ABSTRACT

Title of Document: RETHINKING THE AMERICAN HOUSE: EXPANDABLE-LIFE-CYCLE HOUSES IN SUBURBAN CONTEXT

Victoria Kathleen Kraushar-Plantholt, Master of Architecture, 2011

Directed By: Professor Steven W. Hurtt,

The range of typical single family houses available in the market today does not respond well to the ever changing size of the family, first expanding then contracting. Ideally, a house should be flexible throughout the household's life cycle and respond to its owners' ever changing needs. A life-cycle-family house could grow and contract with the family and meet any new functional needs, such as accessibility for the elderly. Could a new house type allow each household to stay in residence longer, ease the financial trouble of purchasing new houses as aging precipitates changes in lifestyle? This thesis will explore the possibility of ways to provide a new house type, one that can expand and contract with the needs of a typical family.

RETHINKING THE AMERICAN HOUSE: EXPANDABLE-LIFE-CYCLE HOUSES IN SUBURBAN CONTEXT

By

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park in partial fulfillment
of the requirements for the degree of
Master of Architecture
2011

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DEDICATION

In Loving Memory of

Phyllis Mary Kraushar

1935-2011

And

With Love to

Anton D. Kraushar, Jr. and Mary E. Plantholt

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Background: *Life Cycle Houses in Suburbia*

This thesis explores the possibility of an adaptable-life-cycle house within suburban lots. These lot configurations include the Narrow-Deep lot, the Zero-Lot-line lot, the Z-lot, the Shallow-Wide lot and the Zipper lot as illustrated later in this paper. The house system applied to these lots consists of a base component and expansion components. The base component, the bare minimum in this system, provides an anchor to which the expansion components will attach. The goal is to create a system whereby optional components may be added or subtracted to the structure in a variety of ways throughout the house's life span. The nature of the project could allow a first time homebuyer to buy a basic structure at a low cost and then add more space in the form of an expansion component when needed. The houses are designed for accessibility so homeowners may remain independent longer if their mobility decreases. In some cases the houses can compress to include a second floor apartment so that the household can receive supplementary income while residing on the first floor.

Background: *Relevant Architectural, Social and Economic Considerations*

Currently, the average American undertakes a fifteen or thirty year mortgage in order to become a homeowner. This cost is "approximately five years of an average family's earnings [so] it is time…to examine how well our building stock meets [the family's] needs, and to determine how to reuse our buildings."[1] Despite this long term financial obligation, the average American only lives in a house for ten years before

[1] Anne Moudon, *Built for Change: Neighborhood Architecture in San Francisco*. (Cambridge: The Massachusetts Institute of Technology, 1986), XV.

moving and will move seven times within their lifetime.[2] Often these moves are due to lifestyle changes, the need for more space with the expansion of the family, the ability to afford more space once established in a career, or the eventual downsizing that often comes with empty-nesters and retirement. Each of these stages in life requires a different set of spaces, but the house as we know it today rarely changes to accommodate these needs.

This thesis challenges both the existing U.S. house typology and the economy that surrounds the purchase of a house. The trend in houses for the past fifty years is not to modernize the typology of a house as lifestyles change, but to instead bloat them to larger square footages. Although the average American family has decreased in size by 16% in the past forty years, the average American house has grown from 1,500 square feet to 2,349 square feet, an 156% increase.[3]

Builders "currently add two to three percent to our inventory of housing each year, which represents a fraction of our total housing units,"[4] thereby increasing the life expectancy of each house. Currently the average expected life cycle for new residential construction is more than one hundred years, which necessitates that the house will need to accommodate the needs of several families throughout the life of the house and the several families that will occupy it.

A life-cycle-prefabricated house system is an alternative typology that changes to accommodate the size, lifestyle and finances of the household. It investigates the

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[2] Susanne Tamborini, *Living in a Small Space: Experimental Projects from Four Continents.*(Edition Axel Menges, 1999), 16.
[3] William Carpenter, *Modern Sustainable Residential Design* (Hoboken: John Wiley and Sons, 2009), 16.
[4] Anne Moudon, *Built for Change: Neighborhood Architecture in San Francisco*. (Cambridge: The Massachusetts Institute of Technology, 1986), XV.

possibility of the continual adjustment of a house through the physical expansion, and reuse of its spaces. This investigation will manifest itself in a complete kit of prefabricated parts that will allow for the enclosing of additional space. It will also allow for the adaptation of the house to meet the needs of the handicapped. At the core of this kit-of-parts is a base component that could be bought inexpensively to make it less costly to buy a starter house. Additional changes could be made to the house after the purchase of the base component.

There are four major life cycle steps accounted for in this design, although the system will allow for accommodating other household structures. For instance, when a young couple first invests in the system they buy a base component. The second step expands the house, most likely due to the birth of children. The third step contracts the house to better suit aging owners. The fourth step is the reselling of the house to another family to renew the life cycle.

This housing system is to allows more people to enjoy homeownership and eliminates the need for homebuyers to become indebted to large mortgages. After the purchase of the base component, homeowners can add to their house in a fiscally responsible way. The system's flexibility would eliminate the need to move, therefore allowing people to connect with their community. Families would stay in residence longer, allowing for neighbours to bond and children to grow up with one another. The house will be exactly what the homeowner desires. As the household ages, the house can adapt to accessibility needs. The base component allows for turning radii in the kitchen and bathroom. If needed, minor changes to rooms, such as the addition of grab bars in the bathroom, allow the house to accommodate less mobile individuals. This will allow greater independence to aging adults or adults with disabilities.

Site Description

At the beginning of the semester four physical sites in the Washington District of Columbia metropolitan area were taken into consideration, the Adams Morgan neighbourhood in Washington D.C., Columbia Heights neighbourhood in Washington, D.C., Bethesda, Maryland and Connecticut Avenue Estates in Wheaton-Glenmont, Maryland. A criterion was established to choose the best site for a life cycle house system. This criterion included a pre-existing-suitable infrastructure of utilities, roads and sidewalks, the need for a solution to the adaptation of houses and land on which houses could expand.

After analysis of physical sites it became clear that the investigation of a suburban prefabricated system should not be restricted to one actual site since in order to be economically feasible the housing system would need to adapt to many different sites. Instead this thesis explored the appropriateness of the prefabricated-life-cycle house system on typical lot configurations and residential fabrics that are used in the United States of America.

Narrow-Deep Lot

Theory

The Narrow-Deep lot is a basic residential lot strategy (Figure 1). It allows for a densely packed block of close neighbours, yet each yard is deep enough to allow for a spacious and private back yard that is large enough to hold a detached two car garage. This type of block was most common in suburban neighbourhoods up until World War II when the Wide-Shallow lot and other lot varieties emerged.

Set Backs and Site Boundaries

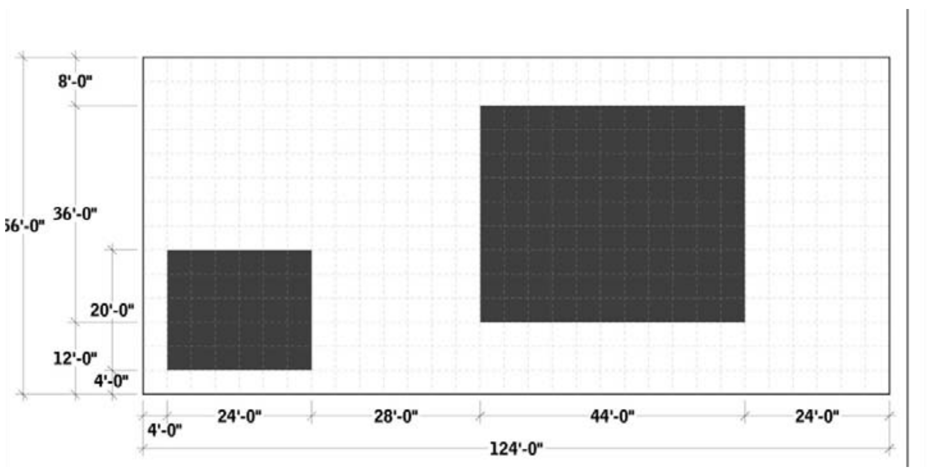

Figure 1: Narrow-Deep Lot

The Narrow-Deep Lot is 56’-0” wide by 124’-0” deep, totaling 6,944 square feet. The house is set back 24’-0”, and allows for a backyard of 52’-0” minimum depth. The back yard may also contain an outbuilding set 4’-0” away from each property line. One side yard is set back 8’-0” and the other is 12’-0” to allow for a vehicle to access the backyard.

Zoning/FAR

A maximum of two buildings can be built on the site. The main building, the house, can have a maximum footprint of 44’-0” by 36’-0”, 1,584 square feet. The house can be built up to two stories, which allows for a maximum square footage of 3,168 square feet, and a height of 35’-0”. On a 6,944 square foot site, this allows for a total FAR of 0.46 excluding the garage.

Aggregation

This site can be aggregated several ways. Without an alley, the secondary building in the back yard could be used as a detached garage accessible via a long driveway (Figure 2). If mirrored, these driveways can be paired so that a shared driveway can provide access to two neighbouring garages.

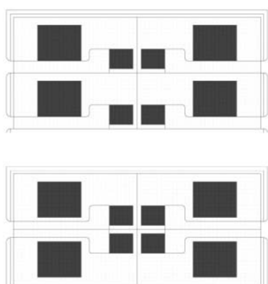

Figure 2: Aggregations of the Narrow-Deep Lot without alleys

The site can also be aggregated with a 24’-0” alley in the middle (Figure 3). Aggregations with alleys allow garages to be accessed from the alley, allowing for a short driveway or a small parking pad. The lot is best laid out in the East to West direction so that the longer elevations of the houses have northern and southern exposure for the best passive lighting and climate control possibilities.

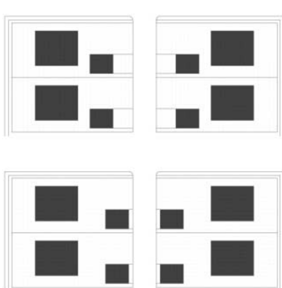

Figure 3: Aggregations of Narrow-Deep Lot with alleys

Zero-Lot-Line Lot

Theory

The Zero-Lot-Line lot was developed in order to reduce what is seen as wasted space in side yards (Figure 4). Instead of creating two smaller side yards, the house can be moved to one edge of the site, a zero lot line, while the other side yard can be widened to create a more usable space.

Set Backs and Site Boundaries

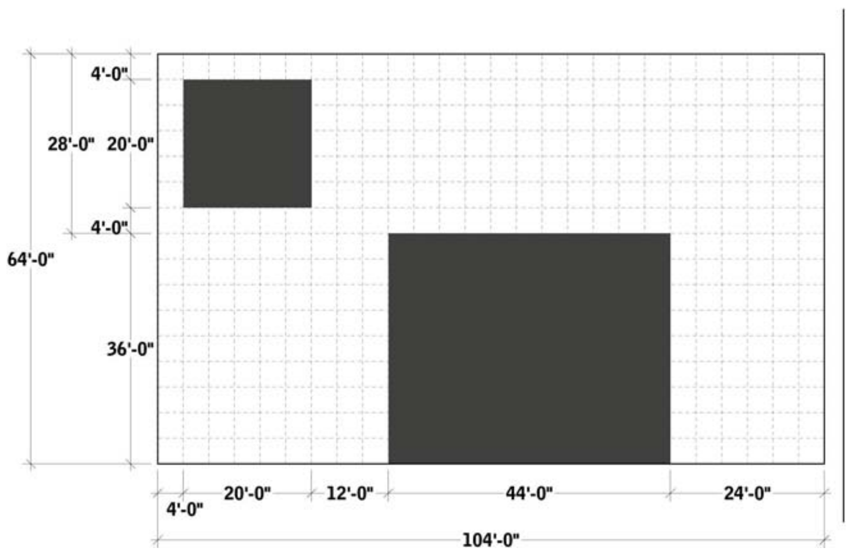

Figure 4: Zero Lot-Line Lot

The Zero-Lot-Line lot is 64’-0” wide by 104’-0” deep, totaling 6,656 square feet. The house is set back 24’-0” and allows for a minimum backyard of 42’-0”and single side yard of 28’-0”. The second side yard has no set back requirement, enabling the house to be constructed directly on the property line. The back yard may also contain an outbuilding set 4’-0” away from any property line.

Zoning/FAR

A maximum of two buildings can be built on the site. The main building, the house, can have a maximum footprint of 44’-0” by 36’-0”, 1,584 square feet. The house can be built up to a maximum two stories, which allows for a maximum square footage of 3,168 square feet, and a height of 35’-0”. On a site of 6,656 square feet this allows for a total FAR of 0.48 excluding the garage.

Aggregation

The Zero-Lot-Line lot can be aggregated several ways. In the first aggregation the houses are sited along opposite lot lines and detached garages can be accessed via long drive ways (Figure 5).

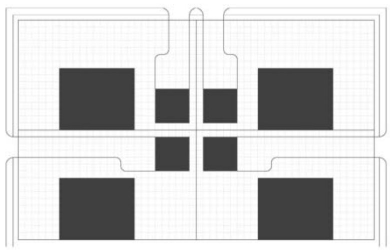

Figure 5: Aggregation of Zero Lot-Line Lot without alleys

The other aggregation includes an alley down the middle of the residential block which would allow for most parking to be moved off of the main streets. Detached or attached garages could then be accessed through the alley. The lot is best laid out in the East to West direction so that the longer elevations of the houses have northern and southern exposure for the best passive lighting and climate control possibilities.

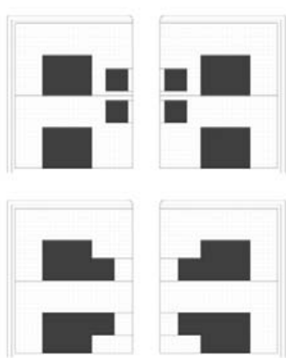

Figure 6: Aggregation of Zero Lot-Line Lot with alleys

Z-Lot

Theory

The Z-Lot formation was developed as a reaction to the negative impacts of the Zero-Lot-line lot (Figure 7). Often in Zero-Lot-line houses, the garage is moved forward towards the street and the entrance is recessed to reduce circulation.[5] With garages occupying over 50% of the house frontage, little habitable space is left facing the street, leaving the house with little character and no visible signs of life.[6] By rotating the house and lot line by about 30 degrees the Z-Lot type exposes more of the house to the street as well as "concentrating yard space in a more usable configuration."[7] Unfortunately, many developers responded to this new configuration by demanding a third car garage which occupies the additional visible space, instead of habitable spaces, thereby propagating the same negative effects of the Zero-Lot Line lot.

