Repeating Success and Avoiding Failures: A Historical Overview of Panelized and Modular Construction in American Housing

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Abstract
Prefabrication and modular production of housing is one of the oldest "new topics" in architectural discourse. Panelization, mini-modules and fully modular housing construction strategies have been in use almost as long as precut and kit homes that date back to the earliest years of the 19th century[1].

This paper will argue that contemporary and prefabrication production methods for housing have and could continue to learn important lessons from the historical record and will illustrate the application of panelization dating back to post civil-war efforts by Col. Lyman Bridges and others through the depression era Missouri-Farms prefabrication project to contemporary SIP panel development from the Forest Products Laboratory in the late 1920's to Pulte Home Science's recent housing products.

Similarly, the development of Modular housing from the TVA's demountables through the mini modules developed in Operation Breakthrough, Paul Rudolph's Masonic Gardens Project, Safde's Habitat 67, to contemporary applications of modular housing will be presented.

This historical overview will focus on the convergences of public policy; market need, labor skill, transportation infrastructure, and production strategies and will discuss the impact of these production methods on the architectural design of the house.

Introduction:
What qualifies as a prefabricated house? A report on the Toyota pickup truck being used to tow the shuttle Endeavor through the streets of Los Angeles indicated that it had 75% American parts, the same proportion of U.S. made parts that are in the Ford F-150 and that alone made it an "American" and not a foreign truck.[2] But what constitutes a prefabricated house? 75% of the parts by quantity? 75% of the parts by weight? It turns out this is an old question asked as early as 1945 by Robert Davison, Director of Research for the John B. Pierce Foundation.[3] Davison never answers the question definitively, and most Americans living in homes with prefabricated roof trusses and wall panels would not self-identify as living in a prefabricated house, even though, key components, the roof, walls, floor trusses, doors and windows are all constructed offsite and simply assembled on their residential lot. Those components all benefit from the kind of supply chain strategies and production controls that are found in Boeing's aircraft production facility, and the San Antonio assembly line that produced the Toyota Truck towing the shuttle.

Much of what is considered "mainstream" in house construction today would have been considered prefabrication in the 1930's and 1940's. The diffusion of prefabrication strategies into residential construction is a sign of the success of prefabrication…it has become prosaic.

And yet there is a greater dream of prefabrication that still exists. Young architects, students, and even home journal editors get almost misty-eyed when discussing the dream of a prefabricated ideal, a house that arrives in parts and is as easy to assemble as an IKEA table, except that you can turn it into a closet or a bed with simple tools. That has been a dream for many years, and in some ways, it's a positive force in the industry, it sets a distant marker for achievement that each generation of innovators strives to meet or exceed.

The innovators don't always look over their shoulder though; they don't always see the investment that previous generations of innovators have made. Perhaps it is the arrogance of youth or the tunnel vision of invention that causes this, regardless; this paper will try to bring some of the brilliance of the past to light as we consider the most successful prefabrication strategies of all time! (…At least those narrowly confined to prefabricated housing in the United States.)

What qualifies as a successful prefabrication strategy? For the purposes of this paper, "success" in residential prefabricated construction is considered as persistence over time; not the persistence of one company's system, or one architects system, but of strategies, approaches to prefabricating housing in America.

General approaches to Prefabrication
Looking back to the earliest years in America, one might categorize the approaches to prefabrication in the following ways:

- Folding, a method using common materials and extensive use of hinges and flexible connectors to expand a shelter from a compact volume to a habitable one. Patents for folding buildings, "portable" buildings and the like date from the middle 1800's, were commonly applied as hunting blinds or camping shelters and which may be the precursors to the tents and portable shelters commonly used for short term events today.[4] This is clearly a topic worthy of future research, but will not be discussed further in this paper.
- Precutting, a method using common materials (studs, joists, rafters) prepared for assembly by cutting, drilling, etc, and labeled for installation in the proposer location. 1624 to present.[5] There were more manufacturers offering precut homes than all other manufacturers of all other forms of prefabrication combined during the earliest years of the twentieth century.[6]
- Kit or systems homes, a proprietary method using parts and connectors designed for multiple roles (walls, partitions, floors, etc.) with the express purpose of allowing a high degree of flexibility, in form and layout to achieve a diverse set of outcomes tailored to individual needs. 1920 to 1960's
- Panelized, larger preassembled components (walls, partitions, floors, roofs) designed to be assembled in a predetermined way, to make a specific design for a house. Panels may be open, allowing field installation of insulation, systems and finishes, or closed panels, complete with finishes and systems.1820s to present, SIP variants, 1930's to present.[7]

- Sectional and demountable, large, structurally independent assemblies of floors, walls, and roof, often with interior finishes preinstalled, transported on, and subsequently removed from road going trailers at the installed site. This system is also called a modular system, which today is fully International Residential Code (IRC) compliant construction. Produces the most prefabricated housing units in America each year. 1930's to present.
- Mobile, developed in parallel with the sectional/demountables and distinguished from same by the mobile units dependence on an integral roadworthy steel chassis, to which wheels were attached. Following the passage of the National Manufactured Housing Construction Safety Standards (also known as the HUD code) in 1974, the industry flourished and produces a large percentage of the prefabricated housing constructed each year. 1920's to present.

