and that is as much truth for Europe, as for all the other industrialized countries in the world. If you read any report of IMF or OECD, you will see the same exigency made, for instance, to Australia which is now on the presidency of G20. Solid public finances and a continuous structural reform process are two necessary pre-conditions to a sustainable growth*". To call for an effective implementation of industrialized methods in construction practices may in this sense be paradoxical, as unemployment can be aggravated, raising other social issues. On the other hand, there is nothing new about it, as such type of processes of adjustment have been occurring since humanity left the tree branches. The center of the discussion here is the quality and sustainability of our built environment, of which a permanent monitoring of reforms also in the construction sector may too be key.

There is no use to implement top-down reforms without bottom-up innovation. With exception for some notable authorship works, although many still predominantly focused on stylistic issues, the construction landscape reveals reduced innovation levels. The vision conveyed by some initiatives such as *Solar Decathlon*[104], despite being highly relevant from the technological R&D insight, end up being not so useful from the point of view of a common architectural practice, since they tend to neglect fundamental social aspects, putting their greater focus in technological achievements. Architectural practice, on the other hand, seems often slow to adjust to the technological times. For instance, producing *green* buildings requires additional expertise to the plenty already existing, and sometimes practice is simply not yet ready to deal with them. But this is also a problem in construction companies. Eco-technology should not overlook history and what it offers for a balanced dialogue towards the construction and preservation of the (built-)environment. Lessons such as the pioneering and impermanence in the US, lessons on tradition looking up to the future such as in Japan, on the power of society such as in Scandinavia, on technological innovation such as in Germany, or on permanent research such as in the UK, should be attentively observed. The tendencies of eco-tech innovation can create specific ways to think and materialize architecture, by preserving the quality of the environment not only through its physical component, but also through its social, symbolic and ideological value, not by groundless idealism, techno-romanticism, political naiveté, or, the worse kind, sole commercial purposes through hollow 'green' marketing as a strategy as any other to move business ahead, throwing (green) sand to people's eyes.

In the Portuguese context with little tradition in this field, prefab housing projects that embed an efficient use of natural resources are still quite few. The same scarceness is verified at the level of requirement in architectural competitions, in which, besides energy efficiency, seldom more demanding items, such as environmental performance assessment, are asked. It is our belief that the way for the future of the construction sector and economy as a whole has no way but to stand on the shoulders of high environmental demands. But this is also an implicit critic to the academia's production of architects, whose focus in many cases seems a revival of the early XXth century discussion of Beaux Arts approach versus the disruptive Modernist way. Formalism, aesthetics, preconceived ideas propelled by media consumption of often circularly moving ideas, image preceding problem tackling, or problems posed through beautiful but meaningless imagery paraphernalia, are just some of the innumerous manifestations of a state of crisis which has reached the architectural profession, and recalls the reluctance to change from the stylistic approaches that was criticized by our Modernist grandfathers. As Juhani Pallasma wrote in the end of his article in 1991, revitalizing architecture "*implies a paradoxical task for architecture to become more primitive and more refined at the same time (…); (it) also implies a view of building more as a process than a (end) product and it suggests a new awareness of time (…); it also seems that the architect's role between the polarities of craft and art has to be redefined. The current philosophical testing of the limits of architecture will be replaced by authentic experimentation with new techniques (…) and new concepts of living. After decades of affluence and abundance, architecture is likely to return to the aesthetics of necessity in which (...) utility and beauty are again united. An ecological lifestyle brings forth the ethical stance, the aesthetics of noble poverty as well as the notion of responsibility in all its philosophical complexity*"[105].

2 PREFABRICATION OF HOUSES: A HISTORICAL AND SOCIO-CULTURAL SURVEY

2.1 Context and challenges of house prefabrication in Europe

The construction sector is currently still one of the most traditional and least innovative industries. In Portugal, the construction of residential buildings can often present average construction periods superior to two years, revealing a backwardness and craftiness of this activity. However, the case is not exclusive of this country alone. In the core of this problem are often the use of constructive systems with large execution times and the use of materials whose application implies too much man labor time. Labor-cost is a major component of the overall construction-cost. Additionally, there are often difficulties in finding skilled workers to execute more specific tasks. Therefore, any methodology that may generate the reduction of construction-time will be a seductive variable as long as it does not increase the total construction-cost and allows equal or better construction-quality. Furthermore, for this construction-quality to be achieved, sustainability factors must necessarily be regarded, since they imply costs—economical, environmental and social—not only upstream the construction, but also downstream throughout the lifecycle of the buildings—e.g. use, maintenance, energy.

As history shows, prefabrication is not a miraculous solution. The successful business achievements in this field rarely bond with what may be considered an architectural success. For prefabrication to work, things need to be technologically fine-tuned, and that requires a strong engagement for multiple actors in the construction scene—architects, builders, promoters, and so forth—as well as a wide social acceptance of the process. The latter is condition for trust in the design and, foremost, in the constructive solutions, as without these, the cultural, legal or financial obstacles that may be faced will hardly be overcome. Moreover, none of this occurs overnight.

It is impossible to express a single (hi)story on the historical evolution of prefab in Europe (or anywhere else for that matter). Firstly, because prefab approaches imply an extraordinary mix of different subjects—these can be, on one extreme, industrial efficiency related issues or, on the other end, artistic concerns. Furthermore, there are remarkable regional differences, propelled not only by natural conditions such as climate or abundance of certain resources, but also political, social or cultural reasons and particular historical contexts which made things evolve differently in different regions, and these also ultimately translate into different constructive cultures.

To illustrate the European state of the art scenario in this matter, we will be further detailing the Nordic countries, The Netherlands, Germany and UK cases. The very division into countries or particular regions may be considered fairly anachronistic, and is certainly debatable. Indeed, in a global context, that sort of categorization may not make much sense, as processes are interdependent and not limited to the idea of a country or a somewhat bounded region. In any case, because of non-neglectable practical issues, such sort of division is, for better or worse, still in most cases the best there is to work with. These practical issues can, for instance, be the information availability—e.g. statistical data—but can also be related with an enduring resilience of regional characteristics, despite unavoidable global processes of homogenization.

These cases were chosen for diverse reasons. The Nordic countries, by an enrooted social acceptance of prefab, translated in a wide recognizance of a high evolution of its state of the art in prefab. The Netherlands, mostly by its historical active role as a society that has always dealt with a need of having a properly planned territory, with outcomes in innovative philosophies of housing and building. Germany, by its historical role, both political and architectural, in the formalization of prefabrication methods and systems' conception, as well as by its acknowledged benchmark positioning in terms of technological development in several sectors. Finally, the UK, by a long prefab tradition and the scale of after-war emergency efforts.

The above reasons are inevitably oversimplifications nonetheless. Yet they stand for their suggestivity power and are proven witnesses of the variety of approaches that can be involved. Some other cases were consciously left behind. Such occurred not because they would not fit, but because they are evocative of a different group of subjects which are either already implicitly referred in some parts of this work, or are not central to the scope of the discussion of prefab single-family houses. Indeed, it is impossible to ignore the role of places such as France or the former Soviet Union have or had in the formulation of the current status of house prefabrication, not only in Europe, but worldwide. As a corpus, these two will only be shortly referred in the following paragraphs.

2.1.1 A BRIEF ACKNOWLEDGEMENT OF THE FRENCH CASE

From the French case, we can highlight seminal figures not only of prefab business history, but of architectural history as a whole. It is unquestionable the role the French had in the development of concrete technologies in its early stages. The French businessman Edmond Coignet was the first to use prefabricated concrete elements in the construction of the Biarritz Casino (1891)[106]. François Henebique, a businessman and constructor, was a pioneer in reinforced concrete modular units. In early XXth century he patented the *Béton Armé* system, which became a huge commercial success, and would dominate the world market. Directly and indirectly, he left a legacy of over 35 000 buildings and structures, including a more famous development of gatekeepers lodges for the French national railways (1896)[107].

Among the seminal architectural figures Le Corbusier stands out, namely from his writings, but also for the development of housing projects. Another relevant figure is Jean Prouvé, as he brought a fresh insight on the relations between architecture, design, engineering and industry. Prouvé also designed several prefabricated detached houses such as the *Meudon Houses* (1950-52) for the Parisian suburbs, or the *Maison Tropicale* (1949-51)[108]. In architectural thinking, the 1983 exhibition *Architecture et Industrie: Passé et Avenir d'un Mariage de Raison* in the *Centre Georges Pompidou* has endured as a reference[109]. The *Centre Georges Pompidou* building (1967-1977), by the non-Frenchmen Renzo Piano and Richard Rogers, is in itself a famous reference image of a dialogue between architecture and industrialized elements, in its archetypical *hi-tech* styling.

2.1.2 A BRIEF ACKNOWLEDGMENT OF THE SOVIET UNION CASE

As for the former Soviet Union, iconically the approach has focused in prefab concrete systems, implemented to multi-story mass housing construction—the *Khrushchyovka's*[110], as they became known. The centralization of political power eased the implementation of housing with coordinated component construction. The Soviets begun developing standardized systems in the 1930's, when German technical teams brought their influence with some industrialization techniques for construction. Generically, the goal was to have as few building types as possible and to compile a catalogue of their parts, as if a giant *Lego* system, to efficiently deploy in any area of their vast territory. The catalogue could be used in a cook-book fashion, relegating design to interchanging ingredients—a cook-book both of typologies and of building components.

Although widely implemented and interesting in aspects such as modular coordination, the *Khrushchyovka's* (1947-1961), and its later variants, fell on social disgrace by their frequent and typical constructive pathologies, becoming an authentic social paradigm of low-quality prefab[111]. The *Micro-rayon*[112], the Soviet term for the state-planned, state-funded, residential districts, marked and still marks a whole urban landscape in former Soviet Union countries—in times they peaked as part of the living environment of more than 80% of the Russian population. These are characterized by their austere appearance, ascribed to the characteristics of the *Khrushchyovka's* systems, with large, *greyish* prefabricated concrete elements and their characteristic visible joints. These features, alongside their pathologies, became important reasons for this type of technology to be stigmatized. Such occurred in the former Soviet Union countries and elsewhere where similar technologies were used, as was the case in Portugal in the 1970s with the so-called *P3* system for schools construction, which made a wide-spread use of concrete paneling and asbestos roofing.

2.2 Prefabrication of houses in the Nordic Countries

2.2.1 CONSTRUCTIVE ROOTS

Three main stages define prefabrication history in the Nordic countries: the pioneer age following the industrial revolution, the mass-production age following war and post-war housing crisis, and the customization and design age following implementation of numerical technologies and the maturity in social acceptance of prefabrication systems. Notwithstanding, prefabrication history in these countries is deeply enrooted in age-old construction practices that have evolved throughout the centuries. As result, the ideological debate on the virtues of prefab, which is verified in other locations, seems to have no relevance in this region. There is a culture where timber frame structures, brickwork or other technologies are valid, each with its own context, regardless of being in a *low-design* or *high-design* building context. Additionally, self-construction is also a common practice, emerging from an age-old tradition of cabins and summerhouses construction. Therefore, the lightweight structural methods, which are so common in low-rise prefab in these countries, are commonly known and accepted among the public in general.

Given the large area of forest, use of wood has always been more predominant than it is in most other places. In Finland, the earliest known vernacular form of shelter, the *kota*, is a timber based construction dating back from the IXth century. It consisted of posts leaning inward to form a cone covered with animal skins. The form would evolve to a rectangular shape by the Xth century, a fact attributed to Russian influences, but similar solutions can be found in many other locations. For instance, in Southern Europe, the Greek timber *megaron* type, which constituted the base of the Doric temples, was in use around 2 500 years ago, when the Mediterranean area was more abundantly forested. With time, the rectangular cabin became more sophisticated, as Swedish and German techniques were imported to Finland in the XIIth century. The increasingly improved constructive knowledge would eventually spread across the entire region[113].

These medieval wood houses were built over stone bases, and often insulated with moss and earth underneath. The dimensions were determined by the logs, cut in the nearby forests and dried for up to two years before use. These could also be disassembled and rebuilt elsewhere. Eventually, such log practice would refine in time. During the Enlightenment, double floors were introduced, and insulation, roofing or rotten prevention materials and techniques evolved: birch bark would be replaced by sawed planks, glass windows introduced, more efficient fireplaces developed, insulation and water-tightening methods added or improved, and so on. Many of these cabin dwellings evolved into building complexes for farming societies. In Finland, the typical wooden town arose out of a blend of urban and agrarian communities, with crafts, trading, livestock and farming closely interacting. These would frequently follow a classical grid plan, with the single and double story houses lined along a street with wood fences, and forming a yard complex[114].

Stylistically, a neo-classical influence would have a deep impact in the Nordic Countries throughout the XIXth century. In Finland, this was most noticeable through the predominantly public work of C. L. Engel, with an admirable grasp of timber construction. Besides, Engel's ideas were broadly published, contributing for a better knowledge of his works and methods. In Sweden, Fredrik Blom, born in 1781, had begun his career as a carpenter (it would be only later in his life that he would begin studying in the *Royal Swedish Academy of Arts*, where some years after he was made professor in 1817). Blom became a pioneer in prefabrication, devising a system of walls that could be assembled, disassembled and moved elsewhere as required. However, popularity came mostly because of the presented solidity, and the smooth, classical-style buildings it delivered. Overall, these features would attract attention all over Europe by 1840.

Blom's houses were handcrafted, but shortly the idea was mechanized by an emerging sawmilling industry. The Swedes developed an ingeniously effective roof truss and post and beam construction, which allowed a bigger size and greater flexibility, with larger window openings and a cavity for sawdust insulation. By publishing *Agricultural Buildings* (1891), Alfred Sjöström's made these techniques available to a wider public. With the invention of the frame saw, it was also possible to reproduce complex ornamental motives, which came with the popular pattern books. Overall, these occurrences contributed to install a classicist flavor that spanned from the highly widespread *Neo-Classical* in the XIXth century, to the *Art Deco* in the early XXth century.

2.2.2 INSTALLATION OF A NEW PARADIGM THROUGH THE XXTH CENTURY WARS

The XXth century conflicts catalyzed a change in the construction business. To the unfolding technological improvements and a required greater efficiency in the construction processes, it added a sophistication of the business and marketing strategies. Since it took over the vernacular log construction in the early XXth century, the American *balloon frame*, and related constructive methods, has been widely used for low-rise housing. In Finland, *balloon frame* was officially introduced in 1909, through the architectural periodical *Arkkitehti* [*The Architect*]. The system brought about obvious advantages, with its standardized sections easing large-scale production[115]. After 1917, post-WWI housing shortage increased demand for prefabrication, triggering industry to standardize and mechanize in Norway and Sweden. By this epoch, building industry became the main driver in the development of mass production methods (and of the economy) in the Nordic countries.

As it happened in the USA, the *timber-frame* industry would soon, and throughout the XIXth century, be marketing their houses via catalogues and pattern books. In the 1920s, the City of Stockholm released typified house plans and pre-cut timber to encourage working class families to build their own houses in the suburbs[116]. By the end of the 1930s, manufacturers of catalogue houses were abundant. Sawmills from densely forested regions provided the wood to produce thousands of buildings per year, the majority houses and villas, but also other kinds[117].

The WWI accelerated the shift from traditional construction to framed structures, with paneling techniques becoming a predominant construction method in the 1920s. Swedish industry would assist war-famished Finland, contributing for a great technological development. The Swedish *gift* houses, as they were known, played a major role at this period[118], with over two thousand wooden houses built in Sweden, with designs made in Finland, calling in favor of the Swedes industry while valuing the Finnish designing skills[119]. Among these, self-building single-family houses were the most popular[120]. However, it was not until the end of WWII, when the housing demand was the greatest it had ever been, that prefabrication saw a great upswing. It has been estimated that in post-WWII, nearly 70 companies were producing more than 50% of housing in Scandinavia. In 1947, 17 500 prefabricated houses were produced in Sweden alone[121].

Meanwhile, in the interim period, while throughout Europe the Modernism was being experienced in materials such as concrete, glass and steel, in places such as Finland it was mostly wood-based, giving it a more warmth flavor. The abundant forests have heavily influenced single-family house technologies, tending to promote a continuity of the traditional house both in material and in style, instead of opening up to a Modernist language. A step forward came when Alvar Aalto designed his *AA-system* in 1937, commissioned by the company *Ahlström Oy*. Influenced by a fruitful earlier incursion in the MIT, Aalto would develop it until 1940[122]. The system would follow its prefabrication intents, and would reveal a new paradigm of mass production with a variability twist[123]. As well as other prefabricated systems, the *AA-system* would be tested during WWII[124].

The war caused material and housing shortages. Given the availability and constructive tradition, wood was a logical choice for the typified houses and war barracks. Anticipating the postwar reconstruction, the *Finnish Association of Architects* employed many prominent architects to design type-planned houses. With the postwar demand, the way was open to implement these designs. Meanwhile, the single-family house had become a *product*, as the individually commissioned design for a specific location gave place to a generalized commodity, the result of a production and marketing mechanism where design authorship is anonymous or simply irrelevant. Notwithstanding the architectural efforts, as a business spirit prevailed, many of implemented type-planned houses lacked the attention to detail and the architectural qualities that Aalto and others had earlier meritoriously developed[125].

2.2.3 ARCHITECTURAL EXPERIMENTATION AFTER WWII

As expressed by Rasmus Wærn, "*part of the reason why prefabricated building developed under the aegis of single-family housing was strong union opposition to the transfer of jobs from the construction industry to manufacturing, restricting such a shift to projects of smaller scale (…) Added to this, short production runs encouraged experimentation*"[126]. The period of the 1940s and 1950s revived curiosity in prefabrication, with new technical solutions tested by individual architects. As prefab became a broader concept—other than just precut wood—and modular principles arouse, new designs were also being made. Attention had also been turning to the use of concrete and brick for multi-dwelling housing. Nonetheless, new town developments and holiday houses kept having an expressive demand, and many famous architectural designs can be found among the summer villas. Mies van der Rohe's steel and glass influence, the modernist language, and an interest in Japanese spatial and material concepts, with open areas and a delicate use of materials (namely wood), would add as important stimuli to a new, experimenting generation[127]. Following Aalto's earlier spirit in *AA-system*, in 1947 the Swede architect Sven Markelius would call for mass production of houses, not based on standardized houses, but on standardized parts to allow greater variability and design choice[128].

The 1960s introduced a new social awareness. The beliefs in a society founded in equalitarian principles were a further motive to deepen the research in prefabrication solutions. Almost every progressive Nordic architect developed prefabrication schemes. However, most of these remained prototypes. Some of the best examples in Finnish architecture can be found amongst Kristian Gullichsen, Kirmo Mikkola or Juhani Pallasma. These have made some joint works, of which *Moduli 225* house—by Gullichsen and Pallasma (1969-1971)—stands out for the use of prefabrication principles. Based on a 225×225cm module, it is an industrially produced prefabricated summerhouse, built in timber, steel and glass. With its precision of detail and structure, carefully studied proportions, minimal gesture and modular grid attributes, it denotes influence by the Japanese house design, the teachings of the mentor Aalto, as well as Mies' openness and lightness. Nonetheless, *Moduli 225* would prove unpopular. Buyers would normally prefer the widely publicized houses sold through the marketing machines of the construction business[129].

One of the exceptions extending beyond a prototypical stage was the *Futuro House*, designed by Matti Suuronen in 1968. In a way, its relative success—around 100 build units—is quite surprising, given its radical UFO-like shape, way out of the aesthetical characteristics of the most commonly sold prefabs. The house was initially designed as a ski-cabin or holiday home. It reflects the confidence of the 1960s, before the oil crisis of the 1970s, when there was an optimistic attitude both in terms of social engagement and in that technology could solve all problems for the human race. It carried the ideal of the space-age era positivity and a vision of a future where everybody would have more leisure time to spend on holidays. The building was delivered completely furnished, and could accommodate eight people. There were ambitious plans to mass-produce it, which envisioned a new concept of mobile living. It was entirely constructed out of reinforced plastic, which made it so lightweight it could be easily transportable by helicopter. Such enabled it to be utterly mobile, adapted to the nomadic lifestyle of the space-age modern man. However, the 1973 oil crisis spoiled the plans, as plastic prices rose, taking production costs to unbearable levels. As a result, the 100 houses that were built felt short on the initial mass-production prospects. Nonetheless, such may be considered a great achievement for a house with such an uncommon shape, and with obvious limitations in some commonly valued specs—e.g. it had little potential of adaptability to client's needs. The house is a true creation of a *new age*, and the result of an era in which architecture becomes increasingly understood as if an ordinary consumer product[130].

In Denmark, a country that also saw a great prefab development in the 1960s, Jørn Utzon designed *Espansiva*[131], and Arne Jacobsen designed *Kubeflex* and *Kvadraflex*[132]. We see Utzon in a remarkable photo sitting on the floor combining several models of his *Espansiva* system. The combinatorial possibilities and the playful attitude would be linked to his *Additive Architecture* principles, where it stands out Utzon's affinity by industrialized methods, adaptation, or variation according to principles derived from the observation of nature, of other cultures, of history: the world. As to Jacobsen, the housing manufacturer Høm Houses had hired him in 1969 to design a holiday home, which resulted in the concept-house *Kubeflex*, which is built out of prefab cubic modules of 3.36×3.36m, with $10m^2$ each. These modules may have different kinds of walls and with numerous layout configurations. Conceptually, it included the possibility for houses to be altered or expanded according to the owner's needs or wishes. First presented in the *Archibo* house fair near Copenhagen in 1970, it would turn out unpopular by its radical appearance and never went into production. Instead, Jacobsen took the prototype and placed it in the seaside to use it has his family holiday house. *Kvadraflex*, a sister-concept of *Kubeflex*, was also limited to a single floor, and also had a square base, but of 4.08m instead of 3.36m. Different materials could be used, and its modular, single-floor logic made use of a hipped roofs of four intersecting sides. A few prototypes were built in Ishøj, having in account void spaces and community areas. More recently, the Danish company *Vipp*, famous for their metal bins which they make since 1939, produced a design morphologically inspired in Jacobsen's, the *Vipp Shelter*. Built on the Nordic lineage of summer and weekend escape huts, the design is $55m^2$ plus an attic, built on a structural steel frame with a façade of glass and galvanized painted steel. Yet, unlike Jacobsen's, it is not possible to add extra elements.

Design based in modular dimensional principles was also being experimented. In Sweden, in 1955, Ralph Erskine designed and built a circular cottage, consisting of sixteen prefabricated sections. The building was thought of to be subsequently produced in a large scale, but such never occurred[133].

Regardless of Erskine's and some other cases, in Sweden in this period most experiments were restricted to state initiatives. Social politics affecting housing was enhanced by the so-called *Miljonprogrammet*, aiming at 1 million apartments in a 10-year period. From the 1960s onwards rational methods of construction became a central matter in housing policy[134].

Despite the architectural experiments and the state programs, the abundant prefab house production of late 1960s, and throughout the 1970s, was dominated by detached *catalogue homes*. The design efforts towards quality and mass-customization were distorted as the built landscape turned visually chaotic, and with individual house forms presenting merely apparent variability. Business took over the production of prefab house space[135].

2.2.4 MARKET AND TECHNOLOGICAL DEVELOPMENTS IN THE PAST DECADES

In the 1950s and 1960s sawmilling industry started to diversify their business into the production of components such as wall panels or roof trusses. It would not take long until activities became specialized: the factory production itself; marketing operations promoting houses in brochures and advertisements, including pattern books; and a network of local builders to assemble the houses in-situ. With some nuances, currently the methods in use are essentially the same, having become the typical mode of house provision in the mainstream house business[136].

The 1940s wartime driven demand, and the 1960s burst in prefabrication offer, nearly eliminated the architect from the design process. Housing shortages in the 70s and 80s were accommodated with concrete and masonry apartment blocks. Nonetheless, in the 1980s an amazing 85% of private homes were made using prefabrication methods of some sort[137]. In today's scenario, prefabricated housing industry dominates housing and results are not brilliant. Nonetheless, there are different housing market realities among the Nordic Countries. As it also occurs in most other European countries, the last few years have been witnessing a slowdown in house construction, which is more acute in multi-dwelling housing than in other house forms. The market numbers also show that in Nordic countries there is a rising tendency for a higher preference for living in single-family houses[138].

As elsewhere worldwide, although new construction technologies have been developed, many constructive issues are still a major source of debate: acoustical insulation, fire safety, low thermal mass, and so forth. Currently there are improved acoustical insulation and effective fire safety methods for lightweight wood or steel structures. However, generally modern acoustic and fire codes still make it harder to build than in concrete. In Finland and Denmark, regulation only allows a single story for public buildings built with wood structure, despite wood construction easily allowing four or five floors, and new laminated technologies and steel truss systems offering numerous structural possibilities. In Finland, building codes only started allowing residential wood-based buildings to have over two stories since 1998, and only with expensive sprinkler systems[139]. Additionally, low building mass in lightweight constructions is a characteristic with effects in the overall thermal insulation philosophy, and with negative effects in the user perception of the building's vibration if not properly mitigated. There are available technological ways to overcome these issues, and these are highly scrutinized both legally and through the very market competition, which occurs more and more at a global scale through common directives, norms, certification mechanisms, and so forth. Additionally, information is widely available and a myriad of products are available in the global market—for instance, not every European country produces OSB panels, although these are available everywhere in Europe. All the same, in lightweight constructions, the overall setting is more demanding than in other kinds of construction, requiring more of a holistic insight. This means that every step of the process has to be carefully pondered in the design stage, and a quality control in manufacturing and assembling must be thoroughly implemented, otherwise with greater risk of constructive flaws, with likely negative effects not only in market perception, but also in insurance fees, financing prospects, and so forth.

A major example is the problem of the thermal insulation in wall systems while preventing water vapor to be trapped, causing unwanted pathologies. Many of the frame systems have been using mineral insulation products that have been developed in the 1960s. These succeeded in thermal performance, but cause condensation problems due to temperature differences if the walls' cavities are not properly ventilated. To attempt to tackle the problem, plastic moisture barriers were introduced, but this has also met difficulties, since if any part is pierced during construction, then the water vapor will collect at that point, causing localized moisture and rotting. The older systems allowed natural breathability, but poor thermal performance. There have been recent advancements in new insulation materials made of sawdust, flax, hemp, paper or wool, which are designed to allow moisture to penetrate in harmony with wood and allow breathing without deterioration, and theoretically thereby eliminating the need for venting and a plastic layer. Additionally, now there are also breathable plastic layers, which pretty much solve the problem in cases where external coating does not require support through mechanical elements perforating the plastic in exposed circumstances.

Regardless the improvements, and information and product availability, current prefab technologies used in the majority of cases are in essence very similar to those used after WWII. Nonetheless, there are different criteria and design methodologies now in practice. Not only the economic and construction features are pondered, but other, such as energy efficiency, low maintenance, sustainable materials and methodologies, are also considered. After, for instance, in Finland, by the 1970s timber had been mostly replaced by concrete and steel, and more standardized components were being used due to a boom in housing, today steel construction is not common. Moreover, there is the beginning of a swing back towards timber because of psychological and health aspects as well as to so-said ecological gains of the use of this technology[140], which in itself is a highly debatable issue. This reveals the great power of social and cultural aspects, and that the quarrels and debates are not always exactly of a scientific or technical nature, often prevailing hearsay truths sustained in corporative agendas of a capitalist ideology behind the defense of certain products over others. If, for some, steel construction is more sustainable than wood construction, such could not be the case in this region, as tradition has proven its cultural strength. Furthermore, currently Norway, Sweden and Finland enjoy a large surplus of mature forests due to a sustainable resource policy in this field.

2.2.5 PLAYFULNESS AND SOCIAL ACCEPTABILITY

It is hard to account how far the innumerous different occurrences contributed to establish a peaceful acceptance of the idea of prefabrication. This is also a story made of a certain playfulness. In 1932, Ole Kirk Christiansen, a Danish carpenter, started making wooden toys in his small company, which would be named *LEGO*, after of the Danish phrase *leg godt*, meaning "*play well*", but also related to the Latin "*I put together*" or "*I assemble*". Initially manufactured in wood, after WWII it expanded to plastic, when in 1947 the company bought a plastic injection molding machine[141]. *LEGO* would become an inspiration source not only for children (future builders or not) and for numerous architects worldwide, including direct reference in the contemporary practitioner Bjarke Ingels, with his *LEGO Towers* (2007), or *LEGO House* (2014). Now with a worldwide, ubiquitous presence, *LEGO* modular construction blocks are truly a microcosm of prefabricated building technologies. A limited set of eight 2×4 blocks of the limited five-color original palette can produce over eight trillion configurations.

Certainly, one of the greatest conquests of Nordic prefabrication is its social acceptability. Comparing with the USA, where the *mobile home* gave prefabrication a bad reputation, or the UK where the same occurred with the postwar *temporaries*, Nordic people have generally viewed prefab as just that: a different method of building. The large historical ballast brings a positive effect in people's minds in order to consider there is good quality construction in prefab. Additionally, prefab is more typically affordable than traditional in-situ buildings[142]. Relevance became so high that the *Royal Danish Academy of Fine Arts* now has a department for research in prefabrication, the first of its kind in comparable institutions. Additionally, many companies are now internationalizing.

An example of innovation in this field is the *IKEA* Company, now with housing branches as well. A joint-venture of this renowned brand with *Skanska*—a major player in the construction business—lead to the creation of *Bo-Klok* (literally *stay-wise*), taking the furniture design concept a step further, into a complete house package, that has business in Sweden, Norway, Denmark, UK and Germany. It is architecture providing, not anymore form exclusively through function, but form through brand, in a fashionable, customizable way. The *IKEA* appeal is one of a global brand that has been set on an idea of quality and low-cost. The furniture's kit-like assembly is one that engages the user in the process. Even the least handyman in the end may feel a sense of accomplishment and fulfillment. The word *kit* itself appeals to a multitude of people[143]—architects, builders or house buyers. It is embedded with the promise of every building virtue—economy, speed, quality, reliability. Likewise, the *IKEA* houses too conjure a mental appeal of the playfulness associated with the *kit imaginary*, although unlike their furniture they have little of *kit*-like construction.

2.3 Prefabrication of houses in The Netherlands

2.3.1 COUNTRY CONTEXT

The Netherlands is one of the most liberal and pro-welfare states in Europe. It has a developed system of social support that includes the field of housing. It is also one of the most densely populated countries. This situation affects the housing market in a country with a very particular geographical setting.

Much of the prefabricated housing industry in the Netherlands was developed by the urging need of reconstruction in the post-WWII. Housing industrialization has been a matter of relatively major concern because of the acute housing shortage, with the added features of having a high population density and very little soil availability. The population, of approximately 16 million, inhabits a relatively small usable land area, since 19% is covered by water and 61% is used for agriculture. Its population density (408/km^2) is the greatest in Europe and one of the greatest worldwide[144]. Additionally, a great part of the land in this country has been retrieved from the sea since the 1930's. The latent tangibility of the land-scarcity problem, allied to a Calvinist rooted cultured, are certainly among the main reasons for the development of a great public awareness of the central importance of planning policies and design quality as ways for a balanced development. Housing, infrastructures, economic activities, or land and water conservation all are regarded as fundamental concerns and this has inevitable repercussions in the country's building construction culture and in its built environment.

The Netherlands is mostly a high-density, urban country, with more than 80% of population living in urban areas. This explains the reasonability of a call for constructive concentration by the Dutch law. Despite its density, the main house type is the single-family attached houses, and most of the rest are low-rise apartment buildings and very few are single-family. This is too springing from historical and cultural reasons, as one of the country's greatest achievements was the number of state-subsidized houses since WWI, with about half of the country's housing stock of 7.5 million (2003 figures) built after 1960[145]. The housing profile is substantially different from the single-family home scenario of suburban USA, or from the much higher density of high-rises punctuating some other countries in Europe (comparatively, 53% of Germans live in apartments and most of the rest in single-family).

Historically, homeownership rates have been low when compared to most EU countries, although with a steady increase over the last decades from 42% in 1980 to 59% in 2009[146]. The rental sector is dominated by social housing, with 75% of the rental stock, with the average rent in 2009 of about 23% of household income. A great part of the current rental stock in the low-rent sector is owned by housing corporations, which build, demolish, buy and sell houses[147]. As in other places, the construction sector was hard hit by the economic crisis, with 5% turnover fall in 2013. In the same year, the granted building permits for new houses reached their lowest number since 1953, and the prices of existing owner occupied houses were on average 6.4% lower than in same period one year before[148].

2.3.2 A SYSTEMS' DESIGN CULTURE

Unlike in other countries, particularly the UK, there was no anti-prefabrication backlash subsequent to the postwar construction. Furthermore, building methods that make far greater use of factory-finished components, such as roofs and walls, have been commonplace in The Netherlands and are not confined to the social housing sector[149]. Up until the 1990s, most of the components used in housing construction were prefabricated on such a large scale that repetition became monotonous. However, given some of the implemented state-subsidized policies, it became possible to develop building systems, mostly concrete-based, that substantially alleviated the in-situ processes, saving time and money, while also enabling variability. Another characteristic is the widespread renovation and reuse works in inner-city housing. Like in Japan, many houses are demolished and re-built, as opposed to being refurbished, therefore contributing for a wider social acceptability of a sort of *impermanence fell*. In addition, the demanding building standards ensure that prefabrication and other fast track methods of construction are popular, helping to reduce costs[150]. A typical housing scheme will use a concrete shell or traditional construction, or variations, releasing floors for a free occupancy with industrialized and/or dry construction. Methods and materials vary, determined by the client's requirements, the budget, number of houses involved and so on, and are especially innovative in panel systems for housing[151].

In debt to John Habraken's theory and related with the idea of open-floor layout, as far as back as the 1960s it was being advocated that two main systems, the *support* and the *infill*, should be considered. During the 1980's this idea evolved into the philosophy of *open building*, where different decision levels that can be identified in a building plan that has different life cycles. Latter developments of this concept introduced deconstruction in the philosophy of building systems, the latest known as *industrial, flexible and demountable* (IFD) building[152]. As in other European countries, after WWII, the Dutch housing market was dominated by the industrialization of the building process, with an emphasis on quantity. As the market became more saturated, the demand for differentiation increased. In the 1970s the average project involved 200 homes, today the figure is between 10 and 20. Following the *open building* research tradition, with the decision-making process gradually transitioning from government or large developers, to customer-focused housing concepts, a higher degree of systems flexibility began to be implemented through mass-customization, industrially driven processes[153].

2.3.3 SOME RECENT CASES

There is a highly dynamic architectural scene in The Netherlands. The state or local initiatives, imbued of the idea of quality control over the built landscape due to land scarcity and so forth, have a long tradition of promoting design competitions to address real problems, and actually implementing them. As result, numerous innovative architectural concepts have been devised and executed over the years. Among some of the most well-known cutting-edge housing designs in the past decades figure Borneo Sporenburg's harbor peninsula designs in Amsterdam, by *West 8* architects, or Waterwijk in Ypenburg, by *MVRDV* architects. In these two examples, there is a clear intentionality of establishing a frank relation with nature. Alongside, it is undoubtedly visible the use of principles of economies of scale which potentiate the individuality of solutions, exhibited either by very strict and clear planning principles in Borneo Sporenburg, or by morphological and structural resemblance in Waterwijk's Hagen Island.

The Borneo Sporenburg plan is located in Amesterdam's former harbor peninsulas of Borneo and Sporenburg, where a total of 2 500 dwellings have been built. The reification plan covered the area with a fabric of low-rise/high-density back-to-back courtyard houses, punctuated by three big landmark buildings. Numerous architects designed each of the expensive patio houses, which resulted in a controlled, but diversified fabric. Given that there was a pre-established urban criterion, limiting heights, widths or lengths of plots, the main architectural challenge in each of these plots was to develop strategies in which daylight could penetrate the houses, while assuring privacy, and so forth. The general concept does not necessarily imply the use of prefabrication methods. Nonetheless, the detailing degree of the devised urban strategy impelled the use of typological similarity. The strategy provided unit to the ensemble, and potentiates spatial and constructive similarity between the different houses[154].

The urban settlement in Waterwijk, an initiative by the Ypenburg Municipality (The Hague), was though of to allocate half the housing for social rent and the other half for sale at relatively low prices. The ensemble consists of several islands, each with different typological characteristics. The bulk of houses are small, in either multi-dwelling or detached single-family houses, occupying relatively small plots of land, and going from enclosed to public or semi-public occupation of space. In any case, all share a non-urban feel. Alongside more conventional house solutions also figure more *extravagant* designs, namely MVRDV's *Watervillas* or *Patio Island*. The *Watervillas*, designed by MVRDV, and picturesquely located by the lake in Hagen Island, form a complex of detached houses, similar in shape, but with diverse finishing materials, such as wood, ceramic tiles, zinc, and so on. Although similar, the houses have a varied distribution, and each house has a small plot of land that the inhabitants can use to cultivate their gardens, overall contributing to create a friendly atmosphere. As to the *Patio*

Island, also designed by MVRDV, it can be described as a mass of 44 houses with very similar typologies, altogether forming a huge block, or *island*, where too a garden feeling can be present, although in a much more circumspect way. The ensemble denotes a typically Dutch systematic approach to construction, with concerns in the economies of scale, through typological repetition, but simultaneously revealing a concern in providing formal variability to the overall ensemble.

In places such as Almere, a new land area envisioned as a suburban, commuting region to the nearby capital, where buildings begun to be constructed in the 1960s, many urban and architectural experiments and less conventional solutions have been proposed, making it a true architectural laboratory. Because all reclaimed land is publicly owned, Almere's municipality has the potential for consistent planning, contrary to places with high private ownership. In 2001, it was completed a new layout of 450 dwellings, distributed over 19 projects with different configurations, from 7 to 70 units. The guidelines required all units to be different, and there was freedom on where to position the dwelling in the plot of land. If buyers were unknown, houses where concluded in a neutral fashion. From these, eventual less-satisfied buyers basically bought a house to be refurbished. A monitoring process took place to assess customers' satisfaction throughout the years. MVRDV's *Oosterwold* master plan is one of such examples, envisioning a broad-band use of use of participatory design principles.

2.4 Prefabrication of houses in Germany

2.4.1 OUTLINE

Prefabrication has a wide acceptation in Germany, which in part can be explained by a wide historical background and thus a consolidated know-how. As early as the XIXth century, *Red Cross* had barracks manufactured by the German company *Christoph & Unmack*. From the 1880s onwards, they produced not only barracks, but also private houses or school buildings in panel or modular construction, exporting them worldwide.

The need for efficient house construction in Germany is acknowledgedly recognized among its planners, architects, sociologists and others at least since the early XXth century. Nonetheless, industrially produced houses only become historically relevant from the 1920s onwards, when an important area of research opened up for the steel and timber industries. It pretty much coincided with the period of the Weimer Republic (1919-1933), during which conditions were created for a cultural effervescence, particularly in the 1924-29 period known as the *Golden Era*, given the economic growth and social stability.

However, the economic crisis, begun in the late 1920s and proceeded throughout the 1930s, and the dawn of the Nazi regime, in 1933, would lead to a political shift, with an abortion of housing policies and changes or closing of some institutions such as the *Bauhaus*. Consequently, the development of the avant-garde methods of design or construction were relegated to a temporary standstill.

