1 Introduction

The logics of digital processes in architecture have begun to structure the way that architects design, the way that builders build, and the way that industry is reorganizing. These processes have generally followed one of three directions that are only now beginning to coalesce into a coherent system of architectural production. The first, designing design, is a procedural issue and addresses how design processes are being influenced by new digital workflows. Vast amounts of information, both descriptive and analytical, are now instantaneously available to help define and assess design options. Much, if not all, of this information gets filtered through software that, by extension, structures the digital environment in which we design. The process of architectural design has become a complex workflow in which geometric and, increasingly, parametric modeling is combined with simulation, analysis, and optimization software to form an integrated building information model that can then generate fabrication and manufacturing files. In addition, custom digital design tools are serving to extend the capabilities and imagination of designers. Designing design poses design as a design problem itself and foregrounds the ways in which architects are beginning to structure the “design space” in which they work.

The second direction of digital processes in architecture, designing assembly, is a material issue and addresses how digital production processes and digitally defined material properties influence design concepts. This centers on the development of direct digital fabrication and material definition that structures links between design intent and the tools and processes that manufacture building components and assemblies. Through CNC technologies, architects can reposition design strategically within fabrication and assembly processes such that design information extends beyond the representational to include highly precise sets of instructions used to manufacture component parts for buildings. Moreover, these instructions can embed the logic of building assemblies in the manufacturing, linking design to a new definition of detail, which has additionally begun to reestablish the role of craft in the design process. Designing assembly suggests that the logics of manufacturing and assembly can become influential design criteria.
The third, designing industry, is an organizational issue with a drive toward integration, where design information across multiple disciplines along with procedural information about the timing and sequencing of construction can be modeled and efficiently managed. The shift towards more integrated forms of digital production within the design and construction industry affords opportunities to not only reconfigure the relationships between the key disciplines, but also incorporate industry sectors not typically associated with building construction. At the core of this shift is the integration of communication through processes, like Building Information Modeling (BIM) and Integrated Project Delivery (IPD), with the ambition of developing a comprehensive body of information that coordinates the process from design through a building’s lifecycle. Designing new models of collaboration in the context of these developments has become an urgent issue because of a need to navigate the increasing complexity of information-rich architectural projects and avoid a continuation of the deeply entrenched separation between design, fabrication, and construction.

These topics are explored in the following three projects, each of which was executed under very different circumstances. As an overview of the work of Marble Fairbanks, these projects also explore the relationship between practice, speculative research, and architectural education that is a core focus of our office. Our interest in digital processes in architecture and building begins with the premise that at its core, digital technology is a tool of communication that bridges various types of information and as such, its most promising potential is to facilitate new types of collaborative processes between people. In these projects, this takes the form of distributed design authorship, design file to digital fabrication that links architects to manufacturers, custom design scripts that bridge technical expertise and architectural design, and project organizations where teams are integrated through information models.

2 Toni Stabile Student Center, Graduate School of Journalism, Columbia University

2.1 Introduction

This new student center for Columbia University’s Graduate School of Journalism in New York City is a renovation and addition to the ground floor of a historic McKim, Mead and White building. The project was used as an opportunity to test a broad array of digital design and production techniques, specifically through implementing environmental analysis tools and custom scripts in the design of three highly engineered surfaces fabricated from custom-perforated steel (Figure 1). This project was also used to test a model of practice based on forming a design collaborative of small, like-minded offices and entities to bring a range of expertise to the project addressing the issue of how, through the use of digital techniques, smaller practices can offer the same level of service as large offices. In addition to the standard project consultants, we brought on three design collaborators to work on specific areas of the project.

Figure 1. Four performative surfaces.
2.2 Surface #1: Acoustic Performance

The first surface, the ceiling of the Social Hub, the main public space, was designed to provide an acoustically absorptive ceiling for a room that had to accommodate a wide range of uses (study area, meeting room, lecture hall, and event space) through a custom generated pattern of perforations.

The logic of the perforation pattern was developed through a two-phase process. First, an acoustic model of the space was developed to establish the performance criteria for the design of the pattern (Figure 2). A pattern script was designed to generate a series of unique iterations, each of which relied on attractor points to increase the density of perforations (increasing sound absorption) satisfying the acoustic performance criteria for the space. The iterations were evaluated both for the density of perforations (which translated directly to fabrication time and cost) as well as overall qualitative effect Figure 3 & 4).

