

# ARTICLE

## OVERVIEW

Pre-fabrication as a concept within the field of architecture has existed as long as the profession itself. Architects, in their ambition to problem solve, increase efficiency, improve material science, and pursue mass customization, have generated innumerable possibilities for how prefabrication can revolutionize architecture as a practice. A historical review of architectural projects and papers reveals a tendency amongst architects to romanticize mechanization and to overly simplify its social implications. Partially obscured by these notions, prefabrication has remained an elusive objective for architecture, while engineering and manufacturing have perfected the processes involved in the implementation of prefabrication as a system for design and production. This paper documents a strategy underutilized by the architectural projects that have preceded it. The combination of decreasing scale while increasing livability positions the InHouse OutHouse project as an accessible solution with immediate appeal and effect.

## HISTORY

Over the past 90 years, such luminaries as Le Corbusier, Frank Lloyd Wright, Yona Friedman, Team X, and Jean Prouvé engaged in the dialogue regarding pre-fabrication. Modernists found it to work in their system of the free plan. Megastructuralists became fascinated with the repetitive unit that the individual could customize after construction. Projects such as Moshe Safdie's Habitat at the Montreal Expo in 1967 and Le Corbusier's Unité d'Habitation imagined a new way of constructing private spaces within a larger social backdrop.

Across its varied history, prefabrication has often worked right at the leading edge of the production methodologies and technology of its day. Architecture's fascination with these methods and delivery systems returns again and again as a reaction against or a reimagining of contemporary means of production, consumption and habitation. A better way to work. A better way to consume. A better way to live. Examples of generations in which particular interest in prefabrication stirred include: early Modernism, Post-War, Megastructuralism, and current sustainability trends, while laying dormant during the period of Post-Modernism. **[SUGGESTED IMAGE: diagram of timeline]**

Each era, has a set of unique lessons that can be learned and, perhaps more importantly, failures avoided. Several situations appear to arise repeatedly throughout Architecture's relationship with prefabrication. One driving factor could be the attachment Architecture has to image and aesthetic, leading it to focus more on appearance or expression than on the actual function or result. Rather than engaging developing technologies and true experimentation, architecture generally reproduces images of these technologies as they come into fashion and become widely distributed in the mainstream. Other fields deal directly with new methodologies and technology. Architecture generally mimics it with a flare for the Utopian.

It is during the 1960s that, along with many other social experiments, the Utopian projections within Architecture reached a tipping point. Design collaboratives such as Super Studio were producing futuristic visions of limitless structural frames for simultaneous uber socialist co-habitation and fierce individual expression. Some public-serving institution would build a redundant structural framework,

in which individuals would come along and construct their own idealized habitat. It can be argued that these self-replicating cities were projective and speculative in nature and held entirely earnest intentions of production. On the other hand, they imagined futures that were anything but plausible due to their technological novelty and over-simplification of altruistic social narratives.

Alternatively, the Modernist ideal -- while not only plausible but *actually* attempted-- is anything except Utopian. Mass production and machines for living allow for a level of efficiency and dictatorial autonomy or high-capitalist propaganda. However, they do not recognize the actuality that individuals seek continuous confirmation that they are indeed unique and cherished, that they belong to a group, but are not mere cogs in the industrial machine. **[SUGGESTED IMAGE: diagrams from neighborhood feasibility]** Can pre-fabrication, a system that intrinsically relies on the predictability and reproducibility of manufacturing processes, succeed in residential scenarios without deteriorating to superficial applique.

Recent examples would suggest the field of architecture is changing; unexpectedly it may occur largely without the participation of actual architects. For example, at the beginning of 2012, in China's Hunan Province, the Broad Group (an engineering and construction firm employing no senior architects) assembled a 30 story hotel in just 15 days. The tower consisted almost entirely of prefabricated components that were assembled quickly on site. While the project may lack in what the Architecture community would consider good aesthetic design, the Broad Group has proven an advanced and challenging process and now has the leisure of integrating aesthetics (arguably the easier accomplishment) into future projects. They currently have plans to construct the world's tallest tower in a mere 90 days and are working on methods for their firm to construct 20 buildings in a single month on a sustainable basis.