Public Policy and Prefabrication

Transportation is the enabling public infrastructure for prefabrication systems. In addition to direct federal funding to develop systems and production facilities (new deal, postwar, and operation breakthrough), the development and maintenance of waterways, railroads (through land grants), highways and interstates are the most important public policy intersections with the prefabrication industry.

Waterways were the earliest transportation modes into the American wilderness.[8] The Federal and State governments funded improvements to increase the navigable length and utilization of natural waterways while both governmental and private entities developed and operated extensive canal systems, by 1915 over 3,000 miles of canals had been constructed.[9] Transcontinental waterways never existed, so the port and harbor infrastructures on the east and west coasts of the United States were the key pieces of public infrastructure supporting the shipping of prefabricated buildings and frames constructed in the east and delivered to the ports of San Francisco and the gold fields boomtowns of the west.

Railroads were the dominant transportation mode for most precut and Panelized systems in the Midwest but the transcontinental railroad (1865) came too late to serve the boomtowns of the far west. Prefabricator Lyman Bridges located his production site in Chicago, along the river in the early 1870's. His plant advertised premade sash and doors, panelized houses and featured its own railroad siding for easy loading. An Iowa homesteader could arrive by wagon, choose a prefabricated home in Bridge's facility, and it would be shipped to the nearest rail siding, almost by the time the farmer completed the ten days return journey from Chicago. By choosing Chicago as his production site, Bridges had access to markets across the northern tier states, the Midwest, and the south. There are no examples of Bridges products known to be standing today. The only documented projects from his prefabrication plant appear in the proceedings from the Paris exposition of 1867 where his "Western Farmers House" and small schoolhouse were highly acclaimed.[10] It appears Bridges production facility was lost in the Chicago fire in 1871. Bridges disappeared from prefabrication history following the fire, reemerging as a railroad executive and engineering consultant in the west years later.

The government emerged as the most significant customer for prefabricated homes during the Second World War as it rushed to provide housing for widely disbursed factory workers producing wartime materials. There was criticism that in its rush to house the most workers at the lowest price, the government may have provided thousands of citizens with firsthand experiences in poorly constructed, poorly finished, and poorly performing prefabricated housing, thus tarnishing the industry for generations to come and making postwar market acceptance less likely.[11] This idea might be substantiated by the 20-year lag between the war years and the rise of consumer acceptance of prefabricated trusses, wall panels, mobile, and modular homes began increasing in popularity.

The Pressure to Prefab

The pressures to prefabricate have included aesthetic currency, shortages of skilled labor and materials, massive population relocations related to the extraction of natural resources and the rapid creation of settlements to serve the housing needs of workers in wartime production facilities.

Many concentrations of precut and panelized houses are found in boom-towns around gold, silver, and oil extraction sites. One of the largest surviving concentrations of Sears Ready Cut houses is in Carlinville

Illinois, a Standard Oil production site,[12] while some of the largest concentrations of Hodgson Panelized homes may be found in the new deal town of Arthurdale, near the coalfields of West Virginia.

The first and second world wars saw large relocations in populations to production sites for war materials. Many of these were sectionalized, demountable modules, the precursors of today's HUD code mobile home. Custerdale, a wartime community built in Manitowac, Wisconsin is an example of this. The National Housing Authority, a wartime agency later folded into the Department of Housing and Urban Development, built a 400 unit development to house civilian employees of the wartime shipbuilding facilities there. These included both insulated stressed-skin plywood panel houses and steel-chassis demountable housing units. Of the original 400, 250 of the apartment units were moved 96 miles to Waukesha Wisconsin and 85 houses were re-arranged to conform to a less dense, and permanent street pattern where they remain in service today, the remaining 65 units are unaccounted.[13]

Aesthetic currency has also played a prominent role in the proliferation of prefabricated homes. The widespread influence of pattern books by architects such as A.J. Downing, and precut and Panelized housing catalogs featuring the latest styles gave prominent citizens a way to attain the latest style, not often available from slower adopting local building cultures. The popular publication "Dwell" is having a similar effect today, advocating minimalist, modernist aesthetics, it has indirectly supported the sales of Rocio Romero's "LV" home, as well as Michelle Kauffman's "glide" house among others. Dwell's advocacy, and the national proliferation of modular, and panelizing producers, has allowed homebuyers to procure a contemporary aesthetic not offered by their local building cultures.