In the post-WWI, hundreds of prefabricated dwelling units were produced using steel frames and clad either with copper sheets, as in the *Hirsh-Kupfer* houses (1931), designed by Gropius, or with thin steel plates, as in the *Kastner* houses (1930s). Between WWI and WWII, focus was mostly put in rationalization or in heavy, concrete prefabrication systems, and although with remarkable exceptions, house prefabrication was taken to a secondary stand. *Christoph & Unmack*'s houses are one of such exceptions, as the company had the benefit of a well-sedimented organization with a large historical ballast, which granted priority in factory rights. Additionally, they had a large demand for barracks from the beleaguered Prussians, which ensured them a steady income from such a product disposal[155]. They would grow to the point of becoming leader in their field in Europe during the 1920s.

The successful story of German prefab can also in part be explained by instilled cultural and educational principles. A playful example comes from Friedrich Froebel's wooden blocks for children's education, in 1826. Froebel, a psychologist, developed a renowned education philosophy based on free self-expression, creativity, social participation, and motor expression[156]. His wooden blocks, which would later be known as *Froebel's Gifts*, would become famous worldwide, influencing central architectural references such as Frank Lloyd Wright. More recently, it became an important influence on the development of the shape grammar theory, with implications on ruled design conceptions envisioning great variability of outputs[157].

Nonetheless, Germany's inculcated cultural principles regarding prefabrication have roots that can be primarily connected with the housing problem. Numerous state subsidized programs have been implemented over the years, of which Berlin's case in the early XXth century is exemplary. The awareness of the housing problem, with a long continuous research tradition, or the key role it had in the modernist foundations, make Germany's case undisputedly a technical and aesthetical reference in the housing and prefabrication subjects, with key importance in the Modernist formulation.

2.4.2 THE HOUSING PROBLEM IN BERLIN IN THE EARLY XXTH CENTURY

Berlin's population had bursted to 4.5 million by 1920, with the city becoming one of the most populous and densest in the world. Overpopulated square blocks of 22 meters high and 150 wide sprang across the city, in agreement to the limits set by regulations. These typically consisted of a frontal portion aligned to street (*vorderhaus*), a side area (*seitenflügel*), two transversal building separating them (*quergebäuden*), and one or several backyards (*hinterhof*)[158].

Many thousands lived in basements, rooms had to be shared to the three or four people, in cases work had to be made from home, and many houses were unbearably icy in winter and agonizingly hot in summer. In *Die Großtädte und das Geistesleben* ["*The Metropolis and Mental Life*"] (1903), the sociologist Georg Simmel warns against the monstrosity of the metropolis. He writes, "*in the life of a city, struggle with nature for the means of life is transformed into a conflict with human beings, and the gain which is fought for is granted, not by nature, but by man*"[159]. People felt the housing issue [literally] to the bone, and such created an ideal setting for energetically address the problem through a common, collective ground.

2.4.3 MARTIN WAGNER AND THE STATE PROGRAMS

Martin Wagner, the head planner of the city of Berlin, leading promoter of the *Großsiedlung* (large scale multiple units), called for the rationalization of design and construction: "*The replacement of manual labor by machines brings greater productivity. What Ford does with his cars, we want to do with the apartments*"[160]. A dedicated socialist, Wagner recognized the weaknesses of purely capitalist projects, and was committed in the search for more sustainable forms of financing. In his view, construction costs should be reduced in order to allow affordable accommodation, industrial companies should replace traditional building companies, and machines should replace manual labor. Such would liberate the workers, while increasing the performance of their work, contributing to improve their satisfaction levels and hence their quality of life. But Wagner also criticized state funding policies, considering absurd to finance a stagnant building sector with the dynamic German industry, thus squeezing the latter with taxes. Construction sector should hence meet the industrial sector.

To improve housing for civil servants, in 1924, the *DEWOG* is created (*Deutsche Wohnungsfürsorgung Aktiengesellschaft für Beamte, Angestellete und Arbeiter*) ["*Shareholder German Company for the Improvement of Housing for Civil Servants, Employees and Workers*"], a company whose role was to centralize capital of the worker's bank with public funding, in order to redistribute it more effectively. Springing from it and too masterminded by Wagner, the *GEHAG* (*Gemeinnützige Heimstätten-, Spar- und Bau-Aktiengesellschaft* ["*Housing Cooperative for Savings and Construction*"] was created in 1924, which would primarily enable collective housing initiatives. These undertakings had the edge of a self-financing method playing the liberal market rules, which resulted in a highly competitive model, which ultimately steamed effects on the housing quality[161].

2.4.4 *GEHAG* WAVE EXAMPLES

Contemporary of Wagner, Bruno Taut had too firm rationalist beliefs, and was inspired by steel constructions found among the industrial landscape. Both shared a rationalistic vision, but one which was critique of a mechanistic minimum—and with a still current argument that the cost per square meter of floor-space does not rise proportionately with the size of the dwelling[162], although that may not be the case with the value of rents paid by the tenants[163]. Taut also saw mass production and prefabrication as way to cut construction costs, as it enabled the elimination of a great share of costs with intermediary suppliers. The first product of the new *GEHAG* wave was built in Britz in Neukölln (1910–1933), embodying the purpose of combating the shortage of affordable living space, while formally following the principles of a *New Objectivity*.

In 1926, together with Hugo Häring, Taut designed the *Onkel Toms Hütte* ["*Uncle Tom's Cabin*"], which would too be financed by the *GEHAG*. In it, Taut envisioned a utopian, classless society bond with nature, and criticized the selfish and utilitarian capitalist system. The complex is a triumph of color and light, of rationalist influence but humanistic in its practicality, diversity and human scale. Taut avoids monotony by including diversity within homogeneity, and several parts of the estate look different to each other in terms of shape, size and color[164]. The sharp lines of a *New Objectivity* are here smoothed by homely details such as invitingly individual doors, asymmetric windows and a polychromatic pallet. Furthermore, space in between buildings is cared with as much importance as the buildings themselves—gardened, with benches, pathways and other *comforting* details. In terms of innovative construction processes, the *Britz* or *Uncle Tom's Cabin* became known by the use of rationalization principles through restriction of the amount of house types, or in the use of technologically innovative machinery such as excavators and conveyor belts, speeding up the construction, enabling a reduction of costs. Nonetheless, despite the improvements, overall the employed construction methods had no major breakthroughs, being mostly still supported by in-situ manual labor.

In any case, prefabricated systems would be used in some of these new neighborhoods. Such was the case with the *Berlin-Friedrichsfelde* estate (1926), where story-height concrete panels were used according to the *Occident process*, a system that had been patented in The Netherlands and had been previously used in Amsterdam's expansion. This was a large, heavy-weight panel construction system of 25cm thick, and between 25 and 40m² per panel, with maximum dimensions of 10×4m. Because of its weight and dimensions, the system had to be produced next to the building location, from where it was directly erected by cranes. The panels were constituted by several layers, with aggregate concrete on the outside and slag concreted on the inside, and the internal walls with slag concrete on both sides. Eventually, the system's characteristics lead to a highly complex manufacturing process which overtime would lead to the appearance of serious constructive pathologies[165].

2.4.5 ERNST MAY AND SYSTEM CONSTRUCTION

Ernst May, the chief planner of the city of Frankfurt, would write *Die Wohnung für das Existenzminimum* in 1929, calling for flats for subsistence living, with a guarantee of minimum standards of quality for a low-income working population. These, according to May, "*should be designed to avoid all the past misery that flats for lower paid workers have inflicted on their inhabitants. Whilst the far-reaching field of engineering technology has been developed through exact scientific methods, until now, building has usually developed along intuitive lines*"[166]. Additionally, these should regard the principles of industrial production as exemplary models: "*the goal must remain the factory produced dwelling – including internal fittings – that can be delivered as a complete product, and assembled in a few days*"[167].

Ernst May would also be the head behind the *Frankfurter Häusfabrik* ["*Fankfurt House Factory*"], which would produce the *System Stadrat Ernst May* (1927), the first concrete panel system of German conception. This system differed from the Dutch original *Occident process*, as the walls and windows were not directly integrated. Instead, openings would occur in the vacant spaces between panels, and since these were smaller, such allowed a greater ease in manufacturing and also to effortlessly adapt to different architectural configurations. The system had three main components: the non-reinforced window-level panels (*fenster-platte*), the non-reinforced spandrel panels (*brustungsplatte*, 300×110×20cm), and the reinforced lintel panels (*sturz-platte*, 300×40×20cm). Given the smaller dimensions, these were also considerably lighter, which enabled the building shell of a single-family house to be erected in one and a half days, and the construction 26 days to be ready to be occupied[168].

Prefabrication as a means for efficient construction in helping to solve the house problem was not limited to those advocating a new modernity with new formal conceptions. Even with the traditionally-oriented *Stuttgart School*, Paul Schmitthenner developed a factory produced half-timber system (the so-called *Schmitthenner System*), using mixed dry and partially dry construction techniques, with the underlying intention of modernizing the traditional *fachwerk* frame construction. The system had serially produced four-sided, closed timber frames with embedded doors and windows, which were then screwed together on site[169]. Final rendering of the buildings would be made in-situ, which enabled the system to be undistinguishable from a compared ordinary construction. Besides using the innovative constructive system, Schmitthenner's traditionalist *Garden City* in Berlin-Staaken (1914-17) was built according to rationalist typological principles, with the buildings spatially based on only five types[170].

2.4.6 BEHRENS AND THE ARCHITECTURE-PRODUCT

In 1906 Peter Behrens received his first commission from the *AEG* company to design advertising material. He would work as an artistic consultant to work on a wide range of projects, doing from typographic design, corporate identity (from which he is precursor), product design of lamps or appliances, or building design, becoming the first so-called industrial designer in history[171]. In 1908 he would design the *AEG* factory in Berlin, raising too the awareness of industrial forms as source of *beauty*. The factory was designed as if it was its own machinery, following an aesthetics resulting directly from the use.

A new aesthetical view and the new industrial designer profession also called for a new view on the notion of architecture as product, where the root of the question is the reproducible unit[172], and where ultimately, architecture is no longer conceptually grounded to a place. Behrens influence would spread and gain new contours by his mentoring of three future key figures of modern architecture, namely Walter Gropius, Mies van der Rohe and Le Corbusier.

2.4.7 WALTER GROPIUS AND A *NEUES BAUEN* THROUGH *BAUHAUS*

The *AEG* factory, and the experience as Beheren's disciple, gave Walter Gropius an unprecedented background. In 1909, he proposed *AEG* the creation of a *General House Building Corporation on Artistically Unified Principles*, to develop a "*search for an underlying geometry for all formal research and the quest for an alliance between art and industry*"[173]. However, in 1910, when Gropius presented a prefabrication scheme to Behrens, he was told it had no practical gains. Regardless, determined to take his ideas ahead, Gropius sought for alliances among industrialists in order to produce his panel system for housing.

As it would widely be expressed in several of his writings, Gropius was foremost concerned about two ideals in architecture: industrialization and social equity. When Gropius founded the *Bauhaus* in 1919, he kept on defending his ideas on prefabrication. In his 1925 text *Die neue Architektur und das*

Bauhaus: Grundzüge und Entwicklung einer Konzeption ["*The New Architecture and the Bauhaus*"] he called for a synthesis of technique and arts through *Bauhaus*, framed within the spirit of a *Neues Bauen* ["*New Architecture*"]. Main ideas were mostly driven by an aspiration of industrializing construction, allowing repetition of mass produced components, in different house designs, adjustable to individual desires: it was as if the poor and deprived too could finally see their needs satisfied.

The housing problem was not a new issue, but among architects the prefabrication was certainly also driven by other, probably less *noble* social factors, which had to do with a not less legitimate artistic aspiration of formal experimentation, where, as Gropius writes, "*the liberation of architecture from a welter of ornament, the emphasis on its structural functions, and the concentration on concise and economical solutions, represent the purely material side of that formalizing process on which the practical value of the New Architecture depends*"[174]. Ultimately this also came to mean that the idea of prefabrication was suited to the planar elements and cubic volumes of a new aesthetics—this despite *aesthetics* being an avoided word, since form was conceptually supposed to be a direct translation of the purpose or *function*.

The world of the *machine* becomes a source of inspiration and enables the creation of *authentic*, *objective* beauty, in an architecture accessible to a much wider audience. The *art object* can be accessed by everyone, and thus the idea of a commoditized architecture is reinforced. As it is known, the *Bauhaus* (literally house of construction) would become a reference for modernist architecture and design with repercussions in the formulation of the built environment thereon. That would be enhanced after its politically-motivated dismissal in 1933, when its main referential figures were forced to exile elsewhere, in Europe or the New World, spreading *Bauhaus*' seeds throughout the world[175]. Among those associated with the *Bauhaus*, the new spirit remained and many, during the *Bauhaus* period (or afterword), would too jump on the prefabrication bandwagon.

In a well-known example, along with Adolf Meyer, Gropius designed *Baukasten* (literally building blocks) in 1922-1923, a standardized system of flat-roofed housing, developed to study prefabricated houses for the *Bauhaus* in Weimer. *Baukasten* was thought of as a system of standardized components to be industrially produced, that would function as a variable kit of interlocking parts, to form a near infinite array of configurations. It was as if a big toy, as Gropius described: "*an oversized set of toy building blocks out of which, depending on the number of inhabitants and their needs, different type of machines for living can be assembled*"[176].

2.4.8 PREFAB EXPLORED THROUGH STEEL CONSTRUCTION

There were plenty of architects and engineers interested in exploring the lightness possibilities of steel during this period. In 1926, Gropius oversaw a housing estate in Toerten-Dessau, where Georg Muche and Richard Paulick designed a steel prefabricated house. In 1927, Marcel Breuer designed two separate steel-framed prefabricated houses, called *Bambos I* and *Bambos II*, designed for the younger Bauhaus masters. Although never built, these prototypical designs served as a starting point for several concrete-panel later produced, and marked *Bauhaus*'s turn towards a philosophy of rationalization to achieve a new unity of art and industry[177]. Around this period, other steel-house prefab prototype designs can be found among the *Carl Kaestner Company*, *Bruane and Roth*, or the *Woehr Brothers*[178].

The housing crisis in the 1920s led some big firms getting interested in the construction business. Such was the case of *Hirsch-Kupfer*, a major firm in the copper and brass industry, which acquired a patent for transportable, insulated metal walls. They created a division for prefabricated houses that was set to develop an eclectic catalogue of prefab houses with exterior face in copper. Walter Gropius was posteriorly invited to refine the design, and make it marketable. He would approach the problem in a quasi-scientific way with a right-angle connection system for the copper panels as well as a catalogue of design choices designated as *Type M2* or *Type K1* depending on the layout[179]. Despite the successful presentation of two prototypes, the company went bankrupt. Nonetheless, the copper house division continued as an independent development. After the National Socialists came to power, the political changes led to a flea of Jews that took it to market in Palestine, where it proved popular and even causing a branch of the company to open in Haifa. Albeit the interest and some initial success, the war would inflate cooper prices, which had become more valuable for arms production than for houses—it is said that the last copper house was immediately melted down upon arrival, copper value being higher than the house cost[180].

The formal preferences expressed by Gropius in the *Hirsch* houses could be observed in houses designed by Josef Hoffman for *Vogel* and *Noot*, Hans Scharoun for *Christoph & Unmack*, or Johannes Niemeyer for *Bohler*, sharing a clear preference for hovering cubic volumes, flat roofs, and tectonically-expressive panel seams[181]. After Bauhaus shut-down in 1933, Gropius, along with Konrad Wachsman would continue its work on prefab systems in the USA, developing the *Packaged House*[182], which would also not be commercially successful.

2.4.9 THE *WEISSENHOF SIEDLUNG* INNER CIRCLE

Also linked to Gropius, and involving some of the greatest European architects of the time, the 1926-27 *Weissenhof Siedlung* ["*Weissenhof Estate*"][183] model housing development, built in Stuttgart as part of the *Die Wohnung* exhibition, would become indelibly linked with the propaganda of these new modern forms, as it would be of propaganda to efficient constructive principles[184]. The development was directed by Mies van der Rohe, and organized under the *Deutsche Werkbund* ["*German Arts and Crafts Society*"], which had been founded in 1907.

As would later be noted by Henry Russel Hitchcock and Philip Johnson[185], the *Weissenhof Siedlung* would be inextricably linked to *CIAM* and the formulation of the Modern Movement through an

International Style, bringing architects such as Le Corbusier, Scharoun, Oud, Gropius, Behrens, or Max and Bruno Taut. The purpose was to show the potential of the ideas related with standardization, rationalization or prefabrication, in order to address the house problem in a wide social scale, becoming a flagship of innovative modern architecture.

Nonetheless, many of the produced examples are closer to bourgeois villas than to houses for the working class. Mies's block was built on a steel frame, but most of the work followed in masonry and coating was in traditional methods. Indeed, regardless the constructive rhetoric (not to mention the social rhetoric), Le Corbusier's or Mies' cases were prefab, but Breuer's or Gropius' were not. Nonetheless, this fact further reinforces the value of prefab and the ethos of the discussion, as the perception of some construction methods when compared with the others is undistinguishable.

The issue of the concordance between appearance and constructive method employed is further stressed when we observe Gropius' *House no. 16* and *House no. 17*. Gropius had devised this pair of two-story houses to be using dry panel system and a steel skeleton, placed at regular 1.06m intervals and a single central column. Both the houses followed the same planning principles, either in the structural dimensioning, or by using the same standards for panels, windows or doors sizes, which allowed a close construction time. However, whereas *House no. 17* used prefabricated elements in a dry-construction assembly method, *House no. 16* used a traditionally laid masonry. The great perceptible difference between both houses was in the visible cover-strips of the external sheets in *House no. 17*. The plans strictly followed a one meter dimensional regulation (or exceptionally half of it), which highly constrained their potential efficiency.

Gropius would have argued that any spatial inefficiency could be offset by constructive economy. With the *Weissenhof* experiment it seemed he would be right. However, the promise would not always be fulfilled, as even in the post-WWII period, when panel system building was conducted longer and at its largest scale, it did not prove particularly cheaper than traditional building methods[186].

Contrary to Gropius, Mies van der Rohe was not particularly interested in prefab, although he was keenly interested in industrialized building as a means of design. From Behrens, Mies had certainly learned an attention to craft and detail, as noticeable through the precision and quality of his buildings. He did use the factory to produce his designs, and rationality and potential of detail replication of construction elements within a single design is normally a rule, but components were mostly customized for each case. He had no particular interest in building houses for the masses and most of his designs were anything but inexpensive. Therefore, his influence was more aesthetically educative towards a wider social acceptance of a *Neues Bauen* than for the design or production of panelized, modular or other types of prefabrication systems.

2.4.10 THE *FRANKFURT KITCHEN*

The *Weissenhof Siedlung* vanguard, and again the streamlining of planning and building through rationalization, prefabrication, or standardization, would too be used as a model by Ernst May as head responsible for the planning of the social housing project *New Frankfurt* (1925-1930), in Frankfurt's suburbs. In this perspective, the *Frankfurt Kitchen*, designed in 1926 by the Austrian architect Margarete (Grete) Schütte-Lihotzky, stood as a milestone for being the first to reproduce the dimensions in relation to the human body, to the movements of the cook and to new equipment (gas, water, electricity)[187].

Designed like a laboratory, the kitchen ascribed to the functional and hygienizing theories. When researching for the design, Grete undertook detailed motion and anthropometric studies, interviewing housewives and women's groups. Around 10 000 units would be built in the late 1920s. Everything was pondered to detail: kitchens came equipped with a gas stove, a swivel stove, built-in storage, a removable trash drawer, a fold-down ironing board, and adjustable ceiling light; labeled aluminum bins provided organization for goods like rice and sugar; the materials were carefully though, with parts ascribing to specific functions such as surfaces to resist knifes. The standardized unit dimensions promoted interchangeability of parts.

The success of the kitchen is now a proven historical fact. Throughout the 1930s until the 1960s, kitchens would often be smaller, and the *Frankfurter* criticized by being too luxurious whether in size as in the materials. Nonetheless, it stood for its principles, which would soon be adapted to other places such as Switzerland or Sweden. Whether design-wise or sociologically, its relevance is so pervasive that would become a collector's desired item and it can be found in the collections of numerous museums, among which figure *MoMA* in NYC or the *Victoria and Albert Museum* in London[188]. The kitchen has undoubtedly set a resolute shift towards the industrialization of house components, and can be regarded as the first great step towards the contemporary kitchens, with their typical 0,60m modules.

2.4.11 THE NAZI HIBERNATION AND A POST-WWII REBIRTH

During the Nazi regime and subsequent wartime period, there are no remarkable developments in prefab. If that is a consensual fact from a German perspective, on the other hand prefabrication may have won WWII to the Allied Forces—through the capacity to set up production, barrack troops or workers in construction that could as easily be built up as they could be moved away, make airfields and so forth, using efficient and often prefabricated construction methods[189]. Nonetheless, after the war, the previous achievements in the production of homes in Germany caught the attention of USA interests who prepared an exhibition of prefab houses in *Stuttgart Zuffenhausen* in 1947[190].

A surge in the development of prefab houses occurred in this period, when reconstruction highly increased housing demand. Examples can be found in system construction by the *Holig-Homogen-Holzwerk* company, in Baiersbroon, or in *J. Hebel* aerated concrete panel houses—the *Hebel* panels had 50cm in width by 200 or 250cm length and a 15+10cm thickness for external and internal walling.

The aircraft designer and manufacturer Willy Messerschmidt became interested in joining the achievements of the industrial state of the art into the building industry, and came up with a solution of encasing the aerated concrete panels covered in metal sheeting to better withstand the elements and enhancing finishing materials possibilities.

Another aircraft manufacturer, *Dornier*, which had previous experience in temporary housing construction, produced ready-built two-story houses, which were structurally built in lightweight steel profiles. They were built ex-situ in box-like modules with complete internal fit-out which would then be transported to their final assembly location, cladded and rendered in-situ. When the company retook aircraft manufacturing, the production of houses was terminated[191]. In the 1950s and 1960s, the German timber industry and house builders started to invest heavily in modern methods of production[192].

2.4.12 GDR'S *PLATTENBAU* AGE

In the former GDR (German Democratic Republic, or East Germany), industrialization of the building industry became a political program with evident, cross-fertilized links with the Soviet regime. As with the Soviets, large modular construction, and large panel construction sprang. The most common system in this period became the *WBS 70* (*Housing Construction Series 70*), which, as it had occurred with the earlier *Occident System*, also consisted of elements with finished surfaces and built-in windows.

This system and several similar concrete-panel systems, at cases with external decorative motives embedded in the very concrete, or using decorative tiles, became known in the GDR as *Plattenbau*[193] (similar to the *Khrushchyovka's* in USSR). These and similar others, in Germany and elsewhere, would determine the appearance of new social housing developments and also of residential areas, such as the *villes nouvelles* and *grands ensembles* around Paris, the suburb of Neuperlach in Munich or the Märkische Viertel in Berlin.

2.4.13 WEST GERMANY SYSTEMS

Despite the somewhat monotonic notes in the East, liberalized alternatives sprang throughout West Germany, as noticed in the example of Günter Behnisch's concrete-based prototypes, such as what as became known as the *System Behnisch*. In 1959-63, together with the engineering school in

Ulm, Behnisch developed what he called the "*the first large-element, fully prefabricated building in Germany*". In 1965, he would write that "*the use of these standardized elements and systems brings us exceptional advantages, so that in the future we will be liberated from the work that, up until now, has overwhelmed our offices (…) The architect will be free for new major undertakings*"[194]. However, as it is well-known, such a mythical *architectural solution to all problems* would face criticism, and different design philosophies and their associated trends would emerge.

In 1970-72, Otto Steidle, together with the Swiss architects Doris and Ralph Thut, executed an experimental housing in Genterstraße in Munich, employing a prefab concrete system allowing variation and flexibility, and inciting dwellers to freely fit-out and adapt their house to changing needs over time[195]. The structural system is openly expressed, providing a frame for different infill elements. The system has load-bearing and non-load-bearing parts, which can be visually recognized, and thereby intuitively provide the inhabitants with knowledge that enables them to alter or add to their respective house without great technical expertise. It is an open system which greatly ascribes to Habraken's *support* and *infill* notions, successfully deploying it. After 50 years, the external perception of the buildings is still *aesthetically* intact, regardless the considerable interior changes that have occurred.

Also related to an open approach to design, Richard J. Dietrich, of the University of Stuttgart, designed a steel-frame modular building system called *Metastadt-Bausystem* (1965-72). As the name states, the design, envisioned as a meta-system, is supposed to provide a concept for a flexible model of urbanism, and which, as if a giant *Meccanno* set with endless parts, can be varied as created. The implemented pilot scheme is developed in a plan that is supposed to expand unlimitedly both horizontally and vertically. The structural module is 4.2×4.2m and 3.6m height, with a spatial modulation of 0.6m. There are main supporting columns every 16.8m and cantilever spans up to 8.4m. Within this setup, spaces can be enclosed as needed. The different elements—loadbearing and non-loadbearing elements, and services—are kept independent: the structure is kept separable from the infill through demountable walls; the frame structure itself is bolted so it can be rearranged as necessary; the external panels are interchangeable. Up to the very name, *Metastadt* (meta-city), hints an idealistic, uncompromising, open nature. The result is a cluster form, resembling a randomly laid set of blocks. In the end, due to technical faults that resulted from cost cutting measures, the building was demolished in the early 1980s[196].

In a totally different approach, but too ascribing to a cluster kind of form, the firm of *Hübner-Forster-Hübner* developed the theme of octagonal capsules, which had been previously worked out by the Israeli architect Zvi Hecker in his design with polyhedric modules' cluster of 720 units for the *Ramot Housing Complex* in Jerusalem in 1974, also known as the *beehive*. Whereas Hecker's modules were made of steel, Hübner's cluster of 23 prefab cells, located in Stuttgart's suburbs, were made of plastic. Each module was delivered to site fully equipped with heating, pumping, wiring and even wallpaper[197]. More than a contribute for housing and construction efficiency problems, these designs contributed to enrich the available formal vocabulary, their greater value standing in their experimental character and vanguard (even if naïve) spirit.

2.4.14 CURRENT PREFAB BUSINESS

The prefabrication industry is now a significant force in the German market. In 2002, over 23 000 lightweight prefabricated homes were completed, equivalent to some 13% of all new detached or semi-detached homes built that year. In Eastern Germany, the proportion was higher than the national average, at around 20%[198]. The use of steel, timber panel, concrete framing and masonry panel systems is growing rapidly, with *many eco-designs* also being marketed.

German clients favor packages that include financial services, assistance with finding sites and a range of standard, customizable house types. This has led, since re-unification, to packages offered by contractors, architects and building societies that combine multiple expertise. In many cases, building societies have been concerned with the increase in house prices, which prevented young families looking for their first home. These building societies recognize that a reduction in housing cost by 22% could generate millions of extra homes and hence, of course, millions of extra customers[199].

Overall and unlike in the 1980s, with the *Plattenbau* hangover, contemporarily prefab in Germany has a good image, being associated with good quality construction. Reasons found on current companies and market practices for a wide acceptation of prefab methods may be ascribed to the continuous innovation and staff training, or in the implementation of quality control processes. Building associations also have an important, dynamic role, promoting conferences, training sessions, contributing in the development of quality standards and certification schemes and consistent promotion of the merits of prefab. Like in the rest of Europe, most construction companies are SME's, nonetheless, the prefab market is dominated by major companies such as *WeberHaus*, *Schwörerhaus* or *Elk-Bien-Zenker*, with some exporting to European markets (e.g. UK, Austria or Switzerland) or World markets (e.g. Japan or Russia).

Ordinary, non-authorship prefab has kept moving at its own pace, but although often with strong architectural contributions, the fervent spirit of the early modernist times has never been felt again. The naïveté of the fervent belief in technology to move humanity forward, or in design to solve the societies' issues is presumably no longer occurring as it was in the 1920s or the 1960s. On the other hand, what is a state-of-the-art technology, when tested in time and proven fit, soon becomes part of regular practices. The speed of our days contributes to a faster obsolescence of new practices, as their novelty is tested and discarded, but it also contributes for an oblivion of good old practices.

From a designer's perspective options are numerous, and is often hard to discern what the best solution can be for a given case. In terms of house construction solutions these are most generically divided in to two types of structural technologies: the *Fertigbauweise* (literally meaning "*Prefab Construction*"), which makes use of lightweight construction elements and is typically linked with a traditional idea of house prefabrication, and among which can be found companies such as *Baufritz* or *Weberhaus*; and the *Massivbauweise* (meaning "*heavy construction*"), which includes concrete or masonry elements, and is normally more dependent of in-situ practices, and among which can be found companies such as *Glatthaar Fertigkeller*, or *Johanni Ziegelhaus*.

In the current state of the prefab market, technologically numerous materials and techniques can be found: from timber, concrete, steel or lightweight steel based structures; in frame, light-frame, panel or modular systems; with composed elements with insulation and with or without internal finishing, and so on. Production-wise, among the different companies the degree of mechanization and automation in the different stages, factory or in-situ, also varies immensely.

Market-wise, prefab is frequently used in new detached single family houses. Most of the pre-designed houses have a *traditional* look, but other forms are marketed, given the substantial flexibility and variety in finishing materials. Prices vary a lot, depending of materials and equipment, and so on: a *starter* house can cost about €80 000, whereas in the top market there are no limits, but can normally range up to €400 000 (2004 figures), depending on multiple factors.

Some companies offer several finishing materials options for similar design layouts to meet the client's budget, or a greater or lesser flexibility in terms to adjustment to the client's greater or lesser spatial or aesthetical expectations, with typically a higher price for more flexibility in the customer's customization options in terms of design layout or materials and vice versa. Customers choose among the numerous procurement options, among which the catalog houses have been growing. In such procurement option, generally the client is also responsible to acquire the land and take care of legal permits and so forth. Houses can too be bought in different stages of the construction process. One of such procurement ways is the *Ausbauhaus*, in which the external part of the house is pretty much built, but the interior is not or only partially built. This has been a growing procurement option, since it allows for buyers to have more latitude to adjust houses to their needs, spending less in the initial buy, and get more engaged in the construction process, with potential savings and certainly with a different sense of fulfillment. It also is important to refer that the German law imposes an additional fee to the real-estate promoters which also design the houses they build. To a certain extent, such discourages prefab manufactures', at least the smaller ones, to go into the real-estate market, leaving it wide open to the prefab *sharks'*.

As in any other competitive market, manufacturers invest highly in promoting their products. Besides individual companies' showrooms house prototypes, to aid customer choice, there is a big investment in presenting prototypes in show villages and home show parks, which have in display dozens of houses of several manufacturers, each fully equipped and furnished. Another important promotional method makes use of magazines, such as *Pro FertigHaus*, to divulge prefab construction, presenting a range of different configurations, styles and products, which helps keeping consumers informed. Some companies are selling kit-of-parts homes in retail stores, which makes them true consumer products.

Companies also develop great efforts in terms of quality delivery, highly investing in areas which are not directly visible to clients, such as R&D or staff training, often with a combined purpose of achieving certain desirable certification labels which too contribute to promote their products. The more recent trends in certification has been the energetic efficiency and/or sustainability labelling, such as the widely implemented *Passivhaus*, which has led many manufacturers to develop new standards in terms of material, light or energy demands. Coordination among real-estate sector expands the scope of some of these companies, allowing them to act in different sectors of the market, where they act not only as house producers, but as real-estate developers, and on the procurement level, offering a complete, integrated package of services to the client. These give more visibility to their brands, and contributes to expand their market into the multiple streams of the sector.

2.4.15 THE CASE OF *WEBERHAUS 'OPTION'* (*BAUART AG* ARCHITECTS) AND *WEBERHAUS SYSTEMS*

A contemporary example of collaborative work between the German industry and an architectural firm is the *WeberHaus 'Option'*. Developed from the *smallhouse.ch* concept by the Swiss architects *Bauart AG*, is a modular built house manufactured in wood, totally ex-situ made. The appearance is minimalist and the house philosophy is, according to the architects, for a minimum cost and maximum design quality—outside is blocky, inside of "*surprising generosity*". The modular house grows with the needs of its residents. Only one thing remains the same—the unconventional mixture of panoramic windows and horizontal wood siding. The small sized, yet sophisticated design and construction, is thought to be a standalone building or to complement existing buildings and facilities.

The basic version modules are of 4.13×10.11m, having a clear interior area of 35m^2 on the ground floor and 30m^2 on the first floor. Four generous windows, located on each face, provide the box with the necessary natural light. These are associated with four spatial zones, characterizing its appearance, contributing for its overall consistent and reduced, functional and object-like look.

Functionally, the basic version of the two-story box-like house offers living and dining room, hallway and complete kitchen, a fully equipped bath, a gallery and, separated by a sliding wall, two rooms for sleeping or working. Access to the house is via the short side straight into a front room with an open connection to the kitchen space that is positioned in the center of the house. Past the kitchen is another room from which the first floor is accessed. The upper story is identical to the ground floor plan.

In addition to the basic box, ground plan variants like an *L-* or *U-shape* with an inner atrium are possible. Other options of this system include the grouping of volumes. The simple, volumetric, form can be either used on its own, or two and three of these volumes can be combined to create a bigger unit. One basic module with a one-story extension can be combined with a mirrored version of the same to form a small courtyard in-between; or, any number of 'L-shaped' modules can be built next to each other. A one-story module can be attached to either side of the back room of the ground floor—either to simply enlarge this room or to create another room. On the first floor this module can become an accessible roof terrace. An option for pitched roof may also be used. Additionally, if building regulations allows, the modular concept and the rational construction allow for later extensions without any problems, allowing a prospective buyer to start with one small house and extend this when needed.

The construction is of wood frame, with final assembly of a panel type of construction. The construction system is developed by the building company *Weberhaus*, which currently provides three main types of wood walls systems: breathable wall construction, styrofoam and PE foil-free. These systems allow virtually any finishing type. The same applies to their other systems—roof, windows & doors, and basement.

The company's philosophy may be regarded as one of developing high standard construction products which may be adaptable to different design specifications. This enables the client to build its own design, adjusting it to their system's characteristics and limitations; for *Weberhaus* to develop their own catalogue; or for the client to use the company's design teams. In all cases, either a more traditional, or more contemporary designs may be developed, as it is the case of *Option*. Additionally, since there is a strong concern on developing certified systems on multiple fronts—sustainability practices, toxicity proof and allergy-friendly standards, product warranty, quality control in construction production and erection processes, and so on—there is an enhanced reassurance for both the designer and the client that the end-product will satisfy demanding requirements.

The compactness of the house can certainly be regarded as an indicator of the willingness of people to actually live in a small, compact house like this, even when such is not dictated by an urban context. Its basic version size foresees a small house for singles, at best a couple; as a vacation home or interim accommodation, some may regard. But nonetheless its expansion possibilities keep a sense of compactness in space that goes beyond the mere vacation bungalow that a distracted look may regard at first sight: it is a compact, adaptable and expandable house fit to contemporary family patterns and a contemporary lifestyle.

2.5 Prefabrication of houses in the UK

2.5.1 OUTLINE AND EARLY EXAMPLES

UK's colonization efforts were probably the main igniter of prefabrication in the western world. These efforts would have increasingly serious and sustained attempts from the late 1700s and early 1800's onwards, when the devised constructive systems would definitely be spread all over the world, propelled by the developments of the industrial age and the prosperity of Victorian Britain. Easy to transport and assemble construction systems were of utmost importance in the military and colonial expansion. In the military, since early stages, the focus has been in speedily erecting and dismantling temporary structures—*barracks*, as they became called. In the colonization efforts, besides house construction, also were included schools, hospitals, churches or storehouses. Simple houses, with not much detail were manufactured in the UK, then dismantled into transportable components, and finally globally shipped as building kits to the USA, Africa, Australia or India[200]. These were not as extensively prefabricated as it can be understood in our current state-of-the-art. Nonetheless, they already represented significant gains in efficiency and speed of construction. Their appearance was usually unpretentious and shed-like, and the construction typically made with precut wood frames and board cladding, with the different parts often requiring some in-situ trim and fixing, and in many cases with doors and windows prepared and shipped as complete components[201].

There are numerous early examples. The first is recorded in the USA in 1624, and consisted of portable cottages shipped from the UK and assembled in the fishing village of Cape Anne. These panelized wood houses, initially destined to be used by the fishing fleet, were subsequently disassembled, moved, and reassembled several times. In the late XVIIIth century a hospital, a warehouse and several small houses (or *cottages* as they were called) were shipped from England to Sidney. The cottages were in timber frame and had wood panel walls, floors and roofs. Similar systems are reported to be shipped to Freetown, in Sierra Leone, to build shops, a church and several other buildings. In 1790, the British shipbuilder John King builds and assembles a double-story house called *The Hut* at his shipyard. He then disassembles it, and hauls it in pieces to its final site in Emsworth, England, re-erecting it in only sixteen hours[202]. In 1820, a colonization mission in Eastern Cape Providence, in South Africa, was accompanied by three-room wooden cottages[203].

Due to the increasing insurance premiums on wooden houses, and the increasing range of areas in which iron was being used, the latter would become a predominant building material by mid XIXth century. Whether in wood or iron, this coincided with the first serious and sustained attempts to devise prefabricated systems, shifting labor from site to controlled and mechanized conditions in factory. Among these, the wood-based *Manning Portable Colonial Cottage*, built in England and shipped to Australia, is probably the most influential throughout XIXth century British settlements. It began as a portable cottage made by Henry Manning for his son, who was emigrating from London to Australia. His son's cottage would become the prototype for what would turn out to be the first widely documented, fully prefabricated and packed house system. It was a commercial success, as Manning developed several models of varying size and cost, testifying to the fact that the houses were provisioned for clients across a range of incomes, and to the notion that the prefabricated house could be a measure of status in the colonial setting. Furthermore, it was widely publicized, as illustrated in a famous 1837 advertisement in the *South Australian Record.* The system included the prefabricated wood frame, infill components, the standardized and interchangeable panels, and used the same dimensional logic with all the elements. Structurally, the cottage consisted of grooved wooden posts, embedded and bolted into a continuous floor plate carried on bearers. The posts carried a wall plate that supported the roof's simple triangulated trusses. The standardization of all parts eased its construction, and spatially constrained all the layouts to rectangular based shapes. The final cladding was performed with various wood panels of standard size occupying the full height of the facade, alternating fully opaque with window or door panels. While many houses in Australia and other British colonies prior to 1833 had been built with materials shipped from the UK, the *Manning Cottage* appears to be the first designed specifically for ease of travel and construction, with Manning stating that a single person could carry each individual piece constructing up the cottage. Some of the generic principles of the system would influence subsequent technologies, pioneering the values that would become common in prefabrication, such as dimensional coordination or components standardization[204].

2.5.2 A GLOBAL REVOLUTION

Through ingenious technical advances occurred throughout the industrial revolution, the ancient knowledge of iron speedily expanded to a mechanized sphere during the XIXth century. Not only the more malleable wrought iron or the harder and heavier cast iron, but also steel (the best of both worlds), could finally be produced in large scales, and such was in a great deal due to several British contributions. By using coke instead of coal, using higher temperatures, compressed air, and other techniques that were feverishly being developed and readily becoming available, it became possible to manufacture better quality iron-based materials in sizeable quantities[205]. From a deepened knowledge of iron and steel, to its employment in construction was just a small step. Initially used primarily in the machines, rail tracks or shipbuilding, soon it became obvious that it enabled longer spans. That meant larger, non-obstructed spaces, useful in building factories with large machines. The employment of the different forms of iron for a wider range of buildings would follow.

