Modern Translations, Contemporary Methods: DL-1_Resonance House®

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Abstract

As the first design-build-fabricate-assemble experiment at our school, the intent of the studio was to design a framework from which to examine a “lived space” through digital-to-digital processes. Moving from digital models and physical stereo lithographic models to hand-fabrication and digital assembly allowed the students to move from creation to completion. As part of our holistic design process, the studio fabricated almost all components for the project. These elements include the wood flooring, the copper and wood skins, the building’s structural panels, and the two-story light vortex.

This single-family, in-fill house is located within an historic downtown neighborhood and is subject to historic district zoning regulations, design guidelines, and Board of Architecture Review approvals. The project is analogous to design challenges presenting themselves in historic districts throughout the United States including the Savannah, Georgia site for the 2005 ACADIA Conference. The scale of the project relates well to the horizontal nature of this context and after a formal, televised review process with the local Board of Architecture Review, the project represents a dynamic, yet sympathetic architectural dialogue with the surrounding buildings. The project develops simultaneously from the exterior and interior resulting in two courtyards that mediate the urban “front door” and the private “terrace.” The students designed these areas through a series of two-dimensional axonometric drawings, three-dimensional physical and digital models, and four-dimensional time-based animations. The building massing separates into two core elements: gabled copper volume and wood screen volume. These elements maintain their conceptual purity by using the same types of modulations on their skins. The copper form with its deep-cut reveals and proportionally placed light scoring patterns reflects the horizontal datum lines of the floor, sill, threshold, and ceiling. In contrast, the wood volume reflects these same lines as applied “shadow screens” which create depths that seamlessly tie together the side, rear, and front facades.

The hinge point of the house is the light vortex. Designed in Rhino, translated in Catia, fabricated out of aluminum, and clad in stainless steel, this two-story sculptural element will literally wrap light around its surfaces. Like a sunflower, the light vortex, with its angel hair stainless steel finish, responds to the incremental differentiation of light throughout the day. Photosensitive floor-mounted lights designed to augment the volume of natural light will provide a continuous light rendition on the sculpture. The project, scheduled for completion at the end of the 2005 summer session, is at the time of this submission about 60% complete.
In the last ten years, the profession has embraced explorations in perception linked to the emerging architecture associated with digital technology. As architects trained to synthesize a wide array of constraints and facts, when working with the digital we must work at the conceptual level where a framework exists. In order for new forms of practice to emerge, we must unite educated knowledge with trained skill. With the great reduction in cost of software such as Rhino, Catia, and Lamina as well as the increasing integration of BIM (Building Information Management) software, it is no longer necessary to translate three-dimensional digital models back into two-dimensional drawings to produce “conventional” working drawings. These types of software allow a very direct synthesis to occur between the original idea and its formal application with a high level of precision and accuracy. The sites for digital architecture are synthetic, ultimately providing the architect a place to improvise within spatial and temporal limits. I posit, that by augmenting the traditional ways of knowing with the more contemporary and technologically advanced ways of seeing, architects will undoubtedly develop the capacity to visualize and understand spatial relationships that would otherwise be too time-consuming to discover. The digital design-build studio illustrated in this paper brings this digital intersection into the field of construction.

Software, technology, and industry are leading and shaping the architecture profession as never before. In response, I established an all-digital design studio in 1999 at The University of Kentucky (then the College of Architecture, now the College of Design-School of Architecture), to combine the strong tradition of handcrafting in the existing design program with those technologically sophisticated tools shaping the profession for the 21st century. Our primary goal was to afford the students a greater flexibility in design, and eventually as future practitioners, develop innovative solutions for design efficiency, affordability, and sustainability. The materials presented here reflect a logical next step of a sequence of comprehensive digital projects produced under my direction from 1999 through 2004. These projects varied in scale, site, context, and material and represented a broad spectrum of design execution, from experimental installations to permanent inhabitations.

