DESIGN PAPER SESSION

Manufactured Processes

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Industrialization techniques in architecture since WWII, including prefabrication and mass production, have been predicated on the standardization of building systems. This methodology of the mass production of materials and resultant building types has been through the use of a uniquely designed and built prototype. While overall configuration could change, tectonics and standardized components were understood to be inflexible, since they had to be identical for mass-production. Since this time, however, designers have begun to no longer view form generation as fixed and ideal, but to instead view its creation as supple and transformable. Through the use of Computer Numerically Controlled (CNC) production processes, new methods of fabrication that manufacture building components directly from 3-dimensional computer data arise and ultimately allow for the introduction of differentiation into mass production. The introduction of specific computational design software has enabled the development of non-standardized building systems through material studies and the use of serial logics. Thus a new paradigm emerges, where local variation formulates continuous, yet differentiated, global structure.

The manufactured housing proposal presented here explores the development of tectonic systems composed of repeatable yet non-standardized building components. This design seeks to capitalize on the change in mass production from the paradigm of the standard or rigid to the multiple or loose, by complicating the relationship between prototypes and tectonic components. The proposal also seeks to augment the current shift within the industry from the stereotypes of impoverished "trailers parks" of yesterday to enriched "land lease communities" of today by infusing what has been traditionally low culture with high technology. Finally, the proposal seeks to offer a new view of manufactured housing that values strength, durability, affect and desire, borrowing strategies from the origins of manufactured housing, the automobile industry. The product would sponsor an image of lifestyle, spatial effects, and aesthetics that lead to more than comfort and stability, but a new type of living 'performance.'

Manufactured housing developed from models of industrialization that have assumed the use of standardization and mass production of identical elements. Industrial production has required the use of factory-based machines built specifically for the purpose of fabricating specific products; the more repeated elements made, the larger the income to offset the cost of production. This allows manufacturing industries to produce a high number of elements for a lower price; it also homogenizes production, thus reducing the design process to one event: the production of a prototype. Design is thus reduced to a singular event predicated on the tooling of a unique machine.

This factory-based paradigm made modular living systems possible, the first being the mobile home which developed in the 1930s as the recreational vehicle industry.[1] After world war II, as standardization broadened the consumer market for commercial products, architects saw industrialization as the way to supply the massive demand for post war housing. Conceivably, an affordable, residential kit of parts could be fabricated on a large scale then purchased and assembled anywhere.[2] For example, Carl Stranlund began one such experiment in his production of the "Lustron House." As a prefabricated house, it was comprised of vitreous enameled steel panels and came complete with environmental control systems and domestic appliances. It was sold as a car, demonstrated by a franchised sales force in nationwide showrooms, then brought and erected at the site. While supported by government funding, the company was unable to efficiently assemble the over 3,000 components in the promised 150 hours and the project failed prematurely.[3] Other more successful experiments, such as John Entenza's Case Study Housing Program in Los Angeles in the 1950s, offered industrial parts assembled into multiple configurations.[4]

What distinguished the manufactured housing industry from the majority of post-war housing experiments, was that these houses were not merely assembled prefabricated parts, they were entirely assembled in a factory and shipped to distribution sites nationwide. The factory-built house had three benefits over a site built house: improved construction quality, increased work efficiency and decreased cost of production. Currently, a typical manufacturing facility can produce 8 homes in about 8 hours with a factory of 250 people at an average cost of $35,000. Figure 1 shows the typical current configuration of multiple separatized components within a standard

manufactured house. This process encouraged, however, not only the repetition of exact housing types within a neighborhood, but even at a nationwide scale— the same house could be in suburban Atlanta, Peoria, or Sacramento. Construction occurred nationwide as well, since the manufactured housing industry located its factories in easy distribution zones based on regional needs to keep transportation distances and costs low. As living modules, they became perfect housing products, inexpensive to make, requiring almost no design, endlessly repeatable and movable to any site. A single model could be generically distributed across the nation regardless of context, cultural difference or individualism.

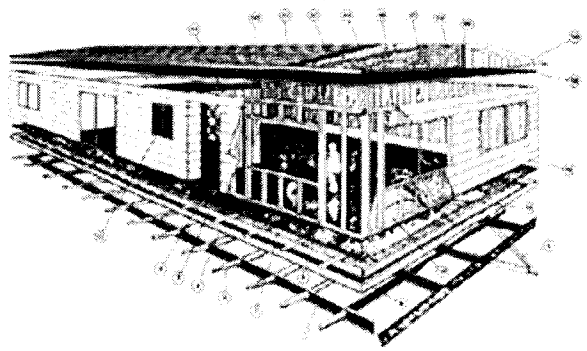

Fig 1: A typical current configuration of multiple separatized components within a standard manufactured house.