There are Architecture firms that are actively pursuing methodologies outside the traditional building practices that have defined the profession for so long. One such firm, Kieran+Timberlake, insists that architecture must look to manufacturing methods employed in such industries as aviation, automotive, and technology if the profession is to remain competitive. Their argument goes beyond just understanding the technologies or mechanical processes available, and outlines the ways in which architecture must become knowledgeable in the business and judicial aspects at play as well. It takes an understanding of how these all play a role in the production and delivery process in order to wield them as integrated and creative tools that can drive the architectural process.

## PROJECT

The InHouse OutHouse (in abbreviation, OutHouse) is a prefabricated building component that seeks innovation in three major areas: residential core consolidation, renovation emphasized over new construction, and urban center revitalization.

The OutHouse is a residential core that consolidates major trade-dependent systems and finishes into a single deliverable unit of 100 sq ft. with a goal that scope and quality exceed the cost and labor of construction.

Similar projects have focused exclusively on new construction, and in most cases, strictly in commercial scenarios. OutHouse, by contrast, is designed with specific attributes that allow its insertion into existing construction. Additionally while it is intended for residential use, it is adaptable for hospitality and commercial applications as well.

Ultimately and most importantly, OutHouse swerves from earlier approaches at the point where it pairs the technical and design issues at play with a greater social vision: revitalizing the existing residential fabric of urban centers.

While it does not attempt to revolutionize architecture's relationship with the construction industry, it does identify underutilized and under explored areas within the system in order to establish a productive friction. Pre-fabrication at the component scale has been driving the construction industry for hundreds of years. In the earliest homes constructed in America, and for many decades thereafter, nearly all components were converted from raw good to finished product on-site. By moving this work off site and assembling these bits of building as larger pieces they can be procured, delivered, and installed as a single product or component. In the case of windows, which used to be measured directly on site, and with the sash, head, jambs, muntins, and glazing cut down and hand built there feet away from their point of installation, in a highly specialized and time consuming process. Now window units can be shopped for as a single product, precisely assembled in a factory and shipped to site for someone other than a window specialist to install.

The concept of the consolidated service "core" (where the kitchen and bathroom share a common wall) is not a novel concept either. It is frequently used throughout architecture and construction as a way to coordinate specialized trades and compact mechanical, electrical, and plumbing services. In the past architects such as, Buckminster Fuller, Jean Prouve, Walter Gropius, Archigram, Wes Jones, Kieran+Timberlake, and others have ventured into this line of research and development.

The combination of this trade consolidation with prefabrication has a much more abbreviated history -- with the notable example of Buckminster Fuller's bathroom pods as well as more recent projects such as the Cornell Bathrooms by Kieran+Timberlake -- and has focused almost exclusively on new construction. To take this a step further and pair a prefabricated core with renovation work opens the door to new territory and a line of productive investigation and research.

Born out of an integrated research/design seminar in the Fall of 2010 at the Rice University School of Architecture and through the Rice Building Workshop (RBW), OutHouse was imagined in response to a simple yet incredibly nuanced prompt: *How can a shippable, prefabricated unit, that incorporates a full kitchen and full bathroom, and can also service an entire house (existing or new construction) with completely new and upgraded mechanical, electrical, and plumbing systems be designed?*

Rather than merely problem solving, OutHouse, as a concept, engaged in two major lines of design research that allow it to project beyond being merely critical or reactionary. The first is an approach for understanding the core unit not as a single solitary entity but as a node in the context of a larger network. A series of units installed on single block or throughout a neighborhood work together to symbolize change. Change in how we build and think of existing structures; change in how we view the rehabilitation of neighborhoods. Reshaping the conceptualization of what a core unit can do, OutHouse functions as a "badge of renewal," both socially and architecturally.

