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protoHouse: Searching For New Form

by

Onezieme Mouton

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REQUIREMENTS FOR THE DEGREE

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ABSTRACT

protoHouse: Searching For New Form

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The end of the twentieth century is marked with the debut of the information age and the beginning of a global society. The dynamic properties of urban landscapes throughout the world are escalating to new levels in direct response to the new social, political and economic paradigms that are being imposed by this new phenomenon. While the dynamic properties of urban landscapes are escalating, architectural innovation in regards to the individuals of modest means seems to be lagging far behind. The protoHouse is an attempt to realize new building types in response to the global influences upon the local condition. With Houston, Texas serving as the typical global city for this study, the protoHouse is a full scale model constructed around the concept of an individual in a dynamic urban landscape. The protoHouse is a modular structure that is able to be easily constructed, deconstructed, transported, and reconstructed by an individual. The protoHouse falls short of being able to be classified as a complete house, and lands more in a category of being a supplement to a house or a temporarily occupied structure.
I have been extremely fortunate to have had the opportunity to work this project, and I am indebted to many people for this privilege, especially Rice School of Architecture, Metalab, and most of all, my wife Toni.
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BACKGROUND

Houston, like many other metropolitan cities at the end of the 20th century, began undergoing rapid and brutal transformations, not only in regards to its continuous sprawl over the natural landscape lying beyond its fragmented perimeter, but also to its own interior urban landscape. Most, if not nearly all of these changes are being carried out by large corporate conglomerations.
Capital Shapes

As the property values escalate and the "house-to-property-value-ratio" decreases, single family dwellings are becoming economically forced into demolition and being replaced with three or four story townhouses where there at least three units per lot. This economic paradigm has shifted the developmental control of the neighborhoods from individuals to corporations where all new housing is speculative in design, and most construction doesn't begin without a pre-construction sale.
A residential neighborhood of 80 city blocks adjacent to downtown Houston was completely razed and rebuilt with new luxury town homes. Some social services were provided by the city for the displaced elderly who qualified. Relocation assistance was not provided to the other residents who were forced to move because there are no laws that require private developers to do so. This process of gentrification is not unique to Houston. The social implications of this phenomenon are summed up in the following statement: "The real threat is not the Balkanization but the Brazilianization of America, not fragmentation along racial lines but fissioning along class lines. Brazilianization is symbolized by the increasing withdrawal of the white American overclass into its own barricaded nation-within-a-nation, a world of private neighborhoods, private schools, private police, private health care, and even private roads, walled off from the spreading squalor beyond. Like a Latin American oligarchy, the rich and well-connected members of the overclass can flourish in a decadent America with Third World levels of inequality and crime." (Lind, 1995 p.14)
Another strong component that is helping to shape the urban landscape is the officially "unrecognized" population of immigrant workers. Many industries and small companies depend heavily on this illegal labor force, who without any legal backing are often forced to live under abject conditions.

It is because of these situations and others like it that this project aspires to discover an alternative housing type.
The Do-It-Yourself Home Improvement Industry has offered a new paradigm to the idea of housing and home ownership. The many able-bodied persons capable of "getting the job done" without the help of "professionals" are a fundamental parameter in this search for a new kind of building type. It is therefore critical that the solution is readily available to the masses, either through local home improvement centers or dot-com retailing. By establishing this as a parameter, it is therefore also necessary that the solution be relatively simple to construct and not depend on specialized skills or professional assistance.
One or Two
By establishing the Do-It-Yourself approach as a parameter, the solution must be able to be implemented by one's self, or with very little assistance. Doing-It-Yourself in this scenario means doing it on your own time, usually after work and on weekends, in probably somewhat of a piece-meal sort of fashion, maybe with the help of a family member. Doing-It-Yourself implies not being dependant on others for labor.

