Industrializing Housing through Factory Production; Future or Fantasy?

by

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Bachelor of Landscape Architecture (2005)
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Submitted to the Department of Urban Studies and Planning in partial fulfillment of the requirements for the Degree of

Master in City Planning

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2009

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Abstract

The purpose of this thesis is to review and assess the state of factory-built housing in the U.S., and to propose a business plan for a new approach. The thesis addresses the question: What would be a viable factory-based home building strategy for the Mid-Atlantic region of the U.S.? The thesis begins with research on the history and early ethos of the factory-built housing industry in conjunction with an analysis of the factory-built housing industry's current image, advantages, and challenges. To assess the image of the industry, a variety of common perceptions regarding the industry were explored. To isolate the specific advantages and challenges facing the industry, the thesis compares the relative and normalized costs of factory-built homes to site-built homes in addition to macro issues, like building regulations.

The thesis also provides a synthesis of the research in the form of a business strategy. The business strategy takes the strengths identified in the initial research and couples them with a viable and forward looking development strategy suited to Pennsylvania's housing market. Key among the proposal's recommendations are using factory production to build secondary homes, like granny flats or summer cottages and marketing the homes as a community. The example given in the business plan includes developing infill retirement communities in small Pennsylvania towns. Other examples could include developing small vacation communities.

Thesis Supervisor: Dennis Frenchman
Leventhal Professor of Urban Design and Planning

Thesis Reader: Larry Sass, Ph.D.
Assistant Professor of Architecture

Acknowledgements

Conceptualizing and then writing this thesis has been a tremendous learning experience for me and is not something I could have done without the support of a number of friends, family, and colleagues. I owe most of my thanks to Dennis Frenchman, my advisor, who encouraged me to explore this topic and then helped me clarify and develop its direction. I also would like to thank Larry Sass, my thesis reader, who has been extremely patient and supportive of my thesis process.

There have also been a number of people within the factory-built housing industry who generously provided me helpful information and their opinions on a variety of issues that were fundamental to my thesis. Some of the these people include Don O. Carlson, Editor and Publisher of *Automated Builder Magazine*; the Sekisui House home building corporation based out of Japan; Perry Caflisch, Sales Manager, and David Reed, President of Penn Lyon Homes; and Roger K. Lewis Professor of Architecture Emeritus at the University of Maryland.

Greg Olsen, a faculty member at the Pennsylvania State University was instrumental in helping me develop and plan out the business plan portion of my thesis. In addition to providing me with his past elder care business ideas he met with me on a number of occasions to discuss and develop the business plan portion of the thesis. I would also like to thank my good friend Toni Dang for copy editing my entire thesis and my mom, dad, and sister who gave me the encouragement I needed to finish my thesis on-time.

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Chapter One

An Introduction to Industrialized Housing

Prefabricated housing in the U.S. can trace its development back to the start of the Industrial Revolution. Beginning in the mid-19th century, changing cultural values and advancements in industrial production came together to produce the first factory-built homes. Today, nearly all home builders in the U.S. and abroad incorporate prefabricated building components into their construction process, though their reliance on prefabrication varies greatly. While some builders use prefabricated roof trusses, windows, and doors, others construct entire homes in factories. Also, the methods of prefabrication vary from basic jigs to robotic assembly lines that rival many automobile plants.

The different methods of prefabrication can be linked geographically. Home builders in Japan rely on robotic assembly lines, whereas builders in the U.S., Canada, and the Netherlands employ a variety of less sophisticated construction methods that include some automation, jigs, and labor intensive assembly line processes. Despite the global variety of assembly processes, the majority of prefabricated residential development in the U.S. is limited to labor intensive suburban development. In fact, only a handful of U.S. home builders rely on highly automated assembly lines and only a few have building systems designed exclusively for urban areas.

Prefabricated home builders in the U.S. have been successful at capitalizing on the quality that comes from building in a factory environment, economies of scale, reduced labor costs, and a faster production schedule. Despite the advantages of prefabricated home building, the majority of housing starts in the U.S. are built using century old construction methods. The primary obstacles that have limited the acceptance of prefabricated home building include the following: unique and proprietary building systems, a culturally ingrained stigma against prefabricated housing, a lack of education about the

benefits of prefabricated housing, a lack of federal support, a lack of customization, poor design, and localized building codes.

Reduced labor costs, increased quality, energy efficiency, and custom homes are goals that the U.S. housing industry can achieve through the use of a factory-based construction process (Jandl, 42). To introduce prefabricated housing into the mainstream residential housing market in the U.S. will require fundamental changes to current prefabricated systems and thought.

Definitions

While prefabricated housing is a general term that describes housing built with factory assembled building components, "factory-built" housing refers to specific methods of home construction. Factory-built homes are entirely or largely assembled in factories and then shipped to a site to be placed or completed. There are four widely recognized categories of factory-built housing in the U.S. and abroad: manufactured, modular, panelized, and precut/kit-built housing.

It is also important to note that there is a distinction between factory-built housing and "stick-built" or "site-built" housing. Both stick-built and site-built housing refer to wooden framed houses that are constructed on-site. A site-built home's foundation, framing, roof, siding, drywall, plumbing, and electrical work are completed on site. On the other hand, the majority of the framing, cutting, and finishing of factory-built homes occurs in a factory.

While site-built and factory-built homes have their differences there are also a number of similarities. In the U.S., both types of housing tend to be assembled out of wood and utilize balloon framing techniques. Also, both types of construction are regulated by building codes.

Manufactured Homes

Manufactured homes are built on moveable chassis and are 100% complete when they leave the factory. The most widely recognized types of manufactured

A manufactured **singlewide trailer**, Kernville, CA, 2008 (Image: Jesse Hunting).

A manufactured **doublewide trailer**, Kernville, CA, 2008 (Image: Jesse Hunting).

housing are recreational vehicles (RVs) and singlewide trailers. Manufactured homes can also be built on multiple chassis and pieced together. Well known examples include doublewide and triplewide trailers.

The production of manufactured homes is regulated by a federal set of building codes called The Federal Manufactured Home Construction and Safety Standards or HUD-Code for short. These codes regulate everything from building design to material choice. While the codes regulate the construction and production of the homes themselves, additions to the homes, like garages and porches, fall under local building codes.

According to the U.S. Census, in 2007, 7.01% of all U.S. private housing starts were manufactured homes (New and Privately Owned Housing Started & Placements of New Manufactured Homes). However, because of their affordability, the homes have disproportionately contributed to the increase in U.S. homeownership in recent years[1]. Another interesting fact about manufactured housing is that once the homes are wheeled onto their site, fewer than 10% of the homes are ever moved again. This suggests that the homes are "no less permanent than site-built housing" (HUD Factory-Built Construction, 5).

Modular Homes

Modular homes are factory-built homes whose three-dimensional components are 95% complete when they leave the factory. Their components can range from room sections to half a house. Once finished, the sections of home are delivered to their site and placed on a foundation with a crane. When the sections are in place, the homes look virtually identical to stick-built homes (Lawrence, 8-15). However, the homes' proportions can be skewed because of engineering technicalities.

It is certainly fair to say that modular homes, as a whole, are built to a higher structural standard than site-built homes. A modular manufacturer in Pennsylvania, Penn Lyon Homes, estimates that they use 30% more lumber in their construction process than site-built homes (Penn Lyon). The extra lumber is used to strengthen the

Penn Lyon Homes constructing a home module in their Selinsgrove factory (image: Penn Lyon Homes).

Modular home placement, Southwestern, US (photo taken by Robert Ellenberg).

[1]According to HUD's Office of Policy Development and research publication titled: Factory-Built Construction and the American Homebuyer: Perceptions and Opportunities, page 5, from early 1990s to mid-1990s, manufactured housing contributed to 17% of home ownership growth.

homes' modular components to minimize cracking and other defects during transport and placement.

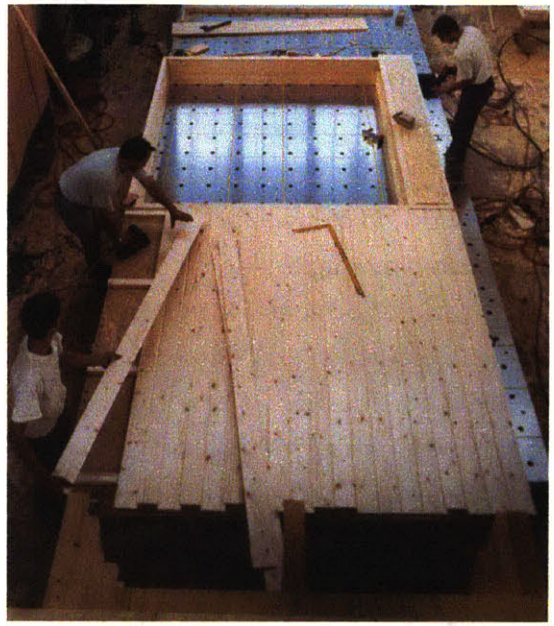
According to the National Association of Home Builders' Research Center, in 2004, modular homes only represented 3% of the annual U.S. single-family housing starts (NAHB Research Center). Don Carlson, the editor and publisher of *Automated Builder Magazine,* believes that the modular housing industry could expand its market share if it fell under the HUD-Code as opposed to local building codes (Carlson). Putting modular housing under the HUD-Code would reduce the complexities associated with permitting and inspections and make it easier for builders to expand their market share.

Panelized Homes

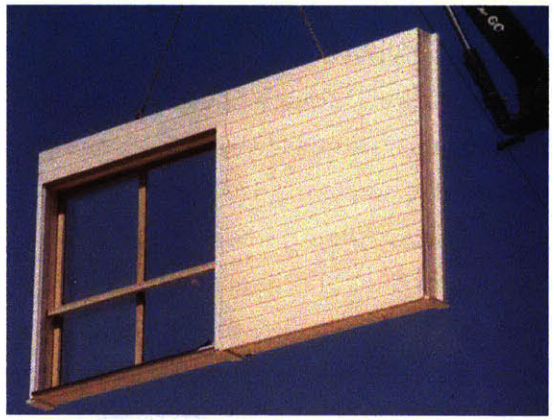
Similar to modular construction, panelized home construction is factory-based and allows builders to capitalize on the labor and assembly efficiencies of a factory-based fabrication process. Within a factory setting, panelized builders assemble roof trusses, wall frames, and structured insulated panels (SIPs). The building components are then trucked out to the site and assembled atop a foundation and/or fitted onto a site-built load bearing structural frame. Techbuilt, Deck Homes, Acorn, Enercept, and Precision Panel are a few contemporary builders who specialize in panelized construction.

Unlike modular construction, panelized builders account for a fairly large percentage of housing starts in the U.S, roughly 11% (NAHB Research Center, 2004). The large percentage is likely tied to the system's flexibility. Panelized home building is easier to transport than modular and is therefore better suited to urban construction. The panels' smaller sizes and two dimensional qualities enable them to be stacked onto mid-sized trucks and shipped into urban areas. Further, the small sizes allow the panels to be easily positioned on site with smaller cranes (Lawrence, 8-15).

Similar to modular building, panelized builders also have to comply with local building codes. Many panelized builders



Workers assemble a **panelized** wall for a home in Austria (Arieff, 106).



Assembled **panelized** wall being placed on site with a crane (Arieff, 106).

embrace traditional stick-built construction practices that enable them to reduce costs through the use of widely used construction methods and readily available building materials. Meanwhile, other panelized homes builders have developed and built unique and proprietary construction systems. Systems, like those designed at MIT's media lab, integrate plumbing and wiring into the home's structural support system and then attach prefabricated building panels to the support frame.

Precut or Kit Homes

Kit homes are also assembled on site from building components that are constructed in a factory. However, precut buildings require more on-site assembly than panelized buildings. Kit homes' framing and other components are cut to size in a factory environment, but assembled on a site.

Kit homes were made popular in the early 20th century by home builders like Sears, Roebuck & Co. However, in recent decades their production has dropped to almost non-existent levels in the U.S. Other countries like Japan still use kit home building techniques in conjunction with panelized building techniques.

Factory-Built Housing: Ethos & Early History

The widespread use of prefabricated building components is a relatively new phenomenon that has its roots in 19th century building trends and social discourse, which emphasize home building within a social and physical context. Exploring this early discourse gives home builders some perspective on why and how factory home building developed into an industry.

In the early 19th century, the publication of housing blueprints in building guide books and pattern books was the first step in standardizing home construction and factory-built housing. Architect Asher Benjamin authored one of the first well-known "builder's guide" books in the U.S, *The American Builder's Companion* in 1827. Published in small quantities, Benjamin's guide book included home elevations, sections, and other drawings. Such guides were influential, but it was not until 1850 when landscape architect Andrew Jackson Downing published *The Architecture of Country Houses* that pattern books became popularized in mainstream culture. Part of the reason behind Downing's success, was that he provided compelling commentary on social and moral issues of the day and illustrated the landscape (the context) of the homes in addition to the homes themselves (Jandl, 7).

Standardized home styles and construction methods were necessary steps forward for prefabricated housing. However, some of the first factory-built American homes owe their origination to a revolution in 19th century perceptions of the home and its role in everyday life. During the latter part of the 19th century, women authors, like Catharine Beecher and Orson Fowler, began to publish women's journals that advocated for bringing new technology, construction materials, and creativity into the home. Popular magazines, like *Ladies' Home Journal*, provided illustrations of what the ideal homes should look like and commentary on how the homes should

A Cottage in the English or Rural Gothic Style.

Fig. 9.

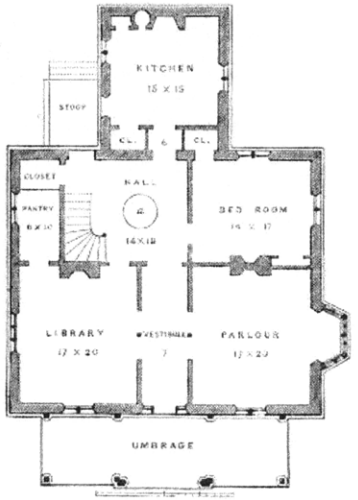


Fig. 10.

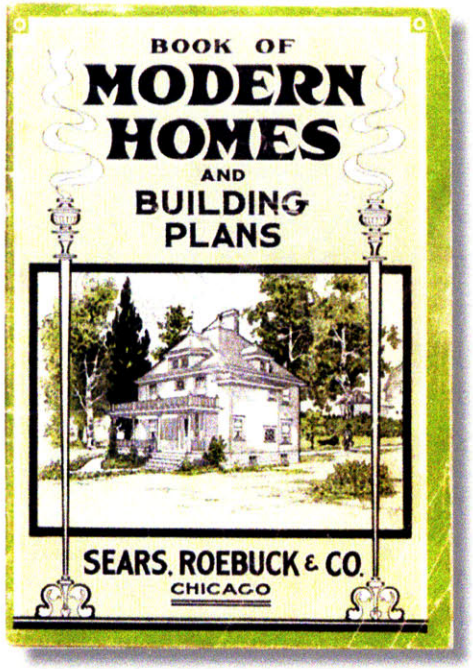
The cottage and its landscape, above, was designed by **Andrew Jackson Downing** and illustrates the home and its context.

support everyday life (Jandl, 8). The importance and implication of popular culture can't be understated – these magazines were encouraging people to think about the future and do so in the context of their home.

"There is a tide of wealth and prosperity setting into our country unparalleled in extent and power, and many Christian men and women will be drawn into a current of worldliness and self-indulgence from which they now would shrink with dismay. Let those who are planning for the future life take thought in good time. Shall your future homes become the abodes of an industry, thrift, and benevolent economy that shall provide means to bless the community all around, by a wise example and an outpouring of beneficence? Or shall they be the proud residences of the indolent, the self-indulgent, the exclusive, and the worldly?"
— Catharine Beecher, *Harper's New Monthly Magazine*, May 1866

Catherine Beecher's quotation in *Harper's* eludes to the palpable, yet restrained excitement that welcomed reforms to housing and cultural norms of the mid 19th century. However, Beecher's restraint only lasted until the early 20th century when architects began to envision using new materials, technologies, and efficient factories to shape America's perception of the home. As in the 19th century, architects of the 20th century, like Frank Lloyd Wright, took advantage of magazines to illustrate their "house[s] of tomorrow" (Jandl, 8).

Professional magazines, like *Architectural Record* and *Architectural Forum*, as well as mainstream magazines, like *Popular Mechanics*, *Life*, and *Business Week*, also became advocates for the home of the future. In addition to incorporating new technology, the homes of the future were manufactured and began to distance themselves from the notion of craft. Momentum for prefabricated homes grew steadily through the beginning of the 20th century with the emergence of mail-order homes. Companies like Sears, Roebuck & Co., Aladdin Houses, Montgomery Ward, and Hodgson sold "precut homes" or "kit homes" and offered traditional styles that could be customized. The kit homes were



Sears, Roebuck & Co. lead the home building industry for the first three decades of the 20th Century, selling 100,000 mail-order kit homes from 1908 to 1940 (Arieff, 14). Pictured above is the cover of one of Sears' mail order catalogs.

assembled at a factory and shipped to their site on a truck or train with everything needed to build, including nails and instructions (Arieff, 13; Jandl, 16).

Kit home builders succeeded at harnessing the power of factory efficiency to industrialize the home construction process, turning it from a local craft into an interconnected nationwide industry. Building on the successes of kit home builders and on the momentum being generated around the home, companies like General Electric, U.S. Steel, and Westinghouse moved into the home appliance market. These companies realized and capitalized on the market potential that existed in outfitting the home with state-of-the-art appliances (Jandl, 16).

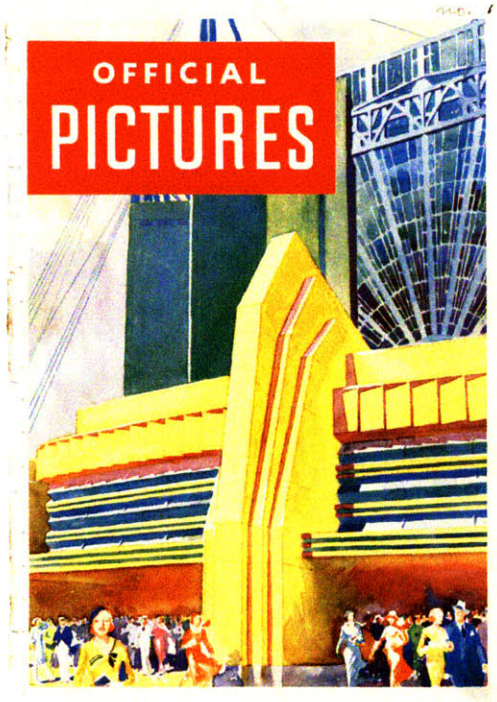
The application of technology and industry to homes coupled with the focus on the future inspired a generation of architects, like Walter Gropius, and industrial designers, like Henry Dreyfus, to begin applying the form of industry and technology to home design. Evidence of this trend can be found in the 1933 Century of Progress Exposition at the Chicago World's Fair that highlighted the application of futuristic technology through model homes and technology.