Set Backs and Site Boundaries

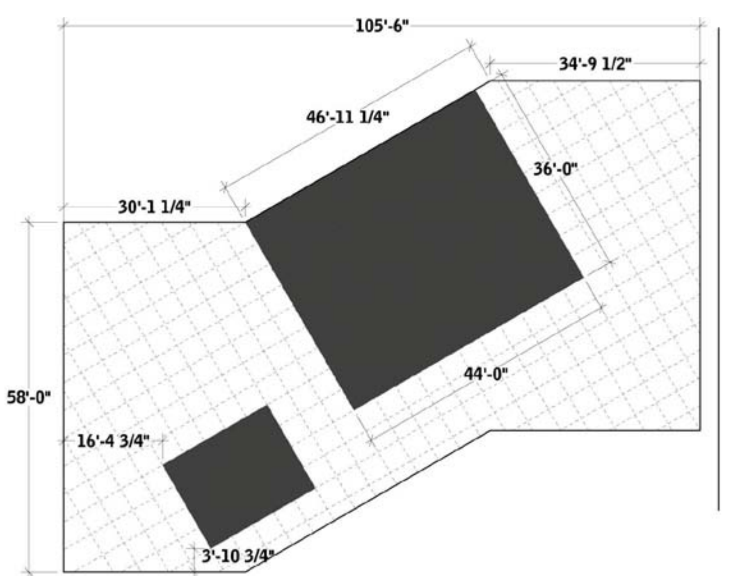

Figure 7: Z-Lot

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[5] James W. Wentling, "Technics Small Lot Housing Typology," Progressive Architecture (June 1991): 47.
[6] Ibid.
[7] Ibid.

The Z-Lot is 58’-0” wide by 105’-6” deep, and totals 6,144 square feet. The house is set back 19’-0” and allows for a minimum backyard of 30’-0”and single side yard of 14’-0”. The second side yard has no set back requirement, enabling the house to be constructed directly on the property line. The back yard may also contain an outbuilding set 4’-0” away from any property line.

Zoning/FAR

A maximum of two buildings can be built on the site. The main building, the house can have a maximum footprint of 44’-0” by 36’-0”, 1,584 square feet. The house can be built up to a maximum two stories, which allows for a maximum square footage of 3,168square feet, and a height of 35’-0”. On a site of 6,144 square feet it allows for a total FAR of 0.52 excluding the garage.

Aggregation

The Z-Lot can be configured with or without an alley. In the aggregation without an alley, the outbuilding in the rear yard best serves as a shed or workshop since there is limited possibility for vehicle access to the backyard (Figure 8).

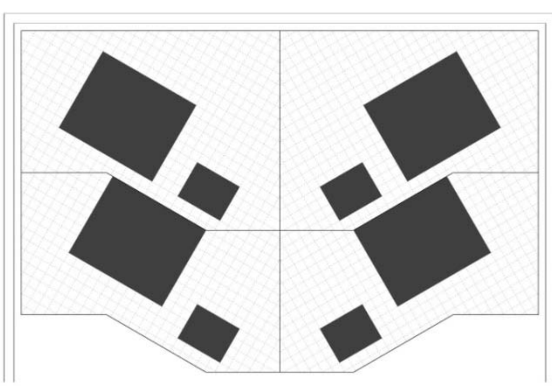

Figure 8: Aggregation of Z-Lot without alleys

In the aggregation with an alley, the outbuilding can easily serve as a detached garage and the alley may take more of the parking off of the main streets (Figure 9). The lot is best laid out in the East to West direction so that the longer elevations of the houses have northern and southern exposure for the best passive lighting and climate control possibilities.

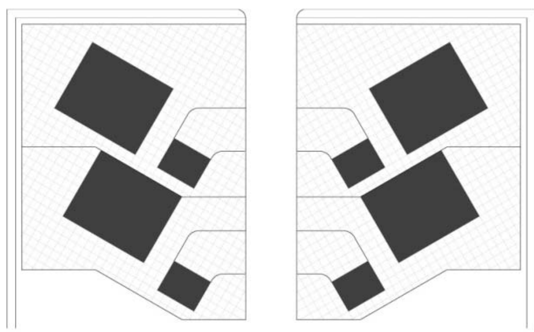

Figure 9: Aggregation Z-Lot with alleys

Wide-Shallow Lot

Theory

The Wide-Shallow Lot was developed as a response to the shortcomings of the Narrow-Deep Lot. Amongst these shortcomings is the lack of habitable spaces along the street. This typology returns the house parallel to the street and the major outdoor spaces to the front and rear of the house. By placing the longer façade parallel to the street it hopes to allow for more habitable space to be seen from the street. It was a major breakthrough in small lot theory by "elevating community design concerns over reducing road and other land development costs."[8]

To construct this lot type without diminishing density, often the lot depths are shortened, and may even produce square lots. Foreshortening the back yard sacrifices some privacy due to the nearness of your neighbour's rear wall. Although the lot type was developed to expose more habitable space on the street, these houses often include two or three car garages which typically occupy most of the front elevation.[9]

Set Backs and Site Boundaries

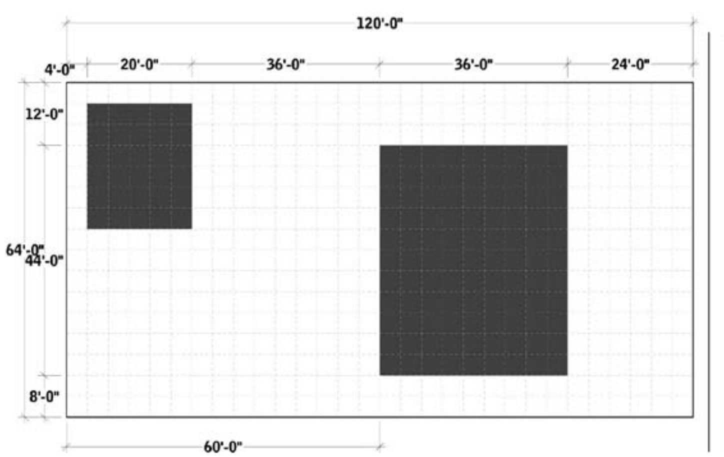

Figure 10: Wide-Shallow Lot

[8] Ibid.
[9] Ibid.

The Wide-Shallow Lot is 64'-0" wide by 120'-0" deep, and totals 7,680 square feet. The house is set back 24'-0" and allows for a minimum backyard of 60'-0". The side yards have 8'-0" and 12'-0" setbacks respectively. The back yard may also contain an outbuilding set 4'-0" away from any property line.

Zoning/FAR

A maximum of two buildings can be built on the site. The main building, the house can have a maximum footprint of 44'-0" by 36'-0", 1,584 square feet. The house can be built up to a maximum two stories, which allows for a maximum square footage of 3,168square feet, and a height of 35'-0". On a site of 7,680 square feet it allows for a total FAR of 0.41 excluding the garage.

Aggregation

The Wide-Shallow Lot can be configured with or without a rear alley. In the aggregation without an alley, the outbuilding may be used as a detached garage, accessed via a long driveway (Figure 11).

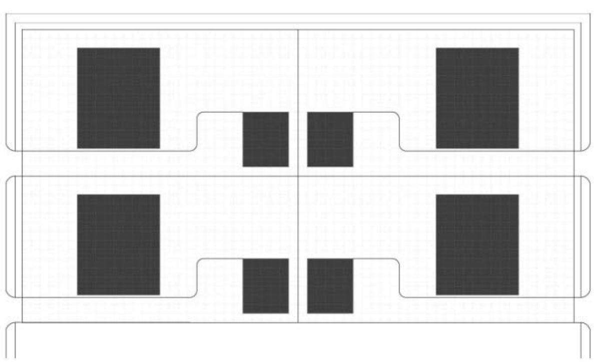

Figure 11: Aggregation of Wide-Shallow Lot without alleys

In the aggregation with an alley, most parking is taken off of the main streets and the rear outbuilding may be accessed via a shorter driveway off the alley (Figure 12). The lot is best laid out in the North to South direction so that the longer elevations of the houses have northern and southern exposure for the best passive lighting and climate control possibilities.

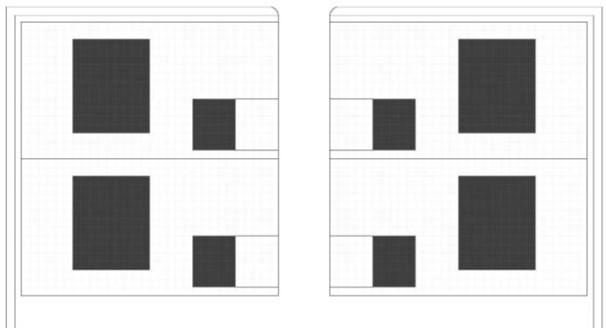

Figure 12: Aggregation of Wide-Shallow Lot with alleys

Zipper Lot

Theory

The Zipper Lot was developed in an attempt to better aggregate a small lot size that is oriented in a Wide-Shallow configuration. In this lot type, the rear lot line jogs to create a more usable almost square rear yard for each house and then close to the rear wall of the house to allow the back neighbour to have their backyard.[10] Although this configuration allows for a better proportion of rear yard and a territorial vista, the rear neighbour's house remains close and allows for little privacy. This lot type, due to the jogging rear lot line is also more expensive and confusing to survey.

Set Backs and Site Boundaries

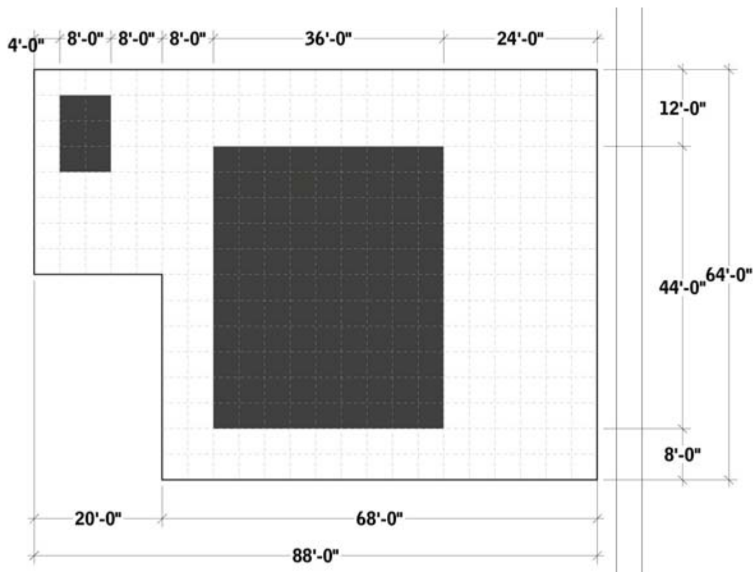

Figure 13: Zipper Lot

The Zipper Lot is 64'-0" wide by88-" deep, and totals 4,992 square feet. The house is set back 24'-0" and a shallow back yard of 8'-0" and a deeper back yard of 28'-0". The side yards have 8'-0" and 12'-0" setbacks respectively. The back yard may also contain an outbuilding set 4'-0" away from any property line.

[10] James W. Wentling,"Technics Small Lot Housing Typology," Progressive Architecture (June 1991): 48.

Zoning/FAR

A maximum of two buildings can be built on the site. The main building, the house can have a maximum footprint of 44’-0” by 36’-0”, 1,584 square feet. The house can be built up to a maximum two stories, which allows for a maximum square footage of 3,168 square feet, and a height of 35’-0”. On a site of 4,992 square feet it allows for a total FAR of 0.63 excluding the garage.

Aggregation

The zipper lot, due to its reliance on the interconnection between backyards may only be aggregated one way, as seen below. The lot is best laid out in the North to South direction so that the longer elevations of the houses have northern and southern exposure for the best passive lighting and climate control possibilities.

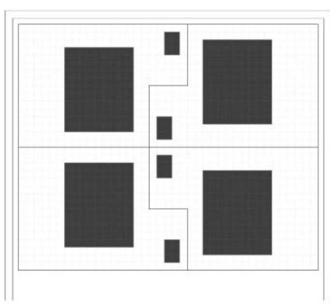

Figure 14: Aggregation of Zipper Lot

Lot Study Conclusions

After the analysis of the lot types it is clear the Narrow-Deep lot has several advantages. For urbanism the Narrow-Deep lot allows for houses to be located closer to their side neighbours, creating a street wall. Close proximity with neighbors and good street definition increases the possibility of the formation of a tight knit community. Financially the Narrow-Deep lot is economical for builders, since it allows for close spacing of houses. The close spacing allows for shorter utility runs as well as less sidewalk and road to be paved. These financial implications make the Narrow-Deep lot ideal for affordable-life-cycle prefabricated houses.

The proportions of the Narrow-Deep lot then dictate the footprint of the house, requiring it also be rectangular with the short end facing the street to allow for appropriate set backs in all four yards. The depth of the lot also allows the garage to be placed in the back of the lot, leaving more habitable space on the street to promote community.

Site Analysis: *Circulation: Vehicular/Pedestrian*

The circulation of vehicles and pedestrians around neighbourhoods of this life-cycle prefabricated house system is largely out of the scope of this thesis. Only the following provisions have been made. Pedestrian and vehicular traffic will be separated through the use of a standard three foot wide sidewalk that is separate from the road by a four foot wide planting strip.

The standard road type will be 26'-0" wide to allow for two lanes of moving traffic, one in each direction, and one of parking although each house has the possibility of a dedicated driveway and one or two car garage. The road width may extend to 32'-0" to allow for two moving lanes, one in each direction, and parking on either side. Some aggregations of the Narrow-Deep Lot, Zero-Lot-line Lot, Z-Lot, and Wide-Shallow Lot may benefit from the addition of an alley system. The addition of an alley system would decrease the width of the streets since cars would be taken off of the street.

