POST-PARAMETRIC DESIGN INTELLIGENCE

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Figure 1. Parametric Steel Components: FABCRAFT seminar, spring 2011.

INTRODUCTION

A critical shift must occur within the generative culture of computational design and digital fabrication, as revolutionary now as Le Corbusier's *Vers Un Architecture* was when originally published in 1921. Parametric Virtuosity, in itself, is no longer sufficient to carry forward the innovations enabled by the confluence of new computational methodologies and digital fabrication. The early promise of pioneering projects such as SHoP's *Camera Obscura* has given way to a culture of parametric, robotic exhibitionism, largely devoid of practical applications beyond the demonstration of the technologies themselves.

Within this context, one may observe a "recalibration" of practice, shifting from the production of objects or projects, towards the development of entirely new material workflows or processes. This new design intelligence, while immersed in the possibilities afforded by parametric tools and practices, is also guided by a "post-parametric" attitude, fundamentally rethinking materiality and its relation to abstract processes of assemblage or aggregation, recalling the early days of conceptual art, as exemplified by Richard Serra's "verb list." [1] Parametric Culture is therefore moving towards a more ubiquitous phase of embedded technologies, subsumed within increasingly intuitive control frameworks, guided by a much more conceptual attitude, transcending the limitations of procedural logic and parametric virtuosity, towards a much richer, "humanist" phase of technological development.

Michael Speaks has written on the "Post-Vanguard" generation that replaced theory-laden "truth" or functionalist innovation, with global "Design Intelligence" fostering a new wave of innovation. This culture continues to thrive and inform contemporary practices, in large part thanks to the emerging technologies offered by computational methods, and advanced prototyping. The era of computational virtuosity and fabrication has been largely mainstreamed, with the adoption of fully articulated robotics now seen as the newly emerging "market" for academic research, leveraging both parametric design and fabrication. Rather than simply scaling up the complexity of projects produced under this new wave of (robotic, parametric) technologies, a new, perhaps "Post-Parametric" Design Intelligence must emerge, transcending the short-term vision of computational exhibitionism, towards a new design rationality, informed, rather than determined by computational methods and robotic fabrication.

What will guide this new phase of research? A return to the conceptual, theoretical positions that Speaks termed the Theoretical Vanguard is unlikely. Similarly, the continuation of computational virtuosity as an end in itself will not produce further innovation. One possibility is a new look at the material-based practices of twentieth century modernism, which ran counter to, or alongside of prevailing modernist ideologies. These practices, such as the work of Jean Prouvé, or the Eames office, pre-figured both emerging technologies and the methods of production enabled by global capitalism. They were early adopters of "Design Innovation."

The author's interest is in REFRAMING FABRICATION within what Aalto called Extended *Techno-Humanist Rationality*[2], repositioning emerging work within the larger sphere of global praxis, leveraging computational and robotic technologies as agents of change and possibility. This reframing aims to question the relation between (deterministic) modernist notions of simplicity, and parametric practices overly determined by complexity. It suggests the possibility for what Andrew Pickering has termed an "Alternate Ontology" for cybernetic thought and experimentation.[3]

The Heideggerian[4] notion of technology as a force for "revealing" as opposed to the determinism of "enframing" is a primary diagnostic tool for examining the impact of computational and fabrication culture on the larger sphere of Design Innovation. Through this critical, reflective lens, a new understanding of the relation between material and conceptual practices may emerge, leveraging both computational and robotic technologies, nevertheless informed by "Post-Parametric Design Intelligence."

FROM PARAMETRIC VARIATION TO PERFORMATIVE DIFFERENTIATION

Within the realm of digital practice and post-vanguard ideologies of production and engagement, one may observe the application of seriality, repetition and variation, as integral aspects of computational (parametric) design and fabrication. These procedural logics today inform much of what are essentially closed axiomatic systems; self-referential and seemingly without purpose or innovation beyond the achievement of computational complexity and virtuosity. The irony is that much of what has been inherited within computational culture today, outside of methods of computation, stems from the interdisciplinary nature of design computing. Despite this affinity, one may observe an increasing lack of conceptual engagement, social agency or broad agendas of innovation, within much of the computationally derived work dominating parametric culture today.