Conventional Vehicle
The components must be transportable from the point of purchase by a conventional vehicle. The idea of having the whole "kit-of-parts" delivered to the site by truck is a practical possibility, but in consideration for future expansion or purchasing the components in incremental stages, transportation by a conventional vehicle grants independence from minimum orders and delivery fees.
Adaptable

In response to the situations where real estate prices are escalating so rapidly that single family dwellings are being forced into demolition, protoHouse takes on the parameter of being a building type that is not permanently affixed to any particular site. In order for it to survive in a dynamic urban landscape, it must be able to adapt, transform, and retreat as the cycles of change ebb and ebb in the city. To facilitate this parameter, protoHouse is to be solution that can easily be deconstructed back into a kit-of-parts and reassembled or reconfigured an unlimited amount of times. By taking on this characteristic, protoHouse will also be taking on the characteristic of being a low-impact-structure in regards to the landscape because it will be completely removeable without leaving behind any part of its structure. The cycles of reconstructing protoHouse can vary greatly in terms of time. Perhaps the situation exists where the structure is moved weekly or on an event-based occasion, or perhaps it is moved only once every 10 years. Either way, it is a solution that offers flexibility to the individual and the landscape.
Gypsy Caravans

After establishing these parameters, the Gypsy caravans of southern France were at the forefront of my thoughts. I had the opportunity to study them as an architectural type a few years before as a recipient of the Morris R. Pitman Award. The modern Gypsy caravan is a pull-behind-the-car-camping-trailer. Though perhaps lacking in the mystique of the horse-drawn caravans depicted by an early Picasso painting, these modern versions function much like their predecessors.
A Way Of Life

To start off with, I think I should state for the record that the Gypsies who live in the caravans choose to do so as a way of life. There are government programs in France that either place those in need in public housing or assist with living expenses. Many persons of Gypsy descent choose not to live in caravans. But those that do however, seem to have made the transition into modern lifestyle while still maintaining the nomadic freedom of their ancient cultural heritage.
Essential Box + Outside Living

What I find most interesting about the caravan lifestyle is the combination of an essential box (the caravan) and outside living. Within the essential box is shelter from the elements, facilities for cooking, sleeping, bathing, and a restroom. Everything is of a very efficient design and minimal proportions. The outside living is usually facilitated by some sort of temporary canopy or umbrella immediately adjacent to or attached to the essential box, and there are usually tables and chairs underneath them. These spaces usually serve as an exterior living and dining room.

Appropriated Space

By making use of the outdoor space that surrounds the caravan, this style of living can be thought of as an appropriation of the immediate exterior space by the essential box. Whenever the caravan reaches its destination, it expands to include more living space.

moveable + permanent

The caravans which are mobile by design are not always used as they are intended. Many of them are rarely moved, some as little as once every five years or whenever the entire
community relocates. Those caravans which aren't frequently mobile tend to accumulate more permanent features such as built in place additions, wash houses, and gardens. Still in these circumstances, the essential box still serves as the nucleus for the living unit, and the exterior space and outdoor living are a vital part of the overall function.

**Freedom**
The inhabitants of these caravan communities are afforded an incredible amount of freedom and security by their living conditions due to the fact that they essentially become home owners for a small sum compared to a conventional house, and their home is not tied to any particular location.

**Ganging Up/Expansion**
What even makes this architectural scenario more interesting is when the caravan community is looked at as a whole. When immediate family members group their caravans and temporary outdoor living extensions together, a more spatially complex entity is created. These groupings often combine with each other and form a relatively large socio-architectural structure made of small and rather simple components.
Street Cafes

The idea of appropriating the immediate external space is not limited only to the Gypsy caravans. Another model which makes use of this idea is the European or sidewalk cafe. When the weather is agreeable, most people choose to have their refreshments on the outside of the cafe rather than on the inside. The European, and especially French, cafe usually has some sort of temporary umbrella or canopy that extends over or into the public domain of the sidewalk. The interior of the cafe serves as the “essential box” and the exterior is the extension of the interior and the two separate spaces function together as one entity. The wall that divides the two separate spaces is usually made of glass and is often times completely retractable. The exterior space is dependant upon the interior space to give it its purpose and function. By placing the furnishings under the temporary canopy and opening the partition wall of the interior/essential box, the exterior space becomes charged or activated. When the essential box is closed, the exterior is deactivated of program and function and is simply the exterior of the essential box.
Taco Stands