The manufactured housing industry currently does not employ a single architect, yet it accounts for approximately 40% of American homes built today. Currently, 21.4 million people in the United States live in manufactured homes, roughly 7.6 percent of the total population of the country. This translates into 8.9 million manufactured homes in the US.[5] While the history of manufactured housing has limited individuation, with the development of new technologies and a rethinking of construction methodologies, there exists the potential for mass-produced customizable houses. The role of designer can reemerge in what had become a significant method of producing domestic space.

NEW PARADIGM

New design and fabrication processes, fostered by software and production technologies, offer the potential of mass individuation— multiplicity rather than the multiple. The prototype, initially the extent of the design process embedded within a singular object, can now be thought of as the process itself, the set of rules or formulas by which variations emerge, extending the design process much further into the production process. Rather than casting an element by using a specific mold, the mold itself becomes fluid. It opens a determine system of manufacturing into an indeterminate one of potential. This loosens and complicates the relationship between the idea of prototype and the tectonics which emerge; it also significantly tightens the relationship between the designer and the product created.

Inevitably, using three-dimensional software techniques then fed to a CNC milling machine, as Greg Lynn states "it is simply as easy to make 1000 unique objects as 1000 identical ones" and the design process is extended to the moment of physical creation.[6] The translation of three-dimensional information into two dimensional milling paths where the information can be variable without impacting the cost of production allows for the creation of continuous yet differentiated structures.

The possibility of manufacturing variable product frames the exploration and reconsideration of the building construction industry as a process of production and assembly versus conventional manual building practices. The more instantaneous modeling and construction of a tectonic system— as a set of constraints, with specific limitations of material, fabrication technique and program— allows for immediacy between the designer and the building processes; there is a tightening of the relationship between the fabrication and the design that reclaims, for the architect, a position in the construction processes and, therefore, industry. The design is less beholden to the limitation of the fabrication process and can instead explore the almost unlimited extent of what the digitally-activated machining can accomplish.

The potential of mass modulation allows assembly procedures to simplify. The elements themselves are no longer identical copies of the designer's intent reliant on the complexity of their integration and assemblage, but are instead unique responses to individual desires building complexity and originality into each component. Thus beauty is inherent, and does not rely on the skill or experience of assembly labor. This is occurring already with the automobile industry, which no longer relies on the limits of developing one machine that can only produce one part. Factories can now be organized around a series of reprogrammable machines that can produce multiple parts or components. The machines are designed for a series of constraints or parameters [generic process] rather than a series of specific products [generic objects].[7] The previous method relied on standardized components with variations of assembly; now the components are variable and the assembly more immediate.

The potential in this area of housing production can also be linked to a closely aligned industry, the fabrication of mobile homes. Within the mobile home, there is a desire for seamlessness which can be seen in several of the systems. The first is the relationship between the interior surfaces and furniture elements. The concept of the 'built-in' allows an almost indistinguishable relationship between

program from enclosure. Architecture at the detail scale perfectly aligns with continuous larger elements.

The second seamless element is the relationship between vertical and horizontal surface, or between wall and ceiling much like the continuity found in automobiles. This is due to the requirements of how surface and frame are interconnected and economic strategies of internal square footage or volume. In looking at the predecessor to the mobile home, the Airstream fuses both chassis and living area volume or frame; thus surface and structure become inextricably linked, as shown in figure 2. The automobile industry has taken this one step further in the development of the Audio A8 frame, seen in figure 3, which transitions continuously between the structure and surface of the car allowing the structure to flatten and respond to the nature of the overall performance of the envelope.[8]

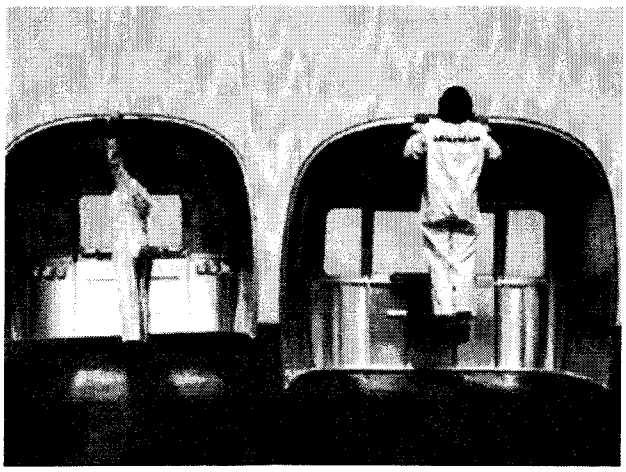

Fig 2: Airstream fused both chassis and living area volume or frame.