The exception to this trend may be observed in the work of emerging (provisional) practices both internalizing, and transcending the adoption of (parametric) strategies as form-generators. These (Post-Edge, Post-Vanguard) practices combine promiscuous entrepreneurial practices with open-systems thinking, embracing both the formal strategies and logics of field conditions, as defined in the writings of Stan Allen, with a diverse toolset from computational, management and environmental domains, occupying, subverting and re-deploying both conventional design and (craft) practices and advanced technologies toward new critical agendas. These practices recall Judd's 1960's examination of emerging art in *Specific Objects:*

> "So far the most obvious difference within this diverse work is between that which is something of an object, a single thing, and that which is open and extended, more or less environmental." [5]

From a *formalist* perspective, the most promising, newly emerging provisional or post-vanguard practices are increasingly transcending the mere *appearance* of complexity, bio-inspired form, and other now familiar tropes of parametric digital culture, in favor of a much more nuanced deployment of form. These practices engage the 'precarious' nature of variation, towards a performative differentiation of detail and surface intellectually affirming innovation beyond the stylistic or techno determinist agenda, confronting the limits of "performativity," as Christopher Hight recently cautioned:

> "The precariousness of performativity today is that lacking a theory of differentiation in favor of normative criteria of design will lead to a rapid stagnation rather than evolution, a story that should be all too familiar. An architectural project once intellectually allied to Deleuzian ontology now appears to be tending towards convergence and minor variation rather than schizogenic proliferation."[6]

The avoidance of these tropes stands in sharp contrast to the production and (uncritical) consumption of bio-complexity and parametric virtuosity produced by an increasingly techno-deterministic (parametric) culture devoid of agendas for social, political or economic engagement or agency. While the conceptual and "literal" artists of the 1960's and 70's deployed repetition, seriality and variation in the service of a larger, critical agenda, contesting and engaging the changing status of the *object*, the *space* (of the gallery) and the *spectator*, today's protagonists of parametric variation lack a broad-based strategy for the repetitive deployment and variation of the component module beyond the exhibition of parametric technique. The encounter between parametric variation and performative material agency, although not without its own difficulties, may provide a means for engaging a broader conception of (parametric) practice, engaging both physical limitations and forces.

The calibration of physical, material performance against both the internal logics of physics-based simulations, and the external encounter with the contingencies of changing environmental, physical and economic forces, may serve to expand the engagement of digital practices towards a composite material-social enterprise (Fig. 2).

The shift from the (pre-digital object) towards an "intensive craft" combining material-process & computational workflows continuously modulated by feedback & physical forces, may allow parametric culture to move towards a broader engagement with social agency and innovation, based on *"performative"* practices. As Antoine Picon and others have recently suggested, this is not without its own dilemmas. [7] The use of the term *intensive* is used in this context to probe latent material qualities that surpass the over-determination

