Chapter 1: A Brief History of Prefabrication

A discussion on historical examples of prefabricated housing

Figure 1: Mechanical Cores at a Panelized Home Manufacturer

Prefabrication is often referred to as "architecture's oldest new idea" for good reason. It's been around for a long time and for most of that time it's been touted as the next big thing in architecture.

What follows on the next few pages is a timeline of some of prefabrication's major achievements and some contributing factors to its development.

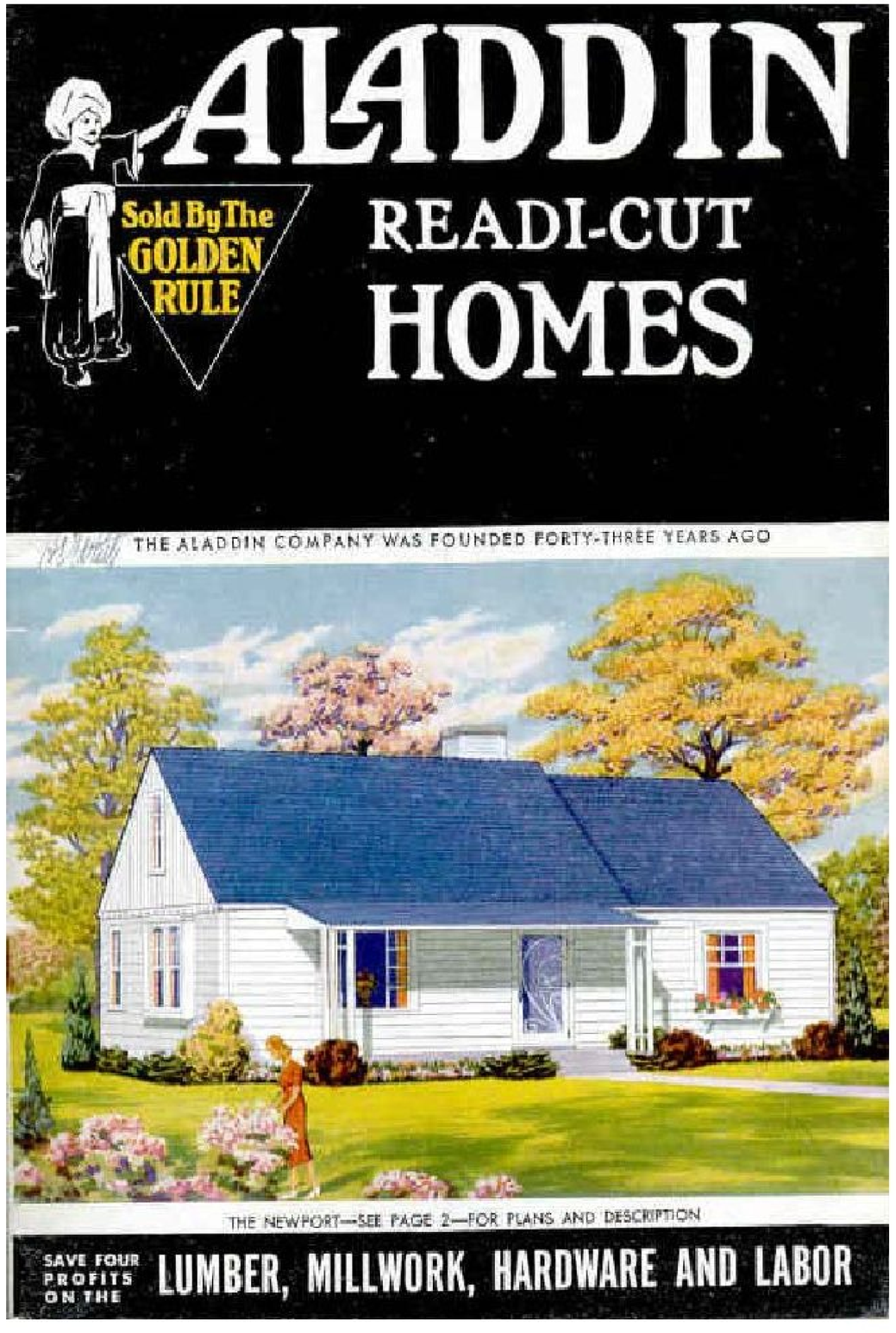


Figure 2: 1949 Aladdin Readi-Cut Homes Catalog cover. from: Clarke Historical Library of Central Michigan University, "Buying an Aladdin House," Clarke Historical Library, http://clarke.cmich.edu/aladdin/buyaladdin.htm.

Timeline:[1]

1624: British use a wooden panelized building to house the fishing fleet in Cape Ann, MA.

1906: Aladdin Readi-Cut Houses produces a kit house of numbered, precut pieces.

1907: AEG hires Peter Behrens as its artistic consultant, creating the role of Industrial designer.

1908: Sears Roebuck & Co. Houses by Mail program established. 100,000 units sold by its demise in 1940.

Poured-concrete house by Thomas Edison.

1913: Henry Ford greatly advances the assembly line.

1914: Domino House by Le Corbusier.

WWI spurs the need for standardization in mass production.

1917: The Hallidie Building, the first to use a glass curtain wall, constructed 1917-1918.

1919: Le Corbusier writes “Mass Production Houses,” a treatise on the beauty of the “house machine.”

1921: Buster Keaton stars in One Week, a film about a newlywed couple who builds their prefab house.