Depression and recession are also drivers of prefabrication.[14] The pent up demand for home ownership frequently produces shortage of housing. History shows that the years following both the great depression and the housing recession caused by the second world war there was a proliferation of prefabricated housing solutions to material and labor shortages. "American Art and Architecture, in its September 1936 issue featured no less than 48 prefabricated home systems. Most were frame and panel systems and as a set of prefabrication strategies, only one persists today, the Forest Products Laboratory Structural Panel House.[15]

Panelization History

The desire to simplify the work of residential construction lies behind the panelization strategy as its key driver. What could be simpler than picking a pre-built wall up off a stack, carrying to a foundation, and bolting it down. Working with larger pieces meant less skill was needed at the workface, muscle was really all that mattered. In agrarian America, less time building meant more time producing crops or chickens. Panelized solutions prior to the balloon-framing period meant a person without the extensive tools, or the extensive knowledge of a timber-wright, and without a large volunteer community labor force could build their own house. The Derrom patent system for "Neat, Effective, and Cheap" sectional portable buildings were being advertised as early as 1876 in "The Manufacturer and Builder." These advertisements showed multistory houses, small single floor houses, shops, and churches "Adapted for Camp Grounds, Seaside and Summer Resorts" If this system is similar to Derroms patent of 1864, it would employ square framing timbers attached to sills and plates with bolts and steel straps, wedged together with dovetail connectors. The roof was framed with smaller joists that were included in the kit along with a canvas roof. The language of the patent application indicates Derrom's interest in military application with references to troops, while the illustrated advertisement clearly shows he is marketing to a broader audience.
While Derrom's company is one of the pioneers in panelizing that print media gives credible evidence to, the Hodgson Company is the earliest panelization system to be documented in photographs.[16] Hodgson's panels were designed to fit inside boxcars, be lifted by two people, assembled with simple nails, bolts, and connectors, and were purpose-built open panels for each building type but all being similar in their use of standard dimension lumber and batten strips to cover joints between the panels on the siding and roof. Hodgson produced an impressive variety of building types from 1892 until 1995.

Hodgson's basic approach, open wall panels framed with dimension lumber sheathed and sided, was the basis for a New Deal program designed to improve the hygienic living conditions of sharecropper farmers along the lower Mississippi River. The Farm Security Administration (FSA) was formed in 1937 to address rural poverty. It was not a relief agency but was a program for "families that had exhausted the means, but

not the desire for success."[17] One of the FSA's major efforts was the Southeast Missouri Farms Project. This was a series of smaller projects scattered along the banks of the Mississippi from Missouri through Louisiana. Like many of the FSA's efforts, notable photographers such as Dorothea Lange, Russell Lee, John Vachon, and Walker Evans and Gordon Parks extensively photographed the Southeast Missouri Farms project. These images present an almost contemporary prefabrication component plant in operation, and an approach to the "kit of parts" components that are rarely encountered. (Fig. 1 through 4) The FSA employed local farmers in what we would today refer to as a site factory where an entire community of residential components were built from raw stock. The site had a single gasoline-powered saw, and employed jigs fixed to tables to insure precision and subsequent fit of the roof trusses and wall panels. Architect William Jones worked on the simple designs for the housing, with production engineers overseeing the component fabrication. Wall panels were stockpiled, and pulled from stock as needed to complete the house. Panels were shipped vertically, "toaster" style to reduce damage to the pre-installed siding. At the house site, a pier foundation supported a site-built floor frame, on which the prefabricated walls and then trusses were placed. The roof was traditionally finished while the privy and its associated septic tank were precast concrete placed with a truck-mounted crane, and topped with a prefabricated wood privy enclosure.

Figure 1. Southeast Missouri Farms Project 1938, Site factory showing truss jig, wall panel jig and prefabricated privies (background). LC-USF33-011499.

Figure 2. Southeast Missouri Farms Project 1938, Site factory showing racks of wall panel types. LC-USF33- 011511-M1.

Figure 3. Southeast Missouri Farms Project 1938, Shipping panels “toaster” style with gable endwall restraints. LC-USF33- 011509-M3.

Figure 4. Southeast Missouri Farms Project 1938, Panel setting. LC-USF33- 011503-M3.

While the industrialization of the platform framing approach was in full use at the Southeast Missouri Farms project, the Forest Products Laboratory (FPL) was undertaking a line of research aimed at reducing the amount of wood used, and the amount of time it took to build a single-family house.

The Forest Products Laboratory was formed in 1909 as a research partnership between the United States Forest Service and the University of Wisconsin-Madison. Among its many research projects was the project on plywood, adhesives, and the building industry. In 1935, the FPL presented an experimental house, made from plywood stressed skin panels, assembled in just 21 hours by a crew of three. (Figures 5 and 6.)