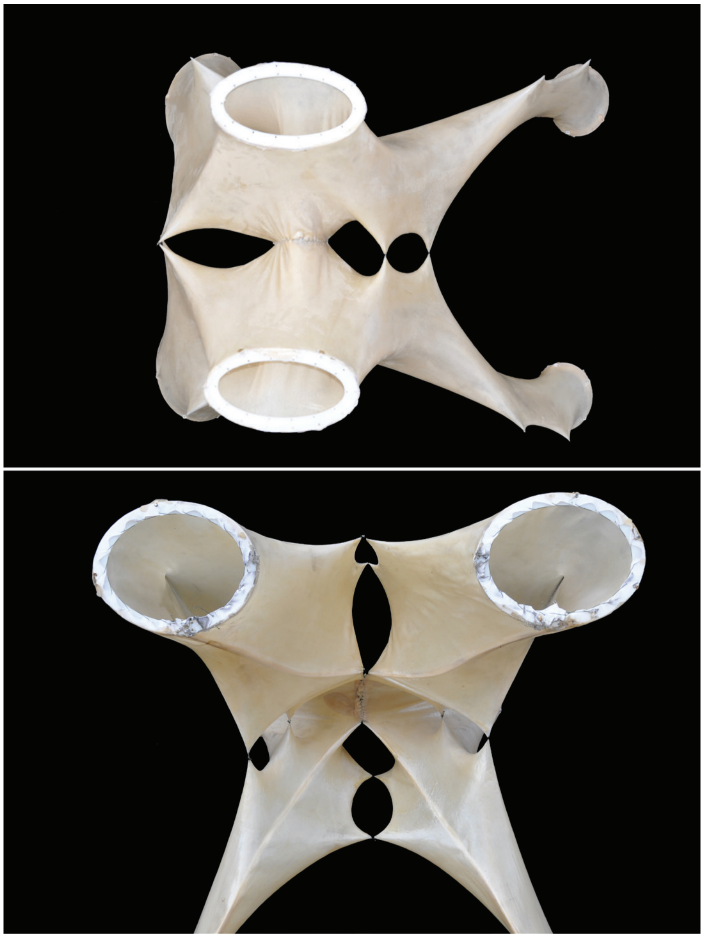

Figure 2. Resin-Coated “Bone” Fabric Experiment. Rethinking Making Seminar, 2012.

of typical fabrication output, such as scripted patterning, or repetitive component assemblies. These qualities arise through the interaction of material and environment, as manifestations of dynamically stable, “near equilibrium” states, embodying physical, chemical or biological transitions or phase changes. [8]

THE POST- FUNCTIONAL DETAIL

How can we move from ornamental patterning, or “intricacy,” based on parametric or algorithmic methods, and seamless surfaces, subsuming the architectural detail, towards a broader rethinking of the post-functional detail in 21st century digital “FAB” culture? [9]

One possibility is to reconsider the influence of 20th c. design innovation focused on the *detail* or *joint*, towards a rethinking of craft and material within a culture of parametric design and fabrication (Fig. 1). The associated implications of digital workflows and detailing will be discussed in terms of their social and labor-practice implications within an emerging culture of robotic construction and digital craft. 20th century material-process innovators such as Jean Prouvé, Konrad Waschmann and Charles Eames utilized both industrial era methodologies of production, and presaged the use of mass-customized components in much of today’s parametric, CNC culture. In particular, the cast or pressed metal components of Jean Prouvé, utilized in the recently rebuilt Centenary Pavilion, and the bent laminated wood furniture produced by the Eames office in the 1950’s may both be seen as direct predecessors of today’s lightweight, customized components produced within a parametric, file-to-fab workflow or “digital chain.” [10]

The shift from identical, discrete elements to customized, adaptive components is the central theme in this evolution. In parallel with the contemporary interest in (parametric) seamless surfaces, we are witnessing a resurgence of Craft, transformed through the lens of digital processes, producing new forms or modes of detailing & connections between elements. By examining the evolving nature of the tectonic *Joint* in 20th c. and contemporary production, we may foreground the potential of digital fabrication to critically challenge current parametric practices based primarily on surface effects, towards a richer confluence of surface + structure transformed through CNC and robotic processes and methodologies, recombining structure and surface in newly emerging configurations (Fig. 3).

Two inter-related streams of geometric and material evolution of detail arise within this context: the Repetitive Linear Element evolving towards an adaptive mesh, and the evolution of the Differentiated Surface as Structure. The wire sculptures of artist GEGO illustrate the shift from strict rationality and repetition, as deployed in Waschmann’s universal joint, towards an adaptive deployment of linear members in space. Similarly, the bent plywood Eames furniture prototypes may be seen as early examples of the adaptive surface, replacing linear repetitive, modular assemblages with custom fabricated joints from surface to surface, or surface to steel tube. Both of these material-logic streams may be seen in the work of twentieth century architects and designers, as precursors of contemporary digital detailing and fabrication processes.

