I, Dru D Furbee, hereby submit this original work as part of the requirements for the degree of Master of Architecture in Architecture (Master of).

It is entitled:
shop-NEXT
Flexible Design and Prefabrication in Retail

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shop-NEXT
Flexible Design and Prefabrication in Retail

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I. Abstract

The continued growth of online shopping has forced retailers to rethink strategies and brand identities. While much has happened in the way of integrating retailers into technology, the design of the spaces remains stagnant. The design and ambiance of a real space, such as a store, is one key difference of online retailing. The brand identity and core values can be better portrayed in real space than in virtual space. While retailers such as J. Crew control all of their inventory through their own highly controlled sales channels (online or in-store), not all retailers have this luxury. The successful retailer of the future will be able to change their physical store as quickly as they can alter their website.

Research shows that retailers are considering consolidating stores because of rising costs of operations and changing consumer behaviors. This reduction of stores could be as much as 30%-40% in some segments.\(^1\) Reports on the future of retail show that flexibility and market adaptability in the physical retail space are going to be a necessity for the most successful retailer. For the architecture of the retail space to be

adaptable, it has to be rapidly changeable. Traditional stickbuilt construction methods do not allow for this.

This thesis recognizes that the retail industry is changing rapidly and will continue to do so as its relationship with other sales channels continues to develop. For this project to be successful, it has to be able to be easily adaptable to those changes. With the current construction methods, only graphics are easily modified. Alternate construction methods must be considered for additional benefit in the retail industry. The architecture and construction industry is not improving and industrializing at the same pace as other manufacturing industries. It is now our turn to make significant advances that benefit the architect, the contractor, and the client. The relationship between the architecture and construction fields needs to be re-examined and redefined. Value can be added to the owner, which is increasingly important in the recent economic downturn. By researching and improving the design methodologies related to prefabrication, we increase the chances that this becomes regularly implemented not only into retail, but into the entire construction industry, thus improving the future relevancy of architects while benefiting efficiency and quality and reducing construction time, costs, and mistakes.
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II. Introduction

Preface

I first became interested in alternate construction methods such as prefabrication when I saw videos on YouTube of these 30-story buildings being assembled in China in just over two weeks. It seemed to me that this building technology had incredible potential if used correctly. If this technology is ignored and not embraced by architects, we are potentially setting our profession up for failure. Architects need to get involved with prefabrication before engineers and developers dominate the market, leaving little room for architects to have a meaningful impact.

In starting to research what building type would be most appropriate for a research based thesis on prefabrication, it seemed clear that the residential segment had already been deeply studied. Medium to large scale commercial had already been researched as well, with several companies such as Kullman Building Corporation in the United States or Broad Sustainable Group in China leading the industry. One area that has surprisingly little integration of prefabrication is the retail industry. This was initially very intriguing to me because similar design elements are repeated hundreds, if not
thousands of times across different locations. Each store layout will likely be different, but the base components are typically the same. It seems that there is a tremendous opportunity for prefabrication in retail, not only because of the potential of shorter tenant improvement times, but also because of the additional flexibility that comes from having a system that is easily assembled and disassembled.

Problem

The idea of prefabrication has been around for quite some time, but new technologies and design methods allow for it to be more practical and necessary than ever before. On-site fabrication is inefficient, inaccurate, and wasteful. Numerous benefits and few drawbacks exist within the method of prefabrication which is why it is necessary for the architecture industry to modernize its design process and construction methods. Prefabrication has the potential to reduce costs, construction time, and mistakes while increasing quality and efficiency. Factory built components and assemblies need to become the standard in the architecture and construction industries with on-site fabrication being the exception, or we risk a future of irrelevance by not adapting to change. The architecture and construction industry is falling behind other
manufacturing industries, such as automobile and ship-making, with regards to improvements in efficiency and quality of the process to create the final product.\(^2\)

These inefficiencies are especially true in the retail industry where most stores are drywall based with the shelving fixtures attached. The same details are repeated across the company’s various stores. Prefabrication is of substantial benefit when repetition of design elements occur. Retailers that have similar stores in cities around the country are prime candidates for incorporating this design methodology into their typical stores.

Background

The failure of these industries to change is likely the cost to learn and implement new knowledge. As with the Loblolly House design by Kieran and Timberlake, contractors are likely hesitant to take on new, unfamiliar, construction types because of the increased potential for unhappy clients and lawsuits. Historically, there has been limited success in the field of prefabrication, but not in the scope of what I believe is necessary. The techniques involved with prefabrication should not be limited to a

certain building type or scale. A fundamental change in the profession and its education needs to occur for the ideas presented in this thesis to be of any consequence.

Prefabrication was popular in the early 1900s with the Sears, Roebuck Home Builder's Catalog: The Complete Illustrated 1910 Edition. Readers were able to select everything from lamps to plumbing fixtures in this version and even an entire house in some other Sears' catalogs. One major flaw exists within the premise of this idea. The houses were designed without a site, orientation or climate in mind, creating inefficient performance for these houses. However, since then, prefabrication has gained a connotation for being a cheap, standardized, and low quality way to design and construct a building. The primary theoretical literature on prefabrication, Refabricating Architecture by Kieran and Timberlake, shows that this no longer needs to be the case. The authors have also written several other books, such as Loblolly House, showing how their theoretical views on architecture can be put into practice. Other, more generalized books on prefabrication, include Prefab Architecture and Prefab Prototypes: Site Specific Design for Offsite Construction. These two books breakdown prefabrication methods into various construction types and familiarize the reader with a multitude of techniques. Also, The Function of Form, while not a book dedicated to prefabrication, is
a larger study of how complex structures can be broken down into parts and pieces, a method essential in creating efficient off-site manufactured design.
III. Retail

A. Current State of Retail

Most retail stores are based on the traditional system of a transactional model. Essentially, this means that the goal of the stores is to make sales within the store. While this might seem to be an obvious goal for a store, if you look deeper, you will find that there are opportunities to have the consumer feel more integrated into the retail buying experience. The key to solving these issues is to look at multiple sales channels, including the growing digital shopping trends. There are of course, a few exceptions to this, but overall, digital and mobile experiences remain separated from in-store experiences. Retail stores have been slow to adopt emerging technologies and even slower to acknowledge the changing marketplace and the growing shift to online shopping. Many brands, for example, still do not allow a customer to search online and check inventory in-store. For customers who are shopping online and want the product as soon as possible, being able to check inventory and reserve in-store is key to this process.