Site Analysis: *Climate/Microclimate*

The life-cycle house system proposed in this thesis is meant to be implemented on sites within the Delmarva area. This area is classified as a temperate climate with four distinct seasons. The area has an average temperature of 55.1°F with the highest temperatures occurring in July averaging in the mid to upper 80s, but occasionally reaching 100°F. The coldest temperatures are in January averaging in the mid to low 20s, occasionally dropping to 10°F.[11] Typically the area receives 40.76 inches of precipitation

[11] "Maryland at a Glance," last modified May 13, 2010, http://www.msa.md.gov/msa/mdmanual/01glance/html/weather.html.

annually. The most rainfall occurs in July and August with thunder storms occurring once every five days on average.[12]

Most climate variation in the Delmarva area is due to topographical changes, and proximity to large bodies of water. The Atlantic Ocean to the East allows for a very different climate than the Appalachian Mountains to the West. [13] The areas to the East are warmer, wetter, and vulnerable to climate disturbance due to tropical storms along the East Coast. At the other extreme is the Western Mountains which are cooler and experience the most snowfall in the region. The central region of the Delmarva area experiences the most temperate climate negotiating between the two extremes. The area is not prone to natural disasters.

Site Analysis: *Contour/Slope*

Restrictions of grade change in residential sites are a financial concern, not a structural limitation. Due to the high cost of the foundation, it is unreasonable to build a single-family house on a property with more than a single story of grade change. In this thesis, the greatest acceptable grade change is 12'-0" (Figure 15). There are two common grade changes seen in residential construction. The first scenario is relatively level, allowing for first story access from all sides of the house. The second scenario has a grade change of one story, a maximum of 12'-0". This change in grade allows for a ground level entrance on the first floor at the front of the lot and a walk out basement at the rear of the lot. Revealing the rear wall of the basement to light and air allows this

[12] "Maryland at a Glance," last modified May 13, 2010,http://www.msa.md.gov/msa/mdmanual/01glance/ht ml/weather.html.
[13] "Maryland at a Glance," last modified May 13, 2010, http://www.msa.md.gov/msa/mdmanual/01glance/html/weather.html.

otherwise, uninhabitable space to be day lighted and naturally ventilated so that it may be usable livable space. As the study developed, the emphasis on an efficient footprint eliminated the possibility of a walk out basement due to the additional cost of the basement and stair.

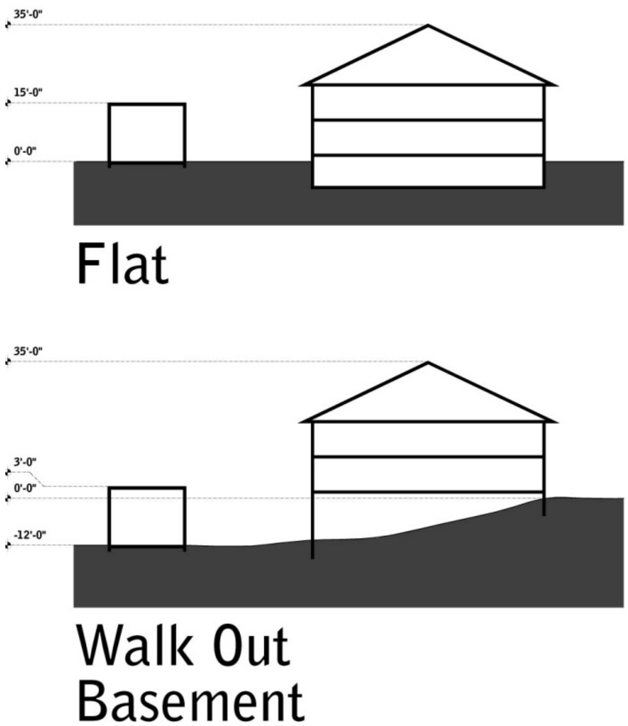

Figure 15: Allowable grade of site

Site Analysis: *Service: Utilities (Water, electric, gas, etc.)*

Water, electric, and gas utilities should be located underground to allow for easy construction on site since above ground utilities could interfere with the ongoing construction and dismantling of the life-cycle houses. The utility connections would be located in the base component's cellar from which extensions could be made as additional modules are added and require their services.

Program Objectives: *Design Objectives*

In a life-cycle house, the program can be changed to suit the life cycle of the family in residence. The life-cycle house should be easy to purchase as a young adult, easy to expand as spatial needs change, and easy to adapt to the changes associated with aging. This program allows for flexibility in living spaces and arrangement to fit varying family lifestyles over time.

Program Special Problems and Issues

Affordable housing requires inexpensive construction practices. Off-site prefabrication is often employed to reduce construction costs. The program is broken down into a series of base components and possible expansions. The size of base components and expansions are dictated by wide load transportation laws in the Delmarva area as well as practical residential room widths. Certain dimensions have similar requirements across several states, although permitting for transporting oversized loads varies with each state. Three widths were chosen as suitable for transportation on state and federal roads, with special permitting, and for residential room widths. The widths used in this system deduct six inches off of the state allowable transportation widths to allow for any additional width added to the module during transportation caused by necessities like weather wrapping or temporary bracing.

The smallest width, 12’-6”, only requires a special permit and minimal escorts to be transported. With an interior width of 11’-6”, it is also suitable for the width of a dining room, width of a small living room or bedroom. The medium width, 13’-6” requires a higher level permit in all states and an additional escort in some states. The additional foot provides a more standard room width when circulation is passing by or through a room, although it is not much wider than the 12’-6” module. The 13’-6” module allows for a 12’-6” interior dimension from finished wall to finished wall. An accessible 4’-0” hallway leaves an 8’-6” dimension for an 8’-0” wide room. The largest width, 15’-6”, is considered a superload which entails a more expensive permit, more escorts, and occasionally police supervision. Transporting a superload also carries greater restrictions in the times and roads it is allowed to travel. 15’-6” is the maximum width allowed to be transported in most states. The 15’-6” dimension allows for a generously sized room, or for a 4’-0” hallway to pass by an 11’-0” wide room. All component types, the base component and each expansion component are available in the widths 12’-6”, 13’-6”, 15’-6”.

Figure 16: Transportation of Modules in 12’-6”, 13’-6”, and 15’-6”

Program Summary

Square footages presented were calculated after the design of the components.

Base Components

100 Base Component 12'-6"	**831 square feet**
101 Entrance Porch	206 sq.ft.
102 Living/Dining	192 sq.ft.
103 ADA Kitchen	87 sq.ft
104 ADA Bathroom	67 sq.ft.
105 Bedroom	154 sq.ft.
105a Bedroom Closet	21 sq.ft.
106 Hall	84 sq.ft.
106a Hall Closet	10 sq.ft.
107 Washer/Dryer Closet	10 sq.ft.

200 Base Component 13'-6"	**896 square feet**
201 Entrance Porch	221 sq.ft.
202 Living/Dining	208 sq.ft
203 ADA Kitchen	107 sq.ft.
203a Pantry	10 sq.ft.
204 ADA Bathroom	63 sq.ft.
204a Washer/Dryer Closet	10 sq.ft.
205 Bedroom	161 sq.ft.
205a Bedroom Closet	24 sq.ft.
206 Hall	82 sq.ft.
206a Hall Closet	10 sq.ft.

300 Base Component 15'-6"	**1,028 square feet**
301 Entrance Porch	253 sq.ft.
302 Living/Dining	254 sq.ft.
303 ADA Kitchen	131 sq.ft.
303a Pantry	10 sq.ft.
304 ADA Bathroom	78 sq.ft.
305 Bedroom	191 sq.ft.
305a Bedroom Closet	25 sq.ft.
306 Hall	47 sq.ft.
306a Hall Closet	18 sq.ft.
306b Washer/Dryer Closet	11 sq.ft.
306c Entrance Closet	10 sq.ft.

Expansion Components

400	**Two Bedroom Expansion 12’-6”**	**425 square feet**

401 Entrance Hall…………………..……………………………………...……45 sq.ft.
    401a Entrance Closet…………………………………………………16 sq.ft.
402 Sitting Room………………………………………………….…….58 sq.ft.
403 Dining Room……………………………………………………………100 sq.ft.
404 Bedroom……………………………………………………..…147 sq.ft.
    404a Bedroom Closet…………………………………………………20 sq.ft.
405 Back Hall………..……………………………………………………39 sq.ft.

500	**Two Bedroom Expansion 13’-6”**	**462 square feet**

501 Entrance Hall…...…………………………………………………..54 sq.ft.
    501a Entrance Closet…………………………………………………18 sq.ft.
502 Dining Room……………………………………………………………120 sq.ft.
503 Bedroom…………………………………………………………..….160 sq.ft.
    503a Bedroom Closet……………………………………………..……40sq.ft.
504 Back Hall…………………………………………………………...…40 sq.ft.
505 Patio…...………………………………………………………………30 sq.ft.

600	**Two Bedroom Expansion 15’-6”**	**465 square feet**

601 Entrance Hall……………………………………………………….…60 sq.ft.
    601a Entrance Closet…………………………………………………20 sq.ft.
602 Dining Room……………………………………………………………100 sq.ft.
603 Bedroom……...…………………………………………………………190 sq.ft.
    603a Bedroom Closet…………………………………………………20 sq.ft.
604 Back Hall……...………………………………………………………25 sq.ft.
    604a Back Hall Closet……………………….………………………….10 sq.ft.
605 Laundry Room……...………………………………………………………40 sq.ft.

700	**Three Bedroom Expansion 12’-6”**	**650 square feet**

701 Entrance Hall…………….…………………………………………………45 sq.ft.
    701a Hall Closet……………………………………………………………10 sq.ft.
702 Dining Room…..………………………………………………………..100 sq.ft.
703 Bedroom….……………………………………………………………..143 sq.ft.
    703a Bedroom Closet……………………………………….…………16 sq.ft.
704 Master Bedroom Suite…………………………..…………………...…186 sq.ft.
    704a Bedroom Closet…………………………………………………22 sq.ft.
    704b Master Bath……………...…………………………………………55 sq.ft.
705 Hall…………….…………………………………………………………24 sq.ft.
706 Mudroom………….……………………………………………………..49 sq.ft.

800	**Three Bedroom Expansion 13’-6”**	**702 square feet**

801 Entrance Hall………………………………………………………..……50 sq.ft
    801a Hall Closet……………………………………………………………10 sq.ft.
802 Dining Room……………………………………………………………..80 sq.ft.

803 Bedroom……………………………………………………….………..160 sq.ft.
    803a Bedroom Closet………………………………………………………21 sq.ft.
804 Master Bedroom Suite…………………………………………………..…211sq.ft.
    804a Bedroom Closet………………………………………………………23 sq.ft.
    804b Master Bath…………………………………………………….……….65 sq.ft.
805 Hall…………………………………………………………………….………19 sq.ft.
806 Mudroom……………………………………………………………………61 sq.ft.

<u>900 Three Bedroom Expansion 15'-6" 806 square feet</u>

901 Entrance Hall……………………….……………………………………69 sq.ft.
    901a Hall Closet……………………………………………………………17 sq.ft.
902 Dining Room……………………………………………………………105 sq.ft.
903 Bedroom…………………………………………………………………...175 sq.ft.
    903a Bedroom Closet………………………………………………………31 sq.ft.
904 Master Bedroom Suite……….………………………………………………225 sq.ft.
    904a Bedroom Closet………………………………………………………20 sq.ft.
    904b Master Bath…………………………………………………….……….64 sq.ft.
    904c Linen Closet………………………………………………………….11 sq.ft.
905 Hall.………………………………………………………………………19 sq.ft.
906 Mudroom…………...………………………………………………………..70 sq.ft.

<u>1000 Loft Expansion 12'-6" 850 square feet</u>

1001 Living/Dining…………………………………………………………….220 sq.ft.
1002 Stair…………………………………………………………………………..32 sq.ft.
1003 Master Bedroom Suite…………………..……………………….……198 sq.ft.
    1003a Bedroom Closet……………..……………………………………32 sq.ft.
    1003b Master Bath………………………………………………………68 sq.ft.
1004 Loft………….…………………………………………………………300 sq.ft.

<u>1100 Loft Expansion 13'-6" 917 square feet</u>

1101 Living/Dining……………………………………………….…………246 sq.ft
1102 Stair…………………………..…………………………….…………32 sq.ft.
1103 Master Bedroom Suite………...…………………………….…………216 sq.ft.
    1103a Bedroom Closet………………………………………..………35 sq.ft.
    1103b Master Bath………………………………………………………68 sq.ft.
1104 Loft……………………………………………………………………320 sq.ft.

<u>1200 Loft Expansion 15'-6" 1,048 square feet</u>

1201 Living/Dining…………………………………………………………300 sq.ft.
1202 Stair…………………………………………………………………………..32 sq.ft.
1203 Master Bedroom Suite…………………..………………………………244 sq.ft.
    1203a Bedroom Closet……………..……………………………………39 sq.ft.
    1203b Master Bath………………………………………………………68 sq.ft.

1204 Loft………….……………………………………………………………365 sq.ft.

<u>2000 Two Story Expansion 12’-6” 1,050 square feet</u>

2001 Entrance Hall/Sitting Room………………………………………………...138 sq.ft.
2001a Entrance Closet……………………………………………..……20 sq.ft.
2002 Hall…...…………………………………………………………………86 sq.ft.
2003 Living Room……..……………………………………………………214 sq.ft.
2004 Stair…………………………….…………………………………………46 sq.ft.
2005 Mudroom…………………………………………………………..……49 sq.ft
2006 Bedroom………………………………………………………………….152 sq.ft.
2006a Bedroom Closet…………………………………………………20 sq.ft.
2007 Bathroom…………………………………………………………………..61 sq.ft.
2007a Bathroom Closet…………...……………………………………………7 sq.ft.
2008 Upstairs Hall……………...……………………………………………..60 sq.ft.
2009 Bedroom…………………...……………………………………………..177 sq.ft.
2009a Bedroom Closet…………………………………………………20 sq.ft.

<u>2100 Two Story Expansion 13’-6” 1,113 square feet</u>

2101 Entrance Hall/Sitting Room………………………………………………...175 sq.ft.
2101a Entrance Closet……………………………………………..…13 sq.ft.
2102 Hall………...………………………………………………………………80 sq.ft.
2103 Living Room……………..………………………………………….…232 sq.ft.
2104 Mudroom…………………………………………………………………49 sq.ft.
2105 Stair…………………….……………………………………………………46 sq.ft.
2106 Bedroom………………………………………………………………….157 sq.ft.
2106a Bedroom Closet……………………………………………..…20 sq.ft.
2107 Bathroom…………………………………………………………………..61 sq.ft.
2107a Bathroom Closet……...…………………………………………………7 sq.ft.
2108Upstairs Hall……………………………………………………….……63 sq.ft.
2109 Bedroom………………………………………………………………….190 sq.ft.
2109a Bedroom Closet………………………………………..…...…20 sq.ft.