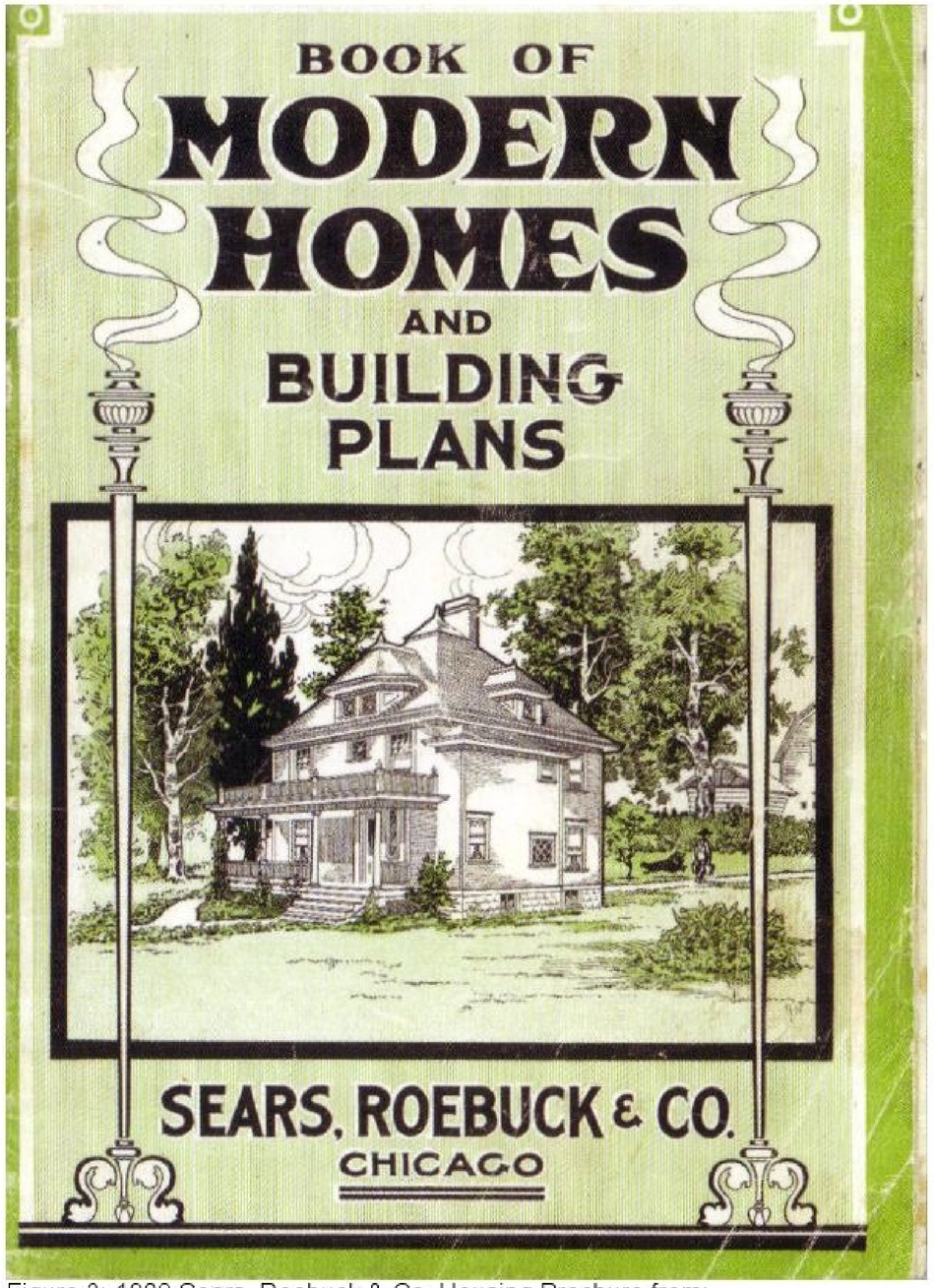


Figure 3: 1908 Sears, Roebuck & Co. Housing Brochure from:
Allison Arieff and Bryan Burkhart, *Prefab*. (Layton, Utah: Gibbs Smith, Publisher, 2002), 14.

[1] Primarily from the catalog of an exhibition titled *Some Assembly Required: Contemporary Prefabricated Houses* at the Yale School of Architecture Gallery, October 27, 2006 – February 2, 2007 and an article titled “Plotting Prefab” in the November 2006 issue of Dwell Magazine.

1923: Walter Gropius and Adolf Meyer develop “building blocks,” a standardized system of housing.

1928: Richard Neutra’s Lovell Health House with prefab steel frame built.

1929: Buckminster Fuller introduces an early concept for the Dymaxion House – his round metal house – at Chicago’s Marshall Fields department store.

Figure 5: Buckminster Fuller's Dymaxion House from:
William J. R. Curtis, Modern Architecture Since 1900, 3rd ed. (London: Phaidon Press Limited, 1996), 267.

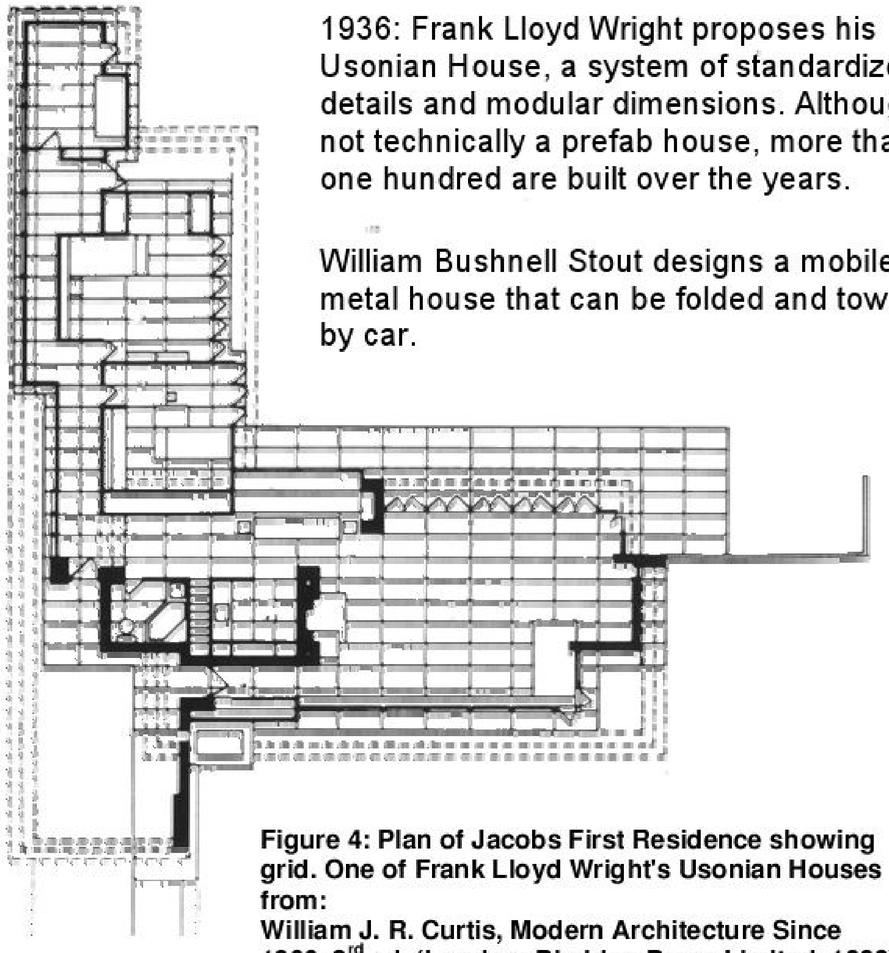
1931: Albert Frey and A. Lawrence Kocher debut the Aluminaire, the first lightweight steel and aluminum house in the U.S.

1932: General Houses Corporation introduces a press-steel panel house for $3,000 -- $4,500. American Houses, Inc. introduces the American Motohome, a simple, box-like, turnkey, steel-framed house.

The MOMA presents its first architectural exhibition, “The International Style: Architecture Since 1922”

1933: George Fred Keck’s House of Tomorrow is toured by more than 750,000 visitors to the Chicago World’s Fair.