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The transactional model lends itself to little change in store design. Decorations for holidays may alter store appearances, but little else, besides minimal graphic changes with seasonal fashion items, occurs to create a dynamic retail environment. Typically, most stores significantly change their design every 7-10 years, often closing or displacing themselves to less desirable locations for several months in the process. The current construction methods condone this type of redesign schedule because of the inherent lack in flexibility within these systems. Metal studs and drywall are not easily reconfigured to change store appearance and layout.

B. The Future of Retail

The future of retail is currently being studied by various consultancy groups in attempt to assist retailers in the transition. Deloitte, one of the largest accounting firms in the world, publishes reports on the future of retail and the evolution of the store. The majority of the study is conducted by a survey given to executives of retail companies. The study mentions that the retailer of the future will understand customers needs and what the customers already understand. They emphasized digital integration as well as training knowledgable sales staff that will be able to supplement the research the
customer has already done. Customers are more informed on the products they are purchasing than ever before and the stores need to respond.\textsuperscript{4} In addition the study talks about how stores are likely to get smaller and effectively become showrooms. The store will be the gateway to a sale that might happen through one of many channels.

The retail model is expected to shift from a transactional approach to an experiential one. The experience is greatly dictated by the design of the store, making the ability to transform that design quickly and easily of extreme importance for future retailers. Technology will likely be heavily integrated into stores, creating a seamless experience between the virtual world of online shopping and the physical store location. Retail executives remain deeply divided on what the experience in a future store will contain, what technology will offer in 5-10 years, and where the industry is headed.\textsuperscript{5} Because of this, spaces need to be able to adapt and re-adapt to continue consumer interest.

Many of the ideas and practices noted in the report are already occurring at several retailers. Apple, as one of the most prolific retailers, has a showroom strategy

\textsuperscript{4} Ibid.
\textsuperscript{5} Ibid.
that many of it’s competitors are trying to emulate. Transactions occur at mobile point-of-sale unites rather than at a typical cash register. In addition, customers can even complete a self-checkout on their own iPhone using the companies EasyPay system for certain items. This essentially has the possibility of eliminating lines and increasing sales capacity. If customers need assistance at a certain products, all they have to do is call an associate from the product information displayed on an iPad adjacent to each product.

In mid-2013, Apple introduced iBeacon, which is an indoor positioning system for primary use in the retail industry. In December of 2013, Apple rolled out this technology to all of its stores. Essentially, this technology allows for Apple to know where you are inside of their stores and send information and notifications to your mobile device based on that information.\(^6\) For example, a store could know that you are looking at iPhone cases and send a notification that select cased are 50% off today. This technology has broader applications as it could help you find items in larger retailers, such as grocery stores or department stores, if connected to a digital map.

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The shift to an experiential showroom type of consumer shopping environment has large implications on the architecture and design of retail spaces. The showroom model of retail is intended to repeatedly draw in customers in and display the products in the best environment possible. It will become necessary for the design of the stores to change with the products being displayed including the fashion cycles, seasons, special events, and holidays. The budget allowance for store design at many retailers will have to increase, possibly being offset by the decrease in average store size. Store designs will become dynamic where customers will visit the store on two different weeks and experience two dramatically different environments. It is necessary, however, that these changes be quick and non-disruptive to the business cycle. For this to be possible, many of the elements will have to be systemized and prefabricated on a retailer by retailer basis so that design changes can occur in one overnight session. In addition to the changes within the stores, retailers will become more mobile being able to deploy stores, or small versions of stores, to any location at any time. This concept is known as pop-up retail.
Pop-up Retail (Puma + Uniqlo)

The term pop-up retail is relatively new, and has been gaining traction in the past few years. The idea is typically one of exclusivity where the space is unadvertised and you must be “in-the-know” to make it to the store before it is gone. Although the stores are initially exclusive, the media often heavily covers these stores, especially those in high profile locations. The stores often come when a brand is introducing a new product or a new collection. This allows a brand to test public reaction and get media attention with little upfront costs. Pop-up retail can take place in existing structures or as standalone stores. Uniqlo, a clothing company that has recently moved into the United States, has modules designed to sit in public plazas in cities where they are opening new stores. Essentially the boxes are an advertisement in a highly traveled area. The boxes are small enough to where they can easily be moved from one city to another.

In addition to Uniqlo, Puma has larger-scale stores that travel to different cities for events. The Puma store is made directly from shipping containers, making it easy for transportation. Most recently, Puma setup a store in San Francisco for America’s Cup. While I was not able to see the installation of the shipping containers, I was able to visit

Fig. 3.1 - Temporary Puma Store, San Francisco, California. Image by Author.

Fig. 3.2 - Image of Uniqlo pop-up from HWKN.com
the store and examine the construction. Every element was modular and easy to disassemble, helping to minimize construction and deconstruction times.

Retailers not only have to be dynamic to compete with their online counterparts, but they have to be Amazon-proof. A company in Seattle called Hointer has come up with several innovative methods to change the experience of buying jeans. This particular store is aimed at men, creating an experience that has a minimum interaction with sales people. The process starts with downloading the Hointer app and scanning a QR code on several pairs of jeans that you want to try on. After choosing the jeans and adding them to your cart, you tap “try on” on the mobile app and it gives you a fitting room number. When you arrive in the fitting room, the items you selected are waiting for you. If the items do not fit, you are able to select new sizes from the app in the dressing room. When you return the jeans down the “reject” shoot, the items instantaneously disappear from your cart.7 This merging of digital technology with the physical retail items is what seems to be the future for physical retail stores.