Via the British contributions, prefabrication soon became a true iron flagship. It certainly was a major contribution to the British colonial movement, with many applications in components such as windows, columns, beams or foundation elements, and with many innovative by-products, such as the corrugated metal sheets. In 1829, Henry Robertson Palmer, Architect and Engineer to the London Dock Company, registered *Patent No. 5786*, for "*indented or corrugated metallic sheets*", envisioning its use primarily for roofs. However, the development of the machines to corrugate the metal plates would be in the hands of Richard Walker and James Jones. Corrugated iron, useful for its lightness and durability, rapidly became popular, and thus widely used in prefab construction. Indeed, with greater or lesser variations, it is still currently broadly used for many different purposes[206].

When in the late 1840's wrought iron became reasonably cheap, its mass use in construction became possible. Prefabrication with timber still continued when in the 1850's numerous different iron structural systems were developed. Initially cast iron was used mostly in a one-off basis for specific customers, in structures which required a high durability, such as lighthouses, and then also in a few grand houses. However, with the introduction of corrugated metal this began to change, since corrugation outstandingly increased the rigidity of the thin sheets while maintaining its lightness, which favored maneuverability and transportability of the constructions[207]. Among the places of export, the Californian story is quite remarkable. Before the opening of the Panama Canal (1914), ships had to travel long down south to Cape Horn and up back north to transport goods from one side of North America to the other, and in practical terms this meant California was nearly at the same distance of Europe as of New York. With the huge house demand caused by the California gold-rush (1848–1855), the context favored the British know-how, with its producers seizing the chance to plentifully export their iron houses[208].

An architectural or a building construction background was rarely the case among the developers of iron prefab. One of the first exported buildings came from Liverpool and was designed by a naval engineer, John Grantham, and built by the shipbuilders *Thomas Vernon & Co*. Shipbuilding remarkably added technical know-how, as it was where iron frame construction was most advanced. Throughout the 1850's prefab iron houses were built by the thousands for the Californian, South American, South African or Australian markets, by producers with diverse backgrounds, such as: John Walker of Bermindsey, son of the first corrugated iron manufacturer; Edward T. Bellhouse of Manchester, a engineer and millwright who had developed his iron construction skills in constructing cotton mills; Edwin Maw of Liverpool, whose background was as manufacturer of railway rolling stock; or Samuel Hemming of Bristol, which would dedicate most of his work to iron prefab.

Among these, there was a wide variety of constructive systems, which were independently developed by each company. For instance, Edward Bellhouse used his 1853 patented system of round cast-iron flanged columns, shaped for ease of attachment of the corrugated iron paneling; Samuel Hemming, one of the most prominent builders entering the Australian market with an astonishing quantity and variety of buildings, typically used either a timber or wrought iron frame, internally clad with wood planks and externally with corrugated iron[209]. But the iron prefab golden era would be quite short-lived, with the business eventually declining after 1860, with several contributing reasons. The rise of iron prices by mid 1950s, and the Crimean War (1853-1856), diverted the trade, setting up a shift. Meanwhile, colonies started to develop their own construction industries, and the corrugated iron got out of fashion because of its lack of thermal mass and high conductivity, unbearable in the hotter tropical or sub-tropical climates.

2.5.3 CRYSTAL PALACE AND A SYNTHESIS OF AN IRON TRADITION

The first iconic architectural use of cast iron had been in bridge construction, in 1779, for the *Coalbrookdale Company Bridge* over the river Svern, designed by the Darby brothers, which was mostly prefabricated. Cast iron construction envisioned the use of mass-produced components as a kit-of-parts. Although not a pioneer, cast iron prefab would become highly visible after the construction of the *Crystal Palace*, by Joseph Paxton, for the Great Exhibition of 1851 in England, which would turn into a worldwide icon of the use of standardized cast iron components. The structure was a seemingly repetitive system of standardized components that took only eight months to design, manufacture and assemble. Such would only be possible with manufactured kit of parts, and the idea of using repetitive, self-supporting bays that could be erected independent from one another by unskilled workers[210]. It reiterated, on a grand scale, a philosophy of construction underwritten by all the pioneers of prefabrication, both in theory and in practice, linking the precut timber frame of a remote ancestor, the *Manning Cottage*, with the new material, the cast iron.

Considering the context of the epoch, the amount of industrially produced parts in the *Crystal Palace* is quite remarkable, with columns made of composite structures that could be connected to extensions or several decorative features, glass panels of standard dimensions and their supporting framework accordingly: a complete building system of modules, components and connections. Besides its intrinsic architectural quality, as stated by Gilbert Herbert, "*its value also resides in its dramatization of the possibilities of prefabrication, in its revelation of the potential of industrial processes speedily to create vast, precision-built, immaculately engineered architectural works – a potentiality that was only hinted at in the pioneer works*"[211]. Paxton's intention of completing most of the work in factory was however undermined by the reality of the construction circumstances that have partially detracted the initial concept. Anyhow, its significance goes beyond the industrial processes it relied upon, to the extension of the rationalization of the building to the entire construction process. About this, Herbert writes: "*in its organizational concept, its realization of the processes of building, its handling of the flow of materials, components, and labor, in its production of systems and subsystems, and in its coordination of the entire vast enterprise as a planned sequence of events, the building is unique for its time*"[212].

According to the modernist angle of Siegfried Giedion, from an architectural perspective, the *Crystal Palace* is, in a great deal, also responsible for an architectural shift of the understanding of the form besides history, and towards an aesthetics derived from the function[213]. It is also important since it proved how architects, engineers and producers could work together, representing, according to R. E. Smith "*a shift in understanding among architects, that beauty may be as simple as the functional means of production*"[214]. The bulk of anonymous prefab would also have a fundamental role in the buildup of a new perspective on form and on a collaborative notion of design. The industrial revolution not only had brought up new materials, and changed manufacturing capabilities and public perception of the desirability of industrialized products[215], but also had brought up great housing needs to cities crowded by a migrated rural population. To fulfill these needs, mass production seemed problematic among some architectural circles. Criteria of economy and efficiency were not consensual as ornament appraisal was valued by architects and the intellectual community at the time, as was the case of William Morris; not to mention that many of these innovative cast iron buildings, or even the bridges or other constructions, were highly ornamented, at least for today's standards, and such was also an indelible mirror of the epoch. However, growing housing needs and its inevitable social pressure would demand large scale production. A new fusion between art, science and industry was required, and such would also be one of the grand projects of architectural Modernism.

2.5.4 POST-WWI PREFAB PROGRAMS

As in other places, the housing shortage would be a major problem in the critical postwar periods. Given the degree of destruction and a convalescing productive tissue, the huge volume of demand following both WWI and WWII conflicts could not be fulfilled. In the UK after WWI, it was estimated a need of 500 000 new houses just for the heroes returning from war. The scarcity of raw materials, shortage of skilled personnel, and the long construction times of ordinary methods, were unable to meet the needs. Skilled labor was about half of the prewar level, and union blocks resulted that progress in training newly demobilized soldiers was slow. Conditions were thus created to the inevitable recognition of the need to use different approaches, leading to a deep reconsideration of construction methodologies towards innovative processes. Wartime development of the armament industry had too produced a considerable spare production capacity, as well as technological advances in construction equipment whose use was feasible by unskilled workers. In such a scenario, the government envisioned a combination of technical innovation and financial incentives as a way to capitalize the available resources[216]. A number of official acts would prepare the way for prefabrication developments. The chief financing instrument was the *Addison Act* of 1919, which introduced considerable subsidies for local authorities, while giving incentives for houses embodying new construction processes. The government also launched the *Homes Fit for Heroes* programme, which encouraged non-traditional house construction. The *Standardization and New Methods of Construction Committee* was another mechanism launched in this period, an agency set up to validate alternatives, approving a great number of system comprising a wide range of new techniques and materials[217].

One of the most successful of these new construction systems approved by the committee would be the *Dorlonco System*, by the steel company *Dorman Long*, which presented a somewhat unusual, hybrid configuration. The system's architects, Adshead, Ramsey and Abercrombie, created a house conforming to the popular, traditional looking, neo-Georgian style with sloped roofs, solid ornamented chimneys, and sash windows. The regulated sizing and placement of door and window openings fulfilled the simplification and standardization aspirations, and was suited to systemized construction. Constructively, the system is a hybrid of dry and wet technologies. The structural frame, consisting of pre-cut rolled steel angles erected in-situ, was designed to accept a number of different claddings, from conventional brickwork to concrete rendering on an expanded metal lath reinforcement. Internal linings were very robust, consisting of plastered clinker concrete blocks. As a result, the houses give the impression of being extremely solidly built. However, in some of the constructions, the system would reveal severe pathologies, with thermal variation derived cracks in the concrete cladding letting in the water and rusting the steel. The *Dorman Long Company* manufactured and erected the steel frame, while the remaining construction was carried out by local builders. The system would be considered the most successful in post-WWI house types, with around 10 000 built in the 1920's. It was not only a success in terms of commercial viability, but also in terms of production longevity, with some examples dating from post-WWII period[218].

The *Duo Slab*, produced by *William Airey and Sons Ltd*, was another of these new systems. It consisted of in-situ wooden cast concrete columns, and precast concrete slabs. The houses were also of a traditional appearance. Around 4 000 were built and would prove remarkably durable. As in the generality of the postwar constructions, since there was shortage of skilled labor and lack of in-situ machinery, construction elements had to be light enough to be manhandled, and more than using ex-situ prefab methods, these used site-prefabrication methods, as was usually the case with precast concrete. After all, concrete was a relatively new and innovative technology, under a great deal of experimentation, and it is common to find a mixed use of concrete cladding or filling with steel frames. Nonetheless, steel paneled houses were also developed in this period, as was the case of the *Cowieson*, the *Atholl* and the *Weir*, the latter with 1 500 units, all with timber frames clad by flat steel plates[219]. Regardless the technology, the systems that emerged during this epoch can be clearly divided into two major groups: those that employed skilled workers in factory and shipyard production, and those that employed a combination of small-scale in-situ precast concrete and in-situ formwork concrete to maximize the use of unskilled workers. *Dorlonco* system, as well as *Atholl*, *Telford*, *Weir*, *Scano*, *Boot* or *Parkinson* systems were among the first group, whereas *Duo-slab*, as well as *Winget*, *Fidler*, *Boswell*, *Dry Walls*, *Easiform*, *Forrester-Marsh* or *Universal* systems were among the second group[220].

With the shortage of materials and labour after WWI and the consequent acute increase in the price of building, the huge demands made on the Treasury by the *Addison Act* subsidy meant that the programme would be severely cut. When it ended, in 1921, only 214,000 houses had been approved, bellow the initial estimated needs[221]. Of these, only some 50,000 *non-traditional* houses had been built, short for the original expectations, but deep in impact. The influence on the country and the building industry was relatively minor, but it would have a long-lasting impact on consumers, producers and building professionals. By the 1930's, the idea of cheap prefabricated bungalows, clad in materials such as asbestos or corrugated steel had proven broadly attractive to the public, in particular in the niche of holiday or retirement houses. Their sprawling effect on the countryside was pernicious, but they had public acceptance and offered advantages in cost and building speed. Initially, one of the major propelled goals of the incentive program had been to contribute to overcome the housing shortage. However, this contribution had had a clear political and economic agenda, set to implement a postwar economic stabilization and employment growth. As time went by, and with the balanced situation of the early 1920's, the initial agenda eventually lost its relevance[222].

Despite the strong inputs, the prefabrication evolution would not occur steadily, virtually ceasing after this period for not being sufficiently consistent to compete with ordinary construction methods. As incentives terminated and skilled labor and traditional materials came back on stream, proven techniques retook their regular use, and so faded the interest in the prefabrication methods. The general lack of price competitiveness in comparable solutions also did not contribute. The government had never been completely committed to prefab, but to the agenda, seeing prefab as a temporary solution. It was useful in the post-WWI period due to the high number of houses being built, but it turned out to have little long-term impact in the construction sector at the time. Nonetheless, UK's post-WWI construction methods, their ebullient development, placed them among the most advanced in the world, and were attentively watched in the US and Germany[223].

2.5.5 THE RISE AND FALL OF THE POST-WWII TEMPORARIES

It was not until post-WWII that the UK would again see great improvements in prefab. Most of the new designs were developed from scratch, rather than evolving from any of the interwar systems, and with a great proliferation of different building techniques. The State was faced with the problem of providing speedily built dwellings on a colossal scale, and how to ensure factories kept on working after the wartime demand had ended, while economy was still in recovery. From this point, to implement a framework of incentives to prefab or system building, it was just a small step[224]. Therefore, again, an incentive program was created, alongside a series of committees, workgroups and the like.

In September 1942, the *UK Interdepartmental Commitee on House Construction* was formed. Its chief goals were to implement and promote the development of alternative materials and construction methods, in order to increase the efficiency, economy and speed of construction. The program was to investigate alternative techniques and materials, consider its application and test them through experimental methods. Prefabs would become a major part of the overall housing construction efforts, envisioned during the government of wartime Prime Minister Winston Churchill, and legally outlined in the *Housing* (*Temporary Accommodation) Act* of 1944, familiarly known as the *Temporary Housing Programme* (*TPS*), with an initial projected state allocation of £150 million. Through the aegis of the programme, some 156 623 two-bedroom temporary bungalow houses would be supplied between 1945 and 1949, exceeding the initial valuation, with a cost of over £200 million. The average price per bungalow was of £1 324[225], also exceeding the first estimates of £1 200 for a house in the country and £1 300 for an urban house, with values including the land cost and all site preparation[226].

The bungalows were subjected to a design brief and a prototype from which a competition was organized. Therefore, the bungalows would not be based in a single spatial or constructive design, but instead in different layouts through different methods of framing and cladding for a basic set of accommodation. These different methods were constrained to the house brief set by the prototype developed through the tutelage of the Ministry of Works (commonly named *Portal Bungalow* after the Minister, Lord Portal), and first exhibited in the Tate Gallery in February 1944[227]. The maximum area that could be built was 92.9m^2 for a two-story house and 86.4m^2 for a bungalow[228]. Due to war, the bungalows were also forbidden to use materials that were in short supply (e.g., timber), and with its construction following strictly economic principles or, in alternative, using available materials that had not been previously associated with housing (e.g., aluminum). When the Ministry of Works opened up the design competition based on these conditions, some 1 400 designs were submitted, with many rejected at a conceptual stage, while others after a prototypical stage.

Of the relatively few approved for construction, only four types would be made in sizeable quantities. The *Aluminium Bungalow* (54 500), produced by *AIROH* (*Aircraft Industries Research Organisation on Housing*), a 62.7m^2, easy to assemble, four sections all-aluminum frame house, with two bedrooms, kitchen and bathroom, and fully furnished down to the curtains. The *Arcon* (38 859 units), developed by Taylor Woodrow and later Edric Neel, a 57.2m^2 asbestos prefab house with fully-equipped kitchen and separate bathroom module, and two non-equipped bedrooms. The *Uni-Seco* (28 999), produced by *Selection Engineering Company Ltd* of London, which had three different versions, made with a timber frame and asbestos paneling, and with a flat-roof. Finally, the *Tarran* (19 014), produced by *Tarran Industries Ltd* of Hull, with timber frame and concrete paneling, and that would have both one- and two-story versions. Produced in incomparable lower numbers, others would however be built in non-neglecting quantities, such as *Spooner* (2 000), *Universal* (2 000), *Phoenix* (2 428), *Orlit* (255), or *Miller* (100)[229].

For the number of built units and for the technical achievements, *AIROH*'s bungalow was definitely the most interesting. It was designed to use the unused capacity of the aircraft industry, and was made in five factories spread across the country: an authentic mass production of houses dream come true. The assembly lines that once had produced airplanes could now produce the four complete sections of the ten tone *Aluminium Bungalow* in just twelve minutes. The frame and external paneling were in aluminum, while the interior was lined with plasterboard and the core filled with aerated concrete for thermal insulation. Roofs had two layers of aluminium sheets resting on aluminum trusses. The floor was the only part in wood. Wiring, plumbing, furniture, doors, windows, or fully equipped kitchens were all installed in the factory in each of the four modules. They were then transported by truck to site, and assembled through an ingenious self-positioning connector blocks mechanism. This was state-of-the art housing technology, yet it looked quite normal both technologically and architecturally, since after built few could distinguish them, for instance, from the relatively more primitive *Arcon*[230].

Despite the successful number of built units steaming from the *TPS* program, the prefabs and, in particularly the *AIROH*'s, were relatively expensive. By 1947 *AIROH*'s were costing £1 610 each, which outstandingly exceeded the initial estimates of (£1 300), as well as the average of its competitors' houses (£1 178). Its costs, alongside its commercially success—since it constituted about one-third of the total *TPS* production—would have an important weight in the overall average house price of the total program, raising it to over £1 300, while the weighted average of the remaining two-thirds of total production was only £1 125. These figures also did not contributed for a very favorable comparison with the average cost of permanent house in 1947, which was £1 400 for a three-bedroom house[231]. According to Davies, given these numbers, in free-market conditions with no state subsidies, as in the USA, the whole *TPS* program would probably have failed[232].

Regardless the construction types, the *TPS* gave people detached bungalows that could be rented through the local authorities[233]. Thought of to be temporary, and using unusual materials, their appearance was considerably different from both the inter-war local authority cottage and the inter-war speculative bungalow. If these, and prefab in general, did not represented a paradigm of industrialized construction for the architect and designer, there was nonetheless an impact in public opinion, which through it became somewhat prepared for the unusual looks and unusual methods of house production. Notwithstanding their unconventional and apparently impermanent materials, the bungalows swiftly became *homes*, that is, places cherished by their inhabitants. Indeed, they have always been popular, particularly because their layout foresaw a garden space to be attributed to each tenant. Although not overjoyed by their appearance, the public would retain a certain affection and nostalgia for these houses and their small gardens, and some have even found their ways into museums. As prove of such affection, a fierce conservationist battle, praising for its heritage value, took place about the *Excalibur Estate* near London, where the last of these *temporary* houses remained. The side favorable to the demolition claimed that the prefabs had no value for any sort of heritage classification, arguing that they were mere "*temporary prefabricated buildings, not architectural gems*". Considering their immense social value the statement is controversial to say the least. In 2011 the Estate demolition was announced, in a conversion program set to last until 2018[234].

Initially the *TPS* envisioned the houses to have an expected life-span of 10-15 years, though many have lasted much longer. But such short life expectancy—as well as its 'temporary' label—had its reasons, which certainly were more of political/publicity statements, than technically based ones. According to Brenda Vale, there were three major reasons for the 'temporary' label: to accommodate the idea of technology in people's minds[235]; to work as an insurance to the traditional building trades and their unions[236]; and last but not least, because of their method of finance. The latter reason seems to be the most important, and was likely related with the past financial experience on post-WWI, in which the *Addison Act* program for permanent housing ended up severely shortened. In the *TPS*, the program implementation was relinquished through licensing schemes to the local authorities. For the bungalows to be produced in the same way as, say, a car or an aircraft, many different production facilities had to be engaged so to achieve the desired economies of scale. Such implied a centralized effort, which nonetheless had to be concealed so to avoid conflict with local authorities. In this sense, the *temporary* label could be regarded as a convenient tag, in what was actually a government-owned emergency housing program[237].

2.5.6 SUCCESSFUL POST-WWII COMMERCIAL SYSTEMS

In terms of permanent housing, the official policy after WWII had many similarities with the post-WWI experience, that is, while taking the chance to further explore the prefab potential, go back to ordinary construction practices as soon as possible. As with the post-WWI workgroups, an *Interdepartmental Committee on House Construction* (also known as *Burt Committee*) worked between 1942 and 1947 in order to "*consider materials and methods of construction suitable for the building of houses and flats, having regard to efficiency, economy and speed of erection, and to make recommendations for post-war practice*"[238]. Among the several systems approved by the committee, the most successful was a steel-framed permanent house, designed by the architect Sir Frederick Gibberd, and the engineer Engineer Donovan Lee, and sponsored by the *British Iron and Steel Federation* (*BISF*).

The *BISF* was an association of steel producers formed in 1934, in order to provide central planning for the industry, and had had a prominent role in output coordination through the War. Gibberd's office had also design the steel-framed *Howard House*, privately developed by John Howard &

Company (1 500 units produced), and both designs were approved by the *Burt Committee*. In total 36 000 *BISF* houses were built between 1946 and 1951. Three *BISF* house types (A, B, and C), with minor differences would be built as prototypes but only a fourth A1 type would be mass-produced. These were built as either semi-detached or terraced houses, with 89.18m². Formally, they were two-floor, double-slope roof houses. Although quite flexible in terms of outer cladding, these normally differed the lower and upper stories' cladding material. Overall, the houses transmitted a solid appearance, which is probably linked with the claddings that were normally used. The external cladding, particularly on the first story had a prevalent incorporation of traditional or simulated-traditional materials, such as brickwork. In some cases, the first story material would be extended to the second story, but usually the latter would be clad with a steel sheet profiled to match timber weatherboarding. The final cladding was set against a 50mm layer of in-situ concrete on expanded metal lath, which was supported by a structure of prefabricated rolled steel tubes. A tubular steel structure was too used to support the floor pavements. The inner cladding and the partitions were usually of timber framing faced with plasterboard or hardboard, and the ceilings were often of site-applied plaster over a layer of concrete on expanded metal lath. Some of the lower story partition walls were often also plastered over concrete blocks masonry, which too ascribed for the overall sense of robustness.

The *Airey Duo Slab* was another successful system which, alike *BISF*, too had prewar roots. Sir Edward Airey was a builder who had used concrete for a house design in the 1930s. As part of the postwar housing programme, he developed a new design with prefabricated concrete columns and prefabricated concrete slabs. The concrete was reinforced with steel tubes extending in the ends of the columns so that first story and second story columns could be fit together. Columns were positioned at 457mm center around the perimeter of the house and clad with shiplap style concrete panels. Internal lining was made with a variety of materials, with plasterboard over glass fiber insulation as the most common (particularly upstairs), but also with concrete block masonry (mostly downstairs). The triangular spandrel panels over the gable ends were finished in timber weatherboarding or plain tile hanging. With time there was a number of pathologies that came to be associated with the system, namely because of the corrosion-prone column joints and the column slenderness, where at best the concrete cover was 12mm. The concrete components were made across nine factories. The system was used to build many house layouts. The most common are the North Aspect (the Urban version), with hipped flat roof, and the far more popular South Aspect (the Rural) house, with a steeply pitched roof, both semi-detached two story three bedroom houses. The *Airey* Company was a pre-cast concrete firm rather than a building contractor and most *Airey* houses were erected by local firms. The components were relatively lightweight, dispensing the need for large cranes, but the building process was relatively slow; substantially slower than panel system. Some 26 000 Airey houses were built after the war[239].

There is an immense proliferation of systems throughout this period. Developed since the 1920s, commercially the most successful in the post-WWII were the price-competitive in-situ concrete systems. Amongst others, renowned styles and trade names include *Airey*, *Boot*, *Cornish*, *Laing Easi Form*, and *Wimpey No-Fines*. These were not strictly prefabs, but had a great degree of systematized building procedures. Used in different business models, the *No-Fines System* was the most successful, particularly among the *Laing Easi Form* company, and most remarkably through the *Wimpey No-Fines* company. Together these two companies would build over 100 000 units. *Laing Easi Form* built over 25 different styles ranging from bungalows, through traditional looking houses to four story apartment blocks[240]. The *Wimpey No-Fines* product was also very flexible, as it could be used for a variety of sizes and styles of housing, low, medium or high-rise, its construction was lighter and used mainly unskilled labor, which overall made it cheaper; finally, the company had a well-established business network, which eased its promotion to local authorities[241].

2.5.7 SOCIAL PREJUDICE AND THE RISE AND FALL OF SYSTEMS

Among architectural circles, the idea of prefabrication or system construction was regarded with some resistance. During wartime, *RIBA* had depreciated prefabrication, regardless the obvious need for some form of mass housing construction. Nonetheless, in 1943, *RIBA* would recognize prefab advantages, yet only in a temporary housing scope. They also regretted the de-skilling that prefabrication would represent to the building industry. Those more conservative feared that it would reduce the need and scope for original design, or even to the point of destroying the demand for architects[242]. There was also a latent fear of permanence of a traditional aesthetics, unlike what was relieved in the work of some remarkable architects such as Richard Neutra in the USA, or Walter Gropius in Germany. However, some architects were more open minded about the idea and would give their contribution in the development of many of these systems. Among the progressive supporters figure architects such as Frederick Gibberd, F.R.S. Yorke, Hugh Casson or Grey Wornum[243].

The goal of building large numbers of houses, while still attempting to maximize the use of space was a permanent concern. By the mid-1950s precast concrete panel systems, more keen to medium or high-rise construction, were proven the cheapest among the different available systems. These were also more appealing to architects, "*who could imagine themselves to be realizing Le Corbusier's Utopian urban visions of the 1920s and 1930s*", as Davies says[244]. Alongside, one of the most relevant realizations of State sponsored research would be the modular coordination in the 1960s, as it introduced a fundamental framework to networked modular prefab systems, which would hardly be developed by commercial firms alone. One of the applications would be in the *Consortium of Local Authorities Special Programme* (*CLASP*), a consortium that was responsible for a major school building program. The *large-panel concrete systems* (LPS) were also developed from this modular coordination research[245]. A key advantage of LPS was that they were cheaper than any other form of construction.

Bison would become the most active company in the development of panel systems, designing and producing several building systems, of which the most prolific was the *Bison Wall Frame*[246]. Using licensed technology developed in Denmark, the LPS were introduced in the UK in the early 1960s. These consisted of precast concrete panels of large dimensions, which relayed on their own dead weight, and the friction it produced, to hold everything together as if a *house of cards*. Assembly on site was thus *simply* a matter of lifting panels into place with cranes, where they were then located onto bolts. In 1965, 163 developers were producing 138 different large panel systems for housing. Each main contractor bought the licenses to produce LPS to a Danish firm—*Taylor Woodrow* bought *Larsen Nielsen*, calling it *Taylor Woodrow Anglian*; *Laings* bought *Jespersen*; and *Wates* developed its own based on similar principles. The variations between the systems stood mostly in the edges of the concrete panels, and thus in the modes of joining.

Many of the buildings constructed at the time with these elements ended up having waterproofing problems, leaks and poor thermal performance. Many of these problems are said to have their most probable cause in the lack of skilled labor and not on design errors. Nonetheless, the perception of poor-quality construction would inevitably become associated with prefab. The episode of the 1968 gas explosion in the *Ronan Point* tower in East London, which used a *Larsen Nielsen* based system, would determine the end of panelized concrete high-rise construction in the UK[247]. The explosion on the 18th floor caused a progressive collapse of an entire corner, whose panels fell like a house of cards. Although it was proved in 1970 that the collapse had not been related with the kind of construction, but of poor workmanship, public confidence in the safety of residential tower blocks was irreparably shaken, and would have legal effects, tightening regulations of panelized concrete construction, with effects that would spread to other countries. State withdrew sponsoring on this type of buildings and a massive demolition of the remaining LPS buildings would be witnessed since[248].

With the cheaper and scalable LPS gone, the needle was pointed back to other alternatives. In the postwar, the *Burt Committee* had rejected timber frame designs because of the shortage of wood supply and the need to import, hence preferring steel or concrete buildings. By the mid-1950s the shortage was less significant and the *Ministry of Housing* began experimenting with timber frame systems. The *National Building Regulation* introduced in the mid-1960s encouraged the use of timber frame. Subsequently, from 1966 to 1975 many timber frame systems were developed, however not differing much from earlier frame systems (and from each other). In total, it was built more than 80 000 timber frame dwellings in over 30 systems[249].

Propelled by the changes introduced after *Ronan Point*, during the 1970s private developers and local authorities begun developing timber frame housing on a big scale, and six years after the explosion, the most common form of prefabrication method was in wood frame[250]. Probably the biggest advantage of wood over steel or concrete is that the investment in manufacturing equipment is relatively minor. One of the most successful systems in the 1970s was the *Frameform*, by *James Riley and Partners*. It was mostly a set of standard construction details, and designs could be sent for *Frameform* to detail, hence appealing to system-minded architects. Timber frame was enthusiastically adopted by private builders in this period, peaking in the late 1970s. By the beginning of the 1980s some 20% of new houses were timber-framed. However, in 1983, a TV broadcasted documentary pointed to technical failures in timber frame houses. Although these were later proven to be primarily related with poor workmanship, the negative publicity undermined public confidence in these. As consequence, the percentage of timber frame houses reduced considerably[251].

2.5.8 REMARKABLE ARCHITECTURAL CASES

Aside the systematic approaches, many architectural experiments related with prefab have been made throughout the years. In the 1960s arouse a design trend which ascribes to a post-industrial, space-age pop vision, with projects such as the *Zip Up enclosures Nos. 1 and 2*, (1968-71), by Richard and Su Rogers, or Archigram's *Living Pod* (1966), by David Greene. These would foremost stand by their appealing images, particularly to architecture students. Emerging in the 1970s, the *High-Tech* movement was conceptually bonded with an idea of factory made components with in clean, glossy appearance, made of plastic, metal or glass, that could be quickly assembled in-situ without the relatively messier wet methods of in-situ concrete or masonry. Most of the outcomes would not be individual houses, nonetheless, a few one-off examples may be listed, such as the *Hopkins House* (1975), by Michael Hopkins, or the *Yacht House* (1983), by Richard Horden and Horden Cherry Lee.

In 1968 the *Dupont* company promoted an architectural competition called *House for Today*, where Richard and Su Rogers came second with the remarkable, pop futuristic *Zip-up House*—a kind of *Yellow Submarine* on pink legs. The design envisioned a house built of insulated aluminum sandwich panels, joined by neoprene gaskets formed into a rectangular tube with rounded corners. The train-like windows, the formally stressed modularity and its site-adjustable slopes, gave it a kind of space-age ship resemblance. The project would stand mostly by the simplicity of the concept and the appealing image[252].

The *Living Pod*, was one of the multiple products of the *Archigram* fantasy factory. One of the most well-known designs, *Plug-in-City* (1964), envisaged a megastructure of diagonal steel tubes, to which thousands of *Living Pods* look-alikes would fly or drive into. It is an odd mix of fantasy and realism: the enormous dimensions of the structure; the complexity and awkwardness it creates. David

Greene's *Living Pod* stands as an investigation into a housing unit that could function independently of the megastructure, as if it was a spaceship. The design draws a clear distinction between the physical envelope of the housing unit—the *pod*—and the mechanical apparatus that makes it livable for its inhabitant[253].

The *Hopkins House* was designed for and by Michael Hopkins himself, a former Norman Foster partner. Hopkins designed his own high-tech version of the Eames house, to function as a house, as well as studio for the recently established architectural practice. Construction techniques used in larger commercial buildings were used in the design, with a structural grid of 2×4m to rule the components dimensions. The high-tech aesthetics is clear, and resulting both of a preference and manifested in elements such as: the visible steel of the structural elements, the glass, the expanded metal lath for decking or corrugated steel for roof, or the use of full-height sliding doors. The floor plans are open and flexible, with venetian blinds hanging between the internal columns defining the various living functions, whereas prefab melamine partitions enclose the more private areas of bedrooms and bathrooms[254].

Finally, the *Yacht House*, was built in 1983 for a family with modest means, which, after the concrete base was laid by a local firm, would themselves build the frame in little over 5hrs. Also a former Foster collaborator, Richard Horden designed a house which is the living example of 'technology transfer', a theme much cherished in the *High-Tech* trend. The particular technological element to be appropriated was aluminium and stainless steel spars from a *Tornado Yacht*, designed by Rodney Marsh—the owner worked for a local yacht component supplier—which would be used to build the spatial frame. The house is a simple assemblage of standard components. The structure follows a 3.7x3.7m grid, on a plan made up of 5x5 bays. If the owner so desires, the roof and cladding components can be moved, rearranging the plan[255].

2.5.9 CURRENT REALITY

In the present-day reality[256], the application of prefab is still currently limited. In 2004, it comprised only about 2.1% of the construction sector, including new buildings, rehabilitation, repair and civil engineering works. The biggest reason for the reluctance of users to accept this kind of innovation is probably related with the difficulty in determining its benefits, and, for many of the actors in the construction process, these are still not clear. There also still a number of barriers to overcome which can be related to an enrooted perception that the prefabricated buildings are of poor quality.

The UK has been since the earliest stages a leader in prefabrication. However, investment in quality has not historically been as recognized as for instance in Germany. Public prejudice on prefab certainly can find many reasons throughout history. However, normally these are due to poor workmanship, rather than to the systems themselves, nonetheless with a contribution to an overall stigmatization of these. It is important to know the associated potential of prefab so that it can be used within a sustainable development frame. Overall, it is clear that its success, on the one hand, and regardless the trends, will be related with a sustainability scope and, on the other hand, that it must satisfy high design quality standards, and not to be exclusively focused in technological standards. Nonetheless, there is a latent concern on these issues reflected in the abundant UK based research, institutional reports, committees, building associations, published materials, and so on.

The mid 1980s break in timber frame houses, adding to the earlier break in LPS and to negative perception of the postwar temporary prefabs, was also a determinant backlash for prefabrication in general, from which it would only begin to recover in the late 1990s and early 2000s, as noticeable in the themes of numerous research reports. Indeed, much of the institutional efforts have been focused in recovering a certain lost enchantment with prefab, trying to move away an installed prejudice. These normally point not only to old-known recipes of economy and speed, but also to the new concerns in environmental sustainability. As result, a number of key reports have come up, namely: John Egan's *Rethinking Construction* (1998)[257]; the DTI report on *Current Practice and Potential Uses of Prefabrication* (2001)[258]; the Housing Forum report *Homing on excellence : A commentary on the use of offsite fabrication methods for the UK housebuilding industry* (2002)[259]; the SFC report *Accelerating Change* (2002)[260]; the EPSRC and DTI report conducted by Gordon University under the *LINK Project*, on *Overcoming Client and Market Resistance to Prefabrication and Standardisation in Housing* (2002)[261].

The construction sector contributes with 6.7% of the total economy in the UK, with around 10% of the employment associated, being the sixth largest construction sector in the world. Prefabrication, or OSM (*Off-Site Manufacturing*) as it is more commonly called in the UK, has historically been, and keeps on being, a highly scrutinized area. Given the importance of the sector for the overall economy, and the relevance of OSM, there are numerous reports available, not only describing the sector companies and market profile, such as the Housing Forum *Manufacturing Excellence UK capacity in offsite manufacturing* (2004), but also looking ahead, tracing scenarios of what may be in the future.

Some 30 years ago, in *A Private Future*, Martin Pawley[262] told that housing was a product in a consumer society. A great majority of people in the UK rented their homes instead of owning them. Additionally, a negative image became associated with prefab. If for the postwar tenant dwellers life could be good in prefabs, it is hard to understand for younger generations how those temporary houses could ever have been good. Meanwhile, the numbers have reversed: in 2009 roughly 80% of British dwellings were owner-occupied[263].

2.6 Prefabrication of houses in the USA

2.6.1 EARLY HISTORICAL LANDMARKS

USA culture is embedded with a feeling of impermanence and pioneering dating from its very foundation. This is reflected on a very different view of the house when compared with the Europeans. The very notion of *traditional* home is certainly a lot different for a USA citizen, with many social, cultural, natural or technical reasons contributing for that fact. The evolution of construction methods throughout history in the USA had different nurturing conditions than in Europe. For instance, for an unfamiliarized southern European, probably more accustomed to observe masonry construction, the *balloon frame* construction can seem somewhat strange. In the least, this signals that, despite the feared dangers of homogenization blowing from globalization, there are social and cultural idiosyncrasies that just stubbornly root things to a place or a common practice.

Nonetheless, the USA prefabrication begins with Europeans, British settlers, in the XVII century. Circumstances such as the expansion to the West and the *Californian Gold Rush* provoked phases of urgent demand in housing, many of which suppressed by British prefab exporters. Demand would nurture the development of new technologies, such as the corrugated iron in the early 1800s. It would also foster the refinement of existing technologies. The case is most obvious in the evolution of wood construction and the development of the *balloon frame*, and later the *platform frame* and subsequent developments, with effects spanning all the way to contemporary frame constructions, whether of wood, light-gauge steel-frame, or others.

The light timber-frame, which includes both the *ballon* and the *platform frame*, resulted from two main factors: abundance of wood and a rapidly growing industrial economy with mass-produced iron nails and lumber mills. Buildings could be erected so quickly that Chicago was almost entirely constructed of this technology before the *Great Chicago Fire* in 1871. The tragic event would lead to a massive rethink of fire-safety issues, insurance policies, and ultimately of construction methods. On the hangover of the *Great Chicago Fire*, the *Chicago World's Fair: Columbian Exposition* (1892-93) would be set with an optimistic view towards the future, with many innovative house appliances on display, and with innovative electrical house appliances making their première and causing great buzz. The exhibition displayed high-end technological products that would find their ways to homes nationwide in the following times, such as the first fully-electrical kitchen, including an automatic dishwasher, and phosphorescent light bulbs.

2.6.2 INVENTIVENESS AND PLAYFULNESS

As in other places, a certain playfulness and feeding of an inventive spirit has become familiar over the time. Evidencing it, are those toys that have spanned generations such as the *Erector Set* or the *Lincoln Logs*.

Erector Set is the trade name of a metallic toy construction originally patented in 1913, invented by A.C. Gilbert in 1911, and manufactured by *A.C. Gilbert Company*, at the *Erector Square* factory in New Haven, Connecticut, from 1913 until its bankruptcy in 1967. It consists of collections of small metal beams with nuts, bolts, screws, and mechanical parts such as pulleys, gears, and small electric motors that became the most popular toy construction in the USA. The brand would be bought and is still currently for sale—currently with the brand name of *Meccano* in the USA. The *Erector Set* is believed by many to have been the subject of the first national advertising campaign in America for a toy. Its great success made it part of American folk culture, although its popularity has faded in recent decades in the face of competition from molded plastic construction toys, electronics, and other more 'modern' toys. As other similar metal building toys, and unlike other building toys, such as *Lego* or *Lincoln Logs*, it is not mimetic of modular or kit-of-parts construction but involves a prescriptive way of bringing together prefabricated unique parts. Many other metal building toys were made in different parts of the world. Brands like *Ami-Lac* would sound in Italy, as *Stabil* or *Armator* in Germany, *Dan Dare* or *Vogue* in England, *Exacto* in Argentina, *Stokys* in Switzerland, *Temsi* in The Netherlands, *Merkur* in the Czech Republic, Steel Tec in China, or *Mecanno*, the most famous worldwide[264].

Lincoln Logs is the brand name of a building toy, that was invented in 1916 by John Lloyd Wright—the patent was obtained in 1920 and the name registered in 1923—the son of Frank Lloyd Wright, and was named after Abraham Lincoln—the President who had begun his celebrated life in a log cabin in Kentucky. They are among the building toys developed in parallel to prefabricated housing research in the XX century, consisting of notched miniature logs, analogous to the ways US log cabins were built. With them, its author makes a convincing case that the vernacular log cabin is indeed a system born of prefabricated way of thinking and making[265].

2.6.3 *FORDISM* AND *TAYLORISM*

Big boys have big toys, and Ford's *Model T* is the epithet of an American way of life, of liberty accessible to everyone. To produce his *Model T*, in 1913 Henry Ford fully implemented its iconic *assembly line*—worked out along the previous five years since he first tested the idea in 1908—in the brand new Highland Park plant, revolutionizing industrial production systems. Although overcome in today's high-end production philosophies—such as the *lean production*—at the time, with Ford's method, lower cost was possible but with higher end-product quality. On the basis was the purpose to achieve a more precise product while decreasing labor and production time per unit[266].