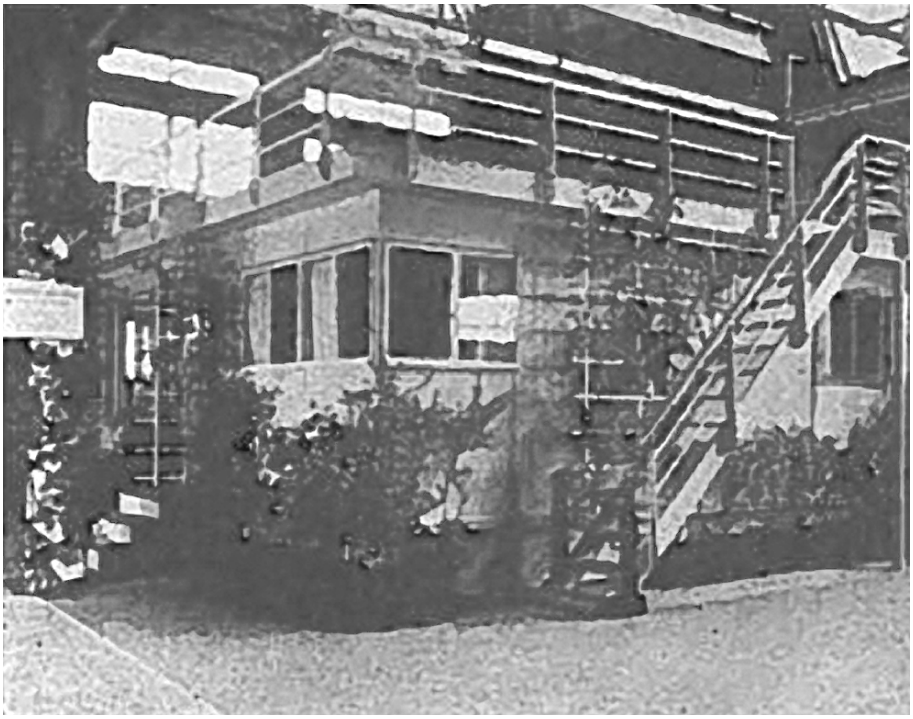

Figure 5. 1935 Forest Products Laboratory Stressed Skin panel house, constructed by a crew of three in 21 hours.

The anecdotal record has it that the FPL house would be brought to state and county fairs in pieces and erected in front of the fairgoers to prove the ease and efficiency of building with their stressed skin system.