<u>2200 Two Story Expansion 15’-6” 1,297 square feet</u>

2201 Entrance Hall/Sitting Room………………………………………………...204 sq.ft.
2001a Entrance Closet……………………………………………..…20 sq.ft.
2202 Hall……………………………………………………………………..…90 sq.ft.
2203 Living Room…………………………………………………………..…266 sq.ft.
2204 Mudroom……………………………………………………………….…52 sq.ft.
2205 Stair……………………………………………………………………..46 sq.ft.
2205 Bedroom…………………………………………………………………185 sq.ft.

2205a Bedroom Closet……………………………………………..…...……26 sq.ft.
2206 Bathroom………………………………………………………………..78 sq.ft.
2106a Bathroom Closet………………………………………………..…16 sq.ft.
2207 Upstairs Hall…..…………………………………………………………..64 sq.ft.
2208 Bedroom…………………………………………………...…………..223 sq.ft.
2208a Bedroom Closet…..……………………………………………………27 sq.ft.

Program Description: *Sample Program*

100 -300 Base Component 831 / 896 / 1,028 sq.ft.

The base component is the minimal residence possible in the life-cycle house system. It is permanent to the site and allows for additional components to be attached to it. This base component is also where the underground utility systems connect to the house. These utility systems can be branched out to the additional components as needed. The base component consists of the following spaces, an entrance hall, a kitchen, a full bathroom, a living room, and a bedroom.

101 Entrance Porch

Before entering the house people encounter a small receiving space. This space is meant to shelter visitors before they enter the house and provide an area for the shedding of coats, shoes and umbrellas in inclement weather. The entrance porch can also function as an outdoor living space. In pleasant weather guests can be entertained on the porch which can be used as an outdoor dining or sitting area.

102 Coat Closet

This storage is meant to house coats and other weather gear. It should be located in or adjacent to the entrance hall for easy retrieval before going outside and easy storage once coming inside.

103 Kitchen

The kitchen is meant for the preparation of food and the storage of food and appliances. At minimum it will feature 15’-0” of linear base and wall cabinet storage. The kitchen will also feature a refrigerator, range, sink, and in cabinet dishwasher. The kitchen will also provide room for a wheelchair turning radius so that it can accommodate the needs of less mobile or handicapped individuals.

104 Pantry

The pantry is a small closet for the storage of food and small appliances. It should be located in or adjacent to the kitchen.

105 Bathroom

The bathroom will be accessible to the single bedroom and the public living spaces from the house. It will feature an in cabinet sink, a toilet and a combination bathtub and shower. The bathroom will also provide room for a wheelchair turning radius, so that it can accommodate the needs of less mobile or handicapped individuals.

106 Linen Closet

This closet is meant for the storage of towels, bed linens and toiletries. It should be accessed in or near the bathroom.

107 Living Room

This room should provide for the entertaining of guests as well as the lounging of the owners. It should allow room for a 6’-0” sofa with end tables, a love seat or two arm chairs all directed towards each other as a conversational area or an entertainment center. It should be adjacent to the kitchen and entry hall.

109 Bedroom

This room should minimally have space for a king bed, two night tables and a long vanity. It should be removed from the living room and kitchen areas to allow for privacy and quiet.

108 Closet

This closet is meant to store the clothing of the owner. It should be accessed from the bedroom.

109 Laundry Closet

This room provides space for a combined washer and dryer appliance.

Expansion Components

400-600 Two Bedroom, One Floor 425 / 462 / 465 sq.ft.

X01 Entrance Hall

The entrance hall is meant to receive guests upon their initial entrance into the house. It should provide room for the household to receive guests and for the visitors to shed their coats, shoes and other weather gear. These articles can be stored in the adjacent closet. The floor of the entrance hall should be an easy to clean material to provide easy maintenance.

X01a Entrance Closet

This storage is meant to house coats and other weather gear. It should be located in or adjacent to the entrance hall for easy retrieval before going outside and easy storage once coming inside.

X02 Living Room

This room should provide for the entertaining of guests as well as the lounging of the owners. It should allow room for furniture to create a conversation area.

X03 Dining Room

This room is meant for the eating of meals and entertainment of guests. It should provide room for a dining room table and chairs to accommodate six people.

X04 Bedroom

This room should minimally have space for a queen bed, two night tables and a long vanity. It should be removed from the living room and kitchen areas to allow for privacy and quiet. The bedroom should also have access to the pre-existing bathroom in the base component.

X04a Bedroom Closet

This closet is meant to store the clothing of the occupant of the bathroom. It should be accessed from the bedroom.

X05 Back Hall

This circulation space should provide access from the existing circulation space located in the base component to the back yard.

700-900 Three Bedroom, One Floor 650 / 702 / 806 sq.ft.

X01 Entrance Hall

The entrance hall is meant to receive guests upon their initial entrance into the house. It should provide room for the household to receive guests and for the visitors to shed their coats, shoes and other weather gear. These articles can be stored in the adjacent closet. The floor of the entrance hall should be an easy to clean material to provide easy maintenance.

X01a Hall Closet

This storage is meant to house coats and other weather gear. It should be located in or adjacent to the entrance hall for easy retrieval before going outside and easy storage once coming inside.

X02 Dining Room

This room is meant for the eating of meals and entertainment of guests. It should provide room for a dining room table and chairs to accommodate six people.

X03 Bedroom

This room should minimally have space for a queen bed, two night tables and a long vanity. It should be removed from the living room and kitchen areas to allow for privacy and quiet. The bedroom should also have access to the pre-existing bathroom in the base component.

X03 Bedroom Closet

This closet is meant to store the clothing of the occupant of the bedroom. It should be accessed from the bedroom.

X04 Master Bedroom Suite

The master bedroom suite should include a private bath and large closet. The bedroom should at minimal have space for a king bed, two night tables and a long vanity.

X04a Bedroom Closet

This closet is meant to store the clothing of the occupant(s) of the bedroom. It should be more generous in size than the other bedroom closets in the house.

X04b Master Bath

The master bath should only be accessible from the master bedroom. It will feature an in cabinet sink, a toilet and a combination bathtub and shower. The bathroom will also provide room for a wheelchair turning radius, so that it can accommodate the needs of less mobile or handicapped individuals.

X05 Hall

The hall should provide access to the master bedroom, mudroom and bedroom. Its square footage should be minimized.

X06 Laundry Room

The laundry serves two purposes. The first is to provide an area to house a separate washer and dryer and for the household to do laundry. The second purpose is to provide a passage of access to the side yard. Due to the presence of laundry facilities and the use of the room as an entrance to the house, the floor finish in this room should be a hard surface that is easy to clean.

1000-1200 Two Bedroom, Loft 850 / 917 / 1,048 sq.ft.

XX01 Living/Dining

This multi-use space serves three purposes. It serves as the main entrance to the house, as well as providing an open space for living and dining. This room should provide ample space for guests to enter the house and be greeted as well as the shedding of weather gear.

XX02 Stair

The stair provides compact vertical circulation to the second floor.

XX03 Master Bedroom Suite

The master bedroom suite contains a bedroom, closet and bath all private to each other. The suite should be somewhat removed from the rest of the house and minimally allow space for a king bed, two night stands, and a long dresser.

> **XX03a Bedroom Closet**
>
> This closet is meant to store the clothing of the occupant of the bedroom. It should be accessed from the bedroom.
>
> **XX03b Master Bath**
>
> This private bath should be accessible from the master bedroom.

XX04 Loft

The loft is un-programmed space on the second floor that overlooks the combination living/dining space on the first floor. It is a flexible space, suitable for several uses including but not limited to a game room, family room, or study.

1300-1500 Three Bedroom, Two Floor 1,050 / 1,113 / 1,297 sq.ft.

XX01 Entrance Hall/Sitting Room

The entrance hall is meant to receive guests upon their initial entrance into the house. It should provide room for the household to receive guests and for the visitors to shed their coats, shoes and other weather gear. These articles can be stored in the adjacent closet. The floor of the entrance hall should be an easy to clean material to provide easy maintenance.

> **XX01a Entrance Closet**
>
> This storage is meant to house coats and other weather gear. It should be located in or adjacent to the entrance hall for easy retrieval before going outside and easy storage once coming inside.

XX02 Hall

This wide hall provides access to the entrance hall, stair, mudroom and living room.

XX03 Living Room

This room should provide for the entertaining of guests as well as the lounging of the owners. It should allow room for a 6’-0” sofa with end tables, a love seat or two arm chairs all directed towards each other as a conversational area or an entertainment center. It should be accessible to the other public areas of the house.

XX04 Laundry Room

The laundry serves two purposes. The first is to provide an area to house a separate washer and dryer and for the household to do laundry. The second purpose is to provide a passage of access to the side yard. Due to the presence of laundry facilities and the use of the room as an entrance to the house, the floor finish in this room should be a hard surface that is easy to clean.

XX05 Stair

The stair provides compact vertical circulation to the second floor.

XX05 Bedroom

Located on the second floor, this room should minimally have space for a queen bed, two night tables and a long vanity. It should be removed from the living room and kitchen areas to allow for privacy and quiet. The bedroom should also have access to the pre-existing bathroom in the base component.

XX05a Bedroom Closet

This closet is meant to store the clothing of the occupant of the bedroom. It should be accessed from the bedroom.

XX06 Bathroom

XX06a Bathroom Closet

XX07 Upstairs Hall

This hall should be accessible from the stairs and provide access to the upstairs bath and two bedrooms. The square footage of this hall should be minimized.

XX08 Bedroom

Located on the second floor, this room should minimally have space for a queen bed, two night tables and a long vanity. It should be removed from the living room and kitchen areas to allow for privacy and quiet. The bedroom should also have access to the pre-existing bathroom in the base component.

XX08a Bedroom Closet

This closet is meant to store the clothing of the occupant of the bedroom. It should be accessed from the bedroom.

Prefabrication Technologies: *Precedents in Prefabrication and Structure*

Modular Unit Technologies

Kitchens and bathrooms are commonly constructed and shipped as prefabricated modules. The modules are constructed under highly controlled factory conditions to the architect's specifications. They are then shipped to the site where the plumbing fittings are ready to connect to the module and half finished interior walls encase it. The module is lowered into place via crane and can be connected in less than a day. Finishes can be customized within the modules and after installation it is impossible to tell that the module is prefabricated.

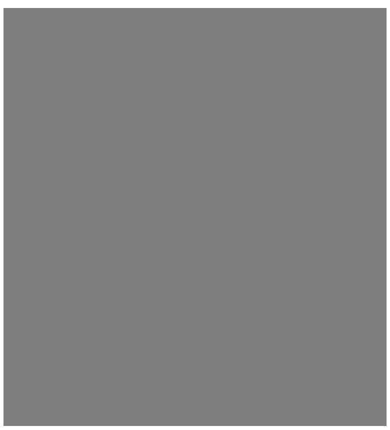

Figure 17: Image by Kullman Offsite Construction

Kullman Bathroom Pods manufactured in Lebanon, New Jersey are often used in multi-family housing. The pods are built based on architect's specifications and manufactured en masse. The more pods made of a certain model, the less the cost per pod.

Figure 18: Plan and Plumbing axon of typical bathroom module by Kullman. Image by Kullman Offsite Construction.

Flat Packed Technologies

Several technologies have been investigated as a method of flat packing prefabrication. Light-gauge-steel framing is relatively inexpensive, sometimes less expensive than wood stud construction depending upon the market fluctuations. The materiality of steel allows for the most flexibility since connections can easily be fastened, unfastened, and re-fastened with simple screw bolts and all parts can be re-used multiple times before they must be scrapped. Steel construction also allows for easy changes in systems. Steel floor joists can come pre-cut with holes or steel floor trusses allow for plumbing work to be threaded through.

Figure 19: Steel floor truss. Image by AEC.

There are also many exterior and interior panel systems which are affixed to studs with simple screw bolts or clips. These panels are commonly made out of metal, pre-cast concrete or EIFS. A typical light-gauge steel stud wall in this system would have three layers. The outer most layer comprises an insulated panel, that would affix to the middle layer of light-gauge-steel studs. Any electrical, plumbing or HVAC work in the wall would also be part of this middle layer. The interior layer would be a panel of fiberboard, a material denser than the typical gypsum board which is stiffer during transport.

Cellophane House

The Cellophane House is a prefabricated house prototype developed by Kieran & Timberlake Associates. The non-permanent house and can be assembled and disassembled quickly. The house is easy and quick to construct since all structural components are steel beams which are bracketed together. The technology of the house is relatively simple, most of the materials are typical and can be bought off the shelf.

The house is also unique in its combination of modular and flat packed prefabrication technologies. The house is three bays wide, the two outer bays are shipped to the site as assembled modules and the middle bay is flat packed and then assembled on site. The general construction process for each level of the house is as follows. The two outer bay modules are placed in position, and then the middle bay is constructed by placing beams that span between the two outer modules.

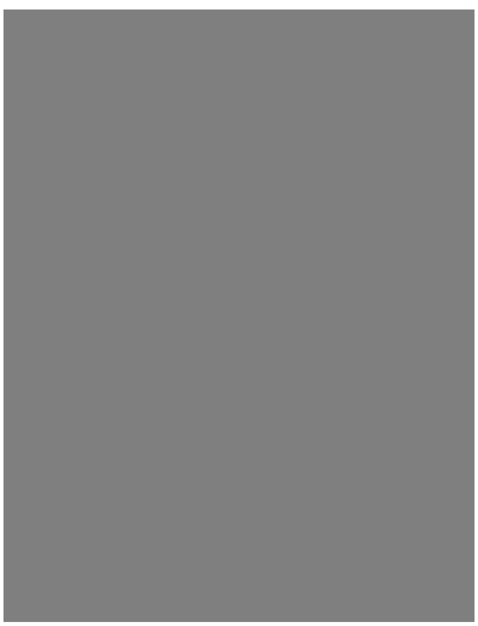

Figure 20: Cellophane House under construction. Image by Kieran & Timberlake Associates

Toma House

The Toma House is a prefabricated-house technology developed by Toma Tech. The Toma House prefabrication is governed by a 4.7 meter (15’-5”) square module. A single module, including the laying of foundations can be built in less than a day. The basic frame of the module consists of four poles in foundations, a floating floor and cross beams for the roof. The whole frame can be assembled using only one tool, and the utilities plug in to the system. These modules can be easily connected for expansion and each module can cantilever out one meter without any extra structural support.[14]

Figure 21: Toma House's flexible structure. Image by Toma Tech.