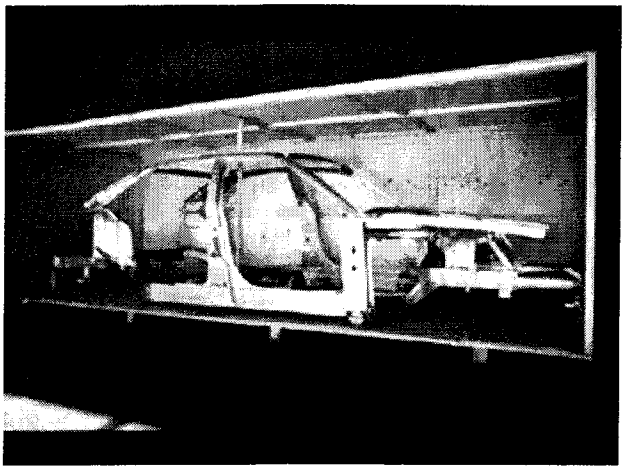

Fig 3: The Audio A8 frame, showing the relationship between surface and structure.

Thus, within this proposal, there is a desire to integrate multiple systems into fewer systems— reducing the complexity of assembly, but opening the potential in the complexity of integrated design. A single, intelligent surface can then perform the functions of what used to be a set of standardized components as pieced together.

This new paradigm which extends the design process through the development of a more articulated, multi-functional surface has the potential to radically change the relationship between design and production of manufactured housing. Our design project and paper proposal is thus to combine multiple systems into singular ones, to create structurally superior, individuated, customized housing which seeks to elevate both the aesthetics and operation through an extended design process completed through new production methods that employ CAD CAM software and CNC milling procedures.

THE DESIGN PROPOSAL

This ongoing research project involves transformation of three primary elements: structure, surface and space. The current structuring model for a manufactured house involves the assembly of framing and chassis. In our proposal, these two components are combined into one structural surface through the creation of wells or corrugations that act as stiffeners, as seen in figure 4. What would typically be thought of as a frame and panel system can now be modeled on the shipping or freight container system: the inflection of the surface provides structural stability and stiffening to reduce components to a single system. Manufactured housing owner often replace the cheap quality flooring located above the chassis. Here we alleviate this problem by fusing the two systems, instead of providing a steel multiple w-section chassis, we offer a stamped steel, single surface chassis; we extended this logic to the ceiling and roof assembly as well. Ultimately, like the Audi A8 frame, structure becomes surface and surface becomes structure.

The transformation of surface, in relationship to structure, came in the development of a panel assembly. Our initial consideration was for a 'thickening' of the individual panels, in response to interior program considerations, just as a Winnebago utilizes hollows or cavities for storage purposes while simultaneously creating a seamlessness between both multiple materials and embedded programs. We first established a module in terms of the specific panel locations; these thickened walls would then interlock to form larger compositions at the scale of the wall, as shown in figure 5. The programmatic responses work primarily at the scale of storage, shelving, seating, but also inhabitation.

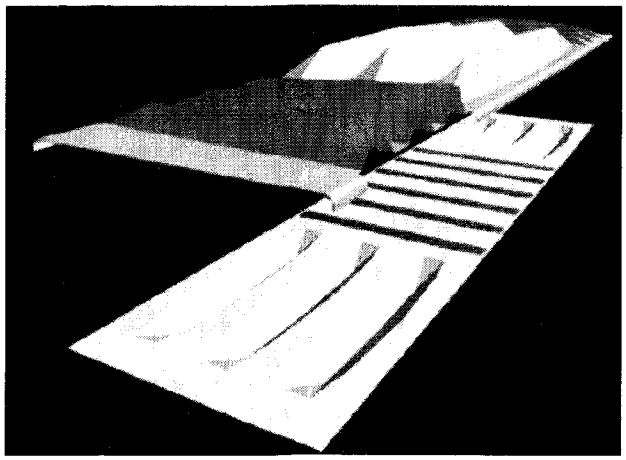

Fig 4: Design Proposal surface steel chassis.

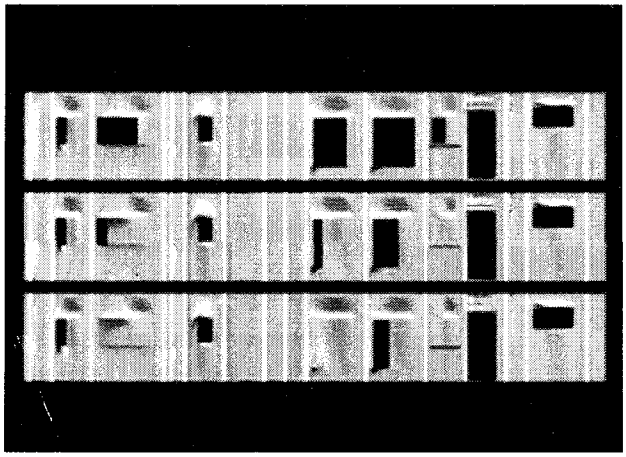

Fig 6: Surface modulation to show changing openings.