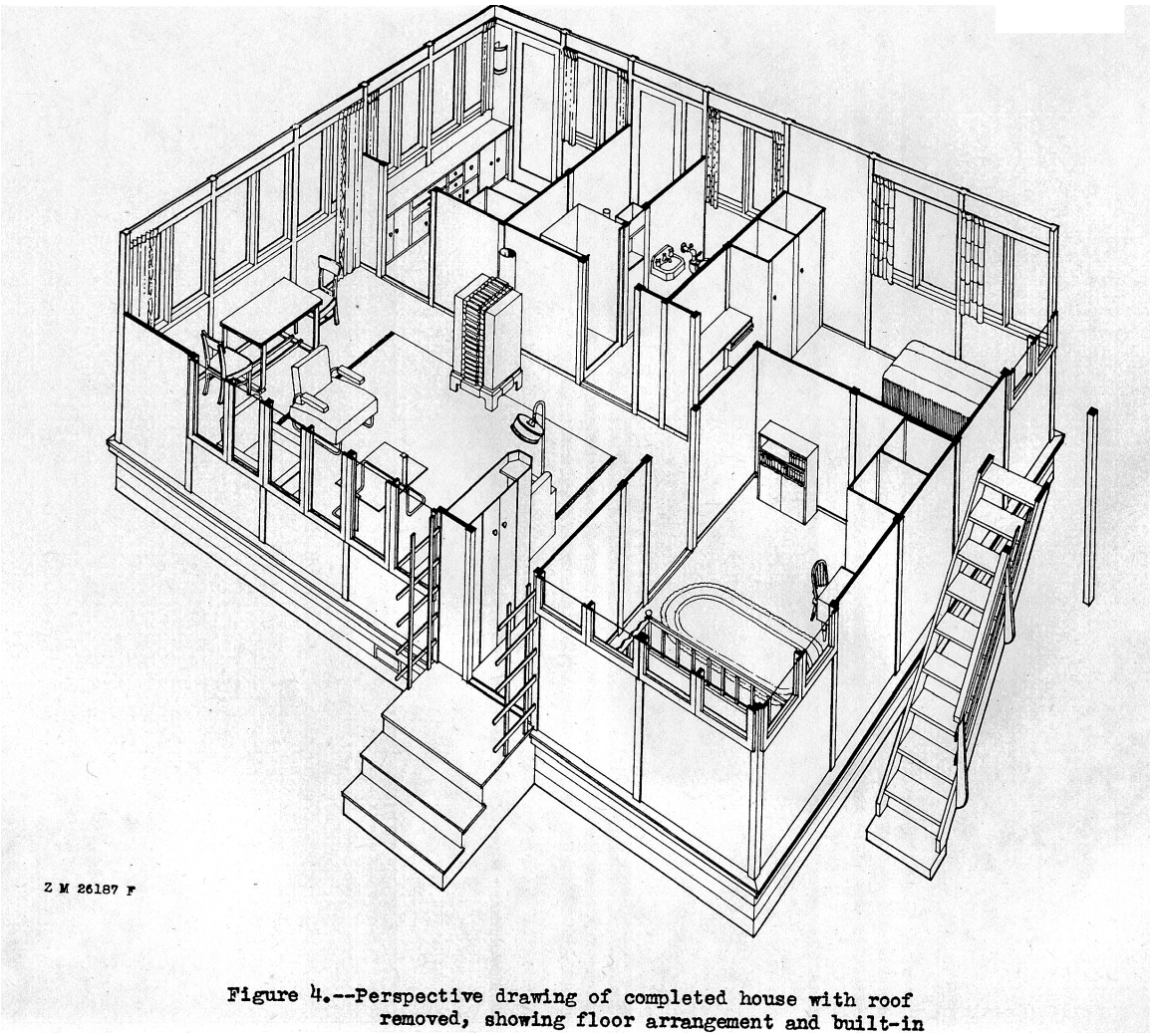

Figure 6. Plan perspective of FPL Stressed Skin House. 1935.

The FPL constructed three more generations of the stressed skin house, in larger sizes and with sloped roofs. Many still stand in northern Indiana. This line of research was credited by Bruce and Sandbank as the most influential research project on the prefabrication industry.[18] Indeed, of the 48 systems of prefabrication presented in the September 1936 issues of American Architect and Architecture, the stressed skin panel, aka the Structural Insulated Panel, is the only strategy still in use today, some 77 years later.

Modular History

The idea of shipping a complete living environment, including all the air inside, has always raised questions in the logistically oriented prefabricator. Precut kits were shipped in thousands of parts, neatly labeled and stacked in boxcars in such a way that anyone could assemble a well-constructed house from it. It must have been more challenging to the amateur builder as the outcomes were satirized by leading comics of the time, Buster Keaton and Laurel and Hardy. (Figure 7).

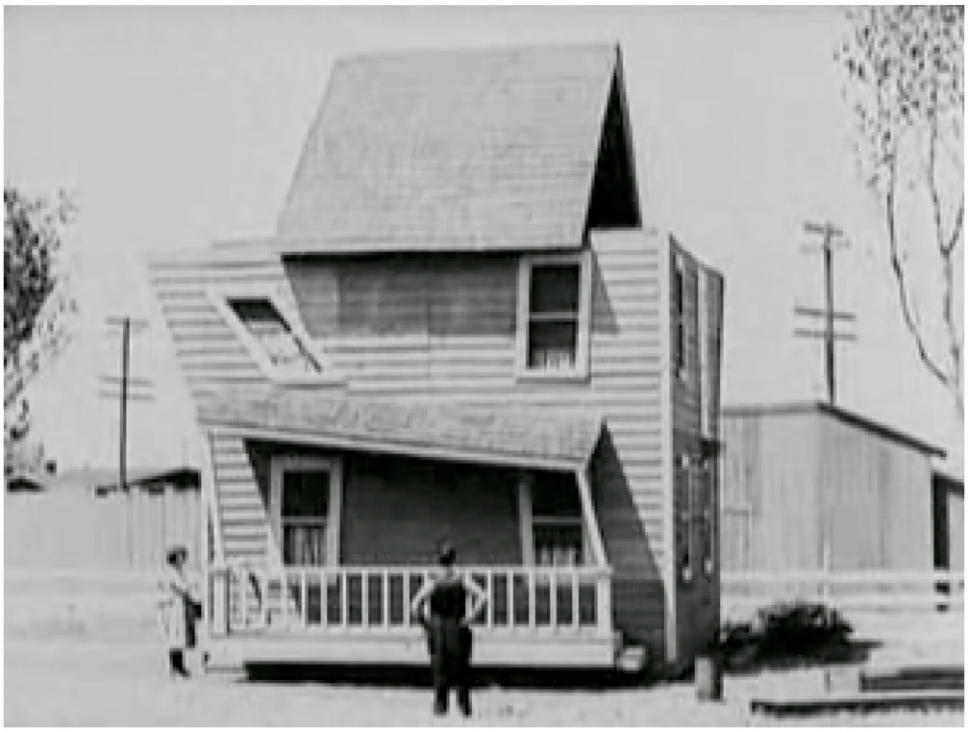

Figure 7 Buster Keaton's satire on the precut house "One Week" 1920.

The panelized prefabricators took some of the possible error out of the site erection of their products by reducing the number of parts. Assembling a dozen wall and roof panels could only be done in so many configurations, the buyer was bound to get it right.

Still, the dream of having a whole house appear, perfectly crafted, with all the latest systems installed remained a dream of many. The Conestoga wagon effectively functioned as the first mobile home for many pioneers, as did the pole-powered flatboat, taking family, possessions, and even livestock down river, then being disassembled and reassembled into a small home, the first shelter.
It wasn't until the quality of highways improved from the mud ruts of the early 1900's that larger traveling homes began to appear. The Firestone company offered the "Dulce Domum," "Sweetly at Home" as a precurser RV in 1929. But these were never thought of as permanent homes, more as camping shelter. Homes constructed on truck chassis were photographed by the FSA in the late 1930's, but the first intentional modular home was constructed by the Tennessee Valley Authority (TVA).