In creating this digital studio at the University of Kentucky, I have forged relationships throughout the College of Design, the College of Engineering, the Center for Robotics and Manufacturing, and the Center for Visualization. Within these interdisciplinary connections faculty from a wide-range of disciplines intersect to develop and further research initiatives. It is from this collaborative context that this project, DL-1_Resonance House®, emerged.
The goal of this fifteen-week design studio project was to generate a framework for fabricating infill-housing solutions in historic neighborhoods. This collaborative studio comprised of historic preservation, architecture, interior design, and engineering students proposed, “A volumetric architectural response to public and private lived space that was bridged by light.” This mission statement provided a generative discourse that produced a set of design development drawings for a 2,800-sqft house, a series of digital and physical models, and formal presentations at design reviews attended by local practitioners and the local Board of Architectural Review. The studio separated into three distinct, yet intertwined components: design and detailing, fabrication and assembly, and documentation.

As the first digital-to-digital design-build-fabricate-assemble experiment at our school, the intent of the fall studio was to examine a “lived space” through digital-to-digital processes.
Moving from digital models and physical stereo lithographic models to hand-fabrication and digital assembly enabled actualization of the project. The students created a series of flexible, open-wall structural panels, which by the end of the spring semester were ready for placement on the site, tilting into position, and assembly. As part of the holistic design process, the studio fabricated almost all components for the project. These elements include the wood flooring, the copper and wood skins, the building’s structural panels, and the two-story light vortex. To understand better, how the pieces of the construction puzzle would fall into place, the students produced a sequential animation of the construction assembly and a $\frac{1}{2}''=1'\cdot0''$ scaled, laser cut, wood structural model. For many of the students it was the first time that their incremental digital drawings, manufacturer discussions, and hand-sketches were actualized.

Introduction

This project is a work-in-progress that offers students from architecture, historic preservation, interior design, and engineering the chance to explore a variety of digital software media and, in a collaborative framework, address issues of design, fabrication, and full-scale assembly. Reflecting the realities of the profession today, this real world, single-family house venture actively integrates advances in software into the design process, allowing students to move beyond basic representation and documentation of the design concept to an advanced analysis and understanding of fabrication concerns.

The studio sought expertise for these projects from the professional design community and forged ties with local and national industries. Practitioners were involved not only in the formal jury reviews but dynamically integrated into the monthly design charrettes. Students developed their designs in the context of a professional design team, which included structural engineers, fabricators, contractors, architects, theorists, code enforcement officers, and civic officials as well as members of local governing organizations, including our local architectural review board. Students displayed their work at a variety of exhibitions and at national and international design and technology conferences to contribute to and learn about emerging ideas in digital design and to witness firsthand how design affects communities. Participating practitioners also learned potential uses for a variety of materials and gained greater insight into how increased and innovative uses of technology could transform their own designs and careers.

While one emphasis of this all-digital studio was to expand the students’ creative and visualization skills, another was to develop technical knowledge through allied seminars and elective classes that centered on the fabrication process. Ultimately, the goal of this course of study was to develop a comprehensive design/build opportunity that would demonstrate that contemporary design could not only enhance the historic context but also create a dynamic resonance between the historic fabric and the methods of building today.
Figure 9. 1/2”=1'-0" Scale Structural Model as Exploded Axonometric

Figure 10. 1/2”=1'-0" Scale Structural Mode

Figure 11. Design/Review Charrette with local practitioners and industry experts, 02.18.2005

Figure 12. Historic Analysis and Growth Patterns of the Western Suburb Historic District
Schematic Design

In the fall 2004 semester, a comprehensive College of Design studio encompassing students from the Schools of Architecture and Interior Design and the Department of Historic Preservation collaborated on various market-responsive proposals for an in-fill site within the downtown Lexington area. After resolving a sequence of complex issues that ranged from understanding local building codes to implementing historic overlay guidelines, student teams formulated designs for presentation that offered a proof-of-concept, real world construction experience for the students. The competitive aspects of the twelve students and the divergent nature of the design teams found a common ground in November 2004 after they attended the 2004 ACADIA National Conference in Toronto, ON. The project that emerged by the fall semester’s end touted a design mission statement of “a market-driven, architectural response to public and private lived space bridged by light.” The students presented this common proposal to the Lexington-Fayette County Urban Government (LFUCG) Board of Architectural Review (BOAR) for schematic design review and then to the College of Design’s all-school review. The lessons learned from these external reviews shaped the design proposal.