Acting as a thermometer of the times, the 1933 Exposition illustrates America's changing values. Out with the old and in with the new could be the mantra of this period in history. Technology and industry were hailed as the future, and plans were made to incorporate these new values into every aspect of modern life - including the home.

The 1933 Exposition also marks the rise of the automobile, which greatly impacts the future of the built form. No longer was the automobile considered just a curiosity or a toy for the rich. As evidenced by their 1930s brochures, automakers began to identify the automobile as an essential component of mainstream American culture and began to market it to the middle class. Architects were quick to realize the significance of the automobile and began designing accordingly.

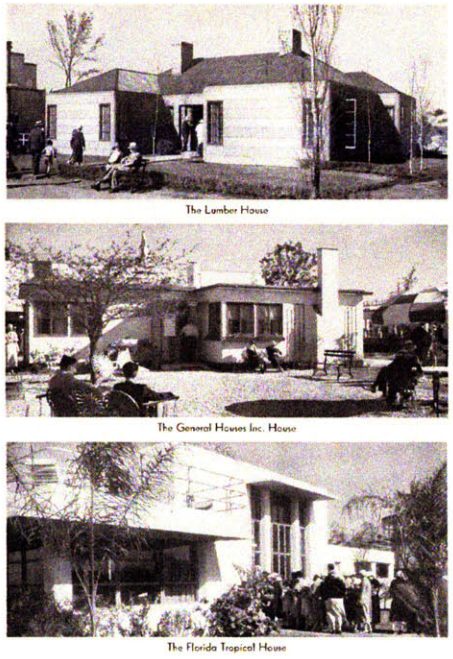
"It is now past argument that the low-cost house of the future will be manufactured in whole, or in parts, in central factories, and assembled on site. In other words, it will be produced the same way as the automobile."

— Poet Archibald MacLeish, Fortune Magazine, 1932



Picture Guide to the Chicago World's Fair, 1933.

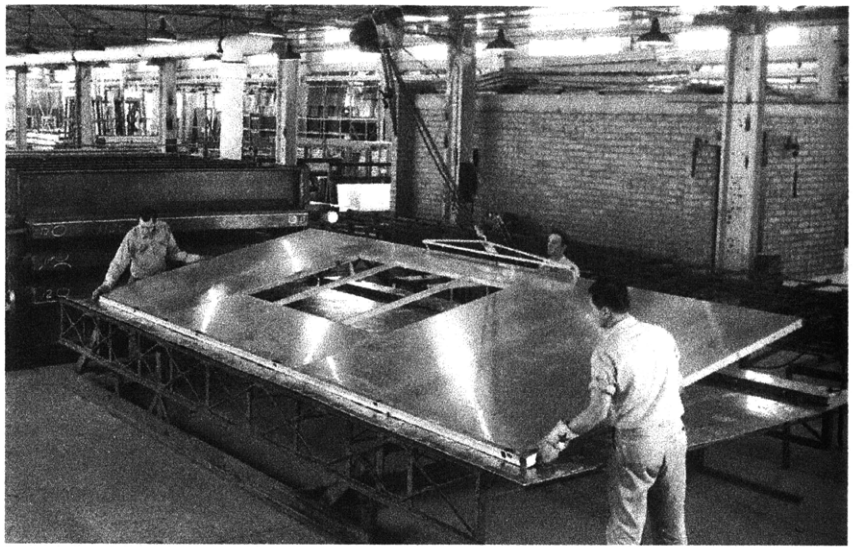
Houses of the Future, Chicago World's Fair, 1933.



Houses of the Future, Chicago World's Fair, 1933.

"This may appear strange at first glance. Tomorrow we will be accustomed to it and will know it to be as right and proper as we now consider Elizabethan exposed half-timbers and ceiling beams of wood."

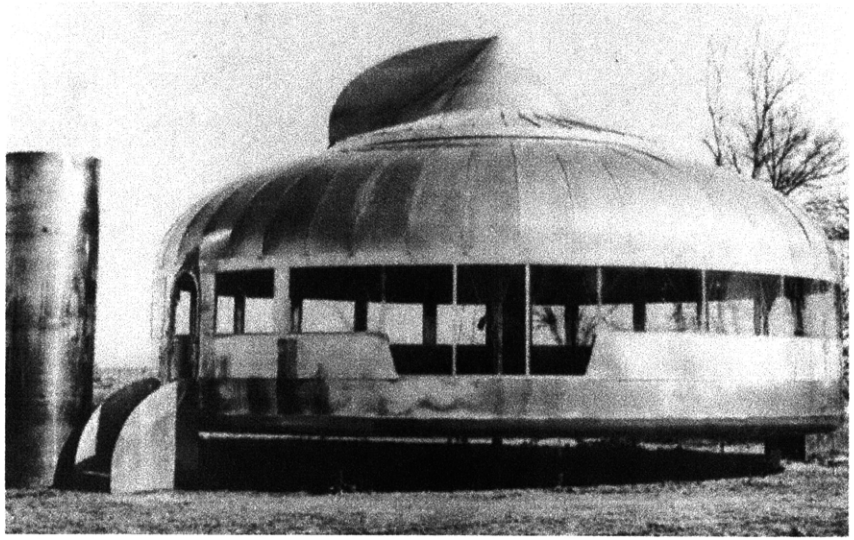
—Promotional Brochure for George Fred Keck's House of Tomorrow, 1933



Workers at the Vultex Aircraft Company assemble aluminum panels for ahouse designed by Henry Dreyfus, 1946 (Arieff, 22).

"Eradicate from your mind any hard and fast conceptions in regard to the dwelling-housing and look at the question from an objective and critical angle, and you will inevitably arrive at the "House-Machine," the mass-produced house, available for everyone, incomparably healthier than the old kind (and morally so, too) and beautiful..."

—Architect Le Corbusier, 1931



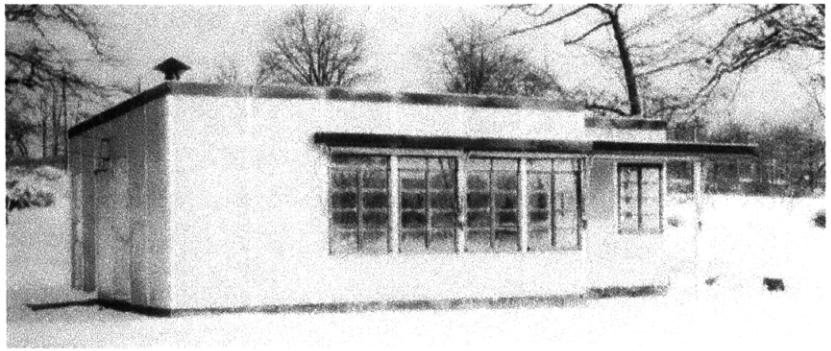
The Dymaxion House engineered and designed by Buckminster Fuller, 1929 (Arieff, 17).

"The architect's efforts today are spent in the gratification of the individual client. His efforts tomorrow, like those of composer, the designer of fabrics, silver, glass and whatnot may be expanded for the enjoyment of vast numbers of unseen clients. Industrial production of housing, as contrasted with the present industrial production of raw materials and miscellaneous accessories, calls for more skill and a higher development of the design element, not its cessation."

—Architect Buckminster Fuller, Lecture, 1929

Freed from the constraints of stone and large wooden timbers, architects in the early 20th century began experimenting with materials like steel and concrete and using old materials in new ways. Influential architects, like Le Corbusier, strongly believed that new buildings required the use of new materials, technologies, and design. Corbusier, Walter Gropius and Frank Lloyd Wright created their own style of design that applied new technology and industry to housing form. The style was mechanical, sleek, angular, metallic, and simplified. Modern homes designed by these architects were a radical departure from the traditional English Tudor cottages and elegant Victorian homes of their day.

In addition to designing futuristic homes, Corbusier's generation of architects believed that the craft that had defined homes of the past was no longer a valid method of home building for the masses. Instead, designers envisioned using methods of mass production to create homes of the future. They drew their inspiration from Henry Ford's assembly line and believed that mass produced homes



MotoHome - a small prefabricated home that "came complete with food in the kitchen," 1933 (Arieff, 17).

"It can almost be taken for granted that when good prefabricated houses become a fact their architectural style will be different from the quaint English cottages and Cope Cod Colonials that are the present favorites of the speculative builders. The idea that we should take new and better building materials and mould them into the lines and textures of old materials possessing any number of shortcomings is abhorrent."

—Engineer Raymond Parsons, 1935

The Clipper, an aluminum mobile home trailer, produced by Wally Byam's Airstream Trailer Company, 1936 (Jandl, 21).

would be healthier, more durable, and would cost less than their predecessors (Arieff, 27).

Incorporating a factory construction process into the home building industry was the vision of many prominent 20th century architects who designed and built sample systems like the Motohome in 1933. However, even with the technology and cutting edge looks, the homes were not widely popularized. A more recent example of a house designed with the future, economy, and technology in mind is the Futuro House (see next page), built in the late 1960s and early 1970s. Like its predecessors, the home incorporated the latest technological advances and was reasonably priced, due to its factory-based construction process, but it failed to catch on.

The Futuro House, the Motohome, and the Dymaxion House were all visionary; they incorporated the latest technologies, they were affordable, and they embodied the progressive architectural thought of their time. However, they failed to capture any significant segment of the housing market. Instead consumers were attracted to homes, like those being built in Levittown, Pennsylvania. The homes in Levittown better reflected the priorities of popular homemaker, Catharine Beecher – all good things in moderation – than modern architecture.

While home buyers of the mid 19th century were eager to buy into the vision that designers like landscape architect Andrew Jackson Downing sketched out for them, home buyers of the mid-20th century hesitantly welcomed mainstream architects' vision for the future home. The factory-built houses of the future showcased at Chicago's 1933 Exposition attracted many curious tourists, but very few buyers (Arieff, 18). Home buyers seemed to appreciate the social and physical context of earlier factory-built homes, but had trouble envisioning living in modern homes that departed from the traditional home styles and cultural norms they were accustomed to.

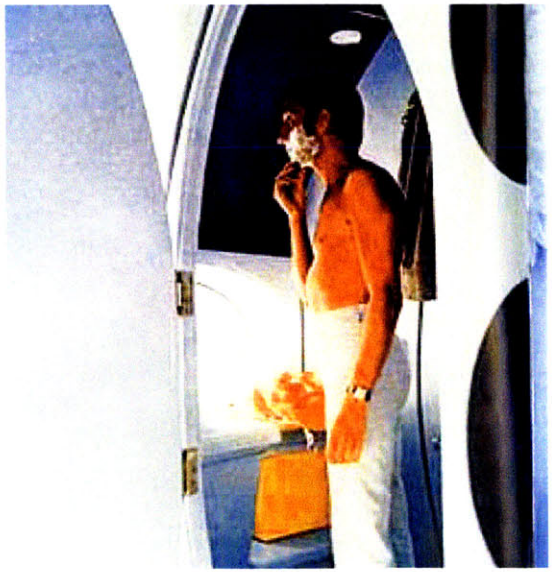
Levittown, Pennsylvania, architecturally neutral and affordable prefabricated homes built for the masses, 1959 (Arieff, 25).

The Futuro House, designed by Matti Suuronen, Late 1960s (images from: www.arcspace.com/books/tomorrows_house/).

Roughly 100 **Furturo** homes were produced from the late 1960s to the early 1970s (wikipedia).

Futuro House, Living Room

Futuro House, Kitchen



Futuro House, Bathroom

Chapter Two

An Expanding Market Share

Site-built home construction represents about 70% of housing starts in the U.S., while factory-built home construction represents about 30% (Adair, 13). Despite the smaller market share, the factory-built housing industry has been expanding its share of the housing market in recent years[2]. This increase is primarily due to technological advances being made in panelized home building.

According to Don O. Carlson, a leader in the factory-built housing industry and the Editor and Publisher of *Automated Builder Magazine*, 50 years from now, all homes will be factory-built (Carlson). However, before this happens, there are a number of obstacles the industry must overcome. First, the industry must make its product more appealing to the lower-middle, upper-middle, and upper classes[3]. The higher a person's income, the less likely they are to live in a factory-built home (HUD Factory-Built Construction, 16). Regardless of income level, the majority of home buyers hold numerous prejudices against factory-built homes[4]. Further, compounding the image problem is a deep-rooted disconnect between factory-built homes and architects.

To improve its image and market share, the factory-built housing industry should bring designers back into the design process and undertake a sustained media campaign that targets the lower-middle, upper-middle, and upper classes. While redesigning its product can happen at a company level, a large media campaign needs to be organized by the industry's advocacy organizations. Some of these organizations include the U.S. Department of Housing and Urban Development, the Manufactured Housing Institute, *Automated Builder Magazine*, and the National Association of Realtors.

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[2]The percentage of factory-built housing starts in the U.S. has been steadily increasing, but still represents a small portion of total home starts. It has been difficult to pin down one definitive source that has tracked the market share of factory-built homes in the U.S, but I was able find two sources that establish the trend. According to: Demographics, the Housing market and Demand for Building Materials. Al Schuler and Craig Adair. Forest Products Journal Vol 53, No 5, May 2003.: In 2001 69% percent of all housing starts (not including manufactured homes) in the U.S. were site-built. This number was down from 90% in 1980. The article goes on to explain that the increase in market share is primarily due to growth made in the panelized home building Industry, which saw its market share increase from 7% to 15% in the same time period. Another source, put out by HUD (Industrializing the Residential Construction Site. Michael O'Brien, Ron Wakerfield, and Yvan Beliveau, Center for Housing Research, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, July 2000, page 19.) explains that in 1998 and 1999 stick-built homes represented 75% of the 1.2million annual housing starts in the U.S. The report goes onto explain that in from 1978 to 1998 site-built homes represented 80% of total housing starts.

Contemporary Architects and the Disconnect

To address the disconnect between architects and factory-built design, it helps to understand their relationship. Factory-built housing, or prefab as it is referred to by many designers, is a driving force in contemporary architecture. The topic is particularly popular among architecture magazines, like *DWELL*, and is re-imagined in just about every major architecture school. Unfortunately, this cutting-edge discourse is, for the most part, unrealistic and lacks any meaningful level of focus on the end user – the home owner. Instead, the conversation focuses on over-efficiency in both production and operation and a minimalist design.

Popular designs push the envelope and incorporate the latest "green" technologies and abstract architectural design trends. The resulting buildings are often marginally functional homes for an average family, with aesthetics that rank an eleven out of ten. An excellent example of this type of design can be found in Michelle Kaufmann's work, which incorporates cutting-edge design and energy-saving technologies. While virtually any architect would be happy to live in one of these homes, the majority of Americans are not interested. It's difficult for most people to envision raising a family in a glass box.

With rare exception, these cutting edge designs stay largely confined to the pages of architecture magazines and to the halls of universities. Those who can afford contemporary prefab homes designed by Michelle Kaufmann and the like are not your typical Americans. Rather, they represent the country's highest income earners and are usually purchasing the dwelling as a second home, rather than a primary residence.

Factory-Built Homes Without the Architect

It could also be argued that architects only design high-end factory-built homes because they can't make a living designing homes for average Americans. Whether it's their designs or the fact it is difficult to make a living designing average homes, architects are absent from the design

The Glidehouse was designed by California architect Michele Kaufman (Image: http://www.csa.com/discoveryguides/green/images/glidehouse.jpg).

[3]In 2005 William Thompson & Joseph Hickey published a book that correlated household income ranges with class. The following is the classification system they developed: Lower Class (20% of total households) generate an annual household incomes under $16,000; Working Class (32% of total households) generate annual household incomes that range from $16,001 to $30,000; Lower Middle Class (32% of total households) generate annual household incomes that range from $30,001 to $75,000; Upper Middle Class (15% of total households) generate annual household incomes that $75,001 to $500,000; and Upper Class (1% of total households) generate annual household incomes in excess of $500,000. (Thompson, W. & Hickey, J. Society in Focus. Boston, MA: Pearson, Allyn & Bacon, 2005.)

process for most residential development in the U.S. Instead, developers and engineers have stepped up to fill the design void. With little or no design training, engineers and developers have been mass producing homes with mediocre to terrible designs. And their poorly designed homes have severely damaged the image of factory-built housing in the U.S.

Without architects, developers have favored cost cutting at the expense of good design. The resulting home designs are poorly proportioned, tacky, resemble a patchwork of different design styles, and lack context. Examples of these cost-cutting practices include designing fewer corners into the house, minimizing the number of windows, and leaving off window and door trim. Builders also cut costs by eliminating the context of their homes by not building porches or integrating their homes into the landscape.

Equally problematic for the design of factory-built homes is that they are often built in sections and assembled on-site. This method of building requires that a home's components meet a strict set of engineering guidelines. While the guidelines allow the components to be transported to the site and placed on a foundation without breaking or cracking, the guidelines also regulate building size, floor width, and roof angles. These engineering complexities have pushed the architect out of the process and require engineers to make the important design decisions.

Since the majority of factory-built housing is produced without the assistance of architects, cost and engineering efficiencies have been leading the design process. The result is poorly proportioned homes that are not as aesthetically pleasing as site-built homes. What's worse is that many of the factory-built homes that are designed by architects have become an architectural statement rather than a functional home that meets the design preferences of average American home buyers.

Modular home built by Driscoll Associates outside Boston, MA (image: http://driscollmodular.com/).

The American House '08, was designed by Architect, William Massie (image: Henrik knudsen).

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[4]Evidence of these prejudices can be found in an interview of 12,000 home buyers/owners that was completed by HUD's Office of Policy Development and Research Titled: Factory-Built Construction and the American Homebuyer: Perceptions and Opportunities. As well as in a variety of publications put out by the Manufactured Housing Institute, like their 2009 report titled: Understanding Today's Manufactured Housing.

An Image Problem

With architects out of the picture, awkward building designs have contributed to the industry's image problem. Not only are the majority of the industry's homes poorly designed, but they are obviously factory-built. The majority of home buyers are cognizant of these design flaws[5]. Consequently, when a home buyer purchases a factory-built house, they are also buying an image. Unfortunately, this image is often regarded as negative, and many home buyers associate factory-built housing with low incomes, negative stereotypes, and poor quality (HUD Factory Built Construction).

To address the design related image problems, the factory-built housing industry has been taking steps to improve their image through technological research initiatives that allow for more design flexibility. For example, even though the Industry is making progress on the design of their homes, homes are still noticeably different and poorly proportioned.