A more dramatic example of an essential box charging an exterior space can be found all over the great state of Texas (and elsewhere) in the form of the Taco Stand. These essential boxes have canopy doors that lift up into an awning position and activate the space directly below it on the exterior. The canopy door extends the domain of the essential box while at the same time, creating a transitional space where interaction can occur between the exterior and interior functions.
Mechanic Garages

I came across a very unique mechanic's garage in Houston where the entire wall lifted up and became a canopy. The essential box was transformed into an open pavilion when the huge canopy doors were lifted. The disappearing walls were not only a source of light for the interior but the work space was dramatically increased as a result. To be confined by the interior dimensions of the essential box would have made it practically impossible to have a functioning auto mechanic's garage in that structure. In the evenings, the canopy doors are closed and the contents within are secured.
There are many locations in Houston where abandoned gasoline stations have been converted into hand-carwashes. There are even some instances where young carwash entrepreneurs have borrowed the idea of the old gasoline station and reduced it in scale to fit their specific need. In the example shown here, the owner used a portable storage shed and added on a covered extension. This is another example where the brains of the operation are contained by the essential box and an area exterior space is defined by an extension of the box, and that area becomes activated as a secondary component of the box when the box is being used.
Tail Gates

As I began thinking more closely about the building type, I began observing other types of structures and began to realize elements that could be very useful. One such element was the tailgate of a pickup truck. The tailgate is a component of the wall system of the bed of pickup truck. It hinges down to expand the space when the occasion arises, and hinges back up to act more as a container when necessary. It is also a device which allows a different kind of human interaction with the space defined by the walls of the bed.
**Draw Tite**

Another device that I noticed from the pickup truck was the Draw-Tite towing system. It is basically a rectangular version of a pin-and-sleeve connection. It offers a rigid connection for a wide array of devices to be easily slipped in and slipped off.
Scaffolding

After noticing the rectangular pin-and-sleeve connection of the Draw-Tite system, I notice the circular pin-and-sleeve connection of a scaffolding system. I've always been intrigued by the rigidity, the easy assembly, and the volume or scale that is possible to achieve with the few simple components of a scaffolding system.
Signs

Another device or system that caught my eye was the road sign technologies, especially the simple fastening systems of adhering the flat sign panels the cylindrical supports systems.
Fencing

The simplicity of the moving devices in the chain-link fencing industry was incredibly interesting. Very durable, galvanized steel clamps, with teeth that clamp onto cylindrical poles create yet another different scenario of pin-and-sleeve connection for gate hinges. These components are installed field installed, and conventionally used in a vertical alignment, but they may be used in a horizontal alignment also.
Unistrut

Unistrut bills itself as "the worlds most versatile framing system." This idea of a mass produced component system of construction will also be used.

Summation

The process of researching and investigating these building types and devices was also a process of defining the direction of the thesis by editing the choices and observations as well as developing a fragmented schematic design. Not all of the building types and devices that made it into the finished project are shown here. Some ideas entered into the project through the suggestions of others during the design/building phase and will be pointed out later on in this document.
Rough Sketches & Models

The process of investigating and editing continued throughout the duration of the project. Most of the time the process involved photographing an existing idea and making rough sketches about how to translate that idea into a workable solution for the project. At first I thought that perhaps at least some of these ideas that I observed could just be used "as is" in this project, but I soon came to accept and realize that the ideas could only be conceptually translated into the project because all of the existing
designs were too specific to fulfill the my particular objectives. I didn’t begin working on a physical design until I had accumulated what I thought was enough observations and fragmented ideas. Once I reached this point, I began designing by working on a physical model. Using bass wood and working at a one inch scale, I began assembling the fragmented ideas together, trying to keep in mind the properties and dimensions of the materials that would eventually be used, but also using the model as a working model or constantly evolving sketch. Working at a one inch scale allowed for moving parts to be primitively developed and changing ideas to be reworked into the model.
Rigid metal tubing
1/8" x 1/2"
Shop welded to hinge
and gusset plate

Two 1" x 1 1/8"
Metal tracks
Forming female
Sleeve fitting.
Screwed to
Male/Rigid tubing.
Putting It In Photos

Once the working model reached a certain level of completeness, I began superimposing it over various site specific backgrounds in photo collages. Besides depicting the design in various states of being opened or closed, and helping to provide a sense of scale for the final product, these photo collages also helped display a temporality that I had hoped the final project would be able to achieve.
Wednesday, October 18, 2000

Worked on physical model.