The Pickwick dam was constructed by the TVA between 1935 and 1938 in Hardin County a rural area in Tennessee. In order to provide housing for the hundreds of construction workers, the TVA developed a series of "demountable" cabins. These demountables (Figures 8 through 10) were approximately 7 feet wide and 21 feet long. Each was traditionally framed with dimension lumber, with the exception of steel "v" grooved wheels attached to the lower joists. These wheels would ride on steel angles to remove the demountable module from the truck chassis, and to precisely align it with an adjacent module to form the cabin.

Figure 8 TVA Worker cabin seven wide foot module for the Pickwick Dam project,1935.

Figure 9 Steel alignment wheels being installed on floor framing for TVA demountable modules. 1935, LC-USE62- D-OA-000047.

Figure 10 TVA workers cabin, two modules comprise this one bedroom demountable cabin for the Pickwick Dam project site. 1935 LC-USW33- 015711-C

The modules would be combined in groups of two, three or four to make one to three-bedroom housing units. Several hundred of these were produced over the course of the TVA projects from 1935 through 1945. Many were demounted and relocated at sites up to a few hundred miles away.

The absence of the integral steel chassis made these TVA demountables distinctly places them as early versions of the contemporary modular house while the demountables that were put in place in Custerville Wisconsin were constructed with integral steel chassis and arrived on their own wheels and axles making them early versions of the mobile home.

Prefabricating the Complex Piece: the mini-module

High cost – high skill components were targeted by housing innovators in the 1930's as prime components for prefabrication. Plumbers, electricians and cabinet makers were among the highest paid trades on a residential construction site, and the conflicts between heating, cooling, plumbing, and structure frequently led to delays. The idea to make a small component that would integrate a number of plumbing, mechanical, and electrical functions was investigated by researchers at the Pierce foundation in the early 1930's and by notables such as Buckminster Fuller in the latter 1930's. The Pierce foundation had developed a steel prefabricated house system called the "Motohouse" which included an integrated kitchen, bath, and utility core element they titled the "Moto-unit". Fuller had originally tasked the mast structure of his "Dymaxion house" with providing both structural and mechanical functionality. He turned this idea into a more tangible product with his 1937 bathroom module produced by Phelps Dodge.[19]

The work of Fuller and the Pierce foundation both are examples of the "mini-module" which was also implemented in the Republic Steel Corporation's Modular system developed for HUD's Operation Breakthrough in 1969. Republic Steel partnered with the Tappan Company and American Standard Corporation to pre-build kitchen and bath "mini-modules." These components were pre-plumbed and pre-wired in a factory setting, removing the most expensive trades from the on-site works.[20]

These mini-modules were the leading edge of offsite fabricated room-scaled assemblies that are becoming more common today in commercial and institutional construction. Moshe Safde's Habitat 67, constructed for the worlds fair in Montreal, stands as a tour de force of concrete prefabrication and became a powerful symbol of the worlds fair, and of the "future" of housing. The architects dream of the ubiquitous spatial

block, the habitable analog of the "Lego" toy block, proved to be difficult to achieve at the scale of a twelve storey residential block due to the accumulated structural loads as the building became taller. The problem was solved by developing specialized zones of reinforcing, making virtual columns, within the walls of each rectangular module at the point of overlap and intersection. This eliminated the possibility of a single module type, requiring a more complex palette of one and two storey modules with varying wall thicknesses.

The spatial agenda for the Habitat included the preservation of individual privacy, the creation of private outdoor spaces for each home, and the development of vital community spaces within the three dimensional stack of housing units. This agenda was quite successful and the continuing demand for opportunities to live in Habitat 67 stands as a testament to Safde's spatial vision.

The complex pattern of offset stacking employed in Habitat 67 has not been achieved by any other modular means to date. But the sight of Safde's urban mountain of modules gave credence to the idea of modular construction heavy enough, durable enough to meet the needs performance codes common to commercial construction.

The "Atlantic Yards" project, just East of Manhattan in Brooklyn promises to push the boundary of modular construction farther out, more specifically, farther up than ever before. The project, as presented by the design team, SHOP Architects, Arup Engineering, and XSite modular constructions, is a carefully engineered and integrated modular solution to a 32 story mixed use high-rise. The steel framed high-rise will be made up of 900 or more steel framed modules, with wind bracing erected to keep pace with the height of the modular placement. This project has some controversy surrounding it, not simply from an engineering or architectural design perspective. The developer had received public funds partly on the basis of jobs created by onsite construction. With the majority of construction moving offsite, union laborers stand to earn less producing the modules in a factory setting than they do in an onsite construction setting. Substantially less. The New York Times cites the pay for a carpenter onsite at $85.00 per hour, while a carpenter working in a factory setting earns $35.00 per hour.[21] The future viability of modular construction may lie more in the negotiations between developer and union than it does in the architect or engineers office.

The HUD Code and the End of Mobility:

The mobile home industry grew from the motorized camper vehicle into more and more sophisticated tow-behind trailers during the postwar years. The ten foot wide trailer came into common use during the middle 1950's, effectively ending the ability of the consumer to buy and tow their home behind their car as it required a heavier truck to pull. This also made the trailers more difficult to relocate, reducing their mobility.