The industry has also been addressing negative stereotypes through informative publications and marketing. Industry organizations, like the Manufactured Housing Institute, have been publishing reports that debunk negative stereotypes, like those discussed in the next section. One recent report called "Understanding Today's Manufactured Housing" offers background on the industry and facts about manufactured housing.

Four Widely Accepted Myths Regarding Factory Produced Housing

In addition to poor design, there are a number of myths that also contribute to the Industry's image problem. While it's impossible to locate the original source of these myths, they are widely accepted and damage the industry's image. These myths have likely evolved from decades of negative stereotypes surrounding trailer parks and have been transferred from trailer parks to other forms of factory-built housing. Not only are the following stereotypes flawed, they also manage to pervade mainstream beliefs:

[5]HUD's 2007 study titled: Factory-Built Construction and the American Homebuyer: Perceptions and Opportunities, surveys roughly 10,000 home buyers to poll, among other things, their perception of how different types of housing compare based on looks and feel. On page 24, table 3-16 shows that site-built homes are most commonly perceived as having excellent looks and feel, where as only 12.92% of home buyers consider manufactured to have excellent looks and feel. Similarly only 22.25% home buyers felt modular homes have excellent looks and feel and only 20.27% of panelized were viewed as excellent.

Myth 1: Factory-built housing is more susceptible to fire than site-built housing

One popular misconception about factory-built housing is that it is more susceptible to fire damage than site-built housing. While the opposite is in fact true, sensational news articles help reinforce this stereotype. The news stories, in addition to reporting the fire, also include subtle commentary on the people and culture that are presumed to live in factory-built housing. Unfortunately, this commentary is not flattering and helps to reinforce negative stereotypes. Examples of two sensational news headlines that come up on Google News when "home" and "fire" are searched are "'Ghosts and demons' led to manufactured home fire" (*The Niagara Gazette*) and "Out-Of-Control Trash Fire Destroys Mobile Home" (*Greeneville Sun*[6]).

Like site-built housing, factory-built housing is strictly regulated by building codes. Modular, panelized, and precut homes all fall under the same local building codes as site-built housing whereas manufactured housing is regulated by the federal Manufactured Home Construction and Safety Standards, or HUD Code. Enforced by the U.S. Department of Housing and Urban Development, the HUD Code went into effect on June 15, 1976 (MHI, 2) and requires that manufactured homes are built to a stringent set of requirements. The requirements are performance-based and include strict standards designed to limit the spread of fire and smoke throughout a home. In fact, the HUD Code regulates the materials that can be used in construction, mandates the use of smoke detectors, and requires at least two exits, "which must be remote from each other and reachable without passage through other doors that are lockable" (MHI, 9).

Further, there have been a number of studies completed by insurance companies that demonstrate manufactured homes experience fewer fires on average than site-built homes. In 2005, a report titled "Manufactured Home Fires in the U.S." by the National Fire Protection Association discovered that manufactured homes experienced 38 to 44 percent fewer fires than other residential dwellings (MHI, 8). The report examined the occurrences of fires in manufactured homes and other residential dwellings during the mid-1990s.

[6]The Google search was completed on March 10th, 2009.

Myth 2: Factory-built housing lowers neighboring property values

The notion that factory-built housing lowers property values is often leveraged by government officials and local advocacy groups as an enabling tool to promote Not In My BackYard (NIMBY) planning. In many cases, planning boards with ambitions to zone manufactured housing out of their district will argue that manufactured and other types of factory-built housing will lower the property values of neighboring site-built homes (Warner, 1).

Unfortunately, this argument is often successfully used to keep factory-built housing out of communities. While the argument is successful, it lacks validity. According to a number of studies conducted by leading planning institutions and businesses, there is no empirical evidence that demonstrates factory-built housing will lower neighboring site-built property values. In fact, there is a body of research that suggests otherwise. A well-known study completed by the Massachusetts Institute of Technology and Harvard University in 1986 though the Joint Center for Housing Studies found that there is no statistically significant evidence that manufactured homes lowered neighboring site-built property values (MHI, 9). The study collected and examined data on 1,500 real estate transactions over a three-year period in New Hampshire. In particular, the study used "regression techniques... to create a model for predicting [the] selling price of homes [that] abutted mobile/manufactured units. If mobile/ manufactured units negatively effect the value of abutting single-family homes, then the predicted selling prices would be higher than actual selling prices" (Enterprise Foundation, 8).

Other research initiatives also confirm the conclusions reached by MIT and Harvard researchers. The Manufactured Housing Research Project at the University of Michigan conducted a study that established that "...rental manufactured home communities, did not appear to have a significant effect, positive or negative, on adjacent residential property values" (Warner, 1). The conclusion that manufactured housing does not impact

the value of neighboring properties can logically be extended to encompass the other forms of factory-built housing as well. More importantly, these studies definitively establish that manufactured housing and by extension factory-based housing have no impact, positive or negative, on neighboring site-built properties.

Myth 3: Factory-built housing is poorly constructed

Home buyers interested in a factory-built home are almost forced to buy a home that was designed by a developer or engineer. As mentioned before, this has its advantages: a lower cost, for one, and a more durable design. However, homes created by engineers and developers are generally poorly designed. A less desirable design coupled with a lower cost leads the general population of home buyers to the conclusion that factory-built homes are lower quality when, in fact, nothing could be further from the truth.

On a structural level, the majority of factory-built homes are more durable than site-built homes. They have to be because the components must be transported to a site without getting damaged during the move. In fact, Penn Lyon Homes, a modular builder in Pennsylvania, estimates that they use 30% more lumber in their construction process than an equivalent site-built home (Penn Lyon).

Additionally, the HUD-Code ensures that manufactured homes are energy efficient, strong and durable, fire resistant, and able to be safely transported. Similar to other building codes, the HUD-Code also has performance measures for Heating Cooling and Air Conditioning, Electrical, and Plumbing. Far from inadequate, the HUD-Code is comparable to the International Residential Code (IRC) in most areas and more stringent in some areas.

Other types of factory-built housing like modular, panelized, and precut fall under local building codes, which means that these homes have to be built to the same standards as neighboring site-built homes. In fact, factory-built homes often exceed the structural minimums required by the IRC because the homes have to be transported from the factory to the site.

The modular home section, above, is built by Penn Lyon Homes and illustrates the over-engineering typical of modular construction (Image: Jesse Hunting).

The modular home section, above, is almost ready to be shipped and illustrates the quality of the finishes and durable structure (Image: Jesse Hunting).

Myth 4: It's more difficult to get financing for factory-built homes

The notion that it is more difficult to get financing for factory-built homes is another myth that lacks validity. Modular, panelized, and kit-built homes are financed the same way site-built homes are because there is virtually no difference among the structures. In fact, these three types of factory-built housing are financed by the same lenders that finance site-built homes, like Fannie Mae and Freddie Mac.

In many cases, it is less risky to finance factory-built housing because there are fewer unknowns involved in the manufacturing process. For example, in a factory controlled environment, the builder can control for bad weather, labor inconsistencies, and theft. On the other hand, site-built home developments are susceptible to the abovementioned factors as well as vandalism (Caflisch). Also, less financing is needed during the construction period for factory-built housing because the construction period is shorter than site-built housing. The efficiencies that are built into the factory-built housing process permit homes to be built exponentially faster than site-built homes. In fact, Penn Lyon Homes, a modular builder in Pennsylvania can build their homes in "one third of the time it takes a stick home to be built" (Penn Lyon Homes, slide 30).

Financing is also readily available for manufactured housing. The process for securing financing for manufactured housing is both similar and different from financing site-built housing. Like site-built homes, manufactured homes can be financed as real property. This is a trend that has become popular in recent years, as manufactured homes have become more permanent in recent years (Factory and Site-Built Housing).

Traditionally, however, manufactured homes were financed "as personal property, on leased land, in a manufactured home community, or on a privately owned site" (MHI, 12). These distinctions mean manufactured housing has more financing options than site-built housing. Consequently, the variety of financing options offers manufactured home buyers

greater flexibility when buying a home. However, and as with any financing arrangement, there are certain advantages and disadvantages that are specific to financing a home as personal property or as real property.

Overcoming Problems with Image and Design

Despite design and image related obstacles, factory-built housing can expand its market to serve middle income earners. There are two important steps that will be necessary for an expansion of the factory-built housing market. Allowing designers to take control of the design process and work with engineers to develop methods of factory building that allow for contextual designs is one part of the solution. Designers can re-introduce context and a variety of well-proportioned design styles into the industry. The other part will have to be a media campaign that debunks the myths of factory-built housing and an advertising campaign that targets middle and upper-income earners.

Valuing Design

Improving the design of their homes will require factory home builders to re-engineer their fabrication process to accommodate more proportional and aesthetic designs. Key to the re-engineering process will be adopting a less rigid and more dynamic assembly method. Currently, the majority of factory-built homes conform to a strict set of dimensional guidelines that limit the number of potential building configurations. The guidelines are also not proportionally correct. Proportionally correct buildings balance all of the architectural and contextual elements of the home like windows, doors, trim, roofs, walkways, and landscaping. To produce well-designed homes, factory home builders will have to reverse-engineer their buildings, starting with design and ending with structural support systems.

Once hired, designers can work closely with engineers to develop cost effective improvements to the design of their homes, while still maintaining the affordability of their homes. One way

this could be accomplished is by focusing design efforts on the "skin" of a home, or its exterior finishes, and making only minor adjustments to the structure of a home.

Having well-designed homes will certainly help factory home builders sell their homes and increase their share of the housing industry. However, well-designed homes will require an investment from builders. Factory home builders will have to invest in designers. For example, builders could give designers a commission for every pattern home that is designed and sold - similar to royalties in the music industry. Offering commissions would help builders incentivize architects to develop designs that are functional and appealing to the general public.

Overcoming Myths and Image-Related Obstacles

While factory-built housing suffers from a variety of flawed stereotypes, the industry can take steps to overcome these negative images with a comprehensive marketing strategy and, by extension, through re-education. The marketing strategy should be an industry wide initiative that has support from the industry's advocacy organizations, like the Manufactured Housing Institute, as well as from builders. The strategy should also be bold and guided by a set of principles created by HUD for the express purpose of marketing factory-built housing:

- An emphasis should be placed on construction quality[7].
- The strategy should employ a variety of marketing mediums such as internet, TV, radio, and print[8].
- The strategy should also target consumers who will most likely be familiar with factory-built housing and who are already the biggest consumers of the homes[9].

In addition to these marketing principles, a marketing strategy should be innovative and encourage home buyers to think about factory-built housing in a new light. To recast the industry in a new light, the industry should start with design. Builders can and should work with industrial designers to re-envision the design of their

[7]According to the HUD study Factory-Built Construction and the American Homebuyer: Perceptions and Opportunities 92% of the 12,700 respondents in their survey of home buyers indicated that the quality of homes construction is very important to them (Factory-Built Construction, vii).

[8]The same HUD study indicates a statistically significant variation in interest in "the likelihood to purchase site-built housing compared to modular and panelized housing. There are smaller differences in the Web-based survey respondents' likelihood to purchase a particular type of home: 55% versus 9%. For telephone respondents, the percentage that indicated they would definitely consider purchasing a particular type of housing ranged from 77% to 8%" (Factory-Built Construction, vii).

[9]Again, the same HUD study suggests that people who are more familiar with factory-built housing are more likely to purchase it. This conclusion makes sense, those who are more familiar with the housing understand that they stereotypes surrounding factory-built housing are just that, stereotypes. Whereas, people not familiar with factory-built housing, are more susceptible to believing the many stereotypes.

factory-built homes. The newly designed homes should appeal to traditional and family design sensibilities while still pushing the design envelope. The designs should be well proportioned, functional, and suited to urban and suburban developments.

Re-envisioning design is a necessary first step. Equally important will be re-educating the public about factory-built housing. Re-education can only be accomplished by highlighting the facts and advantages of factory-built housing. Side-by-side comparisons of site-built and factory-built homes are one place to start. Through the use of factual based media initiatives, builders can help the industry establish positive associations between the words "factory-built" and "housing." While the strategy should target home buyers who are the most likely to purchase factory-built homes, it should also reach out to new demographics that include higher-income earners. Marketing to higher-income earners may not generate immediate returns, but it will help improve the industry's tarnished image. Also, selling and marketing homes to higher-income earners will help establish an essential style precedent that should encourage more sales among middle and lower-income earners.

Following in the footsteps of the fashion industry, the factory home building industry should encourage celebrities to adopt and help sell factory-built housing. In Pennsylvania, builders could offer discounted rates or even free homes to high-profile politicians as well as well-known athletes and radio and TV personalities in exchange for their support of the homes. Similar in concept, the industry should also sponsor high-end design competitions, art exhibits, and other public events to garner as much positive free press as possible.

Summary

The key to any successful business is to offer a better product at a lower price than the competition. This mantra is attainable for factory home builders. Rather than offer an inferior product at a lower price than the competition, factory home

builders have an opportunity to offer a home that is superior in design at a lower price than its competitors. An improved design is possible through a partnership with designers. By engaging architects and landscape architects in the design process, factory home builders can develop a highly marketable line of homes that are contextual, functional, and aesthetic.

Selling homes that are better designed than the majority of site-built homes will give factory builders a tremendous competitive advantage. Their competitive advantage should be highlighted through targeted marketing campaigns directed at costumers likely to purchase their homes. To increase the effectiveness of the campaigns, builders should focus on marketing their homes' design rather than marketing their homes' construction process.

Chapter Three

Comparing Factory and Site-Built Housing

It is a widely held belief that factory-built housing is a cheaper alternative to site-built housing. As it turns out, this notion is both true and false. Factory-built homes can be both cheaper and more expensive than site-built homes because costs in real estate development are variable and change depending on location. Other factors that impact the cost of factory-built homes include loan terms, construction periods, design, prevailing wages, and factory overhead.

General Discussions and Observations

A basic understanding of factory home production leads many to conclude that economies of scale and the efficiencies inherent with factory production, of any kind, will generate a cheaper and higher quality product. This belief can likely be traced back to Henry Ford's first assembly line and basic principles of microeconomics that advocate for specialization. While the factory-based process does generate some savings through assembly efficiencies and economies of scale, there are also significant overhead costs that stick builders don't have. Most notable is the cost of maintaining and operating a factory. In addition to the machinery inside the factory, it costs money to heat and power the buildings, not to mention lease or build them.

Without fully understanding where the savings are generated in a factory-based production process, many businesses and organizations believe, as a rule of thumb, that factory-built homes are cheaper than site-built homes. According to Don Carlson at *Automated Builder Magazine* and Perry Caflisch at Penn Lyon Homes, this belief is commonly held by not-for-profit community development corporations and a number of private sector developers. What these developers don't understand is that the affordability of a factory-built home is situational.

For example, Perry Caflisch explained that while Penn Lyon Homes, located in Selinsgrove, PA, builds homes that are competitive along the New Jersey Shore, Philadelphia, and as far north as Connecticut, his company's homes are not competitive in Selinsgrove. The primary competitive advantage that Penn Lyon Homes enjoys in areas like Philadelphia is lower labor costs. Their location in Selinsgrove allows them to capitalize on unskilled labor that averages around $12 and $15 an hour whereas higher skilled laborers in Philadelphia, like carpenters and electricians, average $23 and $29 an hour respectively.

Factory home builders are able to use unskilled laborers because the factory provides a framework for unskilled workers to operate in. This framework relies heavily on redundancy and assembly line efficiencies. Redundancy and assembly lines dramatically reduce the need for skilled contractors who are being paid to think independently and make on-the-spot construction decisions.

Also, the lower labor costs mean that a smaller percentage of a factory-built home's total cost comes from labor. For example, in manufactured housing, labor costs only makes up 8-12% of a home's total cost, whereas labor typically makes up 40% of a site-built home's total cost (HUD, Factory and Site-Built, 29).

Another competitive advantage that factory home builders have is the efficient integration of technology. MIT research scientist, Kent Larson, makes the point that a factory based assembly process gives builders the ability to integrate technology into the house at a lower cost than site-built developers. The lower installation costs stem from efficiencies associated with the factory process (Larson). And as more technology innovations like solar panels and home healthcare monitoring systems, become common place, factory home builders will gain a competitive advantage.

In addition to cost effectively integrating technology, factory home builders also have the advantage of speed. Factory-built homes can be quickly constructed

because of production line efficiencies and the ability to control for variables like vandalism, fire, and bad weather. Controlling for these variables also brings a higher level of predictability into the construction process, which lenders like. Compared to site-built homes, which can take months to build, factory homes can be built in a few weeks and require shorter construction loans (Penn Lyon Homes, slide 30). With a shorter construction loan, developers pay less interest and can lower the homes' selling prices.

While speed, lower cost technology integration, and lower labor costs are three advantages of factory-based production, there are also a number of costs. Primary among them are the overhead costs associated with operating a factory (Caflisch & 29). The overhead costs of operating a factory, coupled with transportation costs, setup costs, and taxes, prevent many factories from competing in the markets where they are located. Unlike site-built homes, factory-built homes are transported to the site in varying degrees of completion and then assembled on site. A modular home builder in Pennsylvania reported that the transportation of their homes' components make up ~4% of each home's cost. This same home builder reported that the placement and setup of a home can make up ~8% of a homes' cost. Then on top of transportation and set up, factory-built homes are taxed, a cost that site-built homes don't have. Consequently, another ~3% of a home's cost is dedicated to sales taxes.

As a result of these costs, factory-based home builders can't guarantee a less expensive home. Rather, the relative value of a factory-built home is specific to each project and dependent on the location of its target market. For example, while Penn Lyon can't profitably sell its homes in Selinsgrove, PA, they can sell a competitively priced home in Philadelphia.

A Comparative Cost Analysis

To gain a sense of what cost advantages are created through a factory-built housing process, this section compares the costs of factory and stick-built housing. The comparison looks specifically at modular,

manufactured, site-built, and Japanese panelized housing. The costs of these home types are compared in two separate tables on the basis of construction, land, overhead, and financing costs. In the first table, the homes are compared using each home's actual square footage and costs. Then, in the second table, the homes' square footage and costs are normalized so that the homes' costs can be easily compared (HUD, Factory and Site-Built, 29).

This method of comparison was used in a report published by the National Association of Home Builders' Research Center in 1998. The report, titled "Factory and Site-Built Housing: A Comparison for the 21st Century," was prepared for the U.S. Department of Housing and Urban Development. The methods of analysis, two of its tables, and some of the data used in the report have been retooled for this thesis. In particular, the report's data has been adjusted for inflation and represent 2009 cost numbers. Also, the updated tables include 2009 cost numbers collected from Japanese factory based home builders.