In terms of discrete elements, we may observe the lineage from traditional wood carpentry techniques, evolving towards highly specialized seismic joints, in Japanese Joinery, and requiring an intimate relationship between knowledge, skill and respect for material, as exemplified by the notion of “The Craftsman,” discussed in the book of the same name by Richard Sennett.[11]

In contrast to this, the abstraction and anonymity of the joint in the work of Mies van der Rohe, replaces the specialized joint with a continuous network of horizontal and vertical members, veiling the exact nature of the joint, (suppressed with an invisible plug weld, as noted by Tehrani)[12] while accentuating the underlying grid and creating an ambiguous relationship between surface and detail.

This abstraction and reduction of detail reaches its ultimate expression in the space frame structures and universal joints of Konrad Waschmann. Ironically, the extreme specialization of the compo-

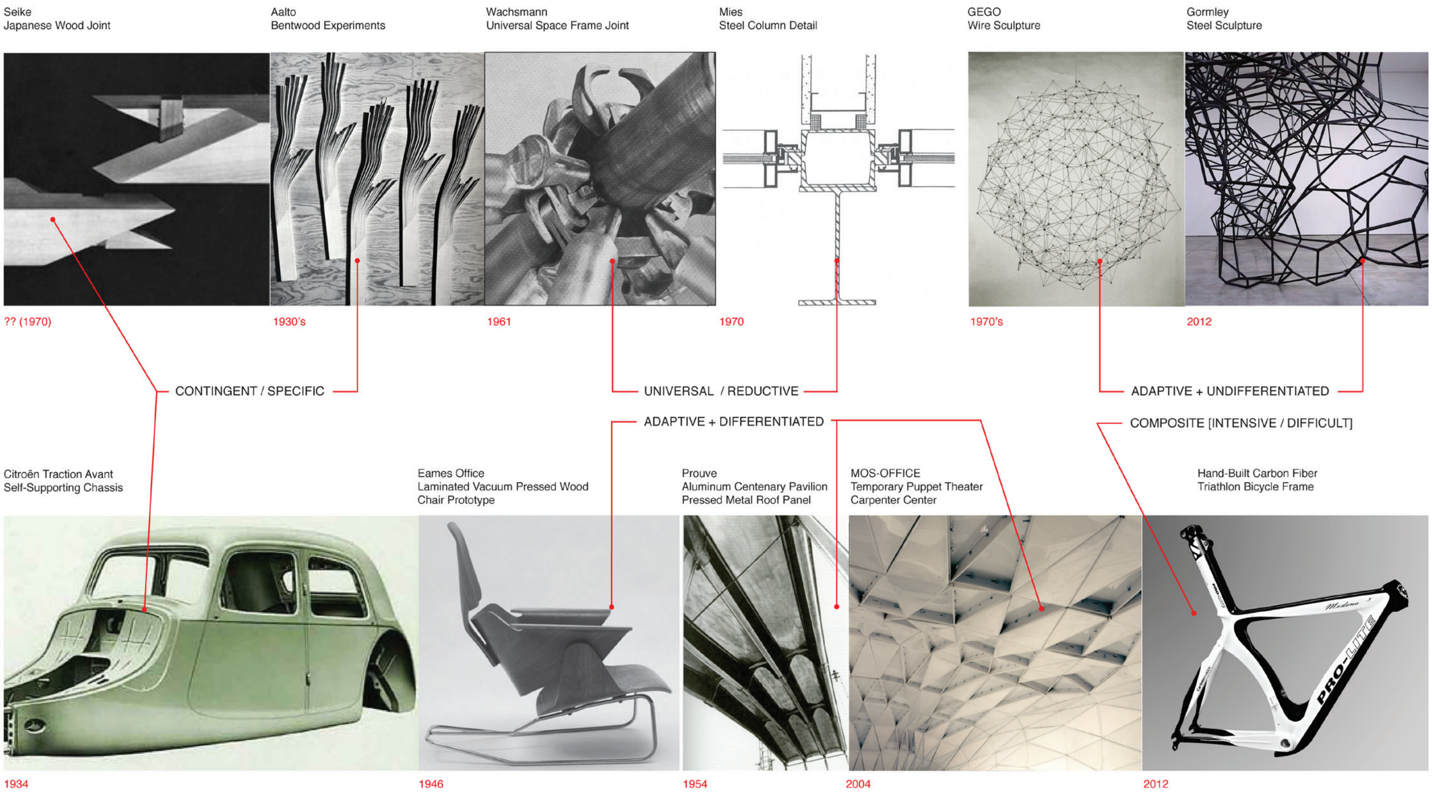

Figure 3. Evolution of the 20th + 21st Century Detail from Discrete Frame to Continuous Surface /Structure

nent parts of Waschmann's assemblages require an unprecedented level of complexity in the geometric complexity of the part, while reducing the resulting structural and spatial whole to an infinite, homogenized, undifferentiated plane.

Waschmann was aware of the problematic relationship between mass-produced component complexity and formal simplicity, tending towards monotony, as he stated in The Turning Point of Building-

> *"Only a superficial appraisal could support the opinion that the technical-scientific approach, the consistent application of automatically controlled, industrial production processes and the systematic modular coordination of all building elements, parts and products, leads inevitably to monotony or, as I am continually hearing with astonishment, the total destruction of every spiritual and emotional impulse."* [13]

His response to this dilemma was to design a "dynamic structure" or component that could adapt to varying loads in multiple directions. This concept remained relatively undeveloped until the advent of parametric detailing, made possible by computational craft. In parallel with the evolution of linear frameworks and structural elements in mid-twentieth century design, we may observe the transformation of the (Miesian) grid into the pliable, adaptive mesh, as exemplified by the sculptural work of the artist GEGO, (Gertrude Goldschmidt). Her prolific drawings and wire sculptures anticipated the structural possibilities afforded by advanced computing and digital-material processes. Sanford Kwinter, in his essay on "Mies and Movement," understood the potential of what he terms intermediate states of material organization, as exemplified by liquid crystals or aperiodic solids, as having the capacity to transform static models of spatial organization into dynamically adaptive structural forms.[14]