### Fig 3.3 - Retail types and their shelf life.

*Diagram by Author.*

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The sales associate still plays an important role in retail which becomes more about service and product information than making a sale.

C. Components of a Store

**Entrance** - The entrance is the gateway to the store and must be dynamic enough to continually draw in customers. The highest priced and most sought after merchandise should be placed near the entrance for maximum impact. A transparent storefront is desirable to allow potential customers to view the full array of offerings.

**Wall Space** - The wall space is one of the most important areas in a retail store. In many retail stores, the walls are used to convey the design and branding of the store. Because walls are perpendicular to the customers eyes, they have a great impact on the feel of the store and product placement must be thought out by a highly trained visual merchandiser.

**Ceiling** - The ceiling typically holds one of the most important elements in retail, the lighting. Depending on the retailer and the products being displayed, there will typically
be very customized lighting that best highlights the space and the product. Retail spaces are typically brighter than other indoor spaces, making the quality and dispersement of the lighting of utmost importance to design. In addition to the lighting, the ceiling also contains the fire suppression system as well as diffusers and return air vents.

**Mid-Floor Space** - The mid floor space is typically filled with either lower shelving or tables to allow the customer to see to the back of the store. This space also determines the navigation through the store. While retailers have different strategies as far as pathways, each one has specifically studied which is most beneficial to their brand. The center ceiling space often consists of more generic can lights which direct light downward onto the products and tabletops.

**Shelving** - From my previous research I have found that there are generally two types of shelving. The most common type is on wall shelving that extends out from the wall. Tracks are attached vertically to the wall and the shelves are attached to the tracks. The second type of shelving system is embedded in the wall with the shelf height being the
only flexible element. While the aesthetics of each system can vary widely, the majority of systems fall into one of these two categories.

**Fitting Rooms** - Fitting rooms of the past were single utility spaces where customers would try on different outfits. In the future store, customers will additionally be able to virtually try on clothes, even clothes that the store does not have in stock. The fitting rooms could even suggest additional clothing items to go along with what the customer is trying on.

**Point of Sale** - The cash register most often appears in traditional retail stores, however, the current trends from retail leaders like Apple show that the cash register will either disappear or be largely supplemented by sales staff with mobile POS (point of sale) or with the customer directly purchasing the item on their smartphone in order to avoid lines. The two latter strategies allow the consumer the convenience of shopping online with the benefit of getting to see and feel the object in person before committing to a purchase.
**Back of House** - This is the part of the retail experience that customers rarely see. Because of this, design considerations are purely functional as the space typically consists of utilitarian areas such as employee restrooms, a break room, return bins, mannequin preparation, storage for overstock items, and offices.
IV. Prefabrication and Flexible Design

Why Prefab?

As mentioned earlier, while the architecture and construction industries are understandably slow to innovate and change their developed methods, they are falling behind other manufacturing based industries. The new and dramatically more efficient manufacturing methods of ships, airplanes, and cars is conceptually, if not directly, related to the possibility of using the processes in architecture. Ships, for example are created in sections called grand blocks. Each grand block is a completed segment of a ship that can weigh as much as 1,000 tons. All of the necessary systems are included within the grand block including structure and machinery. Additional modules are located within the grand block making for a second layer of prefabrication. The conceptual idea behind the blocks is important because it allows various trades to simultaneously work on systems within the same ship.

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9 Ibid., 75.
The automobile industry is also taking advantage of manufacturing advances. With traditional construction the car cockpit is comprised of 104 parts, weighs 138 pounds, and takes approximately 22.4 minutes to install. With a modular assembly the 104 parts are reduced to just one, the weight is reduced to 123 pounds and most importantly installation takes just 3.3 minutes. The implications for architecture could be just as profound. The example is given of a fiber reinforced resin beam and an air duct becoming one item. Cost would likely be reduced, the number of components would be lessened, and weight could potentially be lessened. While it is not necessarily in the architects realm of expertise to invent such a piece, pressure needs to be applied to manufacturers that have the resources to eventually complete such a task.

The primary reason for prefab to become dominant in the retail industry is that it allows for a quick change-out of one design for another. As can be seen in the design portion of the thesis, this can happen at many different scales. Prefabrication can also dramatically reduce waste on construction sites. In fact, very little “construction”, with the exception of the foundation, occurs in a prefab building. The building is assembled and disassembled rather than constructed and demolished. Even when a prefabricated

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10 Ibid., 91.
building has reached the end of its useful life, many of the elements within the assembly could still be reused. In addition to waste reduction, prefabrication also lends itself to more accurate cost estimating, something of utmost importance to retailers. Fewer details are left to chance, especially when assembly occurs within a standardized module. Because every detail must be predesigned and tested in BIM software, very few surprises will occur, leading to minimal change orders and a more predictable and potentially lower final building cost.

Prefabrication does come with its limitations, which at first glance, can seem daunting. The most prevalent limit within the realm of prefabrication is the size of the prefabricated element. It must be able to be transported from one site to another. Typically this involves the use of semi trucks which have to have the capability of loading or unloading the containers or an on-site crane needs to be present for delivery. The trucks must conform to local traffic regulations and be able to clear all overpasses, leading to strict maximum clearances that vary from state to state.
Precedents

The following precedents are the basis of the thesis research on prefabrication in architecture. Within the precedents, there are prefabricated systems, an architecture firm that specializes in prefabricated systems, small-scale prefab, and large-scale prefab. Each one offers a unique take on prefabrication and how it can be implemented to increase efficiency and quality in construction.