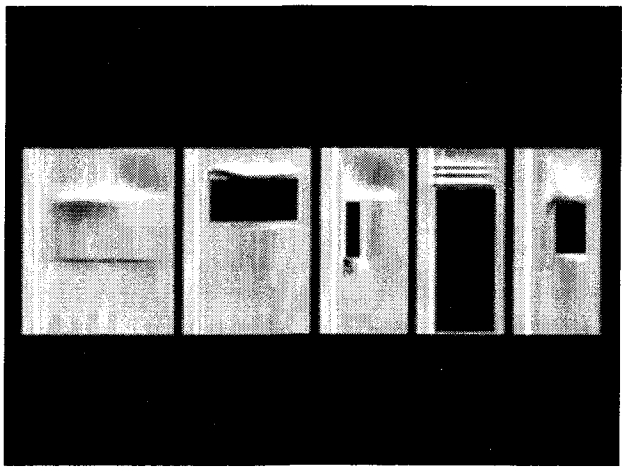

Fig 5: A panel assembly showing surface modulations.

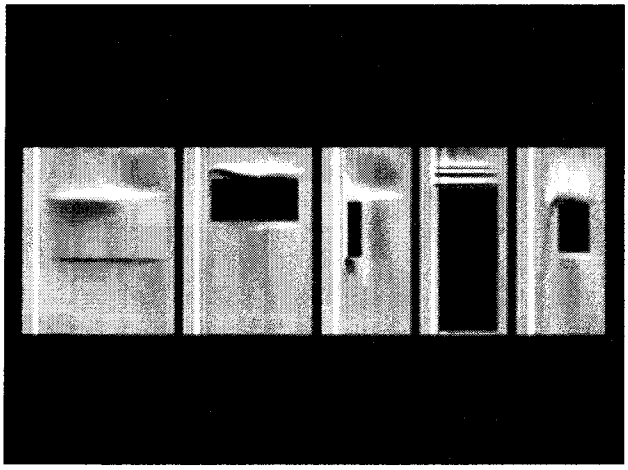

Fig 7: Digital panel assembly.

The second consideration, in terms of the panel system itself, was for a response to the exterior shell and potentials for fenestration. For both the interior and exterior panel modulations, we used the Expressions tool, found within the Alias|Wavefront software's Action Window, to determine the scale of the individual openings as well as the specific profiles of the fenestration. The fenestration is not simply a series of cut outs, however, in a modulated skin, but instead can be thought of more as a set of tears or shreds allowing for a more continuous surface development. The windows do not upset the changing surface, but instead allow the seamless introduction of a new material, glass. Figure 6 shows this modulation.

The shift here, then is from the assumption of an exact module of panel repeated identically to one that has the potential for infinite variation thus affecting elevation, section, space and program. Alias|Wavefront software can then be translated into CAD CAM software to be directed to a CNC mill. The process involves the translation of a three-dimensional sets of information into a two dimensional path that the machine uses to eliminate material thus leaving the desired surface. This information, once passed to the 3 axis CNC mill, allows it to create, a form for the panels to be cast over. Figures 7 and 8 show both a digital version of the panels and the analog, or milled, versions. The casting process is essentially a vacuum forming process which forces a finish material to the contours of the mold (figures 9 and 10). The formed panels were then cut at the edges of the formwork and tack welded together after having had been slipped together at the spine edge, creating a structural bond through interlock. This seaming technique was also adapted from the methods used to make large-scale container industries corrugation technique.

When combined, the individual panels create a single landscape or elevation of the variant surface modulations, based on both interior content, meaning program, and exterior protective strategies, such as rainshields, awnings over openings, etc. A collaboration of form

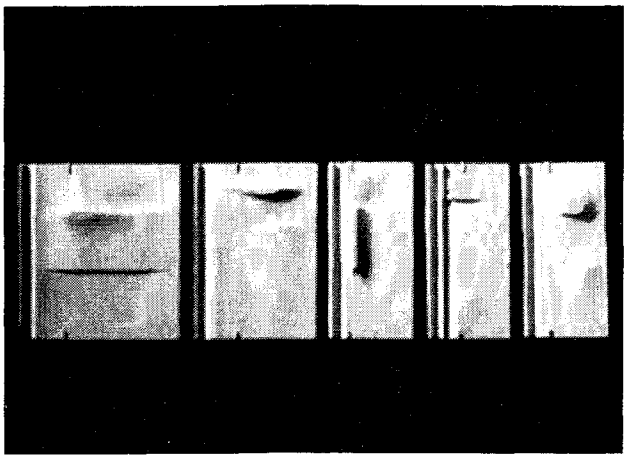

Fig 8: Milled panel formwork.