1935 Wally Byam introduces his iconic, aluminum shell Airstream “Clipper,” a trailer easily towed by an automobile.



1936: Frank Lloyd Wright proposes his Usonian House, a system of standardized details and modular dimensions. Although not technically a prefab house, more than one hundred are built over the years.

William Bushnell Stout designs a mobile metal house that can be folded and towed by car.

Figure 4: Plan of Jacobs First Residence showing grid. One of Frank Lloyd Wright's Usonian Houses from:
William J. R. Curtis, Modern Architecture Since 1900, 3rd ed. (London: Phaidon Press Limited, 1996), 317.

1938: The Farm Security Administration builds 1,000 prefab homes for sharecroppers in Missouri.

1939: The FSA builds 50 Steel-framed dwellings at $1,650 each.

1940: Engineers Peter Dejongh and Otto Brandenberger design the Quonset Hut, a semi-cylindrical structure formed by a ribbed metal shell.

1942: General Panel Corporation commissions Walter Gropius and Konrad Wachsmann to design a panelized house.

1943: IKEA founded.

1944: The July issue of Arts and Architecture magazine, edited by John Entenza, creator of the Case Study House program, publishes the essay, "What is a House," espousing the tenants of modern prefabrication.

U.S. Government establishes guaranteed home-financing program.

Figure 6: Advertisement for Levittown from:
The State Museum of Pennsylvania, "The Most House for the Money: Designing Levittown from the Inside," The State Museum of Pennsylvania, http://server1.fandm.edu/levittown/one/d.html.

1945: Developer and builder William Levitt begins Levittown construction. His traditional stick-built, high-volume house assembly method rivals projected prefabricated housing volumes. By 1948 he was finishing 15 houses per week.

Lindal Cedar Homes established. Using a wooden post and beam system, Lindal offers a customizable and complete kit home package.

1946: President Harry Truman appoints a Housing Expediter to stimulate production of housing for returning veterans.

1947: Industrial designer Henry Dreyfus and architect Edward Larrabee Barnes collaborate on the design of a prefab house for Vultex Aircraft Company consisting of paper core panels skinned in aluminum.

John Bemis, an MIT School of Architecture graduate, founds Acorn Structures, a prefabricated building system.

The first trailer expressly designed as a house (the Spartan) manufactured.

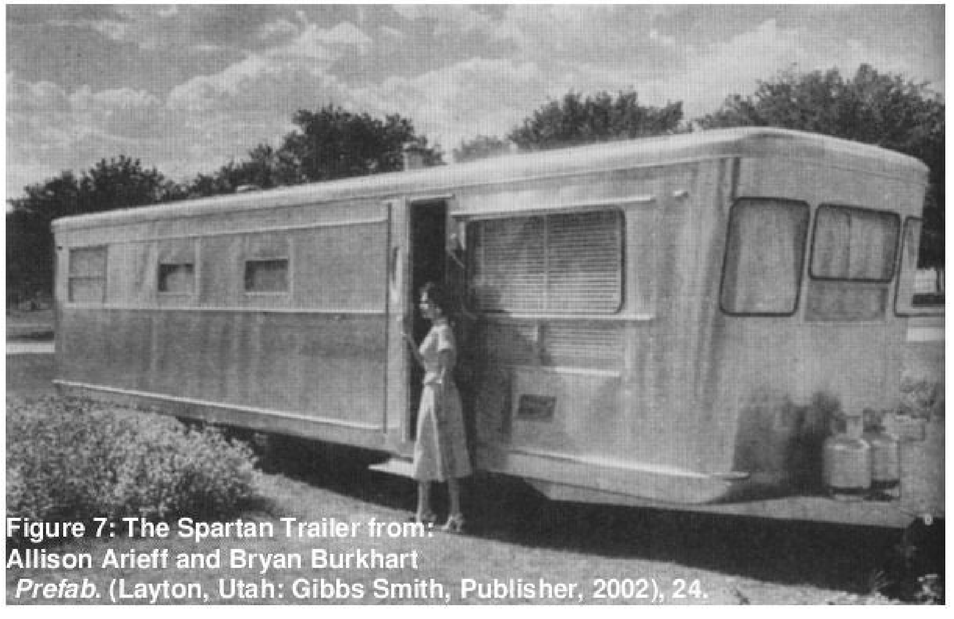


Figure 7: The Spartan Trailer from:
Allison Arieff and Bryan Burkhart
Prefab. (Layton, Utah: Gibbs Smith, Publisher, 2002), 24.

1948: Carl Strandlund starts the Lustron Corporation, which sells about 2,500 of its all enameled-steel houses before closing in 1950.

1949: Designers Charles and Ray Eames finish their one-off home in California, using industrially-produced component parts, as part of the Case Study House program.

Buckminster Fuller introduces his Wichita House, a lightweight, round, standardized aluminum structure. Only two are eventually built.

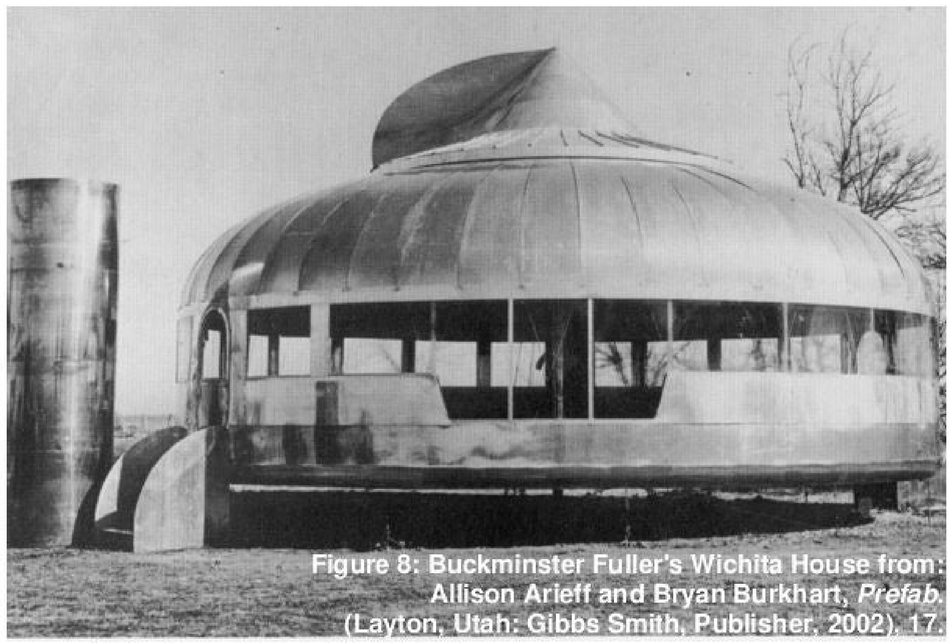


Figure 8: Buckminster Fuller's Wichita House from: Allison Arieff and Bryan Burkhart, *Prefab.* (Layton, Utah: Gibbs Smith, Publisher, 2002), 17.

U.S. Housing Act passed.