Broad Sustainable Group (large scale prefab system)

Broad Sustainable Group is the company that really sparked my interest in prefabrication. Based out of Hunan province, China, Broad has been leading the way in the rapid construction of skyscrapers. Recently, they completed a 30-story hotel in just over two weeks (15 days).\(^{11}\) This includes the interior finishes as they were pre-assembled in the factory. The methods developed are specified to the smallest detail to keep efficiency high and downtime low. This includes the order in which elements are placed on trucks from the factory to the construction site. Broad is able to fit two

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modules with columns, nuts, bolts, etc. on one truck load because the company made the decision to separate verticals from horizontals, thus freeing up space to more densely pack the truck. Once the truck arrives at the construction site, the module, along with all accessories needed for construction, is lifted into place by the crane. The buildings are not only efficient in construction, they are also mindful of the environment, reducing construction waste significantly. The buildings are incredibly strong structurally and are tested to withstand a magnitude 9 earthquake\(^\text{12}\).

The company’s next goal is to build the world’s tallest prefab (one of the tallest buildings in the world) in a matter of months. Delays have plagued the project from the beginning, mostly due to the government. The company stands ready to restart constitution whenever they get the approval. While the methods of construction are an advancement in our profession, the building design will likely leave many architects questioning the worth of these methods. While I agree that the design could be greatly improved (scale, relation to context, volumetric studies, etc.), I also see the value in the method they have developed. I believe that architects can study this method and adapt

it to become more flexible. Even if the changes take 50% longer to construct, the method would still be a dramatic improvement in efficiency.

**Kullman Building Corp. (prefab system)**

In the past few years one of the most prevalent prefab manufacturer’s, Kullman, published the *Kullman Modular Architecture Manual*, which is intended for informational purposes to assist architects wanting to design a prefabricated building within the Kullman system. It is also, however, a comprehensive guide to modular architecture in general, which is a specific type of prefabricated architecture. Because the document is detailing and describing a specific existing system, it is far more in depth than the typical prefabrication-based informational book. Its weakness as a general informational prefab document, however, is in the fact that it only speaks about Kullman’s system and not other proven methods as well. The 100-page manual talks not only about the design of the system (the main focus of this writing), but also of equal importance, the installation and assembly of the system.

The design of the system is based on modules that are typically a maximum dimension of 13’ x 52’, slightly larger than a typical shipping container. The maximum
height of a module is 12’ with a maximum of a 12-story building. While it might seem at first that this is rather limiting, once fully considered, it is clear that the system allows for a wide range of design that will only be limited, not controlled by the system. The module size is predominantly limited by the maximum size of an oversize load on a road as allowed by state law. This can vary slightly from state to state. Ceiling heights are rather limited by this approach, while column spacing is more flexible. Clear spans along the modules are possible if the standard beam depth is increased or if Kullman’s interstitial truss module is used on top of the module for added support.

Along with the structural modules, Kullman also offers service and restroom modules. These modules are able to bring the most efficiency out of any modular component because of the numerous trades that typically need access to this part of the building on the site. The systems installed in the spaces can be kept more organized and closer to the original plans. Connections have to be made from module to module to make the pipes and ducts continuous.

Certain inefficiencies occur in the system such as double walls and double structure that can significantly add unneeded materials and structural steel to the project when compared to traditional construction methods. This is the biggest drawback for a totally modular prefabricated system. If the system were more panelized, more labor on site would occur, but much less redundancy would exist within the building.

While modular architecture should be an option in the arsenal of prefabrication, it is hard for me to recommend that it is the sole way that a company completes its prefabricated projects. While the overall shape of the module is not limited to a rectangle, other limitations such as the limited ceiling heights are more problematic. Many advantages and disadvantages exist within the different methods of prefabrication that it seems limiting if architects are limited to only one. This could be a major contributor to the fact that Kullman when out of business at the end of 2011.

**Loblolly House (innovative prefab)**

The Loblolly house, designed by KieranTimberlake, was constructed completely of ready-made components and offsite fabrications, but took an entirely different attitude about assembly when compared to the Kullman building system. The project was
constructed for Stephen Kieran, part owner of KieranTimberlake, which allowed a
greater deal of flexibility and for the project to be treated as an experiment. This
removed the risk and complexity of the client/architect relationship. It is located on
Taylor’s Island, Maryland on the coast of Chesapeake bay. The project was completely
designed and virtually assembled using BIM (building information modeling) software
allowing the designers to see conflicts within systems helping to avoid typical site delays
that arise from such problems in traditional construction.\textsuperscript{14} While the primary structural
elements are Bosch off the shelf aluminum members, many of the connectors had to be
custom fabricated.\textsuperscript{15}

Most houses that are constructed today are assembled from thousands of
individual parts, one at a time.\textsuperscript{16} The Loblolly house is built from preassembled
elements that dramatically reduce the number of components leading to a much shorter
construction time with less waste and fewer problems. Kieran and Timberlake
established a concept that revolved around scaffold being assembled to hold all of the

\textsuperscript{14} Why Design Now?: Loblolly House, YouTube video, 17:06, posted by cooperhewitt, Feb 10, 2013, \url{http://www.youtube.com/watch?v=wZUpjzr2NV8}

\textsuperscript{15} Ibid.

\textsuperscript{16} Ibid.
prefabricated elements and modules. As illustrated on the previous page, the Loblolly House is assembled of various elements attached to a scaffold. Kieran and Timberlake refer to them as cartridges, which are essentially floor or wall modules, and blocks, which are typically entire rooms (such as a restroom). These terms represent a new idea of construction and assembly. They are specific to note that the building is assembled, not constructed.

The manufacturers, like the architects, virtually assembled and built the prefabricated components in the computer before they ever began fabrication. A key challenge in the construction of the house was to create the connection between the high tolerances of the foundation to the low, exact tolerances of the aluminum frame. Once the connection was established, the construction continued at a much faster pace. The systems (mechanical, electrical, and plumbing) were all integrated within the modules and just had to be connected on-site. The Loblolly House serves as a prime example that factory produced architecture can be high quality, site-specific design.

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17 Ibid.

Many principles from this house can potentially be applied at the retail scale. The extruded aluminum framing system offers flexibility that is currently unrivaled by any other system. This system allows for a design that is able to be changed, disassembled, scaled, and easily customized with connectors that fit into the t-slots.