Site

The location of this single-family, in-fill house is within a historic downtown neighborhood and is subject to historic district zoning, design guidelines, and Board of Architecture Review (BOAR) approvals. The project is analogous to design challenges presenting themselves in historic districts throughout the United States including the Savannah, Georgia site for the 2005 ACADIA Conference. The scale of the project relates well to the horizontal nature of this context and after a review process with the local BOAR, it represents a dynamic, yet sympathetic architectural dialogue with the surrounding buildings.

Design Process

The process of moving from digital-to-physical models to stereo lithographic models to hand-fabrication and digital assembly was important to our studio investigation because it enabled the students’ opportunities to integrate quickly different design solutions. The necessity for this digital-to-digital (D2D) approach stemmed from the narrowness of the existing site, the site’s immediate adjacency to surrounding historic structures, and the temporal weather patterns that often plague construction schedules in the early Kentucky springtime when the house was due to begin construction. The strategy that emerged from the D2D process series of assemblies that could be pre-constructed in the shop, temporarily stored off site, easily transported to the site, and then tilted into place as needed.

Figure 13. Photograph of 1/8”=1'-0” Scale Context Model
A thorough analysis of the historic patterns of development in the area proved that the current in-fill zoning guidelines were incompatible with the immediate context. The studio presented these findings to the BOAR, which in turn, supported our contextual assessment. The building’s orientation now responds in part to two forces—the shift of the surrounding buildings to the railcars that served the Western Suburb in the mid-1800s and the prevalent solar angles in the region. While equally important, the vitality proposed by these opportunities affected the building design in uniquely different ways. Like the storefronts that line the street, the rotation of the building opens the front façade to oncoming traffic. In fact, our building, anchors one of the Kodak moments along the historic streetscape at the intersection of Old Georgetown Street and Ballard Avenue. Likewise, the building’s placement exposed the building to a wider degree angle of southern exposure, which in turn allowed the students to examine the uses of applied shading devices and passive green systems for blocking the sun’s rays during the cooling months while allowing the sun to pass through during the typical heating months.

Over the ensuing weeks, a more formal design development package that responded to the reviewer’s comments began to take shape, including the building massing, the design of the facades, and the selection of building materials. The building massing separates into two core elements: a gabled copper volume and a wood screen volume. These elements maintain their conceptual purity by using the same types of modulations on their skins. Reflecting the horizontal datum lines of the floor, sill, threshold, and ceiling as deeply cut reveals and proportionally placed light scoring patterns, the copper form responds to both material limitation and spatial configuration. In contrast, the wood volume reflects these same lines as applied “shadow screens” which create depths that seamlessly tie together the side, rear, and front facades. The project simultaneously developed from the inside toward the outside and from the exterior through the interior, resulting in a design proposal with two courtyards that mediate the urban “front door” and the private “terrace.” The students shaped these areas through a series of 2-dimensional axonometric, 3-dimensional physical and digital models, and 4-dimensional time-based animations. At the beginning of the spring semester, the studio presented their complete design development package work for final approval. The LFUCG televised this formal critique and broadcasted it locally as a matter of public record. The BOAR unanimously approved the scheme and issued the required Certificate of Appropriateness (COA) on January 18, 2005.
Spring 2005, Design Development: Permitting-Fabrication-Assembly

Upon COA issuance, the structure, DL-1_Resonance House®, began to develop. The studio focus shifted from conceptual design and design development to permitting, constructability, and fabrication. Early in the semester, we wrote a legal easement between the adjacent properties gaining off-street parking for both 147 Old Georgetown Street and our site at 151 Old Georgetown Street. To facilitate the project, the studio also enrolled in a construction methods course entitled Building Systems Integration taught by Professor Bruce Swetnam in the School of Architecture. In this class, the methods of making and realizing the project were predetermined from our initial research. As a collective team, the studio completed a design and fabrication schedule, and (using the BIM software program REVIT) produced a comprehensive set of working drawings and digital visualization models within the first five weeks of the spring semester.