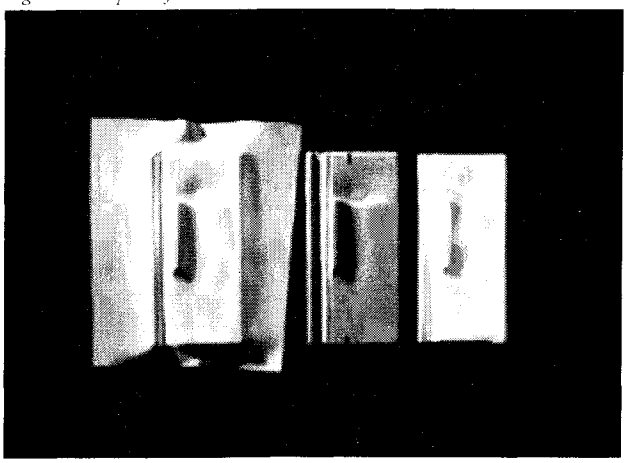

Fig 9: Example of milled panel formwork, vacuum formed panel, and cut final panel.

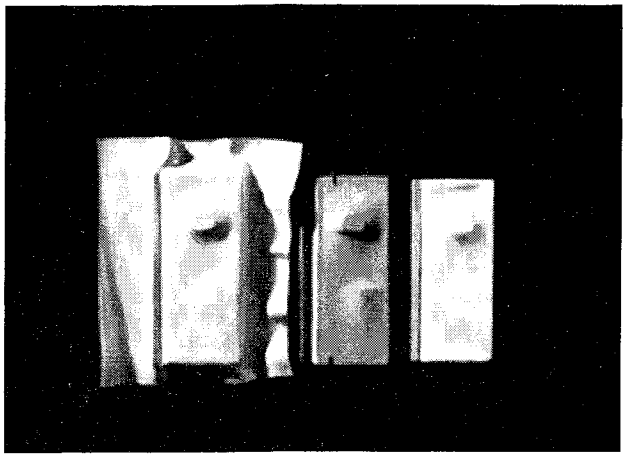

Fig 10: Example of milled panel formwork, vacuum formed panel, and cut final panel.

and fenestration evolves and the idea of ornamentation or decoration as now being inclusive of structural properties is established in the single surface panel.

The differentiation model allows us to engage the client in terms of mass customization. For example, the Expressions tool allows for a series of basic mathematical 'if/then' propositions to be written and keyframed, or tied into, the 3-dimensional panel surface and its variant modulating system(s). We developed a series of algorithms to fuse both the economic and material data-sets resulting in a change of formal panel characteristics. If you have x amount of money, then, y is the exact size and position of the opening (or window) for that panel. The 'swelling wall systems' are easily manufactured in different configurations without changing the cost of the panel; ideally, there could be endless variation via this mass customization technique. The overall shape and the amount of window area opening could be reconfigured from client to client, and their budgets and/or programmatic desires, without either adding or subtracting elements to the design or continually reworking the design. Essentially, we could establish a differentiated, yet repeated set of panels.

The panel system would employ a sandwich-type construction that would contain an insulated, moisture protecting, interior. The skins themselves could be selected from a multitude of materials and coatings available through a customization process. Figure 11 shows a series of metallic finish examples while the interior surfaces could respond to interior desires. The finishes could also be selected from a predetermined palette as a series of yearly updated swatches.

Along with developing the potential of surface modulations, the same ideas could be applied to transform the space and form of the house. We considered the deformation of the housing two methods, the first, at the smaller scale, was the invention of a deployable and retractable the bedroom wing or area; we used the Alias|Wavefront Inverse Kinematics tool, as attached to a roof structure membrane, in order to deploy the surface (see figure 12). As with the Winnebago, as shown in figure 13, we wanted to have multiple volumes push out from the main shell or container, into the site. This could be an armadillo shell or armor plating sheathing, in order to pack and unpack program conditions. The second spatial transformation was a much larger scale and included the development of deployable units that could vastly expand the interior space of the project and even sculpt the exterior into a protected open space. In our proposal we show this as a deployable living unit which would move across the site not only creating additional programmatic space, but leaving a freer internal plan structure as well (see figures 14 and 15).