Developer Joseph Eichler begins producing modern, affordable Eichler Homes.

Philip Johnson's Glass House built.

1950: Jean Prouvé commissioned by the French government to create mass-produced housing. Twenty-five units are produced and installed in Meudon, France.

1951: The Farnsworth House built by Mies van der Rohe.

Alcoa Building, large-scale use of prefabricated aluminum cladding.

1954: Australian architect Harry Seidler creates a prototype production house, a system of prefabricated columns, sections, and beams to allow for extreme flexibility in floor plans.

Marshfield Homes introduces the "Ten Wide," a mobile home two feet wider than industry convention.

1956: Malcom McLean develops the metal shipping container.

Figure 9: A shipping container being transported by train.

1957: Norman Cherner publishes Fabricating Houses from Component Parts, a do-it-yourself guide book.

1959: William Berkes, A graduate of the Harvard Graduate School of Design and disciple of Walter Gropius founds Deck House, a prefabricated residential building system.

1960: George Nelson's modular "Industrial House" presented in Science and Mechanics magazine.

1963: Carl Koch designs the Techbuilt House, a wooden frame structure and panelized system.

1964: Archigram Group creates concepts for Walking Cities and Plug-in Cities.

Dante Bini builds first pneumatically raised dome in 60 minutes.

1967: Buckminster Fuller designs the U.S. Pavillion at Montréal's World Expo, a large geodesic dome.

Moshe Safdie's Habitat Montréal is built for the World Expo. 158 concrete modules stacked atop each other contained eighteen different versions.

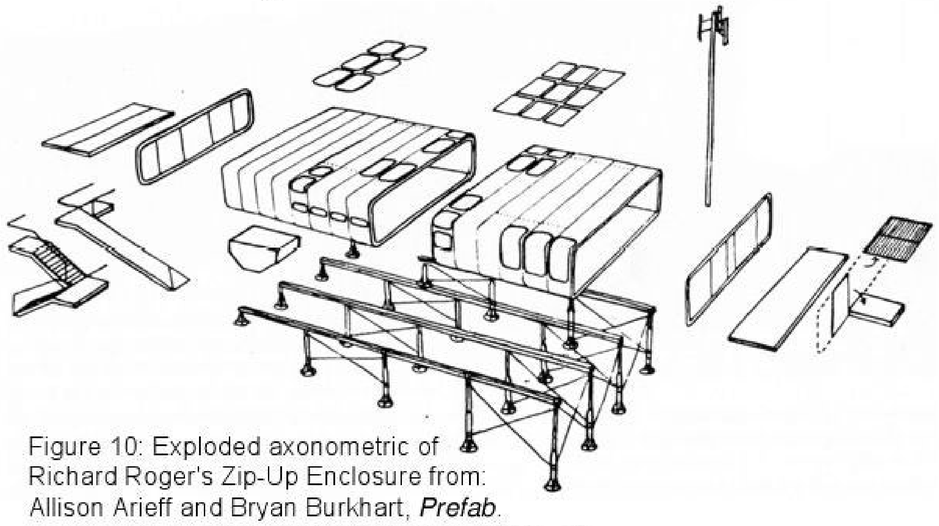


Figure 10: Exploded axonometric of Richard Roger's Zip-Up Enclosure from: Allison Arieff and Bryan Burkhart, *Prefab*. (Layton, Utah: Gibbs Smith, Publisher, 2002), 30.

1968: Richard Rogers proposes his Zip-Up Enclosures, a series of standardized components that users could purchase to expand a living structure.

Paul Rudolph is commissioned by the Amalgamated Lithographers of America to create more than 4,000 prefabricated living units rising more than sixty-five floors. (unrealized)

Mobile homes account for 25% of single-family homes.

1970: The geodesic dome as a do-it-yourself phenomenon is reflected in the publishing of Lloyd Kahn's Domebook One and one year later Domebook 2, which sold more than 175,000 copies.

1971: Paul rudolph's modular housing project Oriental Masonic Gardens completed in New Haven, Connecticut.

1972: Kisho Kurokawa's Nakagin Capsule Tower in Tokyo is realized with living units that can be changed out over time.

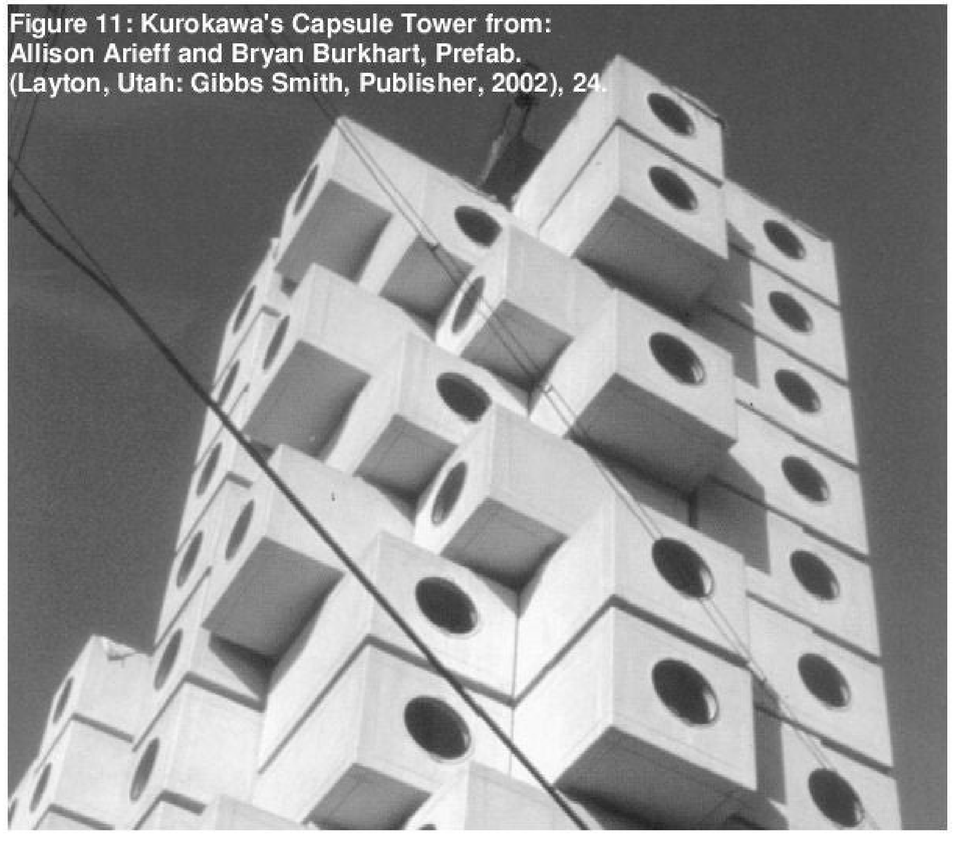


Figure 11: Kurokawa's Capsule Tower from: Allison Arieff and Bryan Burkhart, Prefab. (Layton, Utah: Gibbs Smith, Publisher, 2002), 24.