Paul Rudolph was one of the few architects in the U.S. to consider the mobile home as having architectural merit. Rudolph went so far as to design a number of projects for high-density low-rise residential developments that used the mobile home as an integral unit that he called "the building block of the 20th century."

In 1968, Rudolph arranged and stacked custom-made mobile home units in a cruciform shape to make a four-plex cluster that he repeated across the New Haven site forming a 148 unit development. (Figures 11 and 12) Rudolph saw the inherent ability of the mobile home unit to provide the rapid construction, low cost, and dimensions that would keep the scale of the large project closer to that of a person thus reducing the institutional character common to larger low income units of the time. Rudolph's design took advantage of the integral steel chassis to use the mobile home module as a spanning element, supported on thin steel columns, to provide carport and protected exterior space.

Figure 11. Paul Rudolph, Oriental Masonic Gardens, mobile home units being stacked to make overhead protected outdoor spaces. 1968 PMR-2258, no. 7.

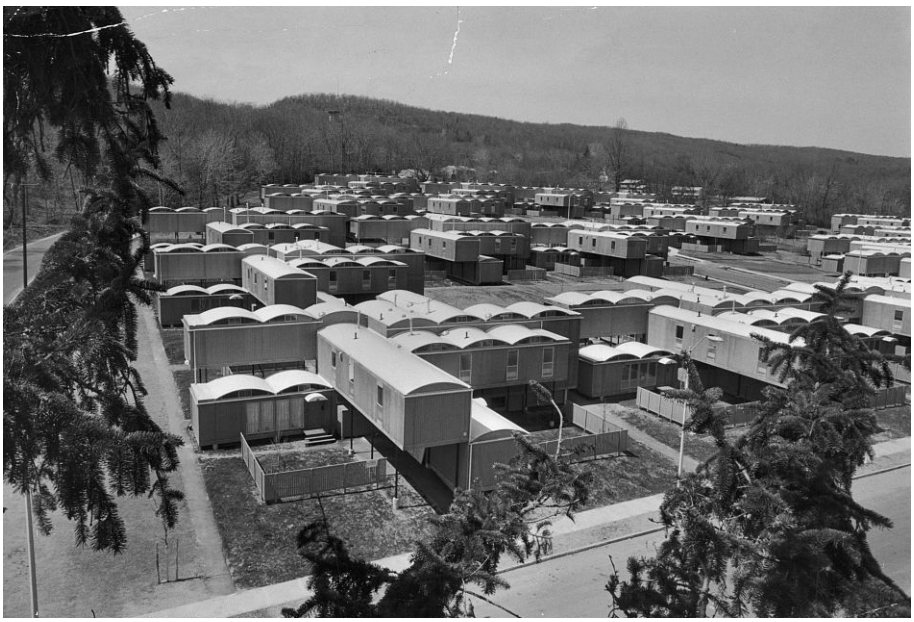

Figure 12. Paul Rudolph, Oriental Masonic Gardens, 1968, overall view of the 148 unit development in New Haven, Ct.

If the ten-foot wide trailer began the end of the mobile period in mobile homes, the passage of the National Manufactured Housing Construction and Safety Standards Act of 1974 (HUD Code) cemented it. This act formalized the recognition that the mobile home, now called a HUD Code or Manufactured Home brought

a standard of quality considered to be high enough that over 360,000 mobile home units were sold in 1999.[22]

Many of these were more than a single 10 or 16-foot wide trailer, many were double or even triple wide assemblages. The Manufactured Home is the dominant form of prefabricated housing in the United States today making up over 7.5% of total housing stock, 8.7 million housing units since the year 2000.[23]

Conclusion: Lessons Learned

Bigger is better:

Carl Strandlund's "Lustron" home (1947) was one of the most successful proprietary prefabrication systems in history having produced over 2,500 homes in 36 states across the United States. It was an extremely thoughtful reconsideration of homebuilding technique, using the minimum quantities of materials to make light, strong walls, and the latest in porcelain enamel on steel production techniques to produce highly durable exterior finishes. For all the innovation, Strandlund's Lustron suffered under a high number of parts required to assemble it in the field. The 30,000 part total could have been reduced had Design for Manufacture (DFM) and Design for Assembly (DFA) principles been applied to the Lustron system. Larger panel sizes would have meant less field assembly time, a reduced chance of error, and associated reductions in cost.

The wall panels of Derrom's, Bridge's or Hodgson's system are excellent examples of the utilization of factory jigs and tools to produce a larger scaled component, still ergonomically tied to the ability of a crew of two or three, but eliminating the precision measuring and cutting operations, thus reducing field installation time, error, and cost.