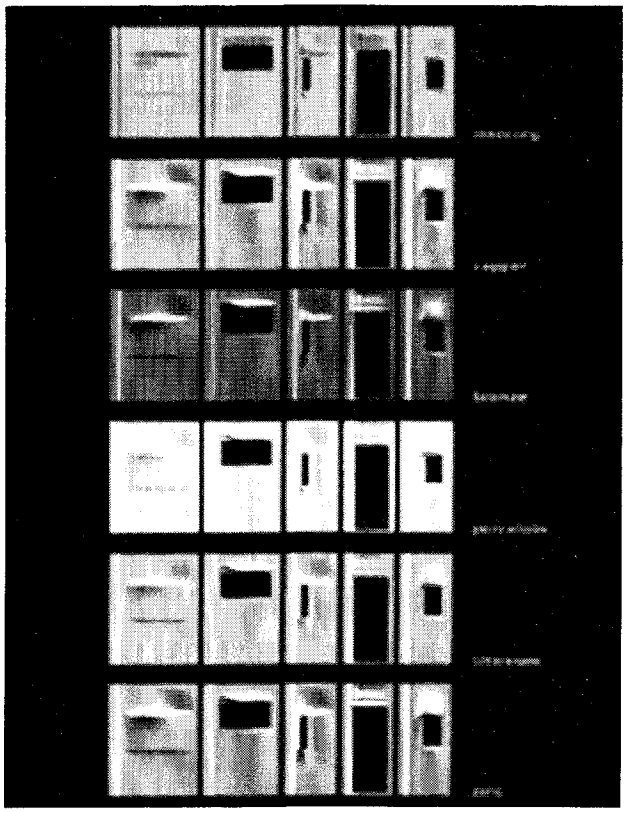

Fig 11: Metallic finish types.

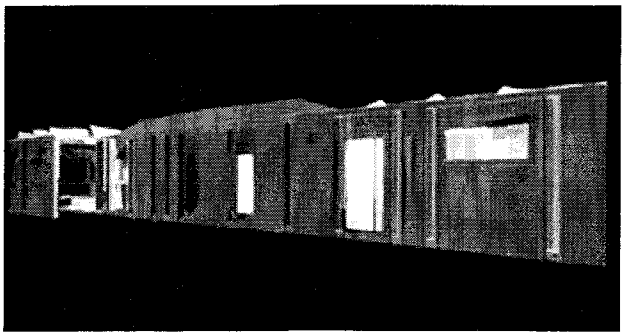

Fig 12: Projected bedroom expander unit.

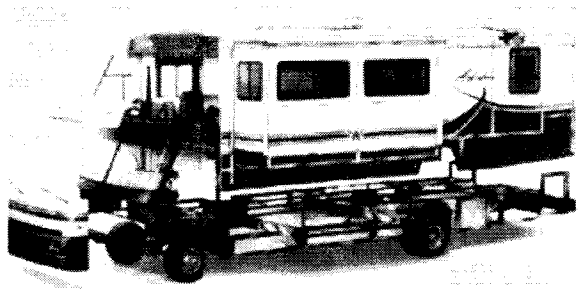

Fig 13: Expander units as seen in a mobile home.

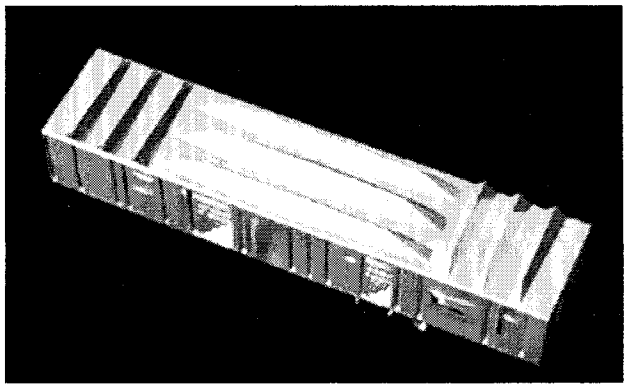

Fig 14: Compacted house proposal.

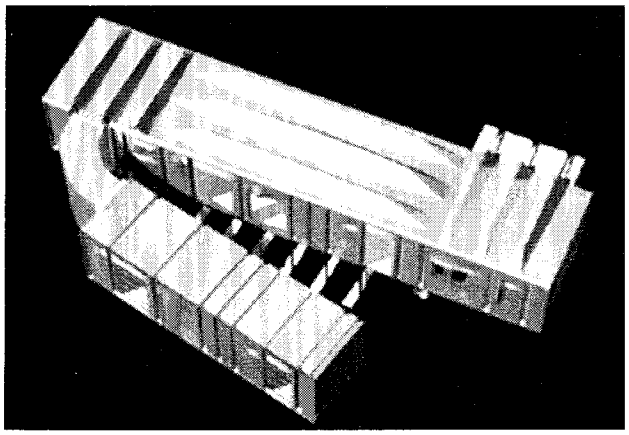

Fig 15: Expander spatial unit deployed on site.