1974: Zvi Hecker's Ramot Housing Complex in Jerusalem of 720 polyhedric modules arranged in a beehive configuration.

1976: U.S. Congress passes the National Mobile Home Construction and Safety Act to ensure the use of approved construction standards.

1980: The National Mobile Home Construction and Safety Act is renamed the National Manufactured Housing Construction and Safety Act, reflecting the difference between truly mobile recreational vehicles and more permanently sited manufactured homes.

1985: Architect Deborah Berke creates the Single Wide and Double Wide, two modular house designs, for developer Harvey Gerber.

1993: Mark and Peter Anderson develop their first balloon-frame panel house on Fox Island, Washington.

Figure 13: A "double-wide" mobile home.

1995: Shigeru Ban completes Furniture House in Japan, which uses factory-finished and site-installed floor-to-ceiling shelving as structural support for the roof.

Wes Jones uses shipping containers as the basis for his Technological Cabins series.

1996: Mass-market retailer IKEA initroduces its more traditional style Bo Klok house in Sweden.

1997: KFN Systems introduces its prefabricated module SU-SI, which is trucked to the site and erected on piers.

2000: Global Peace Containers, a non-profit organization that converts retired shipping containers into housing and community buildings, completes a school in Jamaica.

2001: Rocio Romero Offers the LV Home, a Galvalume-clad rectangular, flat-roof, glass walled home as a partial kit home.

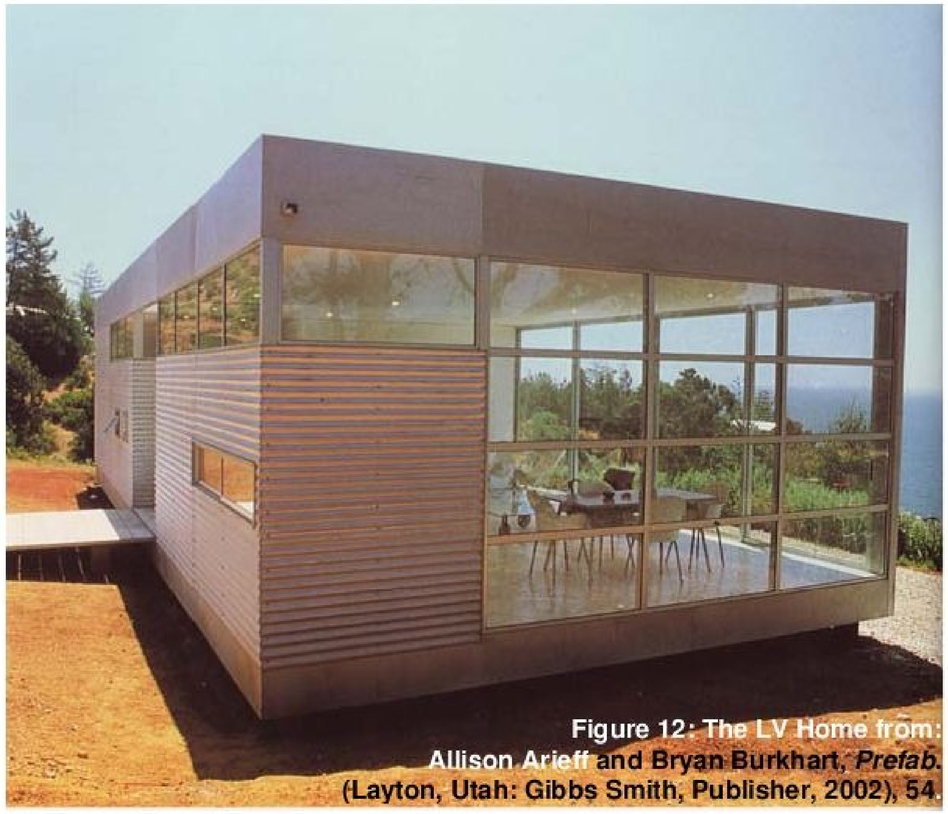


Figure 12: The LV Home from:
Allison Arieff and Bryan Burkhart, *Prefab.*
(Layton, Utah: Gibbs Smith, Publisher, 2002), 54.

Sean Godsell creates Future Shack, an emergency housing prototype built from a discarded shipping container.

Adam Kalkin creates The Collector's House for the Shelburne Museum comprised of three converted shipping containers with an outer shell by Butler Building, an off-the-shelf metal industrial building envelope.

Buckminster Fuller's Dymaxion House is restored and installed at the Henry Ford Museum in Dearborn, Michigan.

David Hertz creates his Tilt-Up Slab House in Venice, California, utilizing precast concrete panels.

2002: Allison Arieff and Bryan Burkart publish Prefab, the first survey of contemporary prefabricated houses and their historical antecedents.

Figure 14: LOT-EK's Mobile Dwelling Unit from: www.lot-ek.com

2003: The architectural firm LOT-EK completes its prototype for a Modular Dwelling Unit, a shipping container converted into a home featuring extendable and retractable modules that increase usable interior square footage.

Alchemy Architects completes its first weeHouse, a one-room prefabricated modular cabin in rural Wisconsin.

Dwell magazine launches its prefab house competition. A design by Resolution: 4 Architecture is selected for construction at a North Carolina site.

2004: The "no-brand" retailer of minimalist consumer goods Muji offers a prefabricated, metal-clad house designed by Namba Kazuhiko in the Japanese market.

Michelle Kaufmann's Glidehouse, a modular prefab home, debuts at Sunset magazine's Celebration Weekend in Menlo Park, California, and enters production.

Charles Lazor completes his prototype FlatPak, a panelized prefabricated system, in Minneapolis. In 2005 the FlatPak is offered for sale by Empyrean International LLC.

2005: Marmol Radziner debuts Desert House, a prototype for a steel-welded frame modular prefab system of living, shade, and deck modules. A factory is established in Los Angeles for production controlled by the architectural firm.

Michelle Kaufmann debuts the Sunset Breezehouse, a modular prefabricated home featuring a series of garden spaces and a choice of roof type, and enters production.

Pinc House based in Sweden adds Black Barn to its home offerings. Based on the Viking longhouse, the pitched-roof structure uses a panelized prefabricated system.