Through a second scripting process, the pattern generated from the acoustic analysis was modified to respond to the preexisting conditions in the ceiling, to accommodate lights and sprinklers, and to address fabrication constraints from the manufacturer. This criteria was incorporated into the script through the following rules:

1. All holes on 1 1/2" grid.
2. All holes can infinitely vary from 1" diameter circles to 5/8" long ovals.
3. No holes within 1" of panel joint lines.
4. Any hole within 6" of panel joint lines must be less than 1/2" in diameter.
5. No holes within 1/2" of light/sprinkler cutouts.
6. Any hole within 6" of light/sprinkler cutouts must be less than 1/2" in diameter.
7. No holes within 1" of bend lines.

The final pattern satisfied the acoustic demands of the space while also providing a visual index of its generative process (Figure 5). This part of the project was designed in collaboration with Mark Collins and Toru Hasagawa of Proxy (Figure 6).
2.3 Surface #2: Cultural Performance

The second surface, the west wall of the Social Hub, was more explicitly graphic in nature and was designed to create an optical transformation of an image as users move from the entrance into the space. The pattern was developed by filtering a photograph of the view looking out from the west wall of the building (a view across Broadway) through a digital process that converted it into a pixilation pattern to be cut from the metal panels (Figure 7). The pattern was calibrated to “snap” into focus at a specific distance of 40’—the point at which one enters the social hub and then dissolve into an abstract pattern as one moves closer to the wall (Figure 8).

The pixilation scripting process used an alphabet of six discrete “characters,” each corresponding to a specific range of tonal values within the black-to-white spectrum. The characters consisted of a gradient from zero (“0”) to one (“1”) — referencing the most basic forms of digital information (Figure 9). This part of the project was developed with graphic designer Luke Bulman of Thumb (Figure 10).

2.4 Surface #3: Environmental Performance

The third surface, a sunscreen ceiling hung below a glass roof of the new cafe building addition, was designed and engineered in conjunction with the glazing specification to reduce the solar heat gain in the space by 80%, allowing for a more efficient conditioning system. Two strategies of patterning—corrugation and perforation—were used to develop the design. A number of solar analyses were run on different days of the year to determine the environmental parameters of the site. The peak load was identified through digital modeling and this load became the benchmark by which the solar shading system was designed (Figure 11). The sun angle information was in turn fed into an algorithm that generated the bend profiles of the ceiling panels (Figure 12). The script also adjusted the corrugations to provide space for lighting and sprinkler heads that were located above the panels.

Once the corrugation pattern was determined, the resultant geometry was fed back into the energy analysis software to determine a maximum allowable percentage of perforation that would satisfy the 80% solar heat reduction requirement. The energy analysis determined the percent open, and the pattern itself was derived from an image of the sky (Figure 13). The size and geometry of the perforations were determined by balancing the need for a resolution that would allow the image to be legible with the cost of laser cutting the holes in the panels (Figure 14). This part of the project was developed with Will Corcoran, Oleg Byashirov and Jonathan Schumacher of the Product Architecture Lab at Stevens Institute of Technology.
3 Platform, Installation for Home Delivery: Fabricating the Modern Dwelling, Museum of Modern Art, NY

3.1 Introduction

As part of the Home Delivery: Fabricating the Modern Dwelling exhibition at the Museum of Modern Art, Platform was commissioned to demonstrate future directions in the evolution of digital design and fabrication techniques. As a full-scale speculative work, it was developed by exploring a new definition of detail in the context of file to fabrication processes by incorporating the logic of its assembly as a driving design parameter based on the constraints and possibilities of 2D laser cutting. It also explored the aesthetics of information by allowing the final form to register the digital information embedded in its fabrication and assembly (Figure 15).

3.2 Platform as a New Model for Designed Assembly

Platform is a structural panel system consisting of flat stock stainless steel sheets that are cut, scored, folded, and then snapped together to form a rigid assembly without external fasteners. The overall geometry and appearance is generated from the topology of precisely designed tab sets that are made up of a major and minor tab, one on each of the facing flat panels, in a precise relationship to each other, that bend and structurally lock together. The deployment of tab sets; including pattern, orientation, and number can adjust to address specific design requirements (Figure 16a,b,c). The variable width of the tab openings, parametrically linked to the overall geometry of the wall itself, allows the wall system to accommodate a wide range of transparency and opacity. The distance between the facing panels is the primary design parameter that also controls the pattern of tab sets.

