

OPEN-SOURCE, PARAMETRIC ARCHITECTURE TO PROPAGATE HYPER-DENSE, SUSTAINABLE URBAN COMMUNITIES

Parametric urban dwellings for the experience economy

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Abstract. Rapid developments in societal, technological, and natural systems suggest profound changes ahead if research in panarchical systems (Holling, 2001) is to be believed. Panarchy suggests that systems, both natural and man-made, rise to the point of vulnerability then fail due to disruptive forces in a process of ‘creative destruction.’ This sequence allows for radical, and often unpredictable, renewal. Pressing sustainability concerns, burgeoning urban growth, and emergent ‘green manufacturing’ laws, suggest that future urban dwellings are headed toward Gladwell’s ‘tipping point’ (2002). Hyper-dense, sustainable, urban communities that employ open-source standards, parametric software, and web-based configurators are the new frontier for venerable visions. Open-source standards will permit the design, manufacture, and sale of highly diverse, inter-operable components to create compact urban living environments that are technologically sophisticated, sustainable, and mobile. These mass-customised dwellings, akin to branded consumer goods, will address previous shortcomings for prefabricated, mobile dwellings by stimulating consumer desire in ways that extend the arguments of both Joseph Pine (1992) and Anna Klingman (2007). Arguments presented by authors Makimoto and Manners (1997) – which assert that the adoption of digital and mobile technologies will create large-scale societal shifts – will be extended with several solutions proposed.

Keywords. Mass customisation; urban dwellings; open source standards; parametric design; sustainability.

Today's architecture is at a turning point. The big trends of the last decade are outlived and only a few buildings in the world manifest architectural perfection while paving new ways into the future (Otto, 2003).

1. Introduction

Rapid developments in societal, technological, and natural systems suggest profound changes ahead, paralleling research findings in panarchical systems (Holling, 2001). Systems, both natural and man-made, rise to the point of vulnerability then fail due to disruptive forces in a process of 'creative destruction'. This process allows for radical and often unpredictable renewal opportunities. Pressing sustainability concerns, burgeoning urban growth, and novel 'green manufacturing' laws, suggest that we are at a point for urban dwellings described by Gladwell as a 'tipping point' (2002). In this state, unmet desires – unknown and not yet articulated – are rapidly adopted once a solution is presented.

Over a decade ago, authors Makimoto and Manners (1997) asserted that continued adoption of mobile technologies will create large-scale societal changes, many of which have already come to pass in the last decade. Emerging trends suggest the need for a new type of living environment for urban dwellers. For the past century, many have proposed flexible dwellings; however, today a new range of solutions are now possible due to parametric design and digital fabrication combined with open-source standards to encourage the creation of diverse free-market components that are prefabricated and easily combined in different ways by consumers. Such a system would permit the creation of urban dwellings that are flexible, adaptable, affordable, sustainable, recyclable, and mobile. Flexible, tall urban structures follow the same logic advanced by John Habraken in *Supports* (1972). Habraken observes, "The problem lies not with architecture, but with the circumstances that lead to architecture."

These new circumstances may enable developments of, and variations on, visions laid out during the past century by the likes of Le Corbusier, Buckminster Fuller, Archigram, Superstudio, and others. Trends that support this conjecture are examined first. Then, several projects by architecture students at Penn State University illustrate the urban dwelling reconsidered as a nomadic consumer product seen through the lens of branding, as postulated by Anna Klingmann in *Brandscapes: architecture in the experience economy* (2007).

2. Trends in urban growth

In 2008, for the first time in human history, over half of the world's population (3.3 billion people) resided in urban environments. Explosive urban growth is projected for Asia and Africa where it is expected to double by 2030. Urban population worldwide will grow to 4.9 billion by 2030, with slower urban growth expected in developed countries. By comparison, the world's rural population is expected to decrease by some 28 million in the next twenty years, with 81% of the world's population projected to live in urban areas. This requires a paradigm shift for housing.

2.1. THE INCREASING COST OF LIVING IN URBAN ENVIRONMENTS

Among many environmental and social consequences, increased housing cost is a hallmark of urban growth. In the U. S. during the period from 2000–2005 the number of cities with housing expenses at or above 50% of one's monthly income increased 330%, from ten to thirty-three. This is of great concern, especially for low-income people.