Thus the house, upon reaching a site, can deploy an entire volume of program, such as the living room, out away from the main volume. This expands the usable floor area and provides, perhaps, for a more dynamic exterior elevation. Therefore, in terms of extending this deployable program logic, we created a courtyard condition (or patio space) by unpacking the interior living room volume to the exterior; we accomplished this by using telescoping triangulated beams as nested in the roof and floor assemblies. This additional volume could be programmed as a library, a studio space or an additional bedroom or living space. Once the interior living space is pushed out and becomes the additional volume, it opens the interior of the main body of the project to become an open programmable space—a "free" plan (figure 16). As shown in figures 17 and 18, the original interior surface becomes an exterior surface and the house is expanded across its site.

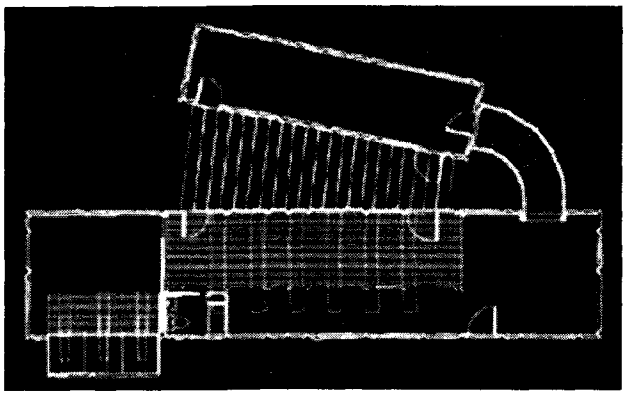

Fig 16: Manufactured Housing Proposal Plan

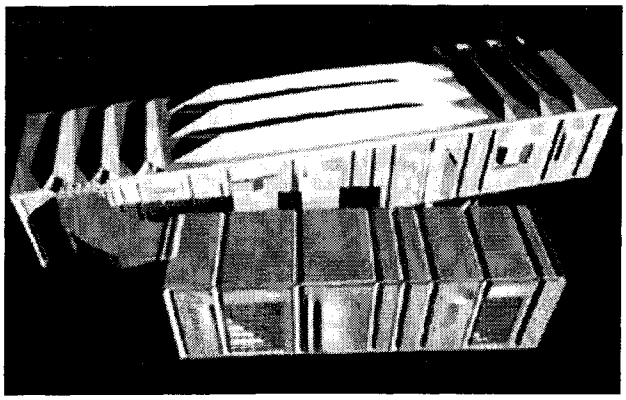

Fig 17: Manufactured Housing Proposal Rendered view.

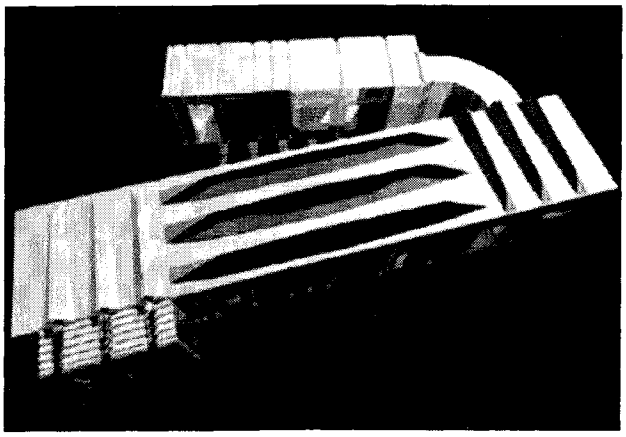

Fig 18: Manufactured Housing Proposal Rendered view.

NEW CONSUMER INTERFACE

"I could already see then that if everyone was to get high quality shelter, houses must be mass-produced industrially, in large quantities, like automobiles." —Buckminster Fuller

This proposal, along with expanding the influence of the designer and restructuring the relationship between design and production, seeks to further affect the interface between designer/producer and the consumer. Again looking to a closely aligned automobile industry, the manufactured housing industry can more closely relate the intentions of the designer with the desires of the consumer thus providing an impressive increase in both the power of the consumer as well as the influence of the designer on culture at large.

The automobile industry has brilliantly strategized through advertising to create not only the functional demand for automobiles but impassioned the desire for lifestyle. Buying a car no longer merely satisfies a consumer need for transportation, it fulfills a consumers self-image and implies status beyond the capacity of even of architecture in contemporary culture. The industry has propagated a sense of the car as a fetishized object, easily identifiable and telling of a consumers social and financial status through the implication of performance, style and power. The manufactured house, however, has long suffered from a poor media image and could strategically use automobile techniques to encourage its success.