A unique feature of the Toma house system is its adaptable geometry. The roof beams are hinged and can take any slope. All exterior walls, roofing, ceilings, and flooring panels snap into the system. These panels can create many different styled houses from the say structure. The possible styles include various modern styles, Bali island styles, and more traditional houses styles.[15]

[14] Ibid.

[15] “Toma House: Prefabricated High Tech Buildings,” accessed on October 11, 2010, http://tomahouse.com/.

Figure 22: Some of the styles possible with the Toma House system. Image by Toma Tech.

FlatPak System

The Flatpak system of prefabricated houses by Lazof Office is a flat-packed prefabricated house system that can be completely customized by the owner. Potential housebuyers may buy a floorplan from a catalogue or develop a completely customized floor plan with the help of a designer.[16]

A Flatpak house is based upon a one story 8’-0” wide module. Columns are placed every 8’-0” around what is to be the perimeter of the house. The homeowner then decides what type of panel fills the space between the columns. Homeowners can choose between panels that are all glass, no glass, high glass, low glass, frosted glass and glass that can open, and they can choose the finish of the solid part of the panels. The interior of the house is also customizable through a series of customizable storage options, kitchens, and bathrooms.[17]

Figure 23: Possible plans and elevation possible with the Flatpak panel system in the right image. Image by Lazof Office.

[16] “FlatPak,” accessed on October 11, 2010, http://www.flatpakhouse.com/.
[17] Ibid.

M House

M House is a housing system designed by Actar Arquitectura in 1998. The project aimed to deliver housing a la carte. The system allows homeowners to buy and add the components they want to the house when they want. Each house is the aggregation of a customized set of spaces that can be changed throughout the life of the building. This flexibility is achieved through the use of a standard module. This module creates an open plan with all water elements, kitchens and baths, to the center of the house.

Figure 24: Possible plans and elevation. Image by Actar Arquitectura

Sears Roebuck Catalogue Houses

Over 70,000 Sears Modern Houses were sold in North America between 1908 and 1940.[18] House kits were ordered through the Sears Roebuck catalogue and shipped to site via railroad. Once on site, the homeowner, often with the help of friends and relatives, could assemble a complete house from the kit. Sold in a variety of traditional styles, suitable for families of different sizes with different budgets, there was no indication that the house was prefabricated. Today the Sears Roebuck Catalogue Houses are largely indistinguishable from similar styled, traditionally built houses. The Sears Roebuck Catalogue Houses are arguably the most successful prefabricated house system ever built. The system's popularity is largely due to its suitability to a variety of budgets as well as the houses' traditional styles. The house system was inexpensive, efficient, easy to construct and met the needs of many families without intrusive styling.

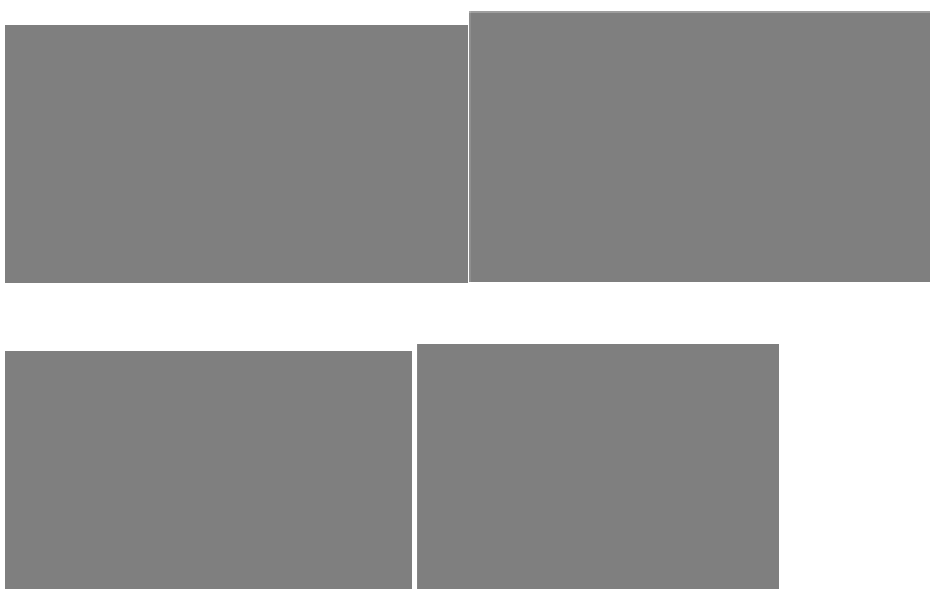

Figure 25: Examples of Sears Roebuck houses in different traditional styles

[18] Sears, Roebuck and Company. Sears, Roebuck Catalogue of Houses, 1926: An Unabridged Reprint. (New York: Dover Publications, 1991) 6.

Building Code Analysis: *Applicable building codes*

This prefabricated-life-cycle house must be in compliance with the 2006 International Residential Code (IRC) for one and two-family dwellings, and the National Manufactured Housing Construction and Safety Standards. Any constructed house in this system must also be in compliance with its site's local codes. Due to the theoretical nature of the sites used in this thesis, local zoning codes would need to be checked to ensure compliance before any life-cycle house in the system could be constructed.

Important restrictions of the IRC include the following:

- General house restrictions that are important in any house with a flexible program include minimum sizes. There can be no room smaller than 70 square feet, with the exception of kitchens, and no room may have a horizontal dimension less than 7'-0".
- All basements and sleeping rooms must at least have one direct rescue exit
- For any house with more than four sleeping units, the house is no longer in the scope of the IRC and then becomes classified as a R-3 use under the International Building Code (IBC).[19]

In Appendix E of the IRC, additional requirements for manufactured housing, the restrictions are most concerned with the foundation, ensuring that the manufactured house is anchored securely to the site. It also restricts the addition of spaces onto a

[19] IRC, 74

manufactured housing, requiring that they must be structurally self supporting unless structural calculations support the omission of that requirement.[20]

Since the house system is prefabricated and needs to be transported along federal, state and local roads, the system is also subject to transportation laws. For each site chosen to receive the housing system the applicable district(s) transportation laws will need to be reviewed and the appropriate permits acquired.

[20] Ibid.

Precedent Analysis:

Vernacular Precedents: *Architecture Native to the Delmarva Area*

Georgian Architecture: *1715-1780*

The Delmarva area has a 300 year history of Georgian architecture. Some of the more well known houses built in this style during this period include the Hammond-Harwood House, the Brice House, and Montpelier. Built between 1715 and 1780, Georgian architecture is characterized by symmetrical chimneys, pediments and cornices often in dentil work and brick walls punctured by rectangular windows.

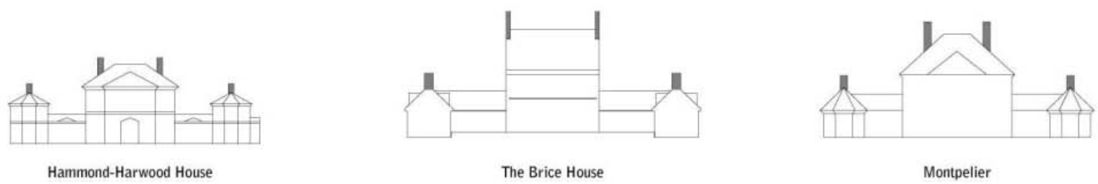

Figure 26: Symmetrical Chimneys

There is an emphasis on symmetry with a "central block with symmetrical dependencies connected by hyphens."[21] The house is overall symmetrical and each massing component has a local symmetry (Figure 48).

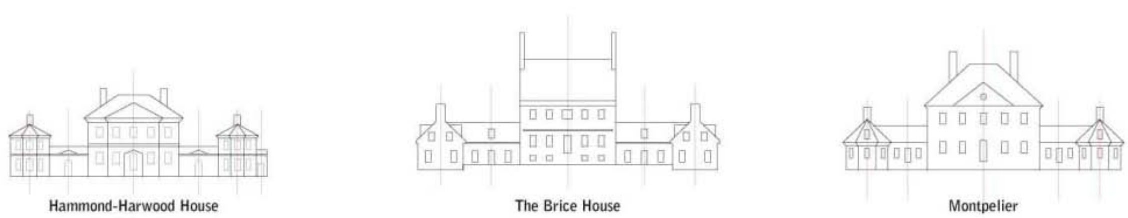

Figure 27: Prevalence of overall and local symmetries in Georgian houses

Georgian architecture has a highly regulated system of punched openings (Figure 49). The windows are stacked on top of one another, often the second story windows are

[21] John Milnes Baker, *American House Styles: A Concise Guide* (New York: W. W. Norton & Company, 1994.), 44.

smaller than the first floor windows. The windows typically consist of nine or twelve panes of glass and the window above the front door, which is located in the middle of the central block, may be larger and more decorative.

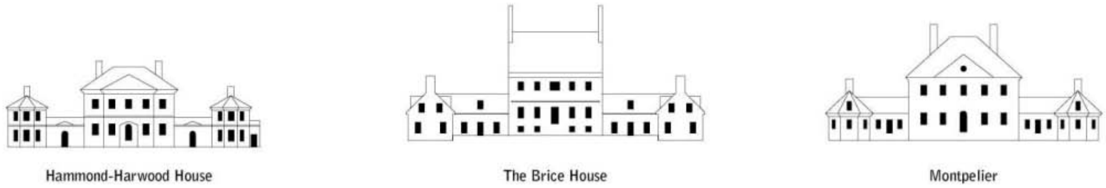

Figure 28: Fenestration in Georgian residences

The Georgian style of architecture provides for expansion over time. A Georgian house starts as a one part building, the central block of the house. When there is a need to expand, the house is expanded symmetrically to become a three or five part house (Figure 50). Consistency of materials and window proportions as well as alternating roof types allow for a seamless composition. Although there is no provision for the eventual contraction of the house, many Georgian houses expanded over generations of the owning family.

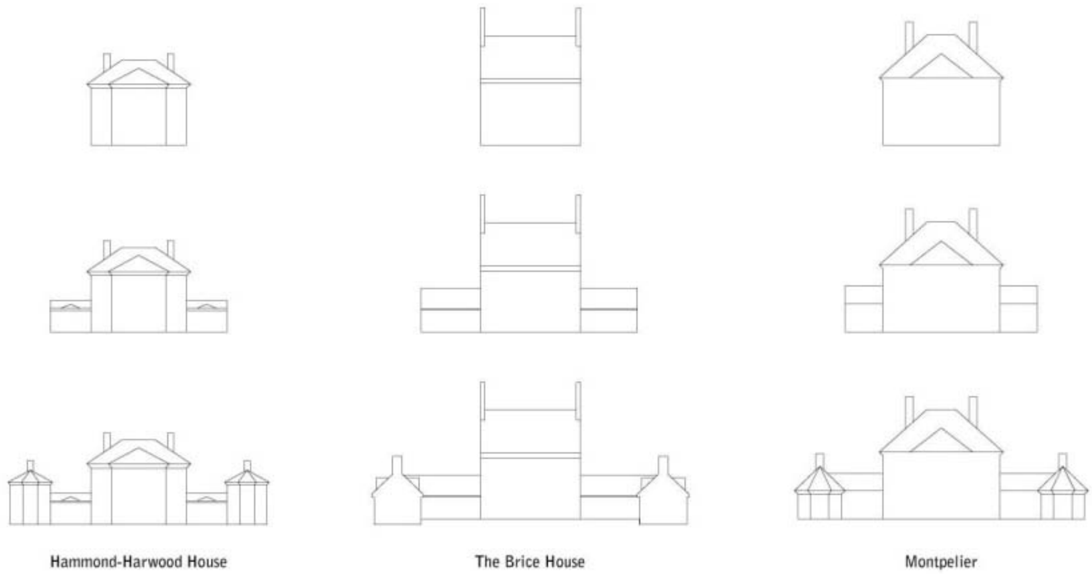

Figure 29: Georgian houses as one-, three- and five- part compositions

Figure 30: Roof types create a unified composition

Federal Architecture: *1780-1820*

Federal Architecture is a further refined interpretation of Georgian Architecture. Built between 1780 and 1820, Federal residences maintained the emphasis of symmetry and brick materiality of Georgian architecture.

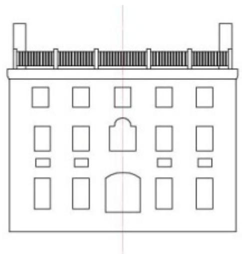

Figure 31: Symmetry in Federal style houses

Residences were enlarged to three stories, with windows decreasing in size on the upper stories. The windows were elongated so that the sills were at floor level. A more decorative Palladian window kept its place on the second floor above the front door. The front door was surrounded by an elliptical-fanlight transom.

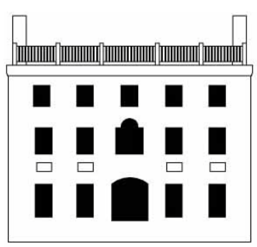

Figure 32: Window arrangement

The brick walls were left generally unadorned with occasional plaques with swags or sheaths of wheat. The roof pitch was reduced to almost flat and a balustrade lined the edge of the roof above the cornice.[22]

[22] John Milnes Baker. *American House Styles:A Concise Guide*, (New York: W. W. Norton & Company, 1994), 55.

Queen Anne: *1880-1910*

The Queen Anne style of house is a variation of the Victorian style that was built between 1880 and 1910. The style is characterized by eclectic facades characterized by "towers, turrets, fanciful gazebos" and full length porches with decorative posts.[23]

Figure 33: Asymmetrical roof forms in the Queen Anne Style

Wood clap board siding and variations of shingles clad the façade in bright colors. There is no overall symmetry to the elevation, but each component has a local symmetry.

Figure 34: Local symmetry in massing and window arrangement

[23] Ibid.