Visited Frederick Scaffold Co. Picked up Catalog of parts, looked around. Leveling jacks, walkboard locks, and swivel clamps were inspiring. Everything was inspiring, but these are the only parts that appear to be "affordable." The system itself is very expensive I find.

Thought about the pick-up truck tail gate as an inspiration for a wall system. The bottom half of the wall folds down and creates an extension of the floor plane, and the top half folds up and creates a canopy. The swivel clamps from the scaffolding company could maybe be used for the support bar swivel for the canopy. Scaffolding "inserts" (that connect scaffolding vertically) could maybe be used as a pivot system for the "tail gates."
Detailing/Hard Lines

After reaching a schematic satisfaction with the physical model, I began trying to figure out the details of the connections with hard-line-drawings. Always at the forefront of this process was reality that the design solution would be something that I would have to pay for and/or fabricate myself. In the beginning of this phase of the project, it wasn’t clear to me that I was still very much in the schematic stage of the design. Several components of the hard-line-drawings had to be reworked several times as the project developed as a whole. It wasn’t until after the Thanksgiving holidays that after several weeks of repeating this process I felt I was ready to begin construction. I had seven weeks until the presentation.
DETAIL OF CANOPY DOOR
DETAIL OF ROOF PANELS
DETAIL OF TAILGATE-DOOR

- 2" x 2" x \( \frac{1}{8} \)" ANGLE
- \( \frac{3}{8} \)" METAL STUD 16" O.C.
- \( \frac{3}{4} \)" PLYWOOD

- 3" x 2" STANDARD HINGE
- \( \frac{1}{4} \)" x \( \frac{1}{2} \)" STOP
- \( \frac{1}{4} \)" PLYWOOD
- METAL STUD 16" O.C.
- \( \frac{1}{2} \)" P.T. CDX PLYWOOD

- 2" x 2" x \( \frac{1}{8} \)" ANGLE
- 2" x \( \frac{1}{2} \)" x \( \frac{1}{8} \)" ANGLE
- \( \frac{1}{4} \)" x "O" UNIV. MILL PLATE

- 5\( \frac{1}{2} \)" x 3\( \frac{1}{2} \)" SQ. TUBING
DETAIL OF TAILGATE-DOOR

3/8" x 3/8" SQ. "UBING

HINGE MADE FROM
5/8" x 1 1/2" H.P. STRIP
5" x 2" x 1/8" TAB
5/8" x 1/8" BOLT
4" x 1/4" CHANNEL

3/8" x 3/8" SQ. "UBING
DETAIL OF TAILGATE-DOOR II

3/8" Sanded Birch Ply

2" x 1" x 16GA.
Pext. Tubing 16" O.C.
Welded to Horiz. Sleeve

Horizontal Sleeve
Slotted 1/2" MEC- Tubing
Welded to 1" x 2"
Rect. Tubing

Horizontal Pin:
1" Sch. 40 Pipe

Steel Stop:
1/2" Sch. 40 Pipe
Welded to Horiz. Pin

Sleeve for Vertical Pin:
1/2" Sch. 40 Pipe
Welded to Channel

4" x 1 1/2" Channel-
Spanning Vept. Supports

Vertical Pin:
3/8" Round Bar
Welded to Horiz. Pin

3/4" x 3/4" x 3/16" Rect. Tubing
DETAIL OF TAILGATE-DOOR II

- 3" x 3" x 3/8" RECT TUBING

- 1/2" Sanded Birch Ply

- 3" x 3" Door Hinge

- 1/4" x 4" Plate

- 1 1/2" Wood Stop

- 1/8" Sanded Birch Ply

- 5/8" OSB Screwed To Joist

18Ga 1/2" x 1/2" Metal Joist 12" O.C.