Tables 1 & 2; a Discussion

Table 1 shows that all four types of manufactured housing sell for substantially less than modular, site-built, and Japanese panelized housing. The biggest percentage differences are apparent in the construction costs and the overhead/ administration categories. While a look at Table 2 shows that the cost differences in the overhead/administration categories are nominal, the cost differences in the construction costs are fairly substantial.

The substantial construction cost differences stem from a variety of factors tied to the factory-based production process. Key among these factors are the labor efficiencies inherent within a factory process. The efficiencies allow builders to boost output while hiring less skilled labor, which reduces costs. Also, factory-based home builders who build homes in large volumes can buy their materials in bulk and have them delivered to one location. The large order coupled with a central delivery location typically lowers the cost of materials. Manufactured home builders also cut costs by utilizing lower

Table 1: Comparing the Costs of Factory-Built and Site-Built Homes

	Site-Built (U.S.)	Modular (U.S.)	Panelized/Kit Home (Japan)	Manufactured Homes (U.S.)			
Description	Two-Story			Double-Section			Single-Section
Foundation Type	Permanent			Blocks	Permanent		Blocks
Square Feet	1,990	1,990	1,381	1,680	1,680	1,680	1,215
Construction Costs							
Structure	$95,936	$80,329	$244,323	$46,975	$46,975	$46,975	$28,266
Foundation	$8,117	$8,117	$12,205	$2,034	$4,067	$4,067	$1,085
Total	**$104,053**	**$88,446**	**$256,528**	**$49,009**	**$51,042**	**$51,042**	**$29,351**
Cost Per Square Foot	$52.29	$44.45	$185.76	$29.17	$30.38	$30.38	$24.16
Land Costs							
Lot Density	4 per acre	4 per acre	N/A	2 per acre	4-6 per acre	4-6 per acre	6-8 per acre
Improved Lot	$46,014	$46,014	N/A	$45,706	$45,706	--	--
Site Preparation	$1,620	$1,620	$2,200	$964	$1,582	$1,582	$964
Monthly Land Rent	--	--		--	--	$339	$271
Total	**$47,634**	**$47,634**		**$46,670**	**$47,288**	**$1,582**	**$964**
Overhead / Administration							
Overhead & Gen. Exp.	$11,323	$8,756	$15,303	$2,587	$4,559	$2,732	$1,589
Marketing	$4,100	$3,503	$9,342	$1,293	$2,280	$1,365	$794
Sales Commission	$6,442	$4,263	$0	$1,431	$3,419	$2,048	$1,192
Profit	$17,765	$19,266	$28,026	$9,700	$17,098	$10,242	$5,961
Total	**$39,630**	**$35,788**	**$52,671**	**$15,011**	**$27,357**	**$16,388**	**$9,536**
Financing Costs							
Construction Financing	$3,904	$1,752	N/A	--	--	--	--
Inventory Financing	--	--		$647	$1,140	$683	$397
Total	**$3,904**	**$1,752**	**N/A**	**$647**	**$1,140**	**$683**	**$397**
TOTAL SALES PRICE	**$195,221**	**$173,620**	**$309,199**	**$111,336**	**$126,827**	**$69,695**	**$40,248**

The cost numbers for site-built, modular and manufactured homes were taken from *"Factory and Site-Built Housing, a Comparison for the 21st Century,"* a 1998 report published by NAHB Research Center, Inc.. Each scenario represents average or typical homes. All of the numbers were adjusted for inflation and represent 2009 costs. The Japanese housing cost numbers were provided by a Japanese home builder and also represent 2009 costs, but represent higher end homes than.

Definitions: **Permanent** foundations are continuous concrete, block, or brick perimeter walls that homes are permanently placed on. Other types of permanent foundations include slabs, crawlspaces, and basements. **Block** foundations consist of concrete block piers that bear the weight of a manufactured home's chassis. **Double-Section** manufactured homes are homes that built on two separate chassis and joined on site at the marriage wall. **Single-Section** manufactured homes are built on one chassis.

Table 2: Comparing the Costs of Factory-Built and Site-Built Homes (Normalized)

	Site-Built	Modular	Panelized/Kit Home (Japan)	Manufactured Homes			
Description	Two-Story			Double-Section			Single-Section
Foundation Type	Permanent			Blocks	Permanent		Blocks
Square Feet	2000	2000	2,000	2000	2000	2000	1215 *
Construction Costs							
Structure	$96,421	$80,722	$353,836	$55,936	$55,936	$55,936	$28,266
Foundation	$8,157	$8,157	$17,684	$8,157	$8,157	$8,157	$7,524
Total	**$104,579**	**$88,880**	**$371,520**	**$64,093**	**$64,093**	**$64,093**	**$35,790**
Cost Per Square Foot	$52.29	$44.44	$185.76	$32.05	$32.05	$32.05	$29.46
Land Costs							
Improved Lot	$46,247	$46,247	N/A	$46,247	$46,247	--	--
Site Preparation	$1,628	$1,628	$3,186	$1,628	$1,628	$1,628	$1,356
Monthly Land Rent	--	--		--	--	$339	$271
Total	**$47,875**	**$47,875**	**$3,186**	**$47,875**	**$47,875**	**$1,628**	**$1,356**
Overhead / Administration							
Overhead & Gen. Exp.	$11,380	$8,800	$22,163	$3,309	$5,224	$3,374	$1,860
Marketing	$4,120	$3,519	$9,342	$1,654	$2,612	$1,686	$930
Sales Commission	$6,475	$5,808	$0	$2,482	$3,918	$2,531	$1,395
Profit	$17,855	$19,359	$40,590	$12,409	$19,590	$12,653	$6,975
Total	**$39,829**	**$37,486**	**$72,095**	**$19,854**	**$31,344**	**$20,245**	**$11,160**
Financing Costs							
Construction Financing	$3,925	$1,760	N/A	--	--	--	--
Inventory Financing	--	--		$827	$1,306	$843	$465
Total	**$3,925**	**$1,760**	**N/A**	**$827**	**$1,306**	**$843**	**$465**
TOTAL SALES PRICE	**$196,208**	**$176,001**	**$443,615**	**$132,650**	**$144,618**	**$86,810**	**$48,771**

*Note: The square footage of single section manufactured homes can not exceed 1215 square feet because the maximum chassis size is limited to 1215 square feet.

cost materials, offering fewer amenities, and by offering lower quality appliances. Additionally, since manufactured home builders only have to comply with the HUD-Code, they benefit from simplified permitting and inspection processes, which lowers their costs (HUD, Factory and Site-Built, 102).

Also evident in Table 1, the sales price of the modular home is 89% of the site-built home. The sales price percentage difference remains virtually identical in Table 2. These values are similar because both types of housing follow the same building codes and have identical land and foundation costs. The majority of the savings created through the modular home process is generated through its lower construction costs. Similar to manufactured housing, these lower costs result from lower labor costs, factory efficiencies, increased production speed, and discounts on bulk materials.

While stick-built homes remain the most expensive method of home construction in the U.S., Japan's panelized home building process is substantially more expensive than U.S. stick-built housing. The majority of their higher cost is seen in their structure, which is 60% more than site-built housing[10]. In addition to using more material to build their homes, Japan's home building process is highly engineered, customized, and automated, all of which add significant cost to their buildings.

Unlike U.S. home builders, many of Japan's home building companies invest significant amounts of money in the research and development of new housing technology, like hydraulic earthquake shock absorber systems. Also, nearly every Japanese home is custom designed, which requires a large and expensive design staff. Compounding the cost of custom designed homes is the resulting assembly process. With each home custom designed, each home also has to be custom assembled, which increases the amount of time it takes to build a home.

The largest costs for Japanese builders are embedded in their factories, which are highly automated. For example, Japan's

[10]It should be noted that the Japanese cost numbers reflect an upper-middle class home, while the U.S. numbers reflect middle class homes. Even with this difference, Japan's higher building costs can traced back to its highly automated production process.

largest home builder, Sekisui House, has computer controlled production lines that automatically reconfigure themselves to produce a variety of building components. Similarly impressive, Sekisui House uses automated welding robots to fabricate steel frames for their houses. Unlike the U.S., the high degree of automation found in Japan's factories is justified by their limited labor pool and higher labor prices. Consequently, the high degree of automation found in Japan would not be profitable in the U.S. due to an abundant supply of low-cost laborers.

Conclusions

There are number of ways factory home builders can reduce the sales price of their homes: they can take advantage of lower labor costs, the HUD-Code, the efficiencies and speed of factory production, and volume purchasing. The majority of savings created by factory production is realized in the construction costs of factory-built homes. Other costs like land, overhead/administration, and financing costs are similar to site-built homes. However, even with the savings in construction costs, factory homes can be more expensive in markets with low labor costs. Penn Lyon Homes is a good example of this phenomenon; their homes are competitively priced for sale along the New Jersey Shore and as far north as Connecticut, but they are too expensive to sell in Selinsgrove, PA, the town where their factory is located.

The sales prices of factory-built homes vary substantially among manufactured homes, Japanese panelized homes, and modular homes. These differences in price are largely attributable to building codes, the materials used in construction, the design, and the level of automation in the factory.

As evident in Table 2, the sales prices of manufactured homes range from 27% to 82% of the modular home. This difference in price can be attributed to the materials used in construction and the method of construction, which are regulated by building code. Modular homes fall under local building codes and cost substantially more than manufactured homes, which fall under the HUD-Code. While the HUD-Code

is generally considered comparable to local codes, in terms of its building requirements, the HUD-Code lowers construction costs through standardization. Having one code to follow is especially useful to factory builders who sell their homes in regions with different local building codes. Also, modular homes use higher quality materials than manufactured homes.

Another major cost for modular, Japanese panelized, and stick-built home builders is design. Design is a cost that manufactured builders don't have to contend with. Most modular and Japanese panelized homes are custom designed, whereas the majority of manufactured homes are not. Rather, manufactured homes are virtually identical in terms of their floor sizes, but may vary slightly in their interior layout. Only having to make small superficial changes to the floor plan of manufactured homes enables builders to save money on their design.

By contrast, Japanese panelized builders offer a plethora of design options, which substantially drive up their costs. Also driving up the costs of Japanese factory homes is the highly automated process they use to construct their homes. However, these high levels of automation can be justified in Japan because of a restricted labor supply and high labor costs.

Using Japan's level of automation in the U.S. is not a realistic goal for U.S. factory home builders primarily because U.S. labor costs are significantly lower. In cases of manufactured home building, labor costs only represent 8% to 12% of the home's total cost. Given that labor represents such a small percentage of a factory-built home's total cost, using automation to replace factory workers can only result in less than a 12% savings, not to mention cost a lot of workers their jobs. Instead, the U.S. factory home building industry should look at ways they can streamline other areas of their home building process, such as reducing transportation costs, setup costs, and by eliminating taxes.

Pushing for a unified building code and the elimination of sales taxes on factory-built homes are the most achievable cost cutting goals for factory home builders. Eliminating

the sales tax on factory-built homes will reduce the homes' sale price by 3% in most states. Currently, this is a tax that stick-built home builders do not have to contend with, which gives them an unfair competitive advantage. It is difficult to put a percentage on how much could be saved by bringing modular housing and specific types of panelized housing under the HUD-Code. However, the savings would be created through a streamlined building process that does not have to change depending on the destination of the home.

Eliminating the sales tax on factory homes and bringing modular and some types of panelized housing under the HUD-Code will require an industry-wide lobbying effort. This effort should be supported by builders, but will likely need to be headed by established factory-building trade organizations and magazines. Trade magazines, like *Automated Builder Magazine*, are in a good position to mobilize political and financial support to make these changes.

Chapter Four

Regulations and Factory-Built Housing

Building regulations are often cited as one obstacle that factory home builders must address before they can become more competitive. Don O. Carlson, the Editor and Publisher of *Automated Building Magazine*, believes that building regulations are particularly cumbersome for modular home builders who have to comply with state level building codes (Carlson). Carlson and others favor expanding the HUD-Code to regulate all the components of manufactured, modular, and panelized home builders. Doing so would reduce the amount of time required to permit and build a home and save money for both the consumer and the builders.

Modular Home Builders

Modular homes are governed by virtually the same regulations that site-built homes fall under. The primary difference between site-built and modular homes is that modular homes are generally regulated by one state-wide building code, while site-built homes are subject to a variety of different local and state building codes.

Starting in 2000, most states began adopting the International Building Code, or IBC, Pennsylvania being one of them. The IBC combined a variety of existing codes into a concise document. While parts of the IBC can be considered performance based, the code is generally more prescriptive than the HUD-Code, which regulates manufactured housing (HUD, Factory and Site-Built, 53).

Included in the IBC is the International Residential Code, or IRC, which many states use to regulate modular housing. The IRC is specific to one and two-family homes and townhouses. Since every state possesses the authority to make amendments to the code to suit local market and environmental conditions, states that follow the IBC don't necessarily have identical codes (HUD, Factory and Site-Built, 53).

Manufactured Housing

Manufactured housing is regulated by The Manufactured Home Construction and Safety Standards or HUD-Code. The HUD-Code regulates the construction and design of every manufactured home in the U.S. The code also supersedes all local and state building codes and regulates "all the technical requirements for construction, including unit planning, structural, fire protection, energy efficiency, plumbing, electrical and mechanical systems" (HUD, Factory and Site-Built, 57).

The HUD-Code is similar to state and local building codes, but allows for more building flexibility through its emphasis on performance standards. As a performance based code, builders are required to demonstrate that their buildings meet load bearing requirements and other requirements through an engineering analysis or physical tests. This level of design freedom allows builders to move away from traditional building methods and experiment with new and more efficient building styles.

While the HUD-Code regulates the building and construction of manufactured homes, it does not regulate "issues related to site installation, utility connections, add-ons or modifications to manufactured houses, warranties, transportation, or siting approval" (HUD, Factory and Site-Built, 57). Instead, these issues are addressed by local and state building codes. The type of state and local regulation varies by location, but all manufactured home builders or homeowners must deal with a dual set of federal and state/local regulations.

Land-Use Restrictions

Land-use regulations don't change how a home is built, but they regulate where a specific type of home can be built. These regulations are developed by local zoning boards that use their authority to place restriction on the placement of manufactured homes in their communities. Known as exclusionary zoning, these restrictions are based on fears that affordable housing will lower neighboring property values and change the quality of their community (HUD, Factory Built Housing Roadmap, 32).

However, these restrictions are limited to manufactured homes because modular and site-built homes fall under nearly identical building codes. Since manufactured homes are built on a chassis and fall directly under the HUD-Code, they are easier to classify and thus place restrictions on.

Conclusions

The various codes that regulate factory-built homes have their advantages and, of course, disadvantages. The consensus among industry leaders is that the fewer codes there are, the easier, faster, and cheaper the home building process becomes. Because of its comprehensive scope, the HUD-Code is widely viewed as a success and many industry leaders would like to see the HUD-Code supersede the IRC. With a basic understanding of the regulatory process, it becomes clear why this change is being advocated for.

Perhaps the biggest advantage created by building a home in a factory is the speed at which the homes are produced. The savings in time directly translates to lower financing costs, lower labor costs, and lower holding costs. However, having to comply with two or more codes exponentially increases the amount of time required for permitting and inspections. If all of the permitting and inspections happened in a timely manner, they would not pose a problem, but governments don't have an incentive to operate efficiently and often allow permitting and inspections to take longer than they should.

If given the choice, factory home builders will avoid important elements of building a home just to avoid the regulatory challenges that come with them. Manufactured home builders are an excellent example of this phenomenon. While manufactured home builders benefit from only having one comprehensive performance based code to contend with, the HUD-Code is limited to just home. Beyond the walls of the home, local and state level codes begin to regulate the building process. This added level of regulation acts as an incentive for builders to ignore the context of their building.

While walking around a manufactured home development, it becomes clear that many developers choose to focus their

design and construction energy on just the home, with almost no thought or energy put into the home's context. Unfortunately, many homes in these developments lack permanent front porches, decks, covered garages, pathways, sidewalks, driveways, and landscaping. (Only occasionally does landscaping require a permit)

Unlike manufactured home builders, modular home builders are regulated by a variety of state-level building codes. For modular builders that do business in multiple states, having to account for each state's building code is challenging and time consuming. However, modular builders have a distinct advantage over site-built home builders who have to contend with both local and state level building codes.

Chapter Five

Is there a place for highly automated home building in the U.S.?

U.S. based Industrial and site-built home builders rely on a low-tech labor intensive approach to home building. In fact, their methods of construction rely on balloon framed construction techniques that were developed more than a century ago. The primary difference is that factory homes are mostly built in a factory, and site-built homes are built on the site.

Balloon framing has become a fixture of both industries primarily because there is no incentive for change. Restrictive building and zoning codes, unions, financing requirements, low material costs, and a continuous supply of low-cost laborers help maintain the traditional method of home building in the U.S. Roger K. Lewis, an architect and professor emeritus at the University of Maryland, comments on this phenomenon in a *Washington Post* article in October of 2008: "For a hundred years, repeated attempts have been made to 'modernize' and reform housing production methods. Most attempts have proved futile because of impediments unrelated to design or industrial technology. Rather the arduous real estate development process kept making assembly line production of dwellings unworkable" (Lewis).

Despite the adherence to traditional home building methods in the U.S., researchers and builders in the U.S. and abroad have developed a variety of highly specialized methods of home building. Countries like Sweden and Japan have become leaders at automating their production process and have developed innovative framing and assembly techniques. Similarly, in the U.S., academic research scientists have been developing ways to use advances in technology to build homes.

Even with financing, labor, and regulatory constraints, some U.S. home builders have succeeded at building high-tech

and affordable homes at a small scale. California architect Michelle Kaufmann has shown that even with a low-tech and labor intensive assembly process her homes are structurally innovative, affordable, and incorporate a high degree of energy saving technologies. Unfortunately, Michelle Kaufmann's design build firm is an exception, the majority of U.S. home builders have been slow to incorporate any type of innovation.

To determine the potential value of highly automated home fabrication, this chapter will examine an innovative fabrication process used by MIT professor Larry Sass and look at the factory based process used by Japanese home builder, Sekisui House. Both methods of home building rely heavily on technology, but one is factory-based while the other is transportable.

Digital Fabrication

Perhaps the most promising method of automated home building is being pioneered by MIT professor Larry Sass. Called digital fabrication, Sass's method of home building could revolutionize the way homes are built in the U.S.

In an effort to address housing shortages in the U.S. and abroad and to reduce the complexities and costs associated with Western home building, Sass is developing an "automated [home building] system that supports generative design production." The system of home building utilizes a Computer Numerical Control (CNC) router to cut out building components. The fabrication process is unique in its ability to translate digital 3D CAD drawings into 2D building components that can be assembled using friction – no nails, screws, or glue needed (Sass, The Instant House, Japan).