**Anderson Anderson Architecture (mixed element prefab)**

A prefabricated building can be designed with many different methods in mind. Anderson Anderson, an architecture firm out of San Francisco has an alternate way of thinking about prefabrication and design. In the early theoretical introduction to the work of Anderson Anderson, the authors state their reasoning for interest in the construction method of prefabrication.

“If the focus of prefabrication is, on the one hand, primarily in the area of cost savings alone—whether from the point of view of producers or consumers—or, on the other hand, if one views prefabrication as a superficial design style rather than a comprehensive systems approach, then the full promise of increasingly industrialized building construction will be much diminished...”  

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This particular statement exemplifies how the advantages of prefabrication must exist together to allow the system to fulfill its true promise. The savings in construction cost could potentially allow for a higher percentage of the building cost to be put towards materials, features, and quality. They mention that not everything can be prefabricated and that a role for hand crafted elements will always exist.20

The “Cantilever House” designed by Anderson Anderson Architecture is another example of a prefabricated house. Instead of using an aluminum scaffold like the Loblolly House, they opted for a steel frame because of special structural circumstances. A small footprint with larger upper stories was advantageous because of the challenging topography and geotechnical conditions. A single prefab system would not give the architects the desired results so they chose to take advantage of the benefits from multiple techniques to ensure a low-cost, high quality, site-specific design. By introducing several established manufactured systems, there is a reduced cost when compared to creating an entirely new system. The steel frame that constitutes the primary structure of the house allows for several flexible variables including the

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20 Ibid., 18.
relationship of the building to the site and the configuration of the frame and the
building skin.²¹

The idea to use multiple types of prefabricated techniques is important because
it allows for a much greater flexibility in the design. By having a primary structure and
attaching prefabricated elements, a highly customized design was possible. Many of
the other prefabricated buildings that I have studied rely on one system for the entire
design. It is obvious that compromises have been made in order to stay within the
constraints of the system. The prefabricated systems used in the design are of simple
and typical construction methods, but combined in a carefully studied manner.

Outside of the main structural steel system, the architects chose to use SIPs
(structural insulated panels) as the primary thermal and weather barrier. The panels
extend from the bottom of the structure to the top, reducing the number of small parts
needed for assembly. The combination of these simple systems helps to achieve the
architects’ primary goal from the outset; to create a basic structure that allows for
customization at any time during the life of the building.²² The SIPs were also used for


²² Ibid., 117.
the floor panels (and roof) which need additional insulation because of the direct exposure to the exterior environment.\textsuperscript{23} The additional customization of the modules could be anywhere from a desk unit, exterior deck, or window boxes to electric generation panels, all with minimal modifications to the existing structure.\textsuperscript{24} The idea of applying totally different systems together to create one building is one that should be considered when designing retail. Just because a certain system can do something doesn’t mean that it should. The system or element that is best for the task should be used regardless of the other systems used in the project.

**Miami Valley Hospital (large-scale prefab)**

The Miami Valley Hospital in Dayton, Ohio is the first large-scale hospital to use a high degree of prefabrication in the United States. Both the construction company (Skanska) and the design firm (NBBJ) had nothing but positive remarks regarding the fluency of the design and construction process. The prefabrication techniques used on the project led to higher quality construction, zero construction injuries, and a

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\textsuperscript{23} Ibid., 122.

\textsuperscript{24} Ibid., 117.
construction timeline that was shortened by more than two months. The 35% of the building that was prefabricated, including many complex mechanical elements, patient rooms, and patient restrooms, was completed in a warehouse two miles away from the construction site. The warehouse was rented for the duration of the project by the construction company. The primary motivations of the use of prefabrication were to reduce construction time, improve quality, reduce cost, reduce the need for a staging area on a tight urban site, and to reduce the impact on the environment.

The main structure of the project was a traditionally built steel frame with the prefabrication consuming most of the interior elements as noted above. Full prototypes were constructed and tested during the design process to ensure that the clients were happy with the design. The design of the room had to be split in three parts for transportation purposes. BIM was a key ingredient in making the project successful as was coordinating with consultants and the construction company early in the process.

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As seen in Fig 6.9, all of the mechanical systems look exactly how the drawings portray and are labeled and organized saving potential future maintenance costs. With some parts of construction, such as plumbing, there was a 300% gain in productivity from a factory setting compared to a typical standard construction. Although the savings in cost with this hospital were minimal (around 2%) both architects and the construction company think that this number will rise as they assess the positives and negatives of each new prefabricated project. Even though 2% might be a small number, it would quickly add up when translated across hundreds of retail stores.

**IKEA BoKlok (prefabricated branded housing)**

BoKlok is a housing line created in a joint partnership between IKEA and Skanska, the construction company in charge of the Miami Valley Hospital. The BoKlok buildings exist in Europe, primarily in Sweden with more than 5,500 units in existence. The original idea was to create high-quality, affordable housing for the masses. The company is largely based on research conducted on typical household sizes and the

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28 Ibid.

amount of rent that a certain sector of the population was willing, or able to pay for housing. The goal was to reduce cost by 30% compared to a typical construction project. Each house is designed with a courtyard and windows are concentrated on the south and west sides of the facades to allow for an abundance of daylight in the house. Also, because the buildings are primarily located in the cooler climate of Sweden, this excess heat would lower the utility costs for owners. Most BoKlok projects are grouped together instead of doing singular residences, which depending on the resident, could be either a positive or negative characteristic to this experimental company.

The success of the BoKlok company is likely largely driven by the success of IKEA, a large international home goods manufacturer and retailer. Because the same house and apartment buildings would be built over and over again, prefabrication was an obvious choice. IKEA presents interested buyers with the total monthly payment of the house before it is purchased, making cost of ownership is easily understood.31

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31 Ikea and Skanska, “The BoKlok Story.”
Prefabrication allowed for numerous competitive advantages for BoKlok when compared to competitors. The houses and apartments had significant pricing advantages, minimal construction times, good quality and functional design, peaceful locations with connections to nature, as well as ecologically minded housing.\(^{32}\) While the design is understated and simple, the popularity and success of the company is hard to ignore.