2.2. URBAN SPRAWL

The number of US cities with more than half of their residents living more than 10 miles from the center has more than tripled in the last thirty years. Urban centers are becoming both more expansive, and more expensive. Will existing urban models serve this sprawl, or are evolutionary changes necessary?

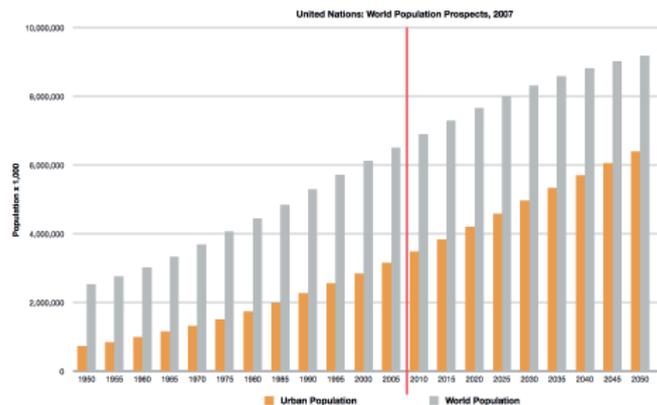


Figure 1. Urban population exceeds 50% of world population (United Nations 2007)



Figure 2. U.S. Cities with monthly housing costs over 50% of monthly income (Joint Center for Housing Studies of Harvard University, 2005).

2.3. PROJECTING FUTURE NEEDS FOR URBAN DWELLERS

The most affordable urban dwelling solutions are provided through rental apartments; a solution which does little to further personal equity. Today, with almost one third of the adult U. S. population renting their dwellings, increasing home ownership for low-income people is an important concern. The average price of new homes in the U.S. is \$290K, while the average wage is \$58,029. New house payments are approximately 1.5 times more than most workers can afford.

Simultaneously, Americans are moving more frequently, with one in five moving annually. This, too, escalates dwelling costs and productivity is diminished due to the time-intensive nature of moving. Many people in urban environments seek a more affordable and responsive dwelling solution than is currently provided. Prefabrication has long aspired to address similar concerns, but not as substantively as hoped. Due to technological advances, the time may have arrived for this pattern to shift. Digital fabrication and parametric design are poised to provide a new type of technologically savvy dwelling that is versatile, affordable, desirable, and sustainable

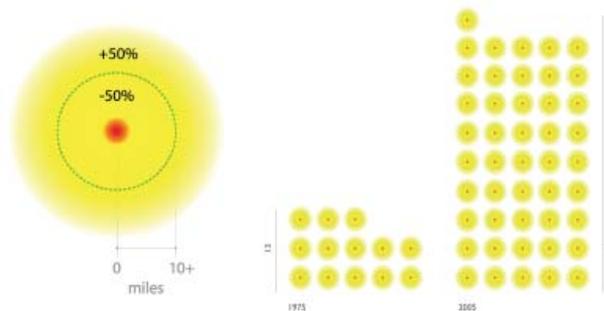


Figure 3. Number of U. S. cities with more than half of residents living more than ten miles from center 1975–2005 (Joint Center for Housing Studies of Harvard University, 2005).

3. The context for prefabrication

Prefabrication is decidedly not new. Over the past century, notable efforts include: Le Corbusier in 1919 writing *Mass production houses*; Walter Gropius and Adolf Meyer develop *Building blocks* in 1923; Buckminster Fuller introduces the *Dymaxion House* in 1929; Frank Lloyd Wright introduces *Usonian House* in 1936; industrial designer Henry Dreyfuss and architect Edward Larabee Barnes collaborate on the design of a prefab house for Vultex Aircraft Company in 1947; Jean Prouvé is commissioned by the French government to create twenty-five housing units in Meudon, France in 1950; numerous imaginative works by Archigram are proposed in the 1960s; Richard Rogers invents *Zip-up enclosures* in 1968; MIT Architecture launches *House_n* in 2003; and a number of emerging works in the past decade are designed by Kieran Timberlake, Marmol Radziner, LivingHomes, Michele Kaufmann, Resolution 4 Architects (winner of the *Dwell* magazine competition), and many others of note.