Although not directly related, Frederick Taylor's economic philosophy expressed in the *Principles of Scientific Management* (1911), would be frequently associated with Henry Ford's production philosophy. Taylor's work was a decisive influence in production management and efficiency that endured in the decades to come, in what came to be known as *Taylorism*. It would only be in the late 1900's that his theory would start being questioned with the rise of new methodologies and theories such as the *Toyota Production System* (TPS) or the *Lean Thinking* philosophies. His scientific management, at times controversial, consisted on four main principles. Firstly, to replace rule-of-thumb work methods with methods based on a scientific study of the tasks. Secondly, to scientifically select, train, and develop each employee rather than passively leaving them to train themselves. Thirdly, to provide detailed instruction and supervision of each worker in the performance of that worker's discrete task. Finally, to divide work nearly equally between managers and workers, so that the managers applied scientific management principles to planning the work and the workers actually perform the tasks[267].

Following the ideas of both these precursors, by the late 1910s, several companies began offering high-quality prefabricated houses. Producing houses in factories, these followed principles derived from consumer goods production, yielding quality and lower costs.

2.6.4 CATALOGUE HOMES AND A CULTURE OF CONSUMPTION

The home appliances, and soon the homes themselves, alongside a myriad of different purposed products, were divulged by numerous publications across country. The advertisement methods found one of its great precursors in 1842, when Andrew Jackson published *Cottage Residences*, and later, in 1850, when he published *The Architecture of Country Houses*. These books contained designs based on the *balloon frame* and dozens of imitations appeared subsequently[268]. In 1876 George Palliser, an English immigrant who had worked as a carpenter and joinery manufacturer, published *Model Homes for the People*, a booklet that would be the first of 21 to be released by him and his brother in the next 20 years. They would market themselves as architects. The potential clients would choose from their catalogs and require its own adjustments from which they would produce the required drawings for permit and production by local carpenters. The Palliser's were not the first firm to offer blueprints by mail-order, but they were the first to turn the process into a kind of architectural consultancy based on the adaptation of standard designs[269]. In another example, in 1903, Gustav Stickley founds and edits *The Craftsman*, a monthly magazine "*set out to cleanse the American architectural palate by promoting a new, simple Arts and Crafts influenced style*"[270]. He would publish pattern books to make the style accessible to clients and builders—*More Craftsman Homes* (1912) contains plans and views of 78 so-called *mission style* houses and bungalows. His business would collapse in 1916 but his style lived on. These cases are marks of the installment of an American suburban vernacular, and signal the beginning of an era where houses by catalogue would dominate the built landscape in a sprawled countryside.

Among other factors, technologies, together with advancements in production methods and an increasingly better transportation infrastructure, namely railways, created great conditions to the development of catalogue companies. *Aladin Homes* and *Sears Roebuck and Co.* feature among the most prominent catalogue houses selling companies, which would have a big boost in the early 1900s, to later fall under the harsh economic conditions of the Great Depression. The *Aladdin Company* was among the first and one of the most long lived manufacturers of mail-order *kit homes* in America. Between 1906 and 1981, the company sold precut home kits (of numbered, precut pieces) that were assembled in-situ by the purchaser, or a contractor hired by the purchaser. The manufacturing process was efficient because it removed the waste associated with in-situ framing, increasing speed and improving precision. Over 75 000 kits were sold along its lifetime[271].

In 1908, *Sears Roebuck & Co. Houses by Mail* launches its first catalogue, *Book of Modern Homes and Building Plans*. Two years after, the company, at the time famous for its multi-product catalogue sales, decided to start the houses program (it had started selling building elements of their catalogues in 1895). In 1940, when it was shut down, the company had sold over 100,000 houses. The owner, Richard Sears, believed that if a company sold an entire house, then it could sell all the items to go inside the house. The company eventually eclipsed competitors mostly due to two reasons: first, not only could a buyer purchase the entire house and furnishings from *Sears*, but *Sears* would also finance the purchase with a house mortgage; second, *Sears* owned the entire fabrication process from the lumber mills to the doors and windows factory. Houses selected by customers on the catalogue were shipped directly to them by railroad, and the packaged precut materials were numbered and assembled according to a plan book, like a giant toy.

The mail-order catalogue promised door-to-door delivery and assembly of every element of the house. The models ranged from simple one-room structures to elaborate multifamily, multistory units. Almost all models used the *ballon frame* or some kind of derivative, but different veneer coatings would hide any traces of the constructive techniques, following the trends in popular home design and affording the client the added benefit of customizing numerous aspects of each house. *Sears* houses also pioneered the use of drywall and asphalt shingles, and they introduced the central heating for residential use. The houses were produced massively, systematically, efficiently, and affordably. Nonetheless, the designers (and customers alike) self-consciously made every effort to bury these qualities underneath an artificial veil of handcrafting that was remarkably easy to spot. This earned the discredit among architecture circles, despite the immense social significance to the history of the prefabricated house[272].

As in other places, the success story of American prefab is essentially a story of people with needs and aspirations that are ought to be satisfied—to live in a nice place, in a nice house with good neighborhood, safely, and so on. Exclusively looking into numbers, these needs and aspirations are more often detached from architectural practices than the opposite. It is a story of the social relevance of an idealized simple, happy and prosperous life, grounded on construction technology, more than artistic or intellectual relevance of an architectural aesthetics, of a taste, or of a way of life. And it is a success that is probably more linked with the psychology of consumption, acquiring or blending within a certain social status through the more or less visible, more or less subtle possessions—e.g. the car, the clothes, the phone, the house with swimming pool, and so forth—than with anything else. Moreover, it is a culture that is inculcated since early stages, as utterly represented in the idea (or narrative) of the *American dream* and of an *American way of life*.

2.6.5 A MEDIA DRIVEN, INVENTIVE AND COMPETITIVE SPIRIT

While many developed experimental new ways to address the production of houses, trying out various materials and technologies, in other cases the endeavors would benefit from a solid financial support by major industry players. Anyhow, it would stand a strong linkage to the media, promoting the buildings, bringing them closer to the public. Publications such as the *American Builder*, the *Building Developer* or the *Popular Science* magazine, would contribute not only for advertising houses, but also for a myriad of products or ideas, towards not only a consumer, but also an inventive audience. Indeed, the American prefab industry is too a story of remarkable *inventors* developing their often commercially non-successful experiments which nonetheless have stood for their innovative, out-of-the-box ideas, and with it contributed to set a more competitive ecosystem from where bigger players would arise.

In 1906, Thomas Edison starts building his *Single Poured Concrete Houses*. In 1927, Robert Tappan designs what is arguably the first steel-framed house, which would be reported in *New York Times* edition of November 7, 1926, and latter publicized in a March 1928 issue of *Popular Science*. That same year Buckminster Fuller introduces an early concept of his *Dymaxion House*. In 1931, Albert Frey and A. Lawrence Kocher debut the *Aluminaire*, the first lightweight steel and aluminum house in the US. Nonetheless, prefab industry was slow to expand, and it would take the Great Depression, and a subsequent impetus to stimulate the economy, to develop real interest in mass prefab in the US. The house industry began following Ford and Taylor's *secrets*, and depression fostered a climate in which factory production seemed the most viable option.

Thomas Edison's *Single Poured Concrete Houses* begun in 1906 as an experiment to expedite the products of his cement plant. After a financial disaster of its cement plant, Edison announces he is going to create its own cement demand by making his houses to produce in a large scale. These would become no less of a mistake, as they would reveal to be technical and financial failings. With probably as much ingenuity as ingenuously, Edison is one of the first designers to imagine that concrete could be used to construct an entire house repeatedly, without a single secondary building material. A continuous mold that formed walls and floors alike with designated voids for windows and doors assembled in the construction site. A specially designed rotating kiln on wheels with a hydraulic vertical pump would then feed the wet concrete mix through a funnel-like opening at the top of the mold. The challenge of maintaining a requisited homogeneous mix through each layer proved nearly impossible for Edison and his team and led to severe cracking in many of the houses. The houses had persistent problems in the following years, yet the ultimate demise of the scheme, in 1919, was more likely due to the limited interest of clients[273].

Another example, the construction of a *model house* in the Jamaica-Hillside area of Queens, New York, by the architect Robert Tappan through the *Jones & Laughlin Corporation*, made news in *The New York Times*. It was news not because of the house itself, but because the *Jones & Laughlin Corporation* was a steel company, not a timber company. Between the *Jamaica-Hillside House* in 1926 and the Big Crash in October of 1929, a few companies and architects pushed steel technology in house construction to higher levels. The Jamaica-Hillside House was advertised as being fire proof, and concordant with an increased concern with safety and sanitation issues, in a typical 1920s appeal to the language of *Progressivism*. It was not until 1928 that the *American Builder* magazine began to make news of the steel trend. However, when the subject was first mentioned, it was with a paid two-page article by *Walter Bates Steel Corporation* (WBSC) of Gary, Indiana, not with Tappan. According to Walter Bates, the steel houses were safe and sanitary, its cost was approximately the same as timber-framed houses, but with better quality and lower insurance fees. In the same year, *American Builder* mentions the activities of contractor *C. H. Dexheimer*, attracting the attentions with his steel-frame house construction in Toledo, Ohio. However, it was not until *Steel Frame House Company* (*SFHC*) entered the business, backed up by a large steel manufacturer, that steel houses would begin its large scale production, with the steel-frame technology coming to dominate residential construction by the fall of 1928. The company's *Shaffer House* was selected while in steel skeleton stage as cover of the *American Builder* in November 1928. *SFHC* was a subsidiary of *McClintic-Marshall Corporation*, which at the time was sold out to *Bethlehem Steel* (in 1931), which was the second largest structural steel manufacturer in the US, only outdone by *American Bridge Company* (subsidiary of *US Steel*). In this steel-frame house construction inceptions, a silent competition, with advertisements and paid articles, was occurring in the backstage to see who would first hit the press (and provoke greater stir). Such is expressive of the aura of excitement surrounding the steel-frame house construction in the late 1920s, which naturally would too be used as a vehicle to display other breakthroughs in residential building[274].

Regardless the seeming widespread interest in steel frame houses, there was a certain distrust climate on the use of steel, motivated either by architectural, economical or psychological reasons. Companies made a considerable investment in the promotion of their products, educating the public opinion, architects and entrepreneurs to the range of advantages of the new technologies, with articles and advertisements either in specialized or popular newspapers and magazines, as *The New York Times*. As expressed in the pamphlet on Henry B. Neef House by *Gate City Iron Company* the use of steel in house construction "*is a revolution in home building methods the public must see to be convinced*"[275]. However, not everyone was convinced. If the economic argument could be straightforwardly set, needing just houses to be cheaper, the psychological reasons related with an industrial-like aesthetics were harder to overcome, and would become the most visible part of the installed doubts. A conflict was particularly set between what was a popular image of the American home and what were some of the aesthetical new visions which some of these new proposes carried. Eventually, the economic downturn derived from the 1929 crash would affect residential architecture, no matter what material or aesthetics was used in its construction, contributing to at least set apart the aesthetical mistrust related with steel construction.

2.6.6 NEW AESTHETICS AND THE MASSES

A repeated argument by steel house manufacturers in the late 1920s was that their technology in no way held up the architect's or owner's aptitude to achieve their design goals, regardless the style. The numerous examples of steel framed houses rendered in popular style of the day, the *Period/Tudor Revival*, were a solid argument to convert those fearing a certain industrial aesthetics connoted with steel. What truly mattered for the companies producing houses was business, and in that sense, any *style* would be good as long as the client bought it. Despite the business perspective of the companies, not everyone in this period was so conformist in what concerned style. By 1927, Richard Neutra had begun the *Lovell House* in Los Angeles, a lightweight prefabricated steel house that would become an architectural landmark[276].

The European vanguard experience of the modernist movements, the debate of the housing problem, and an aspiration to reach building technologies that would be more efficient, were late to touch the architectural forums in American shores. Such would first notably happen when Henry-Russell Hitchcock and Philip Johnson organized the 1932 MoMA entitled *The International Style: Architecture since 1922*. However, the *International Style* did not have a particularly great impact in the USA house building industry, as the established catalogue companies were enjoying success with their products and hence there was no reason to embrace the new modernist aesthetics. However, it would have a tremendous influence in USA architects, with impact on the course of architecture over the following decades[277].

Propelled by the economic mood, in 1932 the Harvard-graduate architect Howard T. Fisher establishes the *General House Inc.* The company sold a kind of design, building coordination and assembly service, with the components produced by third-parties, including the *Pittsburgh Plate Glass Company*, *General Electric* or *Pullman Car and Manufacturing*. The business model targeted the middle class. Technologically it used pressed steel and standardized elements. The several model houses produced by the company, mirror Fisher design vision, where "*the final decision in the matter of design will of course depend on what the public wants (…), but in everything else the public has shown a preference for the best in modern design, and I doubt it will pay extra for fake imitations of the past when they buy their own house*". Fisher's beliefs would ultimately prove wrong, as noticed by the larger numbers of houses produced in dated styles. Nonetheless, other companies such as the *American Houses Inc.*, the *American Homes* or the *Homosote Company* would make their contribution in pursue of Fisher's vision[278].

In 1932, the architect Robert McLaughlin of *American Houses Inc.*, unveiled a prototype directed to the low-cost housing market, from which he would develop the brand of prefabricated houses known as *American Motohomes*. With a steel frame structure, the houses ranged from a simple four-room layout, to a six-bedroom, four-bathroom, and two-car garage layout, promising "*durability, beauty, economy and convenience*". However, the flat roofs and the geometric outline, subtly referenced to the *International Style*, would not appeal to the masses, and the company was forced to abandon the concept for more conventional styled houses[279].

In any case, the need for housing noted around the WWII would indirectly create the perfect conditions for a wider acceptance of the Modern aesthetics. The geometrical shapes showcased in the 1939 *New York World Fair*, illustrated the pronouncement of the supremacy of the Modern.

2.6.7 IMAGINING FUTURES (THE 1933 *CHICAGO WORLD FAIR*)

The *Chicago Century of Progress World Fair*, in 1933, would stand as a milestone of a new spirit. As the US were coming out of the *Great Depression*, the Chicago fair opens with a section dedicated to progressive housing prototypes meant for replication. The houses displayed an eclectic variety of modernist approaches, planned by leading USA practitioners. The fair suggested that America, despite the Depression, was well on the way towards becoming a consumer paradise. Numerous buildings and exhibits drove the message that cooperation between science, business, and government could pave the way to a better future. Americans just needed to spend money and modernize everything from their houses to their cars.

The featured homes revealed synthetic building materials and anticipated a future where new electrical devices such as dishwashers or air conditioning would be common household items. Many houses were commissioned and built, with several companies attempting to create aesthetically pleasing houses combining both modern technology and futuristic design. While some used unconventional materials, others were more traditional, yet included built-in modern appliances. The *Good*

Housekeeping Stran-Steel house, by the *Good Housekeeping* magazine and *Stran-Steel Corporation* and designed by the architectural firm *H. August O'Dell and Wirt C. Rowland, Architects*, as well as *House of Tomorrow* and *Crystal House*, by the builder George Fred Keck stood out for diverse reasons.

The *Good Housekeeping Stran-Steel* joint venture proposed a house that ought to be fireproof, prefabricated, and affordable to the average family. Structurally it was built of steel and baked iron enamel. The baked iron enamel modular panels cladding the steel skeleton were until that moment entirely unknown to the realm of housing. The steel frame consisted of newly designed steel beams developed by *Stran-Steel*. These were the first such beams to have greater flexibility than wood beams while also being lighter and stronger, each beam connecting to the other by interlocking joints rather than on-site welding, which would have increased cost and assembly time. A specially designed nail penetrated the girders and held both the wallboard and exterior enamel panels in place.

The *House of Tomorrow* and *Crystal House*, two glass house prototypes, stood out the popularity since together they would be toured by more than 750,000 visitors. It somewhat anticipated the engineering-oriented direction of later, Miesian influenced, Chicago architecture. *House of Tomorrow* was an eye-catching, three-story, twelve-sided structure built on a steel frame, which took advantage of prefabricated components[280]. The house had central heating, air conditioning, and window-shading devices to control the level of incoming light. Keck used it for his four-point manifesto: (1) open plan in relation to cost effectiveness; (2) the house as the servicer to its inhabitant, not vice-versa; (3) the health of passive heating and the modulation of natural light; (4) the need to design within the boundaries of mass production without relinquishing the 'opportunity for individual expression' tastefully and affordably. Crystal House too took advantage of innovative prefabrication elements, and would be erected in just three days. Nonetheless, its aesthetics seemed a bit too radical for the average buyer. As Keck said "*probably the most important function of the Crystal House was to determine how a great number of the people attending the exposition would react to ideas that entirely upset conventional ideas of a house*". While the house did succeed on that level, it was not a commercial success and was never replicated. Keck would have to sell it for scrap in order to pay the bills. As to the *House of Tomorrow* it would be sold along with six other houses to a Chicago real-estate developer[281].

2.6.8 AROUND WWII

It is understandable that design innovation was not a major concern when housing was urgently required, as it occurred in the post Great Depression and around the WWII. To improve the state of scarcity, government agencies stepped in, contributing with legislation and initiatives such as informing the public about mass-produced housing or sponsoring low-cost housing demonstrations. Despite the efforts, between 1935 and 1940, prefabricated homes accounted for just less than one percent of the total national production in that period.

World War II would bring postwar conditions for advancements mainly marked by business improvements, rather than by technique. Events such as the *Veteran Emergency Housing Act* (*VEHA*), that gave a mandate to produce 850 000 houses in less than two years, would contribute in the rise of prefabrication housing companies over the course of a decade[282]. The late 1950s, early 1960s, period known as *baby boom*, would provoke extended demand in later years, namely in early 1980's[283].

2.6.9 PREFAB BUSINESS TODAY

The types of homes people in the United States live in have changed over the 60-year period from 1940 to 2000. However, percentage of single-family detached homes has endured steady during that period, in around 60%. Since the time of the latest census, in 2000, single-family detached homes, together with the mobile-homes, presented a consistent tendency of 80% and above in house ownership, contrasting with the tendency of flats in apartment buildings of around 10%[284].

Weather in wood or steel, *stick framing* is today still, as in the early balloon-frame and the catalogue kit-of-parts, the most common type of housing prefabrication in the US. The underlying principles remain the same: it requires less knowledge and less skilled labor; it is a comparatively forgiving and easy-to-correct system, even after construction. Classical timber-frame construction that, with its huge, unpractical logs, had given its place to *stick framing*, is currently of commonly observable use in high-budgeted constructions. In this case, the social body sustaining the system is motivated primarily by aesthetics and social valuation, rather than by economic or technical efficiency.

2.6.10 NOTABLE ARCHITECTURAL INCURSIONS ON PREFAB

Around this period, the aesthetical debate surrounding prefabrication finds new proposals from the architectural side. Several remarkable architects stood out for their groundbreaking contributions. Among these stand Buckminster Fuller with *Dymaxion*, Richard Neutra with *Lovell House*, Albert Frey with *Aluminaire*, Frank Lloyd Wright with *Usonian*, or Walter Gropius and Konrad Wachsman with *General Panel Houses.* Although not always successful business-wise, their innovative designs would influence generations up to the present. The latent, unfolding conflict between the conservative spirit embodied in the 'aesthetically safe' business choices, avid to widen clientele, and the architectural proposals, avid of 'risky' experimentation, reaches a peak in this period. Such is a result of a progressive American spirit, expressed in the visionary minds of Buckminster Fuller or Frank Lloyd Wright, but such is also the result of the exile of brilliant European minds that had had a firsthand contact with the Modernist way, bringing these new ideas to the US.

2.6.10.1 Buckminster Fuller

Buckminster Fuller starts investigating housing in the 1920's, as he became aware of "*the chaos in the building industry*"[285]. His focus was in designing appealing and practical houses. Fuller believed that a good house could be produced as systematically as a good car, and that a factory made house had the potential to change the way people lived across the globe. Fuller implies that homebuilding was no longer to be the work of architects or builders, but of machines and an ever-industrializing global economy. In 1927, Fuller introduced an early concept for his "*building machine*", the *Dymaxion House* at Chicago's *Marshall Fields* department store. The systematization of the construction was the main objective behind this project, but it also anticipates the efficiency concerns by decades, by adopting mechanical systems that vastly reduced the use of resources, making it environmentally wise. The house hosted a hexagonal plan and was held together by a tension suspension from a central mast. Such structural configuration had a twofold purpose. On the one hand, it radically minimized in-situ preparations, while it enabled ease of assembly, disassembly, transport and reassembly. On the other hand, the principle, which made use of lightweight materials, enables a spatial maximization, while minimizing surface area, and hence contributing to minimize material use, making it resource efficient. Both materials and construction system were designed to take tension forces. The house weighted a mere 2720Kg, which eased its transport and deployment. Spatially, in the hexagonal plan evolving around the mast there was a living/dinning room, two bedrooms, two bathrooms, a library and a roof sundeck. Fuller mastered all technical aspects. However he would be unable to harvest the public taste. The *Dymaxion* never went into production, which is a subject of continuing debate. The inflexibility of the system to adapt to households of varying sizes, programs, economical means is often cited, as is the disregard for site specificity and any contextual architectural idiom, not to mention a general fear of modernist forms for houses. Fuller, however, would not be deflated, and after World War II he would continue to develop other *Dymaxion* technological concepts, including a fully equipped modular bathroom and even a three-wheeled car[286].

In 1944-46, Fuller introduces the *Wichita House*, a house with a lightweight, round, standardized aluminum structure, an update of the *Dymaxion House*. Only two were eventually built. With the booming economy of postwar America, Fuller saw renewed potential to revisit the *Dymaxion*. The shape of the house was refined from hexagonal to hemispherical with a monocoque dome and a ventilator at its cap. Rather than being suspended, the *Wichita House* sat just a few inches off the ground. The central mast was simplified, retaining only its function as a utility core. *Dymaxion*'s patented bathroom was also added to the layout. The critical reaction to the prototype was significantly more positive. The gentle curves created a more satisfying interior flow and the palette of finishings on the inside were better constructed and more refined. The Wichita was intended to be a 'dwelling machine', and Fuller pursued this notion in lectures and writings, suggesting that industrial design and architecture had never been more compatible. In the end, the *Beech Company* decided not to produce the *Wichita House*, convinced that, despite its reception and improvements, the public was still not prepared to inhabit a machinelike object. Like the *Dymaxion*, the *Wichita House* would enter the annals of replicable utopian homes that would never see the light of day.

2.6.10.2 Richard Neutra

The Austrian émigré Richard Neutra would experiment with prefabrication around this period. With the enthusiastic approval of his clients, he would even use two of Fuller's *Dymaxion* bathrooms (only a total of nine were actually built) in his *Windshield House*, in 1938. However, it was with the *Lovell House* (1927-29), designed for Lovell family in the hills of Los Angeles, that Neutra would primarily gain recognition. It is also through it that Los Angeles architecture first became widely known in Europe. The house is an early example of the *International Style* in the US, with its clean, clear-cut surfaces, its wide windows opening up to the views. It is claimed to be the first house in the US using the kind of steel structure that is typically found in skyscrapers. The structure was prefabricated in sections and transported by truck to site. The lightweight structural elements of floors and ceilings were also welded in factory. The prefab processes involved resulted that the structural skeleton was erected in forty hours. Additionally, the construction had some rather interesting particularities, such as the use of tension cables, either to tie the structure to the rocky cliff, or the cantilevering balconies suspended from the roof frame, or the use of gunite, a kind of sprayed-on concrete in the external walls. Neutra's architectural philosophy emphasized man's relationship to nature, in an aesthetics that merged the prefabricated and industrial building like materials with a natural ambience. His fellow Austrian Rudolph Schindler would also share a common philosophy, although not focusing so much in prefabrication methods. In any case, both their works would render great influence in what came to be the California modernism.

2.6.10.3 Albert Frey

The Swiss born Albert Frey would too be an influential figure in the brought about of a discourse which merged together industry and nature in a new aesthetics. The desert houses *House Frey I* and *House Frey II*, as well as in his influential *In search of a living architecture* book (1939) were some his most remarkable expressions such synthesis. However, what primarily brought him visible in the architectural scene was his more radical *Aluminaire* house (1931), designed and first built years earlier. The experimental house, was conceived together with A. Lawrence Kocher, with whom Frey shared ideas on the prefab construction methods and on the modernist aesthetical influences, and would bring international recognition to both architects. *Aluminaire* was first built in 1931, at the Grand Central Palace in New York, for the 45th annual *Allied Arts and Building Products Exhibition* of the Architectural League. The house was built with the latest materials and technology in the industry, prefab to specified dimensions. These were supplied by great companies such as the *Pittsburgh Plate Glass and Aluminum Company of America*, the *Aluminium Company of America*, the *Westinghouse*, or the *McClintic-Marshall Corporation* (*Bethlehem Steel*). In exchange for publicity, these companies donated the materials and offered their services. It became the first house entirely built of steel and aluminium and glass in the US. The materials gave it an unseen metallic, clear-cut, modern style, which would not everyone attending the exhibition enthusiastically assimilated, nicknamed in expressions such as 'home canned' or 'house rack'. Externally, it was coated by panels of corrugated aluminum and reinforced insulation board; the window and door frames were in steel. Spatially, the ground floor had a garage and a technical compartment, besides the entrance and access to staircase. In the first floor there was a double height living room, a dining room, kitchen, master bedroom, bathroom and stairs. The upper floor had a library, a bathroom and a partially covered terrace. Closing the exhibition, the house was purchased by architect Wallace K. Harrison and moved to Harrison's property on Long Island for use as a weekend retreat. The house was dismantled in just six hours and all the pieces numbered to facilitate the new assembly. From this date the house knew several locations throughout the years.

2.6.10.4 Frank Lloyd Wright

By this period, Frank Lloyd Wright also was designing his *Usonian* houses. Besides the constructive systematization, typical of Wright's buildings, a few variant proposals of the *Usonian* envisioned prefabrication and even precut to self-construction methods. These were developed over a modular grid system, which allowed design flexibility, since each design was unique, while unifying the different building instances. Anyhow, repeated elements and standard details contributed to control costs.

2.6.10.5 Marcel Breuer

In 1943, Marcel Breuer designs the prototype for the *Plas-2-Point House*. The house's plywood substructure was to be given a thin coat of liquid plastic, a novel take on sealants that would render the entire structure more durable and easier to clean. The structure touched the ground in two points only, anchored to foundation blocks that eliminated the need for an expensive grading or a full foundation work. This greatly decreased the amount of time necessary to assemble the house. A massive spinal girder connected the two points from which radiated a tapered truss system - inspired by the trussing of an airplane wing. Vertical posts supported a second spinal girder for the ceiling Modular plywood panels could be configured in variations to form the roofing, flooring, and interior wall divisions. As with the *Yankee Portables*, the *Plas-2-Point* was pitched as postwar housing to officials in Washington, D.C., but the project would never get off the ground, feeding Breuer's increasing frustration with the inability of architects to break into the prefabricated housing market in the United States. In Breuer's eyes, the future of the prefabricated house would unfortunately rest within the hand of "*commercial fabricators who don't bother with architecture*"[287].

2.6.11 *CASE-STUDY HOUSE PROGRAM* MEDIA LEGACY

Aside some negative connotations, prefab has in many architectural circles become synonymous with a somewhat modernist looking, commonly portrayed by detached dwellings set in glamorous, idyllic, landscapes. In brief, what is depicted are houses representing an idealized living inspired and inspiring all sorts of popular items, a place where the objects of consumption, from art to furniture, fuse with the house itself: architecture as a design product piece to show and to consume.

A classic example is the famous *Case Study House Program* (1945–1966)[288], which would produce, in these terms, paradigmatic houses as the one designed and dwelled by the Eames couple. It all started in 1944, when John Entenza, editor of *Arts & Architecture* magazine, publishes *What is House?* in the July issue, introducing the *Case Study House Program* and presenting views for modern prefabricated housing. Between 1945 and 1949, Charles and Ray Eames design *Case Study House #8*, initially with Eero Saarinen, in Pacific Palisades, California. The house used industrially-produced component parts, and was part of the *Case Study House* program.

Overall, the program oversaw the design of 36 prototype homes, and sought to make available plans for modern residences that could be built easily and cheaply during the postwar building boom. It generated designs that would greatly influence the modern home and particularly architecture during the program's existence, and so remaining to some extent today, given, for instance, the great amount of publications dedicated to it that are still being made these days.

This example would be a great contribution in setting a sort of new pop culture founded architecture, currently manifested in a multitude of press and web based publishing's dedicated to it. These are increasingly fused to the point of no-distinction, where virtual representations are at times hard to decipher from real proposals. There is however another additional effect, that is, as consequence of our times and technological development, buildings are, or can now be more industrialized than ever. It is thus with little surprise that sometimes the phenomenon of the *Case Studies* is followed. In 2000, *Dwell Magazine*[289] emerged as a pop culture modern chic magazine for architects, designers, and consumers. Senior Editor at the time, Allison Arieff, and Bryan Burkhart wrote a case-study book, *Prefab*, which featured a history of prefab dwellings by architects and others from the industrial revolution forward. One of the greatest contributions of *Dwell* was a competition held in 2004, calling for a 2 000ft^2 (~186m^2) dwelling under $200 000. Although with different contours than the *Case Study House Program*, it a gave visibility to a new approach to prefab housing.

More recently, two exhibitions marked the pace of a renewed architectural interest in prefab houses: *Some Assembly Required: Contemporary Prefabricated Houses*, curated by Andrew Blauvelt and also supported by the *Dwell* magazine, held in the Walker Art Center in Minneapolis in 2006-2007[290], and *Home Delivery: Fabricating the Modern Dwelling*, curated by Barry Bergdoll and Peter Christensen, held in the MoMA in New York City in 2008[291]. The MoMA show was arguably one of the most thorough collections of history, theory, and practical thought on prefabrication and housing ever to be presented in one setting, taking modern prefab to a higher level of art and a wider audience of designers and design consumers. The premise on both exhibits was that the current resurgence of interest in prefab is owed to recent developments in digital technology. The idea is that industrialization with customization could potentially make the prefabricated dwelling commonplace, offering both variability and predictability.

However, while these exhibitions, especially the latter, brought a fresh insight, bringing prefab to a large audience, they nevertheless made quite visible the fact that design culture seems often too attached to stylistic discussions on prefabrication in architecture, which is often portrayed in the magazines, blogs, and coffee table books. Discussions on this field are only seldom made more meaningful on what are the opportunities and challenges, namely on issues housing affordability and sustainability.

2.6.12 MANUFACTURED HOMES FROM AMERICA

The mobile homes are part of the heritage of a culture of impermanence in the USA, sharing a long tradition in the housing panorama in this country. The rise and development of the industry in America shows a shift from recreational use to permanent housing, but also portrays aesthetical and technological national trends. The need for rapidly constructed houses in the post-WWII would create perfect conditions for the appearance of an US exclusive type of house—the manufactured home, which comes in the lineage of the mobile home. Built on a chassis and transportable anywhere, these houses have the great advantage of following a less demanding code than the rest of housing and construction in general. Many companies that began as recreational mobile trailer manufacturers shifted into producing permanent mobile housing. Despite tending to be disregarded by society and architects, in the year 2000 they accounted for some meaningful 7.6% of the total households in the US, which is an incredible figure for a type of house that only began to exist in considerable numbers in the late 1940s[292].

Their basic technology seems somewhat primitive, but it is a highly developed product, with a large ballast of innovation. Sharing much of the innovative spirit of the automotive industry, the companies building mobile homes can have changes in their products every year in their various home brands, with technical improvements, enhanced insulation methods, improved house appliances and so forth. However, despite a different color or finishing material here and there, improvements in the appearance of each home model are rare. In the case of the Palm Harbor, a mobile home company employing 450 people in its factory, there is a product development team and floor layout creators, although none with architects involved[293].

In its inceptions, the continuous development of the manufactured homes has begun following the come into being of a mature automotive market—and corresponding roadways—and the need for affordable shelters, either for tourism/vacationing, or eventually even as a (im)permanent affordable house to live in. By the 1920's, vacationing families stocked their automobiles, and hit the road around the country in their vehicles and trailers, as part of an auto-camping trend. Using their vehicles, enthusiasts escaped from a civilized America, aspiring a return to nature and embracing a nomadic spirit of exploration, if only for their vacations. Some formed specific tourist associations, where to qualify they had to live in a tent, converted car, a trailer or a temporary hut. In an early stage, it was mostly a do-it-yourself business of car conversions—ranging from simple car adaptations to the most sophisticated trailers, with doors, windows, cooking spaces, beds, and so forth. Eventually, from the late 1920s and throughout the 1930s, a whole industry developed around it, with businessmen and automotive companies entering the market using mass production methods. It is when the trailer coach adopted its iconic streamlined image, as depicted in the classic and shiny aluminium-made *Airstream*. With the Great Depression, these symbols of freedom and joy became one of the few home options for the poor and unemployed.

The trailer gained respectability during wartime, arising as temporary housing for the military and migrant workers of the military supplying factories. It was no longer about a nomadic way of life, but affordable (and patriotic) housing in its own right. However, the government regarded them as temporaries. In 1943, the *National Housing Agency* set minimum standards for war workers housing, and trailer homes did not comply. As a result, after WWII, surviving manufacturers attempted to link their products back to their travelling roots, stressed by a sleek, streamlined automotive design. However, people had got used to live in their affordable trailers, and a streamlined look was not congruent with the domestic. However, the main practical issue had to do with the 8ft (2.4m) width restriction by road authorities throughout the country. These posed layout problems, since there was no room for a corridor, thus rooms had to be accessed in succession. Extensions were possible, but normally they were expensive, hard to use and often struggling with weathertight problems. The first 10ft (3m) wide trailer appeared in 1954, manufactured by Elmer Frey's Marshfield Homes. The 'ten-wide' marked a historical shift between the house and the vehicle. These could hit the road, but only with a special permission, and certainly not too often and/or for tourism. It was also built on a chassis, but now that was only for transporting it to the site, which was in many cases the only site these houses would ever meet[294].

The acceptance by other manufacturers to the new concept would not occur overnight, but it would definitely change the game, although approval from authorities would not come immediately. To the ten-wide, succeeded the twelve-wide in 1959, and the fourteen-wide in 1969. Meanwhile, the mobile homes began to look more and more house-like, and less vehicle-like. There were already millions built, when the double-wide—meaning two mobile homes juxtaposed, each built on its own chassis—was introduced, enabling an enlargement of the house areas. The growth made it apparently indistinguishable from modular prefab homes, although in fact differing by the existence of a chassis. Legally this was an important distinction, since as long as remaining with a chassis meant the 'mobiles' were exempt from local building regulations, and subjected only to federal regulations, namely the regulation that became known as the HUD code (*Housing and Urban Development* code), introduced in 1976. As consequence of these developments, the industry would be split into two. On the one hand, the streamlined, vehicle-like, touristic 'mobile homes', on the other the chassis built 'manufactured homes', which in most cases only travel from factory to site, and remain there their entire lifespan. In the latter, the tin-foil materiality was gradually replaced by house-like materials, with prevalence of timber-frame technologies. Anyhow, a social prejudice would persist among these houses, since 'trailer' was connoted with poor people. Signaling it, throughout the years the *Trailer Coach Manufacturers Association* changed its name first, in 1953, to *Mobile Home Manufacturers Association* and again, in 1975, to *Manufactured Home Institute*, removing all reference to mobility. Notwithstanding, these houses seem to please their inhabitants, and the lack of other options is not the only reason to opt for these[295].

Following the tradition of camping trailers, part of the market ecosystem of these houses is the mobile home parks, which begun to emerge in the 1950s. While some mobile home parks are designed to satisfy the essential needs of an affordable market, others are that take it to a more exclusive level, providing additional services, as golf courses and swimming pools, lining up with a tendency of gated communities for wealthier people that have a particular occurrence in places such as Florida. Trailer parks, either the cheaper or the more exclusive, constitute a substantial part of the manufactured homes market. Nevertheless, still about sixty percent is located in suburban sprawls that extend for miles. For the affordable market, in many cases the manufactured home has become the best alternative to an apartment in the city, and many can be found in this immense network of asphalt. In what can be seen as a subverted—or natural—evolution of Wright's agrarian vision, these suburbs have houses that range from the most humble homes to luxury mansions, many of which are mobile and manufactured homes.

The manufactured homes industry has somewhat evolved to an incongruous state. If houses are desirably to be treated ordinarily in terms of planning, conversely they desirably ought to keep a reputation of speed and affordability that takes a competitive advantage on their special legal status. The HUD code demands to keep up with a non-removable chassis, but many manufacturers also built sited modular homes, whose construction process is in all ways similar, but with the chassis removed after deployment. These houses dodge the zoning constraints, but fall outside the HUD code and thus are ought to comply with local building regulations[296].

As Davies writes: "*the manufactured house (…) is a complex commercial, industrial and cultural system. The individual houses may seem illogical in their design and easy to improve, but they are only the fruit of the tree. To* *understand them, you have to look at the whole organism with its interdependent networks of suppliers, manufacturers, transport companies, dealerships and park owners, and at the commercial and regulatory environment that nourishes it. You have to notice the way that manufacturers benefit from the extended credit offered by suppliers of materials and components while taking cash-on-delivery from the house dealers; the way that the size of a manufacturing plant is governed not by the demands of mass production or the economies of scale but by the population of a catchment area limited by the distance a house can reasonably be towed in one day (anything up to 800 kilometers); the way that the specialized transport sector of the industry has evolved techniques to avoid 'empty back hauls'; the way that dealers generate a critical mass of potential customers by clustering their show-sites together in roadside 'trailer shows'; and the way that park owners are able to take advantage of the flexible, provisional nature of their investment, easy to finance and easy to convert to conventional development should the occasion arise*"[297].

The manufactured homes have been recognized as an increasingly relevant component of the un-subsidized affordable house sector. Their affordability puts homeownership within the reach of many and is perhaps the greatest contributor for their relative popularity, alongside their availability and flex-ibility[298]. These houses can be shipped virtually to any place in the contiguous US territory, including places where it would be hard or expensive to find builders or construction materials supply. Moreover, given their relatively smaller areas, they typically require less space over ordinarily built homes. Besides, since they are literally built on a chassis, they do not require foundations, and this allows to site them nearly anywhere permitted by building codes. On the other side, owners face issues of land tenure, own-ership and financing, or more vulnerability to hazards. In fact, land tenure is a characteristic that primarily distinguishes these houses. The earliest mobile homes were designed for mobility and thus land costs were not included in the purchase, although costs of temporarily sitting them in parks or campgrounds could occur. Yet, mobile home have become more grounded over time—according to the US census, in 2005 about 60 percent of mobile home owners stated their homes had never moved[299].

2.6.13 PATENT YOUR BUILDING

Embodying a competitive American spirit, outstandingly rendered in a run for patent and proprie-tary rights, in 1882, N. G. Rood secures the first US patent related to architectural prefabrication, a design for a *Portable Summer House*[300]. This is one of the first known examples of a patent call for an entire house building in the US. For ages, the intellectual property of architects and other actors in the building construction industry has relied on copyright laws and the like. These laws are known for their protection of original artistic or literary works, and architectural works, from drawings, plans or models to the very buildings can be recognized as works subjectable to copyright protection[301]. As it is known, the theme has generally witnessed a growing awareness, particularly since the arousal of a digital era, with plentiful forums of discussion. Anyhow, it is here important to note that the patent protection[302] is another way that has been used for property protection in the building industry. Although relatively uncommon/unknown in the architectural field, the fact is that not only partial details, but also entire buildings have been patented, and this has found a particular fertile ground in the US.