**St. Ignatius Chapel (tilt-up prefab)**

St. Ignatius Chapel, in Seattle, Washington, uses precast concrete panels for its exterior walls. While not a typical prefabricated project, this is an exemplary use of a low cost method used in an unconventional way to create a building. The rectangular form of the chapel is assembled from 21 tilt-up slabs.\(^{33}\) The slabs were precast on-site in horizontal forms with the exterior face upwards so that the points of connection to mount the slabs would be exposed and eventually covered with a bronze cap, alluding to the construction methodology. After being cured for 18 days, the slabs were then raised and

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\(^{32}\) Gomez, Idone, Meuschke, Tebaul, “BoKlok, Sweek BoKlok.”

\(^{33}\) Smith, *Prefab Architecture*, 312-313.

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*Fig. 4.16 - St. Ignatius Chapel. Image from author.*
assembled in only 12 hours. The thickness of the material is exposed on the four corners where slabs overlap and interlock.\textsuperscript{34}

Windows occur where the interlocking precast panels join together. Stone veneer was originally envisioned for the project, but the integral color concrete panels give a more tectonic and architecturally honest representation of what is truly occurring. Each panel had to be constructed in a certain order to allow for the assembly to be completed. The crane did not release the panels until they were properly braced, allowing for structural connections to be made. The entire building envelope was completed less than 20 days from the original onsite precast pours.\textsuperscript{35}

Because of the panelized nature of tilt-up concrete, the joints become extremely important. Similar challenges will arrive when designing the retail system. The architect deliberately placed the joints between panels at specific places, often adding windows where joints occur, reducing additional labor and creating a unique architectural statement that gives reason to the placement of the windows.

\textsuperscript{34} Ibid.

\textsuperscript{35} Ibid.
DIRTT (interior prefab)

Prefabrication can occur on an interior scale as well. DIRTT which stands for Doing It Right This Time, is one of the few manufacturers of prefabricated interior systems (that are not cubicles) that has arisen within in the research. The company is relatively new, but has been quite successful in their early years. The system used in their design is proprietary to the company. They design and manufacture the system, providing an end to end solution for their customers. Their system covers most interior surfaces except for the ceiling. They have a raised floor panel system as well as power and network distribution, door design, millwork design, along with panelized wall design.

While the company is attempting to cater to many markets, healthcare and office design seems to be their most successful. Also, the system appears to be rather stationary in that it stays in place once it has been assembled. This is a key difference between the core concept of my proposed system design and DIRTT’s existing system. I feel that they are not taking full advantage of the inherent qualities of a modular system, which is the ability to quickly adapt. Because of the prefabrication process and that DIRTT also manufactures their own design, the company does have a reputation for being able to quickly serve customers with a high degree of quality and accuracy.
Shipping Containers as Prefab Architecture

Shipping containers in architecture have become more common in recent years and are no longer a new, unexplored area of the profession. The use of a shipping container in architecture can be considered modular architecture. Shipping containers were first developed in the 1930s as companies looked to make shipping more efficient. In 1970 the International Standards for Organization (ISO) container design was introduced and changed the landscape of the shipping industry.36

A surplus of empty, unused shipping containers has accumulated at many ports across the world because the cost to ship the empty containers back is more than the cost of a new container. As of a few years ago, an estimated 700,000 abandoned containers existed in American ports because of our large number of imports and small number of exports. This has created a used market for shipping containers that can be purchased for as low as $1500 each and around $4000 new. This price can vary depending on size and regional demand. Standard heights of containers are 8’, 8’-6”, and 9’-6” with widths being 8’ and standard lengths of 20’ and 40’37.

37 Ibid.
The inherent structural capacity and durability characteristics are what draw so many architects to the idea of using these containers in the built environment. Most containers are able to be stacked between 5 and 15 high (depending on internal loads) without additional reinforcement. They are able to easily withstand earthquakes, hurricanes, and hard environments. These containers are meant to be moved, but most shipping container designs do not take advantage of the transient characteristics. The tolerances of construction are +/- 3mm, creating a tight constancy that is ideal for interchangeable architectural systems.\textsuperscript{38} The methods for moving, connecting, and placing these containers are all built into the container structure, meaning that a container could immediately enter a interchanging building system with no major modifications.

There are a few disadvantages to using shipping containers in architecture besides the obvious size constraints. Thermal insulation and noise isolation are issues that must be dealt with for the architecture to be successful. In response to the thermal insulation problems, techniques have been developed that include furring out the exterior of the shipping container, adding an exterior skin, or treating the steel with a

\textsuperscript{38} Ibid.
ceramic-based insulation coating. These techniques all try to avoid shrinking the internal size of the container to an even smaller size. If the outside of the container is altered, however, it will lead to a less durable container when it is moved. This must be considered for non-stationary shipping container architecture. Noise isolation, on the other hand, is more simple to deal with because each container only touches at a few certain points. Plumbing and HVAC must be fully thought-out and adapted to the shipping container structure. Depending on the nature of the building, if shipping containers are stand-alone, they each house their own HVAC unit, but if they are interconnected, service containers are used to run pipes and ductworks to all spaces.