Prefabrication has been accepted by the lower end of the housing market (in the form of “mobile homes”) but has struggled to gain acceptance at mid-to upper-income levels. While there is renewed design inquiry in the area of prefabrication – as evidenced by MoMA’s recent exhibition *Home delivery: fabricating the modern dwelling* – the majority of these solutions are for rural or semi-urban areas. Despite a few bold proposals (by Greg Lynn, Kol/Mac, and others) prefabrication is still largely absent from dense urban settings. One of the significant barriers to greater adoption of prefab – beyond the inaccurate but durable perception of ‘inferior construction’ – is that each system is unique unto itself, with little cross-platform compatibility. Additionally, sole-source fabrication is required due to intensive tooling for each model. Unique design strategies are ultimately self-limiting as they violate the basic premise of the ‘bus-model’ of compatibility, which has proven quite successful in computer design. In this model, components from various manufacturers may be easily assembled regardless of brand (Pine, 1992).

4. Prefabrication and Mobility

While prefabrication inherently entails some degree of mobility (since products are manufactured off-site), it does not necessarily *encourage* mobility. Ninety-seven percent of prefabricated structures move just once from factory to installation. On the other end of the spectrum, the RV (Recreational Vehicle) is made *for* mobility but is generally overlooked by architects as a respectable form of prefabrication. This is a mistake. Pre-recession research performed in 2005 by Dr. Richard Curtin of the University of Michigan reveals that

one in six automotive owning families planned to buy an RV in the next five years, while one in twelve already own an RV (Curtin, 2005). These statistics suggest that the RV is quite possibly the most widely accepted and most desirable form of prefabricated dwelling in existence – a consideration which is widely overlooked by both architects and the predominantly “stick-built” prefabrication industry. Makimoto and Manners would contend that the rise of RV purchasing is in part due to the greater liberties offered through mobile computing and cellular phones which began to be widely adopted in the early 1990’s (Makimoto and Manners, 1997).

Given that tax codes and financing instruments both consider RVs as second homes, it seems an oversight to disregard the significance of these consumer products and to overlook their status as prefabricated homes. Not surprisingly, due to the ease of mobility and the capability for people to remain ‘connected’ electronically, increasing numbers are making RVs their full-time homes. With the average ownership age being forty-eight, it is clear that RVs appeal to far more than retirees. RV lifestyles are becoming so popular that the US postal service announced Premium Mail Forwarding five years ago (United States Postal Service, 2005). This is a service that continually forwards mail for the frequently mobile. However, the one main drawback to RVs is that this typology is unwelcome in urban environments. Can we build structures that accommodate urban mobile dwellings?

5. Is urban mobility an oxymoron?

Given current urban growth, along with increased interest in prefabrication, sustainability, and an increasingly nomadic culture resulting from tech-

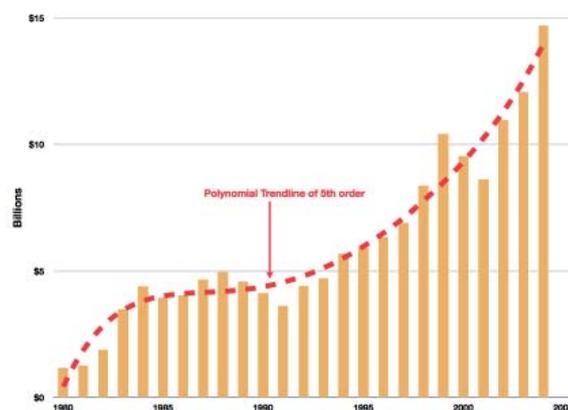


Figure 4. Recreation vehicle revenue 1980-2004 (Curtin, 2005)

nological freedoms, some type of prefabricated mobile dwelling for dense urban environments seems on the surface to be highly desirable; however no such option exists. The necessary ingredients for a solution seem worthy of consideration.

5.1. A RECIPE FOR URBAN PREFABRICATION.

Three ingredients are necessary. If carefully implemented, these suggest possibilities for urban prefabrication for sustainable hyper-dense environments. The first, and most critical, is the development of a set of *universal standards*. In the absence of any overseeing body, an *open-source solution* would easily provide a number of benefits. Due to universal ownership of such standards, this strategy would easily accommodate incremental and proven developments following a number of successful models utilised by the software industry. In some ways, this approach resembles the work by GM for



Figure 5. Hy-Wire chassis by GM (photo by cardesignnews.com)

the Hy-Wire Chassis that permits a standard chassis to accommodate multiple parametrically designed bodies. If open-source standards were implemented, tall-buildings could be constructed to accommodate dwellings of the same dimensions as those used by over-the-road vehicles which must fit through highway ‘keyholes.’