- 5/8" OSB Screwed To Joist

- 2" x 2" x 3/8" Angle

- 1/2" x 10" Plate

- 4" x 4" x 1" Tab Welded To Tubing, B.C. To Plate

- 1 1/2" x 1 1/2" x 3/8" Angle Seat Welded To Tubing

- 3/4" x 3/4" x 3/16" RECT. TUBING
Beginning Without The End

I think that time is a designers best friend, even when it’s working against you. Realizing that I just barely maybe had enough time to finish the construction, I decided to begin the construction even though I had not resolved all of the design problems and details. I had to make the leap of faith that I had enough of the design completed to begin construction, and that I would be able to figure out what remained as the project developed. Once I started this trajectory, I was forced to rely heavily on intuition. I began working on the project more like a sculptor that an architect or contractor. I would generally develop hard-line/working drawings at night, which would consist of cut lengths and angles for raw steel stock, and execute them the following day. I found that working in this was a real workshop method, where the building design comes directly from the building process.
Metalab, Joe & Dave, Tools, Etc.
There's no way that I could have ever conceived of doing a full scale project like this without the benevolent support of the Meta-Dudes, Joe Meppelink and Dave Sisson, two very energetic and entrepreneuring fellows. They are both fellow graduates of the Rice Graduate School of Architecture. Joe graduated the year before me, and Dave the year before him. Together they started
Metalab, a custom design, fabrication, and installation firm while they were still students at Rice. Metalab, which began with very modest means, grew very rapidly into a full scale steel fabrication and production house. I kicked the idea around with Joe very early on in my thesis semester about creating a full scale model for my thesis project. He was very enthusiastic about the idea and very encouraging about the possibility of using their facility to build it. With that in mind I continued to develop the idea of a full scale model. When I was sure that I was indeed up for the challenge, I approached Joe and Dave again about the idea, and they made an extremely generous arrangement with me. They provided me with an adequate space inside their metal shop to construct the project, and unlimited use of their tools and equipment. During the process of building the project, Joe and Dave were also extremely generous to me with their time and technical expertise. There's no way that I would have been able to pull off this project with out there support. I forever thank them.
The Documentary

I love dancing, acting, moving images, and moving buildings. All of these things were incorporated into the making of a documentary video which documented me making the protoHouse. I wanted to make a documentary to show the process and the amount of work involved in the project. Since the protoHouse is composed of components, the repetitive nature of the fabrication process made a good opportunity for filming. Because of the fact I was working solo on this project and I only had access to one video camera, I would place the camera in one location, work on a piece, and for the next identical piece I would relocate the camera. Doing this several times yielded a rich body of footage to edit from. I ended up really enjoying the way the documentary was turning out and found myself in many instances re-enacting a lot of the non-repetitious tasks just so that I could relocate the camera and capture the process from a different angle. This exercise proved to be a worthwhile adventure and the documentary ended up becoming an integral part of the presentation.
Raw Materials: Some by Truck, Some by Fox
The first quantity of steel that I ordered was large enough to be delivered free of charge by truck. After the initial delivery, the quantities that I would order were too small for free delivery and therefore I began transporting the materials on the rack of my personal S.U.V. Keep in mind that all of the materials purchased could have been transported on my S.U.V., it would have just taken more than one haul.
First Step
Once I had cleared out a space in the Metalab, the first thing I began to construct was the flooring system. The idea was to construct two bays of an elevated steel frame somewhat like a conventional steel bed frame. The dimension of each bay was to be approximately 8 feet by 12 feet, and dimension of the two bays together was to be approximately 12 feet by 16 feet. These elevated frames or trays were designed to be three lines of steel girders, connected by rigid braces. The corner points were to act like struts where a girder and a bracing tied in together with a vertical column and an adjustable foot. A sub-flooring system of stressed-skin-panels would then span from girder to girder, and a finished floor would cover the sub-floor panels.