The Undifferentiated Detail

In a similar vein to Washmann's universal joint, contemporary parametric "pliable mesh organizations" exist as both surface and structure, neither promoting the component detail to the level of hierarchical differentiation, (see Ed Ford's *Five Houses, Ten Details* for comparison) nor subsuming the detail within the seamless surfaces of an earlier "blob" generation. Instead, the undifferentiated detail is maintained (in parametric practice), as an ambiguous, undecided object, unproblematized as either surface or structure, without establishing a definitive social or political engagement, lacking the status of what Alexandro Zaera Polo calls a *Thing* rather than an object.

> "In order to enable a viable strand of architectural politics, we need to politicize the discipline as the mediator between humans and non-humans, culture and technology and as the mechanism that will enable us to produce problematized *matters of concern: Things rather than Objects."*[15]

Figure 4. Differentiated Surface: Resin Coated Fabric-Formed Surface.

Deamer, in her essay "Detail Deliberations," has revealed the contemporary problematic status of the joint or detail, as emblematic of the shifting social construction of the Architect and Builder, equating the disappearance of detail with the repressed status of the craftsman or craft practices, within mainstream practices maintaining the Fordist model of production. In contrast to this, the re-examination of detail and joinery in critical practice, may serve to re-engage the early promise of CNC practices, promoting a collaborative culture of making that undermines the hegemony of top-down "command and control" project delivery methods, with a bottom-up culture of entrepreneurial engagement.[16]

DIFFERENTIATION + DIFFICULTY

An emerging sensibility towards critical re-assessment of "parametric" culture has appeared in recent essays on digital fabrication and its impact on material culture. The term "Difficulty" has begun to replace "Intricacy" as an index or measure of the critical value of contemporary practice, for a more rigorous, intellectual understanding of digital fabrication in the service of a conceptually sophisticated, historically aware, critical engagement with materiality (See Fig. 4).