The inspiration for Sass's system comes from plastic manufacturers and architecture studios. The system has adopted assembly methods embraced by plastics manufacturers that join components by snapping them together. Like plastic manufacturers, Sass uses tabs and slots to hold buildings together (friction). Sass's system is also inspired by laser cutters, a common tool found in architecture studios. Laser cutters are a scaled down version of the CNC routers that cut out the

CNC router cutting out building components (Image: http://ddf.mit.edu/projects/CABIN/cabin_full_cnc.html)

building components for digitally fabricated homes. The fundamental production and assembly methods embraced by plastic manufacturers and found in architecture studios are the foundation of Sass's system (Sass, Personal Interview).

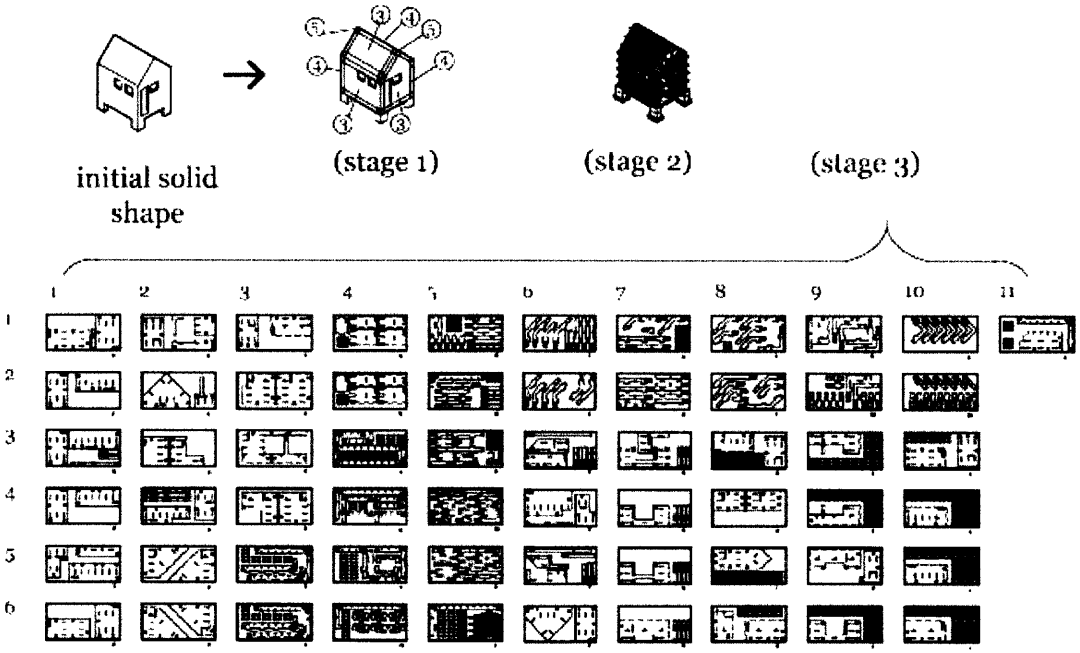
Process Defined

Digital fabrication can be distilled into five basic steps: 1) shape design, 2) design development, 3) evaluation, 4) fabrication, and 5) construction. Elements of this process are present in traditional methods of construction. However, this process is unique because it uses technology to produce "customizable and habitable mono-material plywood structures" that can be assembled with a rubber mallet and a crowbar (Sass, The Instant House, Colorado, 211). The five steps are detailed below:

Shape Design – The architect uses a CAD program to create a building design. Depending on the building's location, its design can vary based on climate, spatial constraints, vernacular influences, and stylistic variation. Also, designs can range from single room cottages to multi-story apartment buildings.

Design Development – Once a design is created, it is then translated into 2D computer shape files so that it can be cut out from a plywood sheet in step four. Step two includes three stages:

a. Design Development Model - Window spaces and door spaces are subtracted from the building and bracing is added to make the building structurally sound. This includes extra bracing around doors, windows, and corners (Sass, The



Design development phase (Image: http://ddf.mit.edu/papers/11_lsass_denver_2006.pdf).

Instant House, Colorado, 213).

b. Part Subdivision – The individual building components are divided up so that they can fit within a plywood panel. Additionally, each component is designed with a T-brace at every subdivision point (Sass, The Instant House, Colorado, 213).

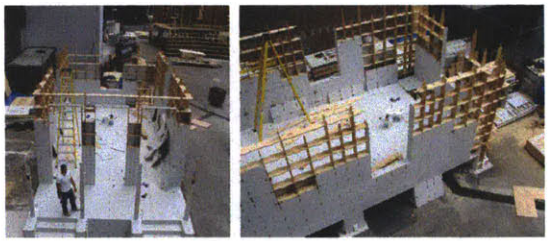
c. Surface Unfolding Operation – Each 2D piece of the structure is fitted onto plywood panels so that space is maximized on each panel.

Evaluation – Digital fabrication is essentially a scaled up version of a laser cutter used by architecture students. Consequently, an exact scale model of the building can be easily made. The fabrication of this scale model is virtually identical to the fabrication of the real building. Therefore, any problems with the fabrication process can be identified during the assembly of the scale model. Also, the model can be used to gauge what design changes need to be made (Sass, The Instant House, Colorado, 214).

Fabrication – Once the scale model is complete, fabrication can begin. Similar to the process used to produce the scale model, the building's CAD model is exported to EZcam for G-Code generation. G-Code drives the table top router, telling the machine how to label and cut the pieces. As parts are cut from ¾" plywood sheets, they are "finished and packed in reverse assembly sequence into one of four crates, while the waste is recycled" (Sass, The Instant House, Colorado, 215).

Construction – Compared to other types of construction, digitally fabricated buildings require virtually no tools – just a rubber mallet and a crowbar. The building components are held in place with friction. Also, the components are small enough that each can be carried by one person, which eliminates the need for a crane or scaffolding. An 8' x 10' room has roughly 1000 pieces and takes roughly six days to assemble with just a rubber mallet, a crowbar, and ladder (Sass, The Instant House, Japan).

Fabrication in architectural studio (Image: http://ddf.mit.edu/papers/11_lsass_denver_2006.pdf).



Construction in progress (image: http://www.momahomedelivery.org/).

Advantages

The technologies and processes that enable digital fabrication offer advantages over the existing construction techniques used by site and factory-based home builders. These advantages come from the process' cost savings, portability, design flexibility, precision building components, and scalability.

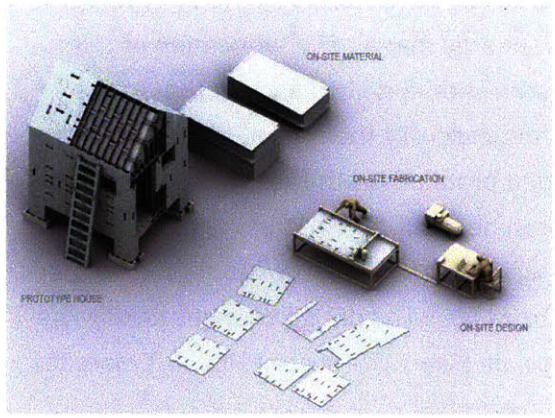
Portability

Different from other building methods, digital fabrication is portable. The only tool needed to cut out the plywood panels is a CNC table top router. Since routers are easily set up at a job site, they eliminate the need for an off-site factory location. Not having to maintain an off-site factory location results in substantial cost savings for builders. Savings would also be realized through the elimination of sales taxes because homes built on a site are not considered factory-built. Additionally, cost savings would be generated through lower transportation and setup costs. However, by not building in a factory, some advantages like assembly line efficiencies and a factory environment would be lost.

In addition to construction sites, the portable CNC machines can also be rapidly deployed to disaster areas (Sass, The Instant House, Japan). Given the global climate change and rising sea levels, temporary housing will become more of a need.

Design Flexibility

Relying on automation to fabricate building components requires the use of CAD/CAM software and eliminates the need for paper construction documents. There are numerous advantages to having all aspects of the design and fabrication process in the digital world. Chief among them is design flexibility for architects. Architects can customize buildings without greatly impacting the cost of production. Additionally, architects can quickly make changes to designs without redrawing the paper construction documents. The paperless design process increases production speed and allows for affordable custom home design (Sass, 2005).



Construction site image illustrates the portability of the system (image: http://web.mit.edu/yourhouse/project3.html.

Building Components

Another advantage of digital fabrication is its use of interlocking joints, which make its homes sturdier than stick-built homes. The joints are held together through friction and form a structure that can bear higher loads than stick-built homes. However, the friction bonds only work when building components are cut to exact specifications, which is only possible through the use of CNC routers (Sass, 2005).

These precise building components are made from plywood and other flat polymer-based sheets. The use of plywood reduces the cost of building materials because plywood is a relatively inexpensive material. The use of plywood also simplifies the fabrication of the building's components because only one type of machine is required to cut out and shape the components. Despite the advantages, plywood homes are only appropriate in a limited number of building scenarios. To expand the system's scope, builders could incorporate other materials like 2x4s and other sizes of lumber into the fabrication process (Sass, The Instant House, Japan).

Scalability and Cost

While Sass has only constructed one-room cottages, his system can be scaled up to single-family homes or multi-story apartment buildings. As the buildings move up in scale, they retain the same basic building components of the cottages, but they become more complex in terms of their layout and assembly process (Sass, Personal Interview). Regardless of the scale of production, the same machine is responsible for cutting out the building components.

In comparison to one full-time employee, this machine is relatively inexpensive. A professional CNC router can cost between $20,000 and $80,000 (K.D. Capital Equipment, LLC.). When builders use these machines to fabricate building components for their homes, they can substantially reduce their labor costs without compromising the quality of their buildings.

Construction underway; photograph illustrates component joints (image: http://ddf.mit.edu/projects/CABIN/cabin_full_plywood.html).

Advantages Summary

The advantages of digital fabrication are apparent in its scalability, cost savings, precision building components, design flexibility, and portability. With these benefits, developers can improve the quality of their buildings while lowering their costs. However, more research and development are required before the system can become commercially viable.

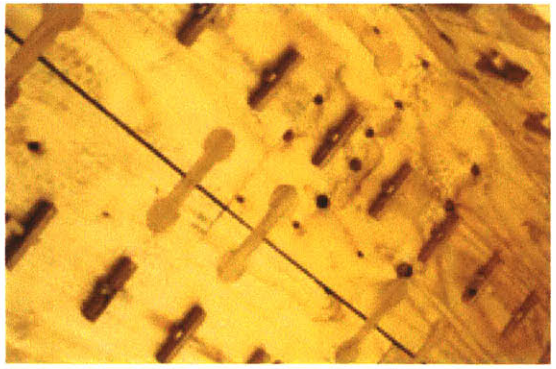
Disadvantages

Despite the many advantages of digital fabrication, there are some obstacles that need to be addressed before the system is made commercially viable. The primary obstacles facing the system are a reliance on a near mono-material fabrication, a lack of fasteners, a complex translation process, long assembly times, and an intricate building structure that makes renovations difficult. However, with a little bit of research and development, these challenges can be overcome and the system could make substantial contributions to the U.S. home building industry.

Mono-Material and Fasteners

The system relies heavily on ¾" plywood for its structure, which increases the number of components required to make a building. Increasing the components also increases the complexity of the assembly process and time required to put the building together. By introducing a variety of building materials into the process, builders could reduce the number of building components and the time required for assembly.

The process would also be improved by incorporating fasteners, like screws, into the fabrication process. While friction joints are a testament to the precision construction of the buildings, they come with some drawbacks. For example, a number of the joints require wedges that stick out from the walls. The wedges are essential for the structural integrity of the building, but make finishing the walls a challenge. Alternatively, a combination of friction joints and fasteners could solve this problem.



This photograph illustrates the wedges that are required to hold building components together (image: http://ddf.mit.edu/projects/CABIN/index.html).

Seamless Design Translation

For Sass's system to be commercially viable, the computer programs that translate CAD drawings into directions for CNC machines need to be user friendly. Creating user friendly programs is possible, but will require a large capital and time investment.

Assembly Time

As it stands, digital fabrication actually takes longer from start to finish than site-built construction and certainly longer than factory-based production. The increase in time comes from the complexity of the designs, which generate roughly one thousand building parts for an 8' x 10' cottage with a roof. Due to the similar size, shape, and number of the pieces, it is sometimes confusing and laborious to fit all of the pieces together (Sass, Personal Interview).

Renovations

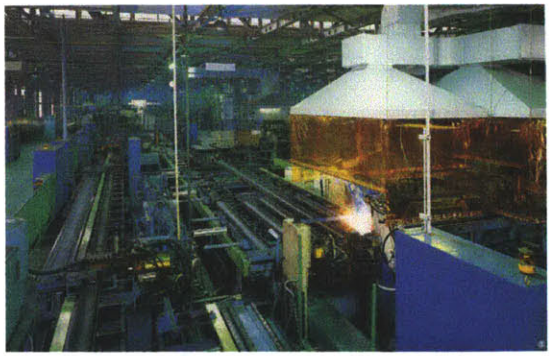
Digitally fabricated buildings are complex structures that are typically built with custom parts made by specialized machinery. The structures are superior in many ways, but when something goes wrong and needs to be replaced, the repairs are difficult to make. Whereas in conventional stick-built homes repairs are easily made with standardized building materials, in digitally fabricated homes, a special order would have to be placed for the necessary custom parts. Additionally, if owners of digitally fabricated buildings decide to make repairs on their own, they could jeopardize the structural integrity of the building.

Disadvantages Summary

While these disadvantages pose a problem for the system, they also represent an opportunity for development and improvement. By making a few minor changes to the model and with some more research and investment, digital fabrication can produce a system of home building that revolutionizes the home building industry by lowering the costd of production and customization.

Highly Automated Home Building in Japan

Sekisui House, Sweden Home, and Daiwa House are three of Japan's leading home



Sekisui House factory building steel framing for detached single family homes, Nagahama, Japan (image by Sekisui House).

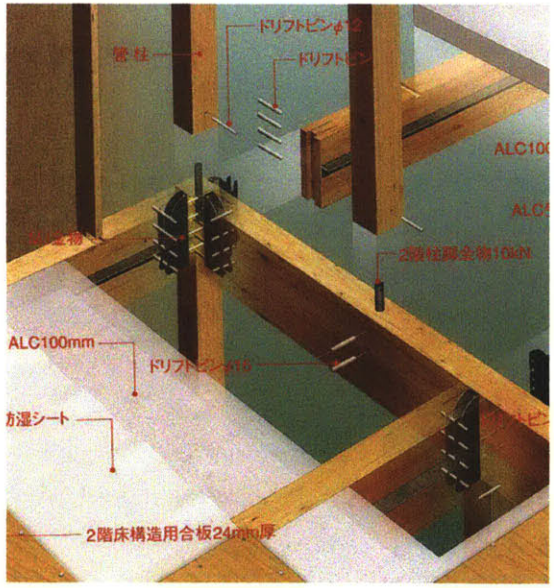
builders. Similar to U.S. factory-based home builders, they fabricate their homes' components in a factory and ship them to a site for assembly. However, unlike U.S. home builders, these companies utilize highly automated fabrication processes in their factories. Japanese home builders' use of factory-based production allows them to quickly build a substantial number of homes with a remarkably small number of people. Further, the automation produces consistently high-quality building components, enables mass customization, and facilitates recycling. However, as seen in the cost comparison section, Japan's use of factory-based home production has dramatically increased the cost of each home.

Enabling Mass Customization

Sekisui House, Japan's largest home building corporation, utilizes computer controlled assembly lines. These lines are connected to a central network that tells the assembly lines the exact specifications of the pieces they are building. At one of their six factories, the production line responsible for milling the timber framing will display the specifications of the piece coming through the line on an LCD monitor. Production lines like this one can automatically re-tool themselves to mill different sized timbers. The production lines ability to automatically re-tool itself allows the company to build custom homes without losing time on the homes' component manufacturing.

Quality and Speed

As stressed in Sekisui's annual report, the greatest value of automated production is the ability to achieve a high rate of home production without compromising the quality of the homes. Sekisui House is a massive company and uses each of its six factories to build 50,000 homes a year. To build 50,000 homes a year, each of its six factories must build over 22 homes a day. To produce this quantity of homes, their factories have to operate with astonishing speed, efficiency, and quality. And since each home is custom designed and has roughly 60,000 components, each factory has to churn out building components at a tremendous rate (Sekisui House).



Specialized building frame assembly system, Sekisui House (image by Sekisui House).

Given the production scale of Sekisui House's operation, it would be easy for the company to produce inferior building components and not even know it. However, the machines on the production runs use sensors to detect defects, and they rarely make mistakes. The majority of mistakes are the result of human error and occur in the translation process where component dimensions are incorrectly entered into the production run. In the event that a component is flawed and not detected by the production line, workers eventually handle every building component and check for defects.

Environmental Efficiencies

Sekisui House's highly automated fabrication process enables the company to recycle scrap building and packaging materials in ways that would be inefficient without automation. For example, in their timber processing plants, scrap wood and sawdust are collected and reprocessed into laminated press board. The press board is then used for interior finishes like molding and wall panels. This level of recycling is made quick and efficient through the company's reliance on highly automated production facilities. In another example, the company has recently introduced ultra-filtration equipment for collecting and reusing excess paint from building timbers and exterior wall panels.

Chapter Summary

Japan's highly automated home building process and digital fabrication have many potential applications to U.S. home builders. Both processes embrace technology and use it to replace labor intensive component manufacturing. While each process does promise a variety of advantages, there are a number of hurdles keeping these processes out of the U.S. housing market.

Highly Automated Factory-Based Production

As demonstrated in Japan, high automated factory-based production has many benefits. Through computer controlled assembly lines that automatically retool themselves depending on the component they are manufacturing, builders can substantially increase their rate of home

Sekisui House highly automated production line making timber framing (image by Sekisui House).

production. All the while, the automated production line produces high quality components and lowers the number of employees required to build a home. Sekisui House is an excellent example of this phenomenon. With 16,697 employees, the company manages to produce roughly 50,000 homes a year. That means that for every employee in the company – including construction workers and corporate executives – there are roughly three homes built. This astonishing level of productivity would not be possible without the highly automated production lines.

However, encouraging U.S. factory home builders to adopt highly automated production lines would be difficult. Builders in the U.S. tend to be small and high levels of automation in a factory seem to be correlated to a company's size. The smaller a home builder is, the more difficult it becomes for that home builder to justify spending money on expensive machinery to speed up the production process and reduce labor costs. The high degree of automation used by Japanese builders seems to be related to the size of the home building companies. For example, Japanese home builder Sekisui House is an enormous company with 16,697 employees and has built 1,906,989 homes since it was founded in 1960 (as of January 31, 2008). Their size allows them to make large capital investments in highly automated machines to process, cut, and assemble the components used in their homes (Sekisui House).