Demountables such as those developed by the TVA, and those utilized in Manitowoc Wisconsin are the apex of the large-part lesson. All precision tradeswork is conducted in controlled factory conditions, site based material pilferage is eliminated, and site installation operations are conducted in hours resulting in an enclosed home in less than a working day in most cases. These large scale demountables, like Safde's modules reduce field error by reducing parts and compensate for the inefficiency of shipping "air" with rapid deployment and completion.

Open defeats closed:

"Open" can mean both literally open, as in wall panels that are sided, but do not have interior finishes applied, which facilitates the installation of electrical and plumbing systems, and reduces the weight of the panel which allows for easier handling by a smaller crew on the jobsite, but it can also mean open, as in extensible.

Extensible, in the context of prefabrication of housing in America has usually meant the panel was made of wood of some kind. America's connection to wood as a primary material in housing goes back to the days of the earliest settlers. It is a material that is easily shaped by amateurs, easily connected by do-it-yourselfers, and is light enough that even the most out of condition desk-bound professional can pick up pieces of it to build an addition with. Wood is a reasonably durable material, is reasonably safe as a material in the near-environments constituting most homes, and when properly designed and joined, is quite strong in most service conditions.

The September 1936 issue of "American Architect and Architecture" illustrated 48 systems of prefabrication. Six were wood based, 25 were steel based, 1 was cork based, 1 asbestos based and 15 were concrete based. Of these 48 systems, one has persisted as a strategy to present day, the Forest Products House that employed insulated stressed skin panels, the precursors to contemporary Structural Insulated Panels (SIP). The article is strange in that it overlooked the Hodgson and similar open stud panel strategies that dominated a substantial segment of the prefabrication market in America.

The numerous proprietary systems described in that article did not produce many units of housing, indeed when just five years later the U.S. government found itself in dire need of housing that could be quickly erected across the country, they turned to the mobile and modular variations on the demountable house, and to the wood panel as the solution. An open system is one that is connected to and adjusting to its

environment, the proliferation of wood products, tools, and construction techniques makes it the ideal solution to the question of adaptability and change over time. While the fifteen concrete based prefabrication systems shown in American Architect and Architecture would all have provided a durable quality residential environment, the "do-it-yourselfer" wouldn't be able to easily remove a wall, and construct an addition of equal quality. Concrete work is perceived as being too complex, the tools are perceived as beyond the homeowners means, and methods are too fraught with variables to be easily used to modify ones environment in America…concrete is not extensible here.

Steel is making inroads, but like concrete, the tools to cut, shape, and connect steel tubes and studs are still seen as being beyond the homeowner's ability, making steel similarly non-extensible when considered over the lifetime of the structure.

History has shown us the enduring strategies. Industry is picking up on those lessons, and prefabrication has a stronger presence in the residential U.S. construction market than ever before. Yet, as architects, we're still a bit unhappy. Perhaps the motives for prefabrication among architects are different than among homebuilders or homebuyers than they are among the design professionals. Perhaps prefabrication is still a frontier for idealism, the kind of idealism that says every citizen should live in a designed environment (even more ideally, and environment that ***I*** design.) Satisfying design ego must be a portion of the reason architects propose, and extensively develop systems of prefabrication to this day. The humbling lesson of history is that, unless the design professionals operate in an extensible way, their efforts will continue to be simply footnotes in history, and not the main text.

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[1] Wrigley, William H. 1881 Portable House, U.S. Patent No. 250.867, filed August 19, 1881, issued December 13, 1881.

[2] Morton, Neal, "Texas-made Tundra gets historic towing job" Houston Chronicle, Houston Tx. Oct. 12, 2012, as downloaded from http://www.chron.com/business/article/Texas-made-Tundra-gets-historic-towing-job-3944725.php

[3] Bruce, Alfred and Sandbank, H., A History of Prefabrication, John B. Pierce Foundation, Raritan, NJ, September 1945. Pp. 1.

[4] Slater, D. C. 1910 Portable House, U.S. Patent No. 960,207, filed June 1, 1909, issued May 31, 1910.

[5] Schweitzer, Robert and Davis, M. America's Favorite Homes: Mail-Order Catalogues as a Guide to Popular Early 20th-Century Houses, Wayne State University Press 1990. Pp. 37. References Edward Winslow's "Great House" at Cape Ann, Massachusetts, and subsequent precut frames shipped with colonists moving from the Plymouth Colony to Connecticut in 1630. The firm of Clarke and Hodgson (no relation to E. F. Hodgson the panelizer from 1890) is referenced as a supplier of precut house frames in 1727. (footnote 31)

[6] Sears "Ready Cut" and "Honor Built" homes are perhaps the most well-known of the precut home manufacturers, but the list would include : Van Tines, Alladin, Liberty, Radford, Sterling, Wardway, Fenner, Bennett's, the Chicago House-Wrecking Company, Pacific Homes,

[7] Derrom, Andrew, 1861, Improvement in Portable Huts, U.S. Patent No. 1,742, filed July 9, 1861, issued August 23, 1864.

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[11] Bruce, Alfred and Sandbank, H., A History of Prefabrication, John B. Pierce Foundation, Raritan, NJ, September 1945. Pp. 15.

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