Shipping containers have previously been used successfully in retail with the most prominent example being the traveling Puma Store. I had a chance to visit the Puma store while in San Francisco. This particular variation was comprised of ten separate 40' containers with two of them being stacked two stories high. The store is moved from city to city in the shipping containers. It has proven to be a successful model that has been expanded over the years to include several variations. This is one

39 Ibid.
of the few designs that truly takes full advantage of the shipping container ability to be easily relocated.

In addition to the Puma store, pop-up malls have recently been assembled in England and New Zealand. Both of the malls are primarily made from shipping containers, but like most other shipping container architecture, the design does not take full advantage of the transient capabilities of the containers. Boxpark, in London, England, is a semi-permanent structure with an expected stay at its current site of 5-10 years. After this time, the building will likely attempt to relocate to another location in London. Boxpark attempts to integrate name brand retailers such as Nike and Puma in with lesser known local retailers to keep the pop-up atmosphere at the forefront. One of the major problems that I find with Boxpark is the lack of connection with the street. The doors are open to the street, but merchandise displays do not come out and visually grab the consumer. From the street, each store looks the same. Retailers value being able to stand out and show their brand to the public, before getting the consumer to enter the store. Because of the standardized design of the Boxpark Stores, very little individuality is able to be shown by the retailers until they get the customer into the

store. The largest downfall of Boxpark is that the pop-up idea is not engrained in its design. It is not an event when a new store arrives, it is merely similar to what happens at every other retailer when a new store arrives. At Boxpark, the term pop-up simply means that short term leases are available, it means very little with respect to experience, design, or culture.
V. shop-NEXT: The Future of Retail Design

The realm of retail occurs at many different scales from a small independently owned store to large department stores, it is important that different scales are studied to determine appropriate solutions. Together these different solutions join together to create a system called shop-NEXT. The system is comprised of three scales starting with shop-PART (system scale), shop-BOX (small store scale), and shop-YARD (department store/mall scale). These three components of the system will work together to create a retail landscape unlike anything we have today. The key goals in creating the system are flexibility and the ability to quickly modify designs at small, medium and large scales. With this flexibility, the system lends itself to consistently change and give consumers new experiences.

A. shop-PART [system scale]

The shop-PART system is a key component in the overall design of the future retail experience. The shipping container (shop-BOX) component allows for entire stores to be swapped out quickly, but what about when those brands want to change a
the look of the store? The shop-PART system is comprised of three primary elements which are the framework, the skin, and the plug-ins. The combination of these three elements, along with the standardized dimensions of the shipping containers, allows for a system that can quickly transform from one design to another. Every element that is a part of the system can be fully disassembled and reused; nothing is demolished. This specific system is designed to sit inside of shipping containers, but its use could easily be implemented in more transitionally constructed retail spaces.

Currently in retail typical transformations consist of graphic changes that consumers may or may not notice. I am proposing that a much more dramatic change, akin to a total renovation, happen several times a year. The quality of the material should be in proportion to the duration it is in use. The characteristics should lend themselves to be lightweight and easily transportable. In the end, it will be up to the retailers to decide how to best use this flexibility. The system is designed so that it can be altered for different kinds of retail such as clothing, electronics, and shoes. The system, as well as the retail spaces that come from that system are able to be easily reconfigured spatially, functionally, and aesthetically. This is essential to give the most value to retailers who would choose to use this system over traditional methods of
design. The sections below are intentionally left vague as to not prescribe the design of each component. These three elements must be able to successfully and uniquely brand a store to the company’s liking.

**Framework**

The framework is the main structural component of the shop-PART system and could be compared to a wall stud in conventional construction. The framework is entirely made from extruded aluminum with t-slots, which were used in the construction of the Loblolly House by KieranTimberlake. This framework allows for a core structural component that is easily and quickly moved and rearranged. The extruded aluminum system can be assembled and disassembled with basic tools allowing almost anyone to reconfigure the space within the shop-BOX. Depending on the scope of the alteration, an electrician might be necessary if lighting is altered. The electrical changes would be rather simple as the system allows each panel of the skin to be placed on hinges meaning that the interior portion of the wall is easily accessed. The ideal design solution, however, would have a “plug and play” lighting solution (outside of the scope of this thesis) that would be user friendly to changes, not requiring a certified electrician for
alterations. While the framework is used only in shipping containers in this thesis, it could be easily used in place of transitional construction in more typical retail spaces.

Skin

The skin is the simplest of the three elements and primarily consists of a panelized material. That material can be anything from metal panels to drywall or even plywood depending on the needs of the company. The standard recommended material would be a metal panel that is attached to the framework. As mentioned earlier, each panel would be able to swing 90 degrees like a typical door swing to allow access behind the panels for any necessary electrical wiring alterations when the design changes. The panels are double-sided allowing for a store to flip the panels and have an entirely different interior environment.

Plug-ins

The plug-ins element is where the system shows its true flexibility. Using the t-slots in the extruded aluminum framework, plug-ins can attach in between the edges of each panel. Plug-ins can be display shelves, flat panel televisions, hanging rods,
mirrors, interactive virtual fitting rooms, etc. As long as a connector could be designed to fit into the t-slot, the possibilities for the plug-ins are nearly endless.

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**B. shop-BOX [store scale]**

The stores, which are contained within one or multiple shipping containers are inherently modular, making it easy to increase or decrease square footage. In addition, because of the transient nature of the shipping container module, they are easily moved across the country and world. Not only will the size and location of the store be flexible, but the entire interior layout will be easily transformable with the use of the system (shop-PART) detailed in the previous section. As mentioned earlier, movable shipping container stores are not a new concept. Boxpark, in London, England, is comprised of shipping container stores, the design does not lend itself to rapid replacement of the containers. While it is true that Boxpark could be moved to a new location with minimal demolition, the concept is not to be a rapidly changing retail space. In addition, most of the retailers at Boxpark and the few other shipping container shopping spaces, use traditional interior construction methods such as drywall which can't easily be manipulated, reducing flexibility.
Each store will be self-reliant in that it will contain its own HVAC in the form of a PTAC (packaged terminal air conditioner). This is a similar system that is used in hotel rooms that allows each container control of their climate as well as providing heating and cooling with one small unit. This requires that the rear of the store be accessible to fresh air. Because the size of each unit is standardized more established companies could potentially sell their used merchandising systems to less established retailers in a secondary market, offsetting a rapid design change cycle. The size of the stores are much smaller than today’s typical retail setting, making it even more vital that new methods of merchandise storage be developed. I propose that the stores only have display items (one of each size for customers to try on), while excess merchandise (what customers actually purchase) is stored in a more efficient manor in a less valuable part of the site. This will allow retailers to fully take advantage of their space rather than wasting it on redundant products. In some cases, merchandise would be stored off-site and shipped to the customer after the purchase is complete.