The second area of research sought to formulate an incredibly simple approach to a series of complicated issues, allowing OutHouse to negotiate the unpredictable site conditions of building renovation. The greatest issue facing the insertion of a prefabricated core unit into existing homes is the potential necessity of altering floor and roof structure. Structural systems are designed to act together to produce an interwoven and autonomous system. By interrupting this continuity, major modifications of the entire assembly could be required. Suddenly, substantial quantities of time and cost are being spent on a

building system that may have been in sound shape when found and which does not directly affect the livability of the interior spaces for the residents on a day to day basis. When thinking about renovation in an affordable sense through prefabrication, it is critical to conceive of as few on-site alterations as possible.

To prevent cutting into these existing structures, OutHouse radically shifted its conception of basic building elements: what if OutHouse didn't have a ceiling? Or a floor? By allowing the plumbing for the sink and toilet to be chased through the walls and building an elevated platform above the floor for the water heater and air handler, the only obstacle that remains is the plumbing line for the tub. With a slight projection from the exterior of the existing house, this can be accommodated. A simple 20" projection, less depth than the traditional bay window, OutHouse not only deals with this real technical problem related to the systems and "guts" of a house -- everything that allows a building to function day-to-day in the modern world -- but emphasizes the link between renovation and renewal. OutHouse is designed to slide into a house through the face of the exterior wall. It is inserted through a relatively modest opening, framed similarly to what would be necessary for a set of french doors. The projection containing this plumbing, actually overhangs the existing floor structure; legible from the exterior of the house and the street it establishes the visible marker the OutHouse was intended to produce. This all achieves the goal of making no alterations to floor or roof structure of the existing building.

With this design moderately refined, as well as a prior and productive relationship with local Houston CDC and non-profit, Project Row Houses (PRH), OutHouse was given the potential for reality. Through PRH, an historic shotgun row house was identified as the new home for the OutHouse prototype. This provided the test subject necessary to further the project. The row house, located on a corner lot, was perfect for testing all of the intentions and implications of OutHouse, while the site offered room to work and experiment with delivery. Furthermore, being adjacent to past RBW projects, the given house would help continue a growing community of artists, working with the community on various arts and public initiatives. Even with only a single OutHouse being built and inserted, the idea of the project creating a network within the neighborhood was possible due to the adjacency of other design driven renewal projects. On its corner, the OutHouse bookends an entire street of similarly intended projects.

## VISION

OutHouse takes the consolidation of the technical trade based systems of a residential project to a new level. The systems that slow down on-site construction -- time, plumbing, electrical and mechanical -- are in this case manufactured, coordinated, and bundled into a single 8'-6" wide by 12'-0" long package that can be built efficiently off-site.

Though designed for both existing and new construction, OutHouse is targeted at renovation situations. It recognizes that many cities have abundant amounts of structurally sound existing housing stock in need of major systems upgrades. OutHouse offers an alternative to the perpetual outward expansion of the metropolis and its fetishization of the new. The housing stock of Houston, and many urban centers, is reaching an age where the decision to demolish or renovate must be made. OutHouse favors the latter, leveraging the material and social fabric of existing homes and communities while contributing carefully designed modern amenities that improve the day-to-day living of its users. If the kitchen is the heart of a home, the insertion of an OutHouse is a heart transplant. Furthermore, OutHouse replaces the entire circulatory system of an existing house, providing a kitchen and bathroom as well as new heating, cooling, electrical, data, and plumbing services with sufficient capacity for the entire house.

Driving the vision of OutHouse, is the idea that a small package can have a large impact. This is true on a multitude of levels. For one, the actual deliverable package, while weighing in excess of 5000 pounds, occupies less volume than the typical shed. Yet it allows for a complete upgrade and overhaul of all the existing systems. Secondly, while merely 20" in dimension, the projection achieves several goals, from the technical (plumbing) to the practical (light) to the social (sign).