Our original BIM models were further engineered into wood and steel fabrication shop drawings after consultation with Peyman Jahed, Ethan Buell, and Gyles Winkler of Buell, Fryer, and McReynolds Structural Engineers. Using these documents as a

Figure 16. Studio Visualizations, View From Rear Courtyard (top); View From Front Along Old Georgetown Street (bottom)
set of shop tickets, the students digitally
dimensioned, cut, and assembled standard
components into open-wall wood structural panels
under the supervision of Carroll Fackler, the
Director of the University of Kentucky, College
of Agriculture, at the Department of Forestry’s
Wood Utilization Center. From our digital models,
the local steel fabricator, Fab Steel, fabricated the
required bearing plates, columns, angles, support
clips, and the structural tubes and beams for our
curtain wall.

In our initial planning schedule, I had allotted two
weeks to complete the 50+ panels, but once the
floor templates were established and cut sheets
produced, the assembly took only three days to
to complete. The students transported the results of
these efforts to a staging warehouse located less
than one mile from our site. As part of our holistic
design process, the studio fabricated almost all
components for the project. These elements
include the wood flooring (four days) and the
wood skins (four days). While one group of
students was fabricating these materials,
professional contractors surveyed and excavated
the site and poured the concrete foundation walls
and slab, while another group of students was
sourcing the next set of building materials.

Figure 17. Panel Fabrication Shop Tickets for the First Floor and Second Floor Structure

Figure 18. Images of CNC Milling Scribing the Wall Templates and Views from the Wall Panel Fabrication

Figure 19. Roof Truss Fabrication
Millwork and Interior Design

The students collectively detailed the millwork drawings for the kitchen, bathrooms, study, and bedrooms. The details and layout of these elements emerged from conversations with Ann Dickson, Director of Interior Design; Jennifer Eaton, an instructor in the School of Interior Design; and local practitioners Brooks Meador (Brooks Meador Interior Design, Inc.) and Carey Spalding (BC Woodworking). Accompanying these detailed drawings, were another set of cut sheets that allowed the students to pre-manufacture the boxes, doors, and pre-drill the hinges of all of the cabinetry. This process started on April 11, 2005 and by the end of the spring semester three weeks later, the students had constructed 75% of the millwork and 80% of the structure for the house.

Summer 2005, Project Erection

Site Construction

Even with the extremely tight tolerances of the digital-to-digital process, the choice to use poured-in-place concrete rather than pre-cast concrete foundation caused a slight delay in the erection of our project. Fortunately, the modulation of the building was able to absorb the discrepancies without negatively affecting the design. To understand better the deviations from the original dimensions, the students digitally measured the building and began developing an alternative as-built digital model to track the changes.

In the six-week gap between spring and summer sessions, six of the original twelve students continued to develop the project. We treated the foundations, corrected surface irregularities, sealed the basement walls, poured the basement slab, set the steel columns, laid the TrusJoist Silent floor system and Parallam beams, glued, and screwed the OSB sub floor, backfilled the excavation, and rough graded the site.

On June 9, 2005, the summer session began in full, with the tilting of the first floor wall panels and framing of the interior walls. By June 15, the second floor sub floor was in place in the rear volume and framing the stair tower was underway. By June 17, the “bridge between the two volumes” was set and work on the front volume’s second floor was beginning. We anticipate that the finish framing and that the enclosed black box will be
complete within two weeks. As of this writing, the framing continues and the students are preparing fabrication documents for the building’s copper skins for a local fabricator. Local professional electrical, mechanical, and plumbing contractors will complete work during late June and early July. As these contractors work inside, we will finish fabricating the interior millwork, detailing the material finishes, installing the redwood and copper siding, and fabricating the hinge point of the house - the “light vortex.”