The sheer scale of factory home building in Japan dwarfs operations in the U.S. For example, Penn Lyon Homes is considered a medium-sized modular home builder in Pennsylvania, and they build roughly 300 homes a year. Given Penn Lyon's size, it would be extremely difficult for the company to put together enough capital to make investments in highly automated production lines.

Also, low labor costs and unions in the U.S. provide additional incentives for U.S. companies to maintain traditional labor intensive home building methods. Similarly, even if a company decides to purchase highly automated production facilities, the company will have to employ a specialized staff to operate the machines. Due to their training and expertise, this specialized staff will cost more to employ

Japanese factory-built home by Sweden House (image: Sweden House)

than regular construction laborers. The higher wages paid to these specialized staff will also eat up some of the initial savings created through a reduction in low-skilled laborers.

Digital Fabrication

Digital fabrication has the potential to change the way homes in the U.S. are built. It could bring the consistent quality and some of the efficiencies of factory home building to the site. Additionally, digital fabrication could prove to be inexpensive and potentially bring down the cost of home ownership. Though before these advantages are realized, more research and development will be needed to refine the process.

Improving digital fabrication to include a variety of building components and a simple CAD/CAM translation process will help make the system commercially viable. As it stands, the system is largely confined to plywood and would benefit from incorporating other readily available building materials like 2x4s and more composite materials. Also, incorporating a variety of building materials could serve as an opportunity reduce the number of building components and cut down on the assembly time.

After overcoming these technical changes, the system will also have to contend with local building codes and regulations. Since the process is a radical departure from traditional building methods, it will likely be difficult to get the required permitting to build the homes. Consequently, the permitting process could artificially extend the construction period of the homes and increase holding costs and other financing costs.

While the permitting and technical challenges are substantial, they are not insurmountable. With some additional research and then lobbying, the system could change the way homes around the world are built. It could bring assembly line efficiencies to the site, increase the speed of home building, and reduce the costs. The system is also portable and could be brought into disaster areas or set up inside of a tracker trailer and leased out to home builders.

Digitally Fabricated Housing For New Orleans (Image: MoMA Home Delivery - http://www.momahomedelivery.org/).

Chapter Six

Developing a Business Concept

Since the 1933 Century of Progress Exhibition in Chicago, the factory-built housing industry has allowed technology to drive its homes' design and production. Unfortunately, the industry's narrow focus on technology seems to have steered it away from focusing on the context of their homes.

The value of homes' context can be traced back to the origins of factory production. Back in the mid-19th century, Andrew Jackson Downing developed a landscape and housing pattern book that captivated Americans. The homes pictured in the book were nothing unusual -- mainly little cottages -- but they were pictured within a context. Instead of just a home or a landscape, Downing was selling a lifestyle and an image. People looked through this book and saw more than just a home; they saw an opportunity to escape from the dirty and noisy city to a quiet and peaceful cottage.

It seems that factory home builders today have lost sight of their homes' context and image. U.S. factory home builders sell homes with little or no attention paid to the homes' community and immediate landscape. Consequently, most factory-based home builders don't design for the home beyond its foundation and exterior walls.

The result is a lack of quality control. The factory-built housing industry is selling homes that could look great in the proper setting. However, after many homes are put on their foundations, some home owners don't landscape them or install porches, resulting in awkward aesthetics. The image of the double-wide trailer on page six is a good example of this. Not only does the lack of contextual design make the double-wide look bad, it also reflects poorly on the community and contributes to a poor image of the industry.

A New Direction for Factory Home Builders

Factory home builders can choose to focus on the context of their homes. There are no regulatory, no financing, no technological, and no labor restrictions preventing the industry from doing so. In fact, from a business standpoint, selling the home and its context opens up a variety of new business opportunities.

This strategy is nothing new. In fact, Deck House, who merged with Empyrean International, has been successful at selling high-end factory-built homes with a context. Deck House is well known for blending contemporary design with community-oriented subdivisions as well as landscape. Like Deck House, other factory home builders can begin to sell their homes as complete packages that include landscaping, porches, driveways, a lifestyle, and a context.

Niches the industry could cater to:

Second Homes

Factory home builders could design and sell stylish and functional second homes, like beach houses and lakefront cottages. In addition to selling the home or cottage, builders could offer an array of add-ons, like front porches and decks. Also, builders could develop the second homes in small clusters that create a sense of community among home owners and offer amenities useful to vacationers.

Family-Oriented Subdivisions

Similar to second homes, factory home builders could develop subdivisions that offer residents a lifestyle and a community. The developments could be designed with amenities that appeal to the targeted demographic. For example, to appeal to young families, builders could organize their developments around a community pool or a park and locate their development in a good school district.

Infill Development

The quickest way for factory home builders to create a sense of community is to locate their development in a pre-existing community. Through infill development, factory home builders can incorporate already existing amenities into their development and lower construction costs.

Retirement Communities

A large number of baby boomers will be retiring soon and will be looking to downsize from their current homes. This demographic shift represents an opportunity for factory home builders to design and develop retirement communities for retirees that offer health care, meaningful activities, and an independent lifestyle.

Integrating a contextual setting into a development creates a well-rounded lifestyle for home buyers and a marketing opportunity for builders. Builders who can market a lifestyle in addition to a factory home can create developments that compete on the same merits as any site-built development. However, factory home builders will be able to offer a comparable, and perhaps a better product at a lower price – thereby giving them a competitive advantage.

In addition to addressing a lack of context, factory home builders must also overcome technical and design challenges. On the technical front, builders must update their century-old home building methods to allow for an affordable integration of technology, new production efficiencies, new building methods and materials, high quality construction, new building details, and low-cost customization. Likewise, factory home builders must also improve the design of their homes so that they are more proportional and appeal to a broader range of home buyers.

Far from insurmountable, these challenges can be addressed by embracing what works and making an investment in emerging technologies, like digital fabrication. More specifically, a company can overcome these challenges by engaging designers in the design process, combining modular and digital fabrication production methods, and addressing the physical and social context of the homes. The incentive for a company to make these investments and changes is market driven and will result in a competitive advantage that will put the company ahead of most factory and site-built developers.

Technical Advances

To upgrade the century-old construction techniques, factory home builders can combine digital fabrication and modular construction. Combining the two processes will give builders the low cost and high quality benefits of modular building as well as the ability to customize exterior building finishes through digital fabrication.

Modular construction techniques are an ideal method for building homes' structures because the process generates consistent high-quality construction at a lower cost than site-built housing. The high-quality construction is the result of a controlled factory environment, and the majority of the lower costs are generated from fast assembly times as well as lower labor costs. Additionally, modular construction gives developers the ability to quickly and efficiently customize the interior of their homes.

However, it is difficult to add customizable and detailed exterior finishes in modular construction due to the system's reliance on low-skilled labor and its rigid design process. Detailed and customizable exterior finishes, like ornate trim and coronus woodworking, porches, decks, and patterned siding, are important to the design of a building and help a building fit into its physical context. Moreover, these design details can be cost effectively integrated into the home production process through the use of digital fabrication. Using methods of digital fabrication, builders can quickly and affordably build customized exterior building finishes. The high level of automation inherent with digital fabrication ensures that detailing can be added to a building's exterior finishes at no extra cost. (See "System Description" for a detailed overview of the system.)

Designing with Designers

The technical innovations achieved through a combination of digital fabrication and modular home building offer factory builders the opportunity to construct detailed, customizable, and low cost homes. However, even with these technical innovations, developers and engineers are not able to design homes that appeal to

large segments of Americans. To create well designed homes, the company will have to hire designers.

Attracting some of the best designers is no easy task and will require the company to incentivize design work by offering designers a commission. Similar to the music industry, designers will be paid every time their design is used to build a home. Every time a home is built using an architect's specific design, the architect will be paid one percent of the home's total development cost. Working on commission, designers will have a monetary incentive to design homes that are functional and appeal to the broadest spectrum of home buyers.

With architects producing a series of reusable designs, there is, however, a risk that the company will be producing "cookie cutter" homes. To avoid this problem, the company will introduce moderate levels of customization into the development process. Home buyers will be able to choose from a set of architectural and landscape features that come standard with every home.

To ensure that these customizable features complement the proportions and style of the homes, designers will create a pattern book for each design style. Each style will include interior options for kitchens, bedrooms, bathrooms, trim, appliances, floors, and fixture packages. Additionally, the pattern book will offer options for a variety of exterior components, like decks, porches, trim, siding, and roof styles.

Relating to Context

Most factory home builders leave their homes' community context, building placement, and exterior features up to chance. Consequently, many factory homes are awkwardly placed on sites with no relation to their context. Focusing on the context of its homes will give the company a unique competitive advantage that few factory home builders can lay claim to. The competitive advantage lies in the fact that the company will be able to sell a lifestyle, rather than just a building.

For the company to market the homes on the basis of lifestyle, it will integrate its homes into new or existing communities. This process happens at two scales: the site and neighborhood. At the site

scale, each home will be positioned with special attention paid to views, open spaces, neighboring properties, existing infrastructure, and landscaping. Additionally, the building's exterior features like porches, decks, exterior doors, and garages will be designed so that they fit within the home's immediate context. At the neighborhood scale, the company will develop its homes in clusters that are designed to meet the needs of specific niche demographics. For example, clusters built for families would include larger homes than clusters built for elders. However, and regardless of each cluster's targeted demographic, all of the clusters will be built so that they take advantage of existing amenities and already built infrastructure.

System Description

A system that combines digital fabrication and modular home building can facilitate designs that appeal to specific demographics, ensure designs are well-proportioned and functional, enable moderate levels of customization, and integrate homes into their site and neighborhood contexts. These benefits are made possible through the system's reliance on already developed production methods and home designs that are based on popular home building styles (see page 63 for a system flow diagram).

Design Precedents

Using historical homes as precedents, designers will develop a variety of home styles that appeal to home buyers' different aesthetic tastes. The variety of home styles will also enable builders to introduce homes that fit into different contexts. For example, in urban areas, like Boston, home buyers will likely choose colonial style homes over California bungalows. Having the variation in design styles is important for the overall marketability of the homes.

Nearly all designers cringe at the thought of designing traditionally styled homes. However, with a vested financial interest in the home styles, designers will likely embrace the challenge and design homes that appeal to the widest range of customers. To reach the widest range of customers, designers will be asked to design homes that represent the following styles: 50s ranch, California bungalow, colonial, English Tudor cottage, Georgian, federalist, and Victorian. Additionally, the company will stock a variety of styles that reflect contemporary designs.

System Mechanics

To increase the company's flexibility and to reduce overhead costs, the production of the homes' structure and exterior components will occur in factories not owned by the company. Rather than incur the overhead costs of maintaining a factory, especially in market downturns, the company will employ a distributed manufacturing system, where it leases factory time from other modular builders. Similarly, the company will lease time on CNC machines for the construction of exterior building components.

The leased and distributed manufacturing strategy has the advantage of being lower risk. The lower risk comes from a lower capital investment than what is traditionally required for other types of factory home building. Also, leasing allows the company to quickly and efficiently adjust to changes in the market place. The value of this flexibility was evident in a recent interview with Perry Caflisch from Penn Lyon Homes. Mr. Caflisch explained that one of Penn Lyon's two factory buildings was closed down due to falling demand for their houses (Caflisch). Although the factory is not generating any income, it is still contributing to the company's overhead.

A distributed production strategy means that the company's homes will arrive on-site in varying degrees of completion. The homes' structures will arrive from a modular home builder with the interior nearly finished, while the exterior detailing will be mostly unfinished. Once the unfinished modular sections are placed on site, then their exterior can be finished using components made from digital fabrication.

Leasing time on a CNC router, the company will cut out a variety of exterior building components from plywood, 2x4s, polymer-based materials, and other materials. These building components will range from patterned siding to ornate trim work to simple backyard decks. Once cut out, they will be packaged and shipped to the site for installation.

Dual System Production Diagram

A Distributed Manufacturing Approach to Home Building

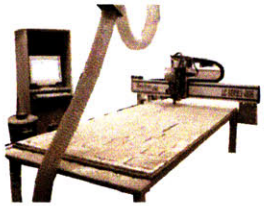
Building Modular Sections in a Factory

Transported to Site

Modular Section

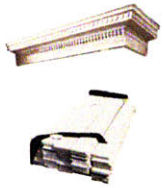
Completed Home

Placing Modular Sections



Digitally Fabricating Exterior Components

Transported to Site



Exterior Components

Installing Exterior Components

Main Line Development Group
Quality & Affordable Housing Solutions for Seniors in Pennsylvania

Overview

The following business concept was prepared to demonstrate that including the context of a home as a component of factory home building is a profitable strategy[11]. The plan is location specific and was developed for factory home builders in Pennsylvania. Also, the plan demonstrates that the factory-built housing industry can develop and build new and innovative products that are both competitive and highly marketable.

The business plan's proposal includes a simple yet forward looking factory-built housing product to serve an immerging senior housing market: accessory dwelling units (ADUs). The ADUs presented in this plan will be built using the dual modular and digital fabrication construction process and designed so that they fit into their community context. Also, because the ADUs will be rented, they will not be custom designed. However, the dual fabrication system is engineered so that developers can build other developments with custom designed homes.

Additionally, the notion that senior housing will become an emerging market is an informed assumption based on current census statistics, numerous studies, and a working knowledge of the built environment. Senior housing, however, is just one of many emerging and existing markets for which factory-based home builders can develop products. The potential profitability of developing senior housing is justified through a rigorous financial analysis. The assumptions made in the financial analysis are supported by current cost and market information collected from a variety of sources including RS Means 2009, AARP 2008, City-data.com 2009 (Elizabethtown, PA), the Brookings Institution 2003, Marshall Valuation Service 2009, the Joint Center for Housing Studies of Harvard 2008, and Penn Lyon Homes Corporation 2009.

[11]While building ADUs for seniors has the potential to be profitable, there is one major obstacle that will have to addressed before building, zoning. Zoning regulations, particularly in PA, vary from one municipality to the next and most do not permit the construction of ADUs. This means that a developer will have to secure the necessary approvals or set up a zoning overlay district before any construction can begin. There are zoning overlay districts for ADUs that have been developed and successfully implemented through a HUD sponsored program called Elder Cottage Housing Opportunity or ECHO. These districts offer one way for developers to overcome zoning related challenges

Mainline Development Group
Overview & Business Summary

Main Line Development Group will meet the current and expected need for retirement facilities in Pennsylvania by building affordable retirement communities in small Pennsylvania towns. The communities will offer more amenities, transportation options, nursing services, and mission-driven activities than competing retirement communities.

In fact, Main Line Development Group (MLDG) can develop and build retirement communities that offer a higher quality of living while cutting the monthly ownership costs of assisted living units by roughly 10%. Substantially cutting costs and increasing the quality of life for seniors is made possible through five key development innovations:

1. Implementing an infill urban development strategy in small Pennsylvania towns;
2. Embracing factory-built construction methodologies to build assisted living accessory dwelling units (ADUs);
3. Incorporating a networked healthcare home delivery system;
4. Creating an environmentally sensitive development; and
5. Establishing mission-based activities for residents.

A Growing Senior Population

Pennsylvania, like much of the U.S., is in the midst of a demographic shift. According to the 2007 U.S. Census Bureau, 2,494,559 Pennsylvanians were over the age of 60. The Census estimates that in 2020 there will be 3,277,908 Pennsylvanians over the age of 60, an increase of 783,349 persons or 31%. To put this shift in perspective, the State's overall population is only estimated to increase 3% from 2007 to 2020 (U.S. Census).

Many current and future seniors will find themselves in a situation where they would like to live in a nursing or retirement facility, but encounter a lack of availability and affordability. Part of the problem is that living in an independent or assisted living

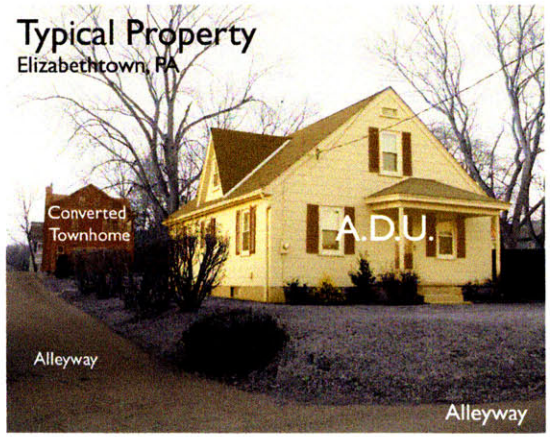
facility is very expensive. In 2008, the average monthly cost for seniors to live in an assisted living facility in Pennsylvania was $3,186. Also, part of the problem is a lack of supply. In Pennsylvania there is a virtual building moratorium on nursing home beds. In fact, there are only 89,000 beds, which will serve less than 3% of seniors in 2020 (PA's Dept. of Health). This also means that by 2020, 97% of seniors living in Pennsylvania will not have the option of living in a nursing care facility or retirement community.

Due to a lack of space and high costs, many seniors will end up living in their own homes, which are often in the suburbs. Unfortunately, the suburbs are not an ideal place for seniors to age in place. Suburban homes and developments are designed for families, not elders. Without a car and even with a car, living in the suburbs isolates seniors from basic services, family, and friends, let alone nursing care. Also, delivering nursing care and other services to seniors in the suburbs is, in most cases, prohibitively expensive.