Indeed, we have all heard of patenting building technologies, systems, details or products. However, perhaps few of us have heard about patenting architecture. The issue became more evident since *Apple* relatively recent trend of patent registration of some of its stores, or in the least some architectural components of these stores. However, there is a rich history of previous examples behind it. Indeed, there are plentiful examples of architectural drawings and building designs that can be found in patents from the 1920s, 30s, 40s or 50s.

The subject raises some perplexities, primarily because it is difficult to assess to what extent we can patent architecture, and which naturally crosses the issue of architecture as a product. We can patent structural systems, materials, details, but it is harder to imagine how to patent conceptual strategies or the look of buildings. We can observe architecture as a language in itself, but it is hard to imagine copyright infringement when it is about architectural design, because it is in the least difficult to assess with precision what makes all the parts of a building a copyrighted entity. In one way or another Frank Lloyd Wright's, Mies van der Rohe's or Le Corbusier's works have been copied, their methods and approaches adopted/adapted. We can only wonder what would have had occurred if they had patented their designs. We certainly have to question if that would have made any sense at all, or in the least, we have to question where the threshold between an original idea and a barrier against progress is.

In the case of *Apple*, there is an issue of branding, which traverses their products and packaging, where in the latter can be included the interior and exterior design of their stores. It is about portraying an image that is ought to be consistent with their products, evoking notions such as clean, sleak, user-friendly or streamlined. Observing the selection and conjugation of materials of an *Apple Store*, it is like looking to an architectural version of one of their products. The model has become familiar to the point that even without any logo or other kind of reference to the brand, that many would recognize their architecture.

For ages, architecture has been patent-free, that is, open to be built upon, improved, innovated, and so forth. So what does it mean for architecture when the U.S. Government granted Apple its first architectural patent on November 15th, 2011 for the design of a store in the Upper West Side in New York City? The design features an all glass facade and glass canopy, opening the entire interior space to the street and to the sky. It is bounded by stone walls on either side. The components of this design are not necessarily original and the patent, which can be viewed here, only gives a cursory view of the design, alluding to the materials and assembly that is to be used. It has also been announced, that *Apple* plans to build similar models of this design in other locations.

2.7 Prefabrication of houses in Japan

2.7.1 TRADITIONAL SYSTEMS FROM JAPAN

Traditional Japanese architecture has developed its own particular modes and vocabulary in time. These have assimilated many influences from abroad, most notoriously from Chinese architecture, yet tempered with resolute indigenous developments[303]. Although with recognizable and often extreme differences in size, plan, decoration, age, and historical development, and considering a great variety of climates charactering the Japanese archipelago, there is a consistent core universally bounding its architecture. The choice of materials is perhaps the most fundamental point, transversally linking both sacred and secular, magnificent and humble buildings. There is generally a preference for natural materials, especially of wood[304].

Although with different degrees of workmanship and expertise, typically most traditional structures are made of wood, with plaster and clay for permanent walls, paper for screens, and straw for mats, wood shingles, or tile for roofs. A main difference from Western, as well as some Chinese architecture, is the scarce use of stone, with exception of castle foundations, temple podia and the like. The same is also mostly verified with the structural systems, based on post and beam wood construction, with thin, non-bearing walls, movable or fixed, disposed in-between columns. Exceptions are only found in the thick wood walls, covered or not with plaster, found in castles and storehouses. In debt to the structural wood systems, the buildings, with few exceptions, tend to present rectilinear over curved forms.

A great roof is supported by the structural skeleton, which is usually the most prominent aspect seen from the exterior, occupying the larger part of the visual field, with the slightly curved eaves extend beyond the walls. In the case of temples and shrines, to support such weight, a complex bracket system, the *tokyō*, is used. In domestic structures, simpler solutions are adopted. Aside the effect, the typical deep eave overhang produces a distinguishing dimness to interiors, contributing to the building's atmosphere where a diffused, mellow light darkens towards the ceiling, a dimness that has been famously described by the novelist Junichiro Tanizaki in his *In Praise of Shadows*.

The internal spatial fluidity is yet another characteristic of the Japanese architecture that contributes to a characteristic feel of space. Probably deriving from the typical post and beam structural approach, the spatial fluidity of the buildings can be observed in the freedom to either partition space with fixed walls, or with freestanding or removable *shoji* screens. In the core of the houses, there is the most important room, the *moya*, from which the lesser significant spaces derive, in a characteristic inside-out fluidity. Although permanent walls are frequently used, the distinction between door and wall is quite flexible, since they are coded to open to the outside elements, swinging up, sliding open, or even removed, aiding to such fluidity. The overhang protected space of the verandas hence also functions as a transitional space, working both as a part of the building as of a part of the outside world, establishing a tuned dialogue with the surrounding environment. The fluidity of spaces is also indelibly related with a proportional measurements system developed throughout the centuries. Each structural element is related by formula to the others through a modular dimensioning system, which assures harmony within a building and between different buildings. Finally, even in the most ornamented buildings, as in the case of *Nikkō Tōshō-gū*, decoration typically has an embellishment purpose, rather than disguising any unintended elements of the construction, therefore contributing to maintain an overall integrity of the designs.

Many of the traditional examples seem almost like ephemeral structures, and notwithstanding there is somewhat a sense of frugal beauty. Supported in lean posts, with module regulated, tatami mat plans, signal of both order and spatial flexibility, rooms connected by removable shutters and *shoji* screens, indoor-outdoor permeability, conveying a feeling of interior protection which is delicately balanced with the control of landscaping and view, drawing an almost imperceptible boundary between building and world. The internal sphere is linked through unnoticeable steps to the external, in a continuous flow where there is ought to be no more than the required. Everything is designed to be just exact, no more, no less. Such feeling transported by the Japanese vernacular practice was an important influence to modern architecture, being appraised by great architectural figures such as Mies van der Rohe, Walter Gropius or Frank Lloyd Wright. To a certain extent, more than offering a way to be mimicked and developed upon, the Japanese way offered a path of conceptual validity for the modernist proposals.

However, the Japanese tradition has not only been made of the sort of upper-class detached buildings that the former description configures, and which became so well known in the West. Besides the upper-class detached residences, with their tranquil permeability and serene gardens, there are also narrow fronted city row houses in traditional construction. The *machiya*, as they are known, may combine both commercial spaces and living spaces and usually face a backyard. Constructively, the systems are identical and similarly age-old encoded to resist earthquakes. Besides both types, typically stands a *kura*, a stronger storehouse made to resist hurricanes, earthquakes or fires. Surprisingly, many of these traditional buildings, including the *kura*, would nevertheless reveal poor performance facing the devastating 1995 earthquake[305].

These structures are part of the Japanese cultural and architectural essence, yet in a more recent period of history, the incorporation of its methods has become somewhat abandoned, and slowly has witnessed its use replaced by wood or steel frame structures resembling the American two-by-four construction. Aside natural catastrophes and the like, other probable reasons for such outcome has been simplification of the typically intricate joinery in order to speed up construction and ease mass-production methods.

2.7.2 A CONTEMPORARY PREFAB PANORAMA

Japanese prefabrication finds strong roots in the country's history and culture. People have learned to think of houses as constructed of post-and-beam frames with infill walls and these frames have always been prefabricated[306]. The rich tradition in wood construction is highlighted by the majority of public preference on these type of houses[307]. Wooden structures make up about two-thirds of all the housing stock when classified by structure, but the proportion of non-wooden structures such as reinforced concrete houses and steel-frame houses, is still increasing[308]. Unlike some other areas in the world, prefabrication is generally seen as a good quality-cost combo alternative rather than the cheap norm.

The big house manufacturing companies make a large expense not only in creating state-of-the-art manufacturing conditions, but also in promoting and marketing their houses in all sorts of ways. Some of the major ones exhibit houses as if it was an outdoor car display. The exhibited houses are made from diverse materials: precast concrete, structural steel, light-gauge steel, and so on. The companies even organize guided tours for the general public or prospective buyers for a close observation of their prototypes, as well as the facilities where these are produced and tested. Such is the case for seismic adequacy, which is of a major importance in Japan, greatly influencing the designs, where the public is invited to witness to their tests. Overall, these selling methods seem to work for the Japanese prospective homeowner[309]. For these companies, sales are as an important activity as producing, reflected in the investment they make in both. Anyhow, in one way or another, the final customer is going to pay for all this fuss. On the one hand, customers benefit from production optimization to get better cost-benefit for their houses. On the other hand, unlike small companies which do not have the financial support of the bigger ones to deliver big, expensive, advertisement strategies, the final house bill ends up getting distorted by such, with negative implications for the client.

Housing shortage after WWII was overcome in Japan through intensive housing construction work. A strong observable characteristic of this effort was tradition holding forces with innovation. Industry in general witnessed the appearance of innovative production philosophies, starred by the *Toyota Production System*[310]. An outstanding example of achievements is given by *Sekisui Company* (the biggest home builder in Japan), that while firmly rooting to traditional house tradition, devised industrial ways to combine standard parts while enabling variety adjusted to the client's requirements. This was made while keeping up to economies of scope, necessary to properly run a business, and becoming a pioneer in what latter, since the 1990's, would be called 'mass-customization'[311].

Japan's chemical company *Sekisui Chemical* has, since the 1960's and in addition to its core business, endeavored in building production. *Sekisui House* and *Sekisui Heim* are two separate subsidiary companies with a combined average annual production of some 68 000 housing units. This output is inconceivable in Europe through the usual project-oriented approach. In 2004, *Sekisui Chemical* generated $7 713 000 000 net sales, of which the residential building sector (*Sekisui Heim*) accounted for 50.4%. The return on equity was 6.8 percent in the reporting year 2004 with an annual production capacity of 16 100 buildings (12 270 single-family homes, and 3 840 multi-story buildings in construc-tion). From 2003 onwards they have developed a zero-cost approach to create a house with zero utility expense, which currently is around 50 percent of their sales. The approach is based on the following four principles: air density, highly-insulated design reducing heating and cooling costs; building integrated, web-based, photovoltaic systems generating electricity during the day and with surplus to be fed into the grid; highly efficient water heating; extensive use of night power in all the electrical systems of the building units allowing a positive net flow balance. The zero-cost concept has turned out to be one of the most important selling points in the Japanese market. As other com-panies have done (e.g. *Toyota Homes*), they produce spatial cells in the factories, which can be used also for the multi-story housing in a steel frame structure.

Passing the critical postwar period, the available houses in Japan would exceed from the households from 1968 onwards. In 2003, it reached about 1.14 times as many as the total households. The percentage of owner-occupied housing began to increase in 1998, reaching 61.2% in 2003. In the beginning of this century, the percentage of detached houses was decreasing, but still was 56.5% in 2003. Despite effects of the global financial crisis, there is however an observable tendency for the number of collective housing units to continue to increase. The average floor area for newly-built housing units consistently increased for owner occupied housing and housing for sale. For housing for rent and company-supplied employee housing, on the other hand, it fell greatly in the 1980s when land prices rose, and subsequently increased in the 1990s due to the fall in land prices. In general, housing size is still increasing[312].

According to Groák[313] the Japanese approach has the following main aspects: the market structure and attention given to providing customer choice; the nature of housing as a product; the dominance of new-build and absence of a developed market in second-hand houses; a distinct framework for innovation formed by government and industry, including regulations, and public and private investment in research and development focusing on production methods and customer requirements; the concept of industrialization as a means to customer choice, to maintenance of built quality, and to flexibility of site operations, rather than simply a means to reduce unit costs; a strong commitment to developing electronic data models of building processes and buildings as products in use, which could lead to the integration of digital data and its access by a wide range of participants; a willingness to exchange ideas to help develop the sector as a whole.

Producers are relatively few but extremely big, as the top five 'giant' firms make most of the country's prefab housing, from where *Sekisui House* (over 60 000 units/year), *Daiwa House Industry* (around 35 000 units/year) and *Misawa Home* (about 30 000 units/year) stand out[314]. Huge manufacturers from other fields of industry, such as *Panasonic* and *Toyota*, have implemented state-of-the art housing production methods and are actively in the market[315]. The manufacturers, or their subcontractors, also make many of the functional components of houses such as kitchens, bathrooms, furniture or windows. Strikingly, in many cases, much work is still done in-situ: interior and exterior finishing, or plumbing and electrical work (exception for unitized bathrooms and kitchens).

In most cases two stories is the maximum allowed height for wooden buildings in Japan. Other buildings, such as steel and concrete ones, may have more stories, but they normally stick to tradition, mostly keeping up to two. Via lifespan estimates, building materials control the taxable value of a house: wooden houses are considered to have a lifespan of twenty years, and concrete ones thirty years. This relatively low lifespan of houses when compared to other countries (e.g. 60+ in the UK) has ensured a regularly recurring housing demand[316]. However, the Japanese government wishes to raise the average lifespan of new housing and there is currently discussion about *zero energy housing*, *100 year life housing*, and the increased use of recycled materials. These factors, together with the low profit margins, are leading many house builders to seek new business strategies[317].

Japan has a big house building business and there is a great level of standardization. Generally, working with a big house builder means clients are stuck with the limited options they provide. To better optimize production and achieve greater economies of scale, big house companies tend to use a limited number of component suppliers, for instance in sanitary ware, glazing or doors, with which they have pre-existent supply contracts with the builders (the final assemblers). Customizing these is possible and mostly has to do with the type of contract and coordination that is established with the builder. Alternative suppliers, even in the case of local craftsmanship, can handle quality and price-competitive solutions. In Japan quality and attention to detail is invariably excellent from major builders to smaller independent builders and subcontractors, and the great market competition assures good care of price control. However, if a careful handling of these issues is not established first hand with the contractor risks are, obviously, of an increase in the final ticket price.

2.7.3 THE CASE OF *TOYOTA HOMES*

From the earliest inceptions of prefab housing, to recent prefab designs, a fundamental idea behind prefab manufacturing has been to use the auto industry as a model for the mass-production of houses. As other Japanese companies, such as *Seikisui House* or *Misawa Home*, the auto-industry giant *Toyota* seems to be pushing this idea to its ultimate level, by developing efforts in attempting to bring together the better of two worlds, design and industry.

The constructive philosophy, as it is possible to understand from the documentation made publicly available by the company, is based on a *structure & infill* approach. They claim that their approach to such constructive philosophy is able to combine a flexible infill with a long-lasting skeleton structure, used to create spacious, long-lasting, flexible houses. Blending the development of housing-related equipment with high-level automobile technology is the motto, which requires a strong technical and financial support by *Toyota Housing Corporation* and the *Related Products Development Committee*[318].

Unlike companies such as *Seikisu* (the biggest house producing company in Japan), at this time, *Toyota Homes* seems to have no plans to manufacture for foreign markets, sticking to the internal market. Although prefabricating housing since the mid 1970s, *Toyota* made a concerted effort, announcing on January 1, 2004, that it established a new branch to begin full-scale production of factory-built homes, gathering some of its disperse companies in this field in one big group, the *Toyota Housing Corporation*. The company started in 1975, selecting as home dealers twenty-four auto dealers in the Kanto, Tokai, and Kinki regions, and beginning production at *Toyota Motor Sotoyama Plant* and *Kanto Auto Works Yokosuka Plant*. In 1976 they would sell 12 houses. Number of houses sold would first pass the thousand in 1987, with 1 383, the two-thousand in 1991, with 2 258, and the three-thousand in 1999, with 3 158. When *Toyota Housing Corporation* was established in 2004, they have sold 4 313 homes, increasing to the 3 936 on the year before. Since then, figures have grown, with a peak of 5 024 in 2006. Economy's downturn in the end of the decade, took figures to a lower point of 3 750 in 2009. In any case, they have been growing up since, with 4 137 in 2011. Although with remarkable number of houses, the overall figures seem to have a neglectable value, the homes company seems to have been created as a way of diversifying *Toyota's* businesses, while testing and make their expertise evolve in new fields.

The company has transitioned its process into the home market by utilizing their world-renowned technique of lean manufacturing. *Toyota*'s innovation of the lean manufacturing process began shortly after the Second World War. Many of Japan's industrialists were impressed by America's speed in which they could build aircraft and vehicles utilizing the *Fordist* mass production model of automation, assembly line, and economies of scale. Taichii Ohno and Shigeo Shingo of *Toyota* incorporated the *Ford* production process with a variety of customized techniques unique to Japanese culture[319]. In starting anew with these processes, they could evaluate the shortcomings of the *Ford* model with a new critical eye, and develop their own process, which became known as the *Toyota Production System* (TPS).

This system has been highly praised and received awards around the globe for its focus on people through mass customization and utilization of economies of scope. Several industries, other than the automotive sector, have been using this production model as a basis in which to ground their own practice. TPS and lean manufacturing have become synonymous with efficient business practices as found in *Lean Thinking*[320]. *Toyota Home* saw the housing industry as no exception to the principles of lean thinking. *Toyota* has taken 5 of its 14 principles used in auto manufacturing and applied them to the prefabricated housing market.

These include: *Just-In-Time*, where each portion of the process arrives just as it is needed to complete the final product; *Jidoka*, where automation is conceived as having a close human element, important in prefabrication housing market in order to bring down production cost and improve overall quality; *Heijunka*, meaning the inventory is kept low and in constant supply, accomplished by manufacturing directly to customer order; *Standard Work*, meaning not all of the elements that are compiled to make the *Toyota Home* modules and finally the completed structure are customized; and *Kaizen*, which has to do with the human element in manufacturing, where employees are asked to find solutions as a non-hierarchical multi-field team, focusing on a series of small tested solutions rather than a macro level fix-all solution, on the quest to produce a quality product efficiently[321].

In *Toyota Homes*, a great deal of the factory production is automated. As in the auto-industry, the different parts which are brought together in the assembly line can come from different sources, either in an adjoining plant, or remotely produced, provided either by themselves of by sub-contractors. In the case of *Toyota* the steel skeleton is produced in their own factory plants and with a largely automated system, including the cold-forming for some of the required steel parts, to cutting, welding, and drilling to latter bolt, screw or pass cables or pipes through where necessary. The two-dimensional frames and remaining structural steel elements are then taken to the automated paint shop, where the frames and remaining elements acquire their solid protective coatings. These finished steel components resemble pretty much a finished car or truck chassis frames. The whole process, where robots do a great deal of the work, is sought of to be quality-control monitoring friendly. As with the steel skeleton, other components, such as panels and boards for walls, floors or ceilings, windows or kitchen furniture, are previously set fit to seamlessly enter the assembly line.

In the assembly line, the two-dimensional steel frames are the base on where the remaining components will be layered on. Two main types of frames diverge in two different assembly paths, the ones which are to become floor/ceilings, and those that are to be external walls. The floors begin by receiving their insulation layers, covering most of the steels profiles. Some wood elements, or other hard and high thermal inertia rigid elements, are punctually placed to later receive the floor boards which will be screwed to it. There is always a constructive gap between the steel and the boards which are laid to make the floor. This gap is always filled with such a wood or wood-like sort of material to later screw and/or glue the boards. After the raw base is completed, it is fully hand-wired, receiving all the necessary electrical and/or other types of cables. Two of these raw and wired floor plates will go through an automated system which will weld together, placing a slim steel column in each corner in what will thereafter become a tridimensional module.

The wall frames begin by receiving the building's external cladding (or its support to be finished in-situ), which is properly screwed and goes through an industrial paint coating which minimizes potential water infiltrations through the building façade via the joints and screwed points. After this stage, the external wall panels are finally joined with the already tridimensional modules consisting of two floor plates and four corner columns. Layered (wood + insulation) boards are then assembled through the interior of the external walls. As in the floors, in the external walls there are also gaps left between the wall's steel frame and these boards, separating both materials.

Toyota claims that their steel-framed prefabs leave the assembly factory 85% complete. The factory expedites self-supported, box-like modules, with a bigger or smaller degree of furnishing, depending on the requirements. In half a day, the modules get stacked into place with a crane, leaving it almost done. Some of the finishings, such as floor pavement, are left to be made onsite in order to avoid unwanted elements such as joints visibilities. The company offers various sizes and designs, with an average family home comprising 12 factory modules.

2.7.4 THE CASE OF *ONJUKU BEACH HOUSE* BY *BAKOKO* ARCHITECTS

Bakoko's *Onjuku Beach House* (2012) is a remarkable example of use of automated processes in construction, combining quality and precision with ease and speed of construction. It is located next to the beach, in Onjuku, Japan, half an hour distance from Tokyo. It is a vacation house for a couple with intention of becoming a permanent house in future retirement times. Concordantly, the house program is quite straightforward. The plan is developed in two levels, plus a typical Japanese access to the roof top, with common living room and kitchen in the ground floor, to which adds a bedroom and toilets, and a multi-purpose open-space with two different areas in the upper floor. The house is mostly centered on its living room, which connects all the spaces in the house: it filters the private zones, connects visually and physically with the upper floor, and relates generously with an external wooden deck. The geometry of the house is characterized by its trapezoidal shape both in plan and section, and two volumetric insertions, next to the entrance and wooden deck with a built-in seat and planter, and on the toilets. The trapezoidal shape gives the house its formal character, but too is a mode for tridimensionally bonding the spaces together.

According to the architects, "*The home's concealed entrance is served by a Japanese* genkan*, a porch separating the home proper from a built-in shed for stashing surfboards and bicycles. This tunnel-like outer porch connects the gated rear entryway and the wooden deck which incorporates a built-in seat and planter. Timber shutters slide across the entire southern eave, securely locking-down the home to protect it from the seasonal typhoons. From the road, the home maintains an intentionally low profile. Its austere stained tongue and groove cladding is sourced from native Japanese cedar. Returning from the beach, a private outdoor shower leads directly into the tiled bathroom. An intimate garden provides a tranquil backdrop to the sunken bathtub. The home's dark exterior skin contrasts with its light and* *airy interior. The double-height living space is occupied by a spruce-clad box that supports a loft space above and contains the master bedroom, WC, and bathroom below. Careful detailing has incorporated the staircase and doors that close flush to conceal these private rooms. Sitting at the built-in desk upstairs, one can gaze out the sea for inspiration. The shallow pitched roof is accessible via a ladder extending into a large pivoting skylight. Since the home is intended for casual entertaining, the loft spaces and a timber-lined lower study double as occasional guest rooms. The home is predicated on passive design principles. Generous south-oriented glazing is shaded by the eaves in summer. Cross ventilation captures cool sea breezes. Slotted perforations milled into the wooden balustrade promote air circulation and cleanly conceal mechanical air conditioning units. In winter, the wood-burning stove provides renewable heat energy*".

The simple program, the geometry, or its materials and attention to detail are, however, just the visible scenario, as the house conceals a peculiar construction process, based on an industrially cut wooden structural mesh. For the manufacturing process, the precut timber supplier translated the architectural drawings into a set of schematics, placing symbols on each post-beam junction according to each respective type of joint. The plant of the precut timber supplier was located in a former *Hitachi* factory, where five workers, along with machinery, produce the structure for 800 to 1 000 houses per year, although with a capacity for up to 4 000. The machinery is completely automated, taking squared timber and processing it to a stack of pre-carved and numbered timber posts and beams. The info for each job is inputted through specialized CAM software and the workers' task can be summed up in feeding the machines with the correct lumber elements, verifying the correct section, length or kind of wood is inserted for the programmed carvings. In a first stage, each element is trimmed to exact length by a big radial saw. Then, the element is moved by a conveyor belt to a large wheel-like armature with five different centrifugally arranged drill attachments. This spinning wheel allows the machine to mill the protruding part of the joint onto both ends of each element. Another part of the machine mills the sockets in the exact required locations of the timber. Additionally, each element is marked with a unique identification in order to ease assembly when it arrives in-situ, assuring the quality control throughout the construction process. Finally, the wood is stacked and prepared for delivery.

The house structure took only one day to erect, and there was only two skilled carpenters working on the job. Everybody, from the electrician, to the interior decorator helped on erecting the structural frame. The pre-numbered members were hoisted by crane and fitted together with the help of a large wooden mallet. For the participants it is a joyous process which resembles the assembly of a large wooden puzzle. As the carved joints are fit, they are reinforced with steel bolts, providing additional stability safety. Only very few elements of the wooden trust could not be precut by the machinery and had to be cut by the carpenters.

Despite recession and shrinking population, Japan continues to build many homes. The workforce of skilled carpenters is also getting old. In these circumstances, the use of automation seems to be an obvious future way. With it, the Japanese builders, renowned for their skill and obsessive attention to detail, can efficiently achieve millimeter accuracy quickly while delivering at highly competitive speeds. Time and cost of cutting and assembly in-situ can be greatly reduced, while respectfully carrying the ancient, traditional and meticulous, great art of joinery.

3 LOGISTIC NOTES—CONTAINERS & PALLETS

In some circumstances, the design options may be influenced by the net dimensions of intermodal containers, the most economic mode for overseas shipping. The net dimensions of shipping containers are limited, and off-size cargo is incomparably more expensive. Containers follow strict principles of economy, both in their handling, as in their very construction. In their simplest version, the chassis is usually a steel frame bolted together and the walls are made of corrugated steel board. There are many variations, from refrigerated containers, to ventilated or isolated, to detachable sides or tops, even to flat (collapsible) containers to avoid having to transport empty space, to tank or gas containers, or the high-cube version (slightly higher), and so forth. Containers are poised to be intermodal, easy to set up by crane or forklift truck, and easy to transported by truck, train or ship. The consistent adoption of the ISO container sizes means transport is very flexible, making use of existing equipment already designed to handle international standard ISO containers all over the world. In any case, size norms such as ISO are not universally adopted, and thus care must be taken in this respect.

The size of an ocean freight is generally referred to as its nominal length in feet. The most commonly used international container sizes are 20’ and 40’ modules. Most European companies’ containers are also aligned to this international system. Nonetheless, the ISO standards recognize several lengths of ISO shipping container dimensions, such as the 10’, 20’, 40’, 45’, or 48’. There are also the intermodal air freight containers, called unit load device, which are coded as LD#, and whose compatibility between different airplanes varies, e.g. the LD1 is less common since it is designed specifically for the 747, yet LD3s are more commonly used in its place because of ubiquity. Dimensions and characteristics of both ocean and air freights are broadly available online, and their dimensions may vary slightly from manufacturer to manufacturer. Ultimately, a previous contact with the transport service provider may prove the most effective way to avoid incompatibilities. On Table 1 are shown some reference figures of some of the most common ocean container dimensions.

		20'	40'	40'highcube	45'highcube
Ext Dim (m)	**l**	6.096	12.192	12.192	13.716
	w	2.438	2.438	2.438	2.438
	h	2.591	2.591	2.896	2.896
Int Dim (m)	**l**	5.71	12.032	12	13.556
	w	2.352	2.352	2.311	2.352
	h	2.385	2.385	2.65	2.698
Int Vol (m^3)		33.1	67.5	75.3	86.1
Max Gross Weight (kg)		30 400	30 400	30 848	30 400
Empty Weight (kg)		2 200	3 800	3 900	4 800
Net Load (kg)		28 200	26 600	26 580	25 600
Door Aperture (m)	**w**	2.343	2.343	2.28	2.343
	h	2.28	2.28	2.56	2.585

Table 1. Common container dimensions.

Concomitantly with the use of containers may be the use of pallets. Again, there is no single standard in pallets sizes. Instead, there are several purposed pallets with diverse dimensions, since a single standard would have to satisfy multiple requirements that are not easy to satisfy altogether: fitting in standard containers, passing doorways, or bringing down labor costs. For instance, companies already using large pallets often see no reason to pay the higher handling cost of using smaller pallets that can fit through doors. The most broadly used pallet in the world is the Euro-pallet (800x1200x144mm), also known as EUR-1-pallet or the equivalent ISO1, initially developed for Eu-ropean railways, with the great advantage of fitting in many doors given its 800mm wide. There are also several derivatives of these, with its own set of ISO standards equivalents, such as the half the EUR-6-pallet (or ISO0, with 800x600mm), or the EUR-2-pallet (or ISO2) and EUR-3-pallet (both with 1200x1000mm, but with length in different directions), closer to the most common American pallet type (40x48 in, i.e. 1016x1219mm). However, the EUR types have the problem of the fitting in standard containers, being far from optimized. Apropos, with wide acceptance, it has been developed intermodal containers about 5cm wider, known as pallet-wide containers, featuring a 2440mm internal width to easily fit two 1200mm pallets side by side. Again, as in containers, information is widely available online, and offers between suppliers may vary, and thus dimensions must be properly crosschecked, between the available containers, pallets and so forth.

4 MASS-CUSTOMIZATION NOTES

4.1 Overview of mass-customization concepts from a business perspective

As the *Toyota* example demonstrated, MC is not 'simply' a process of improvement and ordering. For that matter, several studies on MC, developed from a business perspective, have pointed out likely causes of failures, and recommended practices. One of these studies was conducted by B. Joseph Pine II, Victor, and Boynton. In an article published in 1993, the authors have remarked that, to successfully implement MC in a business, four characteristics would have to be taken into account from the very beginning of its implementation: *instantaneous*, *costless*, *seamless*, and *frictionless*[322]. In a subsequent study, published in 1997, B. Joseph Pine II and Gilmore stated four types of approaches to the MC concept: *collaborative customizers*, *adaptive customizers*, *cosmetic customizers*, and *transparent customizers*[323]. Another study by Zipkin, published in 2001, warned for the limits of a MC process, stating three aspects to take into account, in an integrated manner, by any company considering such a strategy, otherwise with the risk of MC failure: *elicitation*, *process flexibility*, and *logistics*[324].

Not every process to create variability implies the development of a straightforward MC. Because of it, companies and its investors should insist in the development of a business plan, including specificities in process technologies, market, research and real and potential competitors. Companies should investigate potential to increase variability. That includes MC, posing the following questions: to which products a bigger choice might bring added value to the customer; what are in there the key processes; how flexible these are, and how can they can become even more; how can these be redesigned to be more modular or configurable; and which new opportunities do IT's bring to achieve variety[325].

Despite numerous successful examples, MC has been harder to implement than what was initially thought, as utterly illustrated by the *Toyota* example. Nevertheless, MC is not an exotic approach, with limited applicability. Instead is a strategic mechanism that is possibly applicable to most businesses, as long as it is properly understood and implemented[326]. Hence, there is no such thing as a better way to implement a MC, it is a process, more than a goal, for which, according to Salvador et al., three fundamental capabilities must be taken into account: *solution space development*, *robust process design*, and *choice navigation*[327]. These are unavoidably linked with digital tools, from the management of the production chain, to user choice, and so forth.

Applications of the MC concept to several industries have become increasingly common, but in some cases not without some major bumps in the way. Examples of companies such as *Amazon* or *eBay* are widely known. In hardware sales, *Dell* pioneered a MC system with its direct customer approach in product choice and configuration. With more or less success, applications are frequent in textiles, as is the case of custom-made *Levi Strauss* jeans, or in the shoe industry, as it is the case of the *Nike* sport shoes, which can be designed by the client in the company's website. In the auto industry, the *Smart* car was precursor with its online configurator, and is currently just one more example of the plenty in this type of approach. In fact, in more or less subtle ways, most global companies, selling global brands, have been implementing processes and strategies of MC.

MC can also be a useful concept to have in mind in the production of common buildings such as houses or even schools, although not losing sight that is typically more of a business related concept, than an architecturally effective methodology. Nevertheless, some lessons can be taken from it, and with a discrete perspective of the construction elements, and a process view of the design task, its application can be regarded as in the scope of an arguable evolution of the architectural scope to the sphere of the product. LT production methodologies and the IT's serving the design and production, have questioned the old imperatives of MP. With such a perspective, typical architectural tools, such as dimensions and proportions do not necessarily need to be regarded as standardized in order for production to be efficient, although with their own limits.

4.2 Some methodological approaches to MC from an architectural perspective

The case studies hereon presented, display two proposals of MC methodologies, Noguchi's[328] and van der Thillart's[329], that have attempted to bind the seemingly exclusive language of business with the architectural production, particularly in house production.

Noguchi makes a simplified approach to the theme, from a methodological perspective on the diverse components that can be involved in a housing MC scheme. He considers housing MC as a function of both *services* (S) (those coming from the architect, contractor, marketing, and so on, involving interaction with the client) and *products* (P) (e.g. components or materials). The conceptual expression is given by MC={S, P}, where the S and P are conceptual expressions that can be synthetized by S={l, p, t} and P={v, e, i, o}. In this case, in S factors are *location* (l), *personel* (p) and *tools* (t), and in P factors are *volume components* (v) (those that determine the structure as well as the number and size of each compartment), *exterior components* (e) and *interior components* (i) (those that coordinate both the functional and decorative aspects that customize housing). These three (v, e and i) are considered the main elements of the P subsystem. The other, *optional components* (o), may be heating/cooling systems, security systems, domotics', door handlers and other hardware, kitchen appliances, among others. The referred elements may include sub-categories, as roofing, walls, windows, verandas, as well as kitchens, bathrooms, storage or finishing.

The MC methodology developed by van der Thillart, first published in 2004, also concerning the residential sector, refers multiple factors to take in account, such as questions related to project, morphological variability, industrial performance, quality control, IT's, marketing, and intervenient roles, among others. The suggested MC model stands on the key-idea that a design concept can create a *virtual kit-of-parts*[330]. These virtual kits are extensible beyond individual projects and can be used in different locations. Moreover, these virtual kits comprehend all the possible systems that, together, after the client selection procedures, make a series of different buildings. The systems in this virtual package have a ranking of levels. Each selection in a certain level adds a system to the system selected on the previous level. A virtual kit turns into a MC model via a systems organization of the building in decision levels, having as reference a specific marketing concept, supported by drawing, visualization and accounting IT's. Theoretically, from a virtual kit, we can easily generate thousands of final variants. However, creating variants is not an end in itself, since production should satisfy strict economic conditions. The most profitable of these happens when the number of different components is kept to a minimum and the resulting number of products variants is maximized, for which connections between components (i.e. the *relation* element) should be as standardized as possible.

Such variation is optimized through what the author calls the *disentanglement processes* of the different systems in the kit. The issue that disentanglement processes try to handle is related with decisions that may look simple to the consumer may create a very high number of system states for the designer or the contractor to handle, and concomitantly a high number of different connections and of opportunities for it to fail. These can be achieved by in introducing morphological transferability techniques[331], since an early design stage through geometrical strategies, and concomitantly with attempting to attain a broad compatibility in constructive connections, so to deepen the OPP, ideally enabling a free connection of the variable components of any branch in a customer decision tree[332].

Finally, this author illustrates how these points can be managed, devising for that purpose a nomenclature of systems and sub-systems to apply in a housing MC process, where he hierarchically locates: *support* (a), *envelope* (roof and façade) (b), *services* (c), *infill* (d) and *finishings* (e). To exemplify, a subdivision of the infill system may be developed the following way: *Sys (d)* infill, *Sys (d1)* internal partitions, *Sys (d2)* internal doors, *Sys (d3)* kitchens, *Sys (d4)* toilets, and so forth. By attributing a proper nomenclature, the control levels become clearer, and so potentially does the clients' decision tree, thus increasing the potential of applicability for digital-aided, customer-centered choice processes.

Both these works generally reveal a certain closeness with the theoretical tendencies on MC in economics, and with the theoretical tendencies developed in the housing field, namely, for instance, the concept of *Open Building* and the *IFD (Industrial, Flexible and Demountable)*. In these, there is the underlying idea of identifying different levels of decision observable in a building with different lifecycles, adding to the last also the ability of deconstruction in the lifecycle end, in line with the growing concerns on the factors of environmental sustainability in construction. Moreover, both these approaches denote a concern mostly on the construction aspects of the architectural production, on how to handle a certain pre-designed set of components in order to obtain variability in outputs, and so on. In both also, it is notorious an assumption of discreteness and modularity, where processes follow particular hierarchies. This hierarchization comes from a need of structuring and accounting the processes and sub-processes happening in the development of a MC in housing, and which inflict in the logistic performance of the building construction processes. Because both come from an architectural background, it is evident a focus on the overall design/construction process and its relationship with the client. However, as earlier observed, for any MC process to be successfully implemented, many other aspects have to be taken into account. Anyhow, from a strict architectural point of view, these provide already plentiful clues that can be incorporated in any process where variability and efficient construction processes can be involved.

IV Epistemological Notes [A Global Epilogue]

COMPLEMENTARY TEXTS

1 THE PHENOMENON OF GLOBALIZATION

Certainly, in various ways, the debate on globalization is not unanimous. Regardless how it is defined, the term unmistakably indicates that it has to do with important processes which are bounding the globe differently[333]. All in all, it is unequivocal that globalization has a fundamental role in our lives, affecting the formulation of concrete manifestations of spatial and temporal conceptions of our time.

Globalization has been described as being risen from factors such as deterritorialization, growth of social interconnectedness, and speed or velocity of social activity[334]. Its linkage with the evolution and transformations imposed by economy is conspicuous[335]. Indeed, global economy was politically built by deregulation and liberalization mechanisms, decided and operationalized by governments throughout the world[336]. Once in place, it does not mean these mechanisms cannot be undone, but certainly not so easily, as the periods of economic and financial crisis suggest.

Historically, globalization is a process that can be traced back to millennia[337]. It involves basic spatial and temporal[338] contours introduced by multiple technical artifacts developed throughout human history, while trading networks, and hence social and cultural ones, were increasingly developed. From the XV and XVI centuries onwards, a series of events related with the Renaissance period, to which the voyages of discovery relate to[339], are the cradle for the Enlightenment ages and the Positivist spirit. These manifestations took place as western society secularized[340] and are responsible for a tremendous progress flagged by science and technology. Altogether these would define mankind's evolutionary path, with transversal implications in the centuries to come, contributing to the setting of an industrial machine-driven era, and are major constituents of the Modernity to which, considering its multiple manifestations, we all indelibly relate to[341].

Among other technical breakthroughs, the XXth century would bring the ship container, setting a global commodity carrying standard, making "*the world smaller and the world economy bigger*"[342], and from its last decades onwards, the Internet, GPS, and so forth. These contributed to make the process of globalization an inescapable fact[343]. As Alvin Toffler[344] foresaw in the early 1960's, after the agricultural and the industrial revolutions, the information revolution, child of the space age, gave birth to the current post-industrial society, definitely bringing globalization to our vocabulary, setting the pace for its current status.

Globalization is often grasped empirically, and it is common to see it addressed as if it was a mere economical phenomenon, though it is broader than that[345]. If it is unquestionable that, in one hand, it is associated with growth in transnational companies, trade, technology, or international networks and communication, on the other hand it bounces back exploitation and immiseration of continents, peoples and *global* poverty[346]. Just as local economies are influenced, and in many instances dominated by giant corporations, national governments cannot make policy and run their countries in isolation from the rest of the world[347].

If the early myth of globalization meant top-down control, as in the early cartographic idealizations for land ownership of European colonial settlers, such myth is irrevocably put in check[348]. The difficult equation of *Limits to Growth*, first presented in the 1970's and updated around thirty years later[349], involving available *resources*, available *food*, *industrial output*, *population* and *pollution* indicators, should at a minimum be regarded as a wake-up call to the scarcity of means there is at our disposal, remembering that globalization is not unlimited and does have a cost; and, as theorized by Marxism, the capitalist system, the great driving force of globalization, is ultimately unstable, because it cannot endlessly sustain profits.