This last point becomes critical as OutHouse was conceptualized as a renewal project. Its social ambition is apparent in the presence the facade establishes for the residence in which it is inserted, acting as a symbol that asserts the residence's contribution to local urban renewal; think "I Voted" stickers. In addition, by using an existing structure and existing urban infrastructure, OutHouse exhibits "urban sustainability," an approach to sustainability that relies not on high technology but rather re-use, re-densification, and re-habitation of once established neighborhood communities. One OutHouse in one house produces only an anomaly in the neighborhood. One OutHouse in every house creates a visible wave of changing sentiment in how we inhabit our maturing cities.

## EXISTING CONSTRUCTION CONDITION

In construction, time equals money, which begs the question, what requires the most time and the most money simultaneously? Without hesitation, the answer is and always will be kitchens and bathrooms. It is here that the most complicated systems and most expensive fixtures and finishes must be carefully interwoven by skilled professionals. Furthermore, these are the spaces that ultimately determine the valuation of the house vis-à-vis the process of (re)sale. Construction of the shell, regardless of construction system, is easy, relatively inexpensive, and requires the least amount of skill. For confirmation of this paradigm, look to the Habitat for Humanity construction model, which utilizes unskilled volunteer labor to construct the shell, but must still rely on professional trades to install the systems.

The systems must not only be coordinated in space, but also in time. The plumbers, whose system is least flexible, typically lead the charge, but only after certain affirmations from the framers. The electricians typically come next, but only after the plumbers have made way. The mechanical team wants nothing to do with the project until all other trades are out of the way. In this complicated dance, complaints abound: there is not enough space for them to work, there is not enough time to complete their tasks, the timeline does not work with their individual schedules (keep in mind that most trades are simultaneously dancing at several projects around town). In reality, these complaints are well founded: all the systems must share the relatively small amount of space that will be hidden behind drywall. The contractor and construction administrator are reduced to merely "go-betweens" attempting to balance the needs of all parties so as to remain on schedule.

Further complicating the coordination of time, this dance must ultimately be judged by a building inspector. Despite the adoption of the International Building Code by most jurisdictions, two key characteristics undermine its promise of uniformity: each jurisdiction enacts its own amendments to the original text, and each building inspector applies their own subjective in interpretation to the code. It is precisely this lack of uniformity that adds yet another variable to the mix; variables equal time, time equals money.

What if these variables were eliminated from the struggle? Those disparate trades could be teams employed by the same manufacturing facility. That facility coordinates the space and time for each trade to perform their respective tasks in the most productive fashion. That facility provides its own regimen of inspection and quality control. This would result in a more effective and productive construction process --

devoid of scheduling and weather nightmares that plague on-site construction.

## MANUFACTURING CHALLENGES

While the OutHouse leverages the many advantages of prefabrication and off-site construction, it also acknowledges the myriad challenges that come along with it. No method of construction is perfect. The main questions pertain to shipping. What is the appropriate shipping travel radius? What United State Department of Transportation regulations pose the biggest issues? How small does it have to be, but remain large in effect? How can the volume to surface relationship be managed? Can the location of the facility allow us to determine some of these questions?

The decision between pairing with a manufacturing partner or forming a stand-alone start-up is still being investigated, but what has been determined are some ways in which OutHouse can work with the other constraints. Shipping via USDOT regulations is an important factor in the prefabrication process. Cost is directly tied to distance. However, equally important is the “wide-load” designation. Depending on certain widths, a rear, and sometimes front, escort are required, again increasing costs significantly. The breaking point for this is 8’-6”. OutHouse deliberately stays within this constraint so as to maximize the size, yet minimize the shipping cost, allowing the value for the end-user to increase.

This begins to question the idea of the volume to surface relationship. Part of what OutHouse recognizes as a concept is that not only is a shell cheap and easy to build and the part of the house that generally seeks the most customization from owner to owner, it also is where the vast majority of volume exists. Shipping costs relate to volume hence why many projects are shipped in panels laid flat. However, this solution requires a great deal of site work to take place. The interest in shipping panels is in large part because by shipping entire houses, or modules of houses, a large amount of air is also shipped.