With Platform, perforation is extended from a two-dimensional patterning technique into a three dimensional structural system that fuses design, fabrication, and assembly into a qualitative spatial experience (Figure 17). The layering of color on the inside surface of one of the panels and the resulting reflection off the opposing panel accentuates the three-dimensional quality of the tab sets and surface pattern. (Figure 18). This project was done in collaboration with Robert Booth, Andrew Colopy, and Aimee Chang of AARDVARK and Justin Nardone of the Product Architecture Lab at Stevens Institute of Technology.

4 Expanded Alliances: Slide Library, The Department of Art History and Archaeology, Columbia University

4.1 Introduction

Schools of architecture are a vast resource for innovative ideas about all aspects of architecture ranging from history and theory, technology and design. They combine the enthusiasm and originality of student experimentation with the experience and reputation of faculty, who are typically leaders in their respective areas of specialization. The universities they are part of
typically have extensive capital building projects managed by a facilities department that hire architects, consultants, and contractors on behalf of various schools or departments. There are currently over 110 schools of architecture in the United States, and in 2004, $12,186,636,000 was spent on construction projects by colleges and universities around the country. The goal of this project for a new slide library was to form alliances between university departments, facilities departments, and architecture schools to develop a sustainable and repeatable design / fabricate / build educational model that would utilize university funded capital projects as a full scale testing laboratory. The pedagogical goals were to conduct research into: 1) applied new material and fabrication techniques; 2) the design potential of building information modeling; and 3) innovative models of future practice.

4.2 Organization

The Graduate School of Architecture, Planning and Preservation (GSAPP) at Columbia University developed a fabrication lab to expand the ongoing research in digital design and production processes with a mandate of working exclusively at full scale. As faculty members of the GSAPP and practicing architects, we organized a collaborative partnership between the Department of Art History and Archeaology (the client), University Facilities, and the GSAPP to carry out the project. The client department would get a highly unique design at a significant savings; the architecture school would give unprecedented opportunities for students to test new design and fabrication techniques utilizing their fabrication lab; the facilities department would be able to promote innovative design projects on campus; and the university at large would benefit from sponsoring quality design through interdepartmental collaborations.

4.3 Design

One of the primary design parameters was to use the constraints of the available fabrication tools and a limited material palette as a generator of form. The design consisted of four interior walls defining the space of the slide library and a large skylight above as the only source of natural light (Figure 19). The east wall was made up of 435 layers of 1” thick ultralight fiberboard sandwiched together with viewing portals formed by openings milled into the fiberboard layers. Each opening has glass panels sandwiched between these carved out areas (Figure 20). The middle of the east wall curves into the space to bring natural light from the skylight onto the outside face of the wall and into the adjacent area (Figure 21 & 22).

The assembly of the east wall was kept as simple as possible relying only on a linear numbering sequence for each of the layers and an attachment method of internal threaded rods that held the layers of fiberboard and glass in compression. The north, south, and west walls had linear perforations that were the geometry of the tooling paths used to mill each of the layers of the east wall. These perforations transmit lines of light from the skylight through the wall (Figure 23).
One of the goals was to simulate the complexity of building information modeling on a larger scale, and because the project was relatively small, all building components from wall panels to small pieces of blocking were digitally modeled and the fabricated from geometry derived from the model. Drawings with minimal notes and no dimensions existed only for the purposes of describing the sequence of assembly (Figure 24).

### 4.4 Education and The Future of Industry

Schools of architecture played a pivotal role in the initial phases of digital processes in architecture through exhaustive formal experimentation and elaborate visualization techniques that helped to redefine design processes and develop new genres of formal expression. While this was occurring, the construction industry was focused on streamlining the manufacturing and building processes through CNC technologies with little or no emphasis on design innovation. The core goal of Expanded Alliances was to foreground the potential and urgency of a younger generation of architects to begin exploring innovative approaches to integrate design, fabrication, and construction and to rethink and strategically reposition architectural practice as industry reorganizes around new digital processes.