It adds what can be called the media effect, as the enormous transformations undertaken make visible a globalized world that exists much in function of what the ubiquitous social media broadcast. And, as structuralism indicates, the *invisibilities* are nonetheless latent, even if not perceivable. There is a world, the global—of consume, financial, or of show (natural disasters or movie stars)—that is under the media scrutiny, and a rest of the world—of daily struggle, endemic misery, or alternative social movements – that is mostly outside the media focus[350].

Indeed, many of globalization aspects can be portrayed as representation, where the real gives place to a new kind of real. Such is what occurs with cartographic representations, which are more visibly driven from a physical reality, but also what occurs in a simulacra—as in the example of 'virtual-reality'—or when enhancing the real, producing a matrioska type of simulacra, within the simulacra of real—as in the example of the *augmented-reality*. For instance, in economic-financial circles this is every so often represented via the so-called *business as usual*, a representation system, where, in the resemblance between real and its representation, it does not matter if things are true or false, real or simulacra, as long as they keep on going *as they always did.* As Herod writes, "*central to this representation is the portrayal of globalization as a process whereby other spatial scales are eviscerated – globalization, in other words, is the* delocalization *and/or* denationalization *of economic and political life*"[351].

An analogy can be driven to the constructed human shared reality, where these fundamental biological mechanisms are unavoidably mirrored, finding their most visible appearance in media representations. As it occurs neurologically[352], a number of reasons may contribute for global representations to lack accuracy, and ultimately fail. But in the very nature of the idea of representation is embedded the notion of a permanent update in order to adjust to the ever-changing reality(ies), the same way as speech slowly alters language. Globalization as a representation has outstandingly failed in certain historical moments. Famous examples in relatively recent history are the media-enacted political representation of an atomic danger to justify the start of the second Iraq war, or the case of the late 2000's financial crisis[353]. Alternative models for a certain representation are possible because it is always likely that something may have changed, or that something may have been missed: the error is always human.

With the conception of a probable infinite space introduced in the Renascence the globe could seemingly be grasped as a finite totality. According to David Harvey, the invention of perspective introduced individualism, providing "*an effective material foundation for the Cartesian principles of rationality that became integrated into the Enlightenment project. Objectivity in spatial representation became a valued attribute because accuracy of navigation, the determination of property rights in land, political boundaries, rights of passage and transportation, and the like, became economically as well as politically imperative*"[354]. Globalization, as cartography, has the dual power of inducing an imaginary seduction and work as a rational construction. It reveals a desire for fulfillment, a dream of universality. Yet, as noted by Christian Jacob, "*the map entered the era of suspicion. It lost its innocence. We cannot imagine it today without an anthropological dimension, attentive to the specificity of cultural contexts, and theoretically, reflecting on the nature of the object as its intellectual and imaginary powers*"[355].

But current global representation systems are far beyond the commonly acknowledge, rationalist based, cartographic systems, and not exactly always attentive to the specificity of cultural contexts. Universalism of architectural forms too, if ever seriously proposed, can no longer be conceived other than in a sort of delusional proposal.

This system of *death* via simulation processes is a crude, but concise expression of globalization, highlighting its insatiable tautological nature. Death as, for instance, death of the subject and of individuality, of the existentialist nietzschean *superman*, by means of engineered (online and instantly) simulation of exclusivity, as in to reassure (simulate) the return to its own individuality. Death as death of local and regional specificities, as to become part of the global branding cogwheel that presents (represents) itself in a ubiquitous mass (multi)media. Death, like as death of resources, as to give place to the simulation of a global blending, ever simulating, and ever representing: *Caesar's wife must be above suspicion*'.

2 THREE CASES OF GLOBAL COLLABORATIVE WORK

Globalization has certainly been serving as a kind of buzzword, attracting significant attention in many fields, in different contexts, by different people, for different purposes. But architecture has always been somewhat transnational or global, and its history seems to prove this point. Architecture has always been the result of collaborations between different actors, with the architect gathering, combining, organizing. In projects above a certain financial or visibility threshold, it is common to notice collaborative practices occurring at an international level. For instance, the *Sydney Opera House* (1959-73) begun as an international design competition which would be won by a Danish, Jørn Utzon, with creative references spanning from Japanese or Chinese cultures, to African, Magrebian, European, or North-American and Mesoamerican; the structures were calculated by a London firm, *Ove Arup & Partners*, whose founder was Anglo-Danish; the over one-million ceramic tiles cladding the building were manufactured by the Swedish company *Höganäs AB*, which co-developed them with Utzon, and from Sweden shipping them to the building site in Australia.

Another iconic example of international cooperation is the *UN Headquarters* building in New York City (1947-50). The complex is too regarded as a functional and symbolic signal of an affirmation of modernist architecture as a dominant design language of the postwar period. It was designed by an international architectural team, led by the USA architect Wallace K. Harrison. Coming from all over the world, the main architectural players, in which great figures such as Le Corbusier or Oscar Niemeyer were included, disagreed with one another and collaborated in turns for the design process[356]. According to the myth, Wallace Harrison was the 'bad' corporate architect who stole Le Corbusier's design and made it mediocre reality. In its turn, Oscar Niemeyer affirms that the sketch with the final solution was his, under the master's, Le Corbusier, acceptance. Yet the myth has its reversal, as it was a building that perhaps American would not have thought and European would not have built; a collaboration not only between architects but between different cultures—of design, construction, political or ideological—cross-fertilized in a hybrid, authentic archetype of a global modern, *International Style*.

Cross-fertilization between different kinds of expertise, as it visibly occurred in the *Sidney Opera House* is a common fact in architectural practice, as it is the case of the typical relationship of architect and engineer. Spatial and technical designs are often closely related, but nevertheless require different skills. There are also other types of fundamental expertise, such as the commercial, which require additional sets of skills. With different degrees according with the scope and type of project, all these factors concur for the success of any design. But collaborations surrounding the architectural practice often are embedded in the very creative process, on collaborative aspects of it. Such was the case of a particular collaboration between the artist Olafur Eliasson and the architect David Adjaye. A world renowned artist, Eliasson[357] devised an artist's studio that consisting of a team of about 45 people, from craftsmen and specialized technicians, to architects, artists, archivists and art historians, cooks and administrators. They work to experiment, develop, produce, and install artworks, projects, and exhibitions, as well as archiving, communicating, and contextualizing Eliasson's work. Additionally, they contract structural engineers and other specialists, and collaborate with curators, cultural practitioners, and scientists. The artist's works spans all over the world and includes collaborations with architectural offices, such as with David Adjaye's studio in the *Your Black Horizon* exhibition building for the Venice Biennale 2005: Icelandic artist with practice based in Berlin meets in Venice with Tanzanian born architect with practice based in London. Examples such as of the *Sidney Opera House*, of the *UN headquarters*, or of Olafur Eliasson and David Adjaye, are just an illustration of the innumerous possibilities of finding examples relating the architectural profession in some sort of global aura. The collaborative nature of the architectural profession is not simply an indicator of its openness, of its seeming predisposition to be positively contaminated. Such is also a notion which undermines any delusional attempt to set it as a referential discipline, or set it with a methodological foundation, as it has not one discernable body or structure, yet many shades which render ineffective any attempt of universalization.

3 THE *BO-KLOK*, OR ARCHITECTURE AS BRANDED PRODUCT

According to the *IKEA* company, the idea for better housing at lower costs was born in 1996. Apartment construction had more-or-less come to a halt—the demand for newly built apartments was very high, but no-one dared take the initiative to build specifically for the large number of people looking for apartments at reasonable prices. The decisive step would take place in a housing fair in Sweden. Two of the driving spirits behind the concept met—*IKEA* and *Skanska* CEO's—and started to discuss why all new built apartments were only for rich people: ordinary people should have the same right to live in new built dwellings adapted to the needs of modern family. As a concept this was not a novelty. But the firm determination of the proponents, added to a solid financial support, where key drivers to put the idea into practice.

A dialogue between *IKEA* and *Skanska* would soon reveal that both parties were interested in making a move on the empty market. Ingvar Kamprad, the founder of *IKEA*, had long been looking for a partner in the building industry to help build new homes for the many people. *Skanska* and its chairman Melker Schörling, was keen to join forces with *IKEA* to further strenghten its aim of becoming the first construction company in Sweden to create a broad product on the basis of an entirely new approach.

In 1997 the first four residential areas were completed in Helsingborg, Stockholm, Örebro and Sundsvall. They were all a success, as people were queuing at the *IKEA* stores to be able to buy an apartment. That was when marketing teams came up with a system of allocating the demands in order for people to choose the apartments through their plans, enabling a more transparent buying process. Up until 2012 almost 4 000 apartments at over 100 locations in 5 different countries had been built. According to the company, the customer surveys normally reveal that the people living in *BoKlok* dwellings think their apartments and the area they are living in are great, and that their monthly living cost is low and affordable to them.

As with the philosophy used in *IKEA*'s products, the *BoKlok* products are straightforward and designed to attract many people. They include cost efficient and 'smart' solutions. Constructively, all products have a wooden construction. The designs, together with state-of-the-art productions methods, have been devised in order to guarantee an overall small environmental footprint. In terms of layout, the open space solution of the kitchen and living room offer the customer flexibility to adapt the home to their specific needs. The light and airy rooms can be used for different functions at the same time. The kitchen and some other interior features of the dwellings are *IKEA*'s products. One of the design principles used in *BoKlok* homes is that there should always be natural light when entering a home or a room, meaning that given the sort of modules used in construction, that each apartment has at least three window directions. The constructive concept is based on large volumes, standardized prefabricated solutions, and a conscious customer focus from start to finish. The entire process—from the search for land, through detailed plans to the point where the customers move in—is carefully prepared and documented, ultimately meaning short time-spans from decision to completed projects.

The large volumes and efficient building methods give financial strength to involve a team of different competences in the product development phase, ensuring the creation of homes the customers want, featuring modern functionality and sustainable materials. The focus is always on the customers: who they are, how much they can afford to spend on their homes without economizing elsewhere, and how they want to live. All in all, it is a process departing from a solid constructive (physical) sphere, which allows a certain degree of user option in the plan layout (spatial) sphere and, regardless the univocal furniture supplier, a certain degree of freedom in the decorative (ornamental) sphere, and where, overall, the implementation of *mass-customization* schemes is transversal.

4 HOUSING, A GLOBAL ISSUE

Housing is one of the most basic programs with which Architecture deals with and is probably the most vastly documented: creating a shelter for man to dwell, Architecture's primordial act. The UN millennium report stated that "*the greatest challenge we face today is to ensure that globalization becomes a positive force for all the world's people, instead of leaving billions of them behind in squalor. Inclusive globalization must be built on the great enabling force of the market, but market forces alone will not achieve it. It requires a broader effort to create a shared future, based upon our common humanity in all its diversity*"[358].

This inclusion is far from reached, in fact, recent reports, more than a decade after, point out to alarming figures threatening the progress of human development and its inextricable linkage with the environment. Nearly 90 percent of the world population lacks access to modern cooking fuels (C), 80 percent lack adequate sanitation (S) and 35 percent lack clean water (W). Of these, 80 percent experience two or more deprivations and 29 percent face all three, the worse-case is in sub-saharan Africa (C 98.3, S 86.7, W 65.2 percent), followed by South Asia (C 94.1, S 86.4, W 19.4 percent), East Asia and the Pacific (C 75.1, S 62.6, W 30.5 percent), Latin America and the Caribbean (C 54.3, S 41.5, W 24.1 percent) and Europe and Central Asia (C 26.8, S 19.5, W 22.6 percent)[359].

This is not a new issue. Indeed, as stated in the Article 25.1 of the Universal Declaration of Human Rights, "*everyone has the right to a standard of living adequate for the health and well-being of himself and his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control*"[360]. More than 60 years have passed and nevertheless issues concerning housing and housing rights in the context of globalization are far from consensual and we seem a long way from the noble principles stated in the Declaration[361]. Concomitant to the issue of housing rights is the often unclear agenda of political leaders around the globe. According to the authors of a report prepared for the *World Urban Forum III* in Vancouver, "*Improving conditions and addressing the global housing crisis should be a high priority for national governments and international donors, but, for reasons that are not clear, it is not. In many countries around the world, opportunities to achieve economic, social, and civic development goals through housing-related initiatives are being missed*"[362].

A UN report on housing (2005) stated that "*more than 100 million people in the world's poorest countries are projected to be living below the basic subsistence level of a dollar a day by 2015, caught in the poverty trap that is associated with economic globalization's dark side. An in-depth study on the world's 49 least developed countries rejects claims that globalization is beneficial for the poor, arguing that the international trade and economic system is part of the problem, not the solution. Accordingly, the current form of globalization is tightening rather than loosening the international poverty trap. As markets become more entwined, the world economy is becoming increasingly polarized and the least developed countries, particularly their poorest people, are being left behind. It is important to note that this also applies to high-income industrialized countries, where a growing number of households are living below the poverty* *line due to increasing unemployment, and in many cases a simultaneous decrease of social welfare and social security as a result of reduced public investments*"[363].

By the year 2030, an additional 3 billion people, about 40 percent of the current world population, will need access to housing. This translates into a demand for 96 150 new affordable units every day and 4 000 every hour[364]. It adds that one out of every three city dwellers—nearly a billion people—lives in a slum and that number is expected to double in the next 25 years (slum indicators include: lack of water, lack of sanitation, overcrowding, non-durable structures and insecure tenure)[365]. Finally, it is projected that in the next fifty years, two-thirds (approximately 6 billion out of 9 according with several sources) of humanity will be living in towns and cities.

In the light of these smashing numbers on housing globally, it seems inevitable that people, working within the planning and building of the territory at its different scales, should increasingly focus their work with what is happening in cities. This means a concern both in the urban processes of growth, as of strengthening the bonds of the existent ones. But some signal references indicate that this is far from being an absolute idea, and can certainly have different interpretations.

One of these references lays is an idea expressed in the UN-Habitat report of 2006, where the current major challenge is to minimize burgeoning poverty in cities, improve the urban poor's access to basic facilities such as shelter, clean water and sanitation and achieve environment-friendly, sustainable urban growth and development, i.e. cities are and will be crowded and the living conditions are poor in many cases[366].

A second reference arises from the implications of the *core-periphery* model of the economist Paul Krugman[367], which relates economies of scale and transport costs, establishing that these are a major determinant of asymmetries between countries or regions. In turn, these may explain the growth of cities, and particularly the flashing growth of megacities. Nevertheless, possibilities are left open within the theory for different decentralized forces within the periphery to invert the imbalance between cities and the remaining territory, bringing to a more balanced development. If in the one hand, the path towards centralization in major urban centers seems unavoidable, on the other hand the only way for these to be sustainable implies the opposite.

A third references comes from an idea expressed in October 2011, when Rem Koolhaas, a known architectural voice of the theory of congestion, probably unexpectedly for many defended a return to the countryside as a way to the future development. He affirmed that "*rural areas are changing more rapidly than cities*", adding *"millions have moved to cities from the countryside. They have left behind a weird territory for genetic experimentation, intermittent immigration [and] vast property transactions. It's truly amazing when you look closely*"[368]. Capital and its great capacity to intervene in different territorial scales and contexts, using all sorts of strategies, has been transforming what tends to polarize between the global metropolis—taking advantage of capital flow—and the immense marginalized territories left behind.

A true, deep concern on sustainability aspects is and will be a determinant feature in the development of the inhabited space. It also seems clear that there is plenty of work to be done towards it, and that opportunities for it should regard the entire territory and not just a portion of it. Despite the somewhat idealistic character of Frank Lloyd Wright's *Broadacre City*, such seemed to envision precisely that sort of sustainable future. Nonetheless, alternatives to the growing urban centers must be searched, wherever they come from. Contemporary society has produced a proliferation of codes of signification of the city: codes that are fixed in the matter of things, (testimony of past behaviors or lifestyles still active) and mobile and plural code, which follow the erratic life of multiple populations temporarily inhabit the various parts of the territory. To recognize the codes, and code space projected onto the space itself, is their relationship that decides the allocation of a condition of 'place' to a living space. The classic dichotomy city countryside no longer makes sense. In an age where we *google* the map of any planetary location instantly, even the notion of wild nature is gone. Instead, we have to speak in humanized territory, subjected to control, chartered. If there is an urban heritage that needs to be preserved and fed, there is also the entire territory which is subjected to the same needs.

Bibliography

'Aladdin'. (2001). Aladdin Company of Bay City. Clarke Historical Library. Retrieved 2013.01.01, from http://clarke.cmich.edu/resource_tab/resource_tab_index.html

'ARA'. (2012). The Housing Finance and Development Centre in Finland. Retrieved 2012.09.24, from www.ara.fi

'Froebel Gifts'. (2008). *Froebel Gifts*. Retrieved 2013.01.01, from www.froebelweb.org

'Girders'. (2011). Girders and Gears, Prismatrix Inc. Retrieved 2013.01.01, from www.girdersandgears.com

'Lincoln Logs'. (2011). Lincoln Logs, Hasbro Inc. Retrieved 2013.01.01, from lincolnlogs.knex.com/

'SCB'. (2012). SCB Statistics Sweden: Yearbook on Housing and Building Statistics 2012. Retrieved 2012.09.21, from http://www.scb.se

'Statistics DK'. (2012). Statistics Denmark: Statistical Yearbook 2012. Retrieved 2012.09.24, from www.dst.dk/en

'Statistics FI'. (2012). Statistics Finland. Retrieved 2012.09.24, from www.stat.fi/index_en.html

'Statistics NL'. (2014). Statistics Netherlands: Construction and Housing. Retrieved 2014.07.01, from www.csb.nl

'Statistics NO'. (2012). Statistics Norway. Retrieved 2012.09.24, from www.ssb.no/english/

'Statistics US'. (2011). US Census Bureau: Census of Housing. Retrieved 2012.09.18, from http://www.census.gov/housing/census/

'The National Archives'. (2008). Inter-departmental Committee on House Construction (Burt Committee): Minutes, Papers and Reports. Retrieved 2014.06.01, from http://discovery.nationalarchives.gov.uk/SearchUI/details/C8789-details

'University of the West of England'. (2013). System Building. Retrieved 2014.06.01, from www.uwe.port.ac.uk/industbld/Index.htm

Aalto, A. (1994). *The architectural drawings of Alvar Aalto, 1917-1939. Vol.7, Buildings and plans for the A. Ahlström Company in Varkaus, and type houses, 1937-1939*. New York; London: Garland.

Aicher, O. (2001). *Analógico y Digital*: Editorial Gustavo Gili, S.L.

Albrecht, D., & Crawford, M. (Eds.). (1995). *World War II and the American Dream: How Wartime Building Changed a Nation*. Cambridge, MA: MIT Press, National Building Museum.

Alonso-Zandari, S., & Hashemi, A. (2017). *Prefabrication in the UK housing construction industry*. Paper presented at the 5th International Conference on Zero Energy Mass Customised Housing - ZEMCH 2016, Kuala Lumpur, Malaysia.

Anderson, S. (2000). *Peter Behrens and a new architecture for the twentieth century*. Cambridge, Mass.: MIT Press.

Andrews, D., Sánchez, A. C., & Johansson, Å. (2011). Housing Markets and Structural Policies in OECD Countries. *OECD Economics Department Working Papers,* (No. 836). http://dx.doi.org/10.1787/5kgk8t2k9vf3-en

Arieff, A., & Burkhart, B. (2002). *Prefab* (1st ed.). Salt Lake City: Gibbs Smith.

Arribas, I., Pérez, F., & Tortosa-Ausina, E. (2009). Measuring Globalization of International Trade: Theory and Evidence. *World Development, 37*(1), 127-145. doi: 10.1016/j.worlddev.2008.03.009

Atkin, B. (1999). *Innovation in the Construction Sector.* European Council for Construction Research, Development and Innovation Retrieved from www.eccredi.org/downloads/innovation.pdf.

Aymonino, C. (1976). *La vivienda racional : ponencias de los congresos CIAM 1929-1930*. Barcelona: Gustavo Gili.

Bachelard, G. (1994). *The poetics of space* (M. Jolas & J. R. Stilgoe, Trans.). Boston: Beacon Press.

Banham, R. (2002). *The Ford century : Ford Motor Company and the innovations that shaped the world* (1st ed.). New York: Artisan.

Barlow, J., & Ozaki, R. (2005). Building mass customised housing through innovation in the production system: lessons from Japan. *Environment and Planning A, 37*(1), 9-20. doi: 10.1068/a3579

Baudrillard, J. (1994). *Simulacra and simulation*. Ann Arbor: University of Michigan Press.

Benevolo, L. (2009). *O último capítulo da arquitectura moderna* (J. E. Rodil, Trans. Reimp. ed.). Lisboa: Edições 70.

Benjaafar, S., & Sheikhzadeh, M. (1995). Batch sizing models for flexible manufacturing cells: Working paper, Department of Mechanical Engineering, University of Minnesota.

Bergdoll, B., Christensen, P., & Broadhurst, R. (2008). *Home Delivery: Fabricating the Modern Dwelling.* New York: Museum of Modern Art.

Berger, J. (1972). *Ways of Seeing.* London, Harmondsworth: BBC, Penguin Books.

Berger, J., & Savage, J. (2005). *Berger on drawing.* Aghabullogue, Co. Cork, Ireland: Occasional Press.

Blundell-Jones, P. (2002). *Modern Architecture Through Case Studies*. Oxford: Architectural Press.

Brand, S. (1995). *How buildings learn: what happens after they're built*. London: Penguin Books.

Brock, L., & Brown, J. (2000). *The prefabricated house in the twenty-first century: What can we learn from Japan? A case study of the KST-Hokkaido house*. Paper presented at the World Conference on Timber Engineering, Whistler Resort, British Columbia, Canada July 31 - August 3. http://timber.ce.wsu.edu/Resources/papers/4-2-3.pdf

Calinescu, M. (1999). *As cinco faces da Modernidade : Modernismo - Vanguarda - Decadência - Kitsch - Pós-modernismo* (J. T. Meneses, Trans.). Lisboa: Vega.

Castells, M. (2002). *A Sociedade em Rede - A Era da Informação : Economia, Sociedade e Cultura, Vol 1 [English version: The Rise of the Network Society, The Information Age: Economy, Society and Culture Vol I]*. Lisbon: Fundação Calouste Gulbenkian.

Collymore, P. (1994). *The architecture of Ralph Erskine* (Rev. ed.). London: Academy Editions.

Cook, P. (Ed.). (1999). *Archigram*. New York: Princeton Architectural Press.

Damásio, A. R. (1996). *O Erro de Descartes: Emoção, Razão e Cérebro Humano* (D. Vicente & G. Segurado, Trans. 16th ed.). Lisbon: Europa-América.

Davies, C. (1993). *Hopkins : the work of Michael Hopkins and Partners*. London: Phaidon.

Davies, C. (2005). *The prefabricated home*. London: Reaktion.

Descartes, R. (1637). *Discourse on the Method*. Retrieved (2013.01.01) from Project Guttenberg (2008): www.gutenberg.org/files/59/59-h/59-h.htm.

Descartes, R. (1644). *The Principles of Philosophy*. Retrieved (2013.01.01) from Project Guttenberg (2003): www.gutenberg.org/cache/epub/4391/pg4391.html.

Dudley, G. A. (1994). *A workshop for peace: designing the United Nations headquarters*: Architectural History Foundation.

Dwell Magazine. (2012). Retrieved 2012.06.09, from www.dwell.com

Edge, M. (2002). *Overcoming Client and Market Resistance to Prefabrication and Standardisation in Housing*. Aberdeen: Robert Gordon University.

Egan, J. (1998). Rethinking Construction - Construction Task Force to the Deputy Prime Minister, John Prescott. London: Department of Trade and Industry.

Egan, J., & Strategic Forum for Construction (Eds.). (2002). *Accelerating Change* London: Rethinking Construction.

Eldemery, I. M. (2009). Globalization Challenges in Architecture. *Journal of Architectural and Planning Research, 26*(4), 343.

Eliade, M. (1959). *Cosmos and history : the myth of the eternal return*. New York: Harper & Brothers Publishers.

Eliade, M. (1992). *O sagrado e o profano* (R. Fernandes, Trans.). Lisboa: Livros do Brasil.

Eliasson, O. (2012). Olafur Eliasson. from http://www.olafureliasson.net

English Housing Survey team. (2015). *English Housing Survey: Households*. London: Department for Communities and Local Government.

ETU. (2007). Understanding Globalization. *Education and Training Unit for Democracy and Development*. Retrieved 2012.04.12, from http://www.etu.org.za/toolbox/docs/development/globalisation.html

Directive 2009/28/EC of the European Parliament and of the Council of the European Union (23 April 2009). *On the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC* (2009).

European Commission. (2013). *Industry Policy Indicators and Analysis*. Directorate General Enterprise and Industry - Unit A4 "Industrial Competitiveness Policy for Growth" - European Union Retrieved from http://ec.europa.eu/enterprise/policies/industrial-competitiveness/economic-crisis/monthly_notes_en.htm.

Eurostat. (2013). Construction statistics - NACE Rev. 2. *Eurostat, Statistics Explained*: European Commission.

Foucault, M. (1967). *Of Other Spaces, Heterotopias*. Diacritics (1986) (Vol. 16, No. 1, pp. 22-27): Spring.

Foucault, M. (1983). *This is not a pipe*. Berkeley: University of California Press.

Fulcher, M. (2011). Rem Koolhaas turns back on cities. *Architects Journal.* http://www.architectsjournal.co.uk/news/daily-news/rem-koolhaas-turns-back-on-cities/8621130.article

Fuller, R. B., Krausse, J., & Lichtenstein, C. (1999). *Your private sky : R. Buckminster Fuller, the art of design science*. Baden: Museum für Gestaltung Zürich., L. Muller.

Fumiaki, K. (2003). Opportunity and Challenge Changing Housing Market in Japan. Osaka: Japan Management Association.

Gannon, T. (2017). *Reyner Banham and the Paradoxes of High Tech*. Los Angeles: Getty Research Institute.

Gervásio, H. (2010). *Sustainable Design and Integral Life-Cycle: Analysis of Bridges.* (PhD), University of Coimbra, Coimbra.

Gibb, A. G. F. (1998). *Off-site fabrication : prefabrication, pre-assembly and modularisation*. Latheronwheel: Whittles.

Giddens, A. (2004). *Sociologia [English version: Sociology, 4th edition]*. Lisbon: Fundação Calouste Gulbenkian.

Giedion, S. (1941). *Space, time and architecture; the growth of a new tradition*. Cambridge, London: The Harvard University Press; H. Milford, Oxford University Press.

Gil, J. (2001). *Movimento total : o corpo e a dança* (M. S. Pereira, Trans.). Lisboa: Relógio d'água.

Girault, J. (1998). *Ouvriers en banlieue, XIXe-XXe siècle*. Paris: Editions de l'atelier / Editions ouvrières.

Goldhoorn, B. (2002). Microrayon. *Project Russia, 25*.

Golub, J., & Frey, A. (1999). *Albert Frey houses 1 + 2*. New York, NY.: Princeton Architectural Press.

Gomes, R. J. (1978). *Necessidades humanas e exigências funcionais da habitação*. Lisboa: LNEC.

Goodheart, A. (1996). Why Dolores Chumsky hates Thomas Edison. *Discovery.com* . Retrieved 2013.01.01, from http://flyingmoose.org/truthfic/edison.htm

Gropius, W. (1965). *The new architecture and the Bauhaus*. Cambridge, Mass.,: M.I.T. Press.

Guidot, R. (Ed.). (1983). *Architecture et industrie: passé et avenir d'un mariage de raison. Exhibition catalogue, Centre Georges Pompidou*. Paris: Centre de Création Industrielle.

Habraken, N. J. (1972). *Supports: an alternative to mass housing*. New York,: Praeger Publishers.

Habraken, N. J., & Mignucci, A. (2009). *Soportes: vivienda y ciudad - Supports: housing and city*. Barcelona: Universitat de Catalunya.

Hall, E. T. (1990). *The hidden dimension*. New York: Anchor Books.

Hammond, E. (2011). Construction: Across Europe, small builders find they are fighting a losing battle. *Finantial Times*. Retrieved from Finantial Times - Global property insight website: http://globalpropertyinsight.ft.com/#/articles/10

Hansen, B. G. (2005). Gilbert Erector Set Guidebook 1913-1988, A. C. Gilbert Heritage Society. Retrieved 2013.01.01, from www.acghs.org

Harrison, H., Mullin, S., Reeves, B., & Stevens, A. (Eds.). (2004). *Non-traditional Houses: Identifying non-traditional houses in the UK 1918-75*. Digital Edition 2012: IHS BRE Press.

Harvey, D. (2005). *The condition of postmodernity : an enquiry into the origins of cultural change*. Oxford England ; Cambridge, Mass., USA: Blackwell.

Heidegger, M. (2005). *Ser e Tempo : Parte I* (15 ed.). Petrópolis: Editora Vozes.

Hellgardt, M. (1987). Martin Wagner: the work of building in the era of its technical reproduction. *Construction History, 3*, 95-114.

Herbert, G. (1978). *Pioneers of prefabrication : the British contribution in the nineteenth century*. Baltimore ; London: The Johns Hopkins University Press.

Herod, A. (2009). *Geographies of globalization : a critical introduction*. Malden, MA ; Oxford: Wiley-Blackwell.

Hertzberger, H. (2002). *Herman Hertzberger : articulations*. Munich London: Prestel.

Hertzberger, H. (2005). *Lessons for students in architecture* (5th ed.). Rotterdam: 010 Publishers.

Hertzberger, H. (2010) *Schools of thought: Herman Hertzberger/Interviewer: J. Payne*. Architecture Today.

Hertzberger, H. (2010). Schools of thought: Herman Hertzberger. In J. Payne (Ed.): Architecture Today.

HFH. (2012). Habitat for Humanity. www.habitat.org

Hillier, B. (1996). *Space is the machine : a configurational theory of architecture*. Cambridge ; New York, NY, USA: Cambridge University Press.

Hitchcock, H. R., & Johnson, P. (1932). *The international style: architecture since 1922* (lst ed.). New York,: W. W. Norton & company.

Home, M., & Taanila, M. (2002). *Futuro: Tomorrow's House from Yesterday*: Desura.

Housing Forum. (2002). *Homing in on excellence: A commentary on the use of off-site fabrication methods for the UK housebuilding industry*. London: Housing Forum.

Hughes, T. (2010). Four Steel Walls. Retrieved 2014.06.01, from www.foursteelwalls.co.uk

Imperiale, A. (2012). *An American wartime dream: 'The Packaged House' system of Konrad Wachsmann and Walter Gropius*. Paper presented at the 2012 ACSA Fall Conference / Modular Building Institute, Temple University, Philadelphia.

Jacob, C. (1992). *L'empire des cartes : approche théorique de la cartographie à travers l'histoire*. Paris: A. Michel.

Johnson, W. (2007). *Lessons from Japan: A comparative study of the market drivers for prefabrication in Japanese and UK private housing development.* UCL (University College London).

Jones, D. E. (2010). *Fast, Cheap and in Control.* Paper presented at the 98th ACSA Annual Meeting Proceedings, Rebuilding, Tulane University, New Orleans, LA.

Kaila, A. M. (2016). *Moduli 225: A Gem of Modern Architecture*: Aalto University, School of Art and Design.

Kärkkäinen, M. (Ed.). (1991). *International Alvar Aalto Symposium (5 : 1991 : Jyväskylä), Functionalism - utopia or the way forward?* Jyväskylä: Alvar Aalto Museum.

Kavanaugh, L. J. (2007). *The Architectonic of Philosophy: Plato, Aristotle, Leibniz*: Amsterdam University Press.

Kenna, P. (2008). Globalization and Housing Rights. *Indiana Journal of Global Legal Studies, 15*(2), 397-469.

Kennedy, A. J. (2006). *Bauhaus*. London: Flame Tree.

Kinchin, J., & O'Connor, A. (2011). *Counter Space: Design and the Modern Kitchen*: Museum of Modern Art.

Kirsch, K. (2013). *The Weissenhofsiedlung: Experimental Housing Built for the Deutscher Werkbund, Stuttgart, 1927*: Edition Axel Menges GmbH.

Klein, A. (1980). *Vivienda mínima 1906-1957*. Barcelona: Gustavo Gili.

Knaack, U., Chung-Klatte, S., & Hasselbach, R. (2012). *Prefabricated Systems: Principles of Construction*: De Gruyter.

Korvenmaa, P. (1990). The Finnish Wooden House Transformed: American prefabrication, war-time housing and Alvar Aalto. *Construction History, 6*, 47-61.

Korzybski, A. (1933). *Science and sanity : an introduction to non-Aristotelian systems and general semantics* (1st ed.). New York, NY; Lancaster, Pa: International Non-Aristotelian Library Pub. Co.; Science Press Printing Co., distributors.

Kossak, F. (2012). An Architect's Tagwerk: Notes on Otto Steidle's work between the urban and the rural. *ARQ: Architectural Research Quarterly, 15(04)*, 327-340. doi: 10.1017/S1359135512000097

Krugman, P. (2008). The increasing returns revolution in trade and geography. *Nobel Prize Lecture, December 8, 2008*. http://www.nobelprize.org/nobel_prizes/economics/laureates/2008/krugman_lecture.pdf

Kunstler, J. H. (1998). *The geography of nowhere : the rise and decline of America's man-made landscape*: Touchstone Press.

Lagerlund, H. (Ed.). (2007). *Forming the mind : essays on the internal senses and the mind/body problem from Avicenna to the medical enlightenment*. Dordrecht, The Netherlands: Springer.

Lawmart. (2015). Copyright vs Trademark vs Patent. Retrieved 2015.06.01, from www.lawmart.com/forms/difference.htm

Le Corbusier. (1995). *Vers une architecture* (Nouvelle ed.). Paris: Flammarion.

LeCuyer, A. W. (Ed.). (1996). *Richard Horden : Light Architecture*. Ann Harbor, Michigan: College of Architecture + Urban Planning, The University of Michigan.

Lefebvre, H. (2005). *The production of space*. Oxford, OX, UK ; Cambridge, Mass., USA: Blackwell.

Levinson, M. (2006). *The box : how the shipping container made the world smaller and the world economy bigger*. Princeton, N.J.: Princeton University Press.

Lewis, M. (2013). The History of Iron-Prefab Housing. Retrieved 2014.06.01, from http://livingsteel.org/article/the-history-of-iron-prefab-housing

Lihotzky, G. (1927). Rationalization in the Household. In A. Kaes, M. Jay, & E. Dimendberg (Eds.), The Weimar Republic Sourcebook (Vol. 3 of Weimar and Now: German Cultural Criticism, pp. 462-465): University of California Press.

Machado, R., & Geuze, A. (2005). *Residential waterfront, Borneo Sporenberg, Amsterdam*. Cambridge Mass.: Harvard University Graduate School of Design.

Magritte, R. (1929). Les Mots et les Images. *La Révolution Surréaliste*(12), 32-33.

Mandelson, P. (2010). Is The Banking Crisis A Crisis For Globalization? *Forbes*. Retrieved from Forbes.com website: http://www.forbes.com/2010/03/03/banking-crisis-globalization-opinions-contributors-peter-mandelson.html

Mankiw, N. G., & Weil, D. N. (1989). The Baby Boom, The Baby Bust, And The Housing Market. *Regional Science and Urban Economics 19*, 235-258.

Matthews, S., & Reeves, B. (2012). *Structural Assessment of Large Panel Systems (LPS) Dwelling Blocks for Accidental Loading*. Garston, Watford: BRE.

May, E. (1929). Flats for Subsistence Living. Retrieved 2014.06.01, from http://modernistarchitecture.wordpress.com/2011/09/10/ernst-may%E2%80%99s-%E2%80%9Cflats-for-subsistence-living%E2%80%9D-1929-2/

McBeth, D. G. (1998). Francois Hennebique (1842-1921), Reinforced Concrete Pioneer. *Proceedings of the Institution of Civil Engineers - Civil Engineering, 126*(2), 86-95. doi: 10.1680/icien.1998.30436

Meadows, D. H., Randers, J., & Meadows, D. L. (2004). *The limits to growth : the 30-year update*. White River Junction, Vt: Chelsea Green Publishing Company.

Merleau-Ponty, M. (1964). *The Primacy of Perception (And Other Essays on Phenomenological Psychology, the Philosophy of Art, History, and Politics)*. Evanston, Ill.: Northwestern University Press.

Merleau-Ponty, M. (1992). *O olho e o espírito*. [Lisboa]: Vega.

Mersmann, H. (2014). HOFINET - Housing Finance Information Network: Netherlands Country Profile. Retrieved 2014.07.01, from www.hofinet.org/countries/description.aspx?regionID=3&id=119

Miśkiewicz, J., & Ausloos, M. (2010). Has the world economy reached its globalization limit? *Physica A: Statistical Mechanics and its Applications, 389*(4), 797-806. doi: 10.1016/j.physa.2009.10.029

Mitchell, W. J. (2000). *E-topia : "Urban life, Jim--but not as we know it"*. Cambridge, MA: MIT Press.

Montaner, J. M., & Muxí, Z. (2011). *Arquitectura y política ensayos para mundos alternativos*. Barcelona: GG.

Mornement, A., & Holloway, S. (2007). *Corrugated Iron: Building on the Frontier*: Pan Macmillan Limited.

Mourão, J. F., & Pedro, J. B. (2010). *Sustentabilidade Ambiental da Habitação (Relatório 239/2010 - NAU)*. Lisbon: Ed. LNEC.

Noguchi, M. (2010). Mass Custom Home. Retrieved 2013.01.01, from www.masscustomhome.com

Nord, T. (2008). *Prefabrication strategies in the timber housing industry*. Luleå University of Technology - Department of Civil and Environmental Engineering Division of Structural Engineering. http://epubl.luth.se/1402-1544/2008/51/LTU-DT-0851-SE.pdf

Ochi, F. (2005). Housing & Home Warranty Programs World Research: Organization for Housing Warranty Japan

Ohno, T. (1988). *Toyota production system : beyond large-scale production*. Cambridge, Mass.: Productivity Press.

Oshima, K. T. (2008). Postulating the Potential of Prefab: The Case of Japan. In B. Bergdoll, P. Christensen, & R. Broadhurst (Eds.), *Home Delivery: Fabricating the Modern Dwelling* (pp. 32-37). New York: Museum of Moderrn Art.

Pallasmaa, J. (1991). *From Metaphorical to Ecological Functionalism*. Paper presented at the International Alvar Aalto Symposium (5 : 1991 : Jyväskylä), Functionalism - utopia or the way forward?, Jyväskylä.

Pallasmaa, J. (1996). *The eyes of the skin : architecture and the senses*. London: Academy Editions.

Pallasmaa, J. (2009). *The Thinking Hand : Existential and Embodied Wisdom in Architecture*. Chichester, U.K.: Wiley.

Palumbo, M. L. (2000). *New wombs : electronic bodies and architectural disorders*. Basel: Birkhäuser.

Pawley, M. (1973). *The private future. Causes and consequences of community collapse in the West*. London: Thames and Hudson.

Pearson, C., & Delatte, N. (2005). Ronan Point Apartment Tower Collapse and its Effect on Building Codes. *Journal of Performance of Constructed Facilities, 19*(2), 172-177. doi:10.1061/(ASCE)0887-3828(2005)19:2(172)

Phillipson, M., Scotland, B., & Lane, B. (2001). Defining the Sustainability of Prefabrication and Modular Process in Construction 36/08/328 cc2114 Interim Report.