In their recent essay on "Diminishing Difficulty," Willis and Woodward attempt to restructure the relation between Craft + Poetics of construction within a broad understanding of the critical choices undertaken by the architect in utilizing the detail to selectively conceal, or reveal tectonic relationships in the service of the conceptual poetics of architecture.[17] This critical attitude towards recovering material agency while continuing the evolution of structure and surface, and its attendant (sometimes hidden) details is further emphasized by Nader Tehrani, in his essay "Difficult Synthesis."[18]

Tehrani goes further in initially embracing, then immediately indicting, current (parametric + material) practices which tend to subsume or hide the joint / detail or, conversely, to superficially utilize or celebrate the detail, in an uncritical engagement with the resistance afforded by material agency. Both Willis + Woodward and Nader Tehrani sense the emerging shift from appropriation of surface for "Affect" towards a reconsideration of structure + surface in an intertwined, renewed and "difficult" whole.

The second operative term in relation to *Difficulty* that may serve the present discussion, is the notion of Differentiation.

In both the Material Ecology experiments of Neri Oxman at MIT, and the Performance based "parametric wood" experiments of Achim Menges at the Institute for Computational Design in Stuttgart, we may the evolution of detail through a performative understanding of material agency, advancing the historical legacy of material experimentation espoused by the Eames office, towards a radical re-investment of material poetics, grounded in what I will term Difficulty + Differentiation.

This approach has guided the newly emerging work stemming from the author's engagement with digital fabrication + material agency, in a new series of material investigations (Fig. 4). Differentiation, in this context, is understood as continuous adaptation to contingency and shifting forces, through mechanical, material or physical transitions or changes in a component, surface or structure.

STRUCTURAL PATTERNING IN STEEL

The merger of structure and surface may be accomplished through composite material construction, subsuming the detail within the micro-structural patterning of the material itself. This was the approach taken by Prouvé in the development of the corrugated roof panels for the Aluminum Centenary Pavilion, first erected in 1954. The curved sheet metal roof system, held together by shaped cross-ribs, and multiple cast and extruded aluminum fittings, have been the subject of research relating to both their structural performance (by the engineer Jürg Conzett) and the loss of material production technologies, in the reconstruction of the pavilion in the mid 1990's. [19]

The implications of the work of Prouvé towards contemporary experiments in material practice are extensive and relatively unexplored. The achievements in lightweight materials such as aluminum, and the shift from technical thought based on separation of frame + skin, towards the "monocoque" surface-structures developed in the automotive industry as early as the 1934 Citroën Traction Avant, serve as models for parametric exploration of patterned assemblies, utilizing both lightweight aluminum, and the strength of steel plate assemblages. From the standpoint of a contemporary performative, technologically mediated practice, it is important to understand that Prouvé was concerned not only with the tools or logistics of production, but equally with the improvement of basic shelter in various environments. Whether applied for houses in the tropics, an apartment façade or the Centennial Pavilion, Prouvé's material affects were always secondary to a genuine concern for the inhabitant and the quality of the interior environment.

While large-scale industrial metal forming processes are still largely outside the reach of design studios and academic fablabs, one possibility has emerged within the author's fabrication seminar, for combining the structural properties of steel plate, with the supple, surface oriented qualities of weaker materials such as molded plywood. Experiments in Patterning steel using a CNC Plasma Cutter, led to the possibility for strategically weakening steel plate, with the goal of creating an adaptive, pliable surface structure in steel. This parametric steel or "PlySteel" cnc/craft production method enables steel plate to approach the supple qualities of Eames' bent ply experiments, utilizing a much stronger material. The initial results of these experiments are simple demonstration surfaces, emerging from the limitations of bending encountered in the studio, combined with the possibilities afforded by CNC Plasmas Cutting.