The Panels
The first element of this system that I constructed was the sub-flooring panels. They were constructed by screwing 7/16 inch oriented strand board (OSB) to both sides of a 3½ inch, 18-gauge metal-stud frame. I
wanted to use the full uncut dimension of the OSB and I also wanted the finished-flooring system to be uncut sheets of ½ inch birch plywood (three sheets per bay). So in order to prevent the seams of the sub-flooring panels from falling in the same vertical plane as the finished flooring seams, four of the sub-flooring panels were made from the full uncut dimension of the OSB, and four were made by cutting the OSB in half, along the longitudinal axis. It ended up being necessary to trim the length of the steel studs by about ½ inch in order for them not to extend beyond the dimension of the OSB. The full size panels (4’x 8’) weigh 150 pounds, and the half size panels (2’x 8’) surprisingly weigh half as much. Once the flooring system was fabricated I had a secure dimension to determine the exact spacing of the girders and braces.
The Struts

The struts are approximately 18½ inches tall by 3½ inch square and are made of 3/16 inch steel tubing. Theoretically, there are only three different models: the center strut, and a reversible pair of end struts. In actuality however, each one in this prototype is slightly unique due to the inner seam of the rectangular tubing. I wasn’t aware that I would have to grind a groove in the columns in order to insure an easy fit, and therefore, the seams are not consistent with one another making each strut, and consequently each column unique. In order to keep the struts and columns organized I developed a labeling system for this prototype. The two
longitudinal lines of struts are named lines one and two. The center perpendicular line is named C, and the end perpendicular lines are named X and O respectively. Thus the struts along line one are named X1, C1, and O1, respectively, and the struts along line two are named X2, C2, and O2 respectively. (See plan at bottom of page 42.) The tabs that are welded onto the struts are 3/8 inch steel with ¼ inch punched holes, and an angle seat was welded below the tab that the connects to the girder so that the bolts are in compression rather than shear. A cap with a 1½ inch hole was made of ½ inch steel and welded onto the bottom of the struts. After the struts were galvanized, the bottom faces of the struts were ground down and a nuts for a 1 3/8" threaded rod was welded over the center of the holes. This would serve as the connection for the adjustable screw foot. The same size nuts were then welded onto a 12" lengths of 1 3/8" threaded rods, and screwed into the struts.
The Girders

One of the hardest problems to resolve in regards to the girders was getting the weight down to a reasonable level. In order to get the depth necessary needed to resist deflection, the weight options of available sections made the members too heavy. In order to achieve a workable weight, a custom member had to be fabricated. The lightest practical solution was to use a $\frac{3}{4}$" x 10" x 12' steel plate and weld 2" x 2" angles to it in order to form a seat for the stressed-skin panels to sit on. The overall weight of the center girder which had angle seats on both sides was 160 pounds. The end girders which only had one seat weighted 130 pounds. Once the girders were made, a strut was fastened to each end forming a girder line. Each girder line was placed approximately 8 feet apart and awaited to be connected to each other by the braces.
The Braces

The braces do not carry any vertical loads from the stressed-skin panels. The panels span from girder to girder. The braces help hold the panels in place and resist the lateral loads that are placed on the lower part, or foundation system, of the structure. The braces were made by drilling holes in the ends of 4" channels and fastened with ½" bolts to the tabs on the struts. The member is oversized in order to compensate for torque loads that may applied to it by connecting components in the future such as a tailgate door, steps, etc.

The Foundation System

Once the braces connected the girder lines together, the stressed-skin panels were placed into the steel frame. A problem occurred when placing the panels in the frame. I hadn’t compensated for the thickness of the welds on the top of the angle seat and the panels were pushing the frame out of square. To compensate for this, the bottom edges of the panels that rested on the girders were beveled.
The Columns

The columns which are just over 9 feet in length are made of 3" x 3/16" square tubing and weigh approximately 60 pounds. They slip into the struts from the top and rest on the bottom plates of the struts. They are then pinned through the struts to resist any upward loads. Steel sleeves were welded at intervals along the column to serve as connection devices for various components such as shear panels, doors, canopy arms, and things yet to be designed. There are theoretically only two different models of columns, a middle column and a corner column. But as mentioned earlier in the strut section, each column is slightly unique due to the groves that were ground in to compensate for the inner seams of the strut.
The Horizontal Ties