The OutHouse maintains a small footprint and thus the amount of air that is shipped. Design a small package that creates a large impact. OutHouse relies not only on its own designed space, but the synergistic effect that takes place once it is inserted into a house. **[SUGGESTED IMAGE: House plan diagrams]**

## BADGE OF RENEWAL → CONTEXT: HOUSTON

The OutHouse was inspired by Houston’s increasing urban sprawl and need for inner city renewal, a situation familiar to many growing U.S. cities. The initial prototype is deployed in Houston’s Third Ward, in an historic shotgun house that lacked modern services and was rendered unlivable. The house, owned by PRH, will be reborn as an artist’s residence that will benefit community arts initiatives. The prototype and its insertion are intended to demonstrate the promise of OutHouse as an alternative to new construction and traditional renovation methods. Extensive deployment of OutHouse as a strategy for renewal within a neighborhood would satisfy broader social goals that aim to improve the quality of life in Houston’s existing communities.

Gentrification is frequently heard in discussions about Houston's historic wards. Through conversations and interviews with local community members, advocates, developers, and academics we established some opinions about gentrification, its damaging effects, its benefits and its causes. Through observation of Houston's historical development patterns we cultivated an argument for the OutHouse based on the preservation of scale and constituency. By revitalizing the housing stock while maintaining the efficient, vernacular housing footprint, the OutHouse can offer new domestic amenities and design for the

residents that have historically called the wards their home.

Discussions with PRH, and local developers identified the need for more affordable, yet design oriented, housing solutions and the price-points needed to achieve those. **[SUGGESTED IMAGE: RBW project map]** With PRH's guidance, we were able to interview the artists which PRH place in residence, while working within the neighborhood. Each artist is tasked with not only producing work via their preferred medium set against the context of the row house vernacular, but they are charged with engaging the community and children around them through art and outreach. OutHouse is able to provide a new habitable residence for PRH which will allow them to expand their artist residency program and thus help further their mission of community interaction, involvement, and outreach.

The modest, but thoughtful spaces RBW has designed for PRH over the years have stood as a precedent for OutHouse in its efforts to achieve a balance of affordability and design that accommodates the needs of low income communities. It has been PRH's goals that have specifically driven the research and design culminating in the prototype. Through evaluation of existing PRH residences, the needs they have been based on, and the constituency they serve, we developed layouts and options for the OutHouse that we were able to test against the existing housing stock for viability. PRH and local builders were able to provide valuable feedback on our proposals.

## REVIEW

The prototype has provided the chance to study every aspect of the concept from construction details, to cost, to product and material viability, to livability and beyond. In addition to helping to craft a functioning and livable house for an artist, the prototype will be a concrete example of the project's potential to quickly revitalize an existing structure, a proof of concept. It will help to determine its long term livability and perception within a community. The anticipated residents will put a great demand on the appliances, fixtures, finishes, and structure of the OutHouse as they pursue their personal projects and art production. The space and amenities it provides will also face close scrutiny. The reception of the OutHouse project within a small community, wary of outside interventions is also something that will be followed with interest. If the OutHouse is going to succeed in its founding vision it needs to be viewed as a positive and welcome addition to a neighborhood rather than a stigma laden interloper; think of the current notoriety of the "FEMA trailer".

The OutHouse prototype and process of insertion confirm, quite clearly, how it can reimagine the current status quo of site-based construction, both in new construction and renovation. Furthermore, OutHouse as a unit in a larger network embedded within a neighborhood context represents the possibilities for alternative futures of existing urban centers and their envisioning their decaying communities. The benefits of thoughtful design are exhibited through the ability of OutHouse to operate at the levels of building system, residential space, and community emblem. Through re-imagining an architectural system and process, the aspirations for OutHouse parallel the goals of PRH, deploying a solution to both a private necessity and a public vision. A small package can have broad sweeping impact.

The goal is to make OutHouse not only feasible as a renovation idea but attractive to broad sets of audiences from home-owners, to developers, to city entities. In many ways, allowing OutHouse to remain as small a package as possible has afforded this flexibility and adaptability. The OutHouse is positioned to prove that despite being small, a broad impact can be achieved through effect and exhaustive design.