Second, interchangeable components, based upon these standards, could be uploaded to web-libraries permitting web-based configurators to pre-visualise interchangeable designs complete with pricing and web-based ordering. This method would enable diverse variations designed and / or manufactured by unlimited parties while appealing to consumers eager to easily mass-customise their dwellings in a fashion that parallels purchasing expectations shaped by positive experiences with web-based ordering systems.

Third, *stimulation of consumer desire* is required to overcome the stigma associated with prefabricated dwellings. Banwari Mittal, professor of marketing at Northern Kentucky University, writes that our culture relies heavily

upon brand-name products for self-identity. Membership in today's consumer collective is gained through the purchase of celebrated popular products (Mittal, 2006). These observations have also been applied to architecture by Anna Klingman (2007), who views designers such as Frank Gehry, Zaha Hadid, Rem Koolhaas, etc. serving as brands in and of themselves. Co-branding is also an area offering opportunity, with successful examples by Martha Stewart working with KB Homes, Michael Graves with Target, and Christopher Deam with Airstream.

5.2. GLOBAL INFRASTRUCTURE FOR SHIPPING

No inquiry regarding innovative dwellings would be complete without considering the broad number of works that reconsider shipping containers by the likes of Wes Jones, Jennifer Segal, Hybrid Design, LOT-EK, etc. While inventive dwellings made from these modules makes some sense from a purely economic point of view, these solutions offer limited aesthetic appeal no matter how much they are customized. However, shipping containers do offer a valuable lesson for prefabrication; not the container itself, but rather, the standardized chassis that has enabled a global transportation network. Thus, these dimensional standards, closely resembling dimensions for RVs, seem a likely candidate for a starting point for an open-source chassis. Widely varied solutions that conform to this standard could easily be transported via ship, train, and truck, while tall buildings could utilize hoisting mechanisms (interior or exterior) that easily permit these mobile urban dwellings to easily slot into structural bays in a fashion that resembles an apartment building with removable apartments much like a slip that hosts various boats.

6. Conclusions

This inquiry attempts to cover a broad range of topics in an admittedly limited amount of space, which regrettably prohibits substantive breadth and depth to satisfy all concerns and criticisms. Even so, several hurdles may be difficult to surmount. These are likely to be less technological or societal, but rather governmental.

Governing institutions are historically modeled on settlement patterns founded upon agricultural and manufacturing conditions that no longer exist. Among these are voting boundaries, land ownership laws, tax structures, zoning laws, school districts, and land based utility infrastructures. Increased mobility is simply not factored into this historical model. However, in light of current technological considerations, the cost and popularity of urban habitation, predicted environmental changes, and occupational fluidity, fixed dwell-

ings may at some point in the near future become less desirable for some than options that more easily enable greater mobility for urban settings. Despite many challenges, it appears that if demand is indeed as predicted, it will only be a matter of time for the market to advance governmental models that better accommodates societal needs and / or desires.

However, what is clear is that *uniform standards* are required to realise the possibilities proposed here in order for solutions to broadly propagate. What follows are several parametrically designed proposals, exploring the use of branding for various types of mobile urban dwellings with sustainable construction techniques. Should this tipping point indeed come to pass, a process using parametric design and digital manufacturing techniques could support a new product for dwelling that is more culturally relevant and more consistent with expectations forged through positive experiences with consumer products, thus enabling hyper-dense sustainable urban communities which will be in flux for the foreseeable future.



Figure 6. Puma by Gino Colan, Penn State University

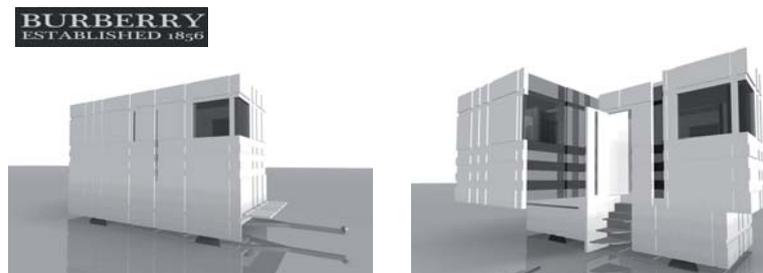


Figure 7. Burberry by Terri Garlewicz, Penn State University



Figure 8. BET (Black Entertainment Television) urban recording studio, by Matt Hoffman, Penn State University.

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