Neo-Colonial Revival: *1950-1970*

These imitations of colonial style architecture were often built by developers in the 1950s through the 1970s. Neo-Colonial Revival houses often borrow the materials and decorative elements from colonial houses but are poorly proportioned. The roofs are low pitched and the windows are sized too large and irregularly spaced.
Decorative elements like false shutters and brick veneer along the front façade are common elements.[24]

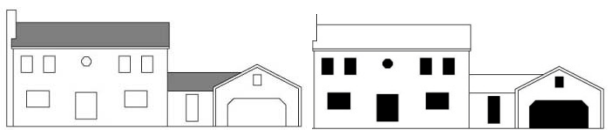

Figure 35: Proportions of Neo-Colonial Revival style

Neo-Colonial Revival, along with imitation Georgian and Federal styles, largely populate post WWII housing developments. Most of these revival styles are watered down ghosts of their predecessors, and largely ignore the tenets of their historic styles. One of the easiest to see indiscretions of the revival styles is the lack of overall symmetry of the composition.

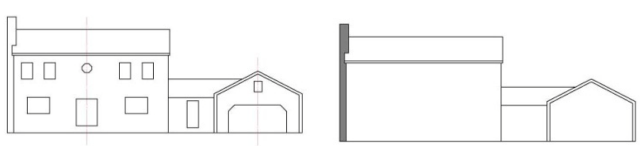

Figure 36: Overall asymmetrical composition of Neo-Colonial residences

[24] Ibid.

Neo-Classical Revival: *1965-1990s*

The Neo-Classical Revival style is often built by developers since the 1960s. The style is a watered down variation of traditional Neo-Classical architecture. In the revival there is still a great emphasis on symmetry, only a chimney may break the symmetry.

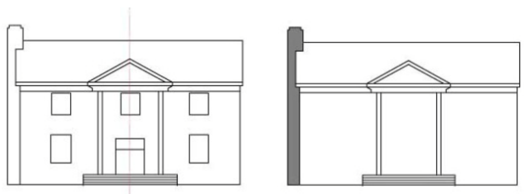

Figure 37: High level of symmetry in Neo-Classical Revival

The houses are typically two stories to allow for a two story pedimented portico which is supported by disproportionate classical columns.

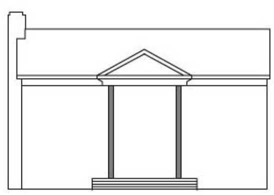

Figure 38:The disproportionate columns in Neo-Classical Revival

The roofs of houses in the Neo-Classical Revival style are largely low pitched and the windows large and poorly spaced.

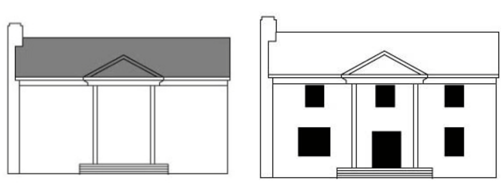

Figure 39: Disproportionate roofs and windows

Vernacular Plans

Residential plans that are commonly found in the Delmarva area were also studied, not for stylistic purposes but rather to identify typical patterns of organizing space. The plans were analyzed in their organization of public versus private spaces, distribution of poché and ability to expand through additions. Privacy is typically dealt with in one of two ways. First, it is all located on the second floor, away from the public realm of the house on the first floor. Or, secondly, it is grouped to one side of the first floor, separated from the public realm by circulation. Poché spaces are best grouped together and then used as a threshold between spaces, often separating the public and private realms. Although these residential plans did not often plan for expansion, many of them allow for easy additions. These additions would most often be made in one of three ways. The first is for a one story house to expand with a second floor. The second is to expand on either or both sides of the house. And finally, the last way a residence can expand frontwards or backwards.

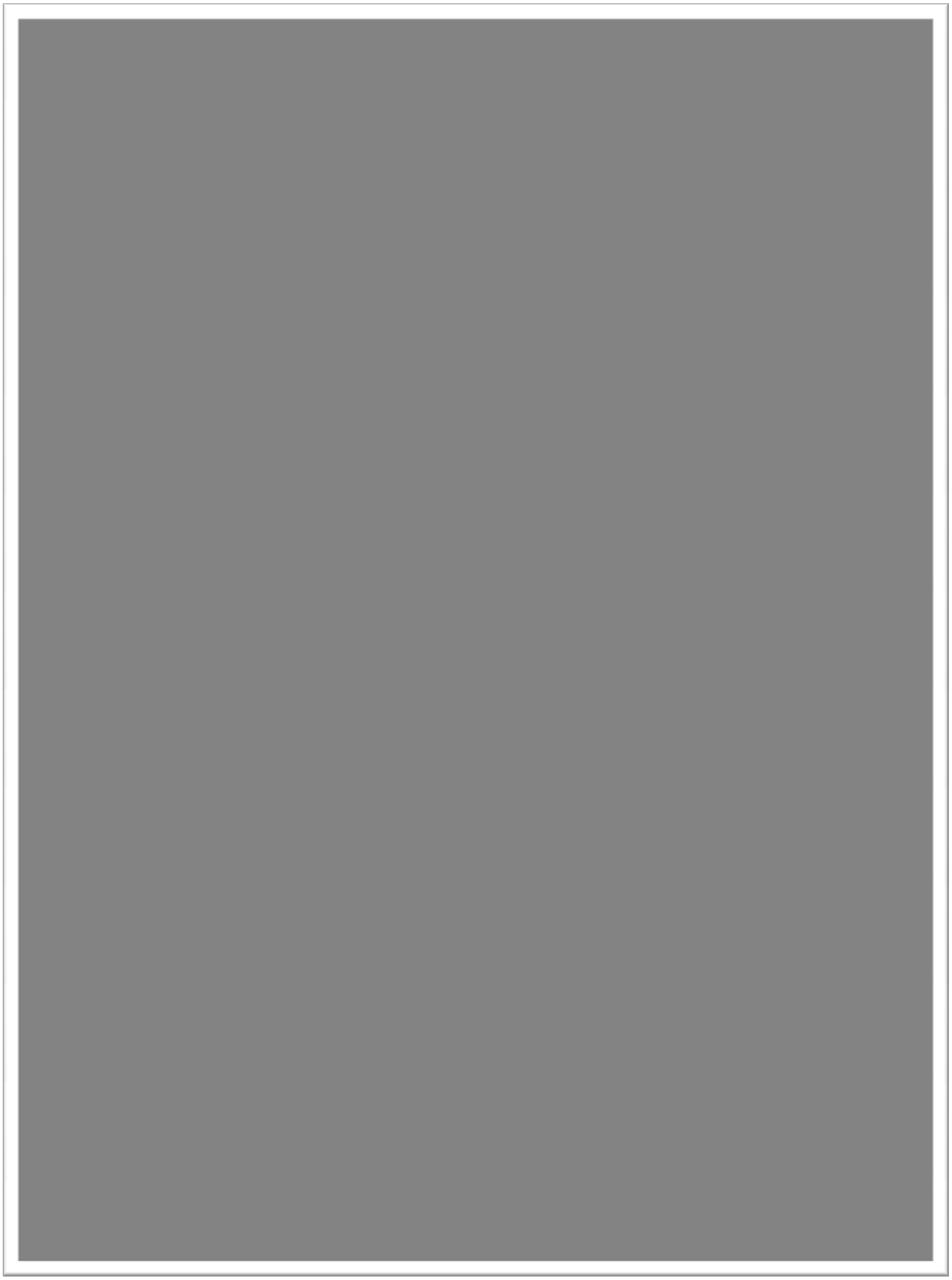

Figure 40: Plans by Rachel Carly's *The Visual Dictionary of American Domestic Architecture.*

Design Approach

The design of this expandable-life-cycle house system begins with the base component. The design of this component must not only be appropriate for when it stands alone but it must also act as the basis for any successive expansion made to it. The siting, structure, and organization of spaces in the house system all begin with the base component. The placement of the base component must allow for the eventual expansion of the house. It must also allow for easy removal of sections of exterior walls without compromising the structure, so that expansions can connect with the base component. The organization of space within the base component dictates the organization of the house once the expansion is added. There is no period obligation that the base component is expanded therefore it is important that the base component looks like a completed house rather than an unfinished component.

Four expansion types can be added to the base component. Although each expansion varies in the spaces it adds to the house, all of the expansions connect to the base component in the same fashion along the elevation of the house that contains the front door. Two of these expansion components are one-floor additions. The other two additions are a loft, and a two-story addition, respectively. The expansions are varied in size and spaces they provide so that they can meet the needs of different families and different budget opportunities.

Base Component Design

The base component is designed as a one bedroom single-family house. The circulation is minimized through the placement of the front door in the middle of the side facade. This in turn allows more wall space for the placement of furniture in the living and dining room. The placement of the front door then requires a deep porch to shelter the entrance to the house. The size of this deep porch creates an outdoor room, which gives the household more living space, needed in a small house.

The base components range in cost from $85,000 for the 12'-6" width, $88,000 for the 13'-6" width and $95,000 for the 15'-6" width components.[25] These costs do not include the cost of transportation which is determined by distance of the site from the prefabrication factory, nor do they include the cost of land.

[25] Mewis, Robert, Christopher Babbitt, and Ted Baker. *RS Means Residential Square Foot Costs: Contractor's Pricing Guide 2010*. (Kingston: RS Means, 2009).

Figure 41: Base Component plans in 12'-6", 13'-6", and 15'-6" widths

Expansions

Two Bedroom, One Floor

The smallest expansion to the base component, it adds a single bedroom, entry hall and dining room to the house. The design presented in this thesis focuses on developing a clear separation of public and private spaces, grouping the bedrooms to the back of the house around a small hallway and pushing all the living space to the front of the house. This design also gave priority to back yard access.

This expansion's components range in cost from $36,000 for the 12'-6" width, $37,000 for the 13'-6" width and $41,000 for the 15'-6" width components.[26] These costs do not include the cost of transportation which is determined by distance of the site from the prefabrication factory, nor do they include the cost of land.

[26] Mewis, Robert, Christopher Babbitt, and Ted Baker. *RS Means Residential Square Foot Costs: Contractor's Pricing Guide 2010*. (Kingston: RS Means, 2009).

Figure 42: Two bedroom, one floor plans in 12'-6", 13'-6", and 15'-6" widths

Three Bedroom, One Floor

This expansion is the largest one level expansion that can be added to the base component. It adds a bedroom, a master suite, a dining room, formal entry and a laundry/ mudroom. The design is based on the more traditional household with the inclusion of a master suite with a walk-in closet and private bath. The other two bedrooms of the house share the original bathroom. This design provides access to the side yard through a mudroom that is spacious enough for a washer and dryer.

This expansion's components range in cost from $57,000 for the 12'-6" width, $58,000 for the 13'-6" width and $64,000 for the 15'-6" width components.[27] These costs do not include the cost of transportation which is determined by distance of the site from the prefabrication factory, nor do they include the cost of land.

[27] Mewis, Robert, Christopher Babbitt, and Ted Baker. *RS Means Residential Square Foot Costs: Contractor's Pricing Guide 2010*. (Kingston: RS Means, 2009).

Figure 43: Three bedroom, one floor plans in 12'-6", 13'-6", and 15'-6" widths

Two Bedroom, Loft

The loft design is the most contemporary and flexible of the floor plans. The flexibility allows for greater use of the spaces. The loft expansion includes a large master suite, a double height living area and a loft. The living areas of this house can serve many purposes. The downstairs living areas can be either separate or combined lounging and dining activities. The loft space is largely un-programmed and could be used as a study, library, or game room.

This expansion's components range in cost from $61,000 for the 12'-6" width, $63,000 for the 13'-6" width and $67,000 for the 15'-6" width components.[28] These costs do not include the cost of transportation which is determined by distance of the site from the prefabrication factory, nor do they include the cost of land.

[28] Mewis, Robert, Christopher Babbitt, and Ted Baker. *RS Means Residential Square Foot Costs: Contractor's Pricing Guide 2010*. (Kingston: RS Means, 2009).

Figure 44: Two bedroom, loft plans in 12'-6", 13'-6", and 15'-6" widths

Three Bedroom, Two Story

The three bedroom, two story expansion is the largest expansion possible in the housing system. It includes a formal entry, two living spaces and a large laundry room with access to the side yard on the first level. The second level is accessed by a U-shaped stair and has two bedrooms that share a full bath.

This expansion's components range in cost from $76,000 for the 12'-6" width, $78,000 for the 13'-6" width and $85,000 for the 15'-6" width components.[29] These costs do not include the cost of transportation which is determined by distance of the site from the prefabrication factory, nor do they include the cost of land.

[29] Mewis, Robert, Christopher Babbitt, and Ted Baker. *RS Means Residential Square Foot Costs: Contractor's Pricing Guide 2010*. (Kingston: RS Means, 2009).

Figure 45: Three bedroom, two story plans in 12'-6", 13'-6", and 15'-6" widths

Structural Design

The life-cycle-house system is prefabricated and made of light-gauge steel constructed off-site. Prefabrication was chosen to reduce the cost of the system. On-site construction is limited to the pouring of the foundation, connection of the expansion component to the base component and the finishing of the roof. Light-gauge steel was chosen due to its popularity in small construction and light weight, allowing for easier maneuvering of the module from prefabrication factory to truck and from truck to its final placement on its foundation on site.

In order to maximize the interior dimension of the prefabricated module, the roof overhangs are shipped detached from the building component. The roof of the component is shipped on site, unfinished. Once in place on site, the overhangs are attached to the component and then the entire roof form receives its breathable water-proof membrane and shingles.