Prefabricated housing is an idea whose time has come, and gone, and come, and gone again, and (at present) returned. Its history is long, the longest, in fact, in all architecture. From time predating humanity itself, it has been the chosen form of shelter for much of the natural world. The natural world, it turns out, is clever in that its citizens frequently rely on their neighbors or ancestors or their own biological functions to provide shelter (when there is any required). Natural examples of site built housing abound (bird's nests, spider webs, ant hills, etc) but even in these cases the tendency is to use materials that have already undergone fairly elaborate manufacture to bring them to their useful state (sticks, silk, sand, trees). More "traditional" prefab housing is also very common. Hermit crabs leap immediately to mind, as they use a ready built house tossed off by another organism that has outgrown it (or died inside it). Coral is a metropolis of magnificent complexity, all constructed on the skeletons of its ancestry. Another form of shelter exists that is not often thought of as such, but it is found in crustaceans, mollusks, and a few reptiles. This is a type of biological architecture that provides constant shelter in the form of an exoskeleton or a shell (where an endoskeleton also exists).[2]

Human beings are fleshy and soft, compared to crustaceans, and we therefore require shelter that exists outside us, and slightly more independently than an exoskeleton, but we have the capacity to make them and all other forms of shelter. The

[2] Yes, there are some overlaps and contradictions in these categories (hermit crabs are crustaceans, etc) as well as the omission of an entire class of animals that do not require shelter at all, but this chapter concerns architecture and presupposes its necessity for humanity, and is not intended as an exploration/classification of animal habitation (other than human).

tendency has recently (last few thousand years) been to move from more mobile and prefabricated systems to site built, custom, permanent residences. But an idea emerged in the eighteenth century (and perhaps earlier) to move back to simpler, more modular elements to be produced with less site labor.[3] This idea has evolved to be known as prefabricated architecture (prefab, for short). Modern, human made prefab architecture does however follow the aforementioned examples (though perhaps not purposefully) and will be categorized into the same three groups: component housing (that of factory built modular elements of varying complexity), modular homes (entirely prefabricated units delivered to the site nearly complete), and motor homes (mobile shelters that move with their occupants). This chapter will describe the advantages and disadvantages of each variety, as well as map some of the overlap and subcategories that occur within them.[4]

The earliest instance of prefab housing in the modern sense dates back to 1624, when the English brought a wooden panelized building to Cape Ann, Massachusetts. It was used as housing for the fishing fleet. The house was mobile in that it was disassembled, moved, and reassembled several times as the needs and location of the fleet evolved.[5] This early experiment marks one of the most prominent uses of prefab housing: temporary settlement. When something more substantial than a tent is required for the site conditions, a prefab

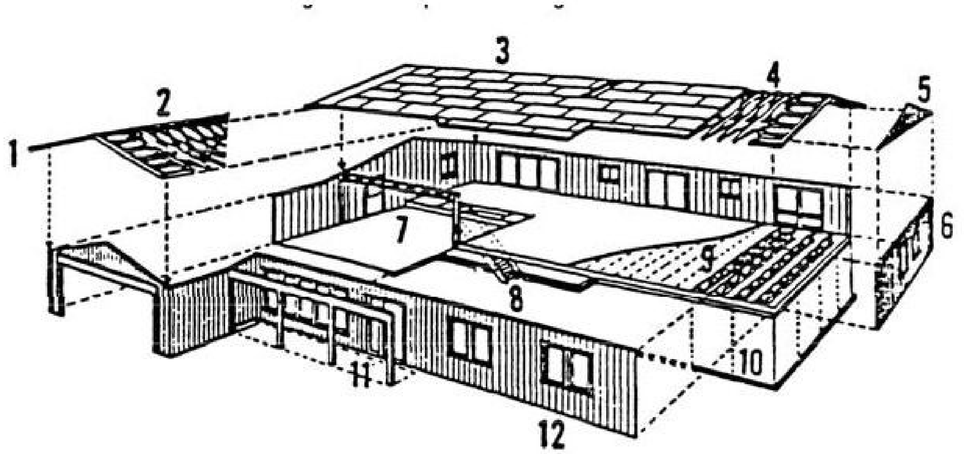
[3] Burnham Kelly, *The Prefabrication of Houses* (Cambridge: The MIT Press, 1951), 7

[4] It is important to note that many of the terms and classifications referred to here are not the industry standard terminology, nor are the classifications common. Panelized construction, for example is often considered in a separate category from component housing, motor homes are thought of less as architecture and more as automobile, etc.

[5] Kelly, 7

solution is often utilized. The reason for using this panelized system, classified as component housing, was its ease in portability. The motor home would have been a tempting option at the time – and the ship they used to bring it over could be classified as a motor home (sans motor) – but component housing allows a much higher degree of density in shipping, in that its pieces can be designed in such a way as to stack flat or fit together in some way that doesn't occupy any more space than the actual material, whereas a motor home or modular home occupies all of the space it intends to shelter while in transit.

The panelized house is but one variety underneath the umbrella of component housing. Another, often referred to simply as components, utilizes prefabricated elements of standard dimensions that can be installed easily into a wide variety of designs.



Newer component framing house part assemblies:
1. Ladder rake overhang assembly
2. Valley roof trusses
3. Roof sheathing
4. Engineered roof trusses
5. Gable end
6. Wall panels
7. Garage door header truss
8. Pre-assembled stairs
9. Engineered floor trusses
10. Wood foundation panels
11. Prehung doors
12. Prehung windows

Figure 15: Exploded View of a house using all prefab components, OTA-TET-315 p20

These elements, such as pre-engineered trusses, panels, foundations, cabinets, and windows, to name a few, have become the standard elements of modern construction, to the point that it is often said by those in the building industry that "90 percent of US housing is built in a factory."[6] This refers to the fact that only the very rich – or those to whom time and effort are uncommonly inexpensive – still use custom designed

[6] Shepard D. Robinson, *Manufactured Housing: What it is Where it is How it operates* (Barrington, Il: Ingleside Publishing, 1988), Ch. 2, P. 1.

stairs, cabinets and window openings that are constructed on the job site. These elements are designed to work in what has become the standard building module for residential construction, studs at 16" on center, and therefore are manufactured in increments of that module. They are also carried to the site on trucks that are limited in width to 8'-0", as that is the maximum that can be transported on a highway without a special permit.

This degree of modularity and its concurrent widespread use by designers, contractors, and manufacturers is impressive. Most often however, the houses they are used in, when taken as a whole, would still be categorized as site built custom homes (despite the high degree of similarity they sometimes have to their neighbors).[7] When the idea of prefab, component construction is expanded further into the design and manufacture of *every* part of the house, it becomes a kit home. This variety was widely popularized in the early to mid twentieth century as the Sears and Roebuck's house kit. Sears no longer sells these houses but a wide variety of manufacturers still make kit homes and precut log homes, usually marketed to builder/dealers, though some are sold to individual customers.[8]

It is in this category of the kit home that many of the more famous examples of prefab housing tend to fall (the British AIROH house, Buckminster Fuller's Dymaxion House and dome houses, among others). These designs mark an effort to free the design of

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[7] Jon Gertner, "Chasing Ground," *The New York Times Magazine*, October 16, 2005, 53.
[8] Robinson, Ch. 2, P. 3

prefab housing from the burden of having to appear to be custom, site built houses, and, while innovative, have met with little appreciable financial success. This is due largely to the fact that to truly be efficient, these designs need to be manufactured on a massive scale and have a distribution and marketing system that either works within the current housebuilding, financing, and realty industry (which largely views it as a threat to its own interests), or reject that well founded infrastructure entirely, substituting its own. This has proven too great an obstacle when the market these homes are designed for tends to reject them (often rightly so) as being too outlandish or uncomfortable to actually live in.[9]

Another set of challenges these designs must overcome are the building and zoning codes of the various municipalities they hope to serve. Building codes have achieved a great deal of standardization in the last twenty years, but they remain largely prescriptive (designating what materials to use and how, precluding unique solutions outside of the vernacular) rather than performance based (specifying criteria to be met in strength, safety, etc., whatever materials and methods are used). Performance based codes do exist, but a large market for these homes is small communities, which are slow to change the rules, compared to large cities, which tend to revisit their building codes more often and whose density precludes much of the prefab designs.[10]

Due to this condition, the extreme difficulty of getting such a massive undertaking and its

[9] Kelly, 67-78.