Stores could also function as stand-alone pop-up units rather than only being a part of a large grouping of containers. The frame of the shipping container would be kept in tact while the sides could open and expand to create a dynamic consumer

Fig. 5.5 - shop-BOX complete (above) and being disassembled (below). Image by author.
experience. In the case of a mall type design, the store specifics would be left up to the individual retailer. In the example designs, it was assumed that the spaces would primarily be showrooms and that the point of sale (cash register) would be sales associates with mobile devices or customers with their own smart phones. The shop-BOXes would be shipped to the shop-YARD location with all of the necessary inventory already in place. The back stock could also be stored within the store as it is being shipped and moved to the shop-YARD storage area once the box has been installed. The company has to have inventory delivered no matter if the store is traditionally constructed or prefabricated. By using this existing transportation, the additional cost of moving boxes is kept to a minimum.

shop-YARD [department store/mall scale]

The shop-YARD is a retail space with multiple shop-BOXes and infrastructure to support them. The modularity of the system lends itself to many different sizes and locations. Because of its scalability, not only could the system succeed in primary markets, but the system also could easily succeed in secondary and tertiary retail markets. The shop-YARD could have several hundred containers or as few as five or
six. The interchangeability of the system would allow more exclusive, high-end brands the opportunity to enter unconventional markets. Because a module might only be at one of shop-YARD locations for a few weeks to a month, long term viability would not be a concern for the company. If they can create enough hype for the time they will be at the space, they will be profitable. The goal of shop-YARD is to create a dynamic, ever-changing shopping experience.

The design of shop-YARDs will mostly depend on the availability to move and stack the containers. In larger locations, cranes could be built in to the architecture allowing a shop-BOX to be swapped out at any time. In one concept a double leg gantry crane is on a track and is able to move the containers laterally along a specified linear path. These types of cranes are similar to what is used in small warehouses and a much smaller version of what is used at major shipping ports. On smaller scale sites, trucks with loading and unloading capabilities would become the preferred method. The side loader truck can typically stack containers two high although some can go as high as three. A roll-off truck is able to pull forward and leave the container sitting on the ground. The roll-off truck requires a significant amount of clearance (double the

![Fig. 5.7 - Concept diagram of shop-YARD showing boxes transferring between different locations. Image by author.](image-url)
container length + 20') to be able to operate successfully. In addition, trucks with built in cranes and storage for the containers are the most flexible option.

Although the larger scale design shopping center with the integrated container mover would have significant expenses with the installation and maintenance, it would be greatly offset by the initial construction savings. The shop-YARD would only have a fraction of the constructed square footage of traditional shopping centers, while still offering the same variety of goods. Several of the containers would be fixed and house the restrooms, mechanical infrastructure, and other required spaces. Because each store is limited in space and has become a showroom for the brand’s items, the storage of merchandise had to be rethought. Each store will likely only carry enough of each size so that people can try on the clothes or shoes on, or in the case of electronics or other hard goods, enough so the items can be experienced. Unlike traditional stores, the majority of the inventory will not be displayed on the store shelves. Instead, retailers will have a large space in a less valuable part of the structure in which to store excess merchandise.

The shopping experience of the shop-YARD does not only differ in its innovative and constantly changing design, it fully harnesses the capability and widespread use of

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Fig. 5.8 - Combination options for larger stores. Image by author.
the smart phone. Customers will make the purchase using their mobile device or a store-supplied device for those without a smartphone and either have their items shipped to them or receive their items at the pick-up location when the are finished. This will encourage shoppers to go to more boxes because they won’t be worrying about the bag they are carrying around. In addition customers could use the app to request specific boxes and see what boxes are currently at shop-YARD and which ones will be there in the near future. The future of shopping is in customer interactivity. Customers will have the ability to choose the stores that they have available to them, creating a connection and loyalty between themselves and shop-YARD.

C. Design Project Conclusion

The proposed design project is one of many potential solutions to the future needs of retail. Using the methods and information gathered in the thesis research about both prefabrication and the future of the retail industry, a project was designed for a very specific purpose, to project the physical store into the 21st century, allowing it to more closely compete with and supplement the continuing surge in online shopping. By creating a dynamic, nimble experience for brands and store owners, they are able to
quickly adapt to changing trends and new products, giving them the necessary tools to constantly create an enriched consumer-oriented experience. In going forward with the thesis, I would look at alternate design methods to achieve an invigorating retail experience as well as the bigger picture of the proposed design method and the necessary logistical solutions that would have to arise for the idea to realistically function. In addition, many more options of the existing system could be explored as well.

The end project is one of many scales and varieties, which is precisely the point of the entire design. An ecosystem, from large scale to small, was created to allow maximum flexibility of the retailers and to gain the most potential interest from consumers. One of the most interesting aspects of realizing this idea is that it could start small, possibly as small as one shipping container. The shipping container could move as the project and idea matures and progresses. The small scale component (shop-PART) of the thesis could be easily built within existing buildings with extruded aluminum profiles that already exist combine with a minimum amount of custom fabricated pieces. The idea of the thesis is not just limited to the one building type made from shipping containers, it is meant to be more widely applied to the retail industry as a
whole. If it is just limited to a few projects, the true impact potential of the idea has not been accomplished. A fundamental change in the way we think about physical retail spaces is needed to compete with and gain customer share back from the internet-only stores.

The original goal of the thesis was to create an improved architectural system that takes advantage of prefabrication technologies to improve the flexibility of current retail design. The typical shopping experience will have to adapt if transitional retailers will compete with their online counterparts. The architecture will have to integrate in with the mobile devices to create a seamless, ever-changing experience that online virtual stores cannot match. The physical retail industry is an important part of our culture that must change before it is too late. The systems presented in this thesis have the potential to start a shift in the retail landscape. Shopping in stores will become much more about the experience and less about the transaction. If the stores adapt to the times and take a more active role in an effort of constant self-revitalization, I believe that physical retail stores will not only continue to exist, but they will thrive in the marketplace.
VI. Bibliography