Once the columns were in place, horizontal ties were made of 1" x 3" x 16 gauge rectangular tubing. A pin made from 1" round bar was welded to the edges of the rectangular tubes. The pins dropped into the sleeves that were welded on the columns and tied all of the columns in together.
The Rafters
The rafters were made from 2 1/2" x 14 gauge square tubing. A tail-piece that was welded on to form a rigid joint, slips down into the open top of the columns. The tail piece is pinned through the column to resist upward loads. The tips of rafters were beveled to form a butt connection at the apex. They are held together by a saddle-sleeve that is part of the ridge component. Tabs were welded on to the sides of the rafters to enable the purlins to be attached.

The Ridges
The ridges are made from 1 1/2" round tubing with rigid saddles welded to each end. These components slip onto the rafters from above and are then through-bolted to the rafter pieces. The saddles were made from 16 gauge sheet that was sheared and bent into a channel shape. An angle was then taken out of the walls of the channel which then allowed it to be bent into the same angle as the rafter apex. The joint was then welded and ground so that the round tubing could be attached.
The Purlins

The purlins were made from galvanized 1" x 2" x 16 gauge rectangular tubing. Holes were drilled on both ends of the component to correspond to the threaded holes on the tabs of the rafters. On one end of the purlins, the top edge was notched out so that it could be slipped into place from below. This allowed made the installation possible to be done by one person.
The purlin is slipped over a tab and hangs on the rafter that is away from the installer and holds it up while the installer screws the purlin to the tab on the near by rafter. Then the ladder is moved and the purlin is screwed on the far rafter. Besides making the installation possible by one person, this design also hides the connection from the view below.

The Shear Panels
In order to achieve enough lateral stability in the columns, shear panels were made to be placed in one corner of the structure. One panel covers the entire vertical plane of the bay, and the other is a truss that spans the top 16 inches of the bay. They are both made of 16 gauge tubing of various sizes (1" x 1", 1" x 2", or 1" x 3").

The Vertical Doors
Three vertical doors were made of 16 gauge tubing to hang below the truss/sheer panel. The two doors on the end were hinged to the columns using the same pin-and-sleeve connection that the horizontal ties and shear panels use. The center door was hinged to one of the end door by conventional door hinges. All three doors swing so that the bay can be completely or partially opened, and the double hinged doors can be configured to form a partial enclosure or straight wall on the exterior of the structure. All three doors were skinned with flat fiberglass panels.

The Canopy Doors
The canopy doors are attached to the horizontal ties with conventional door hinges and hang down to the
midpoint of the bay. They can be pivoted upward to create a canopy or awning over a completely open window. Arms attached to the columns with pin-and-sleeve connections swing out and hook onto the canopy doors on each side to hold it in its upward position. The canopy door is skinned with flat fiberglass panels, and when they are in the upward position, the fiberglass panels tuck under the roof overhang extending the drip edge during rainfall.

**The Tailgate Doors**

The tailgate doors work in conjunction with the canopy doors to completely open the vertical wall plane and to extend the square footage of the floor plane. This is perhaps the most intricate component of the structure. It attaches to the braces of the foundation system by a pin-and-sleeve connection. The sleeves are welded to the braces, and the pins are welded to the hinge pipe of the tailgate door. The hinge pipe of the tailgate door is sleeved by three joints of 1½" mechanical tubing. A frame made of 1" x 2" x 16 gauge rectangular tubing is welded to the three joints of mechanical tubing that sleeve the hinge pipe. A fold-down-foot is connected to the frame in each upward corner of the tailgate door. When the tailgate door is pivoted into the downward position, the fold-down-feet hold the door in the horizontal position. When the tailgate door is in the downward position and the canopy door is in the upward position, a covered porch is created.
The Finishing