[10] Robinson, Ch. 11, P. 1-12

accompanying infrastructure off the ground, an alternate solution has grown in popularity, and been adapted to much more widespread use in the United States as well as the rest of the world, particularly Japan.[11]

This brings us to the hermit crab, and its idea of modular housing. The idea of manufacturing a complete home in the factory and simply placing it on site has become a popular solution for several design problems, however it has found most of its market in areas of very low income. Most of what can be classified as modular housing is mass produced, light frame wood and gypsum construction built onto a steel chassis that either remains a part of the house or is removed at installation. As the loads that govern the design of these structures are those that occur in

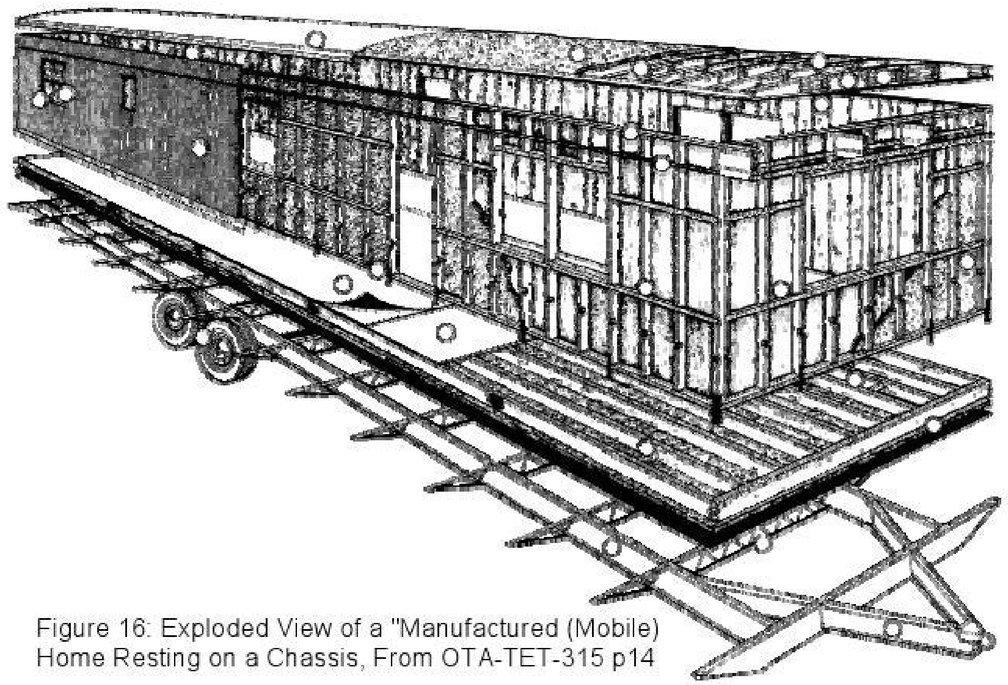

Figure 16: Exploded View of a "Manufactured (Mobile) Home Resting on a Chassis, From OTA-TET-315 p14

transit (which far exceed the average design wind and earthquake load) these units were initially designed to be exceedingly strong. Over the years, how

ever, the structure of the bulk of these designs has been whittled down to the point that ecological designer Jay Baldwin termed them CATNAP (Cheapest Available Technology Narrowly Avoiding Prosecution). The design is under complete control of the manufacturer, who is free to standardize

[11] Emanuel Levy, "P/A Technics Industrialized Housing," *Progressive Architecture* 68 (1987): 92.

dimensions of panels to a degree that reduces waste to nearly nothing.[12]

This solution does not defeat the obstacles that hinder component housing so much as it skirts around them (both figuratively and geographically). Modular homes are not seen as a threat to the custom home builder or its industry, as the customers of modular housing often are such because they can not afford site built construction. Building codes are easily met, as their construction is largely the traditional "stick built" framing prescribed by the codes. The only municipal obstacle that hinders their use is the common practice of "zoning them out" of the more urban developments the zoning regulations seek to "protect," reducing the fate of these units to localized camps or hidden properties on the fringes of rural towns.

There are, in addition to these examples, which largely seek to imitate the aesthetic of traditional western architecture, a variety of designs that reject that goal, replacing it with that of material honesty, believing that if something is mass produced in a factory, it should not be shy about that fact, and embrace the materials and methods that have served mass production so famously in the past (transportation and consumer products).

The earliest examples of this departure sought to fill the housing shortage after World War II. The soldiers were coming home, were promised a house of their own, and the industries of aviation and automobile manufacture that had grown so large during the war were scrambling for something to produce now that they had so much capacity and so

[12] Allison Arieff and Bryan Burkhart, *Prefab*. (Layton, Utah: Gibbs Smith, Publisher, 2002), 9.

little demand. The British AIROH house was one of the most successful,[13] but it had its flaws. Its aesthetic honesty was limited to the materials chosen as structure and cladding, not its form. It did adapt a production line that had been making bombers during the war to cranking out houses (over 54,000 were produced by 1948), but the main reason for its success was its overwhelming necessity. Those that moved into AIROH houses tended to move back out at their earliest opportunity.[14]

Another of this variety is perhaps the most famous of all prefabricated houses, Buckminster Fuller's Dymaxion house, which took its original form in 1927. While its success is measured philosophically rather than financially, this design marks the earliest true movement towards fundamentally rethinking the design of housing as well as its manufacture to adapt to the possibilities of the machine age. Fuller and the likes of Richard Neutra, George Fred Keck, Eero Saarinen, and those that came with and after them created a true movement away from the vernacular. Fuller would later recollect that he sought to "maximize the performance of the house per pound of material in its structure." This quotient is tempting to explore but since that time it has become clear that there is no inherent logic within its prescription. More recent thinking dictates that when a material costs more in financial, social, or environmental terms than a heavier element of similar function, there is little reason to choose the light one. [15]

Fuller's dymaxion house and the designs of his

[13] The AIROH house was not strictly a modular home, as it arrived in pieces to the site, for ease of transportation. Those pieces, however, could only be bolted together in one way.
[14] Kelly, 72

[15] Kelly, 26-27

contemporaries tended toward blurring the lines of classification previously drawn up in this paper. They could not be entirely classified within modular housing, as they tended to require more site work, arriving in several pieces. Nor do they fit tidily within component housing, as their designs, at least for the mass market, tended not to be easily customized (though some were).