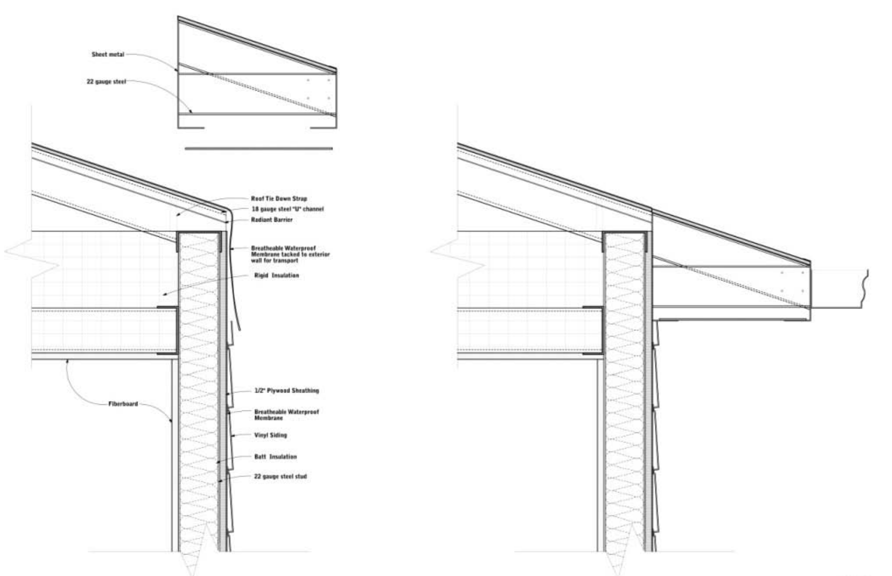

Figure 46: Roof assembly detail

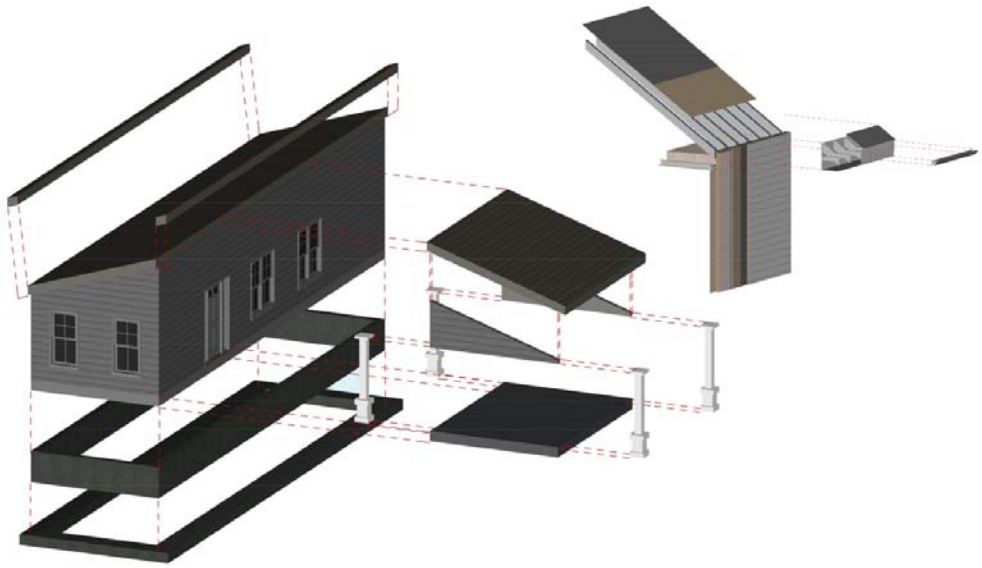

Figure 47: Exploded Axon illustrating the construction of the base component on site

The other structural consideration was the connection detail between the base component and any of the expansion components. These connections are made through the openings on the entrance side of the base component. All of the base and expansion components contain three openings along their common wall which align. When the house exists as just the base component, these openings function as the front door and windows on the side façade. When an expansion is added to the base component, the front door and two windows are removed from their place in the base component. This front door and the windows can be reused in openings in the expansion component. The expansion component is then placed on its foundation and connected to the base component through a series of steel plates. The steel plates are fastened along the openings vacated by the front door and windows, connecting the base components and its expansion. These connections are then concealed under applied millwork and the openings act as thresholds between the base component and the expansion.

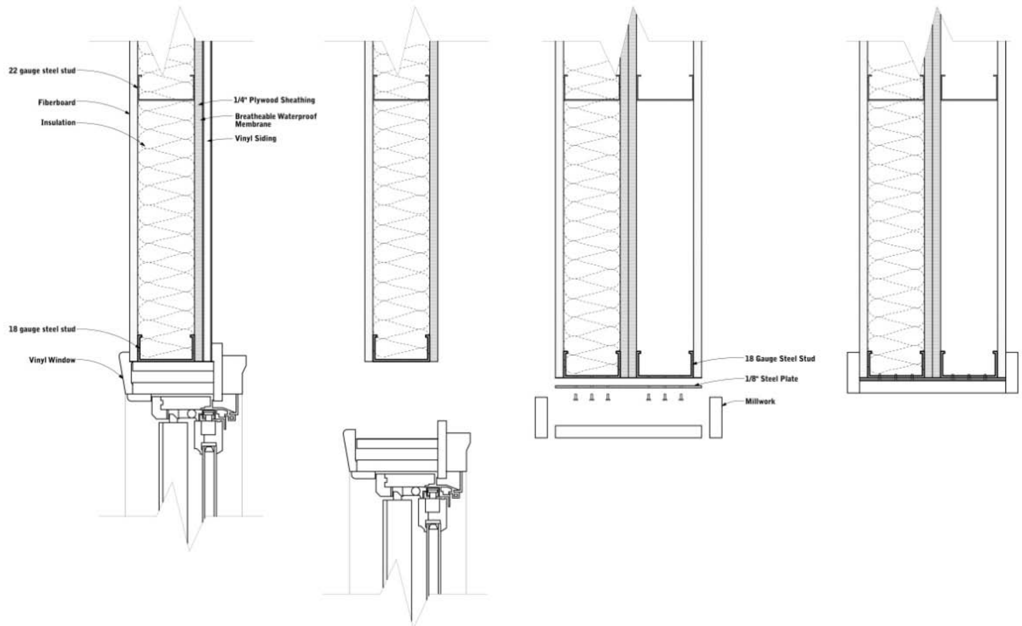

Figure 48: Wall connection detail between base component and expansion component. From left to right 1) The base component window detail in plan, 2) Separating the window from the wall, 3) Joining the expansion component wall to the base component 4) Finishing millwork

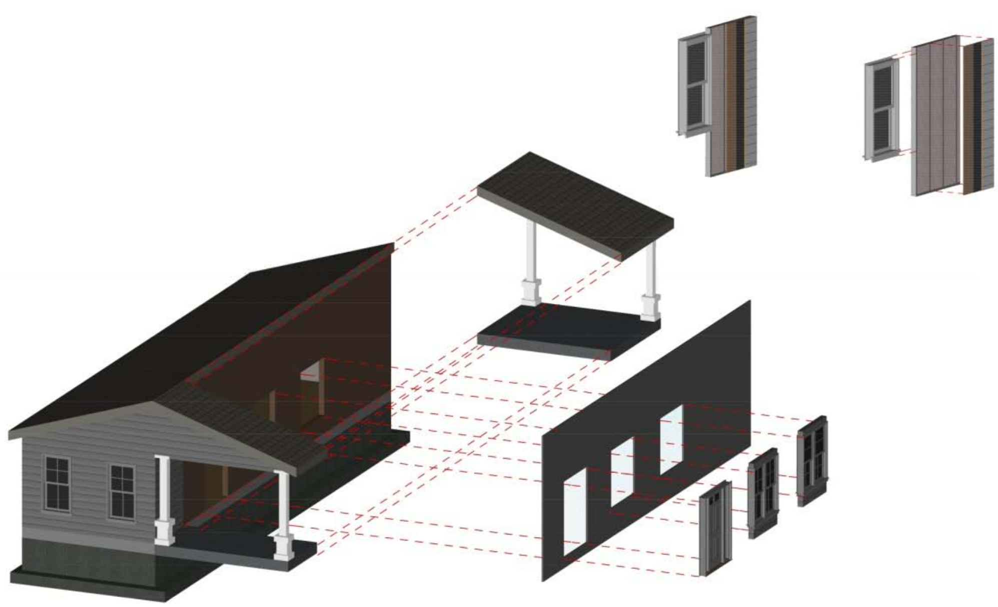

Figure 49: The front door, two windows and part of the porch detach from the base component to prepare for the arrival of the expansion component

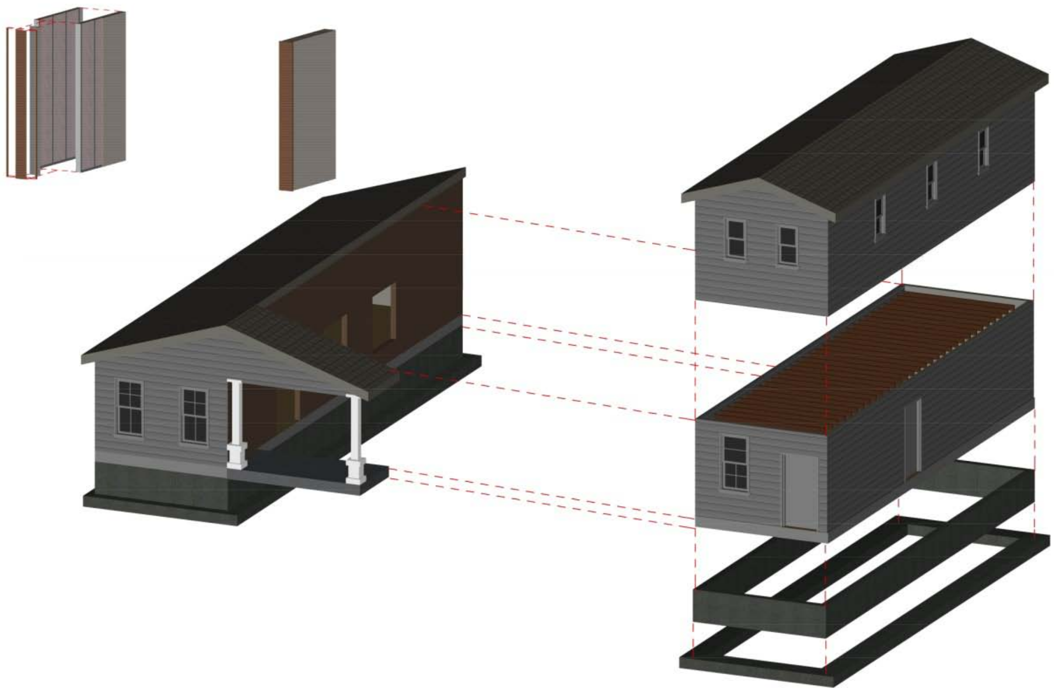

Figure 50: The expansion component is placed alongside the base component and connected

Resulting Houses

This system can be configured into thirty-six unique plans. The smallest of these houses begins with the 12’-6” base component and adds the 12’-6” wide two-bedroom, one floor expansion. The house is a total of 1,126 square feet and costs $121,000 not including the cost of transportation and land.

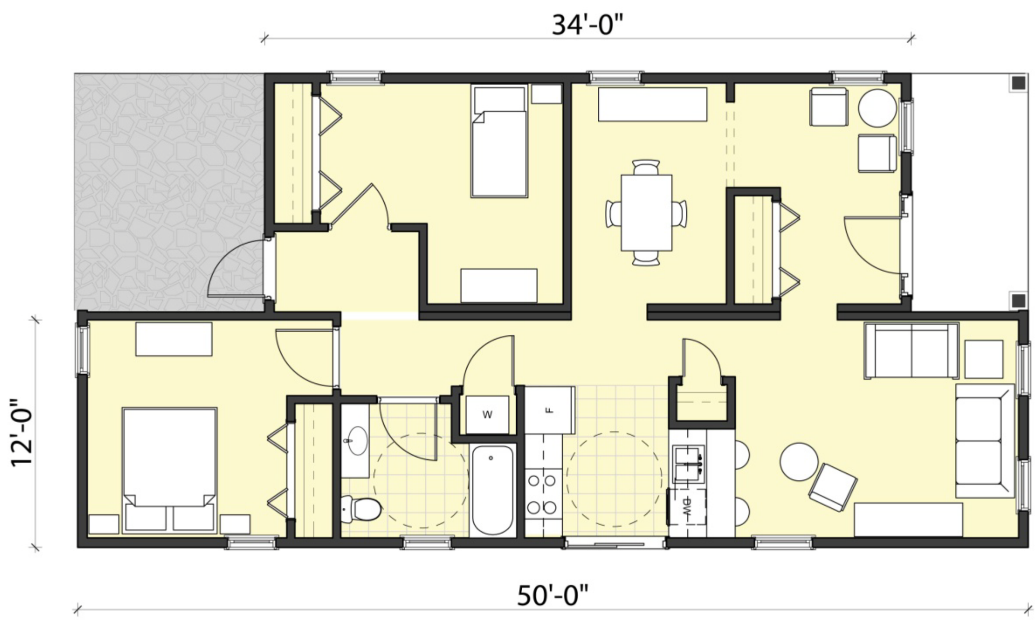

Figure 51: The smallest house possible with the life-cycle system

At the other end of the spectrum the largest house made with this system is a total of 2,232 square feet and costs $180,000 not including the cost of transportation and land. This house begins with the 15’-6” wide base component and adds the three-bedroom, two-floor expansion component.

Figure 52: The largest house possible with the system

Example Life-Cycle

A sample life cycle begins when a young, childless couple, purchases a plot of land and decides to build a house using the expandable-life-cycle system. They decide to buy the 12'-6" wide base component due to their current financial limitations.

Figure 53: Example street elevation of the base component

Figure 54: 12'-6" Base Component on example site

In a few years, the couple decides to have children. They have worked hard over the past years and have saved enough money to expand their house. They decide to purchase the 12’-6” two-story expansion due to its separation of the bedrooms on the second floor and the future possibility of renting the second floor as a separate apartment.