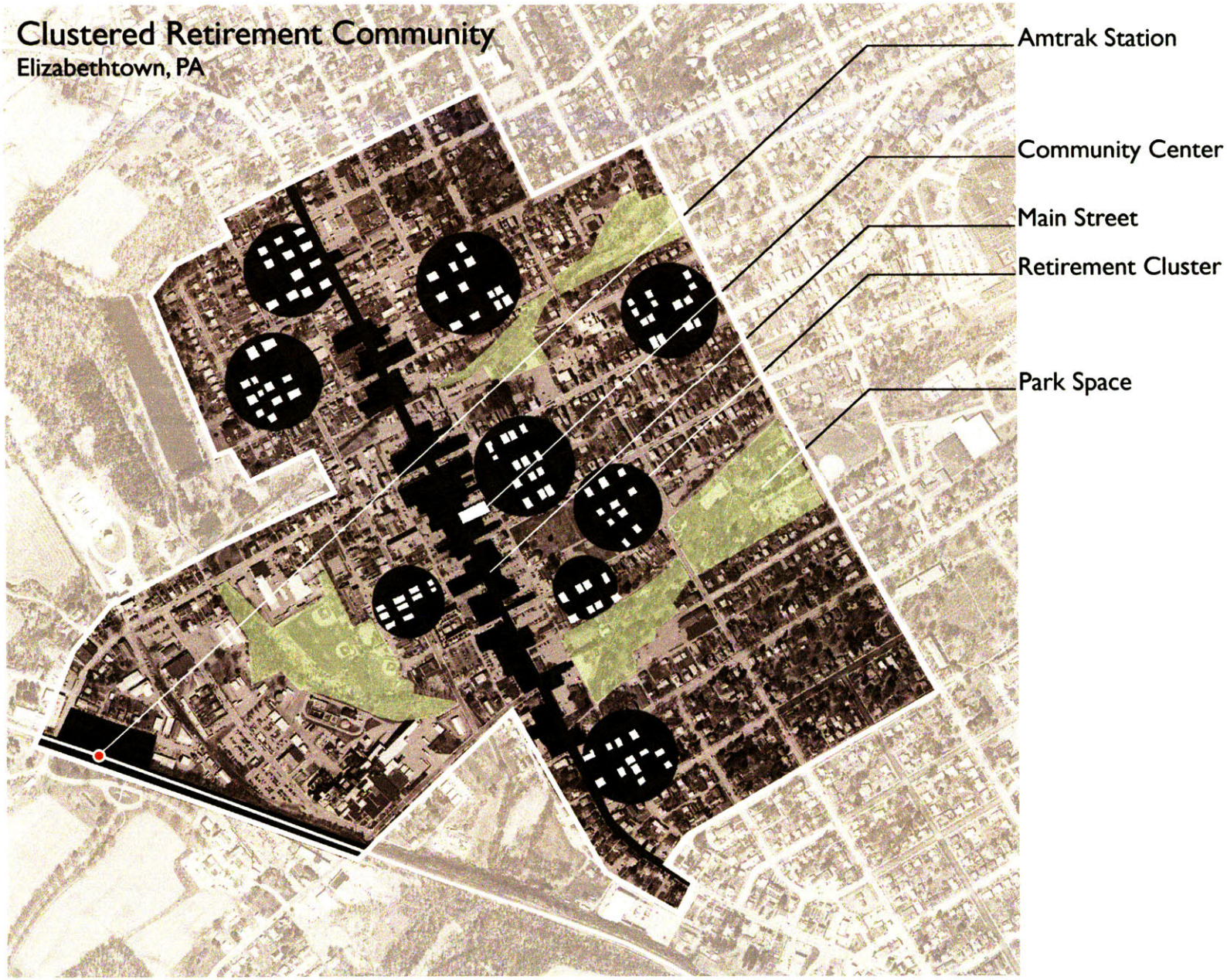
A MLDG Retirement Community

Pennsylvania's growing senior population and undervalued urban areas creates a tremendous opportunity to build affordable retirement communities in urban areas. The company will follow an infill development strategy that integrates retirement homes into the fabric of existing small towns. The homes, which will look no different from other homes in the community, will be located in clusters of 20 to 30 units to form smaller sub-communities based on residents' interests and needs. The small clusters will be located so that seniors can walk or scooter to a community center, the town's main street, the train station, and local parks within in a few minutes. The layout of the development will also offer seniors a level of independence and activity that cannot exist in suburban retirement communities.

The clusters will vary in size from five to eight properties. On each property will be a single family or town home that has been converted into independent and assisted living residences. The converted residences will typically have an independent living



Properties in Elizabethtown and many other small PA towns have long lots that are serviced by a back alleyway. These long lots are ideal for placing an ADU behind the original home.


Clustered Retirement Community
Elizabethtown, PA
Amtrak Station
Community Center
Main Street
Retirement Cluster
Park Space

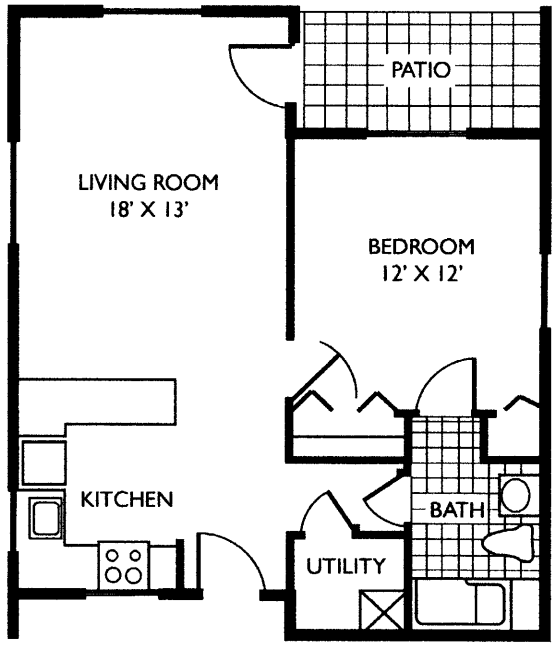
unit on the second floor and two assisted living units on the first floor. Additionally, behind the house and on the same piece of property will be an assisted living Accessory Dwelling Unit (ADU). MLDG anticipates that the retirement communities will range in size from 100 to 200 units. The integration into the existing urban fabric should help seniors feel like members of a fully functional community.

A Construction and Service-Based Business Model

In addition to a construction model, MLDG is also a service-based model that uses its context and design to enable its service components. All of the assisted living units will be ADA accessible and supported by nursing, food, and cleaning services. Depending on the needs of the resident, she or he can receive three hot meals a day at home or in the community center. Residents can have meals at the community center's dining hall or have them delivered to their homes via a cargo bike delivery system. Rather than using a light truck, MLDG will employ four full-time cargo bike staff. The cargo bikers will use three-wheeled bikes equipped with a cargo bay to deliver hot meals and other necessities to the residents. The delivery of meals and other necessities to the residents is made more efficient by the clustered layout.

Residents will also have immediate and one-on-one access to nursing staff through a Telehealth monitoring station[12], which will be installed in both assisted and independent living units. A Telehealth station is a small networked computer that measures residents' vital signs and allows residents to communicate directly with a nurse or care giver in the community center. Using the Telehealth system, nurses can monitor residents' health from the nursing office. In addition to giving residents immediate access to nurses, the Telehealth stations cut nursing costs by increasing the number of patients that nurses can check on each day and eliminate unnecessary house visits.

MLDG also plans to offer residents the opportunity to become involved with meaningful mission-driven activities. The types of activities will vary depending on



Typical ADA accessible one bedroom ADU; 650 sq. ft.

[12]The Telehealth system and other energy saving appliances can be cost effectively integrated into the homes through the factory-based assembly process.


Elizabethtown, PA
A Networked Infill Retirement Community
Legend
Clusters:
- Accessory Dwelling Unit
- Converted Single Family Home
- Inter-Cluster Connections
Community:
- Community Building on Main Street
- Community Connections

the interests of the residents, but MLDG staff will encourage projects like relief work for Haiti and urban gardening initiatives. In the proposed 200 unit retirement community for Elizabethtown, there will be one full-time staff member dedicated to working with residents to organize these projects. The principal idea behind these projects is to get seniors involved with meaningful work that they can apply their life experiences and skills to.

All of these services and amenities are built into the monthly rental cost for residents, which is ~10% lower than the average assisted living facility in PA. The lower cost and high quality of life are the result of MLDG's infill development strategy, which capitalizes on existing assets in the community and the urban fabric itself.

Finding Opportunity in Overlooked Assets: Small Pennsylvania Towns

Key to MLDG's competitive advantage is the planned location of its communities, small Pennsylvania towns. Pennsylvania's overlooked and undervalued towns are poised to play an important role in the State's future. The State boasts an impressive stock of small towns located along commuter rail lines and within close proximity to the State's major metropolitan statistical areas. These quaint, peaceful, and safe towns have functioning main streets with ample services, restaurants, and retail. Further, the small towns are walkable, and they have access to Amtrak, Greyhound, and local municipal buses.

In addition to being ideal places to live, the towns are undervalued. In 2003, the Brookings Institution completed a study called "Back to Prosperity: A competitive Agenda for Renewing Pennsylvania." The study noted that Pennsylvania has been "spreading out and hollowing out." While the State's cities and towns have experienced negative growth, the suburbs have been growing rapidly. The study also found that home prices in Pennsylvania's small towns trail home prices of comparably sized suburban homes by an average of 30%. This price differential creates an opportunity to develop retirement communities in small towns and cities. The primary advantage of building retirement communities is

that they are not marketed on the basis of location, but on costs and services. The location of a retirement community does not dramatically impact the demand for its services. In most cases, retirement communities are comparably priced[13].

Based on the marketing techniques of suburban retirement communities, like Sunrise Senior Living in Haverford, Pennsylvania, prospective residents are more interested in the services the retirement community can offer, rather than the location of the community. Knowing this, developers who can build infill retirement communities in urban areas will be able to capitalize on lower building and infrastructure costs.

In addition to lower land and building costs, building retirement communities located in urban areas have the advantage of utilizing existing infrastructure like sidewalks, roads, sewer lines, and power lines. Also, most urban areas have community buildings, retail buildings, public transportation networks, and public green spaces, all of which can be incorporated into the proposed development at no extra cost. On the other hand, developers who build retirement communities in suburban areas either have to do without many of these amenities or pay for them. Ultimately, by building in an urban area, developers bring these amenities into the proposed development at no extra cost.

MLDG plans to locate its retirement communities in small Pennsylvania towns, like Elizabethtown, Lewistown, and Latrobe. These towns are all located along Amtrak's commuter rail line, which connects to all of Pennsylvania's major towns and cities. The small towns are also self-sufficient and provide residents with an array of goods and services within walking distance of their homes.

Mission-Based Activities

In many cultures around the world, seniors' decades of professional and life experiences are considered valuable assets to society. Sadly, this is not the case in the U.S. In fact, seniors in the U.S. are often seen as a burden to society, rather than an asset. This notion is particularly evident in popular news and research, like the Brookings Institution report, "Back to Prosperity: A Competitive Agenda for Renewing

[13]According to a "2008 Cost of Care Survey" commissioned by AARP and conducted by 2008 Genworth Financial, the average monthly cost of assisted living in PA ranges from $3,708 in Philadelphia to $2,663 in the rest of the state. These monthly costs vary by $1000 a month, but are still high because each facility has to meet specific benchmarks to be licensed and be Medicare certified.

Pennsylvania," which links the State's aging population with an impending economic meltdown. As a result of these negative perceptions, many seniors' opportunities and potential contributions to society are limited. MLDG recognizes the need and value of giving seniors an opportunity to meaningfully contribute to society in local, state, national, and global contexts.

In an effort to bring a variety of meaningful activities into the lives of residents, each cluster of 20 to 30 units will be organized around a specific mission. The missions will be developed to give residents a sense of greater purpose and will provide an outlet for their professional skills - be it legal work, nursing, or construction.

To encourage residents to become involved in the activities, residents will have the support of one fulltime staff member to help plan and organize the activities. Additionally, there will be a computer lab and office in the community center set up for the sole purpose of supporting the activities. Residents will have access to a computer lab with office equipment like printers, copiers, faxes, and phones in the community center.

Many of the potential mission oriented activities will likely have substantial expenses associated with them. These expenses will be partially supported through a $25 monthly fee per resident, which is built into the rental price. MLDG also envisions residents forming their own 501(c)(3)s to raise outside funds to support their activities.

Bundling Healthcare Services

MLDG's infill development strategy allows the company to take money that it would otherwise use to pay for upfront development costs and commit it to providing quality and comprehensive care for its residents. To accommodate the healthcare needs of residents in the community, MLDG has developed a healthcare home delivery system. The system allows residents to maintain their privacy and independence while still receiving the care they need to live comfortably.

The Process of cultivating privacy and independence will be facilitated by technology. Each unit in the development, including independent living units, is equipped with a Telehealth monitoring station that allows residents to remotely check in with nurses. The Telehealth station both saves travel time for the nurses and gives residents a direct 24-hour link to a nurse or care-giver.

When one-on-one care is required, MLDG has budgeted for a staff of 23 full-time care givers and nurses. The nursing staff is available to assist residents at no extra cost. Further, the nursing staff is large enough that each resident in the assisted living community could receive over one hour of personalized care per day. The staff will be available to assist residents with preventative and basic healthcare needs. Examples could include reminding residents to take any medication, helping residents with showering, getting dressed or undressed, and daily exercises, and just having someone to check in on the residents.

For medical care that requires hospitalization and/or surgery, MLDG will refer residents to a local hospital or healthcare provider. To help residents manage the hassle of coordinating any paperwork for a trip to the hospital, there is a full-time dedicated Medicaid and Medicare specialist to work with residents to set up and manage their coverage. Also, all residents, including those in independent living units, will be required to sign up for Medicare Parts A and B.

In addition to Medicaid and Medicare coverage, MLDG will work with residents to set up and purchase supplemental health insurance policies. Unfortunately, these policies will have to be an additional monthly expense incurred by residents. However, to make this process easier for the residents, MLDG will work with a local health insurer to purchase healthcare plans in bulk with the goal of getting a discounted healthcare package for residents.

Another health-related service included in rent is house cleaning. There are five full-time housekeepers who will help residents

keep their units clean and organized. With five full-time housekeepers, residents can expect to have their units cleaned about once every week to week and a half. Also, the housekeepers will serve as another set of eyes to check in on the residents.

Environmental Sensibilities

From a marketing and operational standpoint, incorporating energy saving technologies and design practices into MLDG's business strategy will pay off in the long term. Given that MLDG will own each unit and pay for each unit's utility costs, renovating and constructing buildings that conserve energy will save money over time. MLDG plans to reduce the cost of monthly utility bills through the use of energy efficient technologies and design sensibilities.

Examples of design innovations include orienting new construction to take advantage of passive solar heating. Similarly, using deciduous trees and vines around the buildings will help shield the buildings from the hot summer sun, while allowing the buildings to absorb the winter sunlight. Inside the buildings, MLDG will cut utility bills by installing on-demand hot water heaters, geothermal heating and cooling systems, double-pane windows, extra insulation, and compact fluorescents.

In addition to reducing monthly utility bills, the energy-saving technologies and good design will increase the marketability of the retirement communities. The communities' technology and design will help them be marketed as progressive and environmentally friendly. Part of the image can be created from the fact that the communities will have lower carbon footprints than their competing suburban communities simply by virtue of their location and type: urban infill development. Rather than paving over farmland, the development is reusing existing infrastructure and already developed land and buildings to create new and denser uses. Also, the communities are compact enough that residents don't need a car and can conveniently walk or scooter around the development as well as take public transit, like Amtrak, to larger cities.

Introducing Factory-Based Production

Another key difference that enables MLDG to offer more services and a better quality of life at a lower cost than many suburban retirement communities is its factory-built housing component. Using factory-based production methods, MLDG is planning to build modular assisted living accessory dwelling units (ADUs). In addition to costing less, the units will be structurally superior to site-built ADUs and designed for looks and functionality.

The ADUs will be built in two large sections and be 90% complete when they are ready to leave the factory for the site. From the factory, the sections will be loaded onto trailers and trucked into Elizabethtown or other small towns. Once at the site, the sections will then be offloaded from the truck and placed onto a foundation with a crane. After the units are placed on the site and the interior and exterior finishing touches are complete, they will be ready to live in. The units will be designed to accommodate wheelchairs with comfortably sized bathrooms, living spaces, door frames, and kitchens.

The ADU's will be located on the same piece of property as the renovated homes and will sit on their own foundation. In between the renovated home and the ADU will be a covered parking area for six scooters, a small garden, and a path that connects the two buildings. However, the exact position of the ADUs will vary from site to site depending on orientation to the sun.

Because of planned design innovations and recent advances in modular housing technology, it will be impossible to tell that the ADUs were built in a factory. In fact, MLDG plans to design its ADUs so that they are elegantly proportioned while still embracing traditional design sensibilities. The design of the ADUs will be inspired by the proportionality and size of earlier factory-built kit homes produced by Aladdin Homes and Sears Roebuck & Co. in the early 20th century.

An architect and an industrial designer will be brought in to design the units and create a pattern book with add-ons, like

porches, decks, trim styles, and landscaping improvements. The designers will be expected to work closely with engineers to add a contemporary flare to the buildings while drawing inspiration on building proportions from the early styles of factory-built housing. The designers will also be encouraged to subtly incorporate the developments' energy-saving technologies, like passive solar heating and geothermal heating and cooling, into the design. The advantage to creating well-designed buildings that don't over-emphasize one technology or design style is their ability to retain their appeal over time, giving the development a higher resale value.

The efficiencies inherent with factory-based production (labor, efficient assembly processes, and time) enable MLDG to build a high-quality home for less money than traditional site-built methods of construction. The factory-built construction process will take advantage of lower labor costs in north central, Pennsylvania, which lowers the overall cost of each home. Additionally, a factory-built home is quicker to build than a site-built home. The quicker construction time means that MLDG can save money on interest with a shorter construction loan. Also, the efficiencies and economies of scale associated with the factory-based construction method will save MLDG money.

In the proposed 200-unit retirement community for Elizabethtown, ADUs account for one quarter of the total number of units and a third of the assisted living units, yet they generate nearly 60% of the development's before tax cash flow in year one. The profitability of the ADUs results from the fact that they are inexpensive to build when compared with upgrading and renovating an existing building for independent and assisted living units.

Perhaps the biggest challenge to using ADUs will be the approval process. Each ADU will require approval from the proper authority governing land uses and building codes in Elizabethtown and other small towns. One strategy being developed through the Elder Cottage Housing Opportunity (ECHO), a HUD 202 Demonstration Project, suggests

overcoming these regulatory barriers with a zoning overlay district that allows for infill ADUs. The districts are specific to seniors and prevent couples and younger people from living in the units. MLDG could explore the feasibility of a zoning overlay district as well as individual permitting for each ADU.

Creating Competitive Advantage & Profit

Pursuing an infill development strategy allows MDG to capitalize on already built infrastructure and undervalued property. Instead of building roads, sewers, and large recreational facilities, MDG can focus its energy and money on providing services that enhance residents' quality of life. The infill development strategy allows MDG to offer better services, a stronger community setting, and an active lifestyle at a more affordable price than the competition.

The competitive advantage also generates a reliable profit for equity partners. A 200 unit project can conservatively generate a first-year cash-on-cash return of 8.65% on an equity investment of $7,787,023 (see next page for a summary of the proforma and refer to Appendix A for additional assumptions). In addition, the project can conservatively generate ten-year leveraged returns of 14.84%. All of the assumptions put forth in the financial analysis are conservative. It is likely that many of the estimated costs, such as the length of the construction loan and the number of staff, as well as many annual costs will be lower than the numbers used in the financial analysis.

The financial analysis demonstrates that MLDG can provide better services and a better quality of life to seniors than its competition and do so at a lower cost. These competitive advantages are created through MLDG's infill development strategy, energy-saving technologies, use of factory-based home building, commitment to mission based activities, and networked healthcare home delivery system.