In its search for growth, the manufactured housing industry has capitalized on the seemingly ubiquitous American desire for inexpensive private domestic space and begun to transition from the image once composed of cheap building materials and low income, rural residents, to middle income, carefully-managed suburban neighborhoods. The land lease community development imposes a set of communal rules often encouraged by the neighborhood residents themselves. For example, these rules may stipulate that homes must have a deck and skirting around the foundation, well-tended lawns, and prohibit parking on the grass, hanging laundry outside, television antennas or satellite dishes, pets chained outside and unattended children. Clayton homes, the nation's third largest manufacturer, has created a series of middle-class communities which are filled with residents who are proud to be a member of such a well assembled community. Overcoming a stereotype of the trailer park, these communities have more open lots with units that are firmly attached to solid foundations and knit into their landscapes through front and rear porches, stairways and landscaping. Often, the paved driveways demonstrate the extent of disposable income with multiple cars, boats and recreational vehicles.[9] Residents prefer the controlled nature of their communities which offers security in a quality of life— inevitably, if they become dissatisfied, they can literally pack up and relocate.[10]

Manufactured housing is not only found in rural or suburban areas, however, they are even employed to densify empty lots in ur-

ban neighborhoods. For example, 645 manufactured homes are being installed in Brooklyn as part of a three year strategy to house low and moderate income families.[11] On the other end of the economic spectrum, manufactured housing communities are growing for the upper incomes in places such as San Diego, California. During 1990s economic boom, newly wealthy clients, too impatient to wait for home construction, could purchase so-called pre-built "MacMansions." These houses had numerous options, from expensive marble finishes and gold fixtures to built-in entertainment systems, high-end appliances and even fully furnished living spaces complete with dishware. While the manufactured housing industry already promotes the "single-wide," "double-wide" and even "double-decker" models, these vastly expand the possibilities in terms of production speed and scale.[12] The bulk of the current industry advertising, however, generally targets lower to middle income rural and suburban residents with easy loan applications and accessible sales lots. Their projected image is the American Dream: every family can own a traditional home.

Based on the model of the automobile industry, we propose a revised interface with the consumer that encourages the perception of architecture as more than comfortable, but instead performative and desirable. Along with the new possibilities of customization, it could posit architecture as also a purveyor of lifestyle through the development of aesthetics, spatial and programmatic effects manifest in a base model amplified through a range of options. The options of the house could be thus customized by individual to adapt to site, climate, materials, function, and wants. These options could be selected and prioritized based on individual purchases and affordability. Some possible options are: storage space, deployable awnings, improved insulation, surface steel chassis, expandable living units, increased fenestration, cathedral ceilings, fireplace, built-in fixtures, kitchen islands, subzero appliances, carport, garage, retractable sunshades, built-in terraces, climate control systems, built-in audio or entertainment systems, power sunroofs, and high-end interior finishes. A customer could therefore select an already composed set of features, for example a "luxury package," or individual options to complete a unique combination. These options assist traditional models for consumer purchasing by allaying fears about structural strength and material durability, as well as improve the quality of finishes, connection to site, and offer name brand inclusion into the domestic space.[13] Figure 19 is one possible way to advertise options, based on a promotional poster for the Volkswagen Jetta.

The auto industry has capitalized on the desire for novelty and innovation which keeps the consumer returning for more and the industry quickly evolving. The average duration of house ownership is three years currently in the U.S.; the multi-generational house is already a minority condition. A the economy continues to loosen connection to place and encourage the mobile family, instead of buying a traditional house type every three years, families could improve their living "performance" with each successive purchase— either through refinement, adaptation or packaged options.[14]

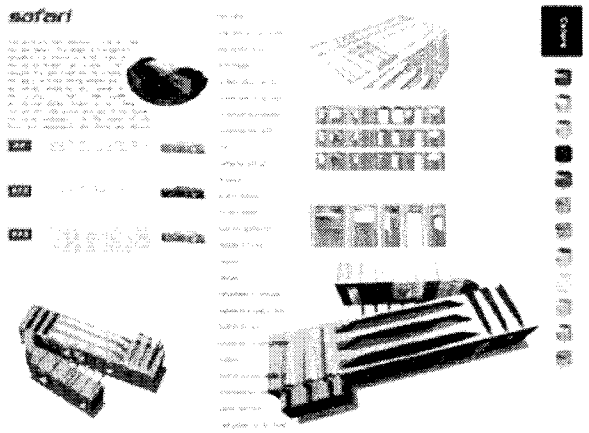

Fig 19: Potential promotional advertising, based on Volkswagen Jetta example.

From it origins in the industrial process and mobile home manufacturing, manufactured housing has bloomed from the development as a response from the housing shortages as the Second World War, into an vastly expanding influential, architectural industry. In this growth, however, it is critical that it respond to the changes in culture and possibilities of technology which offer the potential of customization, fluidity and affect. CAD-CAM and CNC processes have the potential to change supple digital models in realities of the everyday, translating complex algorithmic processes into surface undulations, programmatic evolutions and new material experiences for the population at large. The use of non-standardization in the building techniques of this design proposal posit it as an example of a new paradigm which offers individuality and specificity at a mass scale encouraging the existing shift in both building industries and the image of manufactured housing.

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