The Pliable Joint

The initial plasma-cut patterned steel experiments yielded a number of associated possibilities, based on the concept of the "Pliable Joint" or detail. Utilizing an inversion of Waschmann's universal joint, the Adaptive, Parametric Ply-Joint absorbs the continuously changing vectors of the surface-structure, allowing standard section chord members to be utilized to create a complex surface structure. This method requires the parametric, associative modeling and fabrication workflow available today, resulting in sequenced and mass-customized component nodes, created in a "file-to-fab" or digital chain parametric workflow. This continuous surface / joint may be compared to the interlocking puzzle joints developed by William Massie in what is now a historically significant example of Mass-Customization or "Versioning." [20]

The as yet unexplored promise of this (PlySteel or PlyJoint) technique of strategic, parametric folding or weakening of steel, treating it more as fabric or textile, rather than linear supporting member, may depend on the ability to re-constitute or recover the original pre-cut strength of the material, through an intertwining of steel surfaces, or through the introduction of a composite bond between strong and weak materials. While the patterned steel methodology is still in its infancy, this approach promises to surpass the traditional understanding of steel as a tectonic material dependent on cross-sectional continuity and linearity for its strength. Instead, the PlySteel experiments intend to re-assess the status of the structural surface, perhaps owing a debt to the MOMA "Fabrications" installation by Office dA, viewing steel more as a structural textile with no differentiation between structure and skin.

ADAPTIVE PARAMETRIC DETAILING

Two streams of exploration have resulted from our initial experiments in steel. The first, Structural Patterning, has just emerged as a material strategy, and for all of its promise, awaits further development in our next series of plasma-cutting experiments.

The second strategy, Adaptive Parametric Steel Detailing, while perhaps more normative, has allowed the studio to rapidly develop material assemblages and prototypes leveraging the combination of steel CNC plasma cutting, with the potential afforded by parametric sequencing and automated production of complex geometries. The prototype hybrid CNC and hand-welded assembly requires a substantial investment in labor due to the lack of robotic welding, in this initial experiment. The goal is to move towards a fully robotic workflow for both cutting and welding the adaptive assemblies, in the next generation of adaptive detailing components.

The work in progress, a parametric steel shade tower, is proposed as an amenity to be situated along the town's bike trails, and further enhanced with the addition of experimental shading surfaces (see Fig. 5)

CONCLUSION

The possibilities for extending the present research towards new modes of practice require an assessment of what might constitute a Post-Parametric Practice.

Technologies of control must be *underspecified* instead of over-determined. *Intensive* qualities must be balanced with the pragmatics of extensive material or structural behavior. Utilizing parametric tooling while transcending the limitations of Code as the sole driver of form must be a consideration.

Figure 5. Partially Assembled Parametric Tower

In a post-parametric practice, Code + Matter Matters.

We are already witnessing this transition from the confines of computational practice to a much broader, material-based approach within parametric culture. The development of entirely new material processes, developed by students at the IAAC in Barcelona, under the guidance of Marta Male-Alemany, is but one example. The concrete work of Mark West, driven first and foremost by engagement with material, is now attempting to critically engage the possibilities inherent in computational processes. We are in the midst of an incredible new wave of “post-Parametric” practices, facilitated, but not constrained, by computational processes.

This paper introduces the author’s current research direction and newly emerging material explorations, made possible by the acquisition of a combination 3-Axis Steel CNC Plasma Cutter and 5-Axis Mill, part of the ongoing development of a new FABLAB facility. The work further anticipates the transition to working with a 6-Axis robot, beginning in the fall of 2012.

Viewed from a critical perspective, the emerging work in progress will attempt to move beyond the initial form-making novelty adopted by much recent parametric practice, towards a critical (RE) engagement with Material Agency, Craft and “Differentiated Difficulty” in the production and detailing of both Surface and Structure, into a radically reconfigured whole. The intent is to utilize parametric tooling, while transcending the limitations of technological determinism. A shift towards the social engagement, conceptual practices and material agency, with an awareness of the “material politics” of production, will form the backdrop for this new phase of research, guided by, but not delimited within, robotic fabrication.