Light Vortex

“Metal is the material of our time. It enables architecture to become sculptural; it also expresses technological possibility as well as the time-honored characteristics of quality and permanence.” Frank O. Gehry

In September 2004, my colleague, Robert Ogle from the Center for Historic Architecture and Preservation (CHAP) at the University of Kentucky, and I formed Design Lab, Inc®. Design Lab is a private-not-for-profit company whose

Figure 22. Photographs of Concrete Slab Pour Prior to Finish

Figure 23. Millwork Shop Tickets for Kitchen Cabinetry
mission statement is to “enhance our built environment through research and education” by enabling design/build projects, such as the DL-1_Resonance House® for the University of Kentucky and other schools of architecture. To elevate the digital-to-digital processes that I have been developing over the last seven years and to expand our links to industry beyond the region into the national level, we visited the fabrication plant for the A. Zahner Company, who has fabricated a majority of Frank Gehry’s work as well as Steven Holl’s Turbulence House among others. I wrote a proposal for them to assist us in fabricating, engineering, and installing a portion of our project, a 24-foot tall sculptural light element, and the light vortex. A small section of this sculptural element was on exhibit during the 2005 ACSA National Conference in Chicago and then installed at the all-College of Design exhibition in Lexington.

Designed in FormZ and Rhino, then translated into Catia before fabrication, this two-story element, structured with aluminum fins and substructure and then clad in stainless steel, literally wraps light around its surfaces. Like a sunflower, the light vortex, with its angel hair stainless steel finish, responds to the incremental differentiation of light throughout the day. Designed in collaboration with the Cuban lighting designer, Joe Reybarreau, photosensitive floor mounted light fixtures augment the volume of natural light so that its skin will appear to change colors over the course of the day. In addition to lighting, the form creates a figural focal point enclosure that contains the fireplace box, and acts as a mechanical plenum that conceals all of the mechanical ducts and electrical conduits that rise to the second floor. Due to its placement, this object anchors the entry sequence and is visible in a variety of angles both inside and outside of the house.

Opposite the vortex, a two-story curtain wall marks the edges of the overall light void. In plan, the L-shaped curtain wall inversely relates to the adjacent single-story house on the south end of the site, while in section, it provides striated visual access from the second floor. A terraced area beyond this glazed wall extends the axis of the kitchen and dining room beyond the living room out toward the rear of the site. A water-jet cut copper screen wall at the property boundary terminates this alignment.
Conclusion

Over a six-year period, this all-digital design studio has developed from a pedagogical model for developing new ways of seeing and making architecture to a “proof-of-concept” experience that blends state-of-the-art visualization techniques with contemporary expectations of practice and construction. Creating these links between students, industry, and the profession has allowed the College of Design to provide leadership for practicing architects, to create a dialogue between industrial and design professionals, and to integrate design pedagogy with the technological applications that will shape the future of architecture practice. The resulting effect has been a series of virtual studies with real-world applications and an increased role for
students in shaping a new reality for practice through advances in technology and industry.

Much strength associated with this multi-disciplinary partnership has enabled a rethinking of the traditional teaching of design studio so that it can align with the pursuit of research, funding opportunities, and a deeper understanding of the market place that would not have otherwise been possible. Further, this relationship has celebrated the dynamic relationship between visualization, representation, and fabrication—both by hand and digital making without compromising either one. An innovative partnership between Design Lab, Inc®, a private not-for-profit company, and the University of Kentucky facilitated the DL-1_Resonance House® design build studio. Founded to facilitate design build projects for schools of design and historic preservation Design Lab, Inc.’s mission to enhance the built environment through research and education allows for a unique approach for students to work on real world design, fabrication, and construction solutions while receiving academic credit. Design Lab’s professional volunteers manage all of the business end of the transaction with the client and help source financing for the project through corporate sponsors and other donations. Design Lab also provides grants to their partner schools and scholarships to students of design and preservation. The creation of Design Lab, Inc® and its affiliation agreement with the University of Kentucky, has given the students invaluable real world learning experience that narrows the gap between the design drawing process and actualization methods. It has allowed architecture, interior design, and historic preservation students to form sets of teams with a wide range of practitioners, industry-specialists, and researchers (inside and outside of academia) and it has afforded them access to technologies that we currently do not have within our program. This process will continue to develop as this project nears completion at the end of the 2005 summer session in mid-August.