Assumptions and Analysis

Basic Assumptions			
	Acquisition Rehab	Accessory Dwelling Units	Total
Number of Units	150	50	200
Gross Development Price	$23,106,979	$8,041,111	$31,148,090
Depreciable Base	$20,506,979	$8,041,111	$28,548,090
Depreciable Life (Capital Recovery Period)	27.5	27.5	27.5
Estimated Sale Price	$0	$0	$39,872,189
Expected Year of Sale	10	10	10
Cash Flow From Operations (year 1)	$1,626,488	$817,663	$2,444,150
Annual Increase In CFO	3.0%	3.0%	3%
Maximum Mortgage Amount	$21,457,619	$10,787,104	$32,244,723
Amount of 1st Mortgage (75% of TDC)	$17,330,234	$6,030,833	$23,361,068
Equity Investment (25%)	$5,776,745	$2,010,278	$7,787,023
Interest Rate	6.50%	6.50%	6.50%
Term	10	10	10
Amortization Period	30	30	30
Annual Constant Loan Payments	7.58%	7.58%	7.58%

Break-Even Analysis			
	Acquisition Rehab	Accessory Dwelling Units	Total
Current or Projected Occupancy	95.00%	95.00%	95.00%
Added Margin	7.19%	20.72%	11.06%
Break-even Occupancy	87.81%	74.28%	83.94%
Loan to Value	92.86%	134.15%	103.52%
Debt Coverage Ratio	1.24	1.79	1.38

Financial Analysis			
	Acquisition Rehab	Accessory Dwelling Units	Total
Equity Required	$5,776,745	$2,010,278	$7,787,023
Simple Return Measures			
Capitalization Rate - Purchase	7.04%	10.17%	7.85%
Capitalization Rate - Sale			8.00%
Cash-on-Cash Return (year 1)			8.65%
Increase in Capital Value			28.01%
Discounted Return Measures			
Internal Rate of Return			14.84%
Net Present Value @ 12%			$1,601,550
Profitability Index			20.57%

Reflection

This thesis has examined the history and early ethos of factory home building industry, its current market share and distribution, its advantages over site-built housing, its regulatory constraints and advantages, and its developed and emerging technologies. Understanding these components of factory-built housing helps paint a picture of the industry's strengths and weaknesses. Additionally, a strong understanding of the industry suggests that there is plenty of room for enterprising companies to innovate. However, rather than technological innovations, the largest potential for innovation seems to be tied to a home's context.

Key Takeaways

The U.S. factory-built housing industry has been expanding its share of the U.S. housing market over the past two decades. The increase can be partly attributed to builders who are using more panelized components in their production and to a growing acceptance of industrialized housing among home buyers. As demonstrated by the recent exhibit at the Museum Of Modern Art in New York, designers have begun to seriously re-examine the topic of factory-built housing. These recent exhibits and discussions on the topic have contributed to mainstream acceptance of the industry and have helped improve the industry's image.

Designers, builders, and engineers have looked to technology to create an image for factory housing. Architect Michelle Kaufmann has made headlines for combining green technology with factory home building. Similarly, home builders in Japan have developed highly automated production lines to build their homes' components. However, the mixture of technology and factory production seems to complicate the home building process in addition to increasing the costs of homes. The more technology is brought into the production of homes, the more technology seems to drive the design, cost, and image of homes.

Despite popular misconceptions, using highly automated factory-based production lines does not necessarily create lower-cost homes. The high costs of the equipment, small company sizes, low labor costs, non-uniform building codes, and a target market consisting of low to middle income earners are some of the primary reasons automation does not guarantee lower-cost homes in the U.S. While automation does not directly translate into lower building costs, other elements of factory production do. Factory home builders have successfully capitalized on lower labor costs, quicker production times, the efficiencies of factory processes, and fewer building codes.

As demonstrated in the Main Line Development Group business plan, coupling these proven cost-saving strategies with improvements to factory home design and production can create a competitive advantage. Much of this advantage lies in the redesign of factory homes. Factory home design can be improved by hiring world-class designers to improve homes' proportions, function, and contextual relationship. The contextual relationship of a building to its site and neighborhood is particularly important because it allows builders to market their homes as a lifestyle rather than a production process. Factory home builders can also achieve a competitive advantage through coupling modular and digital fabrication production methods. Combining these two production methods offer builders the ability to affordably enable high-quality design and build customizable homes as well as keep their overhead costs down.

While many American still harbor misconceptions about factory-built homes, there is a growing acceptance of the industry in mainstream culture. Given this recent trend, the percentage of factory-built housing starts in the U.S. is likely to continue increasing, which is why it is essential that factory home builders create a more dynamic and inclusive development process. This thesis provides insight into one way factory home builders could create a more dynamic process.

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Appendix A: Main Line Development Group Financial Analysis

Assumptions and Analysis

		Total Project Projected Cash Flow									
Projected Cash Flow	Assumptions	0	1	2	3	4	5	6	7	8	9	10
Cash Flow from Operations	1.03		$2,444,150	$2,517,475	$2,592,999	$2,670,789	$2,750,912	$2,833,440	$2,918,443	$3,005,996	$3,096,176	$3,189,061
- Financing			$1,770,769	$1,770,769	$1,770,769	$1,770,769	$1,770,769	$1,770,769	$1,770,769	$1,770,769	$1,770,769	$1,770,769
BEFORE TAX CASH FLOW			$673,381	$746,706	$822,230	$900,020	$980,143	$1,062,671	$1,147,674	$1,235,227	$1,325,407	$1,418,292
+ Amortization			$259,953	$277,363	$295,938	$315,758	$336,905	$359,468	$383,542	$409,229	$436,636	$465,878
+ Replacement Reserve			$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000
- Depreciation			$1,038,112	$1,038,112	$1,038,112	$1,038,112	$1,038,112	$1,038,112	$1,038,112	$1,038,112	$1,038,112	$1,038,112
Taxable Income			$75,222	$165,956	$260,056	$357,665	$458,936	$564,026	$673,104	$786,344	$903,930	$1,026,058
- Tax Payable @ 35%	0.35		$26,328	$58,085	$91,020	$125,183	$160,628	$197,409	$235,586	$275,220	$316,376	$359,120
AFTER TAX CASH FLOW			$647,053	$688,621	$731,210	$774,837	$819,516	$865,262	$912,088	$960,007	$1,009,032	$1,059,172
- Equity In		$7,787,023										
+ Net Cash from Sale												$15,033,578
TOTAL RETURN		-$7,787,023	$647,053	$688,621	$731,210	$774,837	$819,516	$865,262	$912,088	$960,007	$1,009,032	$16,092,750
PV			$577,726	$548,964	$520,461	$492,423	$465,015	$438,368	$412,582	$387,731	$363,867	$5,181,435

Purchase Price	$31,148,090	SALES PRICE	$39,872,189	SALES PRICE	$39,872,189
+ Capital Exp.	$1,800,000	NET BOOK VALUE	$22,566,967	- Income Tax	$5,018,213
- Depreciation	$10,381,124	GAIN ON SALE	$17,305,222	- Mortgage Balance	$19,820,398
Net Book Value	$22,566,967			Net Cash From Sale	$15,033,578
		Depreciation taken	$10,381,124		
Land Value		Taxes @ 25%	$3,633,393		
Depreciable Base	$28,548,090	Remaining Gain	$6,924,099		
		Taxes @ 20%	$1,384,820	NET PRESENT VALUE @ 12%	$1,601,550
		Total Taxes	$5,018,213	INTERNAL RATE OF RETURN	14.84%

Appendix A: Main Line Development Group Financial Analysis

Cash Flow From Operations

Cash Flow From Operations				
	Per Unit (monthly)	Per Unit (annual)	Number & Percentage of Units	Total
Rents ADU			25%	
One Bedroom	$2,900	$34,800	50	$1,740,000
Vacancy		5%		$87,000
Total				**$1,653,000**
Rents Acquisition Rehab			75%	
Independent Living	$1,450	$17,400	50	$870,000
Assited Living	$2,900	$34,800	100	$3,480,000
vacancy		5%		$217,500
Total				**$4,132,500**
Effective Gross Income				**$5,785,500**

Operating Expenses						
	Per Unit (monthly)	Per Unit (annual)	Number of Units	Acquisition Rehab	ADU	Total
Replacement Reserve	$75	$900	200	$135,000	$45,000	$180,000
Taxes	$283	$3,400	50	$127,500	$42,500	$170,000
Insurance	$208	$2,500	50	$93,750	$31,250	$125,000
Utilities (Gas, water, electric)	$150	$1,800	200	$270,000	$90,000	$360,000
Total				**$626,250**	**$208,750**	**$835,000**

Appendix A: Main Line Development Group Financial Analysis

Cash Flow From Operations

	Annual Personnel Expenses			
	Per Person Cost	Acquisition Rehab Salary Commitment	ADU salary commitment	Total
Nursing Team (22)				
Head Nurses (1)				
Salary	$65,000	$48,750	$16,250	$65,000
Benefit	$5,000	$3,750	$1,250	$5,000
Nurses (4)				
Salary	$45,000	$135,000	$45,000	$180,000
Benefit	$3,000	$9,000	$3,000	$12,000
Personal Care Staff (17)				
Salary Benefit	$23,000	$293,250	$97,750	$391,000
Benefit	$2,000	$25,500	$8,500	$34,000
Mission Coordinator (1)				
Salary	$45,000	$33,750	$11,250	$45,000
Benefit	$4,000	$3,000	$1,000	$4,000
Management Team (5)				
Senior Management (1)				
Salary	$75,000	$56,250	$18,750	$75,000
Benefit	$5,000	$3,750	$1,250	$5,000
Medicaid/Care Specialist (1)				
Salary	$45,000	$33,750	$11,250	$45,000
Benefit	$4,000	$3,000	$1,000	$4,000
Marketing and Sales (1)				
Salary	$45,000	$33,750	$11,250	$45,000
Benefit	$4,000	$3,000	$1,000	$4,000
Secretary (1)				
Salary	$35,000	$26,250	$8,750	$35,000
Benefit	$3,000	$2,250	$750	$3,000
Accountant (1)				
Salary	$65,000	$48,750	$16,250	$65,000
Benefit	$4,000	$3,000	$1,000	$4,000
Transportation (5)				
Van Driver (1)				
Salary	$30,000	$22,500	$7,500	$30,000
Benefit	$3,000	$2,250	$750	$3,000
Cargo Bikers (4)				
Salary	$22,000	$66,000	$22,000	$88,000
Benefit	$2,000	$6,000	$2,000	$8,000
Kitchen (11)				
Kitchen Supervisor (1)				
Salary	$40,000	$30,000	$10,000	$40,000
Benefit	$3,000	$2,250	$750	$3,000
Cheff (1)				
Salary	$45,000	$33,750	$11,250	$45,000
Benefit	$3,000	$2,250	$750	$3,000
Sous Chefs (4)				
Salary	$24,500	$73,500	$24,500	$98,000
Benefit	$2,500	$7,500	$2,500	$10,000
Dishwashers (2)				
Hourly	$22,000	$33,000	$11,000	$44,000
Kitchen Hands (1)				
Hourly	$22,000	$16,500	$5,500	$22,000
Wait Staff (2)				
Hourly	$22,000	$33,000	$11,000	$44,000
Janitor (1)				
Janitor				
Salary	$24,000	$18,000	$6,000	$24,000
Benefit	$2,500	$1,875	$625	$2,500
IT and Networking (1)				
Network Specialist				
Salary	$45,000	$33,750	$11,250	$45,000
Benefit	$3,000	$2,250	$750	$3,000
House Keepers (5)				
Salaried House Keeper				
Salary	$24,000	$90,000	$30,000	$120,000
Benefit	$2,500	$9,375	$3,125	$12,500
Total		**$1,249,500**	**$416,500**	**$1,666,000**

Appendix A: Main Line Development Group Financial Analysis

Cash Flow From Operations

	Common / Office Building				
	Monthly Cost	Annual Cost	Acquisition Rehab	ADU	Total
Property Tax	$883	$10,600	$7,950	$2,650	$10,600
Insurance	$717	$8,600	$6,450	$2,150	$8,600
Utilities	$1,250	$15,000	$11,250	$3,750	$15,000
Nursing Supplies	$7,000	$84,000	$63,000	$21,000	$84,000
Dumpster Rental	$400	$4,800	$3,600	$1,200	$4,800
Replacement Reserves	$1,500	$18,000	$13,500	$4,500	$18,000
Total			**$105,750**	**$35,250**	**$141,000**

	Van Service				
	Monthly Cost	**Annual Cost**	Acquisition Rehab	ADU	**Annual Cost**
Cargo Bikes (4)					
Maintenance	$100	$1,200	$900	$300	$1,200
Van (1)					
Vehicle Cost (leased)	$850	$10,200	$7,650	$2,550	$10,200
Gas	$1,063	$12,750	$9,563	$3,188	$12,750
Total			**$18,113**	**$6,038**	**$24,150**

	Kitchen / Dining Room				
	Monthly Cost	**Annual Cost**	Acquisition Rehab	ADU	**Annual Cost**
Utilities	$1,500	$18,000	$13,500	$4,500	$18,000
Replacement Reserves	$1,000	$12,000	$9,000	$3,000	$12,000
Food (400 meals per day)	$48,667	$584,000	$438,000	$146,000	$584,000
Avg Cost per Meal ($4)					
licensing and permitting	$100	$1,200	$900	$300	$1,200
Total			**$461,400**	**$153,800**	**$615,200**

	Activity Fee			
	Monthly Cost	Acquisition Rehab	ADU	**Annual Cost**
$25 per resident per month	$5,000	$45,000	$15,000	$60,000
Total				**$60,000**

Appendix A: Main Line Development Group Financial Analysis

Soft Costs

Architectural, Site Engineering & Landscape	Acquisition Rehab	ADU	Total
Design, Documents, Construction Admin			$400,000
Geotechnical Consulting			$40,000
Model 1" = 40'			$500
Total Architectural			**$440,500**

Environmental	Acquisition Rehab	ADU	Total
Environmental Assessments & Testing	$15,000	$15,000	$30,000
Total Enviornmental			**$30,000**

Lender's A/E Review & Inspections:	Acquisition Rehab	ADU	Total
Const Lndr Initial Review			$10,000
Const Lndr Const Monitoring (Per Month)			$10,000
LP Construction Review/ Monitoring			$10,000
Total Lender's A/E			**$30,000**

Appraisal & Survey:	Acquisition Rehab	ADU	Total
Appraisal			$17,500
Existing Conditions/ Topo Survey			$45,000
Title Insurance Plans			$2,000
Survey: Layouts & As-Builts			$2,500
Total Appraisal & Survey			**$67,000**
Total A/E Inspection & Appraisal			**$567,500**

Developer's Legal	Acquisition Rehab	ADU	Total
Acquisition and Negotiation Legal			$25,000
Developer's Financing Legal			$59,500
P&S Documents & Deeds out to Buyers			$5,000
Zoning Appeal, Decision, and Opinion			$10,000
Authority Opinions			$7,500
Unit Documents, Leases, etc			$15,000
Closing Binders			$3,000
Total Developer's Legal			**$125,000**

3rd Party Professionals	Acquisition Rehab	ADU	Total
Construction Accntg & Cost Certification			$15,000
Transportation Consultant			$28,000
Permit Consultants			$20,000
Clerk of the Works			$80,000
Total 3rd Party Professionals			**$143,000**

Appendix A: Main Line Development Group Financial Analysis

Soft Costs

Summary Of Soft Costs	Average Cost	Acquisition Rehab	ADU	Total
Real Estate Taxes during Construction Period	$3,234	50	50	$161,700
Bldrs Risk & Liability Insurance				$200,000
Title Insurance-Lenders & Owners Policies				$16,000
Permits				$160,000
Bonding				$120,000
Allowance for Traffic and Roadway Improvements				$50,000
Marketing - ADU and 2/3Brs (5% of Annual Lease Amounts)	5%			$289,275
Subtotal w/out Counting OH or Mkting				$1,543,200
Soft Cost Contingency (soft less OH less Mkt Rate mktg)	2.5%			$38,580
Developer's OH				$900,000
Total Soft Costs				**$2,771,055**

Soft Cost Summary		
Acquisition Rehab	66.67%	**$1,847,370**
ADU	33.33%	**$923,685**
Total		**$2,771,055**

Appendix A: Main Line Development Group Financial Analysis

Hard Costs

ADU Construction Costs					
	Per Unit Cost	Square Feet	Total Units	Total Sqft	Total Cost
Construction	$25,468	650	50	32,500	$1,273,379
Finishes and Landscaping	$10,000		50		$500,000
Utility Hook-Ups	$15,000		50		$750,000
Site Prep (Grading/Foundation/Demolition)	$20,000		50		$1,000,000
Tax	$917		50		$45,842
Delivery	$1,250		50		$62,500
Set up Charges	$2,250		50		$112,500
TeleHealth System	$9,300		50		$465,000
Construction Contingency (5% of Total Cost)					$181,586
Total					**$4,390,806**

Existing Building Acquisition Costs					
	Avg Cost per Building	Square Feet	Total Units	Total Sqft	Total Cost
Building Aquistion	$195,000		50		$9,750,000
Closing Costs (10%)					$975,000
Two Bedroom Renovation	$50,000	900	50	45,000	$2,500,000
Double Occupancy Asissted Living	$110,000	900	50	45,000	$5,500,000
Geothermal Heating System	$20,000		50		$1,000,000
TeleHealth System	$9,300		150		$1,395,000
Construction Contingency (5% of Total Cost)	$21,120				$1,056,000
Total	$405,420				**$22,176,000**

Appendix A: Main Line Development Group Financial Analysis

Hard Costs

Common Building			
	Building	**Total Sqft**	**Total Cost**
Building Aquistion	$850,000		$850,000
Closing Costs (10%)			$85,000
Renovation			
Nursing Office	$200,000		$200,000
Nursing Supplies	$100,000		$100,000
Office Renovation	$150,000		$150,000
Office Supplies	$50,000		$50,000
Common Room Renovation	$150,000		$150,000
Common Room Supplies (TV, Furniture, etc.)	$40,000		$40,000
Resident Computer Lab Renovation	$50,000		$50,000
Computer Lab and Office equipment	$60,000		$60,000
Kitchen and Dining Hall Renovation	$1,300,000		$1,300,000
Tables and Supplies	$300,000		$300,000
Total			**$3,335,000**

Cargo Bikes	
Cargo Bikes (4)	
Cost	$26,000
Total Hard Cost	**$26,000**

Hard Cost Summary	
Acquisition Rehab	$19,152,750
ADU	$6,384,250
Total Hard Cost	**$25,537,000**

Estimated land Value			
	Estimated Value	Number	Value
Rental Units	$50,000	50	$2,500,000
Common Building	$100,000	1	$100,000
Total			**$2,600,000**