ACKNOWLEDGEMENTS

Figs. 1 & 5: Parametric Tower definition & fabrication by Akihiro Moriya, initiated in the author’s Spring 2011 *FABCRAFT* seminar, University of Arkansas.
Figs. 2 & 4: Resin Coated Fabric Forms by Blake Leonard, with computational simulations by the author. Work produced in the author’s Spring 2012 *Rethinking Making* seminar, University of Arkansas.
Fig. 3: Puppet Theater image courtesy of mos-office (Michael Meredith & Hilarry Sample).

ENDNOTES

1 See the online version of Richard Serra’s “Verb List Compilation: Actions to relate to Oneself,” http://www.ubu.com/concept/serra_verb.html accessed July 16, 2012.
2 For a discussion of Aalto’s terms- “extended rationality” and “technical-humanist rationality,” see S. Perez, “Towards An Ecology of Making,” in *Matter: Material Processes in Architectural Production,* eds. Gail Peter Borden & Michael Meredith (New York: Routledge, 2012).
3 Andrew Pickering, *The Cybernetic Brain: Sketches of Another Future* (Chicago: University of Chicago Press, 2011), 379-402.
4 Martin Heidegger, “The Question Concerning Technology,” *Basic Writings* Ed. David Krell (New York: HarperCollins Publishers, 1993), 321.
5 Donald Judd, *“Specific Objects,”* written in 1964. First published in Arts Yearbook 8, 1965.
6 See Hight’s essay- “High-Performance Anxiety,” along with other theories and essays discussing the limitations and opportunities in performative practice in *Performalism: Form And Performance In Digital Architecture,* Yasha J. Grobman and Eran Neuman, eds. (New York: Routledge, 2012).
7 Antoine Picon, “Architecture as performative art” in *Performalism,* pp. 15-19. The use of the term “performative” in the context of this essay, extends beyond structural or environmental performance, towards event, affect, and the broader connotations elicited by Picon’s critique.
8 See Manuel DeLanda’s “Matter Matters” in *Domus 896,* October 2006.
9 The term “post-functional” is used to indicate the immersion of the architectural detail within a contemporary context that exceeds the strict (20th c.) notions of functionality, towards a much broader and more complex association of “function.”
10 For an introduction and examples of a “Digital Process Chain” see Shindler, Christoph, et al., *Inventioneering Architecture,* in the Acadia 2006 Synthetic Landscapes conference proceedings, 2008, pp. 136-145. Also see Dohmen, Philipp; Rüdenauer, Kai (2007) *Digital Chains in Modern Architecture,* Predicting the Future 25th eCAADe Conference Proceedings.
11 Richard Sennett, *The Craftsman* (New Haven: Yale University Press, 2009).

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13 Konrad Waschmann, (1961) *The Turning Point of Building; Structure and Design* Reinhold Publishing Corp: New York,. p. 194.
14 Sanford Kwinter (1994) "Mies and Movement: Military Logistics and Molecular Regimes," in *The Presence of Mies*, ed. Detlef Mertins. New York: Princeton Architectural Press, pp. 84-95.

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17 Willis, D. and Woodward, T. (2010). "Diminishing Difficulty: Mass Customization and the Digital Production of Architecture," in *Fabricating Architecture: Selected readings in Digital Design and Manufacturing, Robert Corser, ed., pp. 178-208.* New York: Princeton Architectural Press.
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19 For an extended in-depth series of essays on the work of Prouvé, see *Jean* Prouvé*: The Poetics of the Technical Object, ed. Alexander von Vegesack. Weil am Rhein: Vitra Design 2005.*
20 William Massie, (2002). "Remaking in a Post-Processed Culture." in *Versioning: Evolutionary Techniques in Architecture*, eds. Sharples, Holden, Pasquarelli (SHoP) 54-57. West Sussex, England: Wiley-Academy.