Piaget, J., & Inhelder, B. (1997). *The Child's Conception of Space*: Routledge.

Piñar, C. F. (2013). *El AA-system de Alvar Aalto: análisis constructivo. Evolución entre la 1ª y la 2ª serie* Paper presented at the Octavo Congreso Nacional de Historia de la Construcción, 9-12 de Octubre de 2013, Madrid.

Pine II, B. J. (1993). *Mass Customization: The New Frontier in Business Competition*. Boston: Harvard Business School Press.

Pine II, B. J., & Gilmore, J. H. (1997). The Four Faces of Mass Customization. *Harvard Business Review*. Retrieved from Harvard Business Review website: www.hbr.org

Pine II, B. J., Victor, B., & Boynton, A. C. (1993). Making Mass Customization Work. *Harvard Business Review,* 107-116.

Pittini, A., & Laino, E. (2011). Housing Europe Review : The nuts and bolts of European social housing systems. Brussels, Belgium: CECODHAS Housing Europe's Observatory.

Rapoport, A. (1969). *House form and culture*. Englewood Cliffs, N.J.,: Prentice-Hall.

Reiff, D. D. (2000). *Houses from books : treatises, pattern books, and catalogs in American architecture, 1738-1950 : a history and guide*. University Park, Pa.: Pennsylvania State University Press.

Risselada, M., & Van Den Heuvel, D. (Eds.). (2005). *Team 10: 1953 - 81, in Search of a Utopia of the Present*: NAi Publishers.

Rybkowska, A., & Schneider, M. (2011). Housing conditions in Europe in 2009. European Union: Eurostat.

Salvador, F., de Holan, P. M., & Peiller, F. (2009). Cracking the Code of Mass Customization. *MIT Sloan Management Review, 50*(3), 71-78.

Sanz, Y. O. (2013). *Arne Jacobsen: Innovación y prefabricación*. Paper presented at the Octavo Congreso Nacional de Historia de la Construcción, Madrid, 9-12 de octubre de 2013, Madrid.

Scheuerman, W. (2010). Globalization. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Summer 2010 ed.).

Schildt, G. (1994). *Alvar Aalto : the complete catalogue of architecture, design, and art*. London: Academy Editions.

Schildt, G. (1998). *Alvar Aalto in his own words*. New York: Rizzoli International Publications.

Schlereth, T. J. (1982). Mail-Order Catalogs as Resources in American Culture Studies. *Prospects, 7*(1), 141-161. doi: 10.1017/S0361233300003495

Schomaker, T. M. (2003). Urban analysis of Onkel Toms Hütte. Retrieved 2014.06.01, from http://www.lostmodern.net/biglinks/en_onkeltom_web.pdf

Simmel, G. (1903). The Metropolis and Mental Life. In G. Bridge & S. Watson (Eds.), *The Blackwell city reader* (pp. 11-19). (2002). Oxford and Malden, MA: Blackwell Publishing.

Smith, E. A. T., Shulman, J., & Gössel, P. (2002). *Case study houses*. Köln, London: Taschen.

Smith, M. J. (2010). Henry B. Neef House. *National Register of Historic Places*. Retrieved 2014.01.01, from www.nebraskahistory.org/histpres/nebraska/douglas/DO09-Neef-House.pdf

Smith, R. E. (2008). *Lean Architecture: Toyota Homes*. Paper presented at the 2008 UMass Wood Structures Symposium, Amherst.

Smith, R. E. (2009). *History of Prefabrication: A Cultural Survey*. Paper presented at the Proceedings of the Third International Congress on Construction History, Cottbus, May 2009.

Smith, R. E. (2010). *Prefab architecture: a guide to modular design and construction*. Hoboken, N.J.: John Wiley & Sons.

Some Assembly Required: Contemporary Prefabricated Houses. (2006). Retrieved 2012.06.09, from http://design.walkerart.org/prefab

Spoerl, J. S. (2004). A Brief History of Iron and Steel Production. Retrieved 2014.06.01, from www.anselm.edu/homepage/dbanach/h-carnegie-steel.htm

Staib, G., Dörrhöfer, A., & Rosenthal, M. J. (2008). *Components and systems : Modular construction : design, structure, new technologies*. Basel: Birkhäuser.

Stawinska, A. (2010). The EU-27 construction sector: from boom to gloom. *Eurostat, Statistics in Focus*: Eurostat, European Comission.

Steinbeck, J. (1939). *The Grapes of Wrath*. New York: Viking Press.

Stiny, G. (1980). Kindergarten grammars: designing with Froebel's building gifts. *Environment and Planning B, 7*(4), 409-462. doi: 10.1068/b070409

Storr, W. (2011). Bulldozers home in on historic prefab estate: The battle to preserve Britain's largest surviving estate of post-war prefab houses is over. *The Telegraph*. Retrieved from www.telegraph.co.uk/property/8701977/Bulldozers-home-in-on-historic-prefab-estate.html

Strauven, F. (1998). *Aldo van Eyck : the shape of relativity*. Amsterdam: Architectura & Natura.

Stuttgart. (2002). Weissenhofsiedlung - International Architecture Forum 2002. Retrieved 2013.06.01, from www.weissenhof2002.de

Sweeney, M. S. (2011). *Brainworks : the mind-bending science of how you see, what you think, and who you are*. Washington, D.C.: National Geographic.

Tafuri, M. (1976). *Architecture and utopia : design and capitalist development*. Cambridge, Mass.: MIT Press.

Távora, F. (1996). *Da organização do espaço* (3 ed.). Porto: FAUP.

Taylor, F. W. (2007). *The principles of scientific management* (Reprinted ed.). Minneapolis: Filiquarian Publishing.

Teige, K. (2002). *The minimum dwelling*. Cambridge, Mass.: MIT Press, Graham Foundation for Advanced Studies in the Fine Arts.

Thoreau, H. D. (2006). *Walden, or Life in the woods*. Penn State Electronic Classics Series (Original Pub. - Boston : Ticknor and Fields, 1854),

Timmerman, K. (2012). *Where am I wearing? : a global tour to the countries, factories, and people that make our clothes* (2nd ed.). Hoboken, N.J.: Wiley.

Tobriner, S. (1997). Response of Traditional Wooden Japanese Construction. Retrieved 2013.06.01, from http://nisee.berkeley.edu/kobe/tobriner.html

Toffler, A. (1980). *The third wave*. London: Pan books.

Toussaint, M. (2012). *Da Arquitectura à Teoria : Teoria da Arquitectura na primeira metade do século XX em Portugal*. Casal de Cambra: Caleidoscópio.

Toyota. (2013). Toyota Home. Retrieved 2013.06.01, from www.toyotahome.co.jp

Turner, J. F. C. (1976). *Housing by people: towards autonomy in building environments*. London: Marion Boyars.

Umland, A. (Ed.). (2013). *Magritte: The Mystery of the Ordinary, 1926–1938*. New York: MoMA Publications.

UN-Habitat. (2006). World Urban Forum III. www.unhabitat.org

UN. (1948). The Universal Declaration of Human Rights. www.un.org

UN. (2000). United Nations Millenium Report. http://www.un.org/millennium/sg/report/index.html

UN. (2011). Human Development Report 2011. www.hdr.undp.org

UN HDR. (2010). Human Development Report 2010 *UN - United Nations*. Web resource: United Nations.

Urban, F. (2013). *Tower and Slab: Histories of Global Mass Housing*: Taylor & Francis.

Utzon, J., & Weston, R. (2009). *Jørn Utzon Logbook V: Additive Architecture*. Hellerup: Mogens Prip-Buus & Edition Bløndal.

Vale, B. (1995). *Prefabs : a history of the UK temporary housing programme* (1st ed.). London: Spon.

Valena, T. F., Avermaete, T., & Vrachliotis, G. (2011). *Structuralism Reloaded?: Rule-Based Design in Architecture and Urbanism*: Edition Axel Menges GmbH.

van den Thillart, C. C. A. M. (2004). *Customized Industrialization in the Residential Sector: Mass Customisation Modelling as a Tool for Benchmarking, Variation and Selection*. Amsterdam: Sun.

Vegesack, A. v., Dumont d'Ayot, C., & Reichlin, B. (2006). *Jean Prouvé: The Poetics of the Technical Object* (1st ed.). Weil am Rhein: Vitra Design Stiftung.

Venables, T., & Courtney, R. (2004). Modern Methods of construction in Germany - playing the off-site rule. London: Department of Trade and Industry (DTI) Global Watch Service.

Virilio, P. (2000). *Velocidade de libertação [English version: Open sky]*. Lisbon: Relógio D'Água Editores.

Wærn, R. (2008). Scandinavia: Prefabrication as a Model of Society. In B. Bergdoll, P. Christensen, & R. Broadhurst (Eds.), *Home Delivery: Fabricating the Modern Dwelling* (pp. 27-31). New York: Museum of Moderrn Art.

Waskett, P., & Phillipson, M. (2001). Defining the Sustainability of Prefabrication and Modular Process in Construction *DTI Construction Industry Directorate Project Report : Current Practice and Potential Uses of Prefabrication*: BRE Scotland.

Way, S. (2011). Leing Easi-Form Housing. Retrieved 2014.06.01, from www.collier-stevens.co.uk/surveyors-blog/2011/laing-easi-form-housing/#.U-ISrmPP1VA

Weston, R. (2002). *Jorn Utzon: Inspiration, Vision, Architecture*. Hellerup: Edition Bløndal.

Wiencek, H. (1987). *The world of LEGO toys*. New York: H.N. Abrams.

Wilson, W. (1998). *The Finnish Wood House - Yesterday Today Tomorrow.* (Master), University of Washington, Seattle. Retrieved from www.habiter-autrement.org/11.construction/contributions-11/The-Finnish-Wood-House.pdf

Wittgenstein, L. (1995). *Tratado Lógico-Filosófico - Investigações filosóficas* (M. S. Lourenço & T. d. Oliveira, Trans. 2ª ed.). Lisboa: Fundação Calouste Gulbenkian.

Womack, J. P., & Jones, D. T. (2003). *Lean thinking : banish waste and create wealth in your corporation* ([Rev. ed.] ed.). New York: Free Press ; London : Simon & Schuster.

Yarnal, B., & Aman, D. (2009). An Examination of Mobile Homes in Rural Pennsylvania. Harrisburg, PA: The Center for Integrated Regional Assessment at Pennsylvania State University.

Young, D., & Young, M. (2007). *The Art of Japanese Architecture*: Tuttle Publishing.

Zipkin, P. (2001). The Limits of Mass Customization. *MIT Sloan Management Review, 42*(3), 81-87.

Table of Acronyms

AHP	*Affordable Houses Project*
AIROH	*Aircraft Industries Research Organisation on Housing*
BIM	*Building Information Modelling*
BISF	*British Iron and Steel Federation*
BOM	*Bill of Materials*
CAD	*Computer-Aided Design*
CAM	*Computer-Aided Manufacturing*
CEO	*Chief Executive Officer*
CFS	*Cold-Formed Steel*
CIAM	*Congrès Internationaux d'Architecture Moderne*
CLASP	*Consortium of Local Authorities Special Programme*
CNC	*Computer Numerical Control*
DC	*District Capital*
DEWOG	*Deutsche Wohnungsfürsorgung Aktiengesellschaft für Beamte, Angestellete und Arbeiter* ["*Shareholder German Company for the Improvement of Housing for Civil Servants, Employees and Workers*"]
DSME	*Daewoo Shipbuilding & Marine Engineering*
DTI	*Department of Trade and Industry*
EPSRC	*Engineering and Physical Sciences Research Council*
EU	*European Union*
GDP	*Gross Domestic Product*
GDR	*German Democratic Republic, or East Germany*
GEHAG	*Gemeinnützige Heimstätten-, Spar- und Bau-Aktiengesellschaft* ["*Housing Cooperative for Savings and Construction*"]
HHI	*Hyundai Heavy Industries*
HUD	*Housing and Urban Development*
HVAC	*Heat Ventilation and Air Conditioning*
ICAT	*International Congress for Architecture and Town-Planning*
IFD	*Industrial, Flexible and Demountable*
IG	*Independent Group*
IMF	*International Monetary Fund*
ISISE	*Institute for Sustainability and Innovation in Structural Engineering*
ISNSC	*International Scientific Networks in Steel Construction*
ISO	*International Organization for Standardization*

IT's	*Information Technologies*
LCE	*life-cycle end*
LED	*Light-Emitting Diode*
LEED	*Leadership in Energy and Environmental Design*
LPS	*Large-Panel concrete Systems*
LT	*Lean Thinking*
MARS	*Modern Architectural Research Group*
MBOM	*Manufacturing Bill of Materials*
MC	*Mass-Customization*
MHI	*Mitsubishi Heavy Industries*
MIT	*Massachusetts Institute of Technology*
MP	*Mass-Production*
NASA	*National Aeronautics and Space Administration*
NYC	*New York City*
OECD	*Organisation for Economic Co-operation and Development*
OEM	*Original Equipment Manufacturer*
OPP	*Order Penetration Point*
OSB	*Oriented Stranded Board*
OSM	*Off-Site Manufacturing*
PE	*Polyethylene*
R&D	*Research & Development*
RIBA	*Royal Institute of British Architects*
SAR	*Foundation for Architects Research*
SFC	*Strategic Forum for Construction*
SFHC	*Steel Frame House Company*
TPS	*Toyota Production System / Temporary Housing Programme*
TV	*Television*
UC	*University of Coimbra*
UFO	*Unidentified Flying Object*
UK	*United Kingdom*
UN	*United Nations*
USA	*United States of America*
USSR	*Soviet Union*
VEHA	*Veteran Emergency Housing Act*
WBSC	*Walter Bates Steel Corporation (*
WWI	*World War I*
WWII	*World War II*

Table of Figures

Table of Tables

References

1 Cf. Heidegger (2005).

2 Cf. Toussaint (2012).

3 Such designates the doctrine of the scientific in our knowledge, seen as a method that enables the coordination of a certain system that is formed under an idea, or generally the art of constructing systems, implying a whole that is an organized unity and not an aggregate.

As noted by Kavanaugh (cf. 2007), this notion of unity is essential in Kant, as there is the conception of a pure logical corpus of reason. "*Ultimately, the concept of the 'architectonic' was borrowed from Kant, albeit with differing intentions. Kant wished to mount an indestructible defense against speculation in metaphysics, both immutable and legislative, carefully delimiting what could be considered as knowledge based upon pure reason. Kant may have regarded the sum of the cognition of pure speculative reason as an edifice, but prior to all apriori intuitions of space and time lay the determination of philosophy itself as the founding/grounding/limiting of the possibility of all knowledge, whether reason or intuition, practical or pure. Like the surveyor who lays out the benchmarks and outlines the site for the excavation and eventual construction of foundations, philosophy is, at its ground, engaged in the construction or clearing or founding in order to ask the question, the question that "has always been asked". Therefore, philosophy, not just as a metaphysics of transcendence, but all philosophy dealing with the conditions of possibility of all ontology, is fundamentally an architectonic*" (Kavanaugh, 2007: 16).

4 In Aristotle the *architectonic* had been related to an idea of genesis, i.e. a continuous creative search onto the fundamentals, or a hypothetical basic unity from where things come-to-be, which is made of generation and corruption (or de-generation). "*The architectonic in Aristotle is a continuum of infinity, magnitude, time, and place; a never-ending and never-failing circular line of coming-to-be and passing away*" (Kavanaugh, 2007: 14). "*Not only is it comprehensive, but it truly attempts to describe a continuum of not only phenomena, but also a unity of substantial particulars (…) (where) Being and Unity are One. (…) Aristotle's continuum encompasses not only the phenomenal magnitudes, but also the limits of time and place; not only the discrete in mathematics, but the infinite 'unlimited' universe as a sphere. And, in the end, there is no end (nor beginning), (…) the cycle of generation and corruption is infinitely never-ending continuity*" (2007: 69-70). "*(For Aristotle) there are six kinds of change: generation, destruction, increase, diminution, alteration, and locomotion. These changes are arranged into four groups: substantial change (…), quantitative change (…), qualitative change (…), and localized motion or change of place (…). Every change, with the exception of locomotion, is a substantial change, the actualization of a potential. Only generation and corruption are substantial changes*" (2007: 73). "*There are four possibilities of genesis: (…) from Not-Being; (…) from what exists, Being; (…) from some kind of lack or privation, sterésis; or, (…) from a potentiality (dunamis) actualizing into phenomena. (…) Corruption or degeneration (is a) state where some particular being cannot be actualized as itself*" (2007: 83). "*(As example) Nature is Becoming (and) is synonymous with genesis*" (2007: 90).

5 In Leibniz, the idea of being and unity would be dialectically synthesized gathering both the ancient (metaphysical) conceptions, such as those proposed by Aristotle, and the modern (mechanical) ones, such as those proposed by René Descartes (b.1596–d.1650). Furthermore, for Leibniz the idea of unity reflects a state where substances are in perfect agreement and are observed as occurring in a somewhat continuously unfolding event. "*A unity is per definition that which is without parts; yet Leibniz (architectonic) provides another (conception) of unity: a unity of substance that is alive and dynamic, a unity of pre-established harmony of God, and a unity between soul and organic body joined together with a substantial chain or bond. (…) (The) monadic (or atomic) substance is always in an inter-relationship of singulars in a dynamically unfolding unified system*" (Kavanaugh, 2007: 15). "*The architectonic of Leibniz (…) is commonly thought of as a transcendent structure with God at the apex of a complex network of monads, the* intelligentia supramundana. *However, the privileged position of God in the hierarchy of Being can be considered as a "special case monad". (…) The place of Being changes into a metaphysic without a necessary transcendent structure. The ontological structure flattens out in a radical notion of concomitance, leaving God as a special case monad in a system of intersubstantial connectivity where transcendence is merely a special case of immanence*" (2007: 139-140). "*For Leibniz, the continuum is composed of monadic atoms that are substances whilst denying sensible atomism. Space, time, and motion are infinitely divisible; they are not real for Leibniz, rather "well- founded phenomena. (…) An immanent and dynamic architectonic emerges, a structure that manages to account for both the changeable character of phenomena, and the unchanging nature of being.*" (2007: 141). "*The key concept will be unity and consistency*" (2007: 142).

6 For instance, the Neurology of our days regards the brain architectonic as a complex interrelated system of systems working as a full body with the remaining body. As (Damásio, 1996: 30) writes, "*Whatever neurons do depends on the nearby assembly of neurons they belong to; whatever systems do depends on how assemblies influence other assemblies; and whatever each assembly contributes to the function of the system to which it belongs depends on its place in that system. In other words, the brain specialization (…) is a consequence of the place occupied by assemblies of sparsely connected neurons within a large-scale system. In short (…) the brain is a supersystem of systems. Each system is composed of an elaborate interconnection of small but macroscopic cortical regions and subcortical nuclei, which are made of microscopic local circuits, which are made of neurons, all of which are connected by synapses*".

This idea that human reason is architectonic has been taken further by many Kantian followers, i.e. beyond individual human reason, insisting that we shall only know how philosophical knowledge is possible when we can understand its place within a unified system of knowledge. As noted by (Kavanaugh, 2007: 2-5) "*Metaphysics (…) always implies an architectonic, an ontological structure that positions beings and Being within a complex composition. (Understanding it, requires) the inquiry is into its structure, its position within the ontological whole. In doing this analysis, two points become explicit: one, ontology has a structure; and two, the status of Being within this structure. (…) Traditionally, philosophy has been in search of firm foundations. These grounds were seen as immutable, eternal propositions about which no contestation could be made. Upon these foundations, other knowledge based on either experience or reason could be firmly placed in order to reconstruct or to understand the structure of the world. (…) Even critical philosophy, in attempting to question the metaphysical "remains", still attempted to restore philosophy to her true foundations and to retrace the origins of truth. Yet man not only constructed his architectonic of philosophy, he made the building blocks as well. Consequently, (…) we will only discover what we have ourselves constructed earlier. (…) Man, precariously balancing upon shifting foundations, shored up by his tenuous scaffolding, attempts to raise himself far above - perhaps nearer to God. (…) The formulation of the "architectonic" is from Kant. Kant proposes an "architectonic", a tight systematic edifice organizing metaphysics within the limit of human reason, and the transcendental conditions of the possibility of all experience. (…) The architectonic is the possibility of all cognition given by pure reason. (…) "Human reason", he advanced, "so delights in constructions, that it has several times built up a tower, and then razed it to examine the nature of the foundation. It is never too late to become wise…". (…) Kant constructs his architectonic, which is indeed the very art of constructing a system. (…) As a unified whole, the architectonic includes a place for "filling in the gaps", yet per definition does not allow for external appendages to the system, for that would constitute a mere aggregation and not a true unity*".

7 Only an ignorance of what is for instance implied by relativity could lead to an unquestionable assumption of such a universalist perspective. But certainly Kant, influenced by Newton's ideas, could not be aware of the implications of the physics' relativity at the time.

According to Kavanaugh (2007: 10-12) "*in the twentieth century (…) not only does Kant's architectonic break apart and fall into ruin, but also the whole conception of physics as static, fixed and objective. (…) His conceptions have proven anything but immutable. Kant had, in fact, constructed his notions of absolute space and time fundamentally from the paradigms of scientific certainty in his time (…). He though he had found in Newton something solid (and) neutral (…) upon which to construct his metaphysic. (…) (But) the foundations of Euclidean geometry and Newtonian mechanics have indeed proven to be just as uncertain as the other realms of knowledge. (…) (Kant's) architectonic suffered from structural failure (…) (yet) stood solid for quite a long time, influencing philosophical thought well past its original construction*".

Indeed, if it would supposely configure, or attempt to configure a system in its totality, then, accordingly, it would never be fully accomplished other than in a sort of system of all systems, in a God-like, universal sort of figure. Kavanaugh (2007: 7-8) writes: "*Absolute space presupposes an absolute viewpoint from which all other objects in space are measured. In this way any extension into space can only be thought of geometrically (…). This 'taking-measure' requires a conception of space as homogeneous, and time as uniform duration. Displacement has meaning only in context of change in relation to a fixed point – in this case God*".

In a practical setting, the assumption of a totally controlled system can inadvertently conduct to a kind of direct objectification, or attempt of direct objectification, from idea (mental) to real (concrete), where only the most stoic and obsessive spirits can naively aspire to accomplish entirely. Even if seemingly closely so, such objectification is subjected to 'time', i.e., to new, unpredictable circumstances that can most likely come up.

8 Cf. Berger (1972).

9 There is no shred of dogmatism, or pretentiousness, when addressing entities such as space and time in a sort of category of 'essential elements' in the architectural apparatus. On the contrary, it is about proposing the exploration of an idea, not a delusional attempt to define a comprehensive referential, which would just be a self-closed dead-end. There is an evident 'danger' that such a discussion may at times turn onto a sort of philosophical kind of debate, which can be more distant from practical or utilitarian terms towards the praxis. However, since not everything is necessarily measurable, practical, or 'useful', and since the path is often the most valuable destination, we believe that is a 'risk' worth taking. For that matter, we borrow Manfredo Tafuri's somewhat harsh, yet vibrant and concise words, expressed in his *Architecture and utopia : design and capitalist development,* first published in 1972: "*For those anxiously seeking an operative criticism, I can only respond with an invitation to transform themselves into analysts of some precisely defined economic sector, each with an eye fixed on bringing together capitalist development and the processes of reorganization and consolidation of the working class*" (Tafuri, 1976: xi).

10 In logics, in agreement with Wittgenstein's (cf. 1995) notion of reality, we get that the world, the real, is intersubjective, hence it is there an alter *real* which may suddently, and never predictably, appear to our *real.*

11 As Harvey (2005: 204) writes: "*under a materialist perspective, we can argue that objective spatial and temporal conceptions are necessarily created by means of material practices and processes which are needed to reproduce the social life (…). Time and space cannot be understood regardless of the collective human action*".

12 Remarkably illustrative of such is the classical research conducted in genetic psychology by Jean Piaget (b.1896-d.1980), which has shown that, initially, to the child, there are as many spaces as are sensorial domains. According to the theory, the construction of a 'general' space that includes all the others only occurs in the end of the second year of life; it is only later, at about 7 to 12 years of age, that children start to differentiate viewpoints, manipulate mental images and represent movements of objects in space, and so forth. Piaget and Inhelder (cf. 1997) distinguish four stages of spatial awareness in the child's growth. Sensorimotor Stage (0-2 years), where, space is idiocentric, that is, the child sees the location of an object in space to be in relation to their own body. As their mobility increases, they see the object in relation to its surroundings. Piaget believes that young children see objects in a topological sense, whereby the objects they see are not fixed in shape, suggesting four topological concepts that they learn to become aware of which are, proximity (relative position of an object to another object), order (the sequence in which an object or event is observed), separation (understand that an object or event can come between other objects and events) and enclosure (demonstrable through concepts such as inside, outside, in, out and between). Pre-Operational Stage (2-7 years), where the understanding of spatial concepts begins to become apparent through the child's drawings, as early as three years of age they are capable of making scribbles that could be differentiated as open or closed forms. Concrete Operational Stage (7-12 years) where from further development of geometric space is actually built upon previously held spatial conceptions, continuously revising earlier perceptions as undergoing transformations and learning more about the world. The child becomes able to apply projective geometry in his/her thinking or view of the world, and to further understand the placement of objects in relation to each other and take into account vertical and horizontal relationships. Formal Operational Stage (12 year to adulthood) where people are able to visualize the concepts of area, volume, distance, translation, rotation and reflection, and also combine measurement concepts with projective skills.

13 Hillier (1996: 29).

14 In the classical *Walden; or Life in the Woods*, the XIX[th] century transcendentalist Henry David Thoreau (2006: 12) points out—from his introspective journey on the woods and as he experienced an immersive isolation from the world in a hut made with his own hands—four basic necessities of life: food, shelter, clothing, and fuel. Regardless the (more or less) arguable essentiality of these needs (or the accuracy of the words used by Thoreau to describe them), there is a underlying understanding that, besides the rationale of the space, and space with time, in the continuum of existence, space has also a qualitative nature which is in its essence related to the basic (human) life requirements.

15 In its celebrated *The Production of Space*, Lefebvre (2005: 210) addresses multiple aspects of space from a social, as well as philosophical, perspective. In one excerpt it is clear the reference to the 'sensory space' that was here highlighted: "*In what does sensory space, within social space, consist? It consists in an 'unconsciously' dramatized interplay of relay points and obstacles, reflections, references, mirrors and echoes – an interplay implied, but not explicitly designated, by this discourse. Within it, specular and transitional objects exist side by side with tools ranging from simple sticks to the most sophisticated instruments designed for hand and body. Does the body, then, retrieve its unity, broken by language, from its own image coming towards it, as it were, from the outside? More than this, and better, is required before that can happen. In the first place, a welcoming space is called for – the space of nature, filled with non-fragmented 'beings', with plants and animals. (It is when architecture's job to reproduce such a space where it is lacking.) And then effective, practical actions must be performed, making use of the basic materials and matériel available*".

16 In its famous essay *Of Other Spaces, Heterotopias*, Foucault (cf. 1967) reflects on how space affects human behavior and experience. Such as it was earlier mentioned when referring Eliade (cf. 1992), in Foucault (cf. 1967) it seems implicit the notion of sacred acquiring a foundational relevance in the discussion of space, how it is appropriated and limited: "*Now, despite all the techniques for appropriating space, despite the whole network of knowledge that enables us to delimit or to formalize it, contemporary space is perhaps still not entirely desanctified (apparently unlike time, it would seem, which was detached from the sacred in the nineteenth century). To be sure a certain theoretical desanctification of space (the one signaled by Galileo's work) has occurred, but we may still not have reached the point of a practical desanctification of space. And perhaps our life is still governed by a certain number of oppositions that remain inviolable, that our institutions and practices have not yet dared to break down. These are oppositions that we regard as simple givens: for example between private space and public space, between family space and social space, between cultural space and useful space, between the space of leisure and that of work. All these are still nurtured by the hidden presence of the sacred*" (Foucault, 1967: 23).

17 In Lefebvre (2005: 210) there is again, as in Eliade or Foucault, remarks on the idea of boundary, of limit, transition. Yet there is also the idea of classification, hierarchization that a threshold understates for space: the threshold of an entrance is a "*transitional object, one which has traditionally enjoyed an almost ritual significance (…). Objects fall spontaneously into such classes as transitional objects, functional objects, and so on. These classes, however, are always provisional: the classes themselves are subject to change, while objects are liable to move from one class to another*".

18 Cf. Hillier (1996: 27-29).

19 Cf. Kärkkäinen (1991).

20 Cf. Klein (1980).

21 As it is thoroughly presented by Aymonino (cf. 1976), the CIAM of Frankfurt (1929) and Brussels (1930) are key references to the modern movement. In Frankfurt the theme of the *Existenzminimum*, or minimum dwelling, was discussed (cf. Teige, 2002). The house problem acquires a programmatic ordinance based on the uttermost rationalization of the living cell. In Brussels the theme is further developed, with new technical-economic insights, housing as a molecule of the urban organism, with ideas such as densifying *vs* decongestioning (opening up discussion on the conditionings for high-rise developments), or quantity vs distribution (making housing a problem with global dimensions).

22 Cf. Benevolo (2009).

23 Cf. Palumbo (2000: 8).

24 Contemporarily, the man overlapped by the machine is, in effect, a recurrent theme for instance in the sci-fi or cyberpunk literature. In 'real life', experiments in fields such as genetics or nanotechnology, or recent developments in artificial intelligence programming seem to point to not so fictional developments.

25 "*By the word thought, I understand all that which so takes place in us that we of ourselves are immediately conscious of it; and, accordingly, not only to understand (intelligere, entendre), to will (velle), to imagine (imaginari), but even to perceive (sentire, sentir), are here the same as to think (cogitare, penser). For if I say, I see, or, I walk, therefore I am; and if I understand by vision or walking the act of my eyes or of my limbs, which is the work of the body, the conclusion is not absolutely certain, because, as is often the case in dreams, I may think that I see or walk, although I do not open my eyes or move from my place, and even, perhaps, although I have no body: but, if I mean the sensation itself, or consciousness of seeing or walking, the knowledge is manifestly certain, because it is then referred to the mind, which alone perceives or is conscious that it sees or walks*" (Descartes, 1644).

26 "*I continued to exercise myself in the method I had prescribed; for, besides taking care in general to conduct all my thoughts according to its rules, I reserved some hours (…) devoted to the employment of the method in the solution of mathematical difficulties, or even in the solution likewise of some questions belonging to other sciences, but which, by my having detached them from such principles of these sciences as were of inadequate certainty, were rendered almost mathematical*" (Descartes, 1637).

27 "*The action by which he now sustains it is the same with that by which he originally created it; so that even although he had from the beginning given it no other form than that of chaos, provided only he had established certain laws of nature, (…) it may be believed, without discredit to the miracle of creation, that (…) things purely material might, in course of time, have become such as we observe them at present; and their nature is much more easily conceived when they are beheld coming in this manner gradually into existence, than when they are only considered as produced at once in a finished and perfect state*" (Descartes, 1637).

28 The perspective as an expression of rationality, reporting to the subject, through the 'eye', and the mathematization of space, is in the XVII century, where Descartes is located, more even than during the Renaissance, according to the scientific and philosophic vision that characterizes the modern age. Johann Heinrich Lambert, Jacomo Barozzi da Vignola, Abraham Bosse, Jean Cousin, Albrecht Dürer, or Pierre-Henri de Valenciennes figure among some of the most recognized authors of illustrated treateseis on perspective. Abraham Bosse (b.1604-d.1676), a French printmaker and lecturer at the *Académie Royale de Peinture et de Sculpture in Paris*, in 1648 publishes the groundbreaking *Manière Universelle de Mr Desargues pour pratiquer la Perspective*, visually explaining a geometric construction procedure, thus unveiling and promoting the work of the mathematician Girard Desargues, who had independently devised a new method for constructing perspectival images. It was a practical procedure, not exactly innovative mathematics. However, Desargues adds a description of the perspective's vanishing points as points of intersection of plans, which allows recognition of a new conception: in the Renaissance, what mattered was the correct foreshortened reproduction.

29 The subsequent development of these

philosophical conceptions did not escape, in any moment, to give the eye relevance as a predominant sensorial receiver. According to Pallasmaa (1996: 9-12), Nietzsche criticized "*the eye outside time and History" presumed by many philosophers. Jean-Paul Sartre was absolutely hostile on the eye sense to the point of ocular phobia, concerned "with the objectifying look of the other", and "the glance of medusa petrifying everything that comes in contact with it*". According to him, space took over time in the human consciousness as consequence of ocularcentrism. The philosophical works of Martin Heidegger, Michel Foucault and Jacques Derrida also point out towards a critique to the hegemony of vision: "*arguing that thought and the culture of modernity not only continued the historical privilege of vision, but also magnified its worse tendencies. The hegemony of vision was strengthened in our time by a multitude of technological inventions and by the endless multiplication of images*".

30 Merleau-Ponty (1992: 20) writes: "*immersed in the visible by his body, itself visible, the see-er does not appropriate what he sees; he merely approaches it by looking, he opens onto the world. And for its part, that world of which he is a part is not in itself, or matter. My movement is not a decision made by the mind, an absolute doing which would decree, from the depths of a subjective retreat, some change of place miraculously executed in extended space. It is the natural sequel to, and maturation of, vision. I say of a thing that it is moved; but my body moves itself; my movement is self-moved. It is not ignorance of self, blind to itself; it radiates from a self (…)*".

31 According to Palumbo (2000: 13-17) this lead that the "*architectural shapes should be in agreement with the laws of the senses, more than with the proportions of the body". Palumbo also attributes the appearance of Baroque as an unavoidable consequence of this process, which would also determine the "dissolution of rationalism in the visionary research and the dissolution of Neoclassicism through the picturesque*".

32 According to Pallasmaa (1996: 12), such is manifested in the "*collapse of space and time as an experimental dimension. The experiences of space and time have imploded and melted by time*".

33 The Farnese Theater, built in Parma and finished in 1618, is claimed as the first with a permanent proscenium. The architect, Giovanni Battista Aleotti, made a rectangular wooden structure with the stage in one end, and the audience in the other, and an elaborated frame with curtains in-between. Aleotti's proscenium inaugurated the screen experience (cf. Mitchell, 2000).

34 The theatre *Schaubühne am Lehniner Platz*, Berlin (1978-81), designed by Jürgen Sawade, reconverting the remains of the 1928 original, by Erich Mendelsohn, was perhaps the first modern theatre to address so remarkably the flexibility in its design. Unlike in conventional theatres, in its stage, there is no separation between to the place of acting and of the spectator: acting is possible at every space, as both spectator and stage surface are used.

35 The density of our iconosphere tends to be so high in certain areas of urban cultures, that we do not see – or barely see – the images, given that its hyperabundance has trivialize them and disabled, in great measure, its ability to attract the eye. The great paradox is that their very excess tends to turn them invisible.

36 Le Corbusier (1995: 31-48).

37 The eventful story of the design dialogue between architecture and structural stability of the Sidney Opera House is quite expressive in this respect, where after all, the design solution would be achieved by going back to an analogical structure. In the development of the design for the Sydney Opera House, the chief structural engineer, Ove Arup, struggled for years with mathematical formulae to represent Utzon's original freehand concept of the shells. They tried parabolas, ellipsoids and circular arcs, but were forced to concede defeat. No scheme could do justice to Utzon's design. It seemed that three years of work had been wasted. But then Utzon took a remarkable lateral step, remaking the design from segments of a sphere, a concept he easily demonstrated to the partners by peeling off an orange. The scheme had a remarkable simplicity and would prove to fit both architecture and stability concerns. Given the current state of digital tools, both for design and manufacturing, most probably today the design unfolding would have had a different outcome.

38 An experiment described by (cf. 2001) is most clear in this respect. A drawing with three squares is shown to the subject, asking what they may be meaning: "*some would point to mosaics, others to square bonbons, or others window openings. Others would simply say: three squares. And which is not wrong". In the next step of the experiment a second drawing is shown, from which the answer is immediate: a cube. The two drawings in fact are showing the same thing. While in one we observe a pure Cartesian representation – as superior, lateral and frontal perception, allowing to exactly determine the cube and attribute measures to it – in the other, the perception degenerates in a trapezium, being certain that a cube as nothing in common with a trapezium. The second drawing is correct but not truthful but yet it shows immediately what the object in question is. The second drawing is 'analogical' because it gives a clear portrait of the object. It can be contemplated by every human being, no matter what age, gender, race, faith, background, and so on. The first drawing, with three aspects of the cube, is read differently by each subject. It is a fake portrait, but the values that determine it are there, unchanged. Every side can be accurately measured. "From this drawing cubes can be built. But we cannot understand them. And not only cubes are built with this method, but also houses, tools, machines, and so on*" (Aicher, 2001: 117-119).

39 Cf. Damásio (1996).

40 Cf. Foucault (1967).

41 Simultaneously to this dematerializing objectivation of space, the different sciences have increasingly specialized in such a way that it ended up impeding virtually anyone to have an adequate general vision, or to be comfortable in many fields and simultaneously be an absolute creator, as was Leonardo da Vinci or Galileo, what is, in the end, the old romantic vision of the architect. Távora (1996: 21), quoting Ortega y Gasset, calls it the "*barbarism of specialism*".

42 Modern life, and the underlying idea of progress and growth induced by its cumulative (capitalist) matrix, has long relayed in the development of continuous technological improvement (cf. Meadows, Randers, & Meadows, 2004). The costs of this continuous development are yet to be known in its fullest extent, yet we know for a fact that global inequalities are ever more visible. For now the planet has been able to provide enough resources for the population inhabiting it, but not without severe disparities (cf. UN HDR, 2010).

43 Cf. Bachelard (1994).

44 For Merleau-Ponty (1964: 164), "*quality, light, colour, depth, which are there before us, are there only because they awaken an echo in our body and because our body welcomes them*".

45 Neurology research seems to confirm just that. From the current state of the art of scientific knowledge it seems largely consensual, that from the dualist separation of mind and body, rationality and emotion, induced by the Cartesian notion of space, that the body and our emotions have a key role in the way we think and in rational decision-making (cf. Lagerlund, 2007: 15).

46 As it is referred by Damásio Damásio (1996: 87), "*the brain and the body are indissociably integrated by mutually targeted biochemical and neural circuits*". For instance, for the dancer, as for the sportsman, or the painter, only the embodiment, which happens by (body) memory acquisition, through continuous practice of their skills, turns gestures natural for those who practice them. Such effort of embodiment demands a laborious process of acquisition. As Gil (2001: 13-29) writes in reference to the dancer's motion "*the space of*

the body is the body made space". The example of the child that is beginning to walk is most clear, as the child does not walk directly from cradle, but has to undergo a learning curve where it will be developing the neural connections that will finally enable to walk without thinking on how to walk. These processes apply both for movements of the body *per se*, as with extensions of it, such as in the case of the use of tools, which in its full symbiotic extension makes the handler and the handled thing one and the same. Pallasmaa (2009: 50) notes in this respect: "*a great musician plays himself rather than a separate instrument. In drawing and painting, the pencil and the brush become extensions to the hand and to the mind*". A similar notion is stated by Berger and Savage (2005: 3): "*Each confirmation or denial brings you closer to the object, until finally you are, as it were, inside it: the contours you have drawn no longer marking the edge of what you have seen, but the edge of what you have become*".