While at first this ambiguity may seem like a disadvantage, there is an area in which houses (or shelters) that straddle this line have become particularly useful, in the housing of refugees and other displaced families, as well as solutions for very impoverished permanent communities. This market is, for obvious reasons, more apt to accept a unique solution, provided it is feasible immediately, without demanding that it respond to or imitate any vernacular form (though sometimes it helps).[16] The examples of this type are too numerous to mention, but a few will serve to illustrate the great variety of exploration in this field.

There are prefab tent–like structures, made of lightweight, modern materials like mylar, pvc, nylon, etc. as well as natural materials like hemp and thatch, or a mixture of these, that have been adapted to widespread use in situations where immediate installation is of primary concern and transportation to the site is difficult. These solutions tend to be among the most temporary, though some are quite sturdy.[17] More permanent solutions exist in the form of panelized designs like the Global Village Shelters, designed by Daniel and Mia Ferrara and built by

[16] Architecture for Humanity, ed., *Design Like You Give a Damn* (New York: Distributed Art Publishers, Inc, 2006), 33-47.
[17] Architecture for Humanity, 118.

Weyerhauser, which arrive as a flat panel that is literally unfolded and snapped together to form a rigid, complete shelter.[18] The most permanent types employ masonry or utilize construction materials that are in abundance in the region they serve, such as sand, shipping palettes, or various forms of construction waste. Though few of these solutions could be called prefabricated, they do use a form of mass produced design, simplified to the point where nearly any able bodied human can aid in construction. They take advantage of the fact that manual labor is easy to come by in situations like refugee and migrant worker camps, where the occupants are actually building their own shelter.[19]

Although these solutions are designed largely for the poor and underprivileged, prefab designs aimed at high income markets often borrow from their ingenuity. There is an increasing variety of home designs that utilize prefabrication not solely for its ability to reduce cost (some of these houses can run up to $1,000,000)[20] but because it allows the use of materials that can not easily be manipulated on site, and a quality and precision of construction rarely available on site.

These units can range from a collection of modules (each the size of a typical modular home) to a single unit of unique design, to an assembly of hollow sections, to a series of pre-stressed panels. Often, these projects have aspirations of mass production, but not really on the scale of the dreams of the earlier solutions of Fuller et al.[21]

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[18] Ibid.
[19] Ibid, 131-153.
[20] Frances Anderton, "Desert Utopia," *Dwell*, Nov. 2006: 158.
[21] Martin Nicholas Kunz & Michelle Galindo, *Modular Houses* (Los Angeles: Fusion Publishing, 2005), 5.

These designs are often marketed as a solution for the modern nomad, with the ability to be disassembled or detached from their foundations and moved to a new location with relative ease (a concept often referred to in traditional modular housing, but seldom utilized).[22]

In extending the notion of modern, prefab housing for the nomad to its logical conclusion, one arrives at the turtle shell – or rather humanity's answer to it, the motor home. There are examples within this class that predate motors in the modern sense, and could be called mobile homes, if that phrase weren't already taken by modular homes.

The motor home has enjoyed, from time to time, a prominent place on the American cultural landscape, beginning with its invention – in its modern, internal combustion powered form as the "house car" – in the early twentieth century.[23] Having been condensed into cities for several generations and confined, when traveling cross country, to the railroads which had long lost the sense of adventure that they once engendered, much of the nation saw these as a way to experience an undiscovered America in the time of prosperity after the First World War. The depression brought a cruel necessity to these vehicles, as cobbled together versions piled on old pickups became the only home for the displaced families of the dust bowl.[24]

The image of depression era autocamps (not to mention housing for the WPA and the Tennessee Valley Authority) stuck to the house car for several

[22] Ibid, 64-79.

[23] Roger B. White. *Home on the Road: The Motor Home in America* (Washington: Smithsonian Institution Press, 2000), 36-47.

[24] White, 72

years, but (as in all other areas of prefab housing) they enjoyed a boom in the industrial era following the Second World War. It is in this era that streamlined design and mass production brought marketing momentum to the industry, and by the late 1950's the name "house car" was replaced by tags like supercar, landyacht, and motorhome, and interstate highways made the trips possible for a larger market.

Motorhomes evolved from fairly spartan places to sleep on the road (despite a few famous, privately built exceptions) to opportunities to compact as many "modern conveniences" as possible into something portable. Mass produced truck campers had "penthouse" second stories that could be unfolded, electric refrigerators, stoves, running water, and water closets. Designs tended to fit into one of two categories: motorhomes and campers. As suggested by the name, a motorhome is an attempt to imitate the traditional home, and is usually installed or fabricated onto a truck or bus chassis, essentially a summer home with wheels. Campers, on the other hand, are attempts to provide a place to sleep on the road, and are usually vans outfitted with some furniture, such as a folding bed and table, and possibly a small refrigerator or kitchenette.[25]

The compact designs of living units in both moterhomes and campers have borrowed heavily from preexisting designs for modular homes and components, and vice versa, developing the industry to the extent that these technologies can become interchangeable between stationary and mobile homes.[26]

This level of modularity is fairly recent, and

[25] Ibid, 125-127
[26] Kunz and Galindo, 56

provides the opportunity to design prefab dwellings to suit an ever growing range of demands from the consumer. That is one of the ultimate goals of the prefab industry. To be able to satisfy any client's wishes by using the modularity and expediency of modern, machined precision and efficiency.

Possibly its other ultimate goal is one of efficiency. The manufacturing industry has become very adept at the reuse of scrap materials, as well as tailoring different aspects of the materials they use to reduce scrap (ensuring that panels are the proper size so they're not trimming off the same amount, etc). They have also made a good deal of progress streamlining the assembly process of manufactured products.

These two aspects alone have great potential when expanded into the theater of architecture. One imagines a future when the dumpsters on the job site shrink to the point that they all but disappear, with "scrap" materials being reused in the factories and shops that have become so adept at it, and construction is simply a matter of ordering what is desired, assembling/installing it in a matter of days (or hours), and then leaving the site, to do whatever else you want to do with your day.

There is a third level of efficiency in which the manufacturing industry has not made quite as much progress: energy efficiency once constructed. The amount of energy used to make the materials of a building, to bring the components to the site, and the energy used to assemble them is significant. Most of the energy that is used by a home, though, is used after it's built. If a new residential architecture is to be put forth, it is imperative that it be a great deal more energy efficient than its predecessor.