At this point it became clear that time was running out and wouldn’t be able to complete all of the door I had designed. Two bays of the structure would remain open. The focus of the project then turned to the finish-work. I originally wanted all of the components that would come in contact with the elements to have a hot-dipped galvanized finish, but there were several problems with this desire. The first was that the galvanizing industry is not known for its delicate handling of materials. I learned this through observation at Metalab where they tried to dip delicate members and they were returned bent by both the heat of the vat and rough handling. Another problem I was forewarned about was that in order to dip a piece, there cannot be any enclosed air pockets and therefore holes would have to be drilled into the components such as the door frames with regard to function rather than aesthetic. The third problem I was forewarned about was that many times small openings were sometimes clogged by the galvanizing process and the consistency of the coating thickness varied. This could have been a problem for components such as the columns were sleeves were welded. I was concerned that the pins would no longer fit
into the sleeves. So with all of this in mind, I decided to only hot dip the foundation system: the struts, the girders, and the braces.

I decided to powder coat the door frames and the shear panels because they could not be galvanized, and also because Allied Powder Coating had a reputation with Metalab of handling things with extreme care. In addition to this, they pin-and-sleeve connections could also be masked and plugged which would prevent any changes in tolerances. After seeing the results of the powder coating, I fell in love with the finish and decided to powder coat the columns, rafter, and ties as well. This would undoubtedly put me over budget, but I decided to proceed anyway.

In order to apply the finish to the components, the structure had to be dismantled and delivered. It was then reassembled at Metalab so that the fiberglass panels could be applied to the doors, the corrugation could be put on the roof, and to fine tune all of the other details. This would also serve as a timed trial run for reconstructing the protoHouse.
The protoHouse reached its final state of completion at Metalab the afternoon before the presentation. That evening, with the help of a few very good friends (Dave Dupont, Elizabeth McQuitty, and Nicole Blair), the finished protoHouse was deconstructed and packed into a large moving truck. Even though all of the components are moveable by conventional vehicles, it would have been too complicated to line up enough conventional vehicles to get all of the parts...
to the school gallery in an orderly and timely fashion. All of the components were moved out of the gallery by a conventional vehicle after the presentation.

After a late night of loading the moving truck, everything was in place for a move the next day. I arrived at school with the moving truck at approximately 1:15 p.m. when the last presentation in the gallery was just finishing. I had prearranged for several of my friends to help me unload and reconstruct the protoHouse in the gallery, as well as for someone (Nik Nikolov) to video the process. With even more people showing up to help than I had anticipated, we began unloading
and reconstructing the protoHouse in the gallery at 1:30 p.m. We had a full hour to make as much noise as we wanted because the presentations were halted for a lunch break. With approximately 15 people assisting, the protoHouse was completely reconstructed in 3 hours. This even includes having done a few on site extras, making few small errors of planning on my part, and having to work quietly during presentations that were going on nearby. The reconstruction process took on the air of a barn raising, and with many people of the school stopping by periodically to check on the process, it was also like a performance piece being performed for an audience.

For the 5:00 presentation, the video footage that Nik shot of the construction process and the video documentary I made of the fabrication process were projected simultaneously in the gallery.
AFTERWARDS

Tear Down

The protoHouse was allowed to remain in the gallery for one week, after which it was once again deconstructed and moved. This move however was a little different than the previous move from Metalab. I deconstructed and stacked the protoHouse by myself, and then the next day, my friend Alex and I moved all of the components in 5 loads on my conventional vehicle.
Next Destination

The next destination was 401 Peden St. (a.k.a. my back yard) Alex and stacked the components on the back deck, and later on I reconstructed the protoHouse again with the help of my grandfather.
Setting it back up

This would be the first time that the protoHouse was constructed where it was exposed to the elements of nature, and not sited on an existing foundation. In keeping with the temporal nature of the protoHouse, 16” x 16” x 4” precast concrete pads were used for the foundation, and ½” steel shims were placed between the concrete pad and the strut to help disperse the load. The parts of the roof that were left open for the presentation in the Farish gallery were covered with a clear PVC corrugation. There still remains a lot work to be done on the protoHouse. The idea from the beginning was to have a full scale working model that continue to evolve and test new ideas, and hopefully it will remain just that.