Figure 55: Example street elevation of the base component with two story expansion

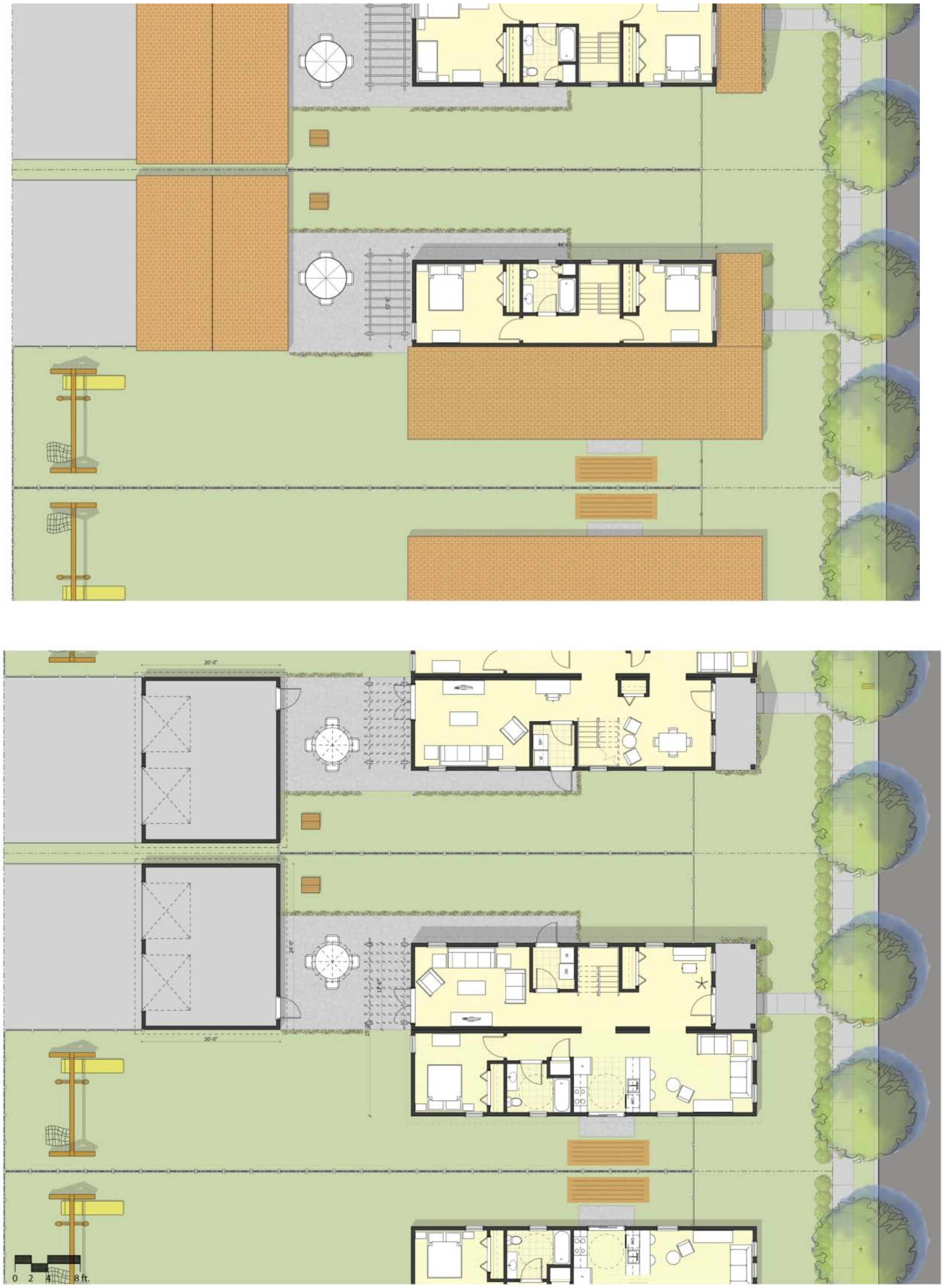

Figure 56: First and second floor plans of base component with two-story expansion

A quarter of a century later, the couple's two children have grown up, moved away and started households of their own. The house's two floors provided plenty of room for a family of four, but now it seems too big and too much to maintain. With the onset of arthritis, it is also becoming difficult for the couple to walk up the stairs. The couple decides that they no longer need the second floor of the house. They move their bedroom back down to the first floor and hire a contractor to convert the second floor into an independent apartment. After the construction is done they find a young tenant to rent the upstairs, which becomes a steady source of income for the now-retired couple. They appreciate having a smaller space to clean and no longer having to take the stairs. As mobility decreases with age and they begin to use walkers, they can easily navigate through the first floor. Eventually they mount grab bars in the bathroom to allow them to more easily navigate the bathroom.

Figure 57: First and second floor plans the base component with two story expansion. Second story converted into a separate apartment.

Flexibility in Style

The houses not only appeal to a variety of lifestyles and lifecycles but also a variety of style preferences. It was the intention of this project to keep the styling of the houses traditional since it seems many precedents in prefabricated construction failed due to futuristic and machine like designs. The exterior of the houses in the system were then intended to imitate the variety of more traditional styles of the Sears Roebuck Houses. Developed in this system are a series of styles, all of which can be adapted to suit any component at any width. These styles are influenced by Frank Lloyd Wright, Craftsmen Victorian, Contemporary Modern, Neo-Classical architecture.

Figure 58: Example elevations in streetscape

Figure 59: Example elevations in streetscape

Aggregation of Houses

Entire communities can be created using the housing system, or a single house made with the system can stand alone.

Figure 60: Axon of different aggregations of the house system

In its most dense aggregation, the houses can be grouped at eleven units per net acre; ten units per gross acre. This aggregation eliminates the garage from the site and spaces the houses close together. The side yards are only four feet wide and the house sits back from the street only ten feet. Despite these dimensions, the property still allows for a thirty foot deep backyard, which provides plenty of outdoor space.

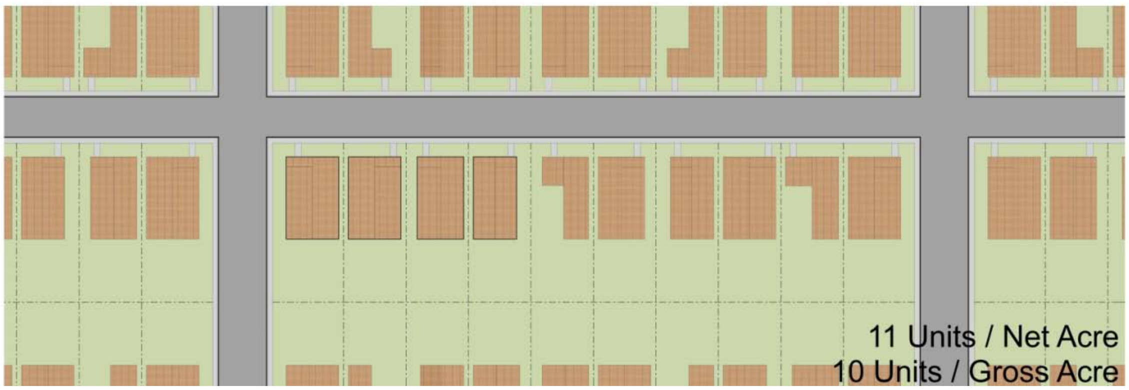

Figure 61: Dense aggregation at 11 units / net acre, 10 units / gross acre

A slightly less dense arrangement can include garages and driveways. If the garage is accessed via an alley system to the rear of the properties, the density is decreased to seven units per net acre; six acres per gross acre. If the garages are instead accessed via a long drive at the beginning of the property, the density is slightly higher at eight units per net acre, seven units per gross acre.

Figure 62: Aggregation with alleys at 7 units/ net acre, 6 units / gross acre

Figure 63: Aggregation with long driveways at 8 units / net acre, 7 units/ gross acre

In much more scattered neighbourhoods, those seen in typical suburban sprawl developments densities of six units per net acre, five units per gross acre can be created.

Figure 64: Court aggregation with 6 units / net acre, 5 units / gross acre

Of course, there is no limit to the property size that the housing system could be placed on. The only limitation that may impede placing one of the system's houses on a large piece of land is that the cost of the system rises the further the components are transported from the factory. At its least dense, the house system can be one unit per acre or less.

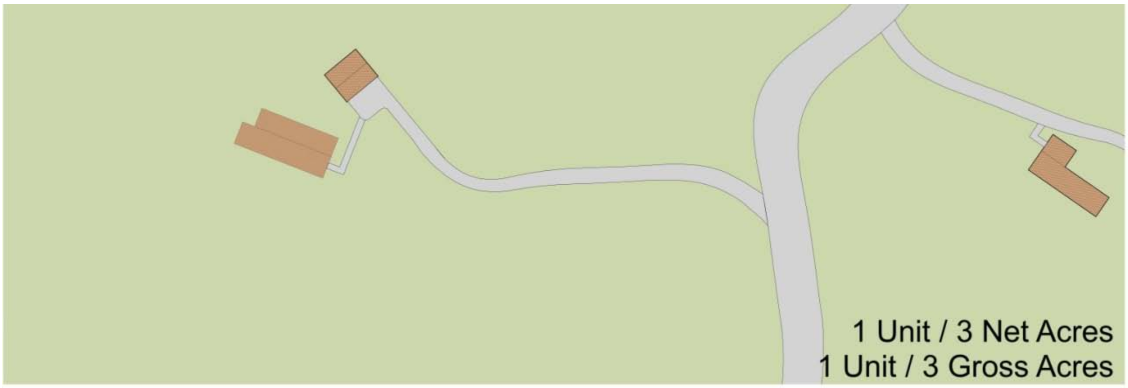

Figure 65: Rural aggregation at 1 unit or less per net and gross acre

A6 Public Thesis Presentation: Criticisms and Response

The guest panel for the public thesis defense consisted of Sara Elizabeth Caples, AIA, and Everardo Agosto Jefferson, AIA of Caples Jefferson Architects, New York, New York, Phoebe Crisman of the University of Virginia, Matthew Geiss of Catholic University of America and Powell Draper, PhD of Manhattanville College, Manhattanville, New York.

The criticisms of the project can be categorized as those dealing with the accepted parameters of the project and those more specific to the decisions I made within the parameters of the thesis.

Criticism:

The criticisms of the parameters of the thesis were largely concerned with the way the houses perpetuate the current suburban model and therefore do not appeal to more urban and younger residents. The current suburban model is criticized as too sprawling, being wasteful of land and unsustainable.

Response:

The focus of the thesis was on the individual house at suburban single family densities and not on the aggregation of the houses. My intention regarding street, block and parcel property subdivision was to demonstrate how the various house types worked in the typical suburban patterns common in the Delmarva region. Certainly an investigation of alternative neighbourhood types, ones that include smaller lots and rely less on the automobile would be an important next step if this project were to continue.

Criticism:

Although the panel liked the ability of the house to adapt to housing multiple families they were concerned about the restrictions in Euclidean zoning that would make such an adaptation impossible in today's suburban neighbourhoods.

Response:

Although many neighbourhoods in the Delmarva Area are Euclidean zoned, thereby separating single-family houses from multi-family housing, it is not unheard of for a developer to work with a zoning district to get a variance for a development. The Congress of New Urbanism has long advocated for mixed-use and mixed-density development; "the Planners Task Force has collected and created resources to promote New Urbanist municipal land development regulations." Their publication, *Codifying New Urbanism* describes the steps needed to get new urbanism principals to work in different communities and relates the success stories of twelve communities which have increased building type variety and density.[30]

Criticism:

The other criticism about the project's parameters was that it did not address environmental sustainability in the design of the house system.

Response:

The thesis was more concerned with social and economic sustainability of house purchases than environmental sustainability. As a construction system, prefabrication

[30] New Urbanist Land Development Regulations www.cnu.org

already begins to save on material and construction waste. The smaller size of the houses created by this system, especially if aggregated on smaller lots, can also be seen as more sustainable than current practices. The design of the modules themselves can include sustainable elements like low flow toilets and recycled materials, which do not represent themselves architecturally. Certainly in a housing system as the one proposed in this thesis, additional, sustainable components can be added to the system to decrease its impact on the environment. Components, like rain barrels and solar panels, could be added to the system and those would increase the sustainability of the house.

I briefly revisited this aspect of the thesis and applied some sustainable technologies to the system. These components can be added to any base component or expansion component in the system. Applicable technologies as seen below include, allow rain water to flow off of the roof into rain barrels, solar panels mounted to the roof, horizontal sun shades on the south elevation and vertical sun shades on the East and West facades. The way these houses are sited also effect the sustainability of the house. All sites considered for the system should be evaluated so the house is sited in the most proper solar orientation and have the least impact on the site. These components should be able to be purchased and added to the house at anytime

Figure 66: Base Component illustrating sustainable components

Criticism:

The criticisms of the project within its parameters concern the level of detail in which I explored the experiential quality of the interior. The panel believed this experience could have been explored through perspectives and sections.

Response:

Although I do believe a section would be helpful to better understand the spatial relationship and connections between the base component and expansion, I do not believe perspectives would have been helpful. The interior of a house is usually personalized and given most of its character through the interior decoration done by the household. Therefore a perspective of a decorated interior would be narrowly focused on only one interpretation of how the house should be decorated. My concern and choice was to focus on the external architectural character of the house and the streetscapes they produced. My goal was to assure variety in the architectural style of the houses while achieving neighbourhood coherence.

Criticism:

Although the panel thought the plans were good, they criticized the modules as not allowing for much customization in plan.

Response:

In an affordable and prefabricated system, the level of customization within the system becomes a careful balance. Not enough customization in a system creates monotony and will not attract buyers. Too much customization increases the expense of the system. It is my opinion that an appropriate level of customization was integrated into the system. With a base component and four expansions, all available in three different sizes and a variety of styles, there is variation intrinsic to the system. Beyond these options, the personal belongings and tastes of the households who occupy the houses would create a great variation in the houses both inside and out.

Criticism:

At the detail level, the guest review panel thought the next step in the project was to explore different construction methods of the foundation. Since the foundation adds much expense to a house they thought that exploring different methods of constructing suitable foundations at less cost would make the system even more affordable.

Response:

I agree that an investigation of the foundation construction would enrich the project and be a logical next step in the investigation.

Reflection

The way in which houses are built, sold and bought in the United States of America needs to change. The current practices are economically, socially and environmentally unsustainable. There are three aspects of housing that need to be addressed, the way we invest in houses, the way we invest in our community, and the way we invest in our environment.

This thesis focuses on the investment aspect. Homeownership should not be a great financial strain. When younger persons are able to purchase a house earlier, they can begin to invest in their house and the community. This earlier investment in a community can help strengthen bonds between neighbours. The next obstacle is to keep households in the communities so that bonds between neighbours can be strengthened and continue throughout their lives. Finally, we must also invest in the natural environment. In order to improve the quality of life of our families we must improve our environment. Our houses should have little negative impact on work to improve the natural environment.

Admittedly this thesis only begins to explore some solution to the problems around single-family houses in the United States of America. It is a large issue that many architects will have to investigate and propose differing solutions for. This thesis hopefully adds to the investigation by the profession. Perhaps it can be the building block for further development and change in the way houses are built and bought in the future.

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