47 Cf. Stuttgart (2002).

48 Aymonino (1976: 245).

49 Aymonino (1976: 249).

50 Aymonino (1976: 247) writes: "*The possibility to use technology to simplify domestic services and ensure the biological condition of the dwelling (…), finds its most suitable development in the large building. The skyscraper is not only more comfortable thanks to technology, but is based on some peculiarities it*".

51 Aymonino (1976: 245-246) writes: "*From the point of view of the user, the construction of low-rise, especially of single-family houses, is very attractive especially for families in full growth. (…) The inevitable massification during working hours, due to the circumstances of serial production and consumption, also the dense cooperation among many people in the office or the factory, drives the opposite desire. Live with freedom of action and accept a long daily commute, rather than live in a minimum free space with lack of green areas". In addition "these small houses often change proprietaries or occupants, even without being amortized*".

52 Cf. (Steinbeck, 1939).

53 Cf. Kunstler (1998).

54 On constancy and change, Rapoport (1969: 78-82) writes: "*certain aspects of human life are constant, or change very slowly, and replacement of old forms is often due to the prestige value of novelty rather than lack of utility or even unsatisfactory relation to the way of life. (…) Architects have suggested that one can usefully distinguish between technological space, such as bathrooms and service spaces, which is changing as equipments and services change, and symbolic, largely living, space, which is constant an usable almost indefinitely. (…) The concept (…) of place is fundamental. (…) (And) the need for security may be one of the reasons why man has to define place. (…) Man, no less than animals, is subject to the stresses generated by penetration of the individual's 'bubble' of space. (…) Man's defense mechanisms seem more constant than his physical mechanisms and specific devices, which are more changeable and culturally defined. (For instance, individually or culturally) attitudes to noise and privacy may vary, since they are social defense mechanisms. It could be said that the form determinants of the house can be divided into constant and changeable ones, and that the whole problem of constancy and change can be related to built form in this way for a number of variables*".

55 On his own account on *structure*, Herman Hertzberger lends a similar idea: "*Structure is cohesion: how things fit together, or rather, how they keep each other together. In a structure, all the various elements are interrelated*" (Valena, Avermaete, & Vrachliotis, 2011: 168).

56 In Aldo Van Eyck's words in *Is Architecture going to reconcile basic values*, in Otterlo: "*Man is always and everywhere essentially the same. He has the same mental equipment though he uses it differently according to his cultural or social background, according to the particular life pattern of which he happens to be a part. Modern architecture has been harping continually on what is different in our time to such an extent even that it has lost touch with what is not different, with what is always essentially the same*".

57 Cf. Gomes (1978).

58 Edward T. Hall gives an example of the Arab to stress cultural changing concepts of privacy, and consequently, different ways of spatial formulation with repercussions in form: "*the Arab dream is for lots of space in the home, which unfortunately many Arabs cannot afford. Yet when he has space, it is very different from what one finds in most American homes. Arab spaces inside their upper middle-class homes are tremendous by our standards. They avoid partitions because Arabs do not like to be alone. The form of the home is such as to hold the family together inside a single protective shell, because Arabs are deeply involved with each other. Their personalities are intermingled and take nourishment from each other like the roots and soil. If one is not with people and actively involved in some way, one is deprived of life. An old Arab saying reflects this value: 'Paradise without people should not be entered because it is Hell'*" (Hall, 1990: 157-159).

59 Cf. Risselada and Van Den Heuvel (2005: 280-285).

60 Cf. Brand (1995).

61 Cf. Strauven (1998: 284-325).

62 (Herman Hertzberger, 2010).

63 "*(He) didn't like it. Aldo Van Eyck was certainly not a structuralist as what we call infill was stable for him. For him it was all structure, so his building was an open structure that could serve as school as well as orphanage. He did not really accept the re-use, or accepted it only because it saved the building. When the students made in his building a sort of temporary building for a show, he was furious*" (Herman Hertzberger, 2010).

64 Umland (2013: 6).

65 Cf. Magritte (1929).

66 "*A map is not the territory it represents, but, if correct, it has a similar structure to the territory, which accounts for its usefulness. If the map could be ideally correct, it would include, in a reduced scale, the map of the map; the map of the map, of the map; and so on, endlessly* (…)" (Korzybski, 1933: 58). "*If words* are not *things, or maps* are not *the actual territory, then, obviously, the only possible link between the objective world and the linguistic world is found in* structure, and structure alone. *The only usefulness of a map or a language depends on the* similarity of structure *between the empirical world and the map-languages. If the structure is not similar, then the traveler or speaker is led astray, which, in serious human life-problems, must become always eminently harmful. If the structures are* similar*, then the empirical world becomes 'rational' to a potentially rational being, which means no more than that verbal, or map-predicted characteristics, which follow up the linguistic or map-structure, are applicable to the empirical world*" (Korzybski, 1933: 61).

67 Cf. Baudrillard (1994).

68 Foucault (1983: 20-21) writes: "*The operation is a calligram that Magritte has secretly constructed, then carefully unraveled. Each element of the figure, their reciprocal position and their relationship derive from this process, annulled as soon as it has been accomplished. Behind this drawing and these words, before anyone has written anything at all, before the formation of the picture (and within it the drawing of the pipe), before the large, floating pipe has appeared-we must assume, I believe, that a calligram has formed, then unraveled. There we have evidence of failure and its ironic remains. In its millennial tradition, the calligram has a triple role: to augment the alphabet, to repeat something without the aid of rhetoric, to trap things in a double cipher. First it bring s a text and a shape as close together as possible. It is composed of lines delimiting the form of an object while also arranging the sequence of letters. It lodges statements in the space of a shape, and makes the text say what the drawing represents. On the one hand, it alphabetizes the ideogram, populates it with discontinuous letters, and thus interrogates the silence of uninterrupted lines. But on the other hand, it distributes writing in a space no longer possessing the neutrality, openness, and inert blankness of paper. It forces the ideogram to arrange itself according to the laws of a simultaneous form. For the blink of an eye, it reduces phoneticism to a mere grey noise completing the contours of the shape; but it renders outline as a thin skin that must be pierced in*

order to follow, word for word, the outpouring its internal text. The calligram is thus tautological. But in opposition to rhetoric. The latter toys with the fullness of language. (…) The calligram aspires playfully to efface the oldest oppositions of our alphabetical civilization: to show and to name; to shape and to say; to reproduce and to articulate; to imitate and to signify; to look and to read".

69 Golub and Frey (1999: 76).

70 Golub and Frey (1999: 76).

71 Golub and Frey (1999: 74-76).

72 Cf. Utzon and Weston (2009: 8).

73 Weston (2002: 11).

74 Cf. Weston (2002: 14-31).

75 Cf. Weston (2002: 112-201).

76 The *Additive Architecture* manifesto, as written by Jørn Utzon, in 1970, is as follows: "*A consistent exploitation of industrially produced building elements is only achieved when these elements can be added to buildings without the components in any way needing to be cut or adapted.*
Such pure addition principle produces a new form of architecture, a new architectonic expression with the same qualities and same effect as the addition of, for instance, the trees in the forest, groups of animals, stones on the shore, goods wagons on a shunting ground, the Danish lunch table, all according to how many different components are added in this game. The game conforms exactly to the demands of our time for greater freedom in the planning of buildings and a strong desire that the building should not be constrained to the shape that could be called the box, limited by a given size, and traditionally divided up by partition walls.

When you work on the basis of the additive principle, you can without difficulty respect and honour all demands concerning the shape of the ground plan and rooms and all demands for expansion and alterations, as the architecture, or perhaps rather the character, is precisely the character of the juxtaposed and not the composed or that determined by the façade.
It is likewise possible when working with the additive principle to avoid offending against the right of the individual components to exist. They all find expression.

The functionalist moral, which of course is the essential background to true building, is respected. The drawings are not and entity in themselves with module lines of no significance or thickness, but the modules lines are the thicknesses of walls, and the lines on the paper are outlines of finished things.

The projects show what freedom in the fashioning of widely different undertakings can be achieved with the additive principle, while at the same time it demonstrates the core problems in the shapping of the elements or components, and there is a hint (for instance in the stadium project) of the superiority achieved when it is a question of controlling production, price and construction time in relation to the building complex based purely on the work of artisans" (Utzon & Weston, 2009: 28).

77 Cf. Turner (1976).

78 The system is still currently in use to build flexible, affordable houses.

79 Turner (1976: 13-16).

80 Turner's conception borrows system's terminology: "*If stability (of a system) is to be attained, the variety of the controlling system must be at least as great as the variety of the system to be controlled*" (Turner, 1976: 32).

81 Cf. Habraken (1972).

82 Cf. Habraken and Mignucci (2009).

83 Herman Hertzberger (2010).

84 Herman Hertzberger (2010).

85 Herman Hertzberger (2010) writes: "*You have less control over the details because there is less making, there is much more assembling of, say a façade. Today nobody is going to detail a façade, it is something you buy, you adapt (…). It doesn't make sense anymore to design a façade; it is a technical feature*".

86 Hertzberger (2005: 106) writes: "*If an architect is capable of fully grasping the implications of the distinction between structure and filling, or in other words between 'competence' and 'performance', he can arrive at solutions with a greater potential value as regards applicability – i.e. with more space for interpretation. And because the time factor is incorporated in his solutions: with more space for time. While on the one hand structure stands for what is collective, the way in which it may be interpreted, on the other hand, represents individual requirements, thus reconciling individual and collective*".

87 Herman Hertzberger (2010) writes: "*I have implied the smaller scale. That makes some people say I am 'knitting' as they get nervous of the small scale I introduced in my building. Even Aldo Van Eyck, who was my teacher in that field, got nervous and did not realize there were so many places or space units possible. I found out that as long as you make the whole out of space units that are connected you get a better building*".

88 Hertzberger (2002: 72).

89 Cf. Aymonino (1976).

90 Cf. van den Thillart (2004).

91 Cf. Pittini and Laino (2011).

92 Cf. Andrews, Sánchez, and Johansson (2011).

93 According to Rybkowska (cf. 2011), the percentages of persons living in flats ranged from 3.1 in Ireland, 7.3 in Norway and 14.2 in the UK to over 60 in Spain, Estonia and Latvia. The percentage of people living in detached houses was greatest in Slovenia (68.7), Hungary (67.6), Norway (62.6), Romania (60.7) and Denmark (58.4), while semi-detached houses were most popular in the Netherlands (61.4), the United Kingdom (60.9) and Ireland (57.6).

94 Cf. Hammond (2011).

95 European Commission (2013: 5).

96 Cf. EU' (2009).

97 Cf. Atkin (1999).

98 Cf. Eurostat (2013).

The criteria for SMEs labelling is the related with personnel number falling behind certain limits. SMEs outnumber large companies by a wide margin and also employ many more people, such is a fact not exclusive of the construction sector. They are too considered responsible for driving competition and innovation in many economic sectors.

99 Cf. Stawinska (2010).

100 Benjaafar and Sheikhzadeh (1995) writes: "*processing parts in batches is preferable to the processing of parts in lots of size one when setup times are significant. By batching parts that have similar manufacturing requirements, the frequency of setups is reduced. Batching is also desirable when material handling is carried out by a set of discrete transporters (e.g., automated guided vehicles, forklift trucks, and tow carts). Larger batches reduce the number of trips between machines required from the transporters. In turn, this reduces the loading of these transporters which decreases the possibility of the material handling system becoming a bottleneck. Excessive batching can, however, result in performance deterioration. Increasing batch sizes increases the batch processing times at machines. Before leaving a machine, a part must wait for the entire batch to be processed before it can be transferred to the next machine. This longer processing time can eventually erode the savings in flow time gained from the reduced frequency of setups and material transports. The deterioration in performance caused by larger process batches can be, in part, limited by allowing for smaller transfer batches between machines. However, this may not always be beneficial since the smaller transfer batches can result in increased loading of the material handling system*".

101 Cf. Mourão and Pedro (2010).

102 Cf. Gervásio (2010).

103 Cf. R. E. Smith (2010).

104 *Solar Decathlon* is an international competition organized by the *U.S. Department of Energy*, challenging under-graduate teams to design, build and operate solar-powered houses that are cost-effective, energy-efficient, and attractive. The winner of the com-

petition is the team that best blends affordability, consumer appeal, and design excellence with optimal energy production and maximum efficiency. So far, editions were held in 2002, 2005, 2007, 2009, 2011, 2013, 2015 and 2017.

105 Pallasmaa (1991).

106 Cf. Girault (1998).

107 Cf. McBeth (1998).

108 These would be built in France and intended to be widely deployed in tropical Africa (Niger and Congo), but never really leave the marketing prototypical phase (cf. Vegesack, Dumont d'Ayot, & Reichlin, 2006).

109 Cf. Guidot (1983).

110 They were developed at a time when Nikita Khrushchev was in power, from 1954, which is why the buildings became known as *Khrushchyovka*.

111 Cf. Goldhoorn (2002).

112 Cf. Goldhoorn (2002).

113 Cf. Wilson (1998).

114 Cf. Wilson (1998).

115 Cf. Korvenmaa (1990).

116 Davies (2005: 158-160).

117 Cf. Wærn (2008).

118 Cf. Edge (2002).

119 Cf. Wærn (2008).

120 Cf. Edge (2002).

121 Cf. Ryan E. Smith (2009).

122 Cf. Aalto (1994).

123 Cf. Schildt (1994: 229-232).

124 Cf. Piñar (2013).

125 Wilson (1998: 10).

126 Wærn (2008: 28-29).

127 Wilson (1998: 10).

128 Cf. Schildt (1998).

129 Cf. Kaila (2016).

130 Cf. Home and Taanila (2002).

131 Cf. Weston (2002).

132 Cf. Sanz (2013).

133 Cf. Collymore (1994).

134 Cf. Nord (2008).

135 Cf. Nord (2008).

136 Davies (2005: 158).

137 Cf. Wærn (2008).

138 In Sweden, in 2010, there was around 56% of the one- or two-dwelling buildings (roughly 2.5 million), 44% in multi-dwelling (roughly 2 million). Housing construction decreased for two years in a row: in 2009 and 2010, 22,821 and 19,500 dwellings respectively were completed in newly constructed buildings. This can be compared to 2008 when 32,021 dwellings were completed. Multi-dwelling buildings accounted for the largest decrease (cf. 'SCB', 2012).

In Finland, at the end of 2010 there were 2,808,000, around 600,000 more than in the 1990's, yet with about half the growth rate than in the 1980's. Of the 5.4 million population, some over half lived in detached one-family houses, one-third in blocks of flats, and the rest (13%) in terraced houses (cf. 'ARA', 2012; 'Statistics FI', 2012).

In Denmark, on 1 January 2011, there were 2,745,458 dwellings, of which 93.7% were occupied. One-family houses accounted for 44%, multi-family buildings for 39%, while the remaining were other types. Owner-occupied houses were just over half of the dwellings, while rented houses were around 46%. Residential construction peaked in the 1970's, with the greatest number of 55,000 dwellings completed in 1973. The economic growth in mid-2000s has again implied an increase in the number of dwellings completed from 2003 to 2007, where it peaked with 31,000 dwellings completed. It was primarily one-family houses, which account for the growth. Since 2008, the crisis has resulted in a strong slowing down: in 2011 reached little over 11,000 (cf. 'Statistics DK', 2012).

In Norway, in January 2008, there were 1.44 million residential buildings, from which there were 2.3 million dwellings. Of these, 52% were detached houses, and almost 80 percent of the households own their dwelling (cf. 'Statistics NO', 2012).

139 Cf. Wilson (1998).

140 Cf. Edge (2002).

141 Cf. Wiencek (1987).

142 Cf. Wærn (2008).

143 Davies (2005: 156-157).

144 Excluding small countries such as Malta, Monaco, San Marino or the Vatican, it is the greatest population density in Europe. Worldwide, in countries with over 10 million people, it ranks fourth behind 1st Bangladesh (954/km^2), 2nd Taiwan [China] (639/km^2), and 3nd South Korea (487/km^2). It is even greater than in Japan (337/km^2), which has similar compactly built areas.

145 Cf. Mersmann (2014).

146 Cf. Mersmann (2014).

147 Cf. 'Statistics NL' (2014).

148 Cf. 'Statistics NL' (2014).

149 Cf. Gibb (1998).

150 Cf. Edge (2002).

151 Cf. Gibb (1998).

152 Cf. van den Thillart (2004).

153 Cf. van den Thillart (2004).

154 Cf. Machado and Geuze (2005).

155 Cf. Jones (2010).

156 Cf. 'Froebel Gifts' (2008).

157 Cf. Stiny (1980).

158 Schomaker (2003).

159 Simmel (1903: 17).

160 Schomaker (2003: 6).

161 Cf. Hellgardt (1987).

162 Hellgardt (1987: 97).

163 As in Jean Nouvel's *Nemausus I* (see corresponding complementary text in Annex I).

164 Cf. Schomaker (2003).

165 Staib, Dörrhöfer, and Rosenthal (2008: 23-24).

166 Cf. May (1929).

167 Staib et al. (2008: 24).

168 Staib et al. (2008: 25).

169 Staib et al. (2008: 26).

170 Urban (2013: 10).

171 Cf. Anderson (2000).

172 According to Hellgardt (1987: 97). "*When we apply Benjamin's concept of technical reproducibility to housing production, we are not so much concerned with the fact that something is being (re)produced-'The work of art has always at root been reproducible', says Benjamin- but more with the question of how it is (re)produced. Both the production and perception of the work of art changed with the change in technical reproduction: the conditions of perception are no longer recognizable behind the units to be reproduced, rather they are barricaded in by them. Technology itself, as it actually exists without the costume of a dictated rationality, teaches us what is to be (re)produced and how*".

173 Bergdoll, Christensen, and Broadhurst (2008: 17).

174 Cf. Gropius (1965).

175 Cf. Kennedy (2006).

176 Bergdoll et al. (2008: 56).

177 Bergdoll et al. (2008: 56-57).

178 Arieff and Burkhart (2002: 15).

179 Cf. Jones (2010).

180 Bergdoll et al. (2008: 62-65).

181 Cf. Jones (2010).

182 Imperiale (2012: 39-43).

183 Cf. Kirsch (2013).

184 Blundell-Jones (2002: 11-46).

185 Cf. Hitchcock and Johnson (1932).

186 Blundell-Jones (2002: 16-17).

187 Cf. Lihotzky (1927).

188 Cf. Kinchin and O'Connor (2011).

189 See the introduction by Donald Albrecht and Peter S. Reed *Enlisting Modernism*, in Albrecht and Crawford (1995).

190 Venables and Courtney (2004: 11).

191 Staib et al. (2008: 29-30).

192 Venables and Courtney (2004: 11).

193 Bergdoll et al. (2008: 122-123).

194 Staib et al. (2008: 34).

195 Cf. Kossak (2012).

196 Bergdoll et al. (2008: 136-137).

197 Arieff and Burkhart (2002: 35-36).

198 Cf. Venables and Courtney (2004).

199 Cf. Edge (2002).

200 According to R. E. Smith (2010: 5), "*the history of prefabrication in the West begins with Great Britain's global colonization effort. In the sixteenth and seventeenth centuries, settlements in today's India, the Middle East, Africa, Australia, New Zealand, Canada, and the United States required a rapid building initiative. Since the British were not familiar with many of the materials in abundance in these countries, components were manufactured in England and shipped by boat to the various locations worldwide*".

201 Cf. Herbert (1978).

202 Bergdoll et al. (2008: 234).

203 Cf. Herbert (1978).

204 Cf. Herbert (1978).

205 Cf. Spoerl (2004).

206 Cf. Mornement and Holloway (2007).

207 Cf. Lewis (2013).

208 Cf. Lewis (2013).

209 Davies (2005: 59).

210 Knaack, Chung-Klatte, and Hasselbach (2012: 24).

211 Herbert (1978: 156).

212 Herbert (1978: 156).

213 Cf. Giedion (1941).

214 R. E. Smith (2010: 8).

215 Cf. Gibb (1998).

216 Harrison, Mullin, Reeves, and Stevens (2004: xiii).

217 Cf. Davies (2005).

218 Cf. Hughes (2010).

219 Davies (2005: 59-60).

220 Cf. Phillipson, Scotland, and Lane (2001).

221 Vale (1995: 88-89).

222 Cf. Phillipson et al. (2001).

223 Davies (2005: 59-60).

224 Cf. Phillipson et al. (2001).

225 Vale (1995: 118).

226 Vale (1995: 127).

227 Vale (1995: 89-94).

228 Vale (1995: 127).

229 Vale (1995: 119).

230 Davies (2005: 61-62).

231 Vale (1995: 119).

232 Davies (2005: 63).

233 Vale (1995: 10-24).

234 Cf. Storr (2011).

235 According to Vale (1995: 87), "*war time had produced drastic changes in both the organization of society and the technologies available to it. Normal caution in assimilating innovation and development was apparently disregarded during the emergency, making new products and methods of manufacture immediately available as the need arose. However, with this explosion of technology must be coupled the desire of the ordinary person for things to return to normal after the war. It was apparent that there were to be changes (the* Beveridge Report *of 1942 had assured that) but permanent changes had to be seen as changes for the better. Housing was one area where traditional values had never been lost despite the experience of many of the population who had lived in prefabricated, factory produced huts and hostels*".

236 According to Vale (1995: 87-88), "*before the war there had been 1,000,000 employed in the building industry but this had been reduced to 387,000 during the war. The government was set to expand the industry to a level of 800,000 skilled personnel by the end of the first year after the war, through adult and apprentice training. Thus the building unions were to be reassured that their skills would not be devalued by the introduction of the factory made house during this period by ensuring its 'temporary' nature*".

237 Vale (1995: 86-89).

238 Cf. 'The National Archives' (2008).

239 Cf. 'University of the West of England' (2013).

240 Cf. Way (2011).

241 Cf. 'University of the West of England' (2013).

242 Cf. 'University of the West of England' (2013).

243 Davies (2005: 66).

244 Davies (2005: 66).

245 Cf. Knaack et al. (2012).

246 Cf. 'University of the West of England' (2013).

247 Cf. Pearson and Delatte (2005).

248 Cf. Matthews and Reeves (2012).

249 Cf. Phillipson et al. (2001).

250 Cf. 'University of the West of England' (2013).

251 Davies (2005: 67).

252 Cf. Gannon (2017).

253 Cf. Cook (1999).

254 Cf. Davies (1993).

255 Cf. LeCuyer (1996).

256 Cf. Alonso-Zandari and Hashemi (2017).

257 Cf. Egan (1998).

258 Cf. Waskett and Phillipson (2001).

259 Cf. Housing Forum (2002).

260 Cf. Egan and Strategic Forum for Construction (2002).

261 Cf. Edge (2002).

262 Cf. Pawley (1973).

263 Cf. English Housing Survey team (2015).

264 Cf. 'Girders' (2011); Bergdoll et al. (2008); Hansen (2005).

265 Cf. 'Lincoln Logs' (2011); Bergdoll et al. (2008).

266 Cf. Banham (2002).

267 Cf. Taylor (2007).

268 Cf. Davies (2005); Reiff (2000).

269 Cf. Davies (2005); Reiff (2000); Schlereth (1982).

270 Davies (2005: 119).

271 Cf. 'Aladdin' (2001); Reiff (2000); Schlereth (1982).

272 Cf. Bergdoll et al. (2008); Reiff (2000); Schlereth (1982).

273 Cf. Bergdoll et al. (2008); Goodheart (1996).

274 Cf. M. J. Smith (2010).

275 M. J. Smith (2010: 9).

276 Cf. M. J. Smith (2010).

277 Cf. Arieff and Burkhart (2002).

278 Arieff and Burkhart (2002: 15-16).

279 Arieff and Burkhart (2002: 17)

280 Cf. Arieff and Burkhart (2002).

281 Cf. Arieff and Burkhart (2002).

282 Cf. Arieff and Burkhart (2002); Davies (2005: 66); Cf. R. E. Smith (2010).

283 Cf. Mankiw and Weil (1989).

284 Cf. 'Statistics US' (2011).

285 Staib et al. (2008: 26).

286 Cf. Fuller, Krausse, and Lichtenstein (1999).

287 Bergdoll et al. (2008: 88).

288 Cf. E. A. T. Smith, Shulman, and Gössel (2002).

289 "Dwell Magazine" 2012).

290 Cf. "Some Assembly Required: Contemporary Prefabricated Houses" 2006).

291 Cf. Bergdoll et al. (2008).

292 Cf. 'Statistics US' (2011).

293 Cf. Davies (2005: 73).

294 Cf. Davies (2005: 75).

295 Cf. Davies (2005: 76-78).

296 Cf. Davies (2005: 83).

297 Davies (2005: 83-84).

298 Cf. Yarnal and Aman (2009).

299 Cf. Yarnal and Aman (2009).

300 Cf. Bergdoll et al. (2008: 234).

301 "*Copyright is a form of protection provided to the authors of 'original works of authorship' including literary, dramatic, musical, artistic, and certain other intellectual works, both published and unpublished. [In the US] the copyright protects the form of expression rather than the subject matter of the writing. For example, a description of a machine could be copyrighted, but this would only prevent others from copying the description; it would not prevent others from writing a description of their own or from making and using the machine*" (Lawmart, 2015).

302 "*A patent for an invention is the grant of a property right to the inventor (…). The term of a new patent is 20 years from the date on which the application for the patent was filed in the United States or, in special cases, from the date an earlier related application was filed, subject to the payment of maintenance fees. The right conferred by the patent grant is, in the language of the statute and of the grant itself, 'the right to exclude others from making, using, offering for sale, or selling' the invention in the United States or 'importing' the invention into the United States. What is granted is not the right to make, use, offer for sale, sell or import, but the right to exclude others from making, using, offering for sale, selling or importing the invention*" (Lawmart, 2015).

303 "*Japanese society has been inundated at various times by cultural influences from abroad. In early times, these influences came primarily from Korea and China; more recently, mostly from Europe and the United States*" (Young & Young, 2007: 11-23).

304 "*Since wood can breathe, it is suitable for the Japanese climate. Wood absorbs humidity in the wet months and releases moisture when the air is dry. With proper care and periodic repairs, traditional post-and-beam structures can last as long as 1,000 years. Other natural building materials are reeds, bark, and clay used for roofing, and stones used for supporting pillars, surfacing building platforms, and holding down board roofs, with an emphasis upon straight lines, asymmetry, simplicity of design, and understatement, exemplified by pre-Buddhist Shinto shrines, farmhouses, teahouses, and tasteful contemporary interiors*" (Young & Young, 2007: 11-23).

305 Cf. Tobriner (1997).

306 Cf. Brock and Brown (2000).

307 Cf. Johnson (2007).

308 Cf. Ochi (2005).

309 Cf. Brock and Brown (2000).

310 Cf. Ohno (1988).

311 Cf. B. J. Pine II (1993).

312 Cf. Ochi (2005).

313 apud Gibb (1998).

314 Cf. Fumiaki (2003).

315 Cf. Oshima (2008).

316 Cf. Edge (2002).

317 Cf. Barlow and Ozaki (2005).

318 Cf. Toyota (2013).

319 Cf. Ohno (1988).

320 Cf. Womack and Jones (2003).

321 Cf. Ryan E Smith (2008).

322 *Instantaneous* – the processes should have the ability to link each other as fast as possible;

Costless – besides the initial investment to create the MC, the linking system to be implemented should add the least possible to the producing costs of the product or service;

Seamless – implementation should not break the ongoing state of things;

Frictionless – the cross-skills required for the MC process to work should be the most transparent and expeditious as possible, for that IT's most likely will be fundamental.

Cf. B. Joseph Pine II, Victor, and Boynton (1993).

323 *Collaborative customizers* – conduct a dialogu with individual customers to help them articulate their needs, to identify the precise offering that fulfills those needs, and to make customized products for them.

Adaptive customizers – offer one standard but customizable, product that is designed so that users can alter it themselves.

Cosmetic customizers – present a standard product differently to different customers.

Transparent customizers – provide individual customers with unique goods or services without letting them know explicitly that those products and services have been customized for them.

Cf. B. Joseph Pine II and Gilmore (1997).

324 *Elicitation* – a mechanism for interacting with the customer and obtaining specific information.

Process flexibility – production technology that fabricates the product according to the information.

Logistics – subsequent processing stages and distribution that are able to maintain the identity of each item and to deliver the right one to the right customer.

Cf. Zipkin (2001).

325 Cf. Zipkin (2001).

326 Cf. Salvador, de Holan, and Peiller (2009).

327 *Solution Space Development* – a mass customizer must first identify the idiosyncratic needs of its clients, specifically the product attributes of which the consumer may diverge more, and from that knowledge clearly define its solution space, delineating what it will offer (and what it will not). For such, is fundamental to have innovative tool kits in which the consumers may traduce their preferences directly to the product design, highlighting the less satisfactory needs during the process. In that perspective and to complement it, developing customer experience intelligence, accumulating data introduced by the consumer may be a value tool for the company. Additionally, virtual concept testing is also of relevance, namely via ways of virtual prototype creation and evaluation to prospective customers.

Robust Process Design – a mass customizer needs to ensure that an increased variability in customer's requirements will not impair the company's operations and supply chains. One possibility is through flexible automation, as is the case of intangible goods supplied via internet. Process modularity may also be a complementary alternative, which can be achieved by thinking of operational and value-chain processes as segments, each one linked to a specific source of variability in customers' requirements. To ensure the success of robust process designs, companies need to invest in adaptive human capital, specifically, employees and managers have to be capable of dealing with new and ambiguous tasks to offset any potential rigidness that is embedded in process structures and technologies.

Choice Navigation – a mass customizer must support customers in identifying their problems and solutions while minimizing complexity and the burden of choice. The consumer, when exposed to too many choices will most likely suffer from what has been called the "*paradox of choice*" in which too many options can actually reduce customer value instead of increasing it. Easing choice and simplifying navigation choice are therefore a must. This can be made via assortment matching, software matching sets of options with a model of the customers' needs and then making product recommendations. Additionally, fast-cycle, trial and-error learning may be implemented, empowering customers to build models of their needs and interactively testing the match between those models and the available solutions. Moreover, by embedded configuration, that is, products that 'understand' how they should adapt to the customer and then reconfigure themselves accordingly.

Cf. Salvador, de Holan, and Peiller (2009).

328 Cf. Noguchi (2010).

329 Cf. van den Thillart (2004).

330 Broadly, a *kit-of-parts* refers to object-oriented construction techniques, where components are pre-designed/pre-engineered/pre-fabricated for inclusion in joint-based (linear element), panel-based (planar element), module-based (volumetric element), and deployable (time element) construction systems.

331 In brief, morphological transferability can be defined as techniques that aim at a minimization of the diversity of connections between objects, in which the greater their geometrical and/or material resemblance, the more likely it is their connections can be similar, thereby contributing to increase production scales.

332 If 10 suppliers are, each, responsible for 10 variants, this results in a final value of 100 variants. This final number is executable if the logistic complexity is dissolved among participants, and for such an elevated number of variants, the client only needs to take 10 decisions. On the other end, it is only possible to manage a virtual number of variants that can be created in a system if there is an agreement in which the sub-systems are compatible and that its suppliers accept the responsibility for their own components.

333 It is known that it is something that it is happening and that it is a process of increasing connectedness. It is also known that it involves a great deal of areas of human endeavor, and that every knowledge field is (or can be) in one way or another related to it. Such is, for instance, evidenced by the multitude of literature one can find on it in diverse areas of e.g. sociology, economics, geography or cultural theory. Eldemery (2009: 344) writes: "*Serving as a buzzword of the decade, the phenomenon of globalization has attracted more significant global attention than perhaps any other issue in recent memory, yet the term is used in so many different contexts, by so many different people, for so many different purposes*".

334 It has also been conceived as a relatively long-term process and understood as a multi-pronged process, since those factors manifest themselves in many different arenas of social activity. (cf. Scheuerman, 2010).

335 Giddens (2004: 123-198) points three general factors contributing for such conspicuous relations: political changes (e.g. the end of cold war, increase of international and regional mechanisms of government such as UN and EU, increase of the intergovernmental organizations – IGO's – and international non-governmental organizations – NGO's); informational flows (historical events increasingly broadcasted live, social networks among others, and consequently growing awareness of that what each one of us do might affect all the others), and transnational companies (responsible for two thirds of the world trade, which works as a networked entity, physically and electronically interconnected).

336 Cf. Castells (2002: 123-198).

This is at least an idea concordant with a certain popular discourse, in which globalization often works as a buzzword to describe liberal or neo-liberal policies in the world economy, seemingly ascendency of westernized or Americanized forms of political, economic and cultural life, spread of (new) information technologies [IT's], or the notion of a seemingly unified world community in a global integration.

337 According to Herod (2009: 230), the global "*tying together has been ongoing since humans first left East Africa millennia ago, it has been a historically and geographically uneven process – spatial linkages between different parts of the globe have been initiated and deepened more at certain times and between certain places than others. There is, then, a material basis to periodizing human existence by suggesting that particular eras experience more instances of what many have come to call globalization than do others. However, given that historical and geographical processes are just that – processes – it is often difficult to say with any great precision when a particular process (as is the case of 'globalization') definitively began*". Indeed, "*it is always hard to date with precision the appearance of a concept*", refers Calinescu (1999: 13), and all the more so when it is so complex, transversal and somewhat of a hype use as *globalization.*

338 Social and geographical theory has formulated a broader concept of globalization that goes beyond some possible misleads by common occurrences of the theme. It has to do with fundamental changes in spatial and temporal contours of social existence (cf. Virilio, 2000), such as spatial compression by increasingly simultaneity of time (Harvey, 2005: 240).

339 It is never an easy task to date with any great precision when a process such as globalization initiated – it can maybe be traced back to when humans begun leaving East Africa thousands of years ago, maybe before. In any case, the primary forms of our current status of globalization seems to have had a definitive boost coming from European sailors in their voyages of discovery in the late XV century, which for the first time would leverage trade to a worldwide level, and would ultimately have a igniting role towards the industrial revolution.

Harvey (2005: 244) writes: "*The voyages of discovery produced an astounding flow of knowledge about a wider world that had somehow to be absorbed and represented. They indicated a globe* *that was finite and potentially knowable. Geographical knowledge became a valued commodity in a society that was becoming more and more profit-conscious. The accumulation of wealth, power, and capital became linked to personalized knowledge of, and individual command over, space*".

340 With secularization are implied what Eliade (cf. 1959) refers to as death of mythology, berth of anthropocentrism and of self-consciousness of the inescapability of historical, linear, time.

341 Cf. Calinescu (1999).

342 Cf. Levinson (2006).

343 For that, we might just look to the clothes we wear and wonder where are they are 'made in'(cf. Timmerman, 2012).

344 Cf. Toffler (1980).

345 As it is noted by Giddens (2004: 52), although economic forces are a part of it, it is wrong to think they do globalization by their own.

346 Economic, political, technological, cultural relations, as with other one might recall, have changed considerably. These can be associated with the rise of huge corporations that spread its influence in several countries around the world, dominating the major areas of economic activity. The annual budgets of many of these are larger than those of small governments, resulting in great influence in the economic and political life of many countries.

Within the giant corporations, the production process of goods and services has become globalized, with often a product being made in different parts of the world and assembled in yet another. This has contributed to create what social and economic theorists called the *new international division of labor*. Labor intensive production has in many cases been 'delocalized' to countries where wages and conditions of employment are low. "*Examples are found throughout the Far East where women and children are employed under conditions which would be outlawed in Western Europe and the United States. High value added production processes such as in the electronics industry takes place in locations with well-paid and highly skilled labor such as Japan and Western Europe*", among others (ETU, 2007).

347 Cf. Kenna (2008).

Seen from above, agents of globalization can be recognized among transnational corporations, *World Bank*, *International Monetary Fund*, *World Trade Organization*, *G8*, *World Economic Forum*, *Bilderberg group*, currency and commodity exchanges, and so on. Seen from below it is possible to observe, for instance, the so-called global citizenship, NGO's, civil society, subaltern globalization or human rights as counter force.

"*At a minimum, globalization suggests that academic philosophers in the rich countries of the West should pay closer attention to the neglected voices and intellectual traditions of peoples with whom our fate is intertwined in ever more intimate ways*" (Dallmayr, 1998 apud Scheuerman, 2010).

348 Surprisingly, in the light of some economic studies that have devised methods for measuring globalization, its level actually seems to be decreasing since the turn of the century. (cf. Arribas, Pérez, and Tortosa-Ausina (2009); Miśkiewicz and Ausloos (2010)).

349 Meadows et al. (2004).

350 Cf. Montaner and Muxí (2011).

351 Herod (2009: 82-83).

352 Indeed, a parallelism of the representation issues can also be established with our neurological bio-mechanisms, which tell us representation is in our very nature, as the brain grasps things through images (visual, tactile or other), i.e. representations, imprints, of the surrounding retrieved by the different sensory receptors. As neurologists found out, perception is the conscious recognition and interpretation of sensori stimuli. Senses, particularly vision and hearing, create representation of the outside world inside our brains. These sensory experiences are largely built upon illusions that have been shaped by millions of years of evolution. (cf. Sweeney, 2011).

Damásio (1996: 105-106) writes: "*Brains can have many intervening steps in the circuits mediating between stimulus and response, and still have no mind, if they do not meet an essential condition: the ability to display images internally and to order those images in a process called thought. (The images are not solely visual; there are also 'sound images', olfactory images', and so on.) (…) behaving organisms (…) not all have minds, that is, not all have mental phenomena (…). Some organisms have both behavior and cognition. Some have intelligent actions but no mind. No organism seems to have mind but no action. (…) Having a mind means that an organism forms neural representations which can become images, be manipulated in a process called thought, and eventually influence behavior by helping predict the future, plan accordingly, and choose the next action. Herein lies the center of neurobiology as I see it: the process whereby neural representations, which consist of biological modifications created by learning in a neuron circuit, become images in our minds; the process that allows for invisible micro-structural changes in neuron circuits (in cell bodies, dendrites and axons, and synapses) to become a neural representation, which in turn becomes an image we each experience as belonging to us.*".

It adds what is called the *change blindness* effect, which is the failure to notice a surprisingly large change from one moment to the next, because the attention capacity of the brain is limited. When we look at our world, we take in a far smaller subset of it than we think we do and what we are focusing on is what we process in a lot of detail and become aware of (cf. Sweeney, 2011).

353 Mandelson (2010) writes: "[the] *credit crunch was, in fact, an information crunch: the market didn't know who had what, or what it was worth. (…) The markets, a transmission mechanism, and now indelibly, for better and for worse, a global mechanism, reproduce and magnify human behavior: they fail because we are fallible*".

354 Harvey (2005: 244-245).

355 Jacob (1992: 21).

356 Others include Sven Markelius, Wallace Harrison, Howard Robertson, Louis Skidmore, Julio Vilamajo, Ssu-Ch'eng Liang, and Max Abramovitz. "*The Board of Design took pains to present the design as the unanimous result achieved by this group, and agreed that no individual credit should be given to any one architect. But Le Corbusier began a campaign after he left New York to claim that the central idea for the UN's design was his alone*" (Dudley, 1994). Indeed his sketches seem to prove so.

357 Cf. Eliasson (2012).

358 Cf. UN (2000).

359 Cf. UN (2011).

360 Cf. UN (1948).

361 Cf. Kenna (2008).

362 UN-Habitat (2006).

363 UN ECOSOC apud Kenna (2008).

364 Cf. UN-HABITAT, 2005 apud HFH (2012).

365 Cf. (UN-HABITAT, 2006b apud HFH, 2012).

366 Cf. UN-Habitat (2006).

367 Cf. Krugman (2008).

